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A Compendium of Information for Use in CONTROLLING RADIATION EMERGENCIES

Including Lecture Notes from a Training Session at Idaho Falls, Idaho, February 12-14, 1958

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ALLEN BRODSKY
G. VICTOR BEARD
Compilers and Editors

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HEALTH PHYSICS ASPECTS OF THE BORAX-1 DESTRUCTION

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This presentation includes collected data gathered jointly and individually by the Argonne National Laboratory and the Health and Safety Division of Idaho Operations Office, AEC.

The BORAX-1 reactor was operated at the Argonne National Laboratory site at the National Reactor Testing Station near Arco, Idaho. The reactor was located 2730 ft northwest of the Experimental Breeder Reactor (EBR) area entrance. It was operated remotely from a control point located approximately one-half mile southeast of the reactor near the EBR area entrance.

The reactor installation consisted of a reactor tank, 4 ft in diameter, inside the shield tank of 10-ft diameter. This was sunk partly into the ground, with earth piled around the installation to provide additional shielding. The reactor core consisted of a number of MTR-type fuel elements, each of which contained 18 fuel plates. The combined U^{235} content was about 140 g per element.

During the year 1953, experimental excursions were produced in the following manner: The reactor was equipped with a number of control rods, one of which could be rapidly ejected downward out of the reactor core by springs and gravity. The reactor was made critical at low power with this rod inserted at a pre-chosen point in the core and the remaining rods fully withdrawn. The control rod was then suddenly ejected and the reactor power allowed to rise rapidly. The reactor would produce sufficient steam to over-compensate for the excess reactivity and to reduce the power level. The remaining control rods were then programmed to be dropped into the core after a preset time interval. These excursions were routinely performed with periods as short as 5 milliseconds. Under these conditions, the ejections of water from the reactor were rather violent, and water was thrown out of the reactor tank to a height of about 30 ft. The decision was then made to make one final short excursion that would result in a possible partial melting of fuel elements with a release of fission products. This experiment was performed on July 22, 1954.

Generally speaking, the radiological aspects were to be taken care of by the previously-mentioned AEC group. With this thought in mind the following operations were prepared and put in readiness for the experiment:

1. Regular emergency monitoring equipment was supplemented with additional instruments and supplies; this included stationary and mobile equipment. All vehicles were previously equipped with two-way radios. A transmitter was installed in the field office.

2. The emergency monitoring teams consisted of five two-man teams with instruments and radio-equipped vehicles. These teams were shifted according to U. S. Weather Bureau recommendations.

3. Mobile smoke generators were located approximately one mile from the reactor installation, were operated in conjunction with remotely-detonated smoke pots in the reactor area, and were fired by ANL personnel.

4. Central maintenance crews were on stand-by with gravel trucks and loading equipment prepared to deliver and spread gravel over roads and highways, if needed. AEC security was on stand-by to effect roadblocks and evacuation, as it turned out to be required.

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Fall-out plates and beta-gamma and neutron film were placed in the general downwind direction from the reactor, as well as within the reactor area proper. This was in addition to the regular site monitoring system. All observers in the control area were issued film badges.

Shortly before 0800, the U. S. Weather Bureau notified ANL officials that conditions were favorable for beginning the experiment. This information was relayed to observers and health physics teams.

The reactor was then made critical, and the central control rod was fully inserted. After a final check to determine that no personnel were in the restricted area, one of the remote smoke pots was fired. Ten seconds later, at 0820, the central rod was ejected from its fully inserted position.

In a very short time after the ejection of the rod, a column of what appeared to be dark gray smoke was ejected from the reactor to a height of approximately 80 ft. Shortly thereafter, the sound of a medium sharp detonation reached the control trailer and a slight tremor was felt. In a few seconds the smoke cleared away and it was apparent that the entire superstructure of the reactor had been carried away.

Monitors at the control point (approximately one-half mile away) recorded an instantaneous exposure rate in excess of 500 mr/hr. This was indicated on a cutie-pie type ionization chamber. Within 30 sec the rate was established at 25 mr/hr and was rapidly declining. Within 5 minutes, exposure rates had decreased to less than 1 mr/hr.

Construction personnel working in the vicinity of the present Zero Power Reactor (ZPR), which is about 0.6 mile from the BORAX reactor, were immediately evacuated pending an evaluation of the situation. At the same time, traffic control was established on U. S. Highway 20 and on Van Buren Avenue leading to the EBR.

