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# IRRADIATION FACILITIES AT OAK RIDGE NATIONAL LABORATORY*

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ABSTRACT

Several irradiation facilities at two of Oak Ridge National Laboratory's nuclear reactors are described. The range of facilities available will accommodate specimen sample sizes from a few millimeters in diameter up to 600 mm square. Nuclear characteristics of these facilities range to a maximum of 1.2 x $10^{19}$ n/m$^2$s fast neutron flux; 2.9 x $10^{19}$ n/m$^2$s thermal neutron flux; and 1.8 x $10^{10}$ R/hr gamma flux.

## 1. INTRODUCTION

Two major nuclear research reactors are utilized at the Oak Ridge National Laboratory to determine the effects of neutron and gamma irradiation on various nuclear fuels and structural materials. The High Flux Isotope Reactor (HFIR) is a 100 MW, beryllium-reflected, light-water-cooled and -moderated "flux-trap" type reactor. The primary irradiation facilities are located in the target flux trap at the center of the core and in the removable beryllium near the control region of the core. A cross section through the horizontal midplane of the core is shown in Fig. 1 indicating both of these positions. The Oak Ridge Research Reactor (ORR) is a 30 MW, light-water-cooled and -moderated materials testing reactor. Irradiation experiments can be performed either within the core, occupying the space of a normal fuel element, or at poolside positions which are located outside the reactor tank. The overall configuration of the ORR is shown in Fig. 2.

## 2. IRRADIATION FACILITIES

A summary of the irradiation conditions and geometrical characteristics of the irradiation facilities at both the HFIR and ORR is presented in Table 1. Each of these facilities is further described below.

### 2.1 HFIR Irradiation Facilities

2.1.1 Target region - There are 30 target positions available in the 127 mm (5 in.) diameter flux trap at the center of the core. Normally, these positions are used for the production of transuranic elements; however, experiments can be irradiated in any of these positions and a typical experiment is illustrated in Fig. 3. The maximum outside diameter for target experiments is presently 16.6 mm (0.655 in.) and the active length can be up to 500 mm (20 in.). One of the highest continuous neutron fluxes in the world is available in the HFIR target region where the peak thermal flux is 2.9 x $10^{19}$ n/m$^2$s and the peak fast flux (E > 0.18 Mev) is 1.2 x $10^{19}$ n/m$^2$s. A peak gamma flux level of about 1.8 x $10^{10}$ R/hr can also be realized. Although at present only uninstrumented experiments can be operated in this facility, modifications to provide for instrumentation access and for operating larger diameter experiments with neutron flux spectrum tailoring are presently being investigated.

2.1.2 Removable beryllium region - Four large facilities are located 273 mm (10.75 in.) from the vertical centerline of the reactor. These facilities, called RB positions because they are located in removable beryllium sections of the reactor, have a permanent aluminum liner with an inside diameter of 36.3 mm (1.43 in.) in which experiments having an active length of up to 500 mm (20 in.) can be performed. Either instrumented or uninstrumented experiments can be irradiated in the RB positions. Instrument leads and access tubes are passed through special penetrations in the pressure vessel upper cover. A typical RB experiment, operated for the High Temperature Gas-Cooled Reactor (HTGR) program, is shown in Fig. 4. The peak neutron fluxes in the RB facilities are also high, i.e., a thermal flux of $1.5 \times 10^{19}$ $n/m^2s$ and a fast flux (E > 0.18 Mev) of $5.0 \times 10^{18}$ $n/m^2s$. The peak gamma flux is about $8 \times 10^9$ R/m.

## 2.2 ORR Irradiation Facilities

2.2.1 In-core region - In-core irradiation experiments are accommodated in the ORR by replacing a fuel element with an aluminum "dummy" core piece that holds the experimental assembly. The dummy core piece can be provided with a hole of up to 72 mm (2.83 in.) diameter into which an experiment with an active length of 600 mm (24 in.) can be placed. Access for instrumentation and control leads is through flanges in the reactor tank top, and experiments are installed with offset tubes so that reactor fuel elements may be inserted and removed without disturbing the experiments (Fig. 2). For experiments up to 44.5 mm (1.75 in.) in diameter provision can be made, by surrounding the experiment with a selective absorber, to tailor the neutron flux spectrum over a wide range of fast-to-thermal ratios. A typical in-core experiment utilizing this spectrum tailoring technique is presented in Fig. 5. The peak neutron fluxes available in these facilities are $3.0 \times 10^{18}$ $n/m^2s$ thermal and $3.6 \times 10^{18}$ $n/m^2s$ fast (E > 0.18 Mev). The peak gamma flux is about $4 \times 10^9$ R/hr.

