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OPERATIONAL PRACTICES IN THE TREATMENT OF LOW
AND INTERMEDIATE LEVEL RADIOACTIVE WASTES--
ARGONNE AND LOS ALAMOS LABORATORIES, U.S.A.

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1. Introduction

1.1 General description

Argonne National Laboratory (ANL), is a research and development laboratory operated by the University of Chicago under a contract for the U. S. AEC. It is located on a 1497 hectare plot 40 kilometers southwest of Chicago, Illinois.

The Los Alamos Scientific Laboratory (LASL), on the other hand, is a weapons and research facility with the research and development phase a constantly increasing percentage of the total effort. It is operated by the University of California under a contract for the U. S. AEC. The county of Los Alamos occupies 286.5 square kilometers in a mountainous region in sparsely populated north-central New Mexico.

1.2 Radioactive waste management philosophies

The philosophy of waste management at both ANL and LASL is essentially the same. It is stated briefly as "concentrate and contain". In fulfillment of the "containment" principle, however, recognition is given to the environmental differences. Operational procedures for final "containment" differ in that no

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wastes are permanently stored at ANL while all wastes generated at LASL are buried on the site.

Both laboratories use the limits for activity in water as set forth in National Bureau of Standards Handbook 69⁽¹⁾ (Recommendations of the National Committee on Radiation Protection) as the maximum concentration of activity in wastes released from control. Both laboratories conform to the statement in Handbook 69, "...thus it is necessary again to urge that all exposures be kept to the minimum practically attainable."

2. Organization for waste management

2.1 Argonne National Laboratory

The Reclamation Group of the Plant Services Division has the ultimate responsibility for the safe handling, collecting, treatment and disposal of radioactive liquid and solid wastes. This group is one of twelve in the Plant Services Division which operates under the Business Manager of Argonne National Laboratory.

2.2 Los Alamos Scientific Laboratory

At Los Alamos, all radioactive wastes are controlled by units of the Health Division, one of eleven technical divisions in the Laboratory. The Health Physics Group, H-1, controls collection, transportation, and burial of all solid radioactive wastes. Vessels for the collection and vehicles for the transportation are the property of the maintenance contractor, Zia Company.

The LASL operation also differs from that of ANL in that collection, transportation, and disposal of non-active solids are the responsibility of the Zia Company and not of the Laboratory.

The Industrial Waste Treatment Group, H-7, is responsible for the collection, treatment and disposal of all liquid radioactive wastes and liquid industrial wastes.

3. Low and intermediate level solids waste control, ANL⁽²⁻³⁾

3.1 General description

As previously stated, no wastes are permanently stored at Argonne. Control consists of collection, storage for decay and shipment.

Solids handled in this program include normal laboratory radioactive wastes; residues from the treatment of liquid active wastes; drums of liquid organic wastes in vermiculite; sludge and sand from the sanitary sewage treatment plant sludge drying beds; and non-recoverable air filters.

3.2 Method of collection

In the individual laboratory, a stainless steel can with 0.03 cubic metre fibre drum insert is provided for the collection of solid contaminated waste materials. Where a larger container is required, 0.13 cubic metre cardboard boxes or 0.09 cubic metre fibre drums are supplied. As the container approaches the radioactive limit or becomes full, it is surveyed by radiation safety personnel of the Industrial Hygiene and Safety Division and tagged with pertinent data. If the collected wastes exceed a 50 milliroentgen per hour limit, shielding vessels with accompanying dolly and jack are provided.

Two personnel of the Reclamation Group perform regular collection of containers from all laboratory facilities, gathering those < 50 mr in a large, truck-mounted receptacle for transportation to the waste storage area.

3.3 Waste storage area operations

This restricted area of 3.72 hectares includes above-ground storage, shielded underground storage and a baling capability. Waste which does not exceed 200 mr/hr nor contain alpha active material other than uranium and/or biological waste is set aside for concentration by baling. The remainder of the wastes, excluding large, bulky items, are placed in storage-shipping-burial containers or bins 1.2 metres wide x 1.5 metres long x 1.8 metres deep constructed of 2.7 mm steel. Shippable waste is stored in the above-ground bins while the more active waste is placed in bins in one of the three concrete-lined underground storage trenches. A fourth vault consists of six larger pits which are used for temporary storage of bulky items. For high level wastes in cylindrical containers, a fifth vault provides a number of vertical pipe casings cast into a concrete slab. The casings extend 5.8 metres below grade and are furnished with lead plugs at the top. A 4.54 metric ton gantry crane which can be remotely operated is used to service the various vaults.

