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RADIOLOGICAL MONITORING OF A NUCLEAR RELEASE

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At the National Reactor Testing Station in the State of Idaho, a network of radiation detection and sample collection devices is operated on a continuous basis in order to provide complete radiological control of local operations. Particular emphasis is placed upon downwind locations from all operating installations. Types of radiation monitoring devices presently in use are: continuous air monitors, gamma scintillation scanners, particle collectors and fallout collectors. In addition to physical observation of meters and recorders utilized with certain of these devices, radiochemical and radioautographic analyses are performed.

Personnel of the various health physics groups support the established radiation monitoring network. In the event of a mishap at any of the experimental sites, or when the nature of experimentation is such that hazardous conditions could develop, these persons are alerted. In some extreme cases, personnel and equipment are based in close proximity to the work in progress.

During the summer of 1953 and spring of 1954 experiments were conducted by Argonne National Laboratory utilizing a small remotely-operated, water-cooled and moderated reactor. During an intentional short period excursion on July 22, 1954 a violent release of energy occurred which destroyed the reactor core and some associated equipment. As this possibility had been anticipated, all precautions had been taken to minimize any resultant hazard. Five mobile radiation-monitoring teams were based around the reactor area at distances greater than 800 meters. Highway barricades were readied for closure of travelled roads should the necessity arise. All operational and observation personnel were based at the control area, a distance of 800 meters from the reactor. In addition all travel had been restricted within this distance. (Fig. 1 - Reactor Location and Adjacent Area)

Immediately following the short excursion, a column of dark grey smoke and dust was observed blowing out through the top of the reactor to a height of approximately 25 meters. A short, sharp explosion was heard, followed by a slight shock wave felt at the control area. At this time the control mechanism, tower, and various other objects were blown into the air, then fell off to the sides of the earth dike shielding the reactor. Following the initial emission the cloud drifted slowly toward the southwest at a speed of about 8 kilometers per hour. At a distance of approximately 1.2 kilometers, the cloud began to rise in a thermal and at an elevation of about 300 meters above the ground gradually diffused until it was no longer visible.

Simultaneously with the release several portable radiation detection instruments located 800 meters from the reactor indicated short radiation exposure rates beyond the limit of the range of the instruments being used at this time, or an exposure rate greater than 500 mr per hour. Subsequent development and interpretation of X-ray film indicated a total dosage of approximately 50 mr at 440 meters, and 30 mr at 580 meters.

Within a few minutes of the release all mobile teams began monitoring downwind from the reactor taking readings 1 meter above ground level. Fifteen minutes after the release the maximum measurement was 6 mr per hour at 1.6 kilometers from the reactor; 25 minutes after the release 2.0 mr per hour at 3.2 kilometers. Meteorological data indicated that the cloud traveled to the southwest for approximately 1 hour at a speed of about 8 kilometers per hour. The wind then reversed 180 degrees as the temperature distribution in the lower layers of the air changed from inversion to lapse, and the cloud traveled toward the northwest at speeds up to 10 kilometers per hour. (Fig. 2 - Meteorological Data) This trajectory was confirmed when an increase of radiation amounting to 6 times the prevailing background was detected by a continuous air monitoring device located 13 kilometers from the point where the wind shift had occurred 3 hours earlier. Stations ranging from 8 to 110 kilometers further downwind did not indicate any radiation as a consequence of the experiment.

The only indication of radioactive fallout was obtained from direct readings of the ground following the cloud passage to the southwest up to a distance of 3.2 kilometers from the reactor. The maximum was determined at a distance of 1.6 kilometers where the readings were 6 mr per hour at 1 hour after the release, 0.5 mr per hour at 6 hours, and .05 mr per hour at 26 hours.

Within the first hour it was established that there was no radiation hazard to anyone outside the 800 meter perimeter as a result of the experiment. Radiation protection activity was then directed toward the reactor area proper in order to establish safe time limits for the purpose of making inspections, and for removing photographic film before it became overexposed from the high level of radiation present. The first attempt to enter the reactor area by way of the access road from the south failed when radiation exposure rates up to 40 roentgens per hour were encountered at 60 meters from the reactor. Further investigation proved that the south side of the reactor area to a distance of approximately 120 meters contained a large number of fuel plate and reactor fragments. However, entry to the reactor area proper was accomplished from the east side in a radiation field of 1 roentgen per hour. Removal of film and initial inspections were possible in radiation fields up to 30 roentgens per hour. At this time, 5-1/2 hours after the release, the radiation level over the top of the reactor pit was 8 roentgens per hour, 10 roentgens per hour at the west end of the pump pit, and 30 roentgens per hour 15 meters south of the reactor from fuel plate fragments scattered on the ground.

Five days after the experiment radiation levels had decreased sufficiently to permit commencement of salvage and decontamination. A change area was set up at the west side of the reactor at a distance of 75 meters, where radiation background levels were less than 1 mr per hour. Instruments and salvageable materials were removed to this location and decontamination performed with a minimum of difficulty. Exposures of persons working on this operation were kept below 3.9 roentgens over the entire period.

The affected area south of the reactor was of particular interest. Five days after the release, expeditions were started into this area to remove and store all visible articles of radioactive debris. Eleven days after the release all of these items had been removed but the radiation level had not been lowered significantly. The area was set up on a 3-meter grid pattern and surveyed at intersections. At each location 2 types or readings were taken with an open window ionization-type instrument. One set of readings was obtained at ground level, the other at 1 meter above. The resultant readings were then plotted according to levels of 1 to 10 mr per hour, 10 to 50 mr per hour, and greater than 50 mr per hour. (Fig. 3A and 3B - Survey of Contaminated Area) An area of approximately 7800 square meters was proven to be contaminated in a strip approximately 60 meters in width and 130 meters in length. It appears that as a result of the explosion, the base plate of the reactor control rod mechanism had tilted as it broke loose from the platform forming an approximate 45 degree angle. Fuel elements and associated debris were deflected toward the south by the obstruction. The entire affected area was later covered with a layer of gravel to a minimum depth of 15 centimeters which reduced the radiation dosage rate to less than 5 mr per hour.

Because the reactor was remotely operated with an established safety distance of 800 meters, no hazard to operating personnel or to others at the testing station was present. The entire experiment was accomplished with no radiation exposure to personnel above permissible levels. A similar release involving a directly operated reactor of similar size would undoubtedly subject personnel within the immediate vicinity to radiation exposures and airborne contaminants of serious magnitude unless adequate shielding and associated safeguards comprised part of the installation.

It would appear that in design criteria for similar experimental reactors that provision be made to control the direction of debris blowing out as a consequence of a release such as occurred in this instance. Entry and cleanup would be facilitated and possibility of contaminating expensive equipment and property minimized.

The health physics function in respect to this experiment was primarily personnel protection. Unfortunately, expenditure for scientific data had not been considered. As a result, much information that would be of value to nuclear science was not obtained.