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THE

NATIONAL LOW-TEMPERATURE NEUTRON IRRADIATION FACILITY

NLTNIF

ORNL/M--110

THE STATUS OF DEVELOPMENT

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MANAGED FOR THE
DIVISION OF MATERIALS SCIENCES
OFFICE OF BASIC ENERGY SCIENCES
UNITED STATES DEPARTMENT OF ENERGY

BY THE

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OAK RIDGE NATIONAL LABORATORY

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INTRODUCTION

In May 1983 the Division of Materials Sciences, Office of Basic Energy Sciences of the Department of Energy authorized the establishment of a National Low-Temperature Neutron Irradiation Facility (NLTNIF) at ORNL's Bulk Shielding Reactor (BSR). The NLTNIF, which will be available for qualified experiments at no cost to users, will provide a combination of high radiation intensities and special environmental and testing conditions that have not been previously available in the U.S. Since the DOE authorization, work has proceeded on the design and construction of the new facility without interruption. This report describes the present status of the development of the NLTNIF and the anticipated schedule for completion and performance testing. A call for proposals is made and for the information of candidate users there is a table of the major specifications and capabilities and a schematic layout of the irradiation cryostat for design and dimensioning of test and experiment assemblies.

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PROGRESS AND STATUS

(The following items pertain to Figure 1)

New LHe Refrigeration System

A LHe refrigeration system previously in service at ANL has been assembled and integrated with an existing 3-pass heat exchanger and a new interface system which connects to the irradiation cryostat. Performance tests of this ensemble (not including the cryostat) gave values for heat capacity and LHe mass flow rates which will meet or exceed the design criterion of 200 W at 5 K in the irradiation cryostat. Tests of a new LN₂ storage tank and distribution system which supplies 80 K refrigeration for precooling, cold shielding, and cryostat operation at midrange temperatures showed rapid response for each function and a consumption of only 1.5 liters-per-hour by the cold-shield circuit.

12-Tesla Magnet and Test Facility

A new 12-Tesla magnet and power supply have been received, and a poolside preirradiation test facility is under construction. A magnet test assembly will be designed for use in either the preirradiation facility or the cryostat.

4.2 K Transfer and Storage

A highly modified 100-ℓ LHe vessel and support assembly for the postirradiation transfer and storage of specimens is ready for installation at poolside adjacent to the cryostat.

In-pool Component Fit-up

The irradiation cryostat, the reactor core, and the zircaloy gamma-ray shield were fitted together just prior to final anchoring of the cryostat in the pool. Permanent stops were installed to provide for the quick repositioning of the movable reactor core at the site of the cryostat.

LAYOUT PLAN FOR NLTNIF AT ORNL'S BULK SHIELDING REACTOR

FIGURE 1

PROGRESS AND STATUS

(The following items pertain to Figure 2)

Reactivity and Nuclear Heating Effects

From criticality measurements the separate and combined effects of the gamma-ray shield and the cryostat (a mockup was used) on the reactivity of the BSR core were found to be small. These results show that a wide latitude remains in the use of materials for experiment assemblies in the cryostat. Using various sensors it was determined that, at full reactor power, the gamma-ray shield does not boil the pool water. Boiling is not permitted for safety reasons.

Fast Neutron Flux

A cursory measurement of the fast neutron flux was made in a mockup of the cryostat using only a Ni activation detector from which the flux was estimated to be $1.8 \pm 10\% \times 10^{17} \text{ n/m}^2\text{s}$ ($E > 0.1 \text{ MeV}$). A fluence of $1 \times 10^{23} \text{ n/m}^2$ can be reached in about 6 days. Detailed neutronics measurements will be made in the irradiation cryostat as part of final performance testing.

Cryostat Performance at 80 K

The cryostat was tested at 80 K by the use of a mockup of the LN₂ heat exchanger. The combined radiant and conductive heat loads were measured to be 19 W, and the cooldown time was 2 hours. From this result total cooldown time to 4 K is estimated at 4 hours.

THE IRRADIATION CRYOSTAT

FIGURE 2

PLANS FOR FUTURE CONSTRUCTION

Final assembly of the connection linking the LN₂ and the LHe heat exchangers in the cryostat to the refrigeration system will be completed early in January. Following assembly, performance testing of the cryostat will supply the data needed to evaluate the safety of the facility. The performance data will also be assembled in a user's handbook to be distributed during the spring.

