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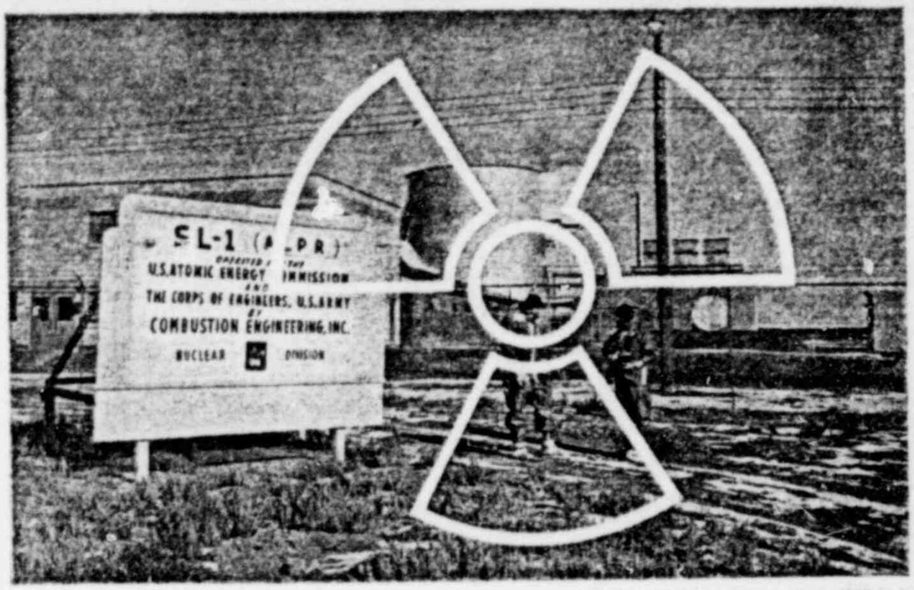

What

Have We

Learned? . . .

Health Physics at SL-1

From first-hand experience at SL-1 we can evaluate our ability to deal with nuclear accidents. For the future we must have larger-range detectors and better methods for handling radioactive casualties

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POOR ORIGINAL

AT THE SL-1 ACCIDENT earlier this year, health physicists encountered many "firsts" in health-physics operations and management. Moreover they were able to evaluate how well their preplanned program worked in a nuclear disaster area and what improvements they must make. The experience of the rescue crews working in a highly contaminated environment point out the following important facts about existing health-physics techniques.

- **Preplanned program worked well.** Although there is, of course, room for improvement in existing health-physics techniques, the preplanned operation allowed rescue crews not only to enter the reactor room where radiation levels were 500–1,000 r/hr, but also to remove the bodies of the three men killed in the accident without further injuries or casualties. Moreover the radiation exposures that members of the early rescue crews received will not keep these men from working in any nuclear programs in the future.
- **But we must improve.** In particular the SL-1 disaster points up a void in the preplanned technique for dealing with highly radioactive casualties. In addition the rescue crew that originally arrived on the scene was not equipped with instruments that recorded radiation levels above 500 r/hr. Consequently the crew could not determine the extent of the radiation in the reactor room (see box on Page 44 for improvements).
- **We learned from experience.** From the SL-1 disaster we not only gained valuable practical health-physics experience, but also were able to analyze our preparedness and ability to handle nuclear accidents in the future. Moreover we gained confidence in dealing with nuclear emergencies.

Preplanning Pays Off

In responding to the SL-1 fire alarm—potentially involving radiation hazards—the division followed its preplanned emergency health-physics program as its fire trucks rolled toward the Army Reactors Experimental Area on that first Tuesday evening in January. This program, set up by the AEC Health and Safety Division at Idaho Falls, (see Box on page 46) not only provides equipment to deal with accidents but also outlines the basic procedures and responsibilities needed to cope with all kinds of emergency situations—plant incidents, natural disasters, enemy attack or security alerts.

