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# PEACH BOTTOM 2 & 3
# REGENERATIVE HEAT EXCHANGERS

## CHEMICAL DECONTAMINATION & SOLIDIFICATION

Presented At:

PENNSYLVANIA ELECTRIC ASSOCIATION
POWER GENERATION COMMITTEE MEETING

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## ABSTRACT

In 1977, Dow Nuclear Services, under contract to Philadelphia Electric Company, chemically decontaminated the regenerative heat exchangers at the Peach Bottom 2 and 3 Atomic Power Station. The purpose of the decontamination was to reduce the radiation levels associated with the subsequent heat exchanger repairs to be performed by PECO maintenance. Samples of piping from the regenerative heat exchangers were analyzed at Dow Chemical, Midland, Michigan, and solvent testing and selection was performed. Nuclear Solvent-1 was selected. Temporary equipment, piping and radiation shielding was installed to perform all necessary functions safely. All designs and procedures were approved by the Peach Bottom Plant Operations Review Committee. The chemical decontamination removed 10.6 curies of radioactive material in the case of Peach Bottom 3 and similarly at Peach Bottom 2, 6.3 curies of material was removed. Radioactive waste generated by decontamination that could not be treated by existing facilities, was successfully solidified by the Dow Solidification process.

Overall, chemical decontamination proved to be a very cost-effective method of radiation reduction at the Peach Bottom regenerative heat exchanger repairs.

In December 1976, Dow Nuclear Services was contacted by Philadelphia Electric Company with questions as to the feasibility of chemically decontaminating the regenerative heat exchangers at Peach Bottom 2 and 3. At this time, Pete Frauson, Dow Nuclear Services, made the initial site visit, ultimately requesting samples to be cut and sent to Midland, Michigan for analysis and solvent testing. The samples were received and surveyed by Dow Health Physics in January, 1977. Warren Strom, Sr. Research Chemist for Functional Products and Systems, R&D, examined and identified the samples with reference to the shipping papers as follows:

Sections from Peach Bottom 2

Peach Bottom 2, Section I - 1 piece, 4 inches diameter by 30 inches length, from V-2 RWCU region, heat exchanger outlet before demineralizer.

Peach Bottom 2, Section II - 1 piece, 4 inches diameter by 9 inches length, inlet to heat exchanger shell side from demineralizers.

Peach Bottom 2, Section III - 1 piece, 4 inches diameter by 14 inches length from the demineralizer bypass line.

Sections from Peach Bottom 3

Peach Bottom 3 Section I - 1 piece, 4 inches diameter by 30 inches in length from V-3 RWCU region, heat exchanger outlet to demineralizer.

Peach Bottom 3 Section II - 1 piece, 4 inches diameter, 18 inch by 18 inch elbow from the heat exchanger shell inlet from the demineralizers.

Small samples of approximately one square inch were cut from the larger sections of pipe. Each sample was appropriately labeled.

Sampling & Preliminary Analysis

The radioisotope identification and quantification was performed by a high resolution Germanium-Lithium crystal gamma ray spectrometer. The standards used for calibration were $^{132}Ba$ at 0.356 Mev, $^{137}Cs$ at 0.662 Mev, and $^{60}Co$ with peaks at 1.173 and 1332 Mev. Table I lists the isotopes identified and quantified. The data shows that the major isotopes present in Peach Bottom 2 to be $^{60}Co$ and $^{65}Zn$, whereas the scale from Peach Bottom 3 has a much higher ratio of $^{65}Zn$ to $^{60}Co$.

Next, the samples were exposed to NS-1 at 250°F for different periods of time. Tables II and III record the results of the Peach Bottom 2 and Peach Bottom 3 samples, respectively. Although other selected solvent systems were tried, none were found to be more effective than the NS-1 Solvent system.

After the timed solvent experiments had been completed, the solvent was chemically analyzed for Iron, Chromium, Copper, Nickel, and Zinc. The results are summarized in Table IV. Finally, the amount of sloughed material was determined for four samples. The used NS-1 solutions were passed through tared Millipore® filters of 0.45 μ pore size. The filters were dried and then weighed. The results are shown in Table V. The activity remaining on the filters was determined by a Germanium-Lithium spectrometer. The percent of activity was calculated by comparison to the original activity of the sample. In all

cases, the undissolved sloughed material was less than 2 percent of the original. Table VI shows this data.

The analytical test data was transmitted to Philadelphia Electric Co., with conceptual flow diagrams, procedural outlines, and contractual agreements. After due considerations and review, Philadelphia Electric decided to proceed with the chemical decontamination and subsequent solidification of generated waste with the Dow solidification process.

Planning, System Modification & Equipment Design

After review of the isometric drawings of the regenerative heat exchangers and piping, a visit to Peach Bottom Station was arranged. The regenerative heat exchanger room was inspected with Mark Rohner, Philadelphia Electric Co., Maintenance Division. The heat exchangers had been isolated from the reactor system by cutting the inlet and outlet piping on both the tube side and the shell side with necessary spool pieces and blanks put in place to allow the reactor water clean-up system to be operated. The open inlet and outlet pipes on the heat exchangers would be utilized as connections for the chemical decontamination. The flow of the NS-1 was to be the opposite of the normal path to act as a back flush and to facilitate circulation in the low flow areas under normal flow conditions. The normal flow path is from the reactor to the top heat exchanger channel inlet through the tube side of all three exchangers and on to the non-regenerative heat exchangers from the lower regenerative heat exchanger channel outlet. The water returns from the cleanup demineralizers to the lower exchanger shell inlet passing through the middle and top heat exchanger and

exiting through the top regenerative exchanger shell outlet returning to the reactor.

The parameters for using NS-1 Solvent decontamination were an operating temperature of 250°F to 260°F at a flow rate of approximately 100 gpm to 125 gpm. The working pressure of the system was calculated to be 30 psig vapor pressure plus 40 psig pump head. The total solvent contact time was to be determined by analytical tracking of solvent chemical parameters. These parameters were total Iron, total activity, and percent NS-1 capacity available. All equipment and piping was specified to operate safely within these given conditions. The temporary circulation pump was a stainless steel 3" x 2" x 6" centrifugal pump rated at 100 gpm at 100 ft. T.D.H. The discharge of the pump was piped to the tube side of a 75 sq. ft. single pass, stainless steel tube and head, carbon steel shell temporary heat exchanger. The fluid was then piped with 2 inch schedule 40 304 stainless steel pipe to the lower regenerative heat exchanger's normal channel outlet. With the concept of reverse flow in mind, this channel outlet became the temporary solvent inlet. The solvent flowed upwards through the tube side and channels of all three regenerative heat exchangers. The normal channel inlet, which now is the channel outlet for the solvent, was connected to the normal shell outlet with a temporary cross over line. The NS-1 passed through all three shell sides and exited through the normal shell inlet on the lower regenerative heat exchanger. From this point the solvent returned to the head tank. The head tank was constructed from six inch stainless steel pipe with sight glasses

attached for level indication. The three inch suction of the temporary circulation pump was drawn from the bottom of the head tank. The pump was protected by an in-line stainless steel strainer. Two large waste collection tanks were constructed and installed. These tanks of approximately 1,150 gallons each were multi-purpose units. They were to act as condensate/cooling water holdup tanks, storage tanks for spent NS-I, and contaminated rinse water to be solidified later and to provide a tank for emergency dump-quenching safety procedure. A small pump with necessary piping was installed between the two temporary waste storage tanks to allow mixing of the two tanks individually or simultaneously. This pump was also used to charge the metering tank to be used in the solidification process. Each tank was individually vented to the hall area through a manifold of six Iodine canisters with their check valves removed. This allowed the tanks to breathe as needed. During the actual decontamination the waste holding tanks were isolated from the pressurized system by a single valve.

The pressurized portion of the chemical decontamination system was protected by a one inch stainless steel relief valve set at 35 psig while a vacuum relief valve was also installed to protect against a negative pressure. Both of these relief valves were located on the top of the head tank and piped to the waste storage tanks. A nitrogen line was also connected to the top of the head tank to allow the system to be kept under a blanket between stages as well as to assist in the draining operations.

Instrumentation to monitor the system were thermocouples, used with thermowell thermometers as a backup, pressure gauges and an ultrasonic flow meter. The temperature was monitored at the temporary heat exchanger solvent outlet, the suction head tank, the cooling water supply and the steam supply to the temporary heat exchanger shell side. Pressure gauges were used on the shell side of the temporary heat exchanger. The solvent circulation pump discharge and the section head tank also had pressure indicators. The ultrasonic flow meter was attached to the two inch pump discharge to monitor flow. This meter was used to confirm flow with the hot water test run but would not function properly with the solvent stage. Flow in the system was then judged on the basis of the differential between the suction head and discharge pressure.

During all phases of this project, the safety of the personnel was the prime consideration. The system was checked, rechecked, and reviewed by Philadelphia Electric Company, Catalytic, Inc., and Dow Nuclear Services for maximum safety and minimal radiation exposure. Work areas were designed to allow as open area as possible while providing measures to contain a "worst case" spill or accident. Floor drains were plugged; the floors protected with layers of plastic and dams erected on each end of the hallway to contain a maximum spill.

