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THE ORNL SHIELD TESTING FACILITY

C.E.CLIFFORD

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FOR THE
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R. N. Lyon, Section Chief

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The ORNL lid tank facility is used to measure the attenuation, through shielding samples, of radiation typical to a chain reacting pile, in order to determine the fundamental data required to design the most efficient type of shield, with respect to materials cost, weight, and thickness, for any particular installation. The facility consists of a large water tank adjacent to the ORNL shield. A rectangular hole, 28" x 32", extends through the west, or discharge side of the pile shield, the axis of the hole lying on the horizontal centerline of the pile. Radiations emerging from the hole consist of both fast and thermal neutron flux as well as gamma rays of various energies. It is hoped that (because of the low background in the tank) neutron and gamma attenuations of the order of that of a full shield can be measured. The fast neutron flux is one to two orders of magnitude below the thermal flux, hence a uranium source plate which covers the hole is placed between the tank and the shield. The source plate absorbs most of the incident thermal neutrons, producing fissions which in turn produce the fast neutron flux of a known spectrum or energy distribution which is required for interpretable shielding measurements. The samples to be tested are placed in the tank and are approximately twice the diameter of the source in size in order to afford an interepretable geometry. The samples are built up of thin slabs of material which are added piecemeal to the tank while the radiation transmitted by different thicknesses is measured in the surrounding volume of water.

A tank containing water was proposed by the author because the water is a very good neutron shield, thus reducing radiation hazards to personnel; at the same time it allows convenient access for insertion,

motion, and removal of detection instruments and sample slabs, without requiring the normal lengthy pile shutdown. Further, since the water is a relatively poor gamma shield, by maintaining a foot or more of water between the samples and the gamma detecting instruments to filter out the neutrons, the ionization due to gamma intensity can be measured without the interference of neutron-induced activities in the ion chambers, etc. In addition, since the tank is several feet larger than the samples it reduces the neutron background well below that of the general level in the operating area, this background being due to neutrons emerging from the ORNL shield itself.

1.1.1 Construction Features

The tank is constructed of 1/4" mild steel plate. The internal dimensions are 7' x 7' x 11', the longest dimension being horizontal and parallel to the shield face. The tank rests on two 14" I-beams connected by three 6" beams which support the samples. These were necessary to avoid overloading the floor since the samples are very dense. The tank is filled with water to within 6" of the top and holds approximately 30,000 lbs. of water. A 4" water line has been provided to fill the tank rapidly with filtered water, and a continuous flow of water is maintained through an overflow just below the top. The tank is surrounded on three sides by two feet of concrete in the form of small blocks to provide additional gamma shielding and also to reduce the gamma background for low level measurements in the tank.

The hole which extends through the shield is 28" x 32" at the outside, and contains three steps which reduce the opening facing the pile to 23-1/2" x 27-1/2". An aluminum tank completely fills the hole and can be

rapidly filled with water or drained; this acts as a radiation valve permitting the source to be turned on or off at will. A source container is placed in a 3" recess in the face of the tank adjacent to the pile shield. The source consists of short natural uranium rods. These rods can be removed individually from the source container, thus reducing radiation hazards attendant upon removal of the source from the tank.

Three boron shutters are provided to control further the radiation emitted by the source. The shutters were constructed by spraying boron carbide as a paint on two sheets of 16 gage aluminum to a thickness of approximately 3/16". The aluminum sheets were then fastened to a steel frame to reduce boron-carbide contamination. The first shutter is a 32" x 36" rectangle and can be interposed between the source and the thermal neutron flux emerging from the hole. This will greatly reduce the fast neutron flux from the source and hence allow background measurements, the background consisting of radiations from the pile rather than from the source. The second shutter is also interposed between the thermal flux from the pile and the source, and contains a circular hole of variable diameter to permit changes in geometry as desired. The third shutter is placed between the external tank and the source to prevent variations of the source strength due to thermal neutrons which would be scattered back into the source from the tank itself.

