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B PLANT ION EXCHANGE FEED LINE LEAK

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B PLANT ION EXCHANGE FEED LINE LEAKINTRODUCTION

One of the objectives of the Waste Management Program is to separate the long-lived heat emitter ^{137}Cs from the bulk of the high-level liquid wastes. This separation is accomplished by the ion exchange process in the 221-B Building. Interim storage of the cesium is in solution as a nitrate. The cesium will later be converted to a solid salt as cesium chloride and encapsulated for permanent storage.

The feed for the B Plant cesium ion exchange process is pumped from the lag storage tank, 105-C, through a pipeline and several diversion boxes to the 221-B Building. On December 19, 1969, a leak was discovered near the 241-C-152 diversion box in the section of this line, V-122, from the 105-C tank.

Although the leak represented a loss of feed for the processing of ^{137}Cs , more important, however, was the consequence of environmental contamination to the soil from the line leak. For this reason, an investigation was made to establish the extent of the radioactivity spread. This report summarizes the results of a well drilling operation undertaken to define the boundary and to estimate the extent of the leak.

SUMMARY

Ten wells were drilled at radial distances from 4 to 16 feet from the leak source and to depths of 30 feet, whenever possible. Analytical results of ^{137}Cs , the major constituent of the waste solution, were used as the basis for determining the configuration and content of the leak volume. Three general concentration zones of 550, 100, and 10 $\mu\text{Ci } ^{137}\text{Cs}/\text{gram}$ of soil were plotted from the analytical data. The highest concentration zone, 550 $\mu\text{Ci } ^{137}\text{Cs}/\text{gm}$ of soil, corresponds to soil saturated with waste solution that contains 4.0 Ci $^{137}\text{Cs}/\text{gal}$. Within an error 10 percent, this saturated region is verified by the ion exchange feed concentration of 4.34 Ci $^{137}\text{Cs}/\text{gal}$.

The volume of waste solution that leaked to the soil was estimated at 2600 gallons. This volume, which included an approximate 100 gallons that surfaced and collected near a

fence line, contained 11,300 Ci ^{137}Cs , 260 Ci ^{144}Ce , 260 Ci $^{95}\text{ZrNb}$, 130 Ci ^{106}Ru , and 100 Ci ^{134}Cs . About 705 cubic feet of soil was contaminated with ^{137}Cs . The ^{144}Ce and $^{95}\text{ZrNb}$ content of the soil is located in about 40 cubic feet of soil surrounding the leak source. The analytical results indicate that ^{106}Ru has a greater radial migration and deeper penetration than ^{137}Cs . Ruthenium-106 appears to have collected in a spheroidal band from 4 to 8 feet beyond the ^{137}Cs boundary.

No heat problems are expected to result from an estimated maximum temperature increase of 30 °F in the soil near the source of the leak. Also, the radioactivity from the leak will not reach the ground water because of the ion exchange properties of the soil, the depth of the water table level and the light regional rainfall.

LEAK DESCRIPTION

The ion exchange feed line, V-122, was buried about 11 feet below grade level. This line was installed in July 1964, and hydrostatic pressure tested to 200 psig for 30 minutes. It was placed into service in December 1967.

The leak was visually detected by Radiation Monitoring personnel who were passing in the vicinity of the 241-C-152 diversion box. The waste stream flowed through a surface area of about one square foot, northeastward, down a slightly declining grade, and pooled along the side of a small dike outside the tank farm fence line. The pool was estimated to be 5 feet square. Pumping from the 105-C tank to B Plant was immediately halted. Two to three feet of gravel and soil were spread over the leak area to absorb, cover, and shield the surface contamination.

The leak surfaced through an area directly above the location of the joint that connects a 3-inch stainless steel pipe to a 3-inch carbon steel pipe⁽¹⁾. Between the flanges of these pipes is a 3/16-inch linear polyethylene gasket which is speculated to have ruptured. No attempt was made to determine the exact cause of the leak, since the high radioactivity in the vicinity of the leak prohibited the excavation and direct examination of the pipeline.

