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PEACH BOTTOM HTGR DECOMMISSIONING AND COMPONENT REMOVAL

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ABSTRACT

Peach Bottom Unit 1, owned and operated by Philadelphia Electric Company, was the first prototype HTGR in the United States. The 40-MW(e) plant operated successfully with an overall nuclear steam supply system availability of 88% from June 1967 until October 1974, when it was shut down for decommissioning which permitted selective component removal.

The decision to decommission the Peach Bottom HTGR was based on a study of the benefits to be derived from further operation beyond depletion of Core 2 relative to the investment necessary to satisfy the AEC's requirement for a full-term license. Based on technical and economic evaluations of several options, a mothballing of the facility under a Part 50 Possession Only License was selected. The decommissioning activities now nearing completion involve the following:

1. Shipment off-site of all fuel and source materials for storage and eventual reprocessing.

2. Removal from the containment of liquids, pressurized gases, and flammable materials.

3. Decontamination and retirement of major equipment.

4. Removal and burial of fission product traps, delay beds, and contaminated materials.

5. Complete closure of the primary system.

6. Release of control room, laboratories, etc. for unrestricted use.

Peach Bottom Unit 1 decommissioning also offered a unique opportunity to conduct end-of-life research and surveillance in an HTGR. With agreement of Philadelphia Electric Company, a contract was negotiated between General Atomic, ERDA, and EPRI, and in March 1975 the Peach Bottom End-of-Life Program was initiated. The prime objective of this program is to validate specific HTGR design codes and predictions by comparison of actual and predicted physics, thermal, fission product, and materials behavior in Peach Bottom.

Three consecutive phases of the program provide input to the HTGR design methods verifications:

1. Nondestructive fuel and circuit gamma scanning.
2. Removal of steam generator and primary circuit components.
3. Laboratory examinations of removed components.

The component removal activities were performed largely by Catalytic, Inc., under subcontract to General Atomic, with site support services provided by Philadelphia Electric.

Component removal site work commenced with establishment of restricted access areas and installation of controlled atmosphere tents to retain relative humidity at <30%. A mock-up room was established to test and develop the tooling and to train operators under simulated working conditions. Primary circuit ducting samples were removed by trepanning, and steam generator access was achieved by a combination of arc gouging and grinding. Tubing samples were removed using internal cutters and external grinding. The special tooling used was developed by Power Cutting, Inc., under subcontract to Catalytic, Inc. Throughout the component removal phase, strict health physics, safety, and quality assurance programs were implemented.

A total of 148 samples of primary circuit ducting and steam generator tubing were removed with no significant health physics or safety incidents. These samples were packaged in special inerted containers for shipment to General Atomic. Additionally, component removal served to provide access for determination of cesium plateout distribution by gamma scanning inside the ducts and for macroexamination of the steam generator from both the water and helium sides. Evaluations at General Atomic are continuing and indicate excellent performance of the steam generator and other materials, together with close correlation of observed and predicted fission product plateout distributions.

It is concluded that such a program of end-of-life research, when appropriately coordinated with decommissioning activities, can significantly advance nuclear plant and fuel technology development.

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1. INTRODUCTION

The Peach Bottom Atomic Power Station Unit No. 1, owned and operated by Philadelphia Electric Company, was the first installation of a High-Temperature Gas-Cooled Reactor (HTGR) in the United States. Power operation began in January 1967 and commercial operation on June 1, 1967. The plant was operated successfully through October 31, 1974 when it was shut down for decommissioning. The Peach Bottom nuclear steam supply (NSS) system, designed and supplied by General Atomic Company, generated more than 3.72 million MW(t)-hr and 1.38 million gross MW(e)-hr for an average gross plant thermal efficiency of 37.2%. The Peach Bottom NSS produced 1000°F superheated steam at a pressure of 1450 $lb/in.^2$, with an overall lifetime availability of 88%. The plant produced over 1.2 million MW(e)-hr for the Philadelphia Electric Company grid over a lifetime of 1349 equivalent full power days (EFPDs), with a gross plant capacity factor of 74%.

In addition to producing commercial power, Peach Bottom was a demonstration nuclear power station. This status required that power changes, including shutdowns, be performed to accommodate testing of plant systems and components under the USAEC-sponsored postconstruction research and development program. Such surveillance programs to monitor core component performance, fission product release and plateout, circulating activity, coolant chemistry, and other important features of reactor operation were continued throughout reactor lifetime by General Atomic and Oak Ridge National Laboratory. In addition, during the operation of Core 2 more than 30 fuel test elements were installed and irradiated as part of a fuel testing program for advanced HTGRs.

The overall performance of the Peach Bottom HTGR, from a standpoint of both fuel and plant, was particularly gratifying. Although fuel problems were encountered in Core 1, Peach Bottom successfully demonstrated that, even with significant fuel failure present in the core, plant operation was not impaired and reactor operation could be continued safely. Throughout Peach Bottom operation excellent agreement was found between predicted and actual core physics characteristics, thus verifying the methods used. Additionally, the steam generators operated almost 8 years without tube leaking or plugging; the reactor control system functioned exceptionally well, receiving commendation from Philadelphia Electric operators; and the performance of almost all reactor systems was without major problems, verifying in many areas the design philosophy applied to Fort St. Vrain and large HTGRs.

Subsequent to reactor shutdown, the Peach Bottom End-of-Life Program, co-sponsored by ERDA and EPRI, was initiated. The prime objective of this program is to validate specific HTGR design codes and assumptions by comparison of actual with predicted physics, thermal, fission product, and materials behavior in Peach Bottom. Additionally, the program complements the surveillance activities which were ongoing throughout the plant lifetime and serves to expand the base of HTGR plant and fuel technology.

The background, scope, and details of activities involved in plant decommissioning and primary circuit component removal under the End-of-Life Program form the basis of this paper.

2. BACKGROUND

The decision to shut down and decommission the Peach Bottom HTGR was based upon several factors. First and foremost was the fact that the program for which the plant had been originally designed was completed; that is, the objective of demonstrating the technical feasibility and commercial operation of an HTGR had met with outstanding success. Second, the continued progress of the evolution of the HTGR was to be continued in the Fort St. Vrain plant, which is currently in the startup phase. Third, the size of the Peach Bottom Unit 1 plant [40 MW(e)] made it uneconomical in terms of operating costs or manpower relative to the large nuclear plants recently placed in operation by Philadelphia Electric (i.e., Peach Bottom Units 2 and 3). Finally, it was determined that the changes incorporated in the USAEC safety and licensing requirements since 1966 would necessitate major retrofitting of the plant to meet revised safety criteria prior to obtaining a permanent operating license. In 1972 Philadelphia Electric and General Atomic consequently decided that continued operation after Core 2 end-of-life was not warranted, and a third core for Peach Bottom was not authorized.

An evaluation of the cost, schedule, safety, licensing, and other implications of the decommissioning was performed by Philadelphia Electric Company and SUNTAC Nuclear Corporation.* Several options for the decommissioning of the Peach Bottom plant were considered including: (1) total removal of all facilities, (2) in-place entombment, and (3) mothballing. Based on the technical and economic evaluations of the various options, mothballing, consistent with keeping the facility under a Part 50 Possession Only License, was selected (Ref. 1). This also resulted in the least personnel exposure (during decommissioning) and the least hazard to the public due to high-level radioactive waste shipping.

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*A joint venture between Catalytic, Inc., and NUS Corporation dissolved in 1975.

The intent of the mothballing was to reduce the controlled access area to include only the reactor containment vessel and spent fuel building. Within the containment vessel, all radiation areas of >1.0 mR/hr or areas which might be contaminated would be restricted and marked to show radiation levels. The maximum radiation level at the facility fence and wall would be reduced to <0.04 mR/hr. By this means, the facility condition would meet the published guidelines for release of decommissioned reactor facilities in all accessible areas.

