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PBF/BNCT Program for Cancer Treatment

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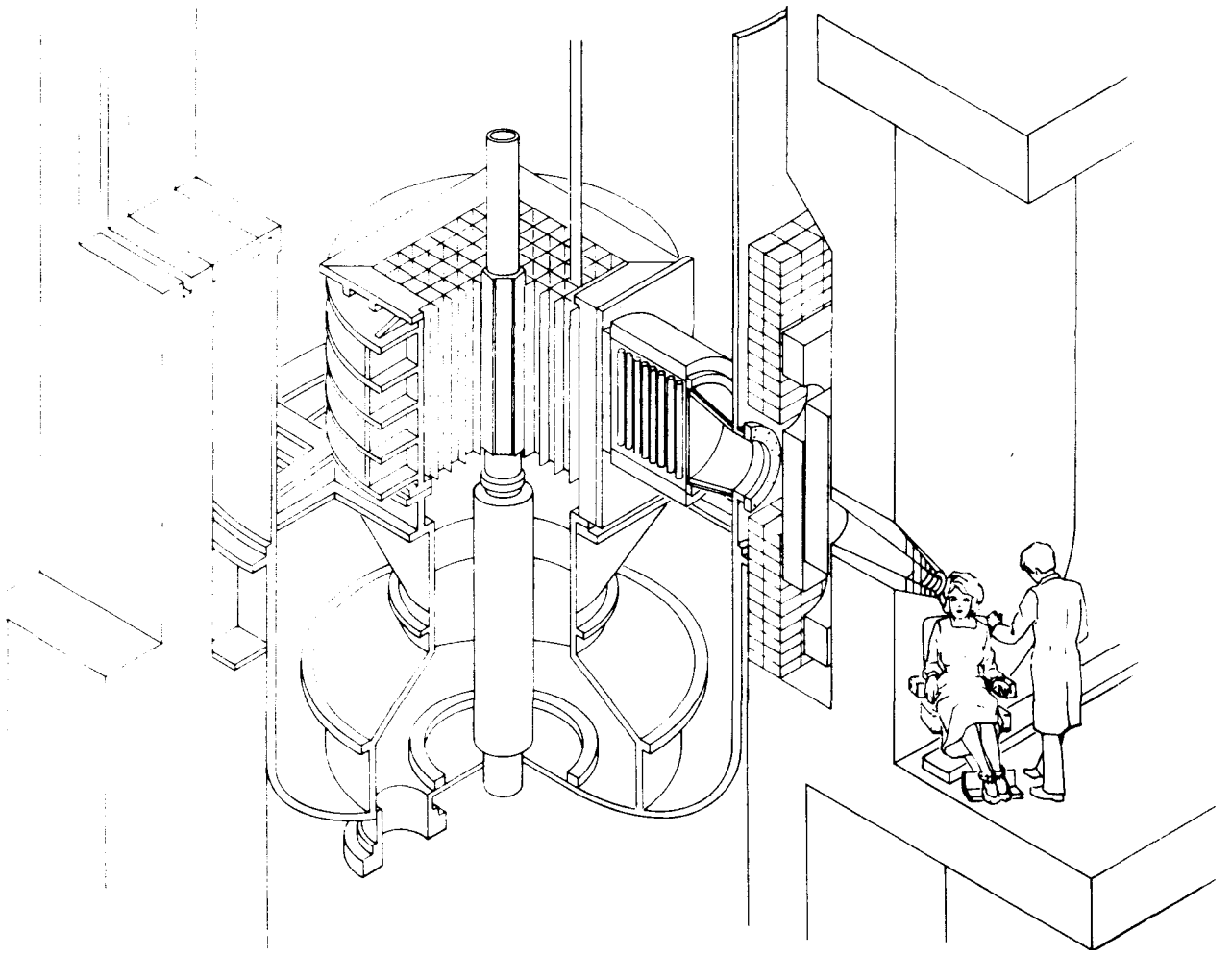

Bulletin

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PRINCIPAL INVESTIGATOR'S HIGHLIGHTS

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This PBF/BNCT Program Monthly Bulletin is the primary vehicle for prompt national and international dissemination of research progress and the development status of tools essential for optimum BNCT clinical application. Accordingly, begining with this issue, PBF neutron-filter design progress and PBF standby task summaries will be added to the subjects previously reported.

Highlights of the PBF/BNCT Program during November include progress within the areas of:

1. Project 1: Supporting Technology Development

   Task 1: Gross Boron Analysis in Tissue Blood and Urine - ICP-AES analysis of Washington State University (WSU) canine and Cornell cell culture samples completed.

