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SUBJECT: Decontamination of the PRFR Pilot Leaching Plant -
Preliminary Process Design

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SUMMARY

The Turco 4501 process is recommended for the decontamination of the PRFR pilot leaching plant equipment. The caustic-tartrate-nitric acid process is recommended for the decontamination of the cell and the equipment exterior.

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Introduction

Direct maintenance of the PRFR leaching plant⁽⁹⁾ requires a reduction of the magnitude of the radiation in the processing cell to levels such that a human being can safely enter the cell. Radiation in the cell before any decontamination procedure is initiated primarily arises from residual fuel and fission products from the spent fuel which has been processed. The following report considers the methods to be used for removing these materials from the equipment in order that these radiation levels may be lowered to safe values.

Removal of Residual Fuel

Before applying any decontamination process to the leaching equipment, any fuel which possibly remained in this equipment should be dissolved and removed. It is recommended, therefore, that a fresh charge of the appropriate dissolving acid be added to the recycle acid tank, the leacher, and the surge tank in the usual manner to dissolve and subsequently remove any of the possible remaining fuel. All equipment should be thoroughly washed prior to any subsequent treatment.

Turco 4501 Process

The Turco 4501 process,⁽¹⁰⁾ which permits high decontamination of many stainless steels with relatively low corrosion, is recommended for the cleaning of the interior of the leaching plant equipment. This recommendation is based on the experience of Parrott^(1,2) who found this method much superior to the previously used caustic-tartrate-nitric acid method for radiochemical plant decontamination. A suggested procedure for this process is as follows:

1. The vessel surfaces are washed with an undiluted Turco 4501 solution near the boiling temperature ($\sim 275^{\circ}\text{F}$) for about one hour. At lower temperatures ($\sim 180^{\circ}\text{F}$), a three hour washing time is required.
2. The vessel is rinsed thoroughly with water.
3. The vessel surfaces are then washed with a solution containing 2 lb/gal Turco 4502 powder near the boiling temperature ($\sim 215^{\circ}\text{F}$) for about one hour.
4. The vessel is rinsed thoroughly with water.
5. The vessel surfaces are washed with 30% nitric acid at room temperatures for about one hour.
6. The vessel is thoroughly rinsed with water.

Turco 4501 solution and Turco 4502 powder may be purchased from the Turco Products Company. These materials are relatively expensive; the Turco 4501 solution being \$4.59 per gal and Turco 4502 powder being \$0.49 per lb.⁽²⁾ Their effectiveness, however, leads to their recommended use.

Decontamination of the Equipment Exterior

Assuming the cell lining and the equipment exterior to be constructed of stainless steel, caustic-tartrate-nitric acid treatment is recommended because of the probable low contamination and the relatively low cost of the chemicals.^(3,4) Thirty percent nitric acid solution is about \$0.05 per liter and 20% sodium hydroxide - 2% sodium tartrate solution is about \$0.03 per liter.⁽³⁾

The following procedure is then suggested for the decontamination of the equipment exterior:

1. Wash all surfaces thoroughly with water.
2. Wash all surfaces with 20% caustic - 2% sodium tartrate solution at 60 to 70°C.
3. Wash all surfaces with 30% nitric acid solution at 60 to 70°C.
4. Alternate Steps 2 and 3 until the radiation level is lowered to a safe value.
5. Rinse all surfaces thoroughly with water.

Use of a Fluoride

For extreme cases where contamination persists after the Turco 4501 and/or the caustic-tartrate-nitric acid treatments, use of a 20% nitric acid - 3% hydrofluoric acid solution is recommended.^(3,4) This reagent is to be contacted with the equipment at 60 to 70°F for about an hour. The use of this solution should be restricted, however, because of its relatively corrosive nature.

Decontamination Jets

Recommendation is made to fit the leacher, the recycle acid tank, and the surge tank with decontamination jets^(3,5) similar to those being proposed for the Darex plant.⁽⁶⁾ The design of these jets is shown in Fig. 1, and they make use of Penberthy steam jets for recirculating the decontaminating solution and Bete fog nozzles for the spray. Advantages of these jets are more thorough rinsings of the surfaces of the vessel and use of smaller amounts of decontaminating solutions.

Each cylinder of the recycle acid and surge tanks should be equipped with one of these recirculation jets. Two jets are recommended for the flat tank of the leacher, and one for each of the cylindrical fuel tanks. The design of the latter two jets probably would have to be unique because

they must not interfere with loading operation of the leacher, and they must be capable of spraying the flanges of the leacher. The spray nozzles of such jets would probably be located in the large top connecting pipes. A recirculation jet should be added to the leacher which discharges at the top of the off gas pipe which will permit the washing of the condenser and the off gas pipe with the decontamination solution present in the leacher.

Decontamination Solution Makeup

Makeup of the decontamination solutions is to take place in the acid feed tank and the rinse solution tank. The combined volume of these tanks is about 300 gal which should be sufficient for the decontamination operations. Steam coils are placed in these tanks for heating the solutions, and funnels are placed on the tanks for adding soluble powders. The solutions are added to the cell through a quick disconnect panel board similar to the arrangement now existing in the Thorex plant.^(3,5) This panel board is equipped with quick-disconnect fittings for lines leading to different parts of the cell. Thus one can pump the decontamination solution from the makeup tanks to various parts of the cell with ease.

