THE INDUSTRIAL ATOM

TID-8017

March 1958

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Date: 2-7-67

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PRINTED IN USA

Available from the Office of Technical Services
Department of Commerce, Washington 25, D. C.

PRICE 50 CENTS

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RADIOACTIVE WASTE DISPOSAL AT KNOLLS ATOMIC POWER LABORATORY

D. A. Manieri and W. H. Truran

The bright prospects for the future growth of the nuclear energy business is now a popular subject for discussion by interested laymen and responsible heads of industry and government. In such discussion, radioactive waste assumes a position of increasing importance.

The hazards of nuclear radiation are today perhaps better publicized and respected, though not necessarily understood, than even those of the automobile. Control of radioactive-waste disposal practices is required by industries using nuclear processes to promote public safety. For this reason, considerable effort is being spent by government and participating industry to evaluate waste-disposal methods. In this paper particular reference will be made to the waste disposal and environmental monitoring program employed at the Knolls Atomic Power Laboratory, near Schenectady, New York, a Research and Development Laboratory operated for the Atomic Energy Commission by the General Electric Company.

GENERAL WASTE-DISPOSAL CONSIDERATIONS

Waste-disposal problems, of course, did not originate with the use of nuclear energy. One of the many features for which the Roman Empire is noted was its system of community sewers. We might expect, then, to find an analogy between the methods of municipal and industrial waste disposal and those methods required for radioactive waste. In either case wastes are ultimately discharged to the ground, surface water, or atmosphere, and it is the presentation of toxic elements to the public from these receivers which must be controlled (see Fig. 1).

Fig. 1 — Radioactive waste-disposal diagram of the Knolls Atomic Power Laboratory. —, normal operation. - - - -, planned after extended storage.

RESPONSIBILITY

It was realized when the Manhattan Engineering District, Army Corps of Engineers, undertook the development and production of the first atomic bomb that the operation of nuclear power plants would create unusual quantities of hazardous waste products. Exhaustive efforts employed to safeguard the public from these materials is commendable in view of the pressures to get on with the war effort. The continued necessity to "Protect the health and safety of the public" was emphasized in the first Atomic Energy Act of 1946 and repeatedly required in the Atomic Energy Act of 1954, which authorized licensing and nonfederal ownership of nuclear facilities. The Atomic Energy Commission contractor operators are directly responsible to the Commission for assuring public safety. The operator, therefore, must adopt methods of operation to contain wastes unacceptable for release beyond the limits of the plant site and to properly control radioactive-waste release, limiting such release to levels meeting acceptable standards.

Annual Volume of Solid Waste Collected

This waste volume, tabulated below, is segregated according to handling and packaging precautions required as determined by associated radiation levels: high-, intermediate-, and low-level waste. This method allows for the handling of 35,000 cu ft of low-level waste, 99 per cent of the total annual volume, by relatively inexpensive direct procedures. The more costly shielded and remote-handling-equipped waste-handling facilities are reserved for the remaining 270 cu ft of intermediate- and high-level waste.

Paper, clothing, rubber goods, and miscellaneous	Low level	Compressible	20,000 cu ft
Metals, wood, glass, filters, floor sweeping, etc.	Low level	Noncompressible	15,000 cu ft
Miscellaneous	High and intermediate levels	Noncompressible	270 cu ft

Low-level Waste

Low-level solid waste is deposited in 20-gal cans lined with water-proof paper bags. Two cans are available at each collection point, one for compressible and the other for noncompressible waste materials. By far the greater original low-level waste volume is compressible. Such waste is transferred to Dempster Dumpster containers (Fig. 2)

and trucked to the solid waste processing building where the volume is reduced 6 to 1 by a hydraulic baler (Fig. 3). An investigation of baling or incinerating low-level waste has demonstrated baling to be the simpler operation, requiring a lower operating cost and less capital investment.

Fig. 2—Hot waste being received for baling.

Fig. 3—Hydraulic baler.

Noncompressible waste is transferred to cardboard or wooden boxes (Figs. 4 and 5), which are constructed to meet I.C.C. specifications and thus prepared directly for off-site shipment to burial grounds.

Small volumes of waste presenting peculiar waste-handling problems because of their particular toxicity, such as plutonium, or their chemical and physical state, such as sodium, are packaged in special inner

Fig. 4—Hot-waste boxes.

Fig. 5—Hot-waste 4- by 4-ft box.

containers designed to meet I.C.C. regulations for transporting by public carrier.