Construction will continue on auxiliary facilities. The 4.2 K radioactive storage dewar, the poolside test facility, and the 12-T magnet test assembly will be completed initially. Radiation modifiers will be built as the need arises—a D₂O tank will probably come first to permit thermal neutron irradiations by late 1986. A 200-keV transmission electron microscope will be ordered. Construction of a LHe stage and a transfer device to move samples from the irradiation cryostat to the microscope will be designed and constructed following delivery of the microscope.

CALL FOR PROPOSALS

The initial construction is expected to be complete and the NLTNIF available for users beginning about April 1, 1986. Proposals for specific experiments are now being accepted. Prospective users should contact Dr. H. R. Kerchner, Solid State Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, (615) 574-6270 (commercial) or 624-6270 (FTS). Please note that all experiments must be reviewed both for scientific merit and for safety. The ambient-temperature irradiation facility is now available for use. Low-temperature irradiations must await a formal safety evaluation of the completed and performance-tested cryostat. Only when this evaluation is concluded can firm scheduling commitments be made. We presently anticipate that the required approval will be forthcoming by April 1, 1986.

A proposal information form is included as an appendix to this report. Additional copies will be furnished on request. A separate form is needed for each time the irradiation cryostat, or the ATNIF, is opened to insert samples and/or a test device. The information requested in the form will allow the NLTNIF staff to determine whether the NLTNIF is capable of meeting the experiment's requirements. A brief summary of the experimental plan and some justification should be attached to permit evaluation of the scientific merit. This description of the experiment should also indicate any special needs that are not included on the proposal form.

MAIN FEATURES AND SPECIFICATIONS OF NLTNIF

- The radiation characteristics at full BSR power of 2 MW are listed below. (Operation at any lower level, even as low as 0.1% of full power, is feasible.)

<u>RADIATION</u>	<u>INTENSITY</u>
FAST NEUTRONS (E > 0.1 MeV)	$1.8 \times 10^{17} \text{ n/m}^2\text{s}^a$
THERMAL NEUTRONS	$1.5 \times 10^{17} \text{ n/m}^2\text{s}^b$
GAMMA RAYS (in Al)	0.32 W/g^b

^aDetermined by scaling more detailed neutronics measurements made in a hollow fuel element device to the results of measurements employing a Ni activation detector in a mock-up of the cryostat.

^bDetermined by computer calculations and neutronics/nuclear heating measurements made in a hollow fuel element device.

- The active irradiation zone is 37.47 mm diameter x 250 mm long. The distance from the access port to the irradiation zone is 5.6 m.
- A 196.8 mm diameter x 300 mm long test chamber into which specimens can be moved without warmup is located 1.5 m above the irradiation zone. The test chamber can be equipped with devices for property change measurements.
- In the primary cryostat, irradiation temperatures from 3.5 to 500 K can be obtained; irradiation at temperatures up to 800 K can be realized in an auxiliary facility.
- Provisions will be made for the transfer of specimens at 4.2 K into test devices or into vessels for shipment to other laboratories.
- On-line data acquisition and computer capability will be provided.
- A 12 Tesla superconducting magnet test assembly will be available for use at poolside and in the test section of the cryostat.
- Radiation modifying devices will be constructed to provide modified fast neutron spectra and highly isolated thermal neutrons or gamma rays.

SCHEMATIC LAYOUT OF THE NLTNIF CRYOSTAT FOR DESIGN AND DIMENSIONING OF TEST AND EXPERIMENT ASSEMBLIES

(THE OUTER REFRIGERATED SHIELD AND VACUUM JACKET ARE NOT SHOWN)

CONSIDERATIONS FOR TEST ASSEMBLY DESIGN

USED FOR INTERMITTANT TESTING DURING IRRADIATION AND FOR POST-IRRADIATION TESTING. SAMPLES ARE MOVED FROM THE IRRADIATION ZONE INTO A TEST ASSEMBLY BY A SEALED PULL ROD.

DESIGN AND MATERIALS SELECTION IS BASED ON MINIMIZING HEAT CONDUCTION INTO THE COLD ZONE.

MASS IN THE COLD ZONE SHOULD BE MINIMIZED TO REDUCE COOLDOWN TIME.

INDUCED RADIOACTIVITY IS EXPECTED TO BE NEGLIGIBLE.

FREE AREA AROUND OR THROUGH THE ASSEMBLY IS NEEDED FOR OPERATION OF THE CONVECTION COOLING LOOP.

A BIOLOGICAL SHIELD IS REQUIRED (SEE ABOVE).