Existing radioactive hotspots were mapped out and new high radiation areas to be generated due to the decontamination were projected and considered. Lead shielding was erected where ever practicable. The

working crews were monitored continuously by Health Physics. In addition to personnel radiation protection equipment, the work area was surveyed, wipe-tested and air sampled on a regular basis. A daily exposure record was maintained, attached to the radiation work permit at the Health Physics desk.

From the flow sheet and isometric drawings, procedures were developed to regulate the operations from the testing stages through the solidification of the wastes generated. The procedures can be broken down into four basic sections. The first area to be addressed was pre-operational testing of the temporary system to assure all design criteria had been satisfied. These tests include hydrostatic tests for leaks, filling the system with deionized water in much the same way the solvent would be injected; running the circulation pumps and testing the temporary heat exchanger. The test water was heated to the operating temperature of the solvent and cooled at a controlled rate. An emergency dump with hot water was performed to test the calculations of the necessary amount of quench water in the waste tank to handle safely the quick removal of the hot liquid in the pressurized system. The over pressure and vacuum relief valves were also tested to assure their proper responses. The temperature, pressure, and flow rate of the system was monitored and recorded in a permanent record.

The next major section was concerned with the solvent injection and circulation. The procedures gave step by step directions on filling, venting, and controlled heat up of the cleaning system. The solvent

chemistry was to be periodically sampled, checked and recorded. The third portion described the cooling, draining, and rinsing of the system. Controls were imposed as to the proper disposal of liquids and minimum acceptable rinse water standard to allow the return of the units to Philadelphia Electric Company.

Finally, the solidification of wastes that could not be handled by Peach Bottom's existing radwaste system was detailed. These procedures were submitted and approved by the Peach Bottom Plant Operations Review Committee.

The testing stages as described earlier for both Peach Bottom 2 and 3, were completed approximately one week before the Dow work crews were scheduled to arrive. With minor exceptions such as valve packing leaks, unlabeled valves and last minute adjustments, all systems performed well.

The crew arrived three days before the NS-1 was scheduled to be injected into the system. This lead time was necessary for Health Physics requirements, security badges, full body counts, system inspection by the work crew, and a final briefing with the necessary crews and support personnel.

Solvent Addition

The NS-1 Solvent, which was packaged and shipped in polyethylene lined 55 gallon barrels, was moved to the work area. The solvent was then moved to a radioactivity clean area near the temporary cleaning

equipment. A self-priming air powered barrel pump was used to inject solvent at the rate of approximately 15 gpm until the system was filled. All high points were vented and NS-1 was injected to assure a full system. The calculated volume needed to fill was 650 gallons. The volume of NS-1 used to fill the system was approximately 625 gallons at Peach Bottom 3, and 605 gallons at Peach Bottom 2.

Circulation

Circulation was then established and heating of the solvent began. The Peach Bottom normally allows a heat up rate of 100°F per hour. As a safety margin, the procedures for the chemical decontamination limited the heat up/cool down rate to 50°F per hour. The solvent steam pressures & temperatures were monitored and recorded on data log sheets for a permanent record. A sample tap was located on the discharge pipe of the circulation pump. Samples were taken at 30 minute intervals for the first 6-8 hours of NS-1 Solvent contact. The samples were then taken on an hourly basis for approximately the next 12 hours and then on a two hour sample time for the rest of the chemical decontamination stages. Residual NS-1 capacity, dissolved Iron and Cobalt 60 were analyzed. Figure 4 and 5 is a composite graph of selected analytical data generated on Peach Bottom 3, in April, 1977 and on Peach Bottom 2 from September 22 to September 25, 1977 respectively. The final data for the solvent is as follows:

PEACH BOTTOM 3 SOLVENT CONTACT
(From April 15, 1977 to April 19, 1977)

Total hours solvent contact at 250°F----------48 hours.
Residual NS-1 capacity at termination----------78%
Iron concentration (maximum detected)----------600 µg/ml

Peach Bottom 3 Solvent Contact - con't.

Cobalt 60 activity (maximum detected)--------1.4 µCi/ml
Total Iron removed----------1453 gms
Total Radioactivity removed ----------10.6 curies

Table VII gives an isotopic breakdown of the activity removed.

PEACH BOTTOM 2 SOLVENT CONTACT
(From September 22 to September 25, 1977)

Total hours of solvent contact at 250°F----- 44 hours
Residual NS-1 capacity at termination------- 70.3%
Iron concentration (maximum detected)------- 900 µg/ml
Cobalt 60 activity (maximum detected)------- 1.6 µg/ml
Total Iron removed---------- 2100 gms
Total Radioactivity removed---------- 6.3 curies

Table VIII gives an isotopic breakdown of the activity removed.

During the solvent run, the piping system was inspected approximately every two hours. Any unusual or abnormal conditions were noted in the engineer's log book and corrected when feasible. The problem of leaks was addressed and planned for during the design phases. The heat exchanger gaskets themselves were leaking and could not be sealed off. These existing leak points had spray belts wrapped around them with any liquid directed to an installed temporary drip pan. Many other small drip pans were made and placed in the area for use in the event of small unexpected leaks such as valve packings, flanged gaskets, or threaded connections. These pans were emptied during the inspections and the waste placed in a lead shielded waste drum to be solidified at a later time. It is also important to note that while leaks were

experienced on both Peach Bottom 2 and 3, no airborne activity was generated.

The termination of the NS-1 stage was based on the relative stability of the previously mentioned analytical parameters. If the residual NS-1 concentration was not decreasing nor the Iron concentration, and Cobalt 60 activity increasing for an eight to twelve hour period, the chemical contact stage was considered completed and the coolin seq- uences initiated. As mentioned before, at Peach Bottom 3, the solvent stage was of 48 hours duration. In the case of Peach Bottom 2, the solvent was in contact for 44 hours before a weld failure in the solvent return lines forced an emergency dump to the quench tank. From the analytical data it can be seen that the NS-1 solvent conditions had been relatively stable for the final 18 hours of the run indicating that the majority of the deposit had been removed.

Drain and Flush

The solvent was cooled and drained under a nitrogen blanket to the Decon Waste Storage Tank #1 for later solidification. The rinse cycles were basically filling the system with demineralized water, circulating the water, sampling the rinse water for purity and then draining the system in much the same way as the solvent was handled. Of course the purpose of rinsing and flushing the system was to remove any residual NS-1 left in the equipment or piping. The rinses were tested for residual NS-1, pH, conductivity, radioactivity, and Iron. Criteria for rinse water quality were set forth in the procedures. From the laboratory results it was then decided if the rinse water should be

barreled and/or allowed to go to the floor drains at a limited rate. In the above case, the rinse water was diluted with large volumes of water in the existing radwaste treatment system to eventually be processed through the demineralizers. If the rinse water was outside the criteria stated in the procedures, it was to be drained to the Decon waste storage tanks to be mixed with the solvent for eventual solidification. In the case of both Peach Bottom 2 and 3, the rinses were of sufficient quality to be treated by the Peach Bottom radwaste system.

The system was rinsed until the conductivity of the water being circulated was no more than 20 μmhos/cm. The final rinse of Peach Bottom 3 was 6.2 μmhos/cm and similarly, at Peach Bottom 2, 5.35 mhos/cm. The system was turned over to Philadelphia Electric Company at this point.

Any waste that was now to be treated by the Dow solidification system was located in Decon Storage Tank #1. The valve line-ups were checked and Decon Pump No. 2 was used to circulate Tank #1 for three to four hours to mix the waste and to blend in a small amount of an antifoam agent.

