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THE SAFE MANAGEMENT OF RADIOACTIVE WASTES

by

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A talk prepared for general presentation before lay groups
from which speaking invitations will be solicited.

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THE SAFE MANAGEMENT OF RADIOACTIVE WASTES

Introduction

The decade of the Sixties will go down in history as the period of man's greatest technological and scientific achievement -- breaking the shackling bonds of gravity which have confined him to earth for his entire existence and his voyage to, and return from, another celestial body. All this sounds incredibly fantastic, and people the world over admire the courage of the men who have pioneered space exploration. These men entered an unnatural and unknown environment with the help of thousands of dedicated supporters. Together they developed the methods and procedures to deal with it safely. Such will be the course of other space exploration yet to come; man will constantly be confronted with environmental challenges. The history of man provides ample evidence of his ability to turn physical phenomena to his advantage and to do so with minimum risk.

Today, as we enter the Moon Age, we can look back just two decades to the advent of the Atomic Age. At that time, too, the achievements of man appeared equally incredible and fantastic as he unlocked the vast energy within the atom. The intervening years have seen this energy pool harnessed effectively and safely to the great benefit of all mankind, an achievement not so much different in principle from the safe

development and employment of electricity after Ben Franklin's experience with his kite. One of the most interesting stories of progress in the safe handling of atomic or nuclear materials concerns radioactive wastes from the chemical processing of nuclear reactor fuels. These operations are called fuel reprocessing plants. It is important that this story be told and given wide public dissemination to prevent misunderstandings which could impede the orderly growth and expansion of nuclear power facilities. Before many more years there will be numerous fuel reprocessing plants throughout the United States, each with its own radioactive waste sources. These plants will be reprocessing spent fuels from over 100 nuclear power plants, 59 of which are being operated or built today with the remainder scheduled for startup in the next 5 to 7 years. These plants will be located in 29 of the 48 adjoining states.

The Hanford Plant

The greatest accumulation of experience in handling radioactive wastes rests with the U. S. Atomic Energy Commission and its operating contractors. Their plants have been in operation for two decades in several states. One of the largest of these facilities is the Hanford Plant in southeastern Washington. Today I will describe the safe management of radioactive wastes at the fuel reprocessing plants at this site.

First, a quick overview of the Hanford Plant. It occupies 585 square miles south of the big bend of the Columbia River

and north of Richland. It is bounded on the south by the Rattlesnake Hills. The AEC facilities there include fuel element fabrication plants, nuclear reactors, and fuel reprocessing plants. Several commercial firms have contracts with the AEC for the operation of these plants, and the necessary research, development, and support facilities. The fuel reprocessing plants are operated by the Atlantic Richfield Hanford Company, commonly known as ARHCO.

The principal factors which led to the selection of this site were the availability of a large and continuing quantity of cool and relatively pure water, an ample power supply, and isolation. These requirements were basic because of the heat released by the reactor operation, the substantial energy called for by a large plant, and the "first-time" operation of large radiation generating processes. It later became apparent that the arid environment and geological formation in the area were characteristics extremely favorable for the radioactive waste storage requirements. The specific location of the fuel reprocessing plants (the 200 areas) is on a plateau-like shelf about 7 miles from the Columbia River. Underlying this area are sedimentary deposits (gravel, silt, and sand) up to 1,000 feet thick with groundwater occurring 200 to 300 feet below the surface. Beneath this are many layers of basaltic volcanic rock. I shall point out later how these features help in the management of some types of waste.

Fuel reprocessing is required after the fuel elements are discharged from the reactors. The principal objective in such reprocessing is to recover and purify that small fraction of the original uranium which has been converted to plutonium, a defense material. The unconverted uranium is also recovered for recycling through other AEC plants, and highly radioactive by-products of the operation (radioisotopes) show up in the waste streams. Reprocessing of commercial power reactor fuels will yield similar end products, so the privately operated commercial reprocessing plants of the future will have waste management obligations similar to those fulfilled for the past 25 years at Hanford.

Process Wastes

Radioactive wastes occur in the same physical forms as wastes from other industrial plants -- gases, solids, and liquids. These wastes have been managed over the years strictly in accordance with standards prescribed to protect man from radiation. These standards may be found in the United States Code of Federal Regulations, Title 10, Part 20. Both past and present waste management practices perhaps can best be understood if separately described according to physical class.

Gases

Gaseous wastes are dispersed from controlled ventilation systems to prevent the release of radioactivity. Most of the

500 billion cubic feet per year of gases discharged from the ARHCO stacks is air, which provides comfortable working conditions for personnel in all parts of the plants. This is exhausted through high efficiency filters and discharged from stacks 100-200 feet high. It is continuously monitored and sampled periodically to determine the quantity of radioactivity released to the atmosphere.

