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MASTER

AQUEOUS RADIOACTIVE WASTE TREATMENT
PLANT AT ROCKY FLATS

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1. Abstract

The operation of an aqueous radioactive waste treatment plant at Rocky Flats will be described, including details of construction, flow charts, operating data, and problems encountered. Plans for additional processing of the effluent will also be discussed.

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2. Introduction

At the Rocky Flats plant all aqueous radioactive wastes which are above one-tenth the drinking water concentration guide for plutonium, as stated in the United States Department of Commerce, National Bureau of Standards Handbook 69, are treated prior to release. Wastes which are below this recommended level (11,000 d/m/liter), and meet the requirements of the United States Public Health Service Drinking Water Standards of 1962, are released off site. Treated wastes failing to meet these guides are impounded in lined evaporation ponds.

The aqueous waste treatment facility consists of a one-story building, approximately 60 ft. by 60 ft., with a basement 60 by 30 ft. Adjacent to the building is a drum storage dock. Reinforced concrete tanks are located outside the building. The facility is divided physically into two sections. Each section contains equipment to accomplish one stage of decontamination. The two sections are called simply the first stage and the second stage.

The bulk of the radioactive material in aqueous waste entering the facility is removed in the first-stage operation by means of a continuous carrier precipitation process. A final cleanup is attained in the second stage which is a batch flocculation process.

The aqueous wastes treated in the facility are generated in chemical processing areas. These plutonium-contaminated wastes can be classified into four categories: high salt basic wastes, low salt basic wastes, high salt acidic wastes, and low salt acidic wastes. Typical alpha activity of the waste is 1.8×10^{-1} $\mu\text{c/ml}$.

3. First Stage (Figure 1)

The wastes are transferred to the treatment facility under vacuum and are received in appropriate receiving tanks, based upon the category of the waste.

Low salt acidic wastes are received in one of two 1400-gallon stainless steel tanks. Ferric sulfate, calcium chloride, and 50 percent liquid caustic are added to the waste to neutralize, adjust pH, and to supply iron for a ferric hydroxide floc. After the liquid is recirculated for 1 hour, the sludge is allowed to settle. The sludge is then transferred to a 200-gallon sludge-holding basin after the supernate has been removed by decantation to one of two 2000-gallon stainless steel tanks. This type of waste produces little sludge. This tank also receives the basic wastes, both low and high salt.

The high salt acidic waste is received in a 100-gallon stainless steel tank, then transferred to a 1000-gallon stainless steel tank for neutralization and pH adjustment with lime and 50 percent liquid caustic. The heat of reaction is removed by means of a heat exchanger. This type of waste produces a large volume of sludge. In order to effectively handle this sludge, the entire volume of neutralized waste is then filtered through a vacuum drum filter. The filtrate is pumped to the second of two 2000-gallon stainless steel tanks. The wastes from the two 2000-gallon tanks are then fed to a stainless steel chemical premix tank of 200-gallon capacity. Ferric sulfate is added to provide 100-125 ppm of iron, along with 400 ppm of calcium chloride and mixed rapidly with a high-speed mixer. The waste and the chemicals are fed to the mixing tank at a slow rate in

order to achieve a 20-minute holdup in the tank for complete mixing. The slurry then passes by overflow discharge to a 1500-gallon flocculator. Coagulation and sedimentation, aided by the addition of Purifloc⁽¹⁾ 501 flocculant takes place in the flocculator. The flocculator supernate is pumped to sand filters for removal of traces of unsettled floc. From the sand filters the once-treated waste is pumped to a 3400-gallon concrete holding tank for the second stage, or to an evaporator feed tank when the facility is placed in use.

Periodically, sludge is withdrawn from the flocculator, pumped to the sludge basin, dewatered through the first-stage vacuum drum filter, and drummed for disposal. The filtrate is pumped to the 2000-gallon stainless steel tank for low salt wastes and recycled. This comprises the first stage of the two-stage treatment process. A decontamination factor of 200 is obtained by this stage of treatment. The processing rate is 250 gallons per hour.

4. Second Stage (Figure 2)

The once-treated waste from the first stage is received and stored in a 3400-gallon concrete tank. Second-stage wastes consisting of the filtrate from the second-stage vacuum drum filter, floor washings, and contaminated laundry water are received in a 6800-gallon concrete tank and stored. Another 6800-gallon concrete tank is then used for batch treatment of 6600 gallons

(1) Trademark of The Dow Chemical Company; Midland, Michigan

of combined wastes. This volume is made up of 2200 gallons of first-stage effluent and 4400 gallons of second-stage wastes.