   Task 2: Analytical Methodologies Development for BSH (Sodium Borocaptate) Purity Determination - Completion of initial matrix evaluations for FAB/MS and investigation into possible use of Crown ether solutions as the involatile matrix

   Task 4: Boron Microscopic (Subcellular) Analytical Development - Standardization of sample preparation methods and assessment of quantification methods

   Task 5: Noninvasive Boron Quantification Determination - Successful completion of hardware modifications to the Eastern Idaho Regional Medical Center (EIRMC) Magnetic Resonance Imaging (MRI) system and development of imaging analysis software

   Task 6: Dosimetry - Computer codes, required to unfold neutron spectra from sandwich foil reaction rates, operational; portable gamma spectrometer assembled; and thermo-luminescent dosimeters prepared for BNL dog irradiations

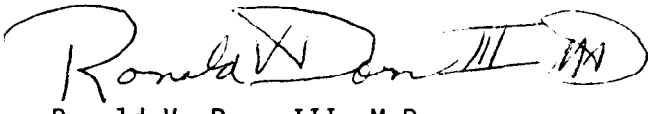
   Task 7: Analytical Radiation Transport and Interaction Modeling for BNCT - Initial version of beam input generator written for Monte Carlo module and Apollo 10000 delivered to INEL

Project 2: Large Animal Model Studies - Tumorous dogs received, MAC-II personal computer acquired, and post-D.V.M. research associate added to WSU research group

Project 5: Neutron Source and Facility Preparation - PBF core physics design progressed; the design of the PBF reactor vessel penetration and aluminum closure flange, required for neutron beam extraction, was revised to improve manufacturability; and the neutron filter cooling system stress was shown to be within code allowables

Core A: Administration and Common Support - BNL support; meetings, conferences, and proceedings; and programmatic functions

Core B: PBF Operations - Inventory and inspection of reactor plant electrical breakers, review and revision of plant operating manuals, plant preventative maintenance, and reactor operator training



Ronald V. Dorn III, M.D.
Principal Investigator
PBF/BNCT Program

ACRONYMS

ASME	American Society Mechanical Engineers
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
BNCT	Boron Neutron Capture Therapy
BSH	Sodium Borocaptate
DOE	Department of Energy
DOE-ER	Department of Energy-Energy Research
DOE-ID	Department of Energy-Idaho Operations
EDF	Engineering Design File
EIRMC	Eastern Idaho Regional Medical Center
FAB/MS	Fast Atom Bombardment/Mass Spectrometry
GE	General Electric
HPLC	High-Performance Liquid Chromatography
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
INEL	Idaho National Engineering Laboratory
MRI	Magnetic Resonance Imaging
NCI	National Cancer Institute
NRC	Nuclear Regulatory Commission
PET	Positron Emission Tomography
PBF	Power Burst Facility
RESL	Radiological Environmental Sciences Laboratory
SSE	Safe Shutdown Earthquake
TLD	Thermo-Luminescent Dosimeter
UofW	University of Washington
WSU	Washington State University

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PBF/BNCT PROGRAM
MONTHLY BULLETIN

PROJECT 1: SUPPORTING TECHNOLOGY DEVELOPMENT

TASK 1: Gross Boron Analysis in Tissue, Blood, and Urine

Routine preparation and analysis of biological samples for boron content by ICP-AES continues. Samples were received from the large animal model studies (Project 2) at WSU. Samples of freeze-dried cell cultures were also received from Cornell University (Project 1, Task 4). The dry weight of the cell samples was less than 10 milligrams. The cell samples were processed using normal preparation and analysis procedures and yielded accurate data. These results demonstrate ICP-AES viability for very small sample analysis.

During the week of November 28 renovation was begun in the INEL laboratory housing the ICP-AES being used for the boron analysis. The modifications are to allow installation of a second ICP-AES.

TASK 2: Analytical Methodologies Development for BSH (Sodium Borocaptate) Purity Determination

Two areas addressed this month were: (1) completion of the initial matrix evaluations for FAB/MS and (2) investigation into the possible use of Crown-ether solutions as the involatile matrix.

Two series of experiments were conducted to complete the initial matrix evaluations. In the first series, an ion-pairing agent (tetrabutyl ammonium phosphate) was evaluated without an additional matrix such as 3-NOBA or PEG600 (designations of commercially available materials). These experiments were initiated because the ion-pairing agent was readily observed, in the positive ion mode, when introduced into the mass spectrometer as a simple aqueous solution. The purpose of the experiments was to determine if the positive ion portion (tetrabutyl ammonium) of the ion-pairing agent would attach or associate itself with the negative ion portion of the BSH molecule to yield a species which could be detected in the positive ion mode. The results were not promising. While observed peaks suggest the desired reaction was occurring, the peaks were sporadic and not useful. This area of investigation will be pursued in the future, if time permits.