Air that comes in close contact with process materials picks up process chemicals and radioactive contaminants. Noxious materials are removed from these gases by chemical reactors, scrubbers and absorbers of various types before the gases are filtered and released through the high stacks. Never in 25 years of operation has there been a release of radioactive materials from the ARHCO stacks which has endangered the welfare of the general public. Not only have all such releases been well within AEC guides but they have also been many factors below the acceptable limits set forth by the National Bureau of Standards and the Federal Radiation Council.

Solids

More than 4.5 million cubic feet of solid wastes containing radioactive materials have been buried near the fuel reprocessing plants since they were first started up in 1944. This solid waste storage has required about 130 acres. Most of this material is so-called dry waste -- soiled clothing,

laboratory supplies, tools, etc. These dry wastes have been boxed in cardboard, wood, or metal and dumped from trucks directly into trenches about 12 feet deep where they are covered with a minimum of four feet of backfill. Large pieces of failed equipment have been boxed in wood or concrete, transported to burial grounds on flatcars, then remotely transferred to a 15- to 25-foot deep trench and immediately covered with as much as 10 feet of soil.

Once buried, no reliance is placed on the container for confinement of the material. The principal concern then involves the pickup of radioactive materials by plants or animals, and the migration of radioactive materials through the ground. Soil sterilization over the burial site has eliminated any possibility of plant uptake, and the burial depth is beyond the reach of burrowing animals. In addition, we maintain a continuing surface and sub-surface surveillance of the burial site to determine if migration of the radioactive material takes place. Monitoring wells around the site provide the sub-surface surveillance. There has never been any evidence of any migration of radioactive materials through the ground at solid waste burial sites in 25 years of operation.

Liquids

The greatest challenge in the safe management of radioactive wastes is posed by those wastes which are liquid in form. In general, there are two broad classifications of

liquid wastes: 1) those which have been discharged to the soil, and 2) those which have been stored for further processing. The fruits of research and practical experience at this particular site have defined the destination of each waste stream. Let us first discuss those wastes which have been discharged to the soil.

Fuel reprocessing is a chemical operation, and nearly six billion gallons of water are used each year, most of which is involved in cooling or heating operations and never comes in contact with radioactive materials. This great volume of water has passed through cooling coils, tank jackets or condensers to remove heat from process streams, or this water is condensate where steam has been used for heating sources. Waste of this type has been discharged directly to the ground surface since the inception of Hanford operations. This is done at a low spot in the terrain near each major plant, where a pond actually forms. The waters percolate continuously through the soil to groundwater. These waste streams are constantly monitored, however, for radioactivity and can be shut off or diverted in the event of a failure in either coils, jackets or tubes which would allow entry of process materials. Although failures of this type are not unknown, they occur very infrequently.

There is also some contribution to these ponds from ancillary or supporting operations such as the laundry,

equipment decontamination and research laboratories. Radioactive contamination is present in these latter streams in very minute amounts. They, too, are constantly monitored and can be shut off if not within acceptable limits.

We know that a large fraction of any radioactive materials sent to a pond is sorbed or filtered and held in the soil beneath the pond area. The rate of movement of these sorbed radioactive materials through the ground is significantly less than that of water. We have determined this both by laboratory studies and from analysis of samples taken from monitoring wells adjacent to each pond. This movement of radioactive particles is slow enough to assure the realization of large decay factors before the material reaches the Columbia River. As a result, these waste waters do not contribute at all to the radiation dose received by the general public, which in the vicinity of the Hanford Plant is, from all man-made sources including world-wide fallout, not more than 10 percent of nationally and internationally accepted guides.

A much smaller volume of liquid, about 200 million gallons per year, does directly contact radioactive materials and, therefore, does become contaminated. Even though the quantities of radioactive materials contained in these "intermediate level" wastes are only a minute fraction of the quantities of radioisotopes processed, they do, nevertheless, constitute a significant quantity in terms of contamination control. These

wastes are primarily process condensates and a variety of salt solutions. We found through extensive experimental work that the radioactive materials in these solutions are readily sorbed on the clay fractions of the soils underlying the 200 areas, much in the same manner as the resin in a water softener removes the "hard" minerals. These wastes, therefore, have been discharged to underground structures called cribs. Cribs are long, narrow trenches which are filled with several feet of coarse gravel, then covered with a plastic membrane and backfilled with surrounding soil. The wastes are introduced to the crib through a distribution pipe in the gravel layer, then percolated down through the soil to groundwater. When the sorptive capacity of the soil for the radioisotopes of concern beneath a crib is reached, as determined by measurements in adjacent monitoring wells, no additional liquids are directed to it. As in the case with waste ponds, cribbing of wastes has not affected the general public's radiation dose.

The second broad classification of liquid wastes includes those which must be stored in high-integrity vessels pending their ultimate conversion to a solid, immobile form. These are direct process waste streams containing highly radioactive materials in large quantities. The decay energy in some of these waste streams is even sufficient to cause them to self-boil in storage. We have just recently put into operation a waste processing plant which is not only working on the

inventory of such wastes accumulated since 1944 but also treating currently generated wastes of this type from local fuel reprocessing.

