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UNITED STATES ATOMIC ENERGY COMMISSION

PROGRAM FOR THE HRT CORE
PROCESSING PLANT

By
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By

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March 21, 5

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Oak Ridge, Tennessee

PROGRAM FOR THE HRT CORE PROCESSING PLANT

A general program for the HRT chemical plant demonstration was described* in June, 1955. The purpose of the plant and the schedule as outlined above have not changed; however, developments during the past nine months have brought about minor modifications in the plant design and plan of operation. It is the purpose of this memo to outline, in as much detail as is presently possible, the program to be followed from the completion of construction, estimated to be July 1, up to but not including blanket processing. A brief description of the general operating procedure is included. The detailed operating procedure is described in ORNL CF-56-3-22.

The program consists of:

I. Cold Shakedown Operation

- 1) Pre-operational checks
- 2) Water operation - high pressure system
- 3) Water operation - low pressure system
- 4) Remote maintenance tests
- 5) System cleanup with trisodium phosphate
- 6) Operation with simulated soup
- 7) Preparation for hot operation

II. Hot Operation

- 1) Determination of availability of solids in the chemical plant
- 2) Removal of solids by the hydroclone
- 3) Effect of hot surface

GENERAL OPERATING PROCEDURE

High Pressure System - A 0.75 gpm slip stream from the reactor main loop will be passed through a heater, screen and hydroclone with an underflow pot for collecting the solids. The overflow from the hydroclone will go to a canned rotor pump and then back to the reactor loop. After 2 days operation, the high pressure system will be isolated from the reactor, cooled to 100°C, vented and circulated through the underflow sampler. Circulation at low temperature should remove any material adhering to the heater, piping and screen and produce a uniform slurry with the material in the underflow pot. Analysis of this underflow sample will be checked, for the first few runs, against a sample of the dissolved carrier contents. In addition to this underflow sample, several hydroclone overflow samples will be taken during high pressure operation.

*R. B. Lindauer, HRT Chemical Processing Program, ORNL CF-55-6-70.

Low Pressure System - After sampling, the contents of the high pressure system will be discharged to a carrier (located in the same cell) and the high pressure system given a D_2O flush. The reliability of the underflow sample must be demonstrated on the first few runs by boiling down the carrier after several days decay, opening the cell and removing the carrier to a dissolving facility where the solids will be dissolved and sampled. After the reliability of the underflow sampler has been demonstrated, batches will be accumulated in the two carriers in the cell. Batches will be discharged to one carrier for three months, boiling off the D_2O from the previous batch prior to addition of another batch. After three months, the high pressure system will be discharged to the second carrier and the first carrier allowed to reflux. After three additional months, the cell will be opened and the first carrier removed to the dissolving facility. The solution from all dissolutions, after sampling, will be stored in a common storage tank prior to processing in the Thorex Pilot Plant for uranium recovery.

COLD SHAKEDOWN OPERATION

Beginning July 1, cold shakedown of the plant will be started with a high pressure loop as the heat source to simulate the reactor core. This loop will be located in cell B and heated by a large canned rotor pump.

Pre-Operational Checks

- 1) Refrigeration system - After pressure testing, charge and startup the refrigeration system. Start the F-11 pump and send F-11 through all lines checking for leaks with a halide leak detector. Check all freeze plug thermocouples. Check automatic switch over to spare pump. Check low level shut-off valves. Determine the minimum F-11 reservoir temperature with circulation through all plugs.
- 2) Leak detector system - Close all valves to flanges. Connect a vacuum pump to the system, pull a vacuum, and open the valves one at a time, correcting all leaking flanges. Fill both high and low pressure leak detector systems with D_2O as outlined in ORNL CF-55-12-113, sections 3.1.5 and 3.2.3. Apply correct pressure to the system and again check all flanges for leak tightness.
- 3) Water cooler - Startup water cooler for cold trap. Check for leaks. Determine temperature rise from cooler to cold trap.
- 4) Water heater - Check temperature control of warm water for overflow sample cooler.
- 5) Jets - Check operation of jets for sumps and condensate tank.
- 6) High pressure system volume - Accurately determine the volume of the high pressure system for adjusting T-5 volume.
- 7) D_2O receiver liquid level - Calibrate thermo-level probe and weigh cell in T-2. Correct weigh cell calibration for D_2O density. Check

delivered volume from D₂O gauge tank, T-5, and modify volume if required. This volume should be determined at a lower temperature than the normal cell ambient temperature, to avoid overcharging of the high pressure system.

- 8) Sump liquid level switch - Check operation of thermo-level probe in cell C sump.
- 9) Hydrostatic test - With the exit side of the cold trap connected to a temporary valve, fill entire system with water and raise pressure to 500 psi by heating the underflow pot; repair all leaks. Close all valves to the high pressure system, heat to 2500 psi and leak check. Raise pressure to 3000 psi and check that vent valves unseat between 2500 and 3000 psi.
- 10) Helium test - Test entire system with helium and leak detector, by pulling a vacuum on the system and applying helium to the joints.