The second series of experiments evaluated the use of Crown ethers. Crown ethers are cyclic compounds containing alternating groups of carbon and oxygen atoms. These compounds have a large internal volume noted for trapping metal cations such as sodium. Since the cations associated with the boronated species of interest are sodium and cesium, it was decided to explore the use of the Crown ether solutions to determine if peaks could be defined that could be used for identification of the BSSB and BSSOB species. Two Crown ether solutions were used: a solution containing a mixture of 18-crown-6 and glycerol and a mixture of 18-crown-6 and 3-NOBA. Of the two, the latter worked best. Peaks were observed which have tentatively been identified as BSSOB. No peaks were observed which could be attributed to the cesium salt of BSSB. This is hypothesized to be due to the size of the cesium cation, which is quite large compared with the sodium cation. The cesium cation may be too large to fit inside the Crown ether ring. Two solutions for this problem are possible: (1) ion exchange the cesium for sodium using ion exchange resin or (2) use a larger Crown ether ring to provide a larger volume for the cesium cation. Both of these possibilities are being investigated.

Microbore HPLC development for analysis of commercially-supplied BSH revealed an additional peak in the pyrrolidone reaction intermediate, which has an elution time very close to that of the BSH compound. A large BSH peak could possibly mask this impurity. Efforts are continuing to identify this new peak.

The BSSB peak shape, from the columns currently in use, has begun to degrade. Several reasons are possible and include degradation of the BSSB solid used to prepare the analytical solutions and/or degradation of the columns themselves. Solutions have been prepared from multiple lots of solid BSSB with similar analytical results. This would tend to rule out degradation of the BSSB as the primary problem. Solutions of BSSB have been analyzed on two different columns and have yielded similar results. Both of the columns being used in these experiments have had large numbers of samples run through them. It is possible both of these columns have been modified or degraded in some manner which results in active site formation, causing degradation of the BSSB on the column. The good peak shape obtained for the BSH pyrrolidone reaction intermediate and BSSOB support this possibility. A new column has been ordered and will be used to examine this theory. Pending arrival of this new column, efforts will be made to rejuvenate the older columns.

TASK 3: Analytical Methodologies Development for Active Form Identification

This task is presently unfunded.

TASK 4: Boron Microscopic (Subcellular) Analytical Development

Progress is continuing on standardizing sample preparation methods. Initial images of boron in liver and spleen sections (from animals in the WSU pharmacokinetic study) are faint, but recognizable. Correlations are being carried out using sister sections having clear morphology with a goal of establishing intra vs intercellular location of boron and determining subcellular resolution. Assessment of quantification methods is underway. Charge-coupled devices and a real-time videocamera are in evaluation for collection and storage of the data signals. Use of either in-situ standards or the more laborious ion implants are being evaluated as comparative references.

TASK 5: Noninvasive Boron Quantification Determination

Hardware modifications to the EIRMC's MRI system were successfully completed and development of the necessary imaging and analysis software is continuing. The hardware is performing as designed and the task of changing from proton imaging to boron imaging and back to proton imaging can be accomplished in less than one-half hour without difficulty. Initial experiments, using some existing GE spectroscopy software modified by Dr. Todd Richards (UofW), to image a phantom containing different ^{11}B compound concentrations were conducted and produced identifiable images and spectroscopy information. Dr. Richards has written special software to reconstruct the chemical shift data and generate either a color image or a 16 x 16 pixel representation of the spectroscopy data for each pixel of sampled data. Preliminary imaging software has been shown to be effective in acquiring data from short T2 signals expected in tissue. This ability will be particularly important when experiments begin with ^{10}B-enriched compounds. Effort will now be concentrated on developing the radio frequency coils needed to perform ^{10}B imaging in canine tumors.

TASK 6: Dosimetry

Computer codes, used to determine neutron spectra from sandwich foil reaction rates, are up and running. The cross-section data files, together with their variance and covariance files (relevant to the BNCT foils), have been prepared. The codes were used to determine the neutron spectrum from the June 1988 BMRR foil activations.

A portable gamma spectrometer has been assembled at INEL for use at BNL to augment available counting capabilities. The portable instrument will be required to count wires implanted in the dog phantom and wires implanted in the first two dogs in the large animal model studies (Project 2). A detector and most of the electronics for this spectrometer were on hand; only the multichannel analyzer was newly purchased.

The TLD-400 rods obtained from Harshaw/Filtrol have been evaluated by DOE/RESL personnel. Approximately 130 rods were selected from the 500-rod batch to assure minimum response variance. Radio-opaque, 14-gauge Teflon catheters have been loaded with eight TLDs each in preparation for the dog phantom irradiations at BNL. Two $LiOH \cdot H_2O$ neutron beam delimiters have been fabricated to restrict the subject irradiation area. These delimiters will limit the exposure area to 5 x 5 cm or 10 x 10 cm, as desired.

TASK 7: Analytical Radiation Transport and Interaction Modeling for BNCT

An initial version of the beam input generator has been written for the Monte Carlo module. The beam input will utilize source file neutron filter calculations and generate input particle characteristics for the neutrons and gammas emanating from the filter collimator. This source input will be very easy to use since all the detail will be previously developed and stored in a restricted source file. The user need only specify the geometric relationship between the beam and the target. This will be simplified since the geometric transformations are all handled by the coding and graphical displays will verify proper alignment.