The accumulated inventory of these highly radioactive wastes has been stored for many years in underground tanks constructed of reinforced concrete with a carbon steel liner on the bottom and side walls. As additional tanks became necessary, increased sophistication in heat control and leak detection facilities were incorporated into the tank design. Today a typical storage tank for boiling waste is equipped internally with many thermocouples for measuring temperatures both in the mud-like solids which settle on the tank bottom and in the clear liquid above. Special airlift circulators to help agitation, and off-gas treatment facilities to promote self-concentration are also provided. Externally the tanks are surrounded by both horizontal and vertical monitoring tubes or leak detection channels, as well as a grid of dry wells to monitor the soil for radioactivity. Storage tanks for non-boiling wastes are structurally quite similar but require less sophisticated auxiliary equipment.

We now have 149 of these underground tanks varying in capacity from about 50,000 to 1,000,000 gallons each. Two more tanks are currently being constructed. Tank storage of radioactive liquid wastes has always been considered a temporary matter because it was not reasonable that they would withstand

forever the stresses imposed by corrosion and heating cycles. The technology to process them to a more fixed state has just become available. This development has been very timely because in the last 11 years we have confirmed small leaks in 11 of our 149 tanks. When a leak occurs, the contents of the tank are transferred to a spare tank. However, some losses of liquid have occurred, up to 50,000 gallons in one instance. The principal radioisotope of concern in this liquid is cesium-137. Again, the soil characteristics at Hanford have been favorable to retention of this material. In no case has any radioactive material penetrated more than 15 feet below any tank.

This experience with leaking tanks did provide great impetus to development of a long-range waste management program on a more formalized basis. The objectives of this program are to:

1. assure isolation of hazardous radioisotopes from life forms for centuries
2. achieve long-term safety in a minimum of time
3. develop and implement the program at minimum cost.

In our waste processing plant today we are removing strontium-90 and cesium-137 from the accumulated self-boiling wastes of the past and also from the high level wastes being produced in current fuel reprocessing. These two radioisotopes are the only by-products which have high decay energy,

consequently high heat, and relatively long half-lives (about 30 years). They are being held in concentrated solution form in stainless steel tanks within the plant while facilities are being prepared for their conversion into solid, encapsulated forms. These forms will then be water- or air-cooled for many years before final disposition can take place, probably in underground vaults of some type.

The other major part of our waste processing activity concerns the nonboiling high level wastes. These are wastes which were accumulated in unconcentrated form in earlier years and have now been in storage long enough to decay away the energy needed to self-boil. We are evaporating these wastes to a moist salt cake form which will eventually dry completely and immobilize the radioisotopes in the same underground tanks where they were held as a liquid. To perform this operation, we are using both standard evaporators and in-tank immersion heaters. By the end of 1975 we are scheduled to have completed the processing of all our accumulated waste inventory, separating out the strontium and cesium and converting the remaining liquid to a solid. From that point on we will have to handle only currently produced waste streams. Today we are also looking at ways to recycle current waste streams within the fuel reprocessing plant to reduce waste volume, as well as diverting some process condensate streams to underground tanks where they can be evaporated to the salt cake form.

It should be clear that the past and present practices in waste treatment at Hanford's fuel reprocessing plants have capitalized on the environmental characteristics of the site in conducting these storage operations safely and with negligible contribution to normal public radiation exposure. These procedures serve to demonstrate that large quantities of radioactive wastes can be handled safely. Each location, however, must plan their own program to assure safety in their own environment.

Future Trends

In the future, radioactive waste management can expect to see a general tightening of disposal limits designed to maximize long-term safety. Already being considered are the waste generation rates from the fuel reprocessing plants which will serve the 100 or more nuclear power reactors mentioned at the outset. Waste forms for long-term storage and the selection of storage sites is under intensive study. Solid waste incineration, where possible, is likely, and compaction of those forms which cannot be burned is a sure step to conserve land. Special vaults or other confinement facilities may be required. Improvements in the methods of trapping radioactive gases will be sought before plant sites closer to populated areas gain public acceptance.

It is probable that all waste streams released to the environment from commercial fuel reprocessing plants will have

to be purified to drinking water limits, requiring a variety of different processes. For direct process waste streams, several methods of solidification are in final pilot plant testing today. These solidified high level wastes will have to be disposed of in sites owned and designated to be safe by the government. Among locations having been proposed are abandoned salt mines, vaults in desert areas, or caverns in deep bed rock. Currently at Hanford a deep well is being drilled into basaltic rock to determine the nature of basalt layers. If an impermeable layer could be found, a cavern could potentially be mined out for the deposition of solid wastes well below the existence of groundwater.

All reasonable potential alternatives for high level radioactive waste disposal are still under evaluation, and development work is expected to continue for some years on the location of disposal sites. These wastes have been managed safely at government plants for years; we can only conclude that it can be done just as safely at the commercial plants of the future.

I have only attempted to highlight waste management problems and practices without going into detail on any one type. At another time, if there is any interest in exploring any facet of this program more thoroughly, I would be very glad to spend more time with you at your convenience.