Operation with Water - High Pressure System

Probably the first month will be devoted to operation of the plant with demineralized water at 300°C and 2000 psi. Water will be heated in the loop in cell B and the overpressure supplied by oxygen. A 0.75 gpm slipstream will be passed through the hydroclone system and the following tests made.

- 1) Fuel charging system - Check the addition of water from the fuel supply tank and D₂O rinse tank. Add remainder of water from the gauge tank.
- 2) T-1 air system - check the time required to heat the high pressure system with hot air. The freeze plug in the vent line should not be frozen to enable the vent valve to act as a relief valve in case of overcharging.
- 3) Leak checking - find and repair all piping leaks. Leak test flanges under thermal cycling.
- 4) Canned rotor pump - Check the control and capacity of the pump vs. frequency and pressure drop across the hydroclone. The orifice flow meter in the test loop take-off will be used for obtaining the flow rate.
- 5) Instrumentation - Check all thermocouples. Check loop high pressure recorder and interlock to let-down valve. Check sound instruments on pump and hydroclone. Check adequacy of temperature control on underflow pot. Check H-3 temperature control and temperature rise for various wall temperatures and flow rates. Calibrate the gamma-eye with a gamma source at the underflow pot to obtain the geometry of the system.

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- 6) Freeze plugs - Check the time required to cool the freeze plugs to -30°C . It will be necessary to stop the pump to test the four plugs in the high pressure system. The five plugs between the high and low pressure systems will be checked after cooling the system.
- 7) Insulation - Check the overall heat loss and the temperature drop from the heat source to the hydroclone.
- 8) Overflow sampler - Obtain curves of overflow sampler valve air pressure vs. flow rate through the sampler. The flow rate will be obtained by collecting the exit liquid for a measured time. Determine the maximum flow which can be cooled from 300 to 100°C . Check mechanical operation of both sampler units. After testing weld the return line to the reactor dump tank line (162).
- 9) Circulation rates - Check the maximum circulation rates for internal loop (P-1 to H-3 to F-1 to T-1 to P-1) and underflow sampler loop. This will require the orifice flow meter mentioned in (4).
- 10) T-1 Cooling - Check the minimum time to cool T-1 and calculate the heat transfer coefficient.

Operation with Water - Low Pressure System

- 1) Batch letdown - Check the time required to drop a hydroclone batch with gravity flow and with 25 and 50 psi pressure. Determine exact volume letdown - this should agree with the amount charged and with the high pressure system volume determined in "pre-operational checks" after temperature correction.
- 2) Carrier refluxing - Determine pressure rise in low pressure system at start of boiling and time required to reach atmospheric pressure. Calibrate steam flow recorders by completely evaporating a known amount of water from each carrier. Prepare curves of boilup rate and system pressure vs. carrier steam coil pressure. Prepare curves of condensate temperature vs. condenser cw rate for various boilup rates. Also determine the need for a gas bleed to prevent a negative pressure due to removal of inert gases.
- 3) Find and repair all piping leaks. Leak test flanges under thermal cycling.
- 4) Carrier boildown - Determine whether an automatic control is required to bleed oxygen into the system to maintain a constant pressure following boil down of a carrier. Determine the liquid head required to flow through unvented liquid seals at several boilup rates.
- 5) Instrumentation - Check operation of all safety interlocks and controls. Check all thermocouples. Check cell static pressure instrument.

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Remote Maintenance

After the completion of water testing, all removable equipment should be replaced from above the cell using remote tools, and with the cell flooded with water. This applies to the pump, screen, heater, hydroclone, carriers, recombiners, valves and thermo-level probes. The tools should be evaluated as to the following:

- 1) Ability to make leak-free flanged joints remotely
- 2) Ruggedness
- 3) Ease of manipulation

The removal procedure should be evaluated as to:

- 1) Ability to freeze all lines to removable equipment
- 2) Shielding water introduced into system on replacing component.

After removal of the shielding water, the equipment and insulation will be carefully examined for water damage. Any damage will be repaired and measures taken to prevent any recurrence of such damage.

System Cleanup

Prior to operation of the chemical plant with simulated soup, the entire system will be cleaned with tri-sodium phosphate and pretreated with oxygen as outlined in ORNL CF 55-9-27, Step II, "HRT Uranyl Sulfate Start-up Procedure."

Operation with Simulated Soup

After all the outlined tests with water have been satisfactorily completed, the supply loop in cell B will be charged with 10 gr/liter uranyl sulfate in water. A solids mixture of a composition similar to that expected during hot reactor operation will be injected into the loop with a high pressure pump. These solids will be traced with La^{140} and later with Zr^{95} and the solids behavior followed with G-M tube probes. The chemical plant will then be operated in the normal manner with the following objectives. During this operation, the LKD system will be in operation and checked regularly.

