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BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

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BOX No.

FOLDER

DATE: March 22, 1955

TO: G. F. Tape

FROM: L. E. Farr, M.D.

SUBJECT: Neutron Source Requirements of the BNL Medical Department

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This memorandum is concerned with establishing, from the viewpoint of the research program of the Medical Department, those features of the ATC Medical Research Reactor design(1) which it is desirable to retain and which to change.

The principal need for a reactor is to provide a source of slow neutrons and other radiations for studying their effects on biological systems and for investigations of medical uses, specifically slow neutron capture therapy. For these purposes the reactor should have: (1) a patient irradiation facility; (2) a narrow-beam animal exposure facility; (3) a broad-beam animal exposure facility; (4) a microbiological irradiation facility; and (5) a means for production of special isotopes.

Experience with the BNL research reactor in the use of thermal neutrons in neutron capture therapy indicates that for biological studies an external beam of thermal neutrons having a flux of 10^{10} to 10^{11} thermal neutrons/cm^2·sec is needed. This thermal neutron beam should be as free as possible from fast neutrons and gamma rays. In the several facilities it should be feasible to install means of altering the character of the emergent radiation. While a purely thermal neutron beam is desirable for part of the program, for other phases a mixture of perhaps half epithermals may be desirable, to be achieved by diminishing the amount of moderating material between reactor core and irradiation port. Other experiments will be based on fission plate arrangements or other forms of converter providing fast neutrons or gamma radiation. This kind of versatility is necessary for fullest utilization of the nuclear reactor in biological and medical research. Because of the proximity of the BNL research reactor, the need for isotope production facilities in the medical research reactor is limited to those for certain isotopes having very short half-lives.

The present ATC design appears to satisfy the requirement for a high external thermal flux, and the low quantities of fast neutrons and gamma rays quoted are the maximum acceptable. The desired characteristics and modifications of the various facilities follow.

(1) ATC A12-19: Final Report - General Arrangement Design Studies for BNL Medical Research Reactor, January 15, 1955.

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I. The Patient Exposure Port. The patient exposure port and preparation room should use a vertical face of the reactor and remain essentially as now drawn. The more detailed design of the port should be modified as follows:

A. A shutter for the port should be provided.

1. The reasons are:

a. To allow access to the preparation room by persons preparing the patient, while the reactor is in operation.

b. To allow more accurate control of exposure time than would be possible if it were necessary to bring the reactor to power with the patient positioned for exposure.

c. To avoid interference with the independent operation of other facilities.

2. The shutter should consist of two parts, a neutron and a gamma shield.

a. The gamma shutter should be motor-driven, and require of the order of 60 seconds or less to open. While the gamma shutter is closed, continuous occupancy of the preparation room should be permissible (total radiation exposure less than 8 millirem/hour); while it is open, limited access to the region of the port should be permissible.

b. The neutron shutter should be of suitable materials for absorbing slow and epithermal neutrons and the total time for its opening or closing should not exceed two seconds. The shutter should be located between the patient headblock and the shielding interposed between the patient and the reactor core. It is anticipated that the patient headblock be rigidly fixed to a cart on which the patient can be completely prepared well-removed from the exposure port. When the patient is completely prepared, the cart can be wheeled to the exposure port. The headblock will be so designed and so positioned on the movable cart that it can be easily "plugged in" to the port opening, following which the neutron shutter can be opened for the exposure.

B. As presently indicated, the shielding and moderating materials between the patient and the reactor core are fixed. The entire assembly in the 20" diam tube leading from reactor core to treatment port, including the shutters, bismuth shield, deuterium tanks, and graphite stringers, should be removable. Graphite stringers should be removable essentially to the core of the reactor. Changing of the assembly should require no more than 2 or 3 days' work.

C. The center of the port should be 36 inches from the floor.

II. The Present Port Beneath the Reactor. This port, as well as the room into which it opens, should be eliminated.

III. Animal Exposure Facilities. Two animal exposure facilities, one narrow-beam and one broad-beam, should be provided.

A. The narrow-beam animal facility should also use a vertical face of the reactor and should have a removable assembly which should be identical and interchangeable with that at the patient treatment port with respect to shutters, graphite and deuterium moderators, and gamma shielding. Drawings indicating possible locations and details of an animal facility which would satisfy these requirements are attached.

B. The broad-beam animal exposure chamber should be designed and located essentially as indicated in the ATC drawings, with the following additional characteristics.

1. A door providing access at level B should be provided. A suggested location is shown in an attached drawing. The door should be motor-driven and should open sufficiently to allow a four-foot clearance.

2. A removable shield sufficient in thickness to reduce the gamma radiation level in the exposure chamber to less than 20 r/hour at full power should be placed against the carbon face. The shield should be removable so that experimental objects can be placed in the chamber and the shield then removed. The shield should be removable in 30 seconds or less.

3. A removable slow and epithermal neutron shield "shutter" should also be placed against the graphite face. This should either be removable separately from the gamma shield, or should slide into place as the gamma shield slides out of position. A separate neutron shield would have the advantage of less weight and, thus, more rapid removal with resultant more adequate shutter action would be possible.

IV. The Microbiological Exposure Facility should consist of a removable concrete plug leading through the shielding directly to the graphite; removal of a graphite stringer also should be provided. This facility could be used for the irradiation or activation of biological materials placed within the graphite reflector, or it could be fitted with a hollow graphite liner for irradiation under collimated beam conditions, for study of radiation effects or neutron depth dosimetry in tissue equivalent media.

V. Isotope Production. A facility for producing isotopes with half-lives of the order of seconds in solution or in gaseous form, should be included. The most satisfactory way of meeting this requirement would be with tubes extending through the graphite and providing for continuous flow of the fluid involved with direct delivery through outlets into the patient treatment room and the narrow-beam animal facility.