2.2.2 Poolside region - External to the ORR tank, but immediately adjacent to the core, is an extremely versatile facility known as the Poolside Facility (PSF) as shown in Fig. 2. In the PSF, experiments as large as 600 mm x 600 mm (24 in. x 24 in.) can be irradiated at an infinitely variable radial distance from the core. This makes this facility ideally suited for transient-type experiments or short duration experiments. By moving an experimental assembly towards the core, the incident neutron fluxes can be varied from essentially zero to peak values of $3.6 \times 10^{18}$ $n/m^2s$ thermal and $5.0 \times 10^{17}$ $n/m^2s$ fast (E > 0.18 Mev) with the accompanying gamma flux peaking at about $1 \times 10^9$ R/hr. At present, the facility is provided with a 97.5 mm (3.84 in.) thick stainless steel shield which is being used to reduce the gamma heating rate to allow the irradiation of very large mechanical properties specimens (4T compact specimens) fabricated from typical LWR pressure vessel weld metal. The general configuration of this experiment is shown in Fig. 6; the PSF is large enough to accommodate two of these experiments simultaneously.

# 3. SUMMARY

The Irradiation Engineering Group at Oak Ridge National Laboratory has designed, fabricated and operated numerous irradiation experiments over the last 25 years for the facilities described here. Each of the instrumented facilities described is provided with instrumentation necessary for data acquisition, control and monitoring of sophisticated experiments. While this paper has concentrated on the two most used research reactors at ORNL, there are several other facilities available, such as the HPRR, a burst type reactor with a radiation spectrum very similar to a fission bomb, and the BSR, a 2 MW pool type reactor. Extensive hot cell facilities are also available for detailed postirradiation examination.

Table 1. General Characteristics of Irradiation Facilities at the HFIR and ORR

| Parameter | HFIR | | ORR | |
|---|---|---|---|---|
| | Target | RB | In-core | PSF |
| Peak neutron flux [(n/m$^2$s) x $10^{-18}$] | | | | |
| Thermal | 29.0 | 15.0 | 3.0 | 1.6 |
| E > 0.18 Mev | 12.0 | 5.0 | 3.6 | 0.5 |
| Peak gamma flux [(R/hr) x $10^{-9}$] | 18 | 8 | 4 | 1 |
| Peak nuclear heating rate (W/gm in SS) | 54 | 17 | 10 | 3 |
| Maximum specimen diameter (mm) | 14.5 | 35 | 70 | *a* |
| Active length (mm) | 500 | 500 | 600 | 600 |

[a] Maximum available area is 600 mm x 600 mm with essentially no limit on horizontal dimension extending away from the core.