NLTNIF WILL PROVIDE: PLUG FLANGE FOR ASSEMBLY SUPPORT
DEMOUNTABLE BIOLOGICAL SHIELD
SIMPLE GUIDE TUBE FOR IN-OUT SAMPLE IRRADIATIONS
INSULATED FURNACE FOR POSTIRRADIATION ANNEALING
4.2 K SPECIMEN TRANSFER FROM IRRADIATION CRYOSTAT
12 T MAGNET FOR USE IN IRRADIATION CRYOSTAT

USER WILL PROVIDE: ANY TEST ASSEMBLY NOT IN THE NLTNIF COLLECTION
ANY SPECIALIZED BIOLOGICAL SHIELDS

CONSIDERATIONS FOR EXPERIMENT ASSEMBLY DESIGN

USED TO SUPPORT AND MONITOR SAMPLES IN THE IRRADIATION ZONE. IT MAY BE INTEGRATED OR NESTED WITH A TEST ASSEMBLY.

UPPER SECTION (4 m LONG)

A BIOLOGICAL SHIELD IS REQUIRED (SEE ABOVE).

DESIGN AND MATERIALS SELECTION IS BASED ON MINIMIZING HEAT CONDUCTION INTO THE COLD ZONE.

INDUCED RADIOACTIVITY IS EXPECTED TO BE NEGLIGIBLE.

LOWER SECTION (1.5 m LONG)

FREE AREA THROUGH THE SAMPLE ASSEMBLY IS VITAL FOR SAMPLE COOLING AND OPERATION OF THE CONVECTION COOLING LOOP.

SIGNIFICANT RADIOACTIVITY IS EXPECTED. REUSE MAY BE POSSIBLE AFTER A LONG STORAGE PERIOD.

MINIMAL MASS AND PRUDENT MATERIAL SELECTION ARE ESSENTIAL TO MINIMIZE NUCLEAR HEATING, NEUTRON ACTIVATION, AND POSSIBLE STORED ENERGY.

NLTNIF WILL PROVIDE: WIRE, BASKETS, AND CAPSULES FOR IN-OUT IRRADIATIONS.
UPPER SECTIONS FROM THE NLTNIF COLLECTION.
TOP FLANGE AND PULL ROD SEAL ASSEMBLIES.
"STANDARD DESIGN" BIOLOGICAL SHIELDS.
REMOVAL AND STORAGE OF SAMPLES AT 4.2 K OR 300 K.

USER WILL PROVIDE: ANY SPECIAL LOWER SECTION OR WHOLE EXPERIMENT ASSEMBLY NOT IN THE NLTNIF COLLECTION.

IRRADIATION CHAMBER - MAINTAINED AT 4 TO 5 K
BY UPWARD FLOW OF LHe CONDENSED ON HEAT EXCHANGER
ABOVE AND DELIVERED DOWN THROUGH SUPPLY TUBE.
IRRADIATION AT HIGHER TEMPERATURES IS POSSIBLE
WITH GHe - MAXIMUM ALLOWABLE DIAMETER = 37.47 mm (1.475 in.)

NEUTRON FLUX PEAK IS ESTIMATED TO BE 100 mw
ABOVE THE BOTTOM. EXACT LOCATION TO BE
DETERMINED BY LATER PERFORMANCE TESTING.

APPENDIX A

NATIONAL LOW-TEMPERATURE NEUTRON IRRADIATION FACILITY

RESEARCH PROPOSAL

Title of Proposal: _____

Participants:

	Name	Address	Citizenship	Telephone
1.	_____	_____	_____	_____

2.	_____	_____	_____	_____

3.	_____	_____	_____	_____

4.	_____	_____	_____	_____

Communications will be sent to the first participant.
Admission to the NLTNIF will be arranged for all listed.

Desired Dates: _____

Impossible Dates: _____

Irradiation Conditions Required

Fast Neutron Flux ($E > 0.1$ MeV): _____ Fluence: _____

Nominal Temperature: _____ Accuracy: _____ Stability: _____

Sample Materials and Masses: _____

Sample-Holder Materials and Masses: _____

Description of Samples and Sample Holder: _____

Test Conditions Required

Nominal Temperatures: _____ Accuracy: _____ Stability: _____

Schedule of In-Situ Testing: _____

Description of Test Facility: _____

Transfer required from irradiation cryostat to: 4 K storage _____,
308 K storage _____, or disposal _____ (check one).

Safety Concerns (any potential hazards): _____

Attach a description of the proposed experiment (2 pages maximum) sufficiently
detailed to permit an evaluation of its scientific merits.