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The CFRMF Neutron  
Radiography Facility\*

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## CFRMF Neutron Radiography\*

Major programs at the Idaho National Engineering Laboratory require neutron radiography for non-destructive examination of irradiated and cold fuel rods. These programs are the Light Water Reactor safety programs at PBF and LOFT and also irradiation experiments in EBR II, ATR and ETR. In reviewing the existing sources for neutron radiography it was determined early that the Coupled Fast Reactivity Measurement Facility (CFRMF) was the logical and economical choice. It is located in the Test Reactor Area (TRA), near the TRA "hot" cells and centrally located with respect to LOFT and PBF. It is a swimming pool type reactor with space available for a collimator-radiograph assembly and a canal depth sufficient to reduce shielding requirements. The neutron source strength is sufficient to provide superior resolution with reasonable exposure times. The ratio of the source-sample distance to the source diameter (L/D) is an aspect ratio commonly quoted to indicate potential resolution; i.e., the greater the L/D ratio the better the resolution obtainable. Based on recent measurements using CFRMF nuclear radiograph facility, an L/D ratio of 200 has been obtained with reasonable exposure times (~ 1hr).

The CFRMF radiograph facility (Figure 1) is a dry tube facility. It is designed for radiographing radioactive materials which in most cases are irradiated fuel pins. It incorporates a platform placed on the canal parapet with shielding extending below the canal water level, shielded doors and positioning dowels for placement of a shielded cask. The dry tube of the radiograph assembly extends to the bottom of the canal, and into a hole extending 245 cm below the canal floor. A tapered collimator passes neutrons from the core to the samples to be radiographed. Dimensions of this collimator are: length 254 cm, maximum source aperture diameter 2.54 cm, object aperture 10 cm by 91 cm. Other source apertures of 1.9 cm and 1.27 cm are also provided. Samples longer than 91 cm require multiple radiographs to cover the entire length. Maximum sample length that can be accommodated is 416 m. Sample containment is incorporated in the positioning fixture so that contamination of the facility by the sample or vice versa is eliminated. Integrity