High-level Waste

The high-level waste that requires shielding during the entire collection, transfer, and storage procedure is packaged where generated in aluminum tubing containers and placed in lead casks by remote-handling equipment. The waste is then transferred to a storage area where the liners are deposited in holes in a concrete slab (Fig. 6). The demand

Fig. 6—Waste being deposited in concrete slab storage area.

for costly high-level waste storage space is minimized by a more economical intermediate-waste storage area to which high-level waste may be removed after sufficient radioactive decay.

Intermediate-level Waste

The intermediate waste not requiring shielding during the entire waste handling procedure is packaged in 55-gal carbon steel drums by remote-handling equipment and placed in 1-ft-thick concrete casks by

a fork-lift truck (Fig. 7). The waste is then transferred to a concrete shielded enclosure for temporary storage. After a sufficient period for radioactive decay, the material is shipped off site for burial.

Fig. 7 —Intermediate waste being transferred from fork-lift truck to concrete casks.

Off-site Shipment

At present, the only permanent burial ground in the eastern part of the United States is located at Oak Ridge, Tenn. The AEC has made arrangements for disposal of KAPL's waste by burial at Oak Ridge. Because of limited local storage space shipments from KAPL are made periodically in two box car lots.

To meet I.C.C. regulations for radiation levels at specified distances from the box cars, advantage is taken of distance and shielding by sandwiching highest level waste in the center of the box car between boxes of baled wastes (Figs. 8 to 10).

DISPOSAL TO SURFACE WATER

The use of surface streams to dispose of large volumes of liquid waste containing low-level concentrations of radioactivity has been practiced since the operation of the first water-cooled production reactor. With the expected increase in the number of Public Utility Nuclear Power Plants, the need for the disposal of cooling water will

Fig. 8 — Initial loading of waste for box car shipment.

Fig. 9 — Photograph showing highest level waste surrounded by baled waste.

Fig. 10—Waste readied for shipment.

increase. In addition, as the needs increase for processing spent reactor fuel elements, the need for disposal of volumes of waste containing fission products will also increase.

Such release of liquid waste with low-level concentrations of fission products to a surface stream was inaugurated at KAPL in June 1955. The dilution capacity of the Mohawk River was investigated by the U. S. Geological Survey with the cooperation of the General Electric Company, the New York State Health Department, and Harvard University. The toxic radioactive and chemical elements in Laboratory waste were investigated by KAPL with respect to standards prescribed by the AEC and the New York State Water Pollution Control Board. The AEC and the Mohawk River Advisory Committee were satisfied prior to its assumption that the proposed release of Laboratory liquid waste with small reliance on river dilution involved no compromise of recognized standards.*

The control of liquid-waste discharge involves hold up for batch sampling. Analyses involve gross activity and isotopic determinations (Fig. 11). Following the analysis of a sample taken from retention tanks (Fig. 12), the tanks contents are released to the combined sewer at a rate permitting the maximum practical dilution before leaving the premises of the Laboratory.

Sewer effluent is proportionally sampled as it leaves Laboratory property (Fig. 13). The sample is analyzed for radioactivity, acidity, and toxic chemical content to promote every reasonable assurance of good disposal practices.

* Evaluation of Potential Hazards Associated with the Release of Laboratory Liquid Waste to the Mohawk River, L. J. Cherubin, Report KAPL-1353, 1955.

Fig. 11—Processing of Laboratory waste. ①, from buildings E-1, E-2, E-3, E-4, G-1, G-2, and H-3. ②, analyzed before release at two locations. ③, continuous daily proportional sample analyzed.

Fig. 12—Retention tanks.

Fig. 13—Proportional sewer sampler.

Although such disposal of waste may now be thought to be routine, opportunity is being taken to increase the fund of technical know-how. By means of the waste tracer, the Mohawk River waste-dispersion characteristics are being studied. The influence of Laboratory waste on river-bed material, plankton, vegetation, and fish is being monitored. Such investigations require the technical qualifications of a chemist, biologist, and a health physicist. The sampling equipment includes an outboard motor powered catamaran (Fig. 14), a 75-ft seine for sampling adult fish (Fig. 15), a minnow trap, a clam bar, an Eckman dredge for sampling river-bed material, a Foerst water sampler, a depth integrating water sampler, and a plankton net.

The results of control monitoring and aquatic biological studies are routinely reported to the AEC and the Mohawk River Advisory Committee. Release of KAPL liquid waste to the Mohawk River has been without adverse effect on river utilization or aquatic life.