Balable waste is stored until a volume has accumulated sufficient to require the services of two men for a day. The baler is a stainless steel lined commercial unit which utilizes hydraulic pressure up to 147.6 kg/cm^2 to produce a 0.11 m^3 bale from approximately 0.45 m^3 of waste. The system is equipped with a filtered exhaust which prevents the spread of contamination.

The capital investment in solids waste handling and storage amounted to \$294,400 as of June 30, 1964. Operating costs for fiscal year 1965 including collection of 1147 m^3 of waste, concentration of 42.5 m^3 and shipment off-site of 1132.8 m^3 averaged $\$165.98/\text{m}^3$.

4. Low and intermediate level liquid wastes control, ANL (2-3)

4.1 General description

Three basic systems are used in controlling radioactive liquid wastes at ANL. One system requires the scientist to put all active waste liquids into vessels provided by the Reclamation Group. Filled containers are monitored, picked up on call and taken to the Waste Processing Building for disposal. The second system provides pairs of glass-lined 5700 litre to 11,400 litre retention tanks at the ends of drain lines in buildings in which radioactive materials are used. While one tank fills, the other full tank is sampled and the waste monitored. If activity exceeds the MPL as established at Argonne for these tanks, (gross count ≥ 1000 d/m/ml, $^{90}\text{Sr} \geq 10$ d/m/l, $\alpha \geq 5$ d/m/ml), the wastes are transferred to portable 3785 litre tanks and hauled to the Waste Processing Building for treatment. If activity is less than the MPL, the tank contents are drained to a separate sewer which empties at the Laboratory Waste Treatment Plant. 1% - 2% of the retention tanks examined are over tolerance in activity and require processing.

The third system provides separate collection and processing for industrial metallurgical liquid wastes which might be contaminated with uranium.

A schematic diagram of the system is provided in Figure 1.

The special drainage system, the Laboratory Site Sewer, carries the retention tanks discharges which are below MPL and waste cooling waters which may contain activity above the MPL to the Laboratory Waste Treatment Plant.

4.2 Waste Processing Building operation

4.2.1 General. Facilities for treatment of active wastes by evaporation, filtration, ion exchange, flocculation and absorption are provided within this site. All wastes to be processed are delivered to the building in containers varying from two-litre bottles to the 3785 litre portable tanks by personnel of the Reclamation Group. Approximately 80% of the total waste treated arrives at the plant in this manner or is produced within the building during decontamination operations. The wastes and rinses flow to either of two glass-lined 15,000 litre waste storage tanks. A sample is collected from a filled tank and on the basis of the analysis, a decision is made regarding the treatment method to be used. The filled tank is then transferred to one of six steel mixer-equipped 6000 litre "feed" tanks which have interiors coated with acid-resistant enamel. The "feed" tanks supply waste to the process selected.

Table I lists the volumes of wastes processed by the various methods.

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TABLE I

LIQUID WASTE PROCESSING OPERATIONS

ARGONNE NATIONAL LABORATORY

FISCAL YEARS 1961-1965

WASTE PROCESSING PLANT OPERATIONS					
	1961	1962	1963	1964	1965
Evaporation and Concentration - 10 ³ Litres	313.8	354.7	888.4	781.7	603.8
Filtration and Ion Exchange - 10 ³ Litres	15.9	92.0	78.4	0	0
Filtration only - 10 ³ Litres	29.5	53.8	0	2.6	1.5
Flocculation - 10 ³ Litres	0	16.3	11.4	70.8	7.2
Absorption - 10 ³ Litres	6.8	7.9	3.0	3.8	3.0
Other	17.0	2.3	1.1	0.4	0
Total Processed - 10 ³ Litres	383.0	527.0	982.3	859.3	615.5
Average Cost per Litre - \$0.105 to \$0.343 per Litre					
LABORATORY WASTE TREATMENT PLANT					
Volume to Outfall - 10 ⁸ Litres	7.68	8.97	7.95	8.71	10.11
Volume Over Tolerance - 10 ³ Litres	0	223.3	0	261.2	0
Alpha Activity Discharged - mCi	13.0	10.8	11.9	13.2	13.0
Beta Activity Discharged - mCi	127	145	197	146	179
⁹⁰ Sr Activity Discharged - mCi	1.89	1.59	3.93	1.18	7.18
Average Operating Cost per 1000 Litres - \$0.28					