The Apollo 10000 computer was delivered to INEL and installed. It has been connected to the INEL ethernet for remote access by authorized users. The DOT 4.3 discrete ordinates transport code (INEL's workhorse for deterministic analysis of radiation transport) has been brought up on the 10000 and appears to be working properly. Work continues on installing other BNCT-related software. The technical scope of a graphics development contract with the University of Utah has been verbally agreed upon.

PROJECT 2: LARGE ANIMAL MODEL STUDIES

Two dogs received and evaluated at WSU this month had brain tumors. Both were infused with a dose of 55 mg boron/kg and euthanized three hours following infusion for tissue sampling. Sampling revealed that both dogs had intra-axial tumors. Histology for both dogs is pending.

A second post-D.V.M. research associate will be joining the WSU research group. Dr. Constance Delaan is moving from the San Francisco area to work with the research project. She will be working toward a Ph.D. and performing radiology residency.

Drs. Gavin and Kraft will meet with UofW researchers in Seattle on December 9 to discuss PET scanning protocol for dogs with brain tumors and to meet with Dr. Richards regarding spectroscopy.

The WSU research group has acquired a MAC-II personal computer and is integrating specialized imaging software developed by Dr. Richards. Dr. Richards' software converts magnetic resonance scan tapes into the proper format for manipulating image data and evaluating "regions of interest" T1 and T2 values.

The latest information on large animal model experiments is summarized on Pages 9 and 10.

PROJECT 3: HUMAN STUDIES

This project is currently not funded.

PROJECT 4: STABILITY, PHARMACOLOGY, AND TOXICOLOGY OF DRUGS

This project is currently funded by a grant from the State of Idaho.

WSU CANINE PHARMACOKINETIC STUDY
SUMMARY OF PATIENT DATA AVAILABLE FROM PBF/BNCT CENTRAL PROGRAM FILES

ANIMAL	NAME OF DOG	EUTHANASIA DATE	EUTHANASIA MIN*	CASE SUMMARY	PATHOLOGY DIAGNOSIS	BLOOD SERUM AND URINE ANALYSIS	TISSUE ANALYSIS	CT UNENH.	CT ENH	MRI UNENH.	MRI ENH
35447-1	"Muffy" Klugh	3/23/87	660	Yes	Pituitary adenoma	Yes	Yes	Yes	Yes	Yes	Yes
35447-2	"Stashi" Christensen	5/18/87	750	Yes	No tumor/positive boron control	Yes	Yes	N/A	N/A	N/A	N/A
35447-3	"King" Henry	5/18/87	Control	Yes	No tumor/negative boron control	Control	Yes	N/A	N/A	N/A	N/A
35447-14	"Marsha" Despain	6/30/87	780	Yes	Invasive Adenocarcinoma	Yes	Yes	Yes	Yes	Yes	Yes
36085	"Amos" Vallangdigham	8/3/87	780	Yes	Invasive nasal carcinoma	Yes	Yes	Yes	Yes	Yes	Yes
35447-18	"Slim" Pozzobon	9/14/87	770	Yes	Invasive nasal adenocarcinoma	Yes	Yes	Yes	Yes	Yes	Yes
35447-20	"Mischief" Scott	11/2/87	90	Yes	Meningioma	Yes	Yes	Yes	Yes	Yes	Yes
35447-23	"Rocky" Christensen	11/13/87	770	Yes	Pituitary adenoma	Yes	Yes	Yes	Yes	Yes	Yes
35447-24	"Mariah" May	11/24/87	410	Yes	Nonenhancing lesion	Yes	(P)	Yes	Yes	Yes	Yes
36845-25	"Sandy" Frazier	1/26/88	770	Yes	Meningioma	Yes	No	Yes	Yes	Yes	Yes
35447-28	"Boots" Belisle	2/22/88	125	Yes	Nonenhancing right cerebellar mass	Yes	Yes	Yes	Yes	Yes	Yes
35447-30	"Sunny" Seeley	3/1/88	420	Yes	Extraaxial lesion	Yes	Yes	Yes	Yes	Yes	Yes
35447-32	"Pip" Hahn	2/26/88	410	Yes	Pituitary/thalamic tumor	Yes	Yes	Yes	Yes	Yes	Yes
35447-33	"Coco" Pechtel	3/23/88	420	Yes	Nasal adeno carcinoma	Yes	Yes	Yes	Yes	Yes	Yes
35447-37	"Tucker" Reeves	4/14/88	420	Yes	No tumor/positive boron control	Yes	(P)	N/A	N/A	N/A	N/A
35447-39	"Fritts" Coglan	5/2/88	110	Yes	Meningioma	Yes	Yes	Yes	Yes	Yes	Yes
35447-40	"Rocky" Underwood	5/3/88	420	Yes	Fungal Granuloma	Yes	Yes	Yes	Yes	Yes	Yes
35447-43	"Blue" Archer	5/23/88	420	Yes	Diffuse cortical astrocytoma	(P)	No	N/A	N/A	Yes	Yes
35447-49	"Jenny" Nelson	6/29/88	420	Yes	Glial cell infiltrate	(P)	Yes	Yes	Yes	Yes	Yes

* Euthanasia time in minutes following start-of-boron administration. Boron administration requires approximately 50 minutes.