Peach Bottom Unit No. 1 decommissioning also offered a unique opportunity to conduct end-of-life research and surveillance on an HTGR. During 1974, several such end-of-life programs of different scopes were proposed by General Atomic, the component removal phases of which were costed out by SUNTAC Nuclear Corporation. These component removal options included (1) complete steam generator tube bundle removal, (2) partial tube bundle removal, and (3) selective tube sample removal. A program incorporating removal of primary circuit ducting samples and tubing sections from each of three sections of a steam generator was finally selected for joint funding by ERDA and EPRI, and in March 1975 the Peach Bottom End-of-Life Program was initiated.

The HTGR design methods verifications under the Peach Bottom End-of-Life Program utilize the input obtained during three consecutive phases of the program together with results from ongoing postirradiation examinations of driver fuel elements at ORNL. The three phases are: (1) nondestructive fuel and circuit gamma scanning at the Peach Bottom site, (2) removal of steam generator and primary circuit components, and (3) laboratory examination of removed components.

Component removal was crucial in providing samples for subsequent radiochemical, metallurgical, and tritium permeation tests and analyses, and for absolute calibration of prior gamma scan results (Refs. 2, 3, 4). Component removal also served to provide access for determination of cesium plateout distribution by gamma scanning inside the ducts (Ref. 4), and for macroexamination of the steam generator from both the water and helium sides (Ref. 2). The component removal activities were performed largely by Catalytic, Inc., under subcontract to General Atomic, with site support services provided by Philadelphia Electric. A detailed account of the work performed by Catalytic, Inc., under the component removal subcontract is given in Ref. 5.

3. DECOMMISSIONING ACTIVITIES

3.1. SCOPE

Peach Bottom Unit No. 1 decommissioning, now close to completion, is being performed by Philadelphia Electric and by Catalytic, Inc. under subcontract to Philadelphia Electric. Catalytic has further utilized construction labor provided by Philadelphia Electric. The following major activities are involved:

1. Preparation and approval of the decommissioning plan and safety analysis report.

2. Defueling of the reactor and shipment off-site of all fuel and source materials for storage and eventual reprocessing.

3. Removal from the containment of liquids, pressurized gases, and flammable materials.

4. Cutting and capping of containment penetrations, and subsequent venting of containment to atmosphere.

5. Decontamination of and retirement of major equipment.

6. Removal and burial of fission product traps, delay beds, and contaminated materials.

7. Complete closure of the primary system.

8. Release of control room, laboratories, etc., for unrestricted use.

The objective of the decommissioning was to establish the facility in a safe unmanned status except for a semiannual inspection. In order to provide for this objective and allow for deletion of appropriate surveillance requirements at key milestones, the Decommissioning Plan (Ref. 6) identified four phases as follows:

Phase 1 - Removal of all fuel from the reactor and degassing of the purification system.

Phase 2 - Shipment of all spent fuel from the Peach Bottom site and removal of contaminated systems.

Phase 3 - Final lay-up of containment and removal of the radioactive waste system and components.

Phase 4 - Unmanned status with responsibility under the Part 50 Possession Only License for periodic inspections of the facilities within the newly established Exclusion Area.

Details of the planning and decommissioning on-site are given below.

3.2. DECOMMISSIONING DETAILS

3.2.1. Planning and Engineering

The Decommissioning Plan and Safety Analysis Report (Ref. 6) was prepared and submitted to the NRC on August 29, 1974. This plan described the activities for decommissioning and presented a safety analysis which demonstrated that the Peach Bottom facility would be placed in a status which would not present a hazard to the health and safety of the public. The plan called for removal of all radioactivity outside of an Exclusion Area fence, within which would remain the containment building and the fuel storage pool (see Fig. 1). All-spent fuel was to be removed from the reactor vessel and shipped off-site. All systems containing radioactivity

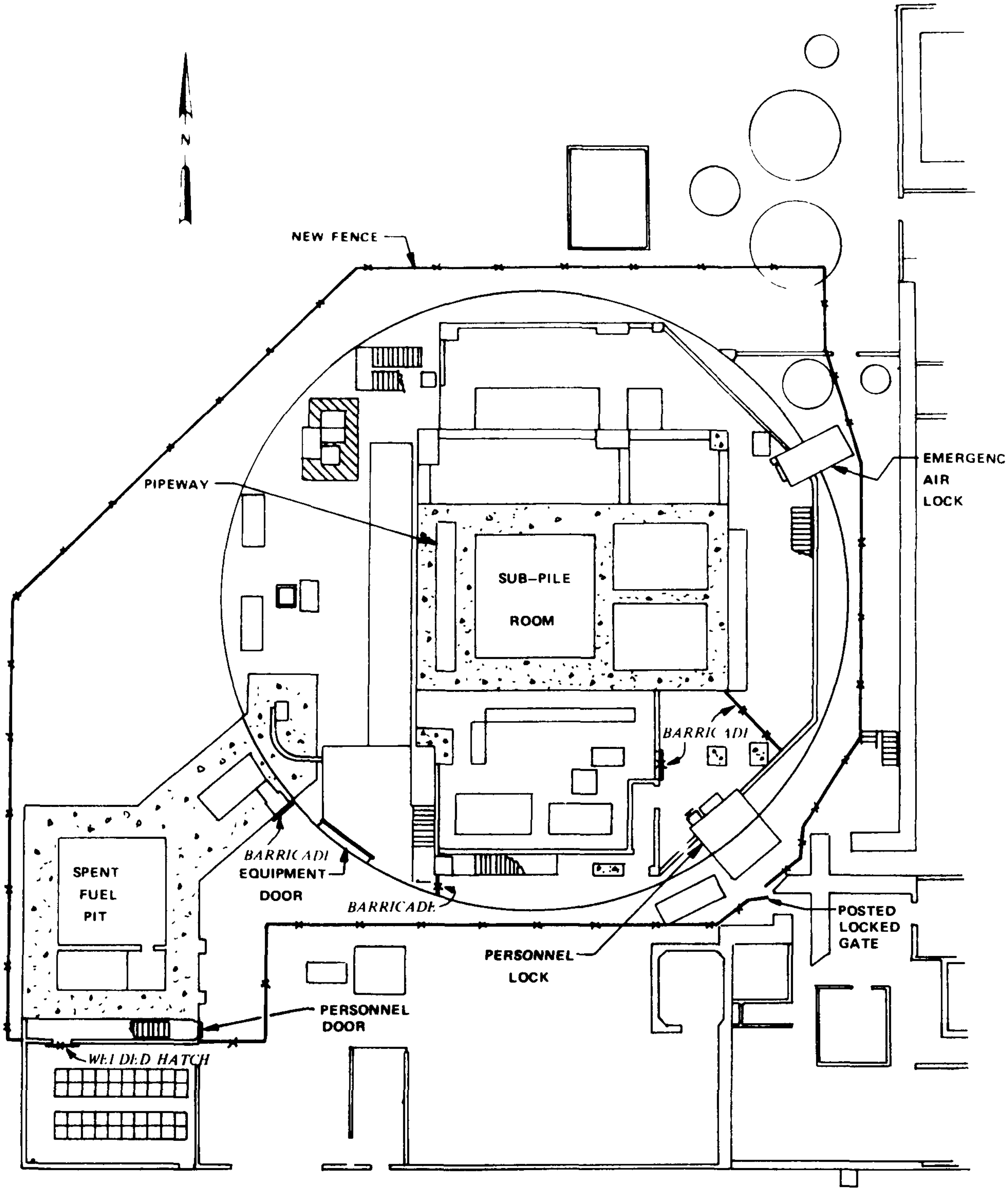

Fig. 1. Peach Bottom HTGR site layout after decommissioning

which were outside of the containment building and spent fuel pool building were to be removed or decontaminated to levels less than those specified in Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, "Acceptable Surface Contamination Levels."