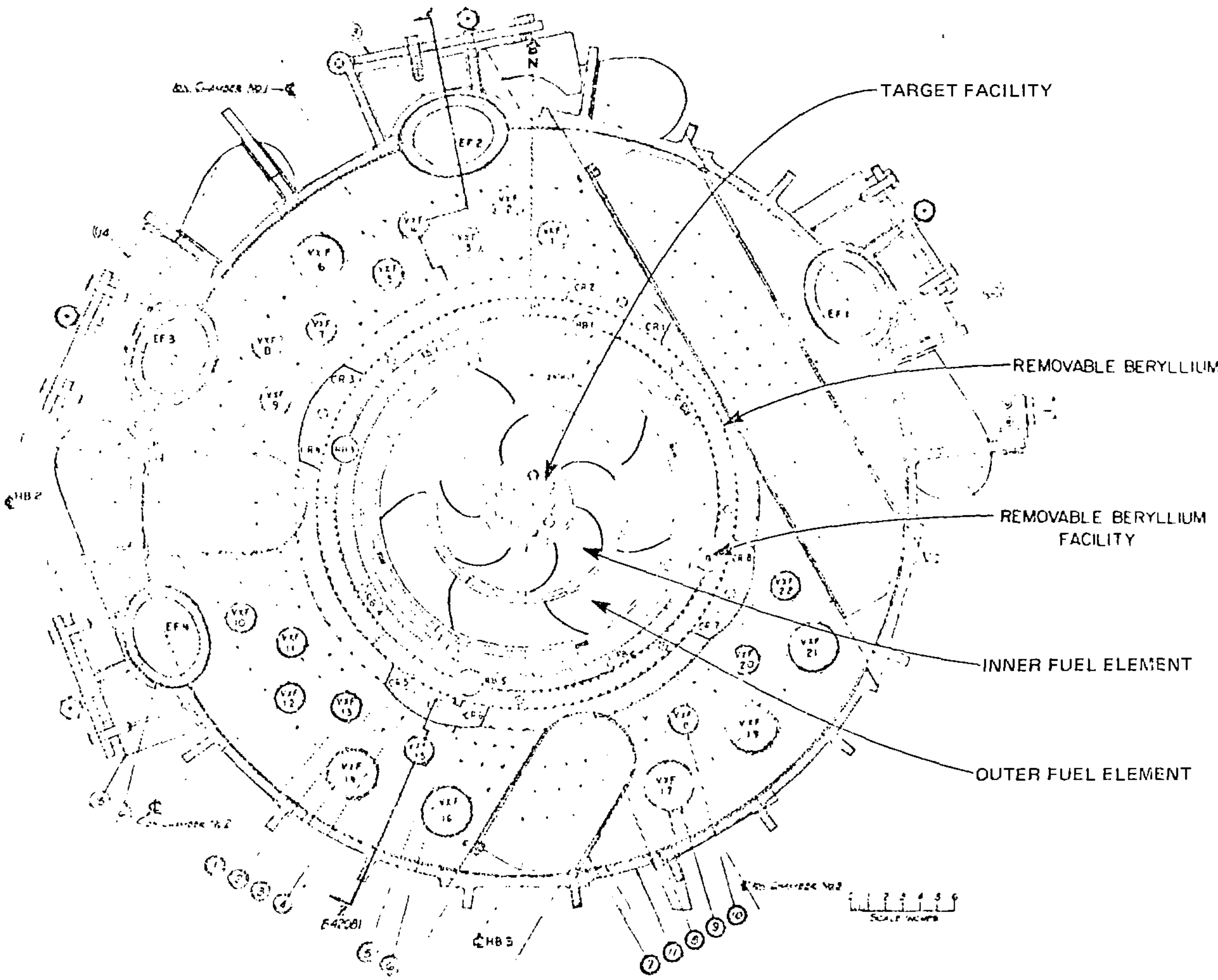


Fig. 1. Cross-sectional view of the HFIR.

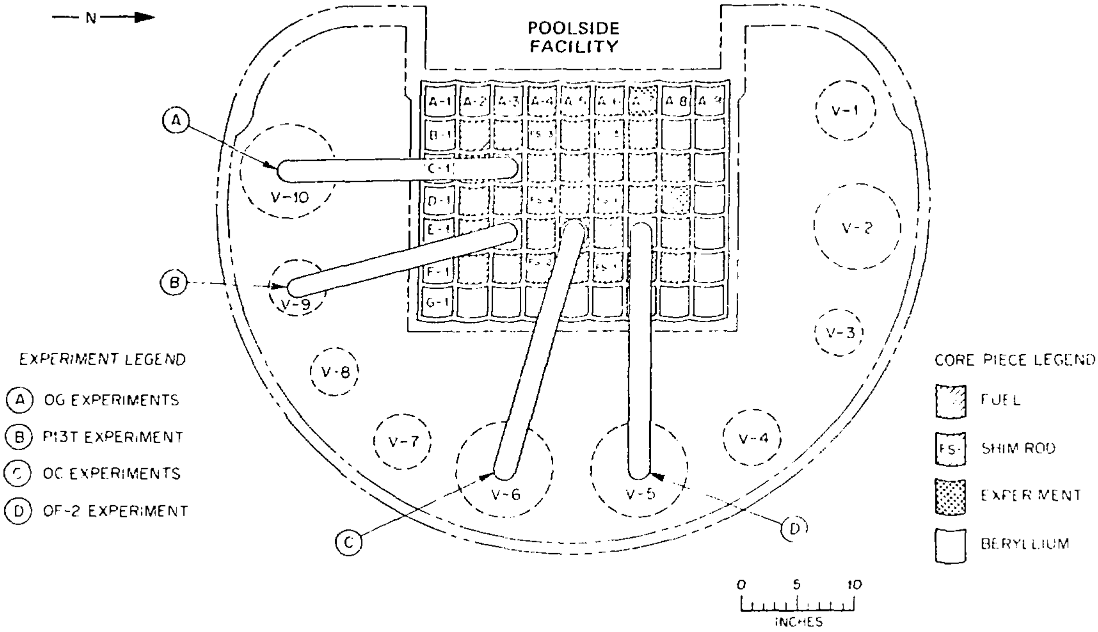


Fig. 2. General arrangement of the ORR.