4.2.2 Processing by evaporation. As noted in Table I, the bulk of the low and intermediate level liquid wastes are treated in the evaporation process. Waste containing an average of 0.2% solids is pumped to one of two stainless steel, natural circulation, vertical tube evaporators. These units consist of steam chest, centrifugal separator and overhead condenser and are rated at 568 litres per hour. Run length is predetermined by a solids analysis of the waste to be processed based on achieving a 20% solids content in the residue. Steam for the operation is taken from the building heating supply and reduced to approximately 2.1 kg/cm^2 . The de-entrained vapor from the waste is condensed in a water-cooled triple-pass unit and drained to one of the 15,000 litre storage tanks for monitoring. This liquid is normally below the MPL and in such case is pumped to the Laboratory Site Sewer. When the solids concentration has reached 20%, the unit is shut down and the waste is pumped to either a 760 litre or a 190 litre stainless steel "bottoms" tank, both of which are equipped with mixers.

In the second phase of the operation, the "bottoms" are drained by gravity to either a 380 litre or a 1140 litre capacity steam-jacketed concentrator. Both units include kettle, demister, condenser and receiver, all of stainless steel. The units are operated under 71 cm of vacuum and achieve a final solids concentration varying between 60 and 90%. The large concentrator has a rated evaporation rate of 94.6 l/h while the small unit is rated at approximately 18.9 l/h . While still hot, the solids are discharged by gravity to a 200 litre steel drum containing 12.7 kg vermiculite. Concentrator rinse water is added to the same drum. The condensate or "overhead" from this phase is normally radioactive above the MPL and is returned to waste storage tanks for retreatment by evaporation.

When evaporator capacity decreases to a given level, the unit is cleaned with boiling nitric acid. This occurs at intervals varying from weekly to bimonthly. The concentrators are cleaned annually with a chemical scale remover.

Decontamination factors average 10^3 but are often as high as 10^5 . Volume reduction ranges in the order of 100 to 1.

4.2.3 Processing by flocculation. When it is determined that the contents of a 3785 litre portable tank will, upon neutralization, deposit most of its activity with the precipitate, the waste is pumped to a 7500 litre stainless steel flocculator tank which is hopper-bottomed and equipped with a mixer. A predetermined amount of sodium hydroxide is added, the waste is vigorously agitated and permitted to settle. Sludge is drawn off to an evaporator feed

tank or acid waste storage tank and the supernate is discharged to the Laboratory Site Sewer.

The decontamination factor achieved by this process ranges between 2 and 10.

4.2.4 Processing by filtration. Filtration is one of the least used of the processes available since activity removal is poor except when present in relatively large particulate matter. The filters are used, however, to pre-treat waste which will later be passed through ion exchange columns.

The three filters, total capacity 757 l/h, are of the porous stone element type which require precoating with diatomaceous earth to remove solids which are 12 microns or larger. The filter housing is carbon steel with rubber-coated interior surfaces.

When the filters are backwashed, cake, collected residue and backwash water are drained to storage for later treatment by evaporation.

4.2.5 Processing by ion exchange. The present Waste Processing Building, placed in operation in late 1962, is equipped with a cation exchange column containing 0.10 m^3 of 68.6 kg/m^3 capacity (as CaCO_3) Nalcite HCR- H^+ resin. Wastes are either prefiltered through the pressure units or pumped directly to the column at a feed rate of 1500 litres/hr. The column feed is adjusted to pH 2.5 with nitric acid and a run is continued until calcium or magnesium ion appears in the effluent. The decontamination factor is in the range of 30 to 10. Exhausted resin is regenerated with 6N nitric acid and the spent regenerant is later treated by evaporation.

4.2.6 Processing by absorption. Relatively small quantities of non-inflammable synthetic oils which have become contaminated require processing before disposal as solid waste. It has been the practice at ANL to add this type of waste to vermiculite in 200 litre drums and treat the whole as a solid.

4.3 Laboratory waste treatment plant operation

4.3.1 General. Influent flow to the Laboratory Waste Treatment Plant consists of the discharge of the Laboratory Site Sewer. Facilities at this location include:

- (a) Manually-raked bar screen.
- (b) pH recording and control equipment.
- (c) Four 265,000 litre mechanically cleaned settling tanks.
- (d) A 1,500,000 litre capacity lagoon for emergencies.
- (e) An ion exchange facility to process wastes above the MPL.