(P) Partial results

N/A Not applicable

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WSU CANINE PHARMACOKINETIC STUDY
SUMMARY OF PATIENT DATA AVAILABLE FROM PBF/BNCT CENTRAL PROGRAM FILES

ANIMAL	NAME OF DOG	EUTHANASIA DATE	EUTHANASIA MIN*	CASE SUMMARY	PATHOLOGY DIAGNOSIS	BLOOD SERUM AND URINE ANALYSIS	TISSUE ANALYSIS	CT UNENH.	CT ENH	MRI UNENH.	MRI ENH
35447-50	"Caesar" Chenoweth	7/13/88	420	Yes	Meningioma	(P)	Yes	Yes	Yes	Yes	Yes
35447-54	"Licorice" Meyers	8/3/88	410	Yes	No	(P)	Yes	Yes	Yes	Yes	Yes
35447-55	"Kelley" Langsston	8/17/88	410	Yes	Diffuse Astrocytoma	(P)	Yes	N/A	N/A	Yes	Yes
35447-57	"Rafferty" Reber	9/1/88	(?)	Yes	No	No	No	No	Yes	Yes	Yes
35447-59	"Heidi" Boyer	9/12/88	180	Yes	Meningioma	Yes	Yes	No	Yes	Yes	Yes
35447-62	"Chester" Scott	10/9/88	180	Yes	Meningioma	(P)	Yes	No	Yes	Yes	Yes
35447-67	"Muffet" Hammel	11/1/88	180	Yes	No	No	No	No	Yes	No	No
35447-70	"Mac" Meyers	11/15/88	180	Yes	No	No	No	No	Yes	Yes	Yes

* Euthanasia time in minutes following start-of-boron administration. Boron administration requires approximately 50 minutes.

(P) Partial results

N/A Not applicable

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PROJECT 5: NEUTRON SOURCE AND FACILITY PREPARATION

Analysis

PBF Core and Physics Design Analysis: Analysis is continuing to refine and validate the November, 1988 update of the CRAY version of PDQ-7. CYBER and CRAY results from the 1/2 core, XY geometry model of the modified PBF core are now in agreement. CRAY PDQ-7 development and validation work is also continuing on the 1/2 core three dimensional flux synthesis and three dimensional explicit calculation for core and filter design. The explicit solution is necessary to validate the results produced by the more economical flux synthesis technique.

Depletion modeling of the modified PBF core was started. PDQ-7 input has been modified for explicit representation of the Xe-135, Sm-149, U-235, and U-238 depletion chains. Cross sections were developed for U-236, Pu-239, Pu-240, and Pu-241 and these data have been input to the model. The neutron absorption caused by the numerous other fission products is handled with a lumped fission product absorption cross section and these data were input to PDQ-7 in a fashion that will allow the fission product absorption cross sections to vary with exposure time. The PBF depletion model has been checked out in both one- and two-dimensional geometry. An XY geometry model that represented the control rods as fully withdrawn was used to simulate depletion for 8325 MW-hr at a power level of 20 MW. This calculation predicted a reactivity loss of \$0.62 versus the \$0.71 predicted by the measured PBF burnup reactivity relationship (0.85×10^{-2} cents/MW-hr). This calculation was made primarily for checkout purposes. The more appropriate approach will represent the control rods in a critical rod bank configuration as the depletion is simulated (3D-geometry).

Filter Cooling System Stress Analysis: The cooling system was analyzed for deadweight, pressure, thermal expansion, and safe shutdown earthquake (SSE) forces using the design criteria of Section III of the ASME Code for Class 2 piping. The skid and equipment mountings were analyzed using the criteria of the AISC Steel Construction Manual.

Pipe system SSE forces were determined using the response spectra dynamic analysis approach with the excitation expressed as a support point response spectra. The applied acceleration spectrum was based on the U.S. NRC Regulatory Guide 1.60 spectra with a zero period acceleration of 0.22 g's horizontal. The skid was evaluated using static equivalent seismic forces derived from these spectra.

All stresses in the piping, skid, and vessel penetration were determined to satisfy the allowable stress criteria. Details of the analysis, pipe support requirements, and equipment nozzle reactor loads are documented in EDF PBF-BNCT-108.

Design

The final design review package for the modification to the PBF Reactor Vessel for the installation of the neutron beam exit nozzle flange was assembled and distributed. The design review is scheduled for December 2, 1988.