An important part of the program is a general notification system that the Health and Safety Division uses not only to request on-site, off-site or off-duty health-physics assistance, but

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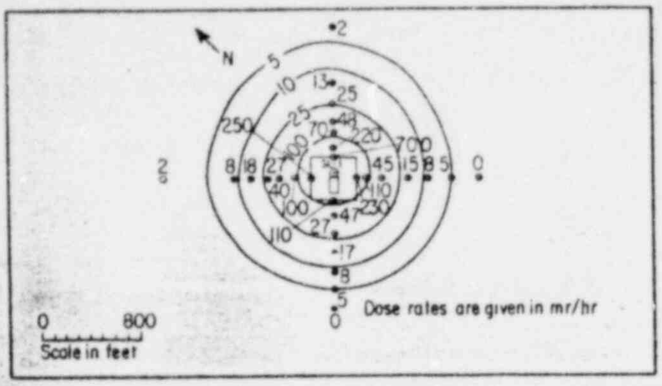

FIG. 1. CONTAMINATION TO ENVIRONMENT was small since major radiation was confined to reactor building

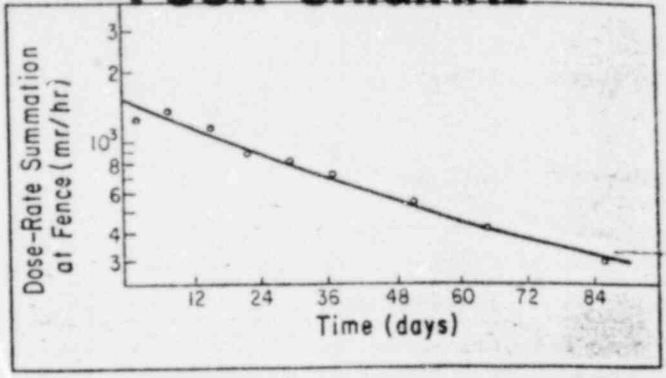

FIG. 2. SUMMATION OF DOSE RATES AT FENCE shows half life of $\sim$36 days indicating long-lived fission products

also to notify downwind facilities of an accident after determining meteorological conditions. The IDO fire department used this system when at 9:02 p.m. on Jan. 3 they requested health-physics assistance from Phillips Petroleum Company at MTR. The program also sets up a field headquarters complete with decontamination and counting-trailer facilities; this field station reports directly to a headquarters control group. In addition, through discussions of plans for action, reviews of possible incidents and field responses to simulated accidents, the radiological assistance plan develops the response capability of the AEC and its contractors. This program provides 30 people trained in health physics and medical practices to deal with emergencies at NRTS. Preplanning also set up exposure guides for workers in a disaster area: they allowed a 100-roentgen dose to a man trying to save a life and a 25-roentgen dose for a man protecting valuable property (Table 1).

The importance of this preplanning became evident when the fire department answered the alarm from the reactor. For example, although the SL-1 site was kept locked instead of having a 24-hr guard, the IDO security and fire department could quickly enter

What We Learned and How We Are Improving Health-Physics Techniques

The most valuable health-physics information from the SL-1 accident comes from analyses of our ability and preparedness to handle nuclear accidents in the future. Although we had reviewed many hazard reports and had discussed the worst possible accidents at NRTS, we found at SL-1 that our actual health-physics preparations were inadequate in several areas. In the table below we have listed some of these inadequacies as well as the improvements we are making.

What we should do . . .	**Therefore . . .**
• Improve our ability to handle radioactive casualties so that personnel will not be exposed to large doses.	• We should have available concrete vaults for transporting contaminated bodies. Also we are evaluating remote decontamination and surgical equipment for handling casualties.
• Maintain more emergency equipment—easily available—on a standby basis; in particular, we should increase the range of detectors and keep a larger supply of full-face masks.	• We are increasing amount of emergency equipment and are supplementing 500-r/hr-range gamma detectors up to 5,000-r/hr-range detectors.
• Have more trained health-physics personnel at disaster site earlier.	• We have taken responsibility for establishing field headquarters away from health-physics group so they will be freer to go directly to disaster site.
• Increase fire department training in health-physics practices.	• Our fire department personnel are receiving more health-physics training.
• Evaluate whether fire department officers should wear alarm dosimeters.	• We are testing and evaluating alarm badges.
• Establish better control at roadblock.	• By having better control we can reduce exposures, insure film-badge coverage of all personnel and prevent spread of contamination.