EVALUATION METHOD

Pacific Northwest Laboratory's Earth Sciences Department personnel drilled 10 wells and obtained all soil samples. These samples were analyzed by the Redox Analytical Laboratory. An excavation permit was issued describing the location of the initial wells, precautions to be taken while drilling, instructions for RM coverage, timekeeping, survey of leak vicinity, and staking of the well locations.

The suspected leak source, the flange near a 36° bend in the pipeline, was used as a base point. From this base point, four initial wells were surveyed and staked to surround the area of the leak. Thereafter, wells were drilled at varied radii closer to the source to obtain data for iso-concentration lines at various depths. The location of these subsequent wells was based upon the position of other existing pipelines⁽²⁾, the degree of contamination in preceding wells, and an effort to secure sufficient data to evaluate the leak. The number of wells was kept at a minimum to minimize the radiation exposure to the drillers. Well locations are shown in Figure 1.

The drilling rig used a 350-pound cylindrical hammer to drive the sectioned 2-1/4-inch OD steel pipe into the ground. Attached to the end of the steel pipe was a Shelby^R sampler, a 24-inch long, split-barrel, stainless steel section with a tapered tip. With this sampler, 1-3/4-inch core samples were obtained. During drilling, the split-barrel sampler was withdrawn from the well at two-foot intervals, disassembled, and its contents examined. The exposed soil was then surveyed with a CP. If any contamination was detected, a field reading was recorded and samples were taken. For significantly high levels of radiation, greater than 50 mR/hr, samples were taken at smaller interval depths.

A variety of soil textures was encountered during drilling, as shown in Figures 2 and 3. The soil layers ranged from sandy clay to kaliche, an almost impenetrable rock-like layer. The very non-porous kaliche layer, nearly 6 inches thick, lay at a depth between 13 to 14 feet, sloping slightly eastward. Except for a few isolated areas, the results from the analytical data indicate that this layer had obstructed the movement of ¹³⁷Cs to lower depths. Most of the radioactive material was adsorbed more readily onto the sandy clay type of soil, rather than the coarser soils.

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FIGURE 1 - SKETCH OF WELL LOCATIONS

FIGURE 2
MONITORING AN OPENED, SPLIT-BARREL CORE SAMPLER

FIGURE 3
SAMPLING SOIL FROM THE CORE SAMPLER

Samples were placed in pint-size glass jars. As the drilling operations progressed, aluminum cans were found to be more suitable sample containers to eliminate the breakage hazard of glass jars. Also, the aluminum cans could be accommodated within a 75-pound lead-shielded "pig". Highly radioactive samples, i.e., greater than 5 rad/hr., were handled in a special waste container designed to minimize surface contamination and exposure to the drillers prior to transfer into sample containers.

An attempt was made to obtain uniform sample volumes to aid in the laboratory analyses. The soil samples were analyzed by the quantitative gamma spectrum analyses and the results reported on a weight basis, $\mu\text{Ci/gm}$ of soil. From these results, the vertical depth profiles were plotted. Concentration profiles for Wells 5 and 11 are shown in Figures 4 and 5. From these profiles, horizontal iso-concentration zones were mapped as shown in Figure 6. The slope of the soil layers and the incline of the pipeline places the center of the iso-concentration contours about two feet east of the base point.

The theoretical shape of the leak in the soil is a sphere for low leak rates or 3 to 10 gpm or teardrop-shaped for higher flow rate leaks of 10 to 20 gpm or greater. The actual shape of the contaminated region based upon the drilling data looks somewhat like that depicted in Figure 7. The kaliche layer and a high leak rate probably caused the leak to move laterally and upward, rather than uniformly outward from the leak source. The concentration contours were considered as circular-shaped in the horizontal plane for calculation purposes. The shape of the iso-concentration lines in the vertical plane is elliptical. The volumes in the lateral directions are calculated as the volumes of an oblate spheroid. The volumes in the vertical direction are one-half the volumes of a prolate spheroid. The major axis is along the center line from the base point to the point where the leak surfaced. See Figure 8.