Turco Decontamination Solution Storage

Storage tanks are suggested for the Turco 4501 and 4502 solutions because these materials are relatively expensive and can be used repeatedly. These tanks must be critically safe in case of an accidental discharge of dissolved fuel into them from the leacher. Also they should be located in some shielded area exterior to the main processing cell.

Because of the volume and criticality requirements, vessels similar to the recycle acid tank and the surge tank are recommended for these storage tanks. These vessels are constructed of two 11 ft lengths of 12 in. Sch. 40 pipe spaced at least 2 ft apart. This will allow them to hold about 120 gal of each solution.

Decontamination Solution Flowsheet

As stated in ORNL 2058,⁽³⁾ the flow of the decontamination solution through the equipment represents the best compromise among the following:

1. Maximum reuse of the decontamination solution.
2. Passing the reagent from vessels of lower radiation level to vessels of equal or higher radiation levels.
3. Simplicity of the solution transfer procedures.

The movement of the decontamination solutions between the process vessels is shown in Fig. 2. Fresh decontamination solutions may be added directly to the recycle acid tank, the leacher, or the surge tank, and solution transfer between these vessels is accomplished by steam jet syphons. The Turco solution storage tanks are connected to the surge tank and provisions are made for the movement of the solutions between these vessels. A steam jet syphon is used for recirculating decontamination solutions from the leacher through the off gas pipe and the reflux condenser and back to the leacher in order to decontaminate the off gas pipe and the condenser. The caustic scrubber which probably will not be used in the processing cell⁽⁷⁾ is shown in the flowsheet for completeness. Additional solution transfer lines such as air lifts or steam jet syphons will have to be included if this item is added to the leaching plant.

Pumps for pumping the dissolved fuel to the chemical extraction plant in Building 3019 at ORNL are located in individual cells to permit decontamination and access to these pumps without decontaminating the entire plant. These pumps can be decontaminated by the appropriate solutions added through the surge tank. Freeze jackets are placed on the inlet and outlet lines of the pumps, in order that the pumps can then be effectively isolated from the rest of the leaching plant by forming freeze plugs.

Vent lines from the various process vessels ordinarily will not be contaminated enough to warrant the addition of the decontamination reagents.⁽⁸⁾ Provisions should be made, however, to add decontamination solutions to these lines if their radiation level becomes appreciable. Layout considerations are necessary to determine the exact locations where the decontamination reagents should be added to these lines. Spray or flooding techniques could be used for decontaminating these lines.

Cell Construction and Decontamination Equipment

All supports for the various process vessels and all process lines within the cell should be constructed of stainless steel to permit decontamination with relative ease. Also, all the cell surfaces should be lined with stainless steel for the same reason. A spray nozzle system connected to the quick disconnect board should be installed to spray the cell surfaces and the equipment exteriors with the decontamination reagents.

Waste

There is a possibility that the decontamination reagents may contain fuel after their use. The solutions used for cleaning the interior of the various vessels should be analyzed for fuel material before discharging them to the waste area. All solutions to be discharged to the waste area, therefore, must pass through the surge tank where a sample can be obtained. Solutions used for cleaning the cell and the equipment exterior should be caught in a catch tank and analyzed before discharging them to the waste area. It is possible for the latter solutions to contain fuel due to the necessity of transferring the fuel within the cell exterior to the vessel and of opening the leacher for charging.

Samplers

The samplers are decontaminated by periodically circulating the reagents through them when taking samples for analysis. Samples should be taken at the end of a solution treatment of a vessel before transferring the solution to another vessel or to the radioactive chemical waste storage tanks. Experience with the decontamination of the Thorex plant indicated that the samples should be recirculated 0.5 hr during each treatment, and for approximately 10 min. for each sample. (3)

Decontamination Reagent Control

Samples taken through the samplers are used for the control of the decontamination reagents as they pass from one vessel to another in the leaching plant. In the Thorex plant, the decontamination reagents transferred within the system were sampled and analyzed for gross beta, gross gamma, and protoactinium. Before transferring these solutions to the waste storage tanks, they were analyzed in addition to the above for thorium, gross alpha, ruthenium, zirconium, and niobium gamma, and total rare earth beta. (3) Attention must be given to the solute concentrations of the decontamination solutions which may be determined by analysis (10) of the samples taken through the samplers. If the solution is too dilute, due to the steam jets used for transfer and recirculation, it may be concentrated by evaporation in the leacher. If the solution is too concentrated, it may be diluted by the addition of water.

Radiation Monitoring

Before the decontamination of the plant is begun, a preliminary radiation survey should be made to determine the radiation levels throughout the cell with instruments such as cutie-pies and fish pole probes. During the decontamination operations, the surveys with these instruments should continue to follow the progress of the decontamination and to determine when the cell may be safely entered.

Conclusions

The Turco 4501 process has been specified for the decontamination of the leaching plant equipment and the caustic-tartrate-nitric acid process has been specified for the decontamination of the cell and the equipment exterior. Decontamination jets have been recommended for more effective decontamination with less reagent. A procedure for the movement of the decontaminating solutions from vessel to vessel has been suggested. It must be emphasized, however, that a definite decontamination procedure cannot be recommended since the radiation situation within the cell will vary from time to time.

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DECONTAMINATION JET (6)

FIG. 1

FIG. 2

DECONTAMINATION SOLUTION FLOWSHEET

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