The decommissioning plan was accompanied by an application for an amendment to the Provisional Operating License requesting that, once all fuel was removed from the reactor, the Part 50 Utilization License (DPR-12) would be surrendered and a Part 50 Possession Only License would go into effect. Amendment No. 6 to the Provisional Operating License was issued on July 14, 1975. This amendment allowed Philadelphia Electric Company to possess, but not operate, the reactor as a utilization facility. Included in this amendment was Change No. 19 to the Technical Specifications. The revised Technical Specifications provided for the maintenance of the retired facility and contained provisions for the deletion of certain sections upon completion of the key milestones in Phases 1, 2, and 3 during decommissioning.

Implementation of the Decommissioning Plan at the site was enhanced by the preparation of a series of work packages which detailed the construction activities to be performed. Separate work packages were prepared for each commitment described in the Decommissioning Plan. The work packages included details on the necessary prerequisites, materials required, Quality Assurance, and radiation protection. An estimate of the man-hours required for each task was made based on the work packages, and a schedule for decommissioning was prepared. The work packages formed the basis for the necessary documentation of the decommissioning and were used to verify that all activities were in compliance with the Decommissioning Plan. All work packages were reviewed and approved by the Philadelphia Electric Company.

3.2.2. Phase 1 Activities

Preparations for defueling the reactor commenced immediately following final shutdown. The removal of Core 2 from the Peach Bottom Unit No. 1 reactor was completed on June 11, 1975. All 804 fuel elements were canned, leak tested, and stored in the spent fuel pool. Fuel inventory was maintained by the use of individual record cards for each fuel element. Several logs and core maps were also utilized to enhance fuel inventory controls. A total of 513 dummy elements were inserted into the core to maintain lateral support of the core during defueling. Dummy insertion control sheets were utilized to document the loading of dummy elements into the core. With the exception of one control rod absorber and three hexagonal reflector elements (GA surveillance program) no other components were removed from the reactor. During defueling, the primary coolant system, purification system, helium transfer systems, closed coolant systems, and emergency power systems remained in service to provide core cooling and control of impurity levels.

Following defueling of the reactor, a temperature monitoring test program was conducted to ensure that heat generation within the reactor vessel would not be excessive. The test was conducted in accordance with the procedure presented in Appendix B of the Decommissioning Plan. All forced and convection cooling was terminated and the reactor vessel was allowed to heat up from activation product decay heat. The test revealed negligible decay heat levels within the vessel, resulting in no significant rise above ambient temperatures. It was, therefore, concluded that there was sufficient dissipation of the activation product decay heat such that the reactor vessel might be safely layed up under an atmospheric environment.

Subsequent to the defueling of the reactor, degassing of the helium purification system delay beds to desorb all gaseous activity was started. The helium purification system, or external fission product trapping system, consists of a series of water and brine cooled charcoal traps as shown in Fig. 2. The purpose of degassing the delay beds was to establish a controlled release of all removable gaseous activity from the site. The charcoal was heated to an average of 110°F, well above normal operating temperatures. The delay bed effluent was collected in a holdup tank and sampled prior to release under controlled conditions and in accordance with the Technical Specifications. At the conclusion of the heating and purging operation, all helium systems were purged with nitrogen. The degassing and

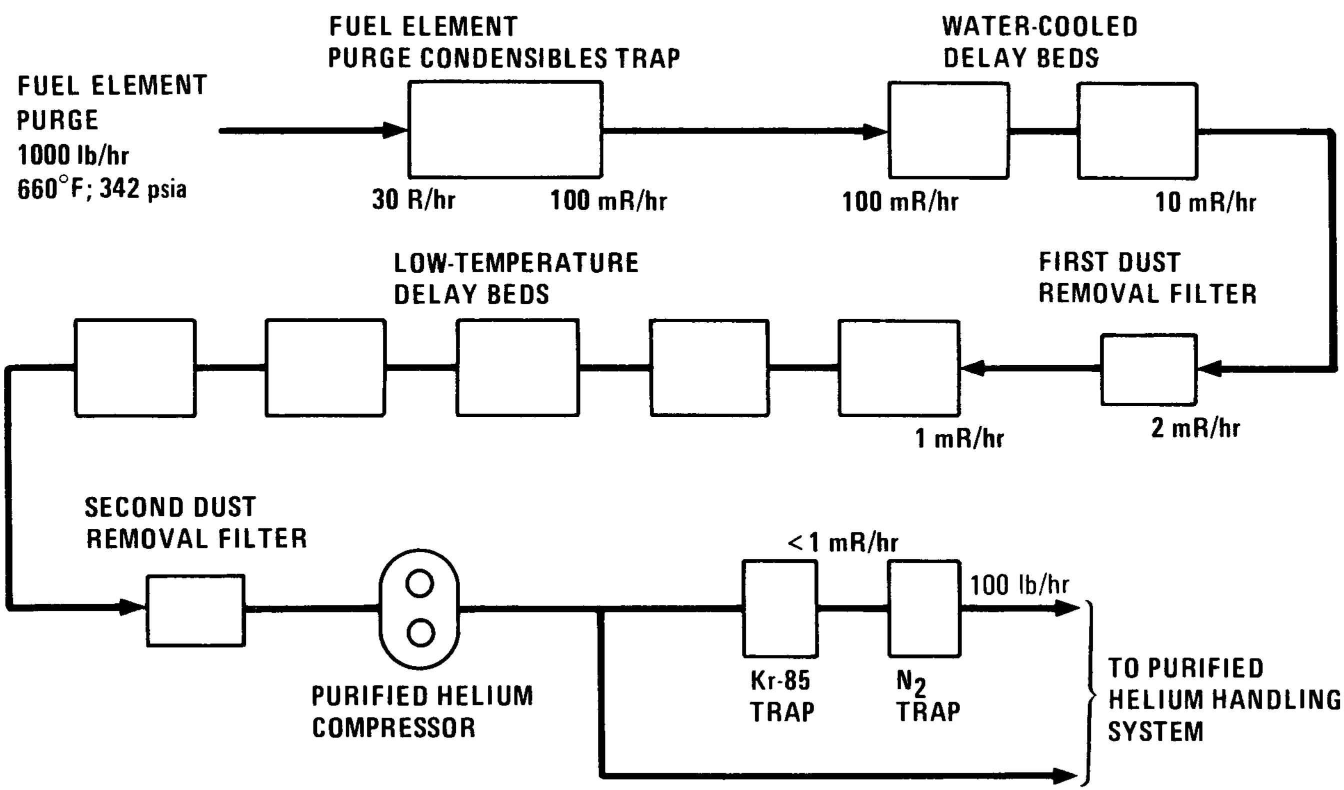

Fig. 2. Simplified schematic of external fission product trapping system showing contact radiation levels

purging of the helium systems were completed on July 24, 1975. The quantity of removable radioactive gases released from the purification system totaled only 3.5 Curies of Kr-85 and 0.25 Curies of tritium.

3.2.3. Phase 2 Activities

Shipment of spent fuel to Aerojet Nuclear Company (now EG&G) in Idaho utilizing two shipping casks was started on June 24, 1975. A total of 44 fuel shipments in the 18 element casks were made. The shipments were made by truck in an overweight cask. The necessity of obtaining overweight permits caused considerable delay in shipping all the fuel from the site. The last fuel shipment was made on February 17, 1977 and was received in Idaho on February 26, 1977. One non-fuel shipment was made in the fuel shipping cask to dispose of a control rod guide tube and reflectors removed from the reactor vessel. In addition to the normal fuel shipments, 27 fuel shipments, were made in the single-element Hallam fuel shipping cask. Of these 27 shipments, 25 contained fuel elements, one a control rod, and one a core reflector. These shipments were made in support of the Peach Bottom Post-Irradiation Experimental Program conducted by General Atomic. Following shipment of all fuel, the spent fuel pool was drained and the water processed through the radioactive waste system prior to release.