4.3.2 Settling tank processing. All wastes received pass through the bar screen and automatic neutralization system before entering one of the settling tanks. Filled tanks are monitored and disposal is in accordance with activity levels established at ANL (gross count < 5 d/m/ml, $\alpha < 1$ d/m/ml, $^{90}\text{Sr} < 2$ d/m/ml). Wastes below MPL are discharged in a line which connects with the effluent line of the sanitary sewage treatment plant prior to final sampling and chlorination. The combined wastes are pumped to the Des Plaines river. Wastes above the MPL are returned to the ion exchange facility for further processing.

The 1,500,000 litre earth lagoon was constructed to provide emergency capacity.

4.3.3 Ion exchange processing. Housed in a separate building near the retention tanks are two - 0.57 m^3 ion exchange columns with associated operating and regeneration equipment. The units, rated at 151.4 l/min each, were designed to permit treatment of the entire contents of one holding tank before requiring regeneration. One of the units contains a cation exchange resin while the other is a mixed bed unit.

6N nitric acid is used for regeneration of the cation resin and 4% sodium hydroxide is used for regeneration of the strong base anion resin. Spent regenerant is transferred to a 3785 litre portable tank for treatment by evaporation at the Waste Processing Building.

Table I provides information on quantity and radioactivity handled for the years 1961 through 1965.

4.4 Industrial waste treatment plant operations

A small waste treatment plant is provided in the vicinity of the waste source for processing special metallurgical wastes which may be contaminated. Three retention tanks, a 30,300 litre unit for plating wastes, a 22,700 litre unit for pickle wastes and a 11,350 litre unit for cyanide waste, permit intermittent plant operation. At present the services of one person for approximately 30% of his time are required to process an average of 26,500 litres per week.

The supernatant of the treated waste is pumped to the sanitary sewer system after filtration through pressure filters, and the settled sludge is pumped to a 3785 litre portable tank for transfer to either the Waste Processing Plant or to the sanitary sewage treatment plant sludge drying beds.

5. Low and intermediate level solids waste control, LASL⁽⁴⁾

5.1 General description

Solids waste disposal at Los Alamos differs from the ANL operation in two important aspects. These are:

- (a) All solids are packaged for burial in pits at Los Alamos.
- (b) The principal contaminant is the alpha emitter ^{239}Pu .

5.2 Method of collection

The individual laboratory is provided with a number of 0.03 cubic metre steel foot-operated trash cans with polyethylene bag liners for the receipt of active waste. If additional space is needed, 33 cm x 33 cm x 61 cm corrugated cardboard boxes with polyethylene bag liners are furnished. Though the Health Physics Monitors of Group H-1 survey waste containers to control activity accumulation, janitors employed by Zia Company are responsible for removal of the trash. All filled plastic bag liners are sealed and collected either in larger plastic bags or in the cardboard boxes which are also sealed. The larger containers are placed in steel transportable waste bins or dumpsters. The bins are picked up on a regular schedule by special trucks controlled and operated by Zia Company and taken to the disposal area for discharge.

A large number of steel 200 litre drums containing radioactive sludges and mortars from waste treatment plants are loaded into open skips for hauling to the disposal area. This service is on a "call" basis when the skips reach a capacity load of nine drums.

5.3 Burial pit operation

The disposal pits are completely fenced and controlled by Group H-1. A particular fenced area may have any number of pits within the enclosure as determined by the geology, proximity to other restricted areas and long range development plans. The physical dimensions of a pit are approximately 9.14 m deep x 30.5 m wide x 152.4 m long with an excavated volume of about 33,640 m³.

All wastes are carried by truck into the pit where they are dumped or set into place. When a 0.9 m layer of trash has been deposited, earth moving equipment covers the layer with about 15 cm of the previously excavated tuff. This operation occurs on an average of every two to three months. The heavy equipment used in the covering operation serves to compact the trash for a net volume reduction of about 30%. New layers are started as covering operations are completed and for the top or final layer of a pit, a minimum of 0.9 m of tuff covering is provided.

For disposal of small items of greater activity, particularly with beta-gamma radiation, vertical concrete lined holes about 6.1 m deep are provided. Waste canisters or small items can be dropped into the holes from a specially designed truck. At a number of levels, concrete plugs are poured for purposes of shielding and leach resistance.

