QUARTERLY REVIEW

WINTER 1991

MICHIGAN MEMORIAL PHOENIX PROJECT
THE UNIVERSITY OF MICHIGAN

NUCLEAR REACTOR LABORATORY
FORD NUCLEAR REACTOR
PHOENIX MEMORIAL LABORATORY

North Campus
The University of Michigan
2301 Bonisteel Blvd.
Ann Arbor, Michigan
48109-2100

(313) 764-6220
(313) 764-6223

QUARTERLY REVIEW

WINTER 1991

Third Year, No. 12

North Campus
2301 Bonisteel Boulevard
Ann Arbor, Michigan 48109-2100

The Nuclear Reactor Laboratory Quarterly Review is published and distributed to University of Michigan faculty and staff members to inform them of the unique research capabilities of the Nuclear Reactor Laboratory and to make them aware of the types of research in progress.

The Michigan Memorial Phoenix Project was founded on May 1, 1948, as a memorial to the 585 University of Michigan alumni, students, faculty, and staff members who died in World War II. The Project's charter is to explore ways and means by which atomic energy can be a beneficent influence in the life of man. Research support and services provided by the Nuclear Reactor Laboratory and a research grant program are the means by which the Project fulfills its charter.

NEW RESEARCH

FORD NUCLEAR REACTOR

Chemistry

Professor Henry Griffin is studying the decay properties of intermediate half-life fission products such as strontium-91. Small quantities of uranium-235 are irradiated in the reactor core. Following irradiation and a decay period of 5 to 24 hours to eliminate short lived fission products, test samples are chemically processed to isolate specific nuclides and counted on an intrinsic germanium detector to quantify the nuclides.

NEUTRON ACTIVATION ANALYSIS

Anthropology

Leah Minc is a doctoral candidate in the Department of Anthropology. Her faculty advisor is Professor Joyce P. Marcus. Ms. Minc is utilizing neutron activation analysis as a tool to examine the degree of centralization in commodity production under the Aztec empire as a key to understanding imperial integration strategies and political economy. The pastes of Aztec Red Ware ceramics from the Valley of Mexico are examined using neutron activation analysis to determine the number of

production sources for this commodity before and after the consolidation of the Aztec empire. The spatial distribution of the products of different sources are then mapped to characterize the scale and location of the exchange system. The title of Ms. Minc's thesis is "Aztec Imperial Integration Strategies: The Political Economy of Commodity Production".

Geological Sciences

Gerald Dickens is a master's candidate in Geological Sciences. Mr. Dickens' advisor is Professor Robert Owen. The title of Mr. Dickens' thesis is "Hydrothermal Sediment Components in Deep Sea Sediments". Hydrothermal sediments can be differentiated form other deep sea sediments by rare earth element concentration ratios. Neutron activation analysis is utilized to determine these concentrations and hence the amount of hydrothermal sediment.

School of Public Health

Allan Tran is utilizing neutron activation analysis to anlyze landfill leachates for heavy and trace metal contaminants. Mr. Tran is a master's candidate. His advisor is Professor James Martin. The title of his thesis is "Neutron Activation Techniques for Measurement of Trace Metals in Leachate Samples". The prmary directions of his work will be to develop basic analytical techniques for application to landfill leachates and to maximize the detection limits of the techniques. Instrumental neutron activation analysis (INAA) will be used wherein samples are irradiated without any pre or post irradiation chemical separation or processing. In addition, radiochemical neutron activation analysis (RNAA) will be applied wherein radiochemical separation techniques are applied to activated samples to increase levels of detection of trace elements.

COBALT-60 IRRADIATOR

Materials Science and Engineering

Professor David C. Martin is attempting to construct and characterize the structure and properties of polymer grain boundaries in a controlled manner. His idea is to carefully and systematically establish the influence of well-defined, specific grain boundary defects on the physical properties of polymers.