3.2.4. Phase 3 Activities

Due to the nature of the Phase 3 activities, it was possible to continue with many of these concurrently with spent fuel shipment under Phase 2. The plant components removed and other activities completed to date are listed in Table 1.

During the period from February 1976 to July 1976 the helium purification system delay beds and other contaminated components were removed and shipped to the licensed burial sites at Morehead, Kentucky and Barnwell, South Carolina. In addition 200 gallons of tritiated liquid radioactive waste and 300 gallons of contaminated oil were solidified and shipped to the burial grounds. Of these activities, the removal and shipment of the

TABLE 1
PLANT COMPONENTS REMOVED AND OTHER
ACTIVITIES COMPLETED TO DATE

Components Removed

- Filter cartridges from lube and seal oil system on the main helium compressors
- Charcoal from oil absorber
- Condensible trap and water-cooled delay beds
- Primary loop dust filters and collectors
- Liquid nitrogen traps
- Chemical mixing tank
- Pump-down plateout absorber
- Charcoal from oil removal filters
- Steam generator purge plateout trap
- First and second dust filters
- Waste disposal drain tank
- Purified helium compressor oil filter cartridges
- Low-temperature delay beds

Pipes and Lines Sealed

- Selected containment pipe penetrations
- Both helium circulator shaft openings

Contaminated Waste Solidified

- 200 gallons of liquid radioactive waste
- 300 gallons of contaminated oil

delay beds constituted the major effort of the decommissioning. The first delay bed, the fuel element purge condensibles trap, had an inlet contact radiation level of 30 R/hr. This was the highest contact radiation level experienced on all of the delay beds removed as shown in Table 2. Except for the condensibles trap, all delay beds were shipped to the burial ground in a plywood crate. The condensibles trap was encased in 1-ft thick concrete and enclosed in a plywood crate. Additional shipments of contaminated components, trash, charcoal absorbers, and miscellaneous piping generated by the decommissioning activities were made to the burial grounds.

In order to facilitate removal of the delay beds, a monorail was erected. Although the removal could have been accomplished using A-frames and dollies, the use of the monorail was consistent with ALARA practices. Personnel exposures were less than 300 mr for delay bed removal. Anticontamination clothing was worn for the condensible trap and water-cooled delay bed removal. No protective clothing was required for the low-temperature delay bed removal. All pipes cut for delay bed removal were capped and seal-welded. A pressure test was made on the seal welds to ensure primary system integrity.

Phase 3 removal and decontamination activities are still continuing; the main outstanding items are shown in Table 3. It is currently foreseen that Phase 3 will be completed in the fall of 1977.

TABLE 2
PEACH BOTTOM 1 FISSION PRODUCT TRAP RADIATION LEVELS

Trap	On Contact (mR/hr)	
	At Inlet	At Outlet
Condensible trap	30,000	100
First WCDB	100	100
Second WCDB	10	10
First dust filter	2	2
First LTDB	<1	<1
Second LTDB	<1	<1
Third LTDB	<1	<1
Fourth LTDB	<1	<1
Fifth LTDB	<1	<1
Second dust filter	<1	<1
Both LN_2 traps	<1	<1

TABLE 3
DECOMMISSIONING ACTIVITIES REMAINING UNDER PHASE 3

Liquid waste system	Remove tanks and piping; decontaminate building
Ventilation system	Remove exhaust filters and ducts; decontaminate if necessary
Spent fuel pit equipment	Remove and decontaminate (including spent fuel cask fixtures)
Spent fuel pit cooling system	Remove; cut and cap building pipe penetrations
Fuel handling equipment	Decommission
Inspection access area	Survey and decontaminate
Radioactive waste tanks	Seal shower, sink and laundry drains
Containment	Install absolute filter; seal containment door
Miscellaneous	Cut and cap miscellaneous penetrations; erect gates, barricades, etc.

4. COMPONENT REMOVAL ACTIVITIES

4.1. SCOPE

In addition to the decommissioning activities covered briefly in Section 3 and in more detail in Refs. 1 and 6, selective removal of primary circuit components in support of the Peach Bottom End-of-Life Program was conducted on-site from October 1975 through February 1976. Catalytic, Inc., under subcontract to General Atomic, performed the component removal activities utilizing local Boilermaker labor with site support provided by Philadelphia Electric Company. The subcontract work scope included responsibility for planning, coordinating, and conducting the complete component removal program, including specialized tooling development, in order to provide the items identified in Table 4. All items were to be provided in accordance with General Atomic Specification 167-56-4 and the provisions of Subcontract SC565235.

Trepan samples and locations, called out in Specification 167-56-4 and shown in Fig. 3, were selected to provide absolute radiochemical calibration data to support previous primary circuit gamma scans. Steam generator tubing samples and locations (Fig. 4) were selected to represent all tubing bundles for subsequent laboratory analyses and also to support previous steam generator tubing gamma scans (Ref. 4). Locations also considered proposed sampling techniques and access restrictions.

The following major activities were involved in component removal:

1. Planning and engineering.

2. Site preparation (scaffolding, erection of tents, humidity control systems, etc.).

TABLE 4
ITEMS TO BE REMOVED OR PROVIDED BY CATALYTIC, INC.

1. Four trepanned samples of primary circuit ducting at each of 10 locations around the circuit (including two hot duct locations).

2. Twenty-six superheater, 20 evaporator, and 20 economizer tube sections, 14 to 18 in. long from the loop 1 steam generator.

3. Six tube sections passing through a baffle plate.

4. Two samples of the steam generator shroud - thermal barrier assembly.

5. One section of steam outlet pipe above the tubesheet.

6. Access to internals of steam generator for macroscopic examination by General Atomic personnel.

7. Access to internals of primary circuit ducting for internal gamma scanning by IRT Corporation.

NOTE: Primary circuit ducting and steam generator tube sample locations are shown in Figs. 3 and 4, respectively.