1.1.2 Sample Handling

Since each layer of a shield sample weighs in the neighborhood of a ton, hoists are installed for handling in the operating area and placement in the tank. The sample sections themselves are 56" x 66" x 1-7/8" maximum, the thickness being further limited by the one-ton capacity of the overhead hoist. Samples which will not absorb water, such as heavy metals, etc.,

are positioned in the tank by means of steel racks having slotted sides. Five racks, each handling several slabs of sample are necessary to keep the volume behind thin shielding samples free of obstructions which would impede movement of the detecting instruments. Samples which would have their shielding characteristics changed by the absorption of water are placed in water-tight containers. These are to be built with a minimum amount of metal in the faces perpendicular to the flux. A plastic bag which can be filled with water will be placed inside the container in order to fill up any space not used by samples, since discontinuities in the medium surrounding the samples would cause difficulties in the interpretation of the measurements.

Instrumentation

The radiations which are of interest in shielding measurements are, of course, the penetrating neutrons and gamma rays emitted by a chain reacting pile. These must be measured preferably over a range of intensity on the order of the attenuation required of shielding around a high flux or power pile. The lower limit to the amount of radiation which can be determined accurately is set by the sensitivity of the detecting instruments and also the background or general level of radiation present with the source removed. The background in the lid tank facility consists of radiations emitted by the pile shield itself, the cosmic ray background and other radiations attendant upon plant operation. However, with the present gamma chamber, GM tubes, etc., gamma intensities as low as 10^{-2} x tolerance (10 mr/hr.) can be determined accurately. Fortunately, the background levels are much lower for neutrons and it is possible to detect thermal fluxes as low as one thermal neutron per sec. per sq. cm. with an instrument such as a BF_3 proportional counter.

The instruments for gamma ray detection include several sizes of ion chambers, a crystal counter and several GM tubes. Three chambers were designed by the Instrument Division of ORNL to cover the range desired. All three are graphite walled chambers and can be filled with any gas desired up to a pressure of 5 to 10 lbs. gage. The chambers were pressurized to exclude water since they will be submerged up to a depth of 7 ft. A small flow of dried gas is maintained through the chambers to avoid current leakage across the insulators. The signal from the chamber is determined by means of a null type vacuum tube electrometer with drift compensation, The most sensitive chamber has an input impedence of 10^{12} ohms and contains the electrometer tube (VX32) within the chamber shell. The other chambers decrease by factors of 100 in sensitivity. The nulling signal is obtained from a standard L & N potentiometer with a range of 0 to 10 volts with a 1 millivolt definition. The crystal counter was designed and built by the NEPA Instrument Division and will be used to determine changes in the gamma spectrum after transmission through various shielding thicknesses.

The detecting instruments are mounted on a carriage which provides a three dimensional movement within the tank. The horizontal movement (x coordinate) is driven by a servo type motor which is actuated by a standard Brown amplifier with a high impedence input. The vertical movement (y coordinate) is driven by a reversible variable speed motor. The movement perpendicular to the source (z coordinate) is hand operated. Gamma measurements are taken by placing a chamber at a fixed z plane and setting a voltage (into the electrometer) proportional to the desired intensity. If the signal from the chamber does not balance the set voltage, the servo is actuated in

such a manner as to drive the chamber toward the center of the tank if the signal is too low, and in the reverse direction if it is too high. The chamber is then moved until a balance point is reached and oscillates a few centimeters about the null point. The vertical drive motor is then actuated, causing the chamber to follow a contour of equal intensity in the tank. The x and y coordinates of the chamber are continuously plotted by means of a two dimensional Brown recorder. By setting some ten to twelve different intensities into the electrometer a complete flux contour map of any given z plane is obtained. A complete integration of the flux through such a z plane can be obtained by measuring the area which each isodose encloses with a planimeter and plotting this area against the intensity for each isodose. The area under this curve is then the required integration. The time required for mapping a z plane is on the order of three hours, whereas to obtain the same information by hand operation would require several eight hour shifts due to the long time constant of the ion chamber.

Neutron fluxes within the tank will be measured both by instantaneously indicating instruments such as BF_3 tubes and fission chambers, and by means of neutron induced activities in the various type foils. Some types of these foils are sensitive to thermal neutrons, whereas other foils are threshold detectors having activities induced only by neutrons well above thermal energy. The indicating instruments will be used in conjunction with the carriage and will allow an integration of the flux (for a given z plane). This will be accomplished by allowing the chamber to move across the tank at a constant speed and recording the total number of counts during its traverse. By taking a number of such traverses in a given z plane and

integrating graphically the total number of neutrons passing through this plane can be obtained.