The cost data following include all materials, services, and supervision necessary. For 1964, totals can be grouped as follows:

Packaging	-	\$ 66,801
Transportation	-	20,520
Disposal Pit Operations	-	23,605
Total Cost		\$ 110,926

The total volume of material handled was 7746 m³ for a unit cost of \$14.10/m³.

6. Low and intermediate level liquid waste control, IASL

6.1 General description of the facilities

The Industrial Waste Group of the Health Division operates two waste processing facilities. The larger facility at Area 50 has been in operation since July, 1963 treating radioactive wastes from the research laboratories which utilize radionuclides in chemistry, metallurgy, physics, fabrication, testing, etc. The radioactivity is low (normally $< \text{MPC} \times 10$) and the volume is of the order of 15.1×10^4 litres per day. This plant also receives wastes from the reactor research Area 35, replacing the chemical coagulation-ion exchange treatment plant described in a previous paper⁽⁵⁾. The various laboratories are connected to the Area 50 plant by the so-called "acid" sewer system which is generally of mild steel, stainless steel, or vitrified clay pipe. In most instances the pH of the waste is automatically adjusted at the source to about pH 7 by the addition of 2 - 10% caustic solution. Eight of these neutralization stations are serviced by tank truck deliveries of 50% NaOH solution which is received in 12,900 litre lots at the Area 50 headquarters.

The Area 21 facility treats wastes from plutonium (Area 21 West) and uranium (Area 21 East) processing facilities. A capability for fixing neutralized ²⁴¹Am - ²⁴⁹Pu solutions in cement was added in 1960. Concentration by incineration is used for low level radioactive oils and organic solutions.

A schematic diagram of the system for control of active liquid wastes in Los Alamos is shown in Figure 2.

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6.2 Waste processing, Area 21

6.2.1 Low level liquid waste solutions. These wastes arrive at the plant on a continuous basis through five sewer lines. Three stainless steel lines, for special wastes, are connected to both the plant influent line and to two 3800 litre stainless steel tanks. The waste is directed to the stainless steel tanks when it contains relatively large amounts of salts and/or radioactivity which would interfere with the routine treatment. These wastes are then processed by batch methods.

Wastes from the Area 21 (East) force main, containing uranium isotopes, are received in two 7600 litre retention tanks. The liquids are monitored and directed, on the basis of radioactivity, either to the treatment plant or to a waste disposal pit which was constructed in 1945 for the "temporary" Area 21 plant. The pit consists of four 6.1 m x 30.5 m absorption beds, each filled with 61 cm of stone, 15 cm of gravel and 15 cm of sand.

As the waste enters the plant influent channel, it is sampled proportional to flow and adjusted automatically to $\text{pH} \geq 7.0$. A 90° V-notch weir measures and accessory equipment records the volume. A manually-cleaned grit chamber removes sand and other heavy solids. All wastes are treated by the process of chemical coagulation at a maximum rate of 189 l/min.

Ferric chloride, lime and a non-ionic polyacrylamide-type coagulant aid are added to the flocculator influent line. (Sodium hydroxide can also be added for pH adjustment.) The 1.5 metre diameter flocculator provides a retention time of approximately 15 minutes at maximum flow. The next unit in the series, a circular sedimentation tank 3.6 m in diameter with 45° conical bottom, provides 2 1/4 hours detention and a surface settling rate of 25,660 l/m²/day before overflowing to filtration units. The filters are constructed with 46 cm of graded gravel covered by 61 cm of anthracite coal media with an effective size of 0.55 to 0.65 mm. The two beds are 0.93 m² each in area permitting a feed rate of 102 l/m²/min at maximum flow.

The filter effluent flows to either of two 59,400 litre retention tanks where it is monitored to determine whether it should be discharged to the canyon, discharged to the tile field or recirculated for retreatment. Table II lists volumes, activities, and costs for the years 1961-1964.

The filters are backwashed with treated wastes after having processed an average of 293,400 litres. The washwater, amounting to 3.2% of the total volume treated, is discharged to the raw waste retention tanks.

Sludge from the sedimentation basin is drawn off on an average of twice per week to a sludge storage tank where it is further concentrated by decanting.