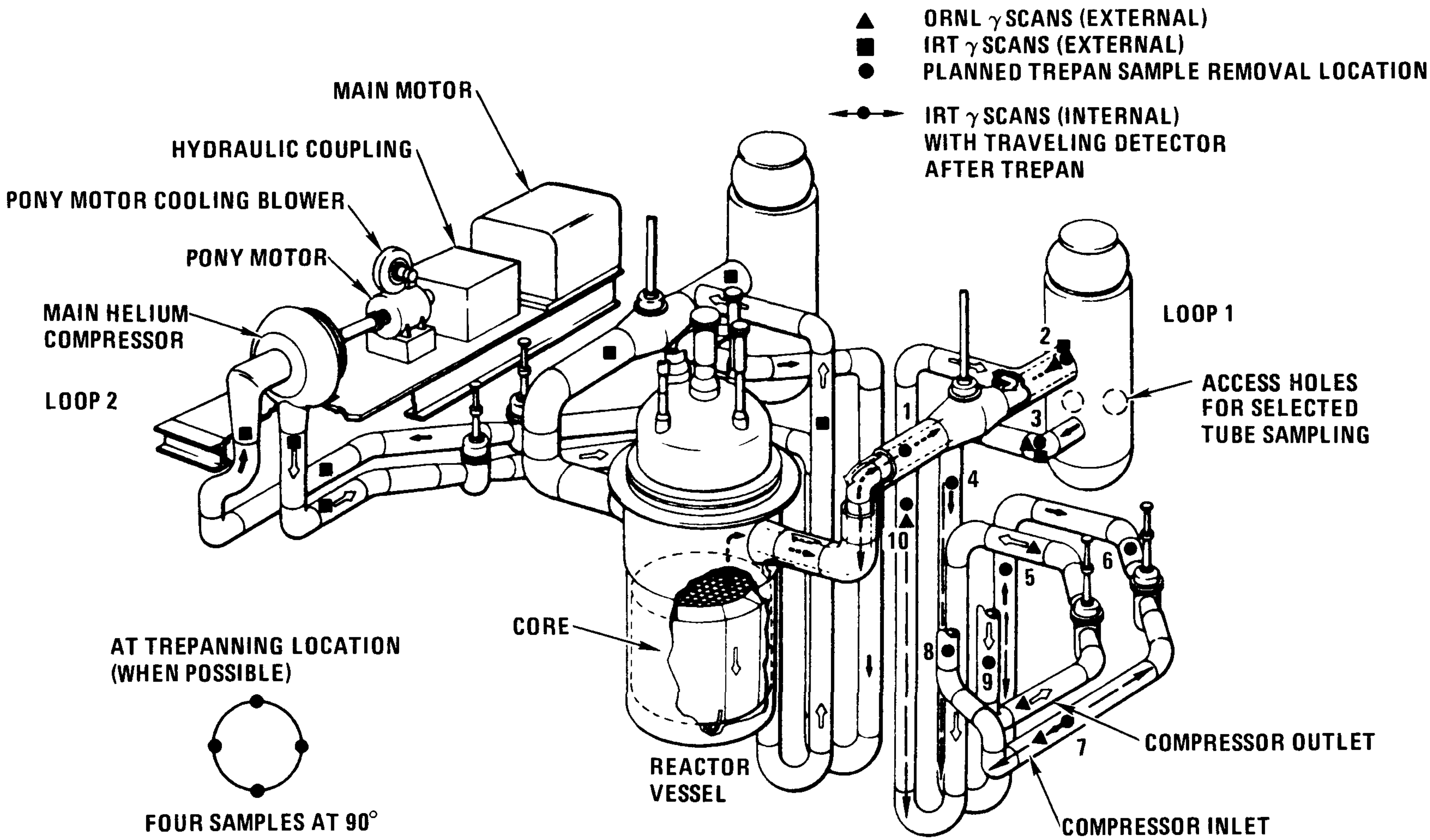

Fig. 3. Peach Bottom HTGR primary coolant system showing gamma scan and trepan sample removal locations

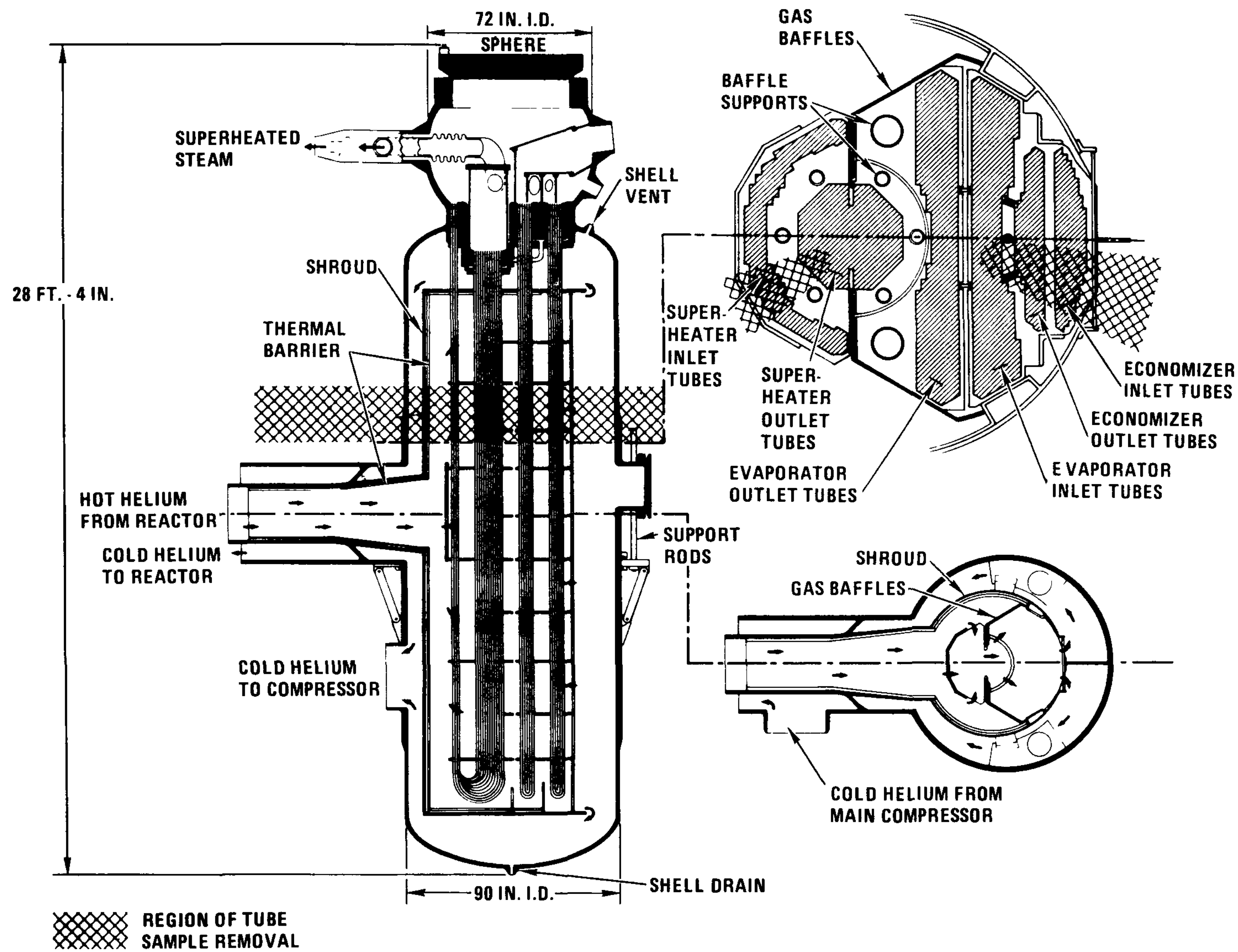

Fig. 4. Steam generator cross section showing regions of tube sample removal

3. Mock-up training and tooling development.

4. Duct trepanning operations.

5. Steam generator access.

6. Steam generator tube removal.

7. Restoration and cleanup.

Due to unanticipated difficulties encountered during certain phases of preparation and steam generator sample removal, the schedule of site activities extended somewhat longer than planned (see Fig. 5). Details of the component removal activities are given below.

4.2. COMPONENT REMOVAL DETAILS

4.2.1. Engineering and Planning

Based on General Atomic Specification 167-56-4, Catalytic Engineering developed specific methods for the removal and packaging of the samples. This involved the integration of the following major functions:

1. Development of engineering specifications.

2. Development of control work packages in accordance with the specifications.

3. Planning and scheduling.

4. Procurement - material and subcontracts.

5. Establishment of a Quality Assurance Plan in accordance with 10CFR50, Appendix B.

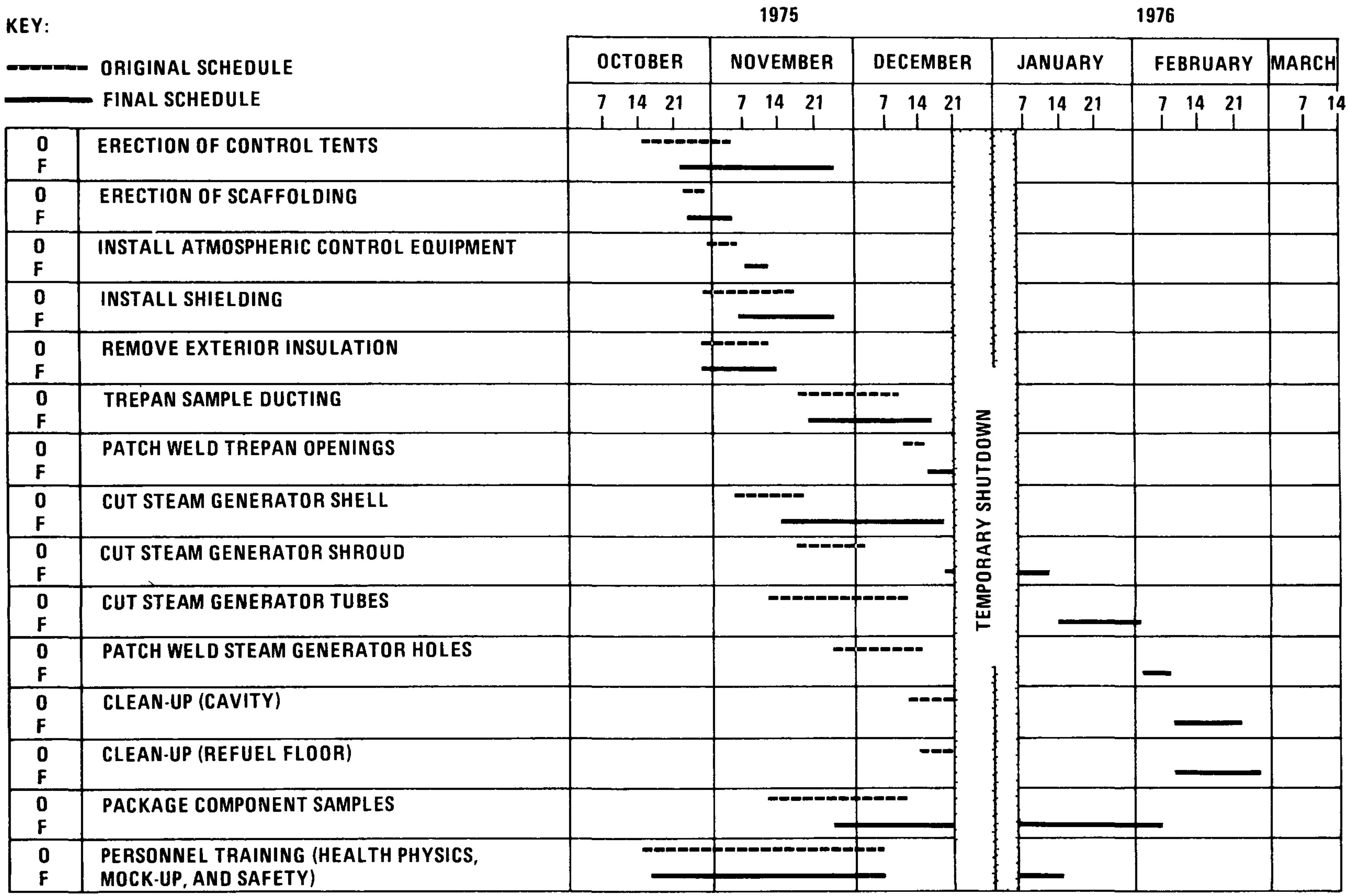

Fig. 5. End-of-life component removal schedules, original versus final

6. Establishment and implementation of health physics and safety programs.

7. Establishment of interfaces and agreements with Philadelphia Electric Company, Boilermakers Union, General Atomic, and Catalytic, Inc.

8. Initial site visits to plan approach to establishing restricted access and obtaining access to the samples.

Included in this phase was the design and fabrication of special packaging and shipping containers for the samples removed; establishment of procedures for ensuring sample identity, orientation, and traceability; and development of the specialized tooling for component removal.

The Quality Assurance program was approved by GA prior to initiation of field work. The Catalytic standard health physics plan was modified to meet the specific facility license of Philadelphia Electric Company. All work was scheduled using the critical path method and was performed in compliance with OSHA regulations.

4.2.2. Site Preparation

The preparation phase of the project included all work necessary prior to initiating actual component removal. This involved:

1. Initiation of site office.

2. Health physics, safety, and mock-up training of craftsmen.

3. Removal of the steam generator head and associated operations by Philadelphia Electric Company.

4. Installation of electrical power supplies.

5. Erection of scaffolding.

6. Erection of refueling floor and steam generator control tents.

7. Layout of cutting points.

8. Installation of atmosphere control system.

9. Installation of shielding.

10. Removal of ducting and steam generator insulation.

The irregular geometry of the cavity necessitated tube and clamp scaffolding for custom fitting. Only one control tent was erected around the steam generator due to space limitations. A second control tent was erected in the cavity around the concentric ducting and hot valve (locations 1 and 2 in Fig. 3) to control possible airborne activity upon removal of the outer duct. Both tents had conditioned atmospheric control as well as humidity control in order to maintain tolerable working conditions and humidity less than 30% as specified by General Atomic.

All air conditioning and atmospheric control equipment was located on the refueling floor. Air was supplied to and returned from the tents in the cavity via insulated flexible ducting. A cavity entrance control tent was also erected on the refueling floor, and a controlled area was established nearby for packaging and testing component samples.

At all sampling locations, asbestos insulation (approximately 4 in. thick) was removed when the scaffold platforms were complete. Shielding was hung from the steam generator as required to ensure appropriate operator protection.

All personnel who worked in radiologically controlled areas received basic radiological safety training. Security training and respiratory equipment training were also prerequisites for all operations.

4.2.3. Mock-Up Training and Tooling

Erection of the steam generator tube bundle and primary coolant ducting mock-ups began immediately upon the initiation of site work. A control tent was built around the steam generator mock-up to create realistic working conditions. When performing mock-up training, craftsmen wore protective clothing to duplicate that required in the actual work area.

Mock-up training ensured complete familiarity with machines and procedures and thereby minimized subsequent errors and personnel exposure. Mock-up work was also very valuable in development and modification of tooling thereby minimizing lost man-hours and total man-rem for the program.

4.2.3.1. Trepanning Mock-Up. The trepanning mock-up consisted of two 28-in. pipe segments of appropriate thickness representing the cold and hot ducting. The trepan cutting tool was mounted with chains directly to the pipe where the trepan sample was to be taken (see Fig. 6). The cutting mechanism consisted of a pilot drill bit and a hole saw attached to the driving assembly. The entire operation could be controlled remotely at distances up to 30 ft.

4.2.3.2. Steam Generator Tube Bundle Mock-Up. The tube bundle mock-up was erected with tubing of appropriate diameter, length, and spacing to simulate the three tube bundles of the steam generator. During training, superheater tubes were cut externally and evaporator and economizer tubes were cut internally.

The external cutter, consisting of two side grinders that were driven through the tubes by a remotely controlled sliding channel, attached to a base that mounted to the superheater shell. External tube cutting was a three-man operation, one craftsman controlling the grinder switch, one craftsman grasping the tube being cut with a remote handling tool, and a third craftsman controlling the drive channel (see Fig. 7). A Quality Assurance inspector was also present during actual sampling to verify that the tube was identified properly.