The vessel flange consists of a 48 inch O.D. stainless steel nozzle, aluminum closure flange and stainless steel backing ring. The flange is a reverse flange which will allow installation from inside the reactor vessel and keep the number of welds which must be made in the reactor vessel to one weld. The closure head is aluminum to keep steel out of the beam path. This closure will be analytically treated as the reactor pressure boundary even though it will normally have a dry air purge on the reactor side. The Preliminary Design Review for the nozzle and flange was held in December of 1987. The configuration of the nozzle and flange has been altered since the Preliminary Design Review as a result of a manufacturability review performed on the nozzle and filter. Since the configuration had changed, it was deemed advisable to conduct an informal peer review of the flange design prior to the Final Design Review. The informal peer review was conducted as a part of the design process and the results incorporated into the design. A suggestion was made during this review which is worthy of consideration. A mock-up of the reactor vessel wall should be fabricated to verify welding and cutting procedures prior to modifying the reactor vessel.

A Failure Modes and Effects Analysis (FEMA) of the nozzle and flange is being performed to support the design. This analysis is about 20 percent complete.

The design of the filter cooling system, which uses D_2O as the cooling medium, is nearly complete. A final design review of this system is tentatively scheduled for mid-December. A peer review of the unreleased Engineering Design File for the Neutron Nozzle/Core Filter system control system (D_2O Cooling System) has been completed. As a result of this review, the EDF is being revised. The cooling system is a skid mounted system with the pumps, heat exchangers, filters, and sample system mounted on a skid which will be located near the canal wall in the building first basement. The main design problems with this system were to design for very low leakage of the D_2O and to minimize the probability of overpressuring the filter housing through an equipment malfunction or operator error.

Drawings that were being revised, for the Neutron Monitoring System, Reactor Ion Chambers (Startup Chambers) and In-Core Instrumentation System, were completed. They will be included in the Design Review close-out package scheduled to be delivered on December 12, 1988. With the completion of these drawings the design on these tasks is to be put on hold pending approval to perform the facility modifications.

CORE A: ADMINISTRATION AND COMMON SUPPORT

Programmatic/Administrative

Preparation and submittal to DOE-ER of a BNCT: Melanoma Treatment Evaluation Program was a major endeavor this month. Proposal preparation did not use funds from this program but is reported herein for completeness. Proposal preparation and submittal timing was driven by the need for DOE-ER awareness and support for plan presentation to the joint Australian/Japanese Melanoma-BNCT Program participants at their December 13-14 workshop in Sydney, Australia. Major input was received from current and prospective researchers and an executive summary was prepared and sent (by DOE-ID) to DOE-ER on November 18 to aid DOE-ER in preparing for plan evaluation. On December 7, program participants will present to DOE-ER: (1) the BNCT: Melanoma Treatment Evaluation Program proposal and (2) the present status of INEL's BNCT deployability assessment. Item 2 consists of a conceptual design of a passively safe, low-cost (< $50 M) medical reactor and an assessment of accelerator technology capability for supplying a usable medical beam.

An early November, two-day planning meeting was held at the University of Rochester and at Cornell University. Those attending were Merle L. Griebenow, Drs. Patrick R. Gavin, Ronald V. Dorn, David L. Miller (INEL), Philip Rubin (University of Rochester), and members of the Cornell University Group (Dr. Morrison and others). Progress and plans related to the collaborative cell culture development work leading to canine-tumor intracellular boron quantifications were reviewed and ion microscopy results were evaluated.

Dr. Dorn met with Dr. John Antoine (NCI, Director of Radiation Therapy Research) on November 17 to discuss progress in the PBF/BNCT Program and the proposed BNCT: Melanoma Treatment Evaluation Program. Dr. Dorn advised Dr. Antoine of our December 7 Melanoma Program briefing with DOE-ER and suggested NCI attendance or an NCI briefing to follow the DOE meeting.

A BNCT status and planning session was held November 29 in Idaho Falls to review progress of the research projects and tasks and to discuss future direction of the program. The planning emphasis centered around the dog irradiations scheduled to begin in early January, 1989 at BNL. The meeting concluded with a tour of the EIRMC MRI facility (to be used in the program) and a discussion of the modifications being completed by Ken Bradshaw (INEL) and Dr. Richards (UofW). PBF/BNCT Program-developed boron imaging and quantification capability was demonstrated.

Meetings, Conferences, and Proceedings

Dr. Dorn gave an invited seminar on BNCT and the PBF/BNCT program to the George Washington University medical staff in Washington D.C.

Merle Griebenow and Dr. Dorn will attend the Third Annual Workshop of the Joint Australian/Japanese Melanoma-BNCT Program and present the PBF/BNCT Program for Brain Tumor status and the proposed BNCT: Melanoma Treatment Evaluation Program.