The project involves the polymerization of poly (diacetylene) polymers via exposure to 30 to 40 megarads of high energy cobalt-60 gamma radiation. The result is photoconductive, optically active material of possible use in many technological applications. For example, these polymers are of particular interest in information storage and retrieval, in optical devices, and as new avenues for high speed infomation processing.

The study of the structure and properties of defects in polymer systems should provide important, fundamental insight into the limitations of polymer solids at the molecular level. The ability to create new materials and devices through interaction with sources of radiation available from nuclear reactions may well represent a new and as yet unexploited means to apply nuclear technology in a manner that is safe, prudent, socially responsible, and commercially useful.

University Hospital - Allergy Division

Patricia Arscott, under the direction of Dr. James Baker, is sterilizing human membrane preparations utilizing the cobalt-60 irradiator. The sterilized membranes act as an antigen and will be used to stimulate cell cultures to prooduce cells for a study.

FEATURE ARTICLE

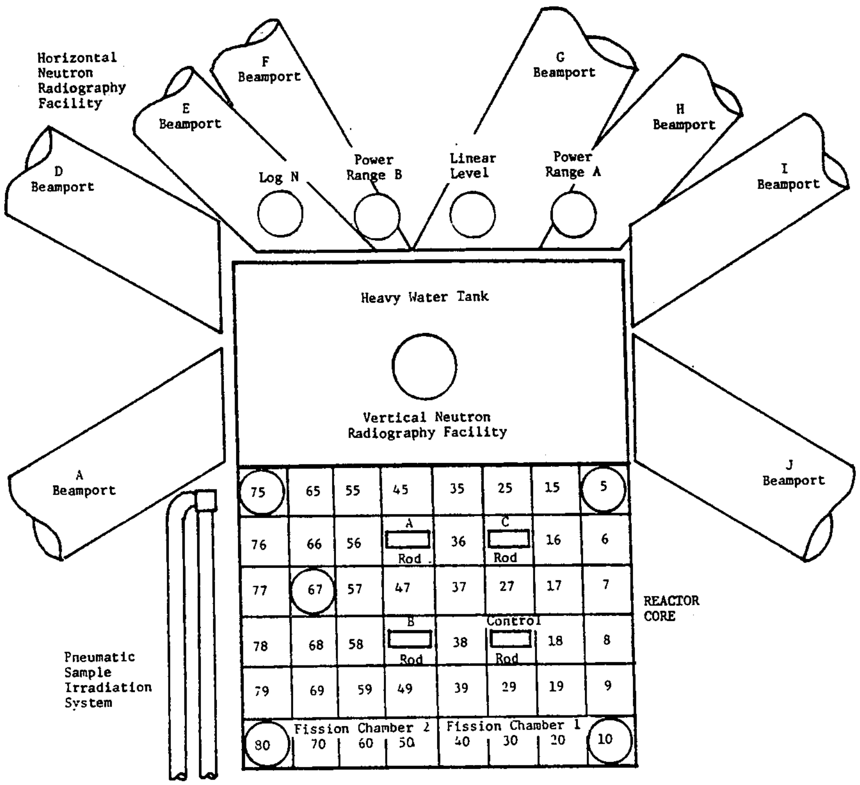
FORD NUCLEAR REACTOR FACILITIES AND SERVICES

FORD NUCLEAR REACTOR

The Ford Nuclear Reactor operates on a fixed cycle at its licensed power level of two megawatts. The cycle consists of ten days at full power followed by a shutdown for four days of maintenance. A typical week consists of 120 full-power operating hours.

A typical reactor core configuration consists of about 36 standard and 4 control-rod fuel elements. Each element is approximately 3 inches by 3 inches by 26 inches long. Standard elements contain 167 grams of U-235 in 18 aluminum-clad fuel plates. Control-rod elements, which are configured with guide channels to permit control rod insertion, have nine plates and contain 83 grams of U-235. Uranium enrichment in the fuel meat is slightly less than 20 percent. Fuel burnup rate is approximately

2.46 gm U-235/day at two megawatts. Ten fresh fuel elements are required for one year of operation.