FIG. 3. HEALTH PHYSICISTS MEASURING GAMMA COUNT from sagebrush found no appreciable contamination

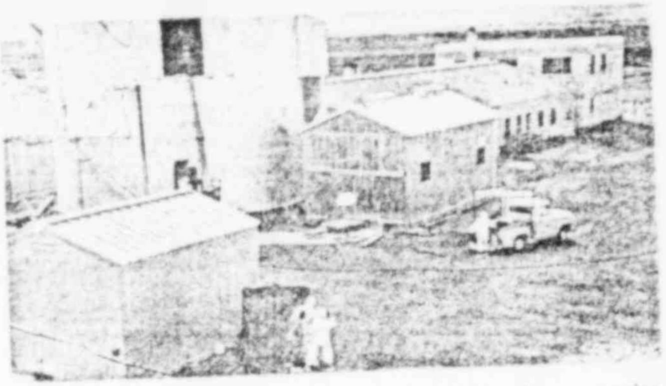

FIG. 4. TO KEEP EXPOSURE TO MINIMUM when removing bodies crew near reactor used protective clothing and shields

the reactor area at the gate house because preplanning had provided them with a key to the enclosure. The men were also equipped and trained to make radiological survey checks when they entered areas without qualified health-physics coverage even though in this case they did not realize that a reactor accident had taken place. Preplanning had provided all roving security patrols with direct survey instruments and the fire department with 200-r hi-range Jordan Radectors.

When the men reaching the stairs to the reactor room found dose rates of ~25 r/hr they had the first evidence that a major accident had taken place inside the reactor compartment. Since pretraining had emphasized that exposures must be kept to a minimum and qualified health-physics assistance must be secured when radiation is high, the firemen waited outside the building until health physicists arrived from MTR and they could plan their next moves.

Disaster plans at Idaho Falls. While the group made its plans, the evidence of large radiation levels had set a vast organizational plan into action 40 miles away at the AEC headquarters in Idaho Falls. Key people were notified, and the NRTS emergency and disaster plan went into action. At 10:25 p.m. the director of Health and Safety called a Class I disaster; this is an emergency in a single area that involves much property and personnel but can be controlled by people in the area with standby assistance from the NRTS fire department, medical and health-and-safety personnel. As it is defined, a Class I disaster actually applies to a larger facility than SL-1 at which the contractor keeps some men even during off-shifts who can help control an accident. Therefore at SL-1 additional contractor personnel including Army cadre men—recruits in training at SL-1 under the supervision of the contractor—had to be called in to assist at the emergency operations.

What were hazards? With the death of the only survivor of the accident at 11:14 p.m. the early emergency phase of operations ended and the crews could pause, take stock of the situation and make plans for recovering the remaining two bodies in the reactor room. They started with two clear-cut problems at hand: first, decontamination of early entry teams and evaluation of their doses; second, evaluation of environment contamination and establishment of the control area around SL-1. In this phase health-physics workers from all NRTS contractors began to arrive at SL-1 and were given assignments.

One administrative problem arose as a result of our using help from these outside groups; many of the organizations had different exposure criteria and, therefore, the range of total permissible exposures for each individual as outlined by the respective managements ranged from 60 mr/day to 25

TABLE 1—Exposure Guides in Early SL-1 Recovery Efforts

Date	*Guide*
Jan. 3	<100 r for lifesaving missions >100 r at discretion of senior health physicist <25 r to prevent major property loss
Jan. 4	<12 r to recover second body
Jan. 5	Up to 10 men to receive <10 r in recovering third body and decontaminating bodies
Jan. 6	<3 r for all other operations

NUCLEONICS and NUCLEONICS WEEK Cover SL-1

Five feature articles cover the events of the accident; one is based on on-the-spot coverage by a NUCLEONICS editor.

Explosion at SL-1 Kills Three, First Reactor Fatalities, NU Wk, Jan. 5, 1
SL-1 Inquiry Proceeds Slowly; Cause of Accident Still a Mystery, NU Wk, Jan. 12, 1

SL-1 Explosion Kills 3; Cause and Significance Still Unclear, NU, Feb., 17
AEC's Pittman Reports on the SL-1 Accident, NU March, 62
SL-1 Radiation Down Sharply After Cleanup; Remove Vessel? NU, Oct., 22
For background: ALPR on the Line, Reactor Foldout No. 7, NU, Jan., '59

In addition, the following shorter articles have appeared in our pages:

NU Wk, Jan. 26, 1
NU Wk, Feb. 2, 1
NU Wk, Feb. 9, 2
NU Wk, Feb. 23, 3
NU, March, 30
NU Wk, April 6, 1
NU, May, 17
NU Wk, May 11, 2
NU, June, 26
NU Wk, June 15, 2
NU, July, 22
NU Wk, Aug. 17, 4
NU Wk, Sept. 7, 3
NU Wk, Sept. 14, 2

roentgens over an indefinite period of time. In part this discrepancy was due to the different amounts of contact with radiation that a man had either received or was likely to encounter in his own job. In our selection of groups of men for jobs involving radiation hazards we considered the ages of the men and chose older men whenever possible.