BNL Support

Monte Carlo calculations were performed to define physics constraints on the desired BMRR biological evaluations. Initial analyses modeled the lucite dog phantom. Flux distributions in the phantom were calculated using a preliminary model of the Al_2O_3 filter. The study will define materials and thicknesses of the beam delimiter required to restrict the effective beam diameter and protect tissue from excessive collateral dose. Detailed edit regions were included in the model to determine brain-volume, neutron-flux contours obtainable with a 5 x 5 cm beam delimiter. As expected with a neutron beam, it is not possible to isolate one brain hemisphere from another. However, a 2:1 ratio in hemibrain volumetric neutron capture can be achieved by an offset alignment. The relatively long BMRR irradiation time for the required doses, associated with the 5 x 5 cm delimiter, may mandate the use of a larger beam opening (10 x 10 cm) to increase the thermal flux intensity.

It was determined that polyethylene, containing $LiOH \cdot H_2O$ (enriched in the ^6Li isotope), is an effective epithermal neutron shield. The high-energy neutrons and gammas in the beam will be only slightly attenuated with delimiter thicknesses currently being considered. Formal, long-term storage documentation of study results are being prepared.

BNCT program participants will meet with BNL management at BNL December 6 to discuss INEL/BNCT collaborative efforts. Dr. Gavin (WSU) will meet with Dr. Joel (BNL) on December 6-7 to finalize the upcoming dog irradiations interface with BNL.

CORE B: PBF OPERATIONS

In response to DOE notices that electrical breakers previously purchased and installed in reactor plants could potentially contain defective, counterfeit components; an inventory and inspection plan of the PBF plant electrical breakers has been established. The first phase of the inspection plan, which involves an inventory of the electrical breakers in the plant and a record search to establish the supply and purchase source, has been initiated. Once this data base has been determined, subsequent physical inspection of the breakers in the plant will be conducted to detect possible counterfeit components.

A review and revision of the plant operating manuals to incorporate plant changes has been initiated. These revisions will incorporate deletion of those plant systems which will not be used for the BNCT program and are currently inactive. Additional revisions will be required to incorporate the specific BNCT plant modifications once the final designs and modifications are completed.

Plant preventive maintenance performed during the month included; (1) annual disassembly and inspection of the plant auxiliary air compressor, (2) health physics emergency bus generator inspection, (3) annual inspection of the 5/15-ton overhead crane, (4) heating and ventilation system boiler, and (5) fire system electrical pumps.

The routine monthly operational safety walkthrough of the plant was completed. A schedule for the correction of the deficiencies has been established and the items are being corrected. A health physics operational audit was conducted by the "Environmental, Safety and Quality" operational unit. No deficiencies were revealed during this audit.

Reactor operator training conducted during the month of November included; (1) medical first aid training, (2) chemistry lecture on the plant chemistry requirements, (3) quarterly refresher training for the emergency bus drivers, (4) emergency response drills for a fire in the plant process area and and earthquake, and (5) conduct of the annual total plant evacuation exercise. Routine annual whole body counting was completed for personnel assigned to the reactor area.

Inventory of Boron Salt and Standards

BNCT	8	$Na_2{}^{10}B_{12}H_{11}SH$	3 gms
	9	$Na_2{}^{10}B_{12}H_{11}SH$	4 gms
	10	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	11	$Na_2{}^{10}B_{12}H_{11}SH$	.75 gms
	13	$Na_2{}^{10}B_{12}H_{11}SH$	~2 gms
BNCT	12	$Na_2B_{12}H_{11}SH$	500 mg
	15	$Na_2B_{12}H_{11}SH$	.140 gms
	14	$Na_2B_{12}H_{11}SH$ (BNCT 14 returned by W.A.)	~ 2 gms
	23	$Na_2B_{12}H_{11}SH$	1.5 gms
	24	$Na_2B_{12}H_{11}SH$	.3 gms
	27a	$Na_2B_{12}H_{11}SH$	500 mg
	22	$Na_2B_{12}H_{11}SH$	~ 6 gms
BNCT	17	$CsB_{12}H_{11}SCN(CH_3)(CH_2)_3CH_2$	100 mg
	27	$CsB_{12}H_{11}SCN(CH_3)(CH_2)_3CH_2$	100 mg
	30	$CsB_{12}H_{11}SCN(CH_3)(CH_2)_3CH_2$	1 gm
BNCT	19	$Cs_4B_{12}H_{11}SSB_{12}H_{11}$	500 mg
	25	$Cs_4B_{12}H_{11}SSB_{12}H_{11}$	400 mg
	29	$Cs_4B_{12}H_{11}SSB_{12}H_{11}$	1 gm
	31	$Cs_4B_{12}H_{11}SSB_{12}H_{11}$	200 mg
BNCT	26	$Na_4B_{12}H_{11}SOSB_{12}H_{11}$	400 mg
	28	$Na_4B_{12}H_{11}SOSB_{12}H_{11}$ (opened 12/7/88)	1 gm
BNCT	16	$CH_3(CH_2)_2N(CH_3)CS$	5 gm
	18	$LiB_{12}H_{11}XH_2O$	1 gm
BNCT	32	$Na_2B_{12}H_{11}SH$ (opened 12/19/88)	1 gm
	33	$Na_2B_{12}H_{11}SH$	1 gm
	34	$Na_2B_{12}H_{11}SH$	1 gm
	35	$Na_2B_{12}H_{11}SH$	1 gm
	36	$Na_2B_{12}H_{11}SH$	1 gm
	37	$Na_2B_{12}H_{11}SH$	1 gm
	38	$Na_2B_{12}H_{11}SH$	1 gm
	39	$Na_2B_{12}H_{11}SH$	1 gm
	40	$Na_2B_{12}H_{11}SH$	1 gm
	41	$Na_2B_{12}H_{11}SH$	1 gm