Ford Nuclear Reactor Core

NEUTRON IRRADIATION SERVICES

The Ford Nuclear Reactor provides neutron irradiation services in three locations: in-core, pneumatic tubes, and beamports.

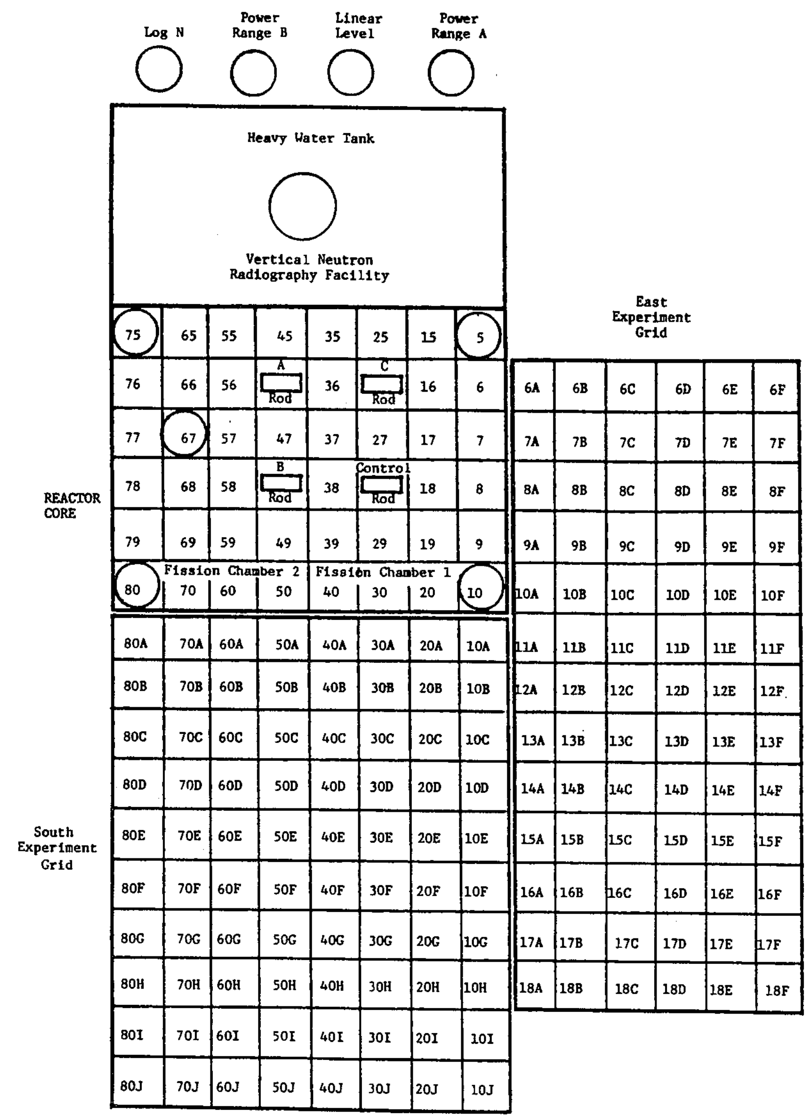
In-Core Irradiations

Targets of various sizes and shapes can be irradiated by placing them in or near the reactor core. The peak thermal neutron flux at the center of the core is approximately $1.5x10^{13}$ n/cm^2/sec; at the edge of the core, thermal flux is approximatley $7x10^{12}$ n/cm^2/sec. Sample irradiations can be conducted for periods ranging from a few minutes to more than a year.

Large experiment grids project from the south and east faces of the reactor core to permit precise placement of samples for irradiation.