DISPOSAL TO THE ATMOSPHERE

Radioactive materials in ventilation exhaust air may be in particulate or gaseous form, resulting from the venting of chemical process vessels, laboratory hoods, machining and metallurgical operations, etc. Filters, scrubbers, and chemical reactors are employed when required to reduce concentrations in exhaust air. Stacks may be used to increase atmospheric dilution.

The exhaust stack effluent is sampled continuously and monitored for radioactivity concentrations. When airborne radioactive waste involves a variety of physical forms, a series of samplers is employed—a filter to collect and concentrate particular material, a scrubber to remove chemically active gases, and a chamber which includes a beta gamma sensitive detector to continuously monitor the inert radioactive gases.

Filter and scrubber solution samples are assayed by Laboratory radiochemical techniques and electronic counting of radioactivity to determine concentrations of the various elements in the effluent air sampled.

In order to assess the influence of ventilation waste discharged on the environs, monitoring stations are situated at appropriate distances from the points of discharge. Environmental monitoring stations are equipped to determine area radiation levels and concentrations of radioactive materials in air, precipitation, soil, and vegetation. The stations are located generally in the directions of the four cardinal points of the compass with the source as the center, due regard being given to prevailing wind direction. Monitors and samplers at environmental monitoring stations include air filtering equipment, continuous area nuclear radiation detectors sensitive to beta and gamma activity, film dosimeters, and rain collection and measuring equipment (Figs. 16

Fig. 14—Sampling for Mohawk River waste dispersion.

Fig. 15—Seining for adult fish and river-bed material.

Fig. 16—Monitoring and sampling equipment.

and 17). Soil and vegetation are routinely sampled on and off the Laboratory site. The samples of air content, rain, soil, and vegetation are analyzed in the Laboratory by radiochemical and electronic counting techniques.

Background data at the site obtained before the start of operations improve the assessment of local operations influences on the environment. Environmental monitoring data for KAPL through seven years before and during operations have indicated no significant exposure of the public over the exposure to natural background radiation from Knolls Atomic Power Laboratory Operations.

SUMMARY

Disposal of radioactive wastes from KAPL is considered with respect to the three physical categories of waste—solid, liquid, and airborne—and the three environmental recipients—ground, surface water, and atmosphere. Solid waste-handling includes monitoring radiation levels, segregation, collection, processing, packaging, storing if necessary, and shipping to a remote burial ground at the Oak Ridge National Laboratory. Liquid waste is collected by controlled drain systems, monitored for radioactivity content, and stored if necessary or released to the Mohawk River. Exhaust air is cleaned before released and continuously monitored. The environment is monitored to assure safe and proper disposal of wastes. The cost of operations and the depreciation of facilities incurred by KAPL for disposing of radioactive contaminated waste is less than 0.7 per cent per year of the total cost of the Laboratory.

Fig. 17 — Nuclear radiation monitoring instrument.

Such surveillance provides reasonable assurance of no adverse effect on the environment, the neighbors, or the Laboratory employees resulting from the disposal of radioactive wastes from KAPL.

REFERENCE INFORMATION

For further information, both general and detailed, regarding radioactive-waste handling, the following reports of the United States Atomic Energy Commission, available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., are suggested:

TID-7513(Part 1), Fourth Atomic Energy Commission Air Cleaning Conference, Held at Argonne National Laboratory, November 1955. June 1956. 320 pages. \$1.50.

TID-7517(Part 1a and 1b), Sanitary Engineering Aspects of the Atomic Energy Industry, A Seminar Sponsored by the AEC and Public Health Service, Held at the Robert A. Taft Engineering Center, Cincinnati, Ohio, Dec. 6-9, 1955. October 1956. 635 pages. \$3.10.

NYO-7830, Radioactive Waste Disposal Practices in the Atomic Energy Industry, A Survey of the Costs. Arnold B. Joseph. Dec. 31, 1955.

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Order from Office of Technical Services,
Department of Commerce, Washington 25, D. C.

- TID-8001 Proposed New Method of Wholesaling Fresh Meat Based on Pasteurization by Gamma Irradiation. L. E. Brownell, J. V. Nehemias, and J. J. Bulmer.
(\$0.15)
- TID-8002 Facility Design Utilizing Gamma Radiation for Meat Pasteurization. L. E. Brownell, J. J. Bulmer, and J. V. Nehemias.
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- TID-8003 Gamma Facilities at the Materials Testing Reactor. Brewer F. Boardman.
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