Evidence obtained during the phase assured us that no immediate danger existed from exposure of the early rescue teams or from contamination to the environment. This evaluation was based on the following:

- The maximum whole-body gamma exposure to members of the early rescue team was 27 roentgens (Table 2).
- Despite existing inversion conditions, contamination to the environment was slight (Figs. 1 and 2).
- Air samples collected at the fence around the site and at the control point gave concentrations of I^{131} $<10^{-9}$ $\mu c/cm^3$.
- Aerial and biological monitoring early on Jan. 4 confirmed these small contamination concentrations beyond the SL-1 area (Fig. 3). The largest activity—125 cps above a 200-cps background—detected by the first aerial-monitoring flight was ~3 miles southwest of the reactor site. The gross gamma count from sagebrush in the same area was <50 times background.

TABLE 2—SL-1 Exposures >5 r Through Jan. 9

Individual	Penetrating radiation (roentgen)	Thyroid dose from I^{131} (rads)
AEC health physicist	27	4.2
Contractor supervisor	27*	1.2
Contractor supervisor	25	0.6
Contractor supervisor	25	1.2
Contractor health physicist	23	5.5
AEC project officer	21	0.0
Cadre supervisor	18	2.0
AEC physician	16*	0.5
AEC nurse	15	0.6
Support patrolman	11	0.5
Support health physicist	11	0.4
Cadre supervisor	9	0.7
Support health physicist	7.4	0.6
Army support	5.9	0.0

* Estimated exposure.

Recovering Bodies

During Phase 3—recovery of the bodies of the two remaining crew members—health physicists set an exposure guide to workers in which ten men would be allowed to reach 10 roentgens during the rescue work (Table 1). Fortunately because of carefully planned and executed team work this limit was never reached. To minimize the exposures three two-man teams were organized to go in the reactor room for not more than 1 min each to recover the second body. All the teams were staffed by Army cadre men who knew the facility; thorough briefings gave them clear pictures of their missions. Fortunately only one two-man team was actually used inside the reactor building.

Because of this careful planning, the first two-man team, which retrieved the first body and descended midway down the stairway within the allotted minute, received whole-body exposures of only 9 and 4 roentgens respectively. Although there were areas on the victim's body that gave 500-r/hr readings at ~1 ft, the second crew, which carried the body as far as the gate house, received only 260 and 305 mr, respectively.

To reduce the radiation levels inside the cab of the ambulance that carried the bodies to the decontamination room at the Idaho Chemical Processing Plant, the crews removed the clothing from both bodies. Although the clothing was wet and very contaminated, removing it did not greatly reduce the general radiation field because of the gamma-emitting particles imbedded in the bodies by the explosion. Therefore the men improvised lead coats as partial shieldings for the bodies; the fireman driving the ambulance the 11 miles to the plant received only a 180 mr dose.

An eight-man medical monitoring team from Los Alamos Scientific Laboratory helped physicians from NRTS decontaminate the bodies to 1–10% of their original levels. This team was a great boon to IDO since by turning over the important decontamination job to someone else, the health physicists in the Health and Safety Division could give their undivided attention to other jobs at the disaster site.

Similar health physics practices were used during the photographic, TV and other entries connected with removing the third body (Fig. 4). During these operations the crews received exposures in the range of 2–6 roentgens.

After the recovery of the third body health-physics responsibilities were gradually shifted from the Health and Safety Division back to the health-physics staff of Combustion Engineering, the operating contractor for the reactor. Since that time their general duties have been to give health-physics support to the remote operations for the SL-1 recovery program. In late May these responsibilities were handed over to General Electric, the SL-1 decontamination contractor.

What the Health and Safety Division Does for NRTS

To grasp fully the significance and scope of the health-physics program that went swiftly into operation at SL-1, one must understand the unique position held by the Health and Safety Division in the entire AEC complex. Unlike the situation at other sites where contractors take over much of the health-physics operations, it is the job of the division to develop, coordinate and maintain an effective program for conventional safety and radiological safety at NRTS. By taking over this program the division avoids any confusion that might result if the seven operating contractors and varying number of construction companies at NRTS organized independent operations. In connection with its program, the division provides film-badge services, portable survey instruments, fire protection, industrial medicine and bio-analysis although the responsibility for providing common services varies with the installation size and the extent of the operating contractor's health and safety programs. Moreover the division provides environmental monitoring outside the immediate fenced area surrounding each reactor site; the contractors help man the Region 6 radiological assistance teams administered by the Health and Safety Division.