Pneumatic Tubes

Two horizontal pneumatic transfer systems allow small samples to be dispatched from remote laboratories to the face of the reactor core. Samples up to 15/16 inch in diameter and 2 inches long can be irradiated for as short a time as one second and for as long a period as two hours in the pneumatic tubes. Thermal neutron flux is approximately $2x10^{12}$ n/cm^2/sec.



Ford Nuclear Reactor
Experiment Grid

Beamports

Eight horizontal beamports are available for long term irradiation and neutron beam extraction experiments such as neutron radiography and neutron spectroscopy. The beamports penetrate the reactor pool wall and terminate at a heavy water tank adjacent to the north face of the core. The heavy water tank provides a high themal-to-fast neutron flux ratio. Thermal neutron flux from the beamports is nominally $8x10^6$ $n/cm^2/sec$.

NEUTRON ACTIVATION ANALYSIS

The highly sensitive analytical technique of neutron activation analysis can be performed by researchers using the Laboratory's facilities and is available as a service perfomed by the Laboratory staff.

Neutron activation analysis is a method of identifying and measuring minute quantities of trace elements in many types of materials. Sixty-seven common elements become radioactive when exposed to the neutron flux in the reactor, and subsequently emit radiation that is characteristic for each element and permits identification. More than fifty of the sixty-seven elements can be identified and measured quite readily. The technique is particularly useful for analyzing geological and environmental samples and for analyzing industrial samples to maintain quality control. The sensitivity, accuracy, variety of types of materials that can be analyzed, large number of elements that can be detected, and essentially non-destructive nature of the technique make neutron activation analysis an excellent analytical tool.

Table 1
Neutron Activation Analysis Elements

Aluminum	Neodymium
Antimony	Nickel
Argon	Niobium
Arsenic	Osmium
Barium	Palladium
Bromine	Platinum
Cadmium	Potassium
Calcium	Praseodymium
Cerium	Rhenium
Cesium	Rhodium
Chlorine	Rubidium
Chromium	Ruthenium
Cobalt	Samarium
Copper	Scandium
Dysprosium	Selenium
Erbium	Silver
Europium	Sodium
Gadolinium	Strontium
Gallium	Tantalum
Germanium	Tellurium
Gold	Terbium
Hafnium	Thulium
Holmium	Thorium
Indium	Tin

Table 1
Neutron Activation Analysis Elements
(Continued)

Iodine	Titanium
Iridium	Tungsten
Iron	Uranium
Krypton	Vanadium
Lanthanum	Xenon
Lutetium	Ytterbium
Magnesiu	Yttrium
Manganese	Zinc
Mercury	Zirconium
Molybdenum	

ISOTOPE PREPARATION AND RADIOCHEMICAL PRODUCTION

Preparation of and custom labeling with radioisotopes is available for medical and industrial research. Several radioisotopes and radiolabelled chemicals are routinely produced by the Laboratory.

Elemental bromine-82 is produced for pharmacological research. Bromine-82 labeled motor oil is prepared for use in research programs to help improve engine oil economy and bormine-82 labelled toluene is prepared for use in oil refinery flow tests.

Large quantities of methyliodobenzylguanidine (MIBG) labelled with iodine-131, iodine-123, and iodine-125 and iodomethylnorcholesterol (NP-59) labelled with iodine-131 are synthesized at the Laboratory. Both are investigational drugs approved by the Food and Drug Administration. MIBG for medical diagnostic purposes is used at the University and in over 80 other institutions to detect diseases of the adrenomedulla. NP-59 is used in the diagnosis of adrenal gland diseases. Over 120 medical research institutions in the United States and abroad receive regular shipments of NP-59 from the facility. MIBG in therapeutic dose strenghts is produced for use in patients at the University and in three other hospitals.

GAMMA IRRADIATION SERVICES

A cobalt-60 source of approximately 10,000 curies is available for gamma irradiations. Typical applications include sterilization of bones and cartilage for human grafts; sterilization of animal food for germ-free animal colonies; radiation pasteurization of food; studies of radiation effects on reactor materials, chemical systems, electronic components, biological materials, animal populations, and crystals; and irradiation of seeds, plants, and fungi to change growth and develop mutants. The peak dose rate in the center holder of the cobalt-60 source is approximately $1x10^6$ rad/hour.