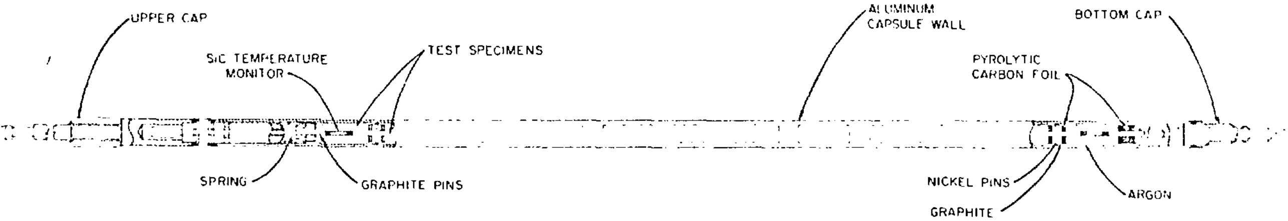


Fig. 3. General arrangement of a HFIR target experimental assembly.

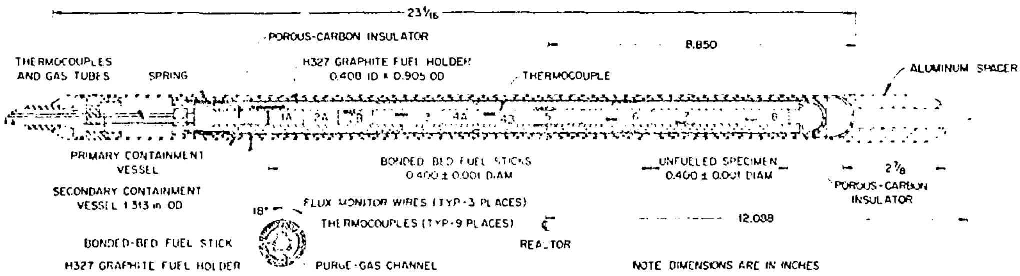


Fig. 4. General arrangement of a HFIR RB experimental assembly.

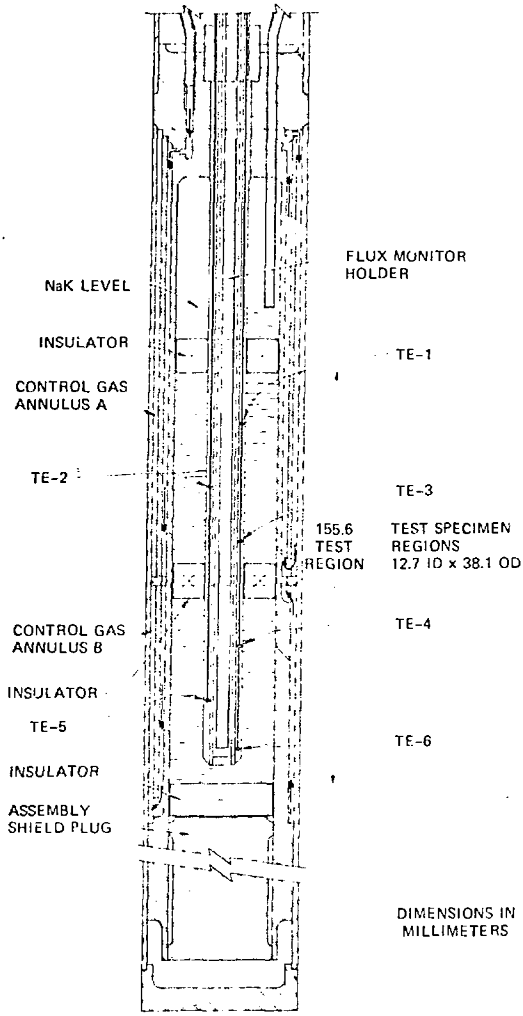


Fig. 5. Schematic of ORR in-core experiment designed for spectrum tailoring and specimen reencapsulation.

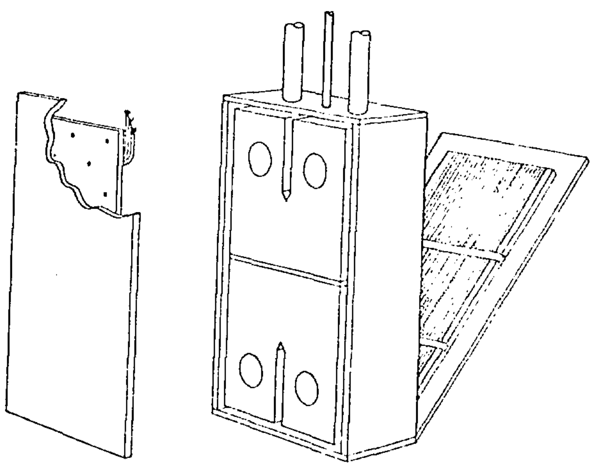

Fig. 6. ORR poolside facility experiment used to irradiate large mechanical properties specimens.