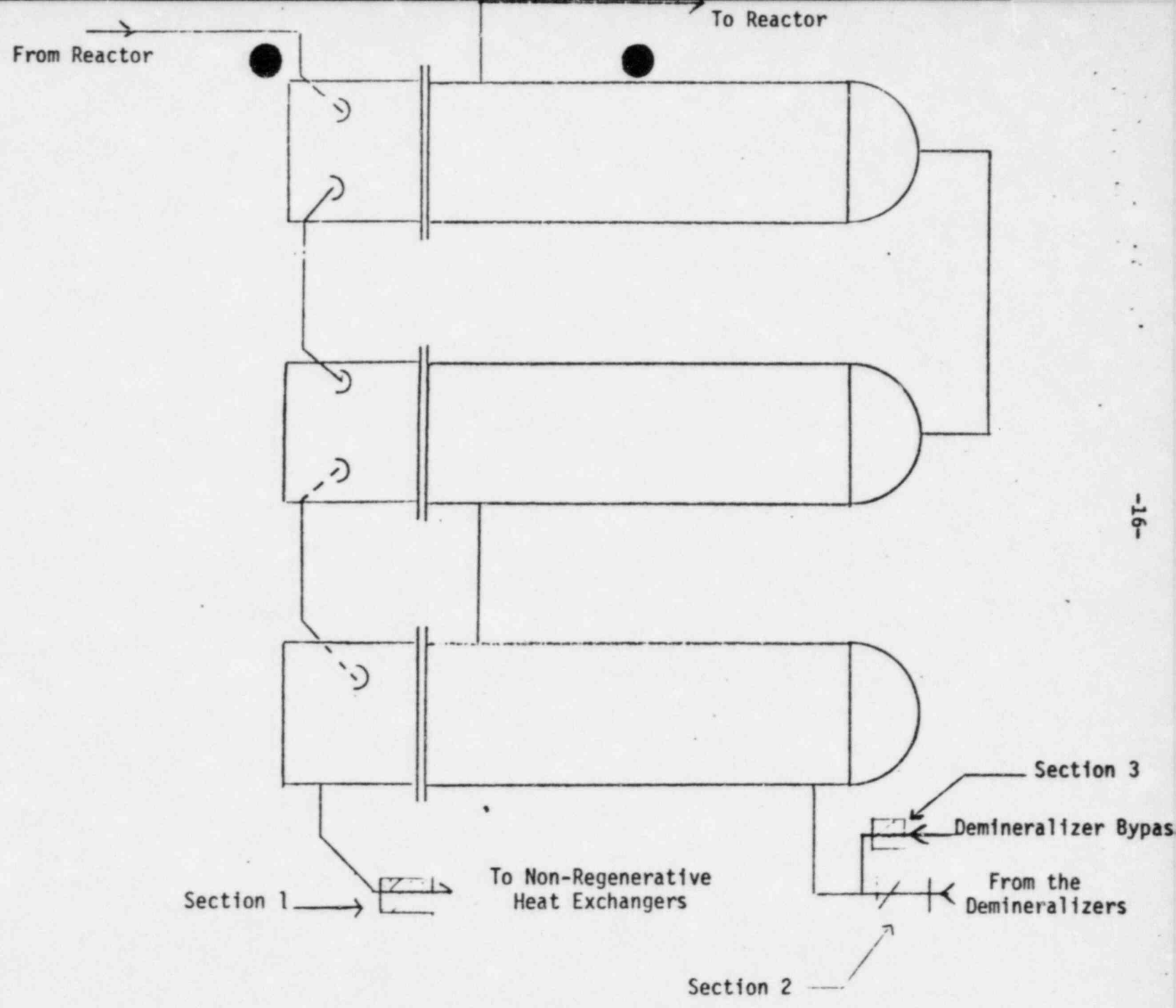
Waste Solidification

The solidification system was comprised of the Waste Storage Tank, Decon Pump No. 2, a metering tank and an air powered mixer. By a remote switch, Decon Pump No. 2 was energized drawing suction from Decon Tank #1 and discharging to the metering tank. At a pre-deter

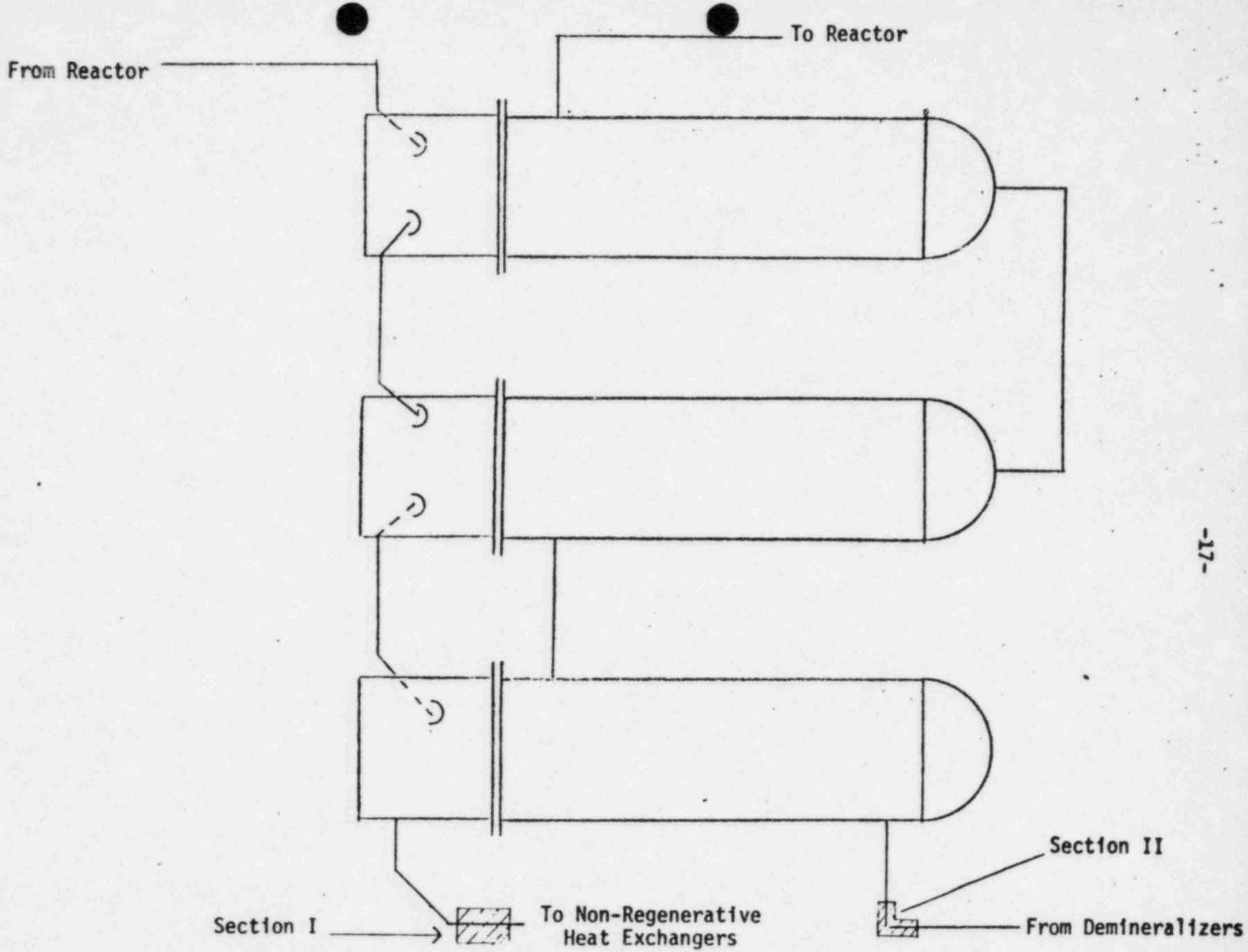
mined volume, the waste liquid would overflow, as observed by a liquid flow through a section of clear tubing, the excess returning to the waste tank. A 55 gallon drum that had previously been filled with the prescribed amount of binder and promotor was locked into position at the mixer. The air powered mixer was lowered and the mixing began. The valve on the metering tank was cracked open and the waste slowly blended into the barrel. A shroud had been attached near the top of the barrel. This shroud was connected by a flexible hose to a portable HEPA Filter to eliminate any vapors or airborne particles generated during the mixing. After the metering tank had emptied, the catalyst was injected into the barrel and mixed. The air motor for the mixer was shut off and the mixing head raised. With a drip pan moved under the shaft of the mixer, the full barrel was rolled out from under the mixing unit to a curing area. Another "prepped" drum was placed under the mixer and the process continued. The mixed drums were allowed to cure for approximately one hour and then checked for hardness. With Philadelphia Electric Health Physics approval, the lids were sealed and bolt rings installed. Each barrel was wipe tested and surveyed by Health Physics. This information was recorded in a permanent record. After the tests, the barrels were removed to a temporary storage area to be properly disposed of by Philadelphia Electric Company. At Peach Bottom 3, a total of 34 barrels were solidified with a surface radiation dose ranging from 1,000 to 1,200 mr/hr. At Peach Bottom 2, 38 barrels were solidified with surface radiation dose ranging from 350 mr/hr to 800 mr/hr.

## CONCLUSIONS

The objective of the decontamination of the regenerative heat exchangers at Peach Bottom was to reduce the radiation fields associated with the proposed repairs. Extensive surveys were conducted before and after the chemical decontamination. Tables IX and X, pages 36 and 37 respectively, list the results of these surveys for Peach Bottom 3 and 2 respectively. In conclusion, the chemical decontamination significantly reduced the radiation levels resulting in greatly reduced personnel exposure. All wastes were disposed of quickly and in an environmentally acceptable manner.