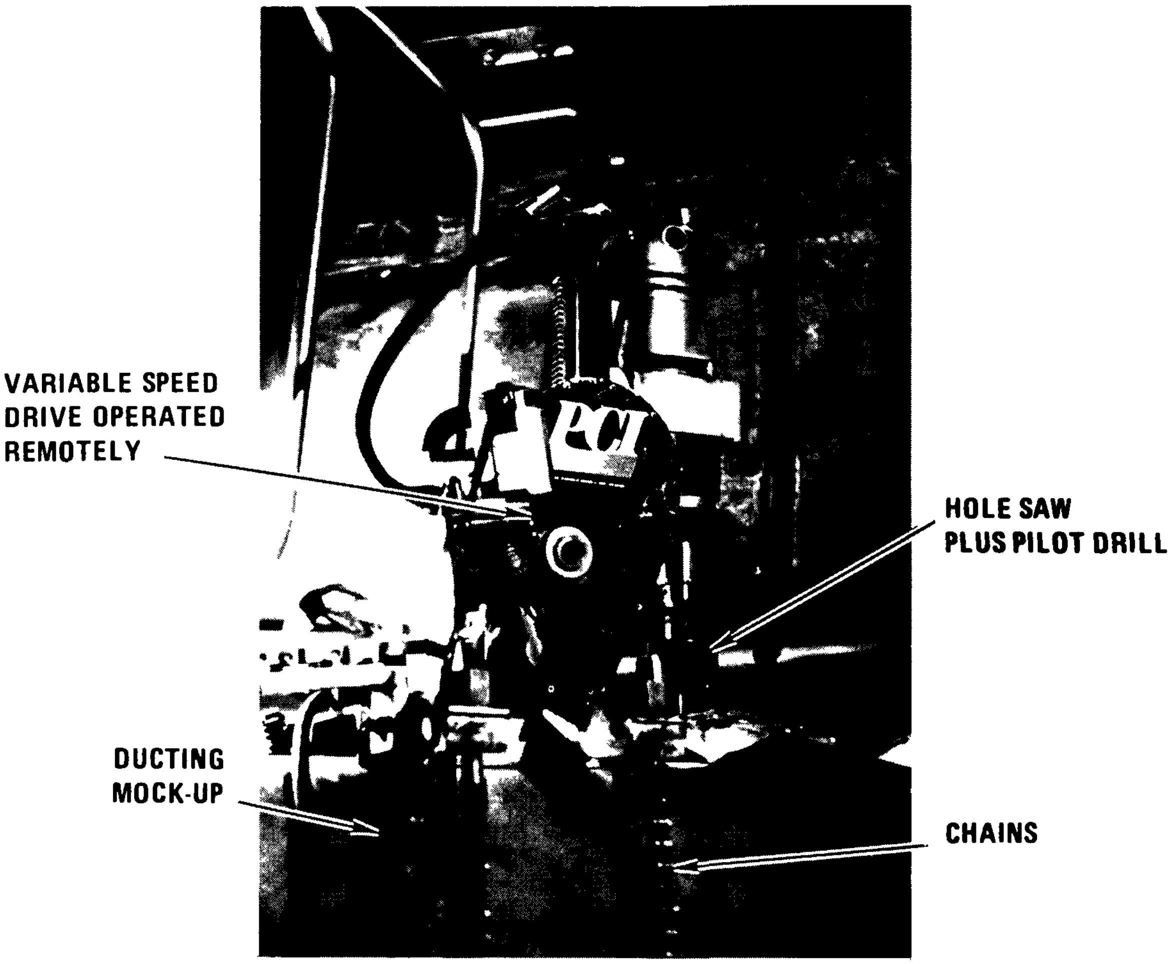

Fig. 6. Trepan cutting tool mounted on ducting mock-up

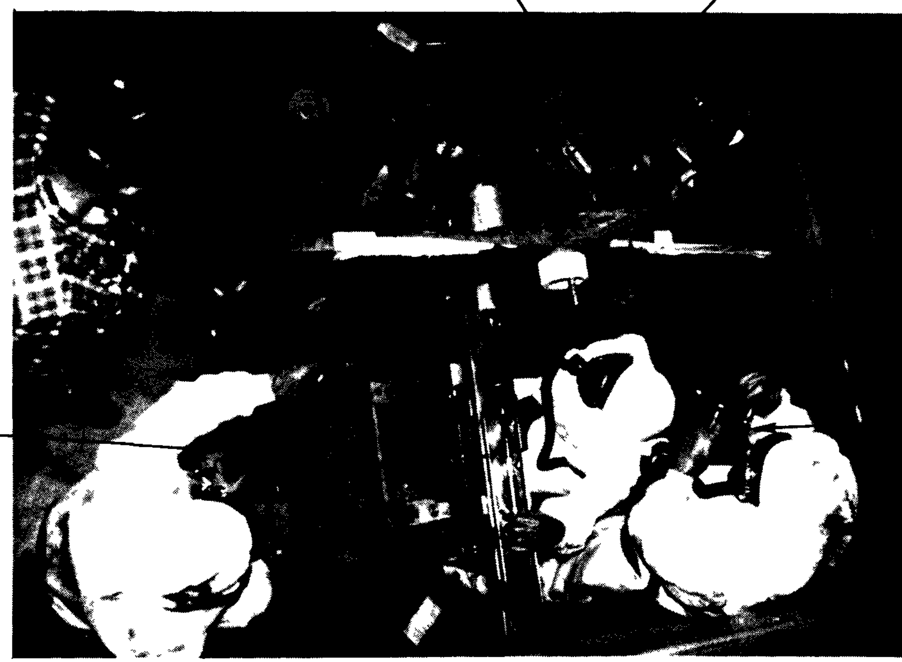

Fig. 7. Steam generator tube bundle mock-up showing practice tube removal in progress

The internal tube cutters consisted of long shafts equipped with bits that would pierce the tube and make a complete cut when rotated 360 degrees from above the tube sheet. The tube sample was grasped from within the steam generator tent, however, as in the external cutting process.

4.2.3.3. Other Mock-Up Work. In addition to the two major mock-ups referred to above, the configuration of and techniques used for cutting the steam generator shell (by arc gouging and sawing), cutting the steam generator shroud (by grinding and sawing), and packaging and testing samples were also reproduced.

4.2.4. Trepanning Operations

All samples of main loop ducting, including samples of thermal barrier insulation at hot duct locations, were removed by trepanning using the tooling shown in Fig. 6. After removal of external asbestos insulation from the ducting, sampling locations (Fig. 3) were precisely identified and the trepan cutter was mounted directly to the primary ducting with chain clamps. Trepanning was accomplished remotely through a control box. Upon cut completion, the tool head and trepan sample were removed, a protective cap installed with the sample remaining in the tool head, and the assembly placed into a temporary airtight container with dessicant. After all four samples were removed from a given location, the samples were transported to the refueling floor for packaging and testing.

Sampling at concentric hot duct locations (see Fig. 3) required removal of a section of the outer cold duct. No significant airborne activity was encountered at these locations, but location 1 had to be deleted due to inaccessibility.

The trepanning operations were successfully completed on December 17, 1975, in comparison to the original critical path network completion date of December 10, 1975. The trepanning portion of the project was not on the critical path of the schedule and had no effect toward extending project completion. Subsequent to completion of trepanning, locations 4 and 10 (Fig. 3) were further enlarged to provide access for internal gamma scanning of the ducts, as discussed in detail in Ref. 4.

4.2.5. Steam Generator Access

Access to the steam generator was attained by a combination of arc gouging and grinding. Arc gouging proved to be a disruptive noisy operation causing considerable repair work on the tent. Final cutting of the shell was completed by grinding since the metal of the shell apparently heat hardened in the arc gouging process.

After removing the access opening of the superheater shell, the shroud was exposed. A strip of the shroud and thermal barrier insulation 2-1/2 in. wide by 15 in. long was ground out, packaged in a 4-in.-diameter container, and inerted with nitrogen.

The superheater shroud was completely removed on January 9, 1976, in comparison to December 1, 1975 on the original critical path network. This extension was a result of the extra time required for shell cutting, rework of the tent, a 10-day job shutdown over Christmas and New Year, and the additional time for grinding out the shroud sample. The activity levels measured in the steam generator tent which strongly affected subsequent tube removal operations are shown in Fig. 8.

As each new section of the steam generator was exposed, General Atomic examined its end-of-life condition in detail for comparison with that of its virgin condition. Specifically, the surfaces were inspected for signs of wear, deposits, cracks, distortion, etc. Results of these examinations, together with those of subsequent laboratory metallographic examinations, are reported in Ref. 2.