Ferrous sulfate is added to provide 145 ppm of iron, along with 2000 ppm of calcium chloride, and 22 ppm of Purifloc 501 to the waste. Mixing is accomplished by recirculation of the waste within the tank for at least 1 hour. After approximately 30 minutes of mixing, a sample is withdrawn for visual inspection of the floc and supernate. If the floc is bluish-green, calcium hypochlorite is added to oxidize the iron to the ferric state. If the floc is reddish, the iron has been oxidized. If the supernate is cloudy or reddish, indicating the presence of colloidal iron, magnesium sulfate is added for removal of the suspended iron.

The floc is then allowed to settle for 16 hours, at which time the supernate is decanted, passed through sand filters, and into a 14,000-gallon concrete holding tank. The sludge is pumped to the second-stage sludge basin, dewatered by the second-stage vacuum drum filter, and drummed for disposal.

The treated aqueous waste is then sampled for radioactivity and noxious chemicals. If the waste has been decontaminated to the release level for plutonium and above the release level for nitrate and fluoride, it is pumped to lined evaporation ponds. Treated wastes below the release level for activity and noxious chemicals are released off site. If the treated waste is above the radioactivity level, the waste is retreated in the second stage. When the proposed evaporator, which is discussed next, is in operation, the treated waste will be blended with aqueous waste from the lined ponds, or will be the feed itself for the

evaporator. A decontamination factor of 200 is obtained in the second stage. The processing rate is 17,000 gallons per day.

Mildly contaminated wastes, such as analytical, laboratory, and laundry wastes, receive a one-step decontamination treatment by utilizing the equipment in the second stage.

5. Evaporator (Figure 3)

Under our present operations, highly salted aqueous wastes containing toxic chemicals, but low-level radioactivity, are released to lined evaporation ponds. However, in order to eliminate the pollution of nearby water courses with these chemicals, an evaporator is to be installed in an adjacent building. The following process is planned for the evaporator facility. The pond water, which is acidic, will be pumped to a 150-gallon stainless steel tank at a controlled rate for neutralization with 50 percent liquid caustic. The liquid caustic is to be fed by a proportional feeder with violent agitation with a mixer to provide complete mixing. The feed will leave the neutralizing tank by overflow discharge to the second-stage sludge basin. The solids are to be removed by vacuum drum filtration, using the second-stage drum filter. The filtrate is to be pumped to the evaporator feed tanks. These tanks will be mild steel, with a capacity of 10,000 gallons each.

Depending upon the decontamination achieved in the first stage, treated waste from the first stage will be blended with second-stage treated waste, with neutralized pond water, or used by itself to provide the feed for the evaporator.

The evaporator is designed to concentrate the incoming feed of approximately 20 percent solids to 70 percent solids in the bottoms liquor. The overhead vapors will be discharged to the atmosphere through a stack. The 70 percent solids liquor will be fed to a double-drum dryer for dewatering. The resultant dry salts will be satisfactory for drumming and disposal. Water vapors coming from the dryer are to be mixed with diluting air and channeled through an off-gas cleanup system for decontamination prior to discharge to the atmosphere through the stack. The evaporator is designed for a decontamination factor of 10^4 and a processing rate of 250 gallons per hour.

6. Organic Liquid (Figure 4)

A quantity of radioactively contaminated organic liquid waste is generated in various production areas. This waste, composed of carbon tetrachloride and oil, cannot be shipped for off site disposal. Packaging costs to assure no leakage during transportation makes disposal by this means prohibitive. Also, the burial ground will not accept this liquid waste for fear of leakage and sealing of the burial ground.

In order to produce a solid suitable for shipment, the following method of treatment is employed: The liquid waste is filtered through cartridge filters and into mild steel feed tanks. From the feed tanks the liquid is fed to a distillation column for separation of the oil and carbon tetrachloride. Open steam distillation at 25 psi is used. Contacting is attained by means of a packed section of berl saddles. By using open steam the boiling point is reduced and high recoveries are attained at a temperature where tarring will not occur. In addition, the water in the

condensed overhead will take up any volatile water-soluble impurities. Should an acidic condition develop in the distillation column, as indicated by a monitor, 50 percent liquid caustic is added to the column for neutralization.