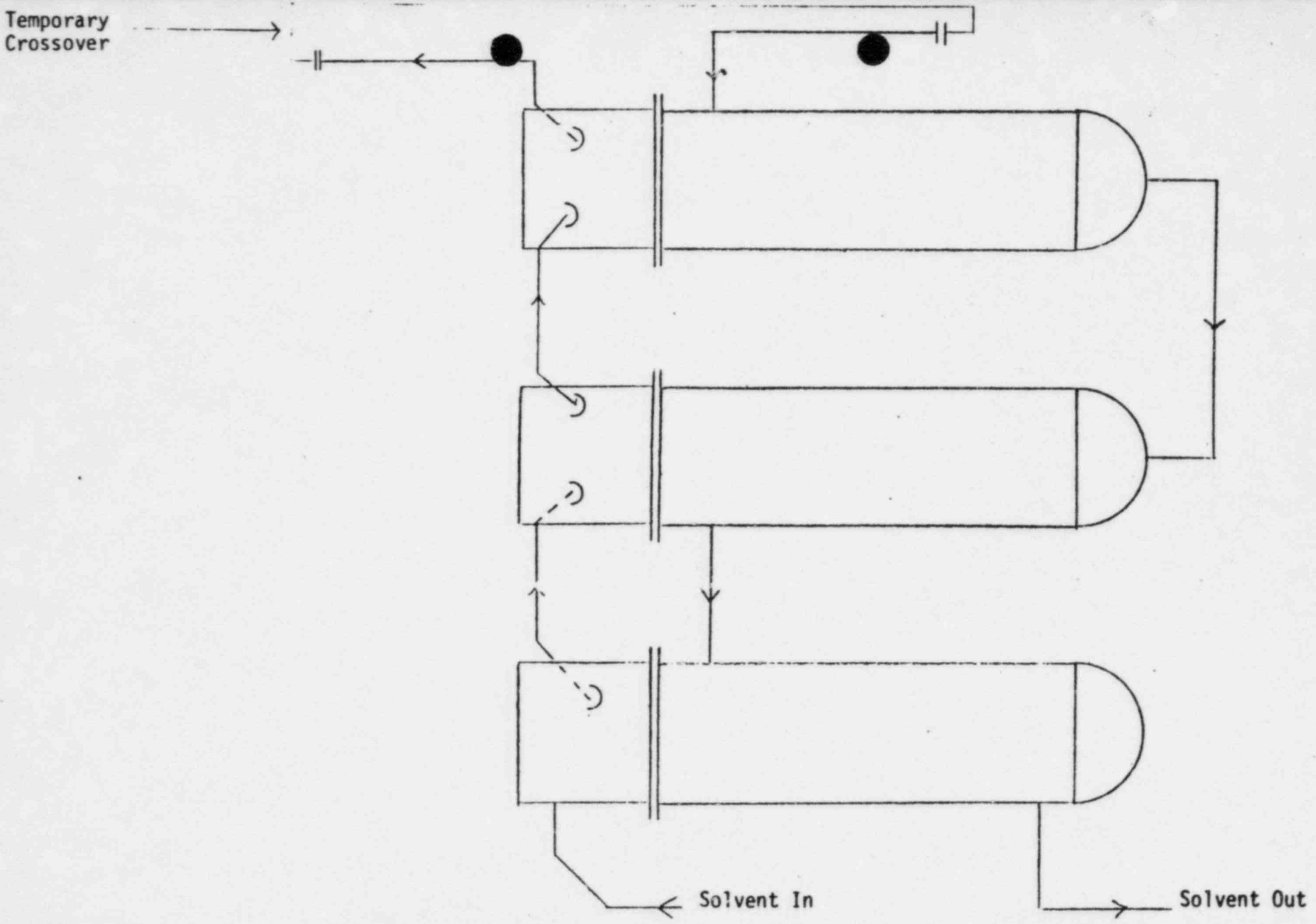



Samples From Peachbottom II
Figure 1




Peachbottom III

Figure 2




SOLVENT FLOWPATH

Figure 3

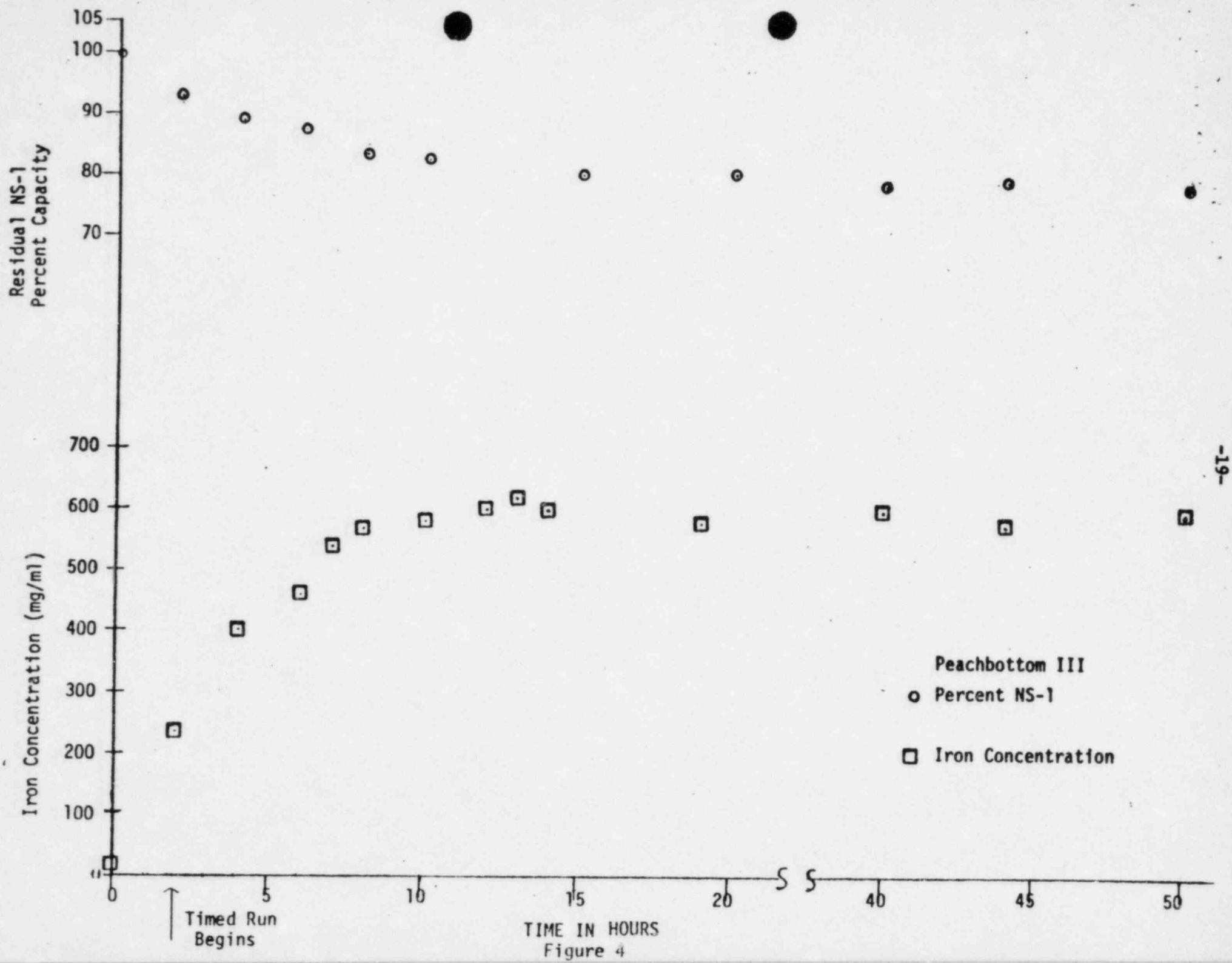

105
100
90
80
70
Residual NS-1
Percent Capacity
700
600
500
400
300
200
100
0
Iron Concentration (mg/ml)
0
5
10
15
20
40
45
50
Timed Run
Begins
TIME IN HOURS
Peachbottom III
Percent NS-1
Iron Concentration