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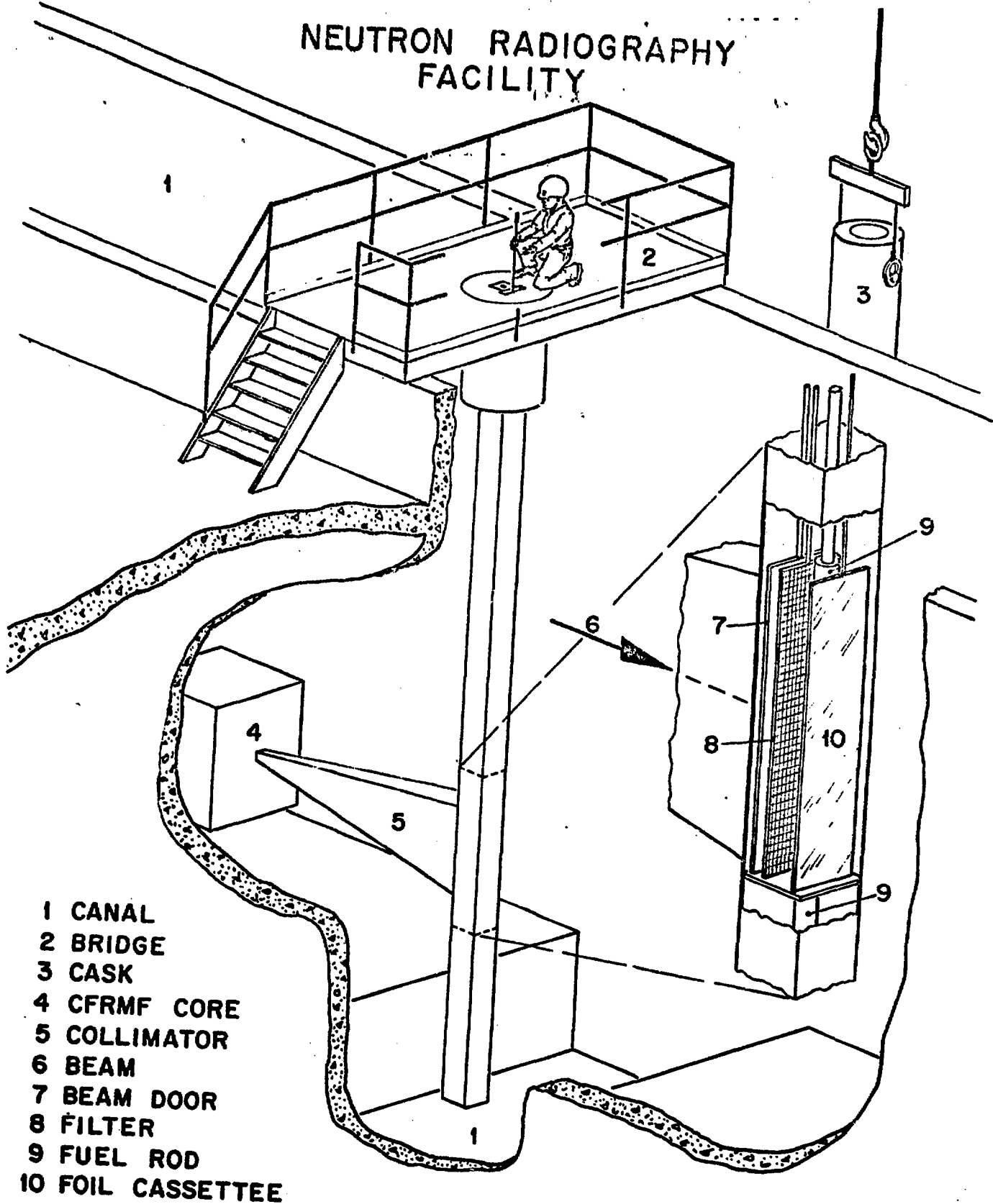
of the sample is, therefore, maintained during the radiographing process. The facility also has the capability of rotating sample objects while inside the unit. With this feature radiographs can be obtained for different sample orientations in 1° rotational increments over the full 360°.

The neutron beam intensity at the object position is  $6.8 \times 10^6$  n/cm<sup>2</sup>sec for a 1.27 cm diameter source aperture (L/D = 200). Flux measurements indicate that the flux is flat over the object aperture.

Because most of the objects to be radiographed are radioactive, the facility was designed to use the transfer method of neutron radiography. Inspection of these hot fuel rods would be impossible with the direct process or with x-radiography because the ionizing radiation emitted by the object would expose the photographic film. When utilizing transfer method, neutrons pass through the object to be radiographed and activate a transfer foil made of indium or dysprosium. The foil is then allowed to decay adjacent to x-ray film at a site removed from the object; consequently, the film is not exposed to direct radiation to the sample. Figure 2 is a typical CFRMF radiograph. This radiograph is of two PBF test samples and was made using an indium foil irradiated for 1 hour with an aspect ratio L/D = 100.

An attempt was made to measure the resolution of the facility. Two test objects containing holes with varying diameters, and uniform holes with varying spaces between the holes were radiographed. The test objects were fabricated from 20 mil cadmium sheet. Both indium and dysprosium foils were used. The smallest hole had a diameter of 4 mils and was clearly visible indicating that the resolution is much better than this.

# NEUTRON RADIOGRAPHY FACILITY



- 1 CANAL
- 2 BRIDGE
- 3 CASK
- 4 CFRMF CORE
- 5 COLLIMATOR
- 6 BEAM
- 7 BEAM DOOR
- 8 FILTER
- 9 FUEL ROD
- 10 FOIL CASSETTEE

Fig. 1



Neutron Radiograph of PBF  
Test Sample  
Figure 2