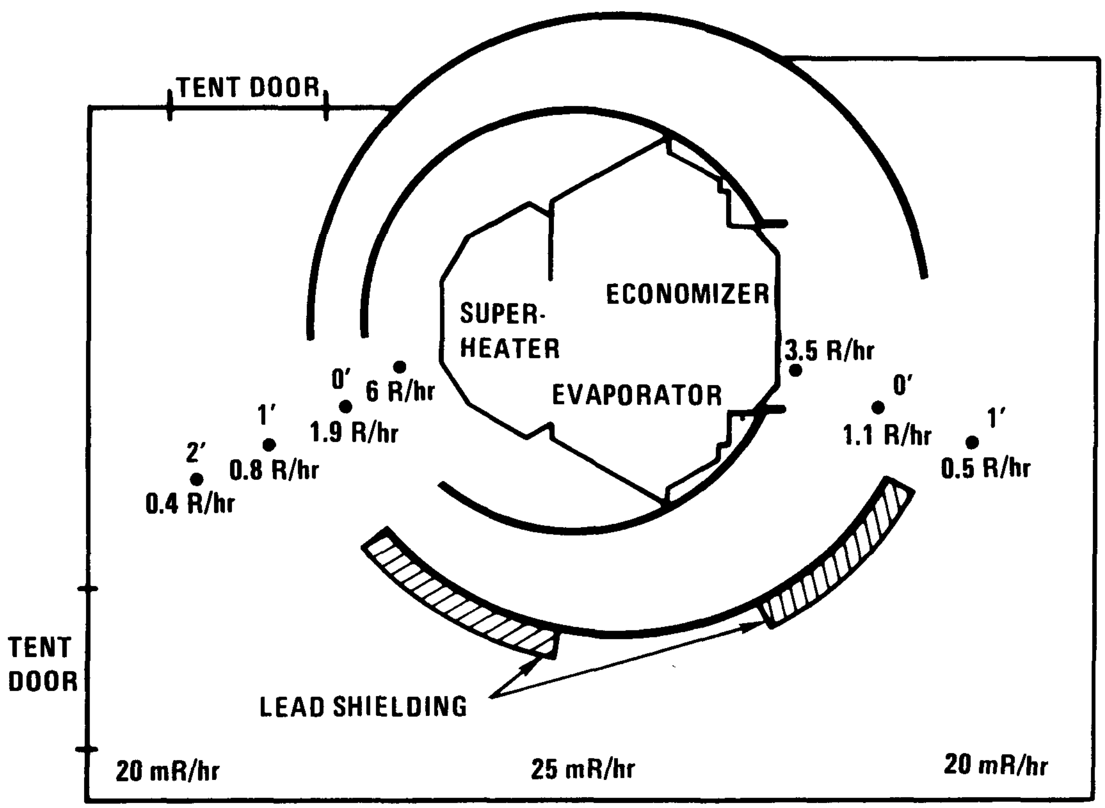

Fig. 8. Radiation levels at various locations in the steam generator tent

4.2.6. Steam Generator Tube Sampling

This activity constituted the most important part of the overall sampling program to provide samples for subsequent radiochemical, metallurgical, tritium permeation, and blowdown tests. The superheater was of most interest, since it had experienced the most severe in-service conditions and the tubes were of Incoloy 800, the large HTGR superheater reference material.

Removal of superheater tubes proceeded as planned with the external grinding apparatus, but internal tube cutting proved impossible for economizer tubes because of internal oxide films and the difficulty experienced in engaging and piercing the tubes (not experienced on the mock-up). The economizer tubes were therefore also removed by grinding.

All tube samples were identified and marked for in-place location and orientation. Each tube in a specific section was assigned a unique number and marked and labeled upon removal. A Quality Assurance representative was present at all times during tube removal to ensure proper identification and marking of the tubes.

Superheater tube cutting operations using the external grinding apparatus in Fig. 7 went extremely well, attesting to the value of the previously detailed mock-up training. A total of 48 tubes and 3 tube stubs were cut from the superheater section over a period of five days. Supervision monitored the work in a nonradioactive environment through the use of a closed-circuit television and loudspeaker system.

External cutting of the economizer tubes proceeded smoothly. Over 150 total tubes were cut in this section to facilitate a tube removal path to the evaporator section. This operation extended over a five working day span (January 23, 1976 to January 29, 1976). Of the 150 tubes cut, 36 were shipped to GA. The remainder were placed inside the steam generator.

The evaporator tubes were cut internally without difficulty. A total of three days (January 29, 1976 to February 2, 1976) were expended in the evaporator section and the effort produced 18 tube samples.

Further tube sampling was attempted, but a series of blocked tubes, which would not permit insertion of the tool from above the tubesheet, prevented retrieval of additional tubes through the economizer window. No evaporator outlet tubes were therefore obtained. Table 5 lists all the samples removed and shipped to General Atomic.

4.2.7. Restoration and Cleanup

After sampling work was completed, the steam generator cavity was decontaminated to levels below the limits required for a decommissioned facility.

All openings which had been made in the primary system were seal-welded. The control tents were decontaminated, then dismantled, and disposed of as radioactive waste. Although the contamination levels within the tents in the steam generator cavity had been as high as 100,000 dpm/100 cm^2 during the work, the area outside these tents was less than 2000 dpm/100 cm^2 after the work was complete, proving the effectiveness of the control tents.

TABLE 5
PEACH BOTTOM HTGR PRIMARY COOLANT SYSTEM
SAMPLES SHIPPED TO GENERAL ATOMIC

Trepan samples (cold duct)	27
Trepan samples (concentric duct - outer pipe)	3
Trepan samples (concentric duct - inner pipe)	5
Trepan samples (concentric duct SOLAMI[a])	5
Superheater tube samples	48
Economizer tube samples	36
Evaporator tube samples	18
Superheater tube sections through baffle plate	3
Superheater shroud sample	1
Economizer shroud tie-rod	1
Superheater steam outlet pipe	1
	148

[a] Thermal barrier material.

5. SUMMARY AND CONCLUSIONS

Based on technical and economic considerations, a mothballing of the Peach Bottom HTGR facility under a Part 50 Possession Only License was selected by Philadelphia Electric Company. Currently decommissioning of the Peach Bottom HTGR is almost completed. All fuel has now been removed from the reactor and shipped off-site, together with other radioactive components such as fission product traps, etc. Isolation of the containment and decontamination of all other areas to levels acceptable for release of the facility to general use is scheduled for completion by the fall of 1977. Throughout the period of decommissioning (October 1974 to date) no significant health or safety hazards have been encountered.

During the decommissioning period, Catalytic, Inc. under subcontract to General Atomic, removed 148 samples of primary circuit ducting, steam generator tubing sections, and other significant samples in support of the Peach Bottom End-of-Life program. This important work required development of specialized tooling and procedures, humidity and temperature control, extensive mock-up training, and sampling operations under adverse conditions. These included surface contamination, high radiation fields, and protection against possible airborne activity. Throughout the component removal activities, strict health physics and safety procedures were enforced, and the sampling program was successfully concluded with no significant incidents.

The samples removed were critical to the success of the design methods verification work under the Peach Bottom End-of-Life Program. In addition, the steam generator and ducting access permitted nondestructive examinations of the internal condition of the steam generator and the plateout distribution in the ducting. Evaluations at GA are continuing and results to date indicate excellent performance of the steam generator and other materials, together with close correlation of observed and predicted fission product plateout distributions.

It is concluded that end-of-life surveillance and selective component removal, when appropriately controlled and coordinated with decommissioning activities, can significantly advanced nuclear plant and fuel technology development.

REFERENCES

1