Inventory of Boron Salt and Standards (continued)

BNCT	42	$Na_2B_{12}H_{11}SH$	1 gm
	43	$Na_2B_{12}H_{11}SH$	1 gm
	44	$Na_2B_{12}H_{11}SH$	1 gm
	45	$Na_2B_{12}H_{11}SH$	1 gm
	46	$Na_2B_{12}H_{11}SH$	1 gm
	47	$Na_2B_{12}H_{11}SH$	1 gm
	48	$Na_2B_{12}H_{11}SH$	1 gm
	49	$Na_2B_{12}H_{11}SH$ (opened 12/6/88)	1 gm
	50	$Na_2B_{12}H_{11}SH$	1 gm
	51	$Na_2B_{12}H_{11}SH$	1 gm
	52	$Na_2B_{12}H_{11}SH$	1 gm
	53	$Na_2B_{12}H_{11}SH$	1 gm
	54	$Na_2B_{12}H_{11}SH$	1 gm
	55	$Na_2B_{12}H_{11}SH$	1 gm
	56	$Na_2B_{12}H_{11}SH$	1 gm
BNCT	57	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	58	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	59	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	60	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	61	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	62	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	63	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	64	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	65	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	66	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	67	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	68	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	69	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	70	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	71	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	72	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	73	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	74	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	75	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	76	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	77	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	78	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	79	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	80	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm

Inventory of Boron Salt and Standards (continued)

BNCT	81	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	82	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	83	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	84	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	85	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	86	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	87	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	88	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	89	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	90	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	91	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	92	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	93	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	94	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	95	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	96	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	97	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	98	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	99	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	100	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	101	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	102	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	103	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	104	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	105	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm
	106	$Na_2{}^{10}B_{12}H_{11}SH$	1 gm

Major Upcoming Events

Dec 13-14, 1988	Third Australia-Japan Workshop on Neutron Capture Therapy for Malignant Melanoma, Sydney Australia
Feb 10-11, 1989	24th Annual San Francisco Cancer Symposium, "The Present and Future Role of Monoclonal Antibodies in the Management of Cancer", San Francisco, CA
Feb 25-Mar 1, 1989	Society for Magnetic Resonance Imaging, Los Angeles, CA
Feb 23-Mar 4, 1989	Oncovail - Three-dimensional Treatment Planning and Execution, Vale, CO
March 16-17, 1989	The Workshop on Biomedical and Space Related Research with Heavy Ions at the Bevelac, Berkely, CA
March 18-23, 1989	37th Annual Scientific Meeting Radiation Research Society/Ninth Annual Meeting North American Hyperthermia Group, Seattle, WA
March 18-24, 1989	American Society of Neuroradiology, Orlando, FL
March 30-31, 1989	Workshop on Neutron Beam Design, Development, and Performance for Neutron Capture Therapy, Massachusetts Institute of Technology, Cambridge, MA
April 15-19, 1989	71st Annual Meeting of the American Radium Society, Virgin Islands.
May 7-10, 1989	7th International Symposium: Radionuclides in Nephro-Urology (sponsored by International Society of Nephrology and American Society of Hypertension), Williamsburg, VA
May 19-24, 1989	American Society of Neuroradiology, Orlando, FL
Jun 13-16, 1989	Society of Nuclear Medicine, St. Louis, MO
Jul 23-27, 1989	Joint Meeting of the American Association of Physicists in Medicine (AAPM) with the Radiological Society of North America, Memphis, TN
October, 1989	Western Society of Neuroradiology, (place to be determined)

Major Upcoming Events (continued)

Aug 5-9, 1990	Joint Meeting of the American Association of Physicists in Medicine (AAPM) with the Radiological Society of North America, St. Louis, MO
Aug 27-31, 1990	V World Congress, World Federal of Nuclear Medicine and Biology, Montreal, Canada

For further information on upcoming meetings, please contact Arlene Ackermann, BNCT Research Programs Office, (208) 526-9264 or FTS 583-9263.