Gamma irradiations also can be performed in reactor spent fuel storage racks where the peak dose rate is approximately $5x10^6$ rad/hour. The fuel storage racks are particularly useful for irradiating large objects.

NEUTRON RADIOGRAPHY

Neutron radiography services are available to researchers who wish to pursue problems in non-destructive testing. Neutron radiography is a technique similar to x-ray radiography except that neutrons, unlike x-rays which interact with electrons, interact with atomic nuclei. Whereas dense materials such as lead, iron and uranium are opaque to x-rays, they are easily penetrated and examined with neutrons. Neutron radiogrphay also reverses to an extent the relative order of imaging possibilities. For example, details of plastics, oil, water, and fractures or voids inside heavy materials can be determined with good resolution.

The laboratory currently operates two neutron radiography facilities. A three-inch diameter vertical facility with a length-to-diameter ratio of 300 provides extremely fine resolution of small objects. A larger, horizontal facility associated with E beamport can produce full, eight-by-ten-inch radiographs with excellent resolution. That facility has a length-to-diameter ratio of 50, and neutron intensity variations of not more than ten percent over the exposed film can be attained.

Real time radiographic imaging is conducted at the beamport facility. This technique allows imaging of dynamic systems such as operating automobile engines, fluid sprays, and flow through porous media.

RADIATION, CHEMICAL, AND MECHANICAL TESTING SERVICES

Limited materials testing programs are conducted at the laboratory. Neutron and gamma radiation damage studies are performed in the reactor core, in spent fuel storage, and in the cobalt-60 source.

Neutron attenuation tests through shielding materials are conducted utilizing beamport spectrometers and by neutron radiography. Gamma attenuation tests are performed with small, well collimated gamma sources.

Typical mechanical and chemical tests include tensile strength, cantilever flexure, dimensional stability, weight change, specific gravity, hardness, gas evolution and analysis, and chemical analysis for boron in neutron shields.

LABORATORIES

The facility offers eight chemistry and two physics laboratories. In addition to standard equipment such as air, gas, vacuum, and water lines, the laboratories are equipped with radioactive drains to retention tanks, hoods that exhaust through absolute particulate filters, and utility supplies for portable glove boxes. Two of the laboratories have walk-in hoods and one has a pneumatic tube station from which samples can be sent to the face of the reactor core for irradiation.

Also available are a variety of specially equipped laboratories including a green house, organic synthesis laboratories, an x-ray room, a photographic darkroom, and a cold room. Services are available from machine and electronics shops.

Two shielded rooms called hot caves are available for remote handling, examination, and limited machining of radioactive materials. Each cave is equipped with master-slave manipulators, a remotely operated hoist, and ports for service connection.

NUCLEAR REACTOR LABORATORY DIRECTORY

Hours of Operation

Monday-Friday 8:00 a.m. - 5:00 p.m.

Facilities can be made available 24 hours a day, if required.

Tours

Monday-Friday 9:00 a.m. - 4:00 p.m.

Tours should be scheduled at least 24 hours in advance

Telephone Numbers

Director

Ronald F. Fleming (313) 764-6213

Manager

Reed Robert Burn 764-6224

Assistant Manager, Operations

Gary M. Cook 764-6222

Assistant Manager, Research Support Activities

Neutron Activation Analysis
Radiation Damage Studies
Radiochemical Prooduction

Philip A. Simpson 764-6221

Senior Research Associate

Neutron Radiography

John T. Lindsay 936-1583

Research Associate II

Cobalt-60 Irradiation
Radioisotope Preparation

Robert B. Blackburn 936-1582

Information and Tours

Michelle Derry 764-6223
Zonda Ketola 764-6220