- 1) Find any low points or regions of low velocity where solids can collect and cause plugging.
- 2) Determine whether the screen may be expected to plug during a run of normal duration.
- 3) Determine the effect on plugging of operating the heater at various wall temperatures and the ability to unplug the heater by reducing the temperature.
- 4) Check the operation of the underflow sampler with solids. Determine the circulation time required for complete mixing of the underflow pot, screen, and heater solids.

- 6) Check carrier boilup rates and entrainment with uranium and solids. This will require a temporary connection for sampling condensate. Carriers should be operated on total reflux only with no concentration in the carriers for ease of cleaning.
- 7) Check uranium material balance from fuel supply system to carrier.

Preparation for Hot Operation

If operation of the plant with simulated soup has been satisfactory and no equipment modifications are required, the uranium solution will be removed from the plant and the system washed with distilled or demineralized water until a pH of 4 is exceeded, the resistivity is greater than 25,000 ohm-cm, and the uranium concentration is less than 100 ppm. The system will then be dried by pulling a vacuum on the system while heating all low points in the system. A final helium leak test will then be applied to all the process piping and equipment. The cold trap is now welded to the off-gas line. After installing the roof plugs and welding the sealing membrane, the cell will be pressured to 5 psig with air containing helium. The membrane welds and all the wall penetrations will then be checked with a helium leak detector.

HOT OPERATION

The chemical plant should be ready for hot operation on reactor soup by October 1. This program describes the operation of the chemical plant for the six months prior to startup of the sulfate blanket on April 1, 1957. It is planned to operate the core processing plant during sulfate blanket operation as a demonstration of long term reliability under optimum conditions as defined during the six month development period.

Before hot operation of the chemical plant, the reactor critical experiments must be completed. The hot startup date for the chemical plant will also depend on the time required for the fission products to saturate the soup and the walls of the reactor piping and equipment. This will probably require between one and two months of operation at 5 mw. The time required to saturate the soup will be determined by observation of the reactor high pressure sampler. When the reactor fission product concentration has exceeded the solubility and is increasing at a uniform rate, reactor soup will be sent to the chemical plant. Hot operation can be broken down as follows:

1. Saturation of chemical plant equipment - Reactor soup will be circulated through the chemical plant high pressure system with the heater off and without passing through the screen holes and hydroclone. The D_2 and O_2 formed can be vented by opening the overflow sample valve for a few seconds every three hours. Every two days the system will be isolated, cooled and sampled. This will be repeated until the fission product concentration is building up at a uniform rate, at which time hydroclone operation will be started. If the solids concentration in the soup due to corrosion becomes objectionable it may be necessary to begin processing before this data can be obtained.

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2. Removal of solids by the 400 mil hydroclone - With the heater off, reactor soup will be circulated through the chemical plant in the normal manner at various flow rates. The rate will be held constant for an entire 2 day run and changed each week. Runs will be made at 0.65, 0.75 and 0.85 gpm. The overflow stream will be sampled every 8 hours beginning 10 minutes after uniform flow has been established. The underflow will be sampled at the end of the run. Samples will be analyzed for Zr, Fe, U, I, Cr, and the various fission products. Comparison of the separation achieved for the different solids at different flow rates will indicate the relative particle size and establish what rate (and therefore efficiency) is required for adequate solids removal. The representativeness of the underflow sample will be checked on the first two runs by removing the carrier and dissolving and sampling the contents.
3. Removal of solids by the heater and clone - The chemical plant will next be operated with both hydroclone and heated surface. Runs will be made with heater wall at 310, 320 and 330°C and with the hydroclone operated at the design rate of 0.75 gpm unless previous runs indicate much improved separation at a different rate. Samples will be taken and analyzed as in previous runs. It is believed that certain fission products, too small to be removed by the hydroclone, will adhere to the heater wall and be removed in this manner. Plugging of the screen and piping may be a problem at the higher heater temperatures and pump frequency will be noted as an indication of increased pressure drop.
4. Removal of solids by the heater alone - To evaluate the removal of solids solely by a hot surface, several runs will be made in which the hydroclone is by-passed. The heater will be operated at the optimum temperature as found in the previous runs. It may be found necessary to operate on a shorter cycle with more frequent descaling. This would be feasible since the holdup volume is much less without an underflow pot. The amount of uranium depositing on the heater wall will be an important factor.

If additional time is available before shutdown of the reactor for changing to the sulfate blanket and results of the runs to date indicate the need for a more efficient hydroclone, the 400 mil clone will be replaced with a 250 mil clone and several runs made. It is also possible that the remaining time would be used for additional 400 mil clone operation under slightly different conditions of flow and temperature.

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