TABLE II
LIQUID WASTE PROCESSING OPERATIONS
LOS ALAMOS SCIENTIFIC LABORATORIES

FISCAL YEARS 1961-1964

AREA 21 WEST PROCESSING PLANT				
	1961	1962	1963	1964
Influent Waste (Sewers) - 10 ⁶ Litres	9.42	11.13	12.15	5.75
Influent Alpha Activity - mCi	5607	5166	2508	1924
Effluent Alpha Activity - mCi	6.1	3.8	3.5	1.8
Decontamination Factor	919	1359	717	1069
Dewatered Sludge - m ³	21.0	27.0	20.8	18.2
Volume Reduction Factor	448	412	584	316
Processing Cost per 10 ³ Litres - \$2.60 to \$5.20				
AREA 21 WEST AMERICIUM WASTE PROCESSING				
Waste Treated - 10 ³ Litres	59.53	84.14	95.64	64.15
Total ²³⁹ Pu - Ci	3.62	5.73	6.14	4.38
Total ²⁴¹ Am - Ci	282.0	176.3	135.4	137.8
Total Volume of Mortar - m ³	115.1	163.2	190.7	127.8
Total Material Cost per Litre - \$0.26				
AREA 50 WASTE PROCESSING PLANT				
Influent Waste - 10 ⁶ Litres	52.85	56.64	58.18	51.53
Influent Alpha Activity - mCi	465	375	433	359
Effluent Alpha Activity - mCi	9.5	6.9	8.6	3.6
Decontamination Factor	49	54	50	100
Dewatered Sludge - m ³	65.0	71.0	86.2	64.4
Volume Reduction Factor	813	798	675	800
Volume Treated Through Both Chem. Coag. and Ion Exchange - 10 ⁶ Litres ¹	1.54	1.58	5.44	10.16
Processing Cost per 10 ³ Litres - \$5.20 to \$10.40				

- 1 Area 50 ion exchange columns were placed in service Nov. 1963.
A small plant at Area 35 was used prior to this.

The sludge is transferred at a concentration of 6 - 12% solids to a pre-coat type vacuum filter where it is dewatered to 35 - 40% solids.

The dewatered sludge is collected in 200 litre steel drums which are sealed when full and loaded into trucks for transfer to the solids waste burial ground.

6.2.2 Intermediate level liquid waste solutions⁽⁶⁾. Wastes containing americium and plutonium in 4N - 8N nitric acid solutions are delivered in 1000 litre tank trailers to the Area 21 treatment plant. This material is treated on a batch basis by neutralization with sodium hydroxide and ultimate fixation in cement and vermiculite. Plant equipment includes a 3785 litre stainless steel waste storage tank, 1300 litre and 850 litre stainless steel neutralization tanks, a double drum tumbler, a 1900 litre heated steel storage tank for 50% caustic solution and an 8 m³ cement silo.

380 to 570 litres of the waste are transferred to either of the neutralization tanks and a predetermined amount of 50% NaOH solution is added by vacuum transfer while the solution is mixed. Circulating cooling water keeps the mixture cool. 200 litre steel drums are prepared by placing 128 kg of cement, 4.1 kg of exfoliated vermiculite and two half-bricks in each and fastening the gasketed steel covers. Two drums are loaded in the tumbler, and 76 litres of the cooled, neutralized waste is transferred by vacuum into each drum. The drums are tumbled for 15 minutes, then removed and loaded into a truck for transfer to the solids waste disposal pit.

For process control, static leach tests of samples of the mix are conducted. The radioactivity leached from samples which have soaked for periods of up to two years has ranged from 0.001% to 0.2%.

6.2.3 Spent KOH scrubbing solution. About 1100 to 1700 litres of KOH solution containing large quantities of KF and relatively large amounts of ²³⁹Pu are received monthly. This waste is treated with lime in 850 litre mixer-equipped tanks. The resulting sludge (about 50% by volume) is pumped to the vacuum filter for dewatering and the dewatered sludge is packaged in 200 litre drums for burial. The supernatant is directed to the main treatment plant. A volume reduction factor of ~5 and a decontamination factor of 10³ to 10⁴ are obtained.

6.2.4 Incineration of low level wastes. Inexpensive (\$25.00) 2 to 4 litre per hour "salamander" gravity heaters are used for incineration of low level organic wastes after dilution with kerosene to a mix containing 67% (by volume) waste. Two to four units are operated at one time under controlled

conditions on berms in the tile field. The units have been used for incineration of low level tributyl phosphate wastes, tricresyl phosphate wastes and minor amounts of other organics.

6.2.5 Miscellaneous processing methods. Intermediate level organics are mixed with a gelling agent and lime to form a semi-solid and are sent to the solids burial pit in 11 to 19 litre containers placed in sludge-filled 200 litre drums.