It was soon evident that no significant exposure had been received at the control point. With a northeast wind prevailing, the smoke from the smoke pots continued to rise to a considerable height before becoming highly diffused. At 0936, after determining that the exposure rates on Van Buren Avenue and the EBR area were less than 0.5 mr/hr, restrictions were lifted to allow traffic and construction personnel to continue normal operations. Subsequent examination of film badges worn by observers at the control point gave no evidence of exposure received at this location.

Monitoring teams that were dispatched shortly after the excursion had by 0900 determined the trajectory to have been roughly in a southwesterly direction, passing over Adams Boulevard approximately 1½ miles from the Van Buren-Adams junction and continuing over the Union Pacific Railway in the same direction. Within 45 min after the excursion, the bulk of the airborne material had passed beyond the railroad right-of-way and the initial fall-out surveys were completed. The following readings of the significant trajectory fall-out summarize the effect of the cloud. Readings were taken in a standard manner, that is, in air at 3 ft above ground.

Across Adams Blvd.	0835	5 mr/hr
Across Union Pacific Railroad	0845	2 mr/hr

The following readings were taken at 1 in. above ground:

Across Adams Blvd.	0915	6 mr/hr
Across Adams Blvd.	1430	0.5 mr/hr
Across Union Pacific Railroad	0920	6 mr/hr
Across Adams Blvd.	1030(July 23)	0.05 mr/hr

After approximately 1 hr, it had been determined that no widespread hazard existed and a cooperative maximum effort was exerted to salvage film and records from the reactor area.

The first attempt to enter through the main gate failed when personnel encountered a field of 40 r/hr at approximately 100 ft from the gate. However, at 0930 an entry was made by cutting through the rear fence and utilizing existing earth shielding. Film were successfully removed while personnel were exposed to a maximum dose rate of 1 r/hr. The following read-

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ings were taken to establish emergency time limits for the removal of essential material. All readings were taken at 3 ft above ground:

75 ft NE of reactor	0930	0.1 r/hr
75 ft SE of reactor	0930	0.8 r/hr
60 ft SE of reactor	0930	1.5 r/hr
West end of reactor pit	1400	10.0 r/hr
Over reactor tank hole	1400	8.0 r/hr

Further investigation showed that an area 350 × 200 ft and lying south of the reactor area fence had been covered with radioactive debris. On August 2 the area was divided by a grid and measured. A number of the side plates of fuel elements were found holding clusters of end fragments of fuel plates, the remaining plates having been melted or torn away. Some elements were found with no fuel plates remaining.

RESULTS

The positioning of the fall-out plates did not coincide with the trajectory center, so worthwhile information was not obtained from the trajectory plates. The plates located within the blowout area were grossly contaminated and could not be used as representative fall-out samples. The trajectory plates were all radioautographed. No significant increase in activity was noted in the locations of these plates.

Film Packets

Film packets placed inside the reactor were highly overexposed and interpretations could not be made. A number of film packets placed in conjunction with the outer area fall-out plates gave the following results:

Distance from the reactor, ft	mr
1450	50
1500	50
1900	30
2250	20
5300	0

Since the fall-out plates in the same locations showed no contamination, it is safe to assume that this recorded exposure resulted from the initial release.

Analysis for Alpha

Over 50 samples were analyzed for alpha activity. These included filter paper samples, samples from the continuous air monitors located on the site, and gummed paper fall-out samples. No unnatural alpha activity of any significance was detected in any of the samples tested.

Analysis for Beta Activity

A section of plastic shoe cover worn in the BORAX area a few hours after the excursion was counted and a decay curve was developed.

Cleanup and Salvage

On July 26, an attempt was made to reduce the radiation background by physically removing all visible pieces of radioactive material that had been scattered south of the reactor. Many such fragments, some reading as high as 50 r/hr, were collected; however, their removal did not reduce the background by very much. It was then necessary to rope off an area of approximately 11,000 sq ft. Within this roped-off area another area of approximately 5,000

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sq ft was covered with a 6-in. depth of gravel. Dosage rates were reduced to less than 5 mr/hr over the entire area, compared to rates of 500 to 800 mr/hr before laying gravel.

The salvage operations were conducted jointly by AEC and ANL. Decontamination facilities were set up at the reactor site and much of the material was successfully decontaminated. Exposure rates ranged up to 5 r/hr. Salvaged equipment and materials were utilized in the construction of BORAX-2 at a nearby site.

In conclusion, it can be safely assumed that at a distance of one-half mile there was no evident hazard. The airborne activity could have presented a hazard to anyone in the direct trajectory, but would not have caused chronic exposure from long-lived isotopes. Therefore the radiological hazard that we should be primarily concerned with is obtained in the immediate area affected by the blowout material.

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