Figure 4

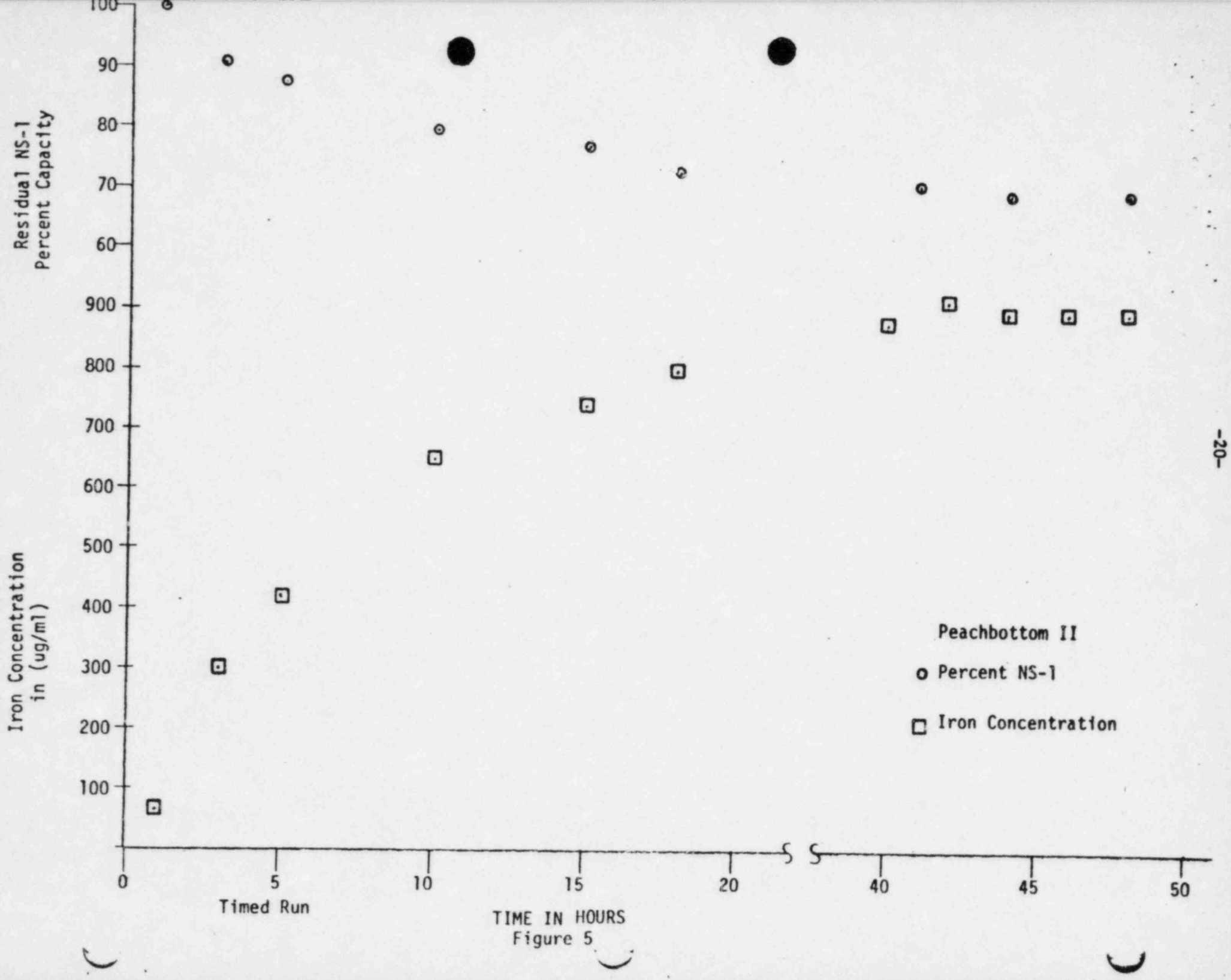
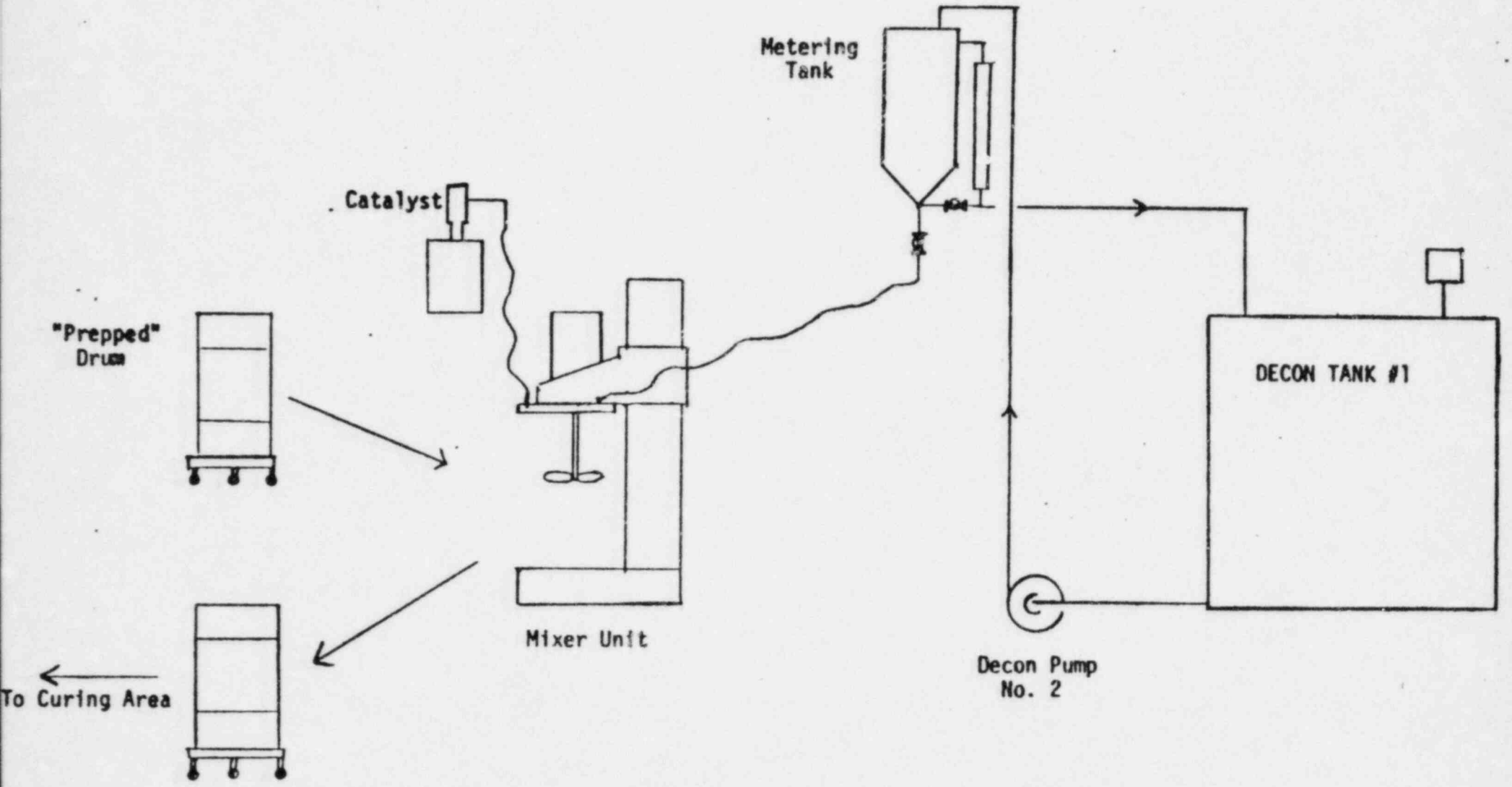

Residual NS-1
Percent Capacity
Iron Concentration
in (ug/ml)
100
90
80
70
60
900
800
700
600
500
400
300
200
100
0
5
10
15
20
40
45
50
Timed Run
TIME IN HOURS
Peachbottom II
Percent NS-1
Iron Concentration

Figure 5




SOLIDIFICATION FLOW DIAGRAM

Figure 6

Table I

RADIOISOTOPE IDENTIFICATION AND QUANTIFICATION OF PEACH BOTTOM DEPOSITS

| ISOTOPE | ENERGY (Mev) | HALF-LIFE | PEACH BOTTOM II Section I ($\mu Ci/cm^2$) | PEACH BOTTOM II Section II ($\mu Ci/cm^2$) | PEACH BOTTOM II Section III ($\mu Ci/cm^2$) |
|---|---|---|---|---|---|
| $^{65}Zn$[1] | 1.115 | 245d | 1.32[1] | 0.026[1] | 1.10[1] |
| $^{60}Co$[2] | 1.173 | 5.62y | 1.15 | 0.003 | 0.24 |
| $^{60}Co$[2] | 1.332 | 5.62y | 1.20 | 0.003 | 0.25 |
| $^{58}Co$ | 0.810 | 71.3d | 0.18 | 0.002 | 0.10 |
| $^{51}Cr$ | 0.320 | 27.8d | N.D.[3] | 0.008[4] | 0.04 |
| $^{54}Mn$ | 0.835 | 303d | N.D. | N.D. | N.D. |
| $^{95}Nb$ | 0.765 | 35d | N.D. | N.D. | N.D. |
| $^{137}Cs$ | 0.662 | 30.0y | N.D. | 0.001 | N.D. |
| $^{137}Cs$ | 0.606 | 2.05y | N.D. | N.D. | N.D. |
| $^{134}Cs$ | 0.606 | 2.05y | N.D. | 0.005 | N.D. |

[1]Values are corrected for 50% efficienty for 1.116 Mev gamma rays of $^{65}Zn$.

[2]Two gamma rays per disintergration.

[3]N.D. - Not determined, may have been present in small amounts.

[4]Values are corrected for 9% efficiency for 0.320 Mev gamma rays for $^{51}Cr$.

Table I

RADIOISOTOPE IDENTIFICATION AND QUANTIFICATION OF PEACH BOTTOM DEPOSITS

| ISOTOPE | ENERGY (Mev) | HALF-LIFE | PEACH BOTTOM III Section I ($\mu Ci/cm^2$) | PEACH BOTTOM III Section II ($\mu Ci/cm^2$) |
|---|---|---|---|---|
| $^{65}Zn$[1] | 1.115 | 245d | 12.68[1] | 2.58[1] |
| $^{60}Co$[2] | 1.173 | 5.62y | 4.13 | 0.10 |
| $^{60}Co$[2] | 1.332 | 5.62y | 4.95 | 0.10 |
| $^{58}Co$ | 0.810 | 71.3d | 1.24 | 0.03 |
| $^{51}Cr$ | 0.320 | 27.8d | 1.32[4] | 0.33[4] |
| $^{54}Mn$ | 0.835 | 303d | 0.61 | 0.01 |
| $^{95}Nb$ | 0.765 | 35d | 0.14 | 0.01 |
| $^{137}Cs$ | 0.662 | 30.0y | 0.11 | 0.03 |
| $^{137}Cs$ | 0.606 | 2.05y | 0.11 | 0.03 |
| $^{134}Cs$ | 0.606 | 2.05y | N.D. | N.D. |

[1]Values are corrected for 50% efficiency for 1.116 Mev gamma rays of $^{65}Zn$.