Both the tank and the instrumentation were constructed with the view of allowing the maximum flexibility in the type of experiments which can be carried on in the facility. This was necessitated by the fact that while many of the problems connected with shielding are solvable on a theoretical basis, an experimental program is required as a check, and to aid in the improvement of the theory. While the major problem is to develop the thinnest and lightest shield for military applications of an atomic powered pile, many other problems such as streaming through apertures, effects of voids in shields, the design of specialized segments of the shield, etc., may be approached experimentally with use of this facility.

FIGURE I. VIEW FROM ABOVE

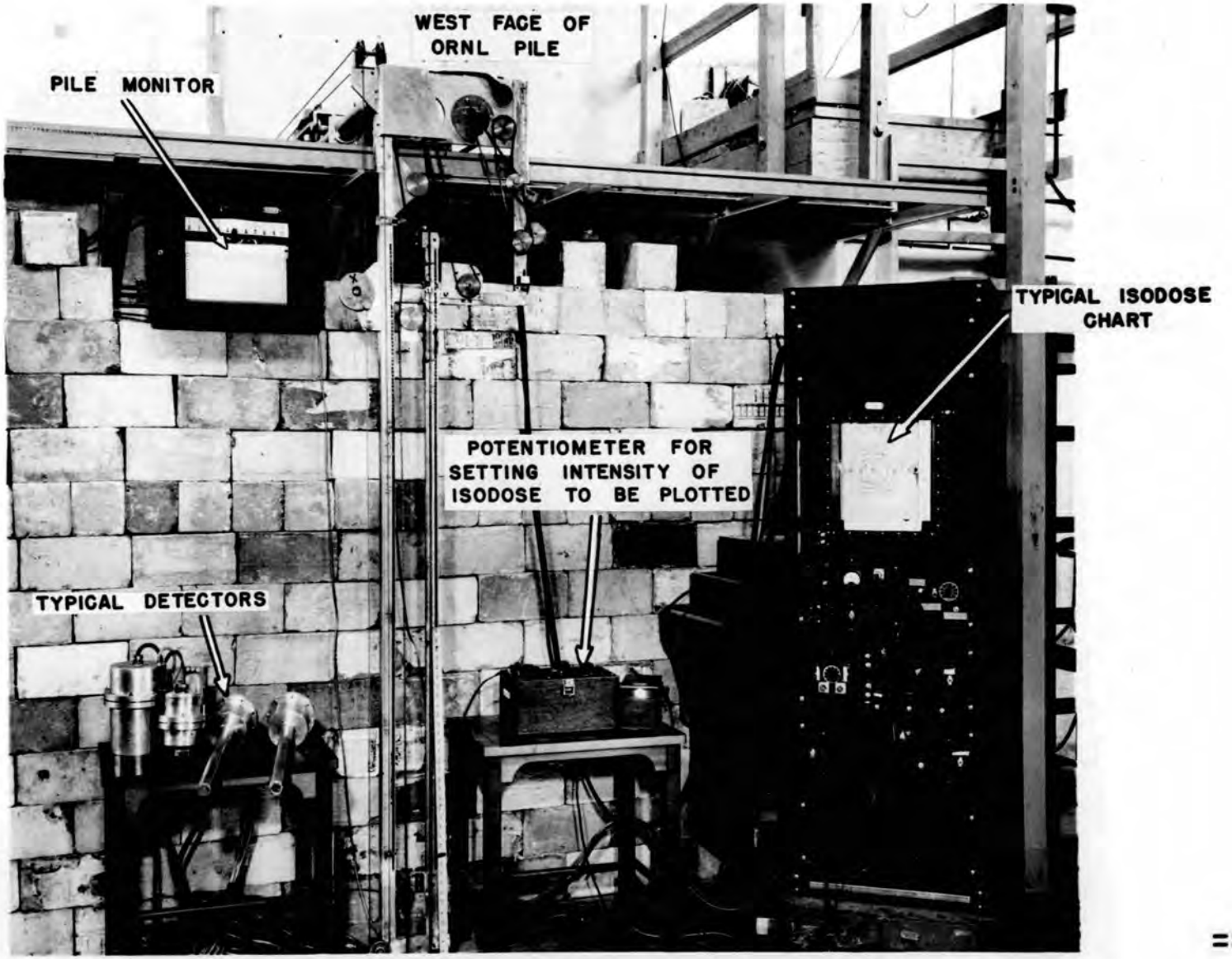

FIGURE 2. VIEW FROM OPERATOR'S DESK