The average ^{137}Cs concentration of the region surrounding the leak source was $550 \mu\text{Ci } ^{137}\text{Cs/gm}$ of soil or $4.0 \text{ Ci } ^{137}\text{Cs/gal}$ of solution, assuming the soil has a 35 percent vol. fraction with a volumetric ^{137}Cs distribution coefficient of 0.6 $(\text{Ci/ft}^3 \text{ soil})/(\text{Ci/ft}^3 \text{ sol'n})(3)$ and an average bulk density of 1.8 gm/cc . This value is within 10 percent of the ion exchange feed concentration of $4.34 \text{ Ci } ^{137}\text{Cs/gal}$ of solution and verifies that this region around the leak source is saturated.

FIGURE 4 - CONCENTRATION PROFILE OF WELL #5

FIGURE 5 - CONCENTRATION PROFILE OF WELL #11

FIGURE 6 - ISO-CONCENTRATION CONTOURS
($\mu\text{Ci }^{137}\text{Cs}/\text{gm soil}$) at a Depth of 11 feet
Relative to Test Wells and Pipe Line

FIGURE 7 - ACTUAL LEAK CONFIGURATION

FIGURE 8 - CALCULATIONAL LEAK CONFIGURATION

The ^{137}Cs curie content of each of the iso-concentration regions was calculated from the product of the volume multiplied by the concentration. The total calculated volume of soil contaminated with ^{137}Cs was 705 cubic feet. The total curies of ^{137}Cs that leaked, the sum of each region and the quantity that surfaced, divided by the ion exchange feed solution concentration equals the number of gallons of feed lost through the leak. A leak loss of 2600 gallons and 11,300 curies of ^{137}Cs was calculated. Other radionuclide losses are listed in Table 1, together with the ion exchange feed composition.

TABLE 1
PSN-IX FEED COMPOSITION AND RADIONUCLIDES
LEAKED TO THE SOIL

<u>Radionuclide</u>	<u>Feed Composition</u> <u>$\mu\text{Ci/gal}$</u>	<u>Activity Leaked</u> <u>to Soil, Ci</u>
^{137}Cs	4.34	11,300
^{144}Ce	0.10	260
$^{106}\text{RuRh}$	0.05	130
$^{95}\text{ZrNb}$	0.10	260
^{134}Cs	0.04	130

Drilling in Well No. 6 was terminated when a sample reading of 110 rad/hr was encountered at a depth of 11 feet. Facilities for handling such a hot sample were not available at that time so the soil was knocked out of the sampler and left in the well. The 110 rad/hr soil undoubtedly contained, in addition to ^{137}Cs , ^{144}Ce and $^{95}\text{ZrNb}$ from the feed, since the radiation reading of 30 rad/hr was measured from a sample saturated with only ^{137}Cs . These radionuclides, whose volumetric distribution coefficient, K_D , is greater than 500, were sorbed or precipitated onto an estimated 40 cubic feet of soil around the leak source.

Analytical results indicate that a broader and deeper migration of ^{106}Ru than ^{137}Cs into a spheroidal band between 4 and 8 feet beyond the ^{137}Cs boundary. The short-lived ^{106}Ru (one year half-life) presents less of a potential hazard than ^{137}Cs (30-year half-life).

A complete thermal analysis of the pipeline leak was not made. Only a maximum temperature increase in the saturated region near the leak source was estimated. From a previous study⁽⁵⁾, a computer program generated data for estimating the temperature increase in the soil of a leak from a waste tank containing the similar type of waste solution that was used for the ion exchange feed. Based on a calculated volumetric heat generation rate of 0.60 Btu/hr/ft³ for the feed solution and the previously mentioned soil characteristics, a 30 °F maximum temperature increase in the soil was estimated.

Due to the ion exchange properties of the soil, the depth of the water table level, and the light regional rainfall, it is concluded that the radioactive contamination from the leak will not reach the ground water. The water table level in the vicinity of the leak is located more than 200 feet below the ground level. The average annual rainfall in this region is less than 6 inches and would require a flooding storm of disastrous proportions to force the migration of radioactivity to such depths through the soil. In addition, the ion exchange properties of the Hanford soil will sorb the radioactive contaminants before they could reach the ground water.

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