[2]Two gamma rays per disintergration.

[3]N.D. - Not determined, may have been present in small amounts.

[4]Values are corrected for 9% efficiency for 0.320 Mev gamma rays for $^{51}Cr$.

TABLE II

DISSOLUTION OF PEACH BOTTOM II DEPOSIT USING NS-1

| γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|
| A. 1. Section I Sample #1 - 24 hours at 250°F | | | | | |
| 0.69 to 0.88[1] | $^{58}Co$ | 90.4 | 0.75 | 120 | 99.2 |
| 0.99 to 1.40[1] | $^{65}Zn$ + $^{60}Co$ | 167 | 1.31 | 127 | 99.2 |
| 2. Section I Sample 2 - 69 hours at 250°F | | | | | |
| 0.69 to 0.88[1] | | 104 | 0.40 | 260 | 99.6 |
| 0.99 to 1.40[1] | | 190 | 0.69 | 275 | 99.6 |
| 3. Section I Sample #2 using Ge(Li) system - 69 hours at 250°F | | | | | |
| 0.512[2] | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 13.3 | 0.03 | 490 | 99.8 |
| 0.812 | $^{58}Co$ | 12.1 | 0.02 | 600 | 99.8 |
| 1.115 | $^{65}Zn$ | 30.2 | 0.14 | 216 | 99.5 |
| 1.173 | $^{60}Co$ | 52.3 | 0.22 | 237 | 99.6 |
| 1.332 | $^{60}Co$ | 46.9 | 0.20 | 235 | 99.6 |
| SURFACE AREA OF SAMPLE = 4.86 $cm^2$ | | | | | |
| 4. Section I Sample #3 - 93 hours at 250°F | | | | | |
| 0.512 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 9.94 | 0.03 | 330 | 99.7 |
| 0.812 | $^{58}Co$ | 9.54 | 0.02 | 380 | 99.8 |
| 1.115 | $^{65}Zn$ | 22.4 | 0.14 | 160 | 99.4 |
| 1.173 | $^{60}Co$ | 39.5 | 0.21 | 188 | 99.5 |
| 1.332 | $^{60}Co$ | 35.0 | 0.20 | 175 | 99.4 |
| SURFACE AREA OF SAMPLE = 4.94 $cm^2$ | | | | | |

[1] NaI (Tl) detector

[2] Ge(Li) detector

Table II (Continued)

| γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|
| 5. Section I Sample #4 - 118 hours at 250°F | | | | | |
| 0.512 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 13.3 | 0.03 | 440 | 99.8 |
| 0.812 | $^{58}Co$ | 13.1 | 0.02 | 655 | 99.8 |
| 1.115 | $^{65}Zn$ | 30.7 | 0.14 | 219 | 99.5 |
| 1.173 | $^{60}Co$ | 34.2 | 0.22 | 250 | 99.6 |
| 1.332 | $^{60}Co$ | 48.5 | 0.19 | 255 | 99.6 |
| 6. Section I Sample #5 - 48 hours at 250°F | | | | | |
| 0.512 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 11.8 | 0.04 | 289 | 99.6 |
| 0.812 | $^{58}Co$ | 11.4 | 0.02 | 590 | 99.8 |
| 1.115 | $^{65}Zn$ | 27.8 | 0.15 | 186 | 99.5 |
| 1.173 | $^{60}Co$ | 48.9 | 0.21 | 232 | 99.6 |
| 1.332 | $^{60}Co$ | 43.2 | 0.20 | 216 | 99.5 |
| B. 1. Section II Sample #1 - 71 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 20.7[1] | <.5 | >40 | >99% |
| 0.812 | $^{58}Co$ | 1.37 | 0.065 | 21 | 95.3 |
| 1.115 | $^{65}Zn$ | 11.7 | 0.250 | 47 | 97.9 |
| 1.173 | $^{60}Co$ | 2.78 | 0.270 | 10 | 90.3 |
| 1.332 | $^{60}Co$ | 2.48 | 0.290 | 8.5 | 88.3 |
| 2. Section II Sample #4 - 48 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 17.6 | 0.15 | 117 | 99.2 |
| 0.812 | $^{58}Co$ | 1.31 | 0.06 | 22 | 95.4 |
| 1.115 | $^{65}Zn$ | 10.5 | 0.19 | 55 | 98.2 |
| 1.173 | $^{60}Co$ | 2.42 | 0.42 | 5.8 | 82.6 |
| 1.332 | $^{60}Co$ | 2.27 | 0.35 | 6.5 | 84.6 |

[1] Different sample counting position than Section I, same as Section III.

Table II (Continued)

| γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|
| B. 3. Section II Sample #2 - 48 hours in NS-3 | | | | | |
| 0.321 | $^{51}Cr$ | 2.24 | 0.06 | 37 | 97.3 |
| 0.511 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 1.17 | <.05 | >23 | >96% |
| 0.812 | $^{58}Co$ | 1.87 | 0.03 | 62 | 98.4 |
| 1.115 | $^{65}Zn$ | 3.43 | 0.11 | 31 | 96.8 |
| 1.173 | $^{60}Co$ | 4.05 | 0.11 | 37 | 97.3 |
| 1.332 | $^{60}Co$ | 3.58 | 0.14 | 26 | 96.1 |
| C. 1. Section III Sample #1 - 71 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 164[1] | 0.27 | 607 | 99.8 |
| 0.511 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 130 | 13.8 | 9.4 | 89.4 |
| 0.812 | $^{58}Co$ | 114 | 4.88 | 23 | 95.7 |
| 1.115 | $^{65}Zn$ | 728 | 99.7 | 7.3 | 86.3 |
| 1.173 | $^{60}Co$ | 317 | 91.4 | 3.5 | 71.2 |
| 1.332 | $^{60}Co$ | 290 | 79.8 | 3.6 | 72.5 |
| 2. Section III Sample #2 - 44 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 71.3[1] | 0.40 | 180 | 99.4 |
| 0.511 | $^{58}Co$+$^{65}Zn(^{+}\beta)$ | 70.6 | 12.9 | 5.5 | 81.2 |
| 0.812 | $^{58}Co$ | 53.0 | 3.25 | 16.3 | 93.9 |
| 1.115 | $^{65}Zn$ | 346 | 90.5 | 3.8 | 73.8 |
| 1.173 | $^{60}Co$ | 153 | 72.5 | 2.1 | 52.6 |
| 1.332 | $^{60}Co$ | 138 | 60.1 | 2.3 | 56.4 |
| 3. Section III (14") Sample #5 Dry Cut, 48 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 127 | 0.75 | 170 | 99.4 |
| 0.511 | $^{58}Co$+$^{65}Zn$ | 91.8 | 15.3 | 6.0 | 83.3 |
| 0.812 | $^{58}Co$ | 74.1 | 5.52 | 13.4 | 92.6 |
| 1.115 | $^{65}Zn$ | 517 | 131 | 3.95 | 74.7 |

Table II (Continued)

| γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|
| C. 3. Section III (14") Sample #5 Dry Cut, 48 hours at 250°F (continued) | | | | | |
| 1.177 | $^{60}Co$ | 184 | 56.5 | 3.26 | 69.3 |
| 1.332 | $^{60}Co$ | 162 | 50.6 | 3.20 | 68.8 |
| 4. Section III Sample #3, 48 hours in NS-3 | | | | | |
| 0.321 | $^{51}Cr$ | 108 | 0.60 | 180 | 99.4 |
| 0.511 | $^{58}Co+^{65}Zn$ | 81.4 | 6.33 | 12.9 | 92.2 |
| 0.812 | $^{58}Co$ | 71.4 | 2.16 | 33.1 | 97.0 |
| 1.115 | $^{65}Zn$ | 449 | 44.9 | 10.1 | 90.0 |
| 1.177 | $^{60}Co$ | 185 | 43.8 | 4.22 | 76.3 |
| 1.332 | $^{60}Co$ | 164 | 39.6 | 4.14 | 75.8 |

[1] Different sample counting position that Section I, same as Section II.