Small batch quantities of intermediate level acid solutions are added to the americium waste for incorporation in cement mortar.

6.3 Waste processing, Area 50

6.3.1 Low level alpha waste solutions. The low level alpha waste enters the plant continuously, is adjusted to $\text{pH} > 7.0$ by automatic addition of NaOH, is sampled proportionately and passed through a mechanically-cleaned grit chamber before flowing to either a 95,000 litre or a 284,000 litre retention tank. The raw waste retention tanks are equipped with mixers and lined with acid-resistant paint.

The chemical coagulation facility is designed for a maximum treatment rate of 950 l/min. Pumps deliver the waste from the retention tanks to either or both of two flash mixers, depending upon whether the plant will be operated with mixers, flocculators and sedimentation tanks in series or whether it will be operated with these units in parallel. Chemical solutions or slurries of lime, ferric sulfate, sodium carbonate and a non-ionic polyacrylamide coagulant aid are added to the flash mixer and vigorously agitated for about two minutes. The mixture flows to the flocculator portion of the circular combination flocculator-clarifier units where it is retained for about 40 minutes. It then passes through a bottom port into the clarifier. The clarifier surface area provides an overflow rate of $31,100 \text{ l/m}^2/\text{day}$ at design flow. Settleable solids are scraped by a mechanical device to a central hopper for periodic withdrawal to a sludge retention basin. The overflow liquor is collected in a peripheral channel and directed to the filter beds, where, with a surface area of 8.4 m^2 , a filtration rate of $114 \text{ l/m}^2/\text{min}$ is maintained at design flow. As the waste flows to the filters, a small amount of sodium hexametaphosphate is added to prevent after-precipitation of calcium carbonate.

The two filter beds are constructed of five 10 cm to 15 cm layers of anthracite coal and one 61 cm layer of anthracite 0.55 to 0.65 mm effective size.

Filter effluent drains to either of two concrete 95,000 litre retention tanks. The contents of a filled tank are monitored and pumped to an adjoining canyon if below the limit of 5 d/m/ml. Wastes containing more than this level are returned to the raw waste retention tanks.

Table II provides volume, activity and cost data for the years 1961-1964.

The filters are backwashed when head loss becomes excessive. This has been necessary in 1965 after treatment of approximately 3.4×10^6 litres. Backwash water has amounted to 3% of the waste treated.

The stored sludge is decanted to achieve a 5 - 10% solids concentration. Approximately twice per week, the solids are pumped to a precoat-type vacuum filter, 0.91 metres in diameter x 1.22 metres long, for further dewatering to about 40% solids.

6.3.2 Low level beta-gamma solutions. When dilution and treatment through the chemical coagulation plant cannot successfully reduce ^{90}Sr to less than 2 d/m/ml, facilities for treatment by ion exchange are available. The facilities are designed to permit pumping chemically treated effluent or raw waste to the columns.

Two 1.98 m diameter units, each containing 4.15 m^3 of cation exchange resin of 68.6 kg/m^3 capacity, are available. Influent flow at 950 l/min is adjusted to a pH of 2.5 to 3.0 with HNO_3 for operation in the hydrogen cycle. The columns are normally operated beyond the hardness breakthrough point to a strontium breakthrough before regeneration.

Regeneration is accomplished with 6N HNO_3 and spent regenerant is collected in a stainless steel tank for chemical treatment. Strontium nitrate is added to act as a carrier; the solution is neutralized with caustic; and soda ash, ferric sulfate and lime are added. The resulting sludge, containing over 99.9% of the activity removed from the columns, is drained to separate storage tanks for eventual mixing with cement and ultimate burial. The supernatant is drained to the raw waste retention tanks.

Concentrated nitric acid for the system is purchased in tank truck lots and stored in a 15,000 litre tank on the site.

7. Summary

Several fundamental differences exist between waste disposal practices at Argonne and Los Alamos, but the basic "concentrate and contain" philosophy is identical. There is also complete agreement between the laboratories as to the primary responsibility for protection of operating personnel and the public in pursuing the established practices. Environmental surveys provide witness to the fact that precautionary attitudes are successful.

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FIGURE 1
LIQUID DISPOSAL SYSTEM-ANL
FLOW DIAGRAM

FIGURE 2
DISPOSAL SYSTEM FOR LIQUID RADIOACTIVE
WASTES - LASL