The overhead vapors are totally condensed in a water-cooled surface condenser with the condensate passing into a neutralizing tank. Here again, any acid which may have been carried over is neutralized with liquid caustic. The carbon tetrachloride then passes into a 100-gallon separator tank for gravity separation of the water and carbon tetrachloride. The carbon tetrachloride is then pumped to two storage tanks, each of 400-gallon capacity. After analytical analysis the carbon tetrachloride is returned for reuse. The still bottoms are cycled to a bottoms reheater to remove residual water from the oil.

The still bottoms are then pumped to two 300-gallon mild steel holding tanks. These tanks also serve as the oil feed tanks for a mixer-extruder. In the mixer-extruder, Micro-Cel⁽²⁾ absorbent is blended with the oil bottoms to produce a gel or grease. The product from the mixer-extruder is drummed for disposal. This system is designed for a processing rate of 40 gallons of carbon tetrachloride and oil per hour with a decontamination factor of 10^5 . This equipment is in a separate one-story building approximately 40 by 30 ft., with a drum storage dock and a materials storage shed on the dock.

(2) Trademark of Johns-Manville Corporation;
Celite Division; Lompoc, California

7. Equipment and Materials of Construction

7.1 First Stage

- (a) Receiver Tank -- 100-gallon, stainless steel.
- (b) Neutralizer Tank -- 1000-gallon, stainless steel.
- (c) Liquid Caustic Tank -- 6000-gallon, mild steel; temperature within tank maintained by a hot water coil.
- (d) Receiver-Neutralizer Tanks -- Two 1400-gallon, stainless steel, with decantation tubes, pH sensing units, and sight glasses.
- (e) Feed Tanks -- Two 2000-gallon, stainless steel.
- (f) Mixing Tank -- 150-gallon, stainless steel.
- (g) Chemical Feed Tanks -- Two 50-gallon, one of mild steel and rubber-lined for ferric sulfate, and one of stainless steel for calcium chloride.
- (h) Flocculator -- 1500-gallon, stainless steel; top of tank is enclosed and fitted with vent exhausted to the building ventilation system.
- (i) Sludge Basin -- 200-gallon, stainless steel.
- (j) Sand Filters -- Two 4- by 7-ft. tanks, stainless steel.
- (k) Drum Filter -- 2- by 1 $\frac{1}{2}$ -ft. precoat rotary vacuum drum filter, stainless steel; rotary drum and reservoir enclosed and vented to building ventilation

system. Associated equipment for the filter includes vacuum receiver tank and precoat preparation tank.

- (1) Feed Tank for Purifloc -- 50-gallon, mild steel.

Wherever necessary, the tanks are equipped with liquid-level recorders, controllers, and alarms.

7.2 Second Stage

- (a) Holding Tanks -- Two 3400-gallon, reinforced concrete.
- (b) Treatment Tanks -- Three 6800-gallon, reinforced concrete, with common decantation tube.
- (c) Sludge Basin -- 1800-gallon, stainless steel, with agitator.
- (d) Drum Filter -- 3- by 4-ft. precoat rotary drum filter, stainless steel. Vacuum receiver tank and precoat preparation tank are also associated equipment.
- (e) Sand Filters -- Two 5- by 7 $\frac{1}{2}$ -ft. stainless steel tanks.
- (f) Final Holding Tanks -- One 30,000-gallon and two 14,000-gallon, reinforced concrete.

Wherever necessary, the tanks are equipped with liquid-level recorders, controllers, and alarms.

7.3 Evaporator (to be constructed)

- (a) Neutralizer Tank -- 150-gallon, stainless steel.
- (b) Sludge Basin -- Second-stage sludge basin to be used.
- (c) Drum Filter -- Second-stage drum filter to be used.

- (d) Evaporator Feed Tanks -- Two 10,000-gallon, mild steel.
- (e) Evaporator -- 48 tubes, 14 ft. by 1½ inches, of 12-gauge stainless steel; evaporator body and de-entrainment section of stainless steel.
- (f) Bottoms Dryer -- 80-sq.ft. double-drum dryer, chromium-plated cast iron drums.
- (g) Dryer Scrubber -- System consists of stainless steel intake hood over dryer, blower, venturi scrubber, and ductwork.
- (h) Exhaust Stack -- 60- by 2½-ft. epoxy stack reinforced with glass fiber to which ultraviolet absorbers are added.

Wherever necessary, units are equipped with liquid-level gauges, alarms, and pressure gauges.

7.4 Organic Liquid Process

- (a) Filter Station -- Two 1-micron cartridge-filter units within drybox.
- (b) Feed Storage Tanks -- Two 400-gallon, mild steel, epoxy-lined, with sight glasses.
- (c) Distillation Column -- Upper section, 8 ft. by 8 inches, and lower section, 3- by 1-1/2-ft., of Hastelloy C (3) metal alloy with 36-inch packed column.
- (d) Condenser -- Tube-and-shell-type with floating head, tubes of Hastelloy C and shell of stainless steel.

(3) Trademark of Haynes-Stellite, Division of Union Carbide Corporation; Kokomo, Indiana

- (e) Bottoms Reheater -- Tube-and-shell-type with floating head, tubes and shell of Hastelloy C.
- (f) Separator Tank -- 100-gallon, epoxy-lined, mild steel.
- (g) Carbon Tetrachloride - Storage Tanks -- Two 400-gallon, epoxy-lined, mild steel.
- (h) Oil-Storage Tanks -- Two 300-gallon, mild steel.
- (i) Neutralizing Tank -- 100-gallon, epoxy-lined, mild steel, with mixer.
- (j) Feed Tank for Micro-Cel E -- Mild Steel, 125-cu.ft. capacity.
- (k) Mixer-Extruder -- Continuous self-cleaning processor; mixing and extruding paddles, chamber and all submersible parts are of stainless steel.

Wherever necessary, units are equipped with liquid-level recorders, controllers, alarms, pressure gauges, and sight glasses.

8. Facilities Costs

8.1 First- and Second-Stage Operations

(a)	Structure	\$ 400,000.
(b)	Equipment (installation, engineering, etc.)	418,000.
Total Cost		\$ 818,000.

8.2 Evaporator (to be constructed)

(a)	Structure, estimated	\$ 80,000.
(b)	Equipment (installation, engineering, etc.), estimated	320,000.
Total Estimated Cost		\$ 400,000.

8.3 Organic Liquid Process

- (a) Structure \$ 99,000.
(b) Equipment (installation, 190,000.
engineering, etc.)

Total Cost \$ 289,000

9. Processing Rates and Processing Costs

	Rate (gal./hr.)	Cost (per gal.)
9.1 <u>First-Stage Operation</u>	250	\$0.20
9.2 <u>Second-Stage Operation</u>	10,000	0.03
9.3 <u>Evaporator</u>	250	0.14
9.4 <u>Organic Liquid Process</u>	40	0.03 *

* Based on cost of carbon tetrachloride recovered
and reused.

9.5 Summation

	Cost (per gal. of feed)
Total	\$0.71
Less savings on reusable CCl ₄	0.68
Net	\$0.03

10. Problem Areas

Some of the problems which have been encountered in the operation of the decontamination facilities include:

- (a) The formation of colloidal iron in the first-stage treatment, thus preventing the desired decontamination.

- (b) The inability to economically decontaminate solutions which contain complexing agents. These solutions require special handling at the present time and are not fed into the process.
- (c) A poorly designed flocculator which does not provide the necessary mixing.
- (d) The difficulty of obtaining satisfactory material balances.
- (e) The lack of sufficient tankage and associated pumps.
- (f) The high attrition rates on the mixer-extruder paddles by the material used in solidifying the oil bottoms.
- (g) Pumping difficulties with the movement of the Micro-Cel E to the mixer-extruder.

Some of the above problems have been solved, some will only be solved by replacement of equipment, and some will only be solved by a continuing search for more suitable equipment and chemicals.

FIGURE 1. FIRST STAGE, PROCESS WASTE TREATMENT

FIGURE 2. SECOND STAGE, PROCESS WASTE TREATMENT

FIGURE 3. EVAPORATOR (TO BE CONSTRUCTED), PROCESS WASTE TREATMENT

FIGURE 4. ORGANIC LIQUID, PROCESS WASTE TREATMENT

1. Abstract

The operation of an aqueous radioactive waste treatment plant at Rocky Flats will be described, including details of construction, flow charts, operating data, and problems encountered. Plans for additional processing of the effluent will also be discussed.