Table III

DISSOLUTION OF PEACH BOTTOM III DEPOSIT USING NS-1

| | γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|---|
| A. 1. | Section I, Sample #1 - 48 hours at 250°F | | | | | |
| | 0.321 | $^{51}Cr$ | 19.5 | 0.33 | 59.1 | 98.3 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 64.5 | 6.31 | 10.2 | 90.2 |
| | 0.812 | $^{58}Co$ | 62.1 | 2.50 | 24.8 | 96.0 |
| | 0.834 | $^{54}Mn$ | 31.0 | 0.33 | 93.9 | 98.9 |
| | 1.115 | $^{65}Zn$ | 217 | 33.0 | 6.58 | 84.8 |
| | 1.173 | $^{60}Co$ | 136 | 6.12 | 22.2 | 95.5 |
| | 1.332 | $^{60}Co$ | 122 | 5.68 | 21.5 | 95.3 |
| 2. | Section I, Sample #1 - 120 hours at 250°F* | | | | | |
| | 0.321 | $^{51}Cr$ | 19.5 | .341 | 56.5 | 98.2 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 64.5 | 5.55 | 11.6 | 91.4 |
| | 0.812 | $^{58}Co$ | 62.1 | 2.55 | 24.4 | 95.9 |
| | 0.834 | $^{54}Mn$ | 31.0 | 0.49 | 63.3 | 98.4 |
| | 1.115 | $^{65}Zn$ | 217 | 31.0 | 7.00 | 85.7 |
| | 1.173 | $^{60}Co$ | 136 | 4.95 | 27.5 | 96.4 |
| | 1.332 | $^{60}Co$ | 122 | 4.90 | 24.9 | 96.0 |
| 3. | Section I, Sample #2 - 70 hours at 250°F | | | | | |
| | 0.321 | $^{51}Cr$ | 12.5 | 0.27 | 46.3 | 97.8 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 45.3 | 3.07 | 14.8 | 93.2 |
| | 0.812 | $^{58}Co$ | 42.9 | 1.58 | 27.2 | 96.3 |
| | 0.834 | $^{54}Mn$ | 20.6 | 0.23 | 89.6 | 98.9 |
| | 1.115 | $^{65}Zn$ | 143 | 20.7 | 6.91 | 85.5 |
| | 1.173 | $^{60}Co$ | 91.4 | 3.30 | 27.7 | 96.4 |
| | 1.332 | $^{60}Co$ | 80.9 | 2.93 | 27.6 | 96.4 |

*Fresh NS-1 Solvent used.

Table III (Continued)

| | γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|---|
| A. 4. | Section I, Sample #2 - 94 hours at 250°F* | | | | | |
| | 0.321 | $^{51}Cr$ | 12.5 | 0.46 | 27.0 | 96.3 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 45.3 | 3.33 | 13.6 | 92.6 |
| | 0.812 | $^{58}Co$ | 42.9 | 1.22 | 35.2 | 97.2 |
| | 0.834 | $^{54}Mn$ | 20.6 | 0.25 | 82.4 | 98.8 |
| | 1.115 | $^{65}Zn$ | 143 | 18.7 | 7.65 | 86.9 |
| | 1.173 | $^{60}Co$ | 91.4 | 3.25 | 28.1 | 96.4 |
| | 1.332 | $^{60}Co$ | 80.9 | 2.80 | 28.9 | 96.5 |
| B. 1. | Section II (elbow) Sample #1 - 48 hours at 250°F | | | | | |
| | 0.321 | $^{51}Cr$ | 3.34[1] | 0.80 | 4.18 | 76.0 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 3.34[1] | 1.59 | 2.10 | 52.4 |
| | 0.812 | $^{58}Co$ | 0.89 | 0.26 | 3.38 | 70.4 |
| | 0.834 | $^{54}Mn$ | 0.17 | ---- | >10 | ---- |
| | 1.115 | $^{65}Zn$ | 28.4 | 12.93 | 2.20 | 54.5 |
| | 1.173 | $^{60}Co$ | 2.22 | 0.83 | 2.67 | 62.6 |
| | 1.332 | $^{60}Co$ | 2.00 | 0.70 | 2.86 | 65.0 |
| 2. | Section II (elbow) Sample #1 - 120 hours at 250°F | | | | | |
| | 0.321 | $^{51}Cr$ | 3.34 | 0.27 | 12.4 | 91.9 |
| | 0.512 | $^{58}Co+^{65}Zn$ | 3.34 | 0.86 | 3.88 | 74.2 |
| | 0.812 | $^{58}Co$ | 0.8 | 0.18 | 4.89 | 79.6 |
| | 0.834 | $^{54}Mn$ | 0.17 | <.05 | >3.40 | ---- |
| | 1.115 | $^{65}Zn$ | 28.4 | 5.74 | 4.95 | 79.8 |
| | 1.173 | $^{60}Co$ | 2.22 | 0.44 | 5.05 | 80.2 |
| | 1.332 | $^{60}Co$ | 2.00 | 0.37 | 5.41 | 81.5 |

*Fresh NS-1 Solvent used.

[1]Same counting geometry as Section I.

Table III (Continued)

| γ Energy (Mev) | Isotope | Original c/sec | After Cleaning c/sec | DF | % Removed |
|---|---|---|---|---|---|
| B. 3. Section II (elbow) Sample #2 - 70 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 3.12 | 0.48 | 6.50 | 84.6 |
| 0.512 | $^{58}Co$+$^{65}Zn$ | 3.32 | 0.98 | 3.39 | 70.5 |
| 0.812 | $^{58}Co$ | 0.89 | 0.18 | 4.94 | 79.3 |
| 0.834 | $^{54}Mn$ | 0.25 | 0.004 | 62.5 | 98.4 |
| 1.115 | $^{65}Zn$ | 27.6 | 7.95 | 3.47 | 71.2 |
| 1.173 | $^{60}Co$ | 2.25 | 0.52 | 4.33 | 76.9 |
| 1.332 | $^{60}Co$ | 2.02 | 0.46 | 4.39 | 77.2 |
| 4. Section II (elbow) Sample #2 - 94 hours at 250°F | | | | | |
| 0.321 | $^{51}Cr$ | 3.12 | 0.09 | 34.7 | 97.1 |
| 0.512 | $^{58}Co$+$^{65}Zn$ | 3.32 | 0.99 | 3.35 | 84.3 |
| 0.812 | $^{58}Co$ | 0.89 | 0.08 | 11.1 | 91.0 |
| 0.834 | $^{54}Mn$ | 0.25 | 0.06 | 4.17 | 76.0 |
| 1.115 | $^{65}Zn$ | 27.6 | 6.23 | 4.43 | 77.4 |
| 1.173 | $^{60}Co$ | 2.25 | 0.40 | 5.63 | 82.2 |
| 1.332 | $^{60}Co$ | 2.02 | 0.42 | 4.81 | 79.9 |

Table IV

CHEMICAL ANALYSIS OF PEACH BOTTOM DEPOSITS

| SAMPLE | µg Fe/cm² | µg Cu/cm² | µg Ni/cm² | µg Cr/cm² | µg Zn/cm² |
|---|---|---|---|---|---|
| A. PEACH BOTTOM II | | | | | |
| 1. Section I, Sample #3 | 330[1] | 3.85[1] | 40[1] | 53[1] | |
| Section I, Sample #3 after Decon | 20 | N.D.[2] | N.D.[2] | N.D.[2] | |
| Net | 310 | 3.85 | | 53 | |
| | | 4.5[3] | | | |
| 2. Section II, Sample #1 | 275 | Not determined | 14 | 30 | |
| 3. Section III, Sample #1 | 700 | Not determined | 42 | 44 | |
| B. PEACH BOTTOM III | | | | | |
| 1. Section I, Sample #1 | 612[1] | 25[1] | 57[1] | 175[1] | 181[1] |
| Section I, Sample #2 | 563 | 22 | 49 | 142 | 141 |
| 2. Section II, Sample #1 | 341 | <1 | 21 | 58 | 42 |
| Section II, Sample #2 | 228 | <1 | 10 | 66 | 37 |

[1] Atomic Absorption Analysis

[2] N.D. - Not detedted, may have been present in very small amounts

[3] X-ray fluorescence

## Table V

INSOLUBLE MATERIAL AFTER DECONTAMINATION

Weight of sloughed-off and undissolved material in Peach Bottom II Samples.

| SAMPLE | Inner Surface Area ($cm^2$) | Wt. of Residue(g) | Wt. per $cm^2$ |
|---|---|---|---|
| Section I, Sample #5 | 5.00 | 0.032 | 0.006 |
| Section II, Sample #2 | 4.68 | 0.033 | 0.007 |
| Section III, Sample #3 | 4.23 | 0.32 | 0.008 |
| Section III, Sample #5 | 3.51 | 0.038 | 0.011 |

## Table VI

Radioactivity of undissolved material in Peach Bottom II Samples

| | γ Energy | Isotope | Original c/sec | Residue c/sec | % Activity on Filter |
|---|---|---|---|---|---|
| 1. | Section I, Sample #5 | | | | |
| | 0.321 | $^{51}Cr$ | MN.D. | 0.20 | ----- |
| | 0.512 | $^{50}Co$+$^{65}Zn$ | 354 | 0.83 | 0.2 |
| | 0.812 | $^{58}Co$ | 342 | 0.65 | 0.2 |
| | 1.115 | $^{65}Zn$ | 834 | 4.55 | 0.6 |
| | 1.173 | $^{60}Co$ | 1467 | 10.8 | 0.7 |
| | 1.332 | $^{60}Co$ | 1296 | 9.77 | 0.7 |
| 2. | Section II, Sample #2 | | | | |
| | 0.321 | $^{51}Cr$ | 67.2 | ---- | <0.1 |
| | 0.512 | $^{58}Co$+$^{65}Zn$ | 35.1 | 0.06 | 0.2 |
| | 0.812 | $^{58}Co$ | 56.1 | 0.02 | <0.1 |
| | 1.115 | $^{65}Zn$ | 103 | 0.43 | 0.4 |
| | 1.173 | $^{60}Co$ | 122 | 0.57 | 0.5 |
| | 1.332 | $^{60}Co$ | 107 | 0.64 | 0.6 |

Table VI (Continued)

| | γ Energy | Isotope | Original c/sec | Residue c/sec | % Activity on Filter |
|---|---|---|---|---|---|
| 3. | Section III, Sample #3 | | | | |
| | 0.321 | $^{51}Co$ | 108 | -- | <0.1 |
| | 0.512 | $^{50}Co$+$^{65}Zn$ | 81.4 | 0.25 | 0.3 |
| | 0.812 | $^{58}Co$ | 71.4 | -- | <0.1 |
| | 1.115 | $^{65}Zn$ | 449 | 0.52 | 0.1 |
| | 1.173 | $^{60}Co$ | 185 | 0.65 | 0.4 |
| | 1.332 | $^{60}Co$ | 164 | 0.67 | 0.4 |
| 4. | Section III, Sample #5 | | | | |
| | 0.321 | $^{51}Cr$ | 127 | 0.78 | 0.6 |
| | 0.512 | $^{58}Co$+$^{65}Zn$ | 91.8 | 0.51 | 0.6 |
| | 0.812 | $^{58}Co$ | 74.1 | 0.41 | 0.6 |
| | 1.115 | $^{65}Zn$ | 517 | 3.40 | 0.7 |
| | 1.173 | $^{60}Co$ | 184 | 3.50 | 1.9 |
| | 1.332 | $^{60}Co$ | 162 | 2.81 | 1.7 |

## Table VII

RADIOSOTOPES REMOVED FROM PEACH BOTTOM III

REGENERATIVE HEAT EXCHANGER

| Radioisotope | μ Ci/ml | Error | Ci/System (625 gal) |
|---|---|---|---|
| $^{60}Co$ | 1.25 | ±2% | 2.94 |
| $^{65}Zn$ | 2.72 | ±2% | 6.39 |
| $^{134}Cs$ | 0.07 | +15% | 0.16 |
| $^{137}Cs$ | 0.09 | ±10% | 0.21 |
| $^{58}Co$ | 0.18 | ±6% | 0.42 |
| $^{54}Mn$ | 0.15 | ±7% | 0.35 |
| $^{51}Cr$ | 0.06 | ±17% | 0.14 |
| Total Ci/system | | | 10.6 |

Table VIII

RADIOSOTOPES REMOVED FROM PEACH BOTTOM II

REGENERATIVE HEAT EXCHANGER

| Radiosotope | μ Ci/ml | Error | Ci/System (605 gal) |
|---|---|---|---|
| $^{60}Co$ | 1.48 | ±3% | 3.38 |
| $^{65}Zn$ | 1.22 | ±5% | 2.79 |
| $^{54}Mn$ | $2.9X10^{-2}$ | ±5% | 0.07 |
| $^{58}Co$ | $2.5X10^{-2}$ | ±5% | 0.06 |
| $^{137}Cs$ | $1.1X10^{-3}$ | ±50% | 0.002 |
| $^{57}Co$ | $8X10^{-4}$ | ±20% | 0.002 |
| Total Ci/system | | | 6.30 |

## TABLE IX

REGEN. HEAT EXCHANGER DOSE RATES mR/HR.

| NO. | Contact Readings- LOCATION | Before $H_2O$ Flush | Before NS-1 Flush | After NS-1 Flush |
|---|---|---|---|---|
| 1. | Channel Drain | 600 | 400 | 75 |
| 2. | Channel Drain | 800 | 400 | 15 |
| 3. | Channel Vent | 2000 | 500 | 150 |
| 4. | Channel Vent | 2000 | 550 | 100 |
| 5. | Channel Drain | 6000 | 500 | 100 |
| 6. | Channel Drain | 5000 | 550 | 80 |
| 7. | Channel Vent | 600 | 300 | 130 |
| 8. | Channel Vent | 800 | 500 | 75 |
| 9. | Channel Drain | 8000 | 350 | 200 |
| 10. | Channel Drain | 15000 | 350 | 75 |
| 11. | Channel Vent | 300 | 200 | 75 |
| 12. | Channel Vent | 300 | 200 | 50 |
| 13. | Bottom of Channel Hd. | --- | 200 | 15 |
| 14. | Bottom of Channel Hd. | --- | 250 | 15 |
| 15. | Bottom of Channel Hd. | --- | 200 | 15 |
| 16. | Shell to Channel Joint | --- | 200 | 50 |
| 17. | Shell to Channel Joint | --- | 300 | 50 |
| 18. | Shell to Channel Joint | --- | 250 | 50 |
| 19. | Shell Flange | 2000 | 700 | 100 |
| 20. | Shell Flange | 2000 | 600 | 140 |
| 21. | Shell Flange | 2000 | 500 | 150 |
| 22. | Channel Outlet | 500 | 600 | 75 |
| 23. | 4" Crossover (Channel) | --- | 400 | 60 |
| 24. | 4" Crossover (Shell) | --- | 400 | 100 |
| 25. | 4" Crossover (Channel) | --- | 400 | 80 |
| 26. | 4" Crossover (Channel) | --- | 350 | 150 |
| 27. | 4" Crossover (Channel) | --- | 350 | 100 |
| 28. | Channel Inlet | 1000 | 200 | 50 |
| 29. | Channel Outlet | --- | 400 | 100 |
| 30. | Shell Inlet | --- | 200 | 50 |
| 31. | 4" Crossover (Shell) | --- | 100 | 30 |
| 32. | End of Shell | --- | 70 | 30 |
| 33. | End of Shell | --- | 350 | 100 |
| 34. | End of Shell | --- | 1000 | 75 |
| 35. | Shell Drain | --- | 1000 | 700 |
| 36. | Midsection of Bottom Shell | --- | 500 | 175 |
| 37. | Midsection of Middle Shell | --- | 500 | 200 |
| 38. | Midsection of Top Shell | --- | 2000 | 325 |
| GENERAL AREA DOSE RATE MR/HR AVERAGE | | 265 | 250 | 35* |

*After removal of 11 Curies

($CO_{60}$, $ZN_{65}$, $MN_{54}$)

## TABLE X

REGEN. HEAT EXCHANGER DOSE RATES mR/HR.

| NO. | Contact Readings - LOCATION | Before $H_2O$ Flush | Before NS-1 Flush | After NS-1 Flush |
|---|---|---|---|---|
| 1. | Channel Drain | 2000 | 1500 | 600 |
| 2. | Channel Drain | 2500 | 1500 | 500 |
| 3. | Channel Vent | 7000 | 6000 | 200 |
| 4. | Channel Vent | 2500 | 3500 | 250 |
| 5. | Channel Drain | 2500 | 2200 | 275 |
| 6. | Channel Drain | 2000 | 2000 | 300 |
| 7. | Channel Vent | 3000 | 2000 | 400 |
| 8. | Channel Vent | 2500 | 3000 | 350 |
| 9. | Channel Drain | 2800 | 5000 | 500 |
| 10. | Channel Drain | 2500 | 2000 | 400 |
| 11. | Channel Vent | 1500 | 800 | 350 |
| 12. | Channel Vent | 1500 | 1000 | 350 |
| 13. | Bottom of Channel Hd. | --- | 500 | 125 |
| 14. | Bottom of Channel Hd. | --- | 500 | 110 |
| 15. | Bottom of Channel Hd. | --- | 400 | 200 |
| 16. | Shell to Channel Joint | 500 | 350 | 150 |
| 17. | Shell to Channel Joint | 600 | 150 | 125 |
| 18. | Shell to Channel Joint | 2500 | 250 | 150 |
| 19. | Shell Flange | 600 | --- | 220 |
| 20. | Shell Flange | 700 | --- | 280 |
| 21. | Shell Flange | 2500 | --- | 400 |
| 22. | Channel Outlet | 500 | 600 | 150 |
| 23. | 4" Crossover (Channel) | 500 | 500 | 180 |
| 24. | 4" Crossover (Shell) | 700 | 400 | 200 |
| 25. | 4" Crossover (Channel) | 700 | 1800 | 150 |
| 26. | 4" Crossover (Channel) | 1500 | 800 | 125 |
| 27. | 4" Crossover (Channel) | 2000 | 1000 | 150 |
| 28. | Channel Inlet | 500 | 600 | 200 |
| 29. | Channel Outlet | 500 | 300 | 100 |
| 30. | Shell Inlet | 150 | 50 | 40 |
| 31. | 4" Crossover (Shell) | 75 | 75 | 50 |
| 32. | End of Shell | 75 | 50 | 50 |
| 33. | End of Shell | 150 | 75 | 150 |
| 34. | End of Shell | 100 | 75 | 80 |
| 35. | Shell Drain | 100 | 3000 | 600 |
| 36. | Midsection of Shell (Bottom) | 150 | 100 | 150 |
| 37. | Midsection of Shell (Middle) | 300 | 300 | 300 |
| 38. | Midsection of Shell (Top) | 2800 | 700 | 125 |
| GENERAL AREA DOSE RATE MR/HR AVERAGE | | 350 | 300 | 60* |

*After removal of 7 Curies

($CO_{60}$, $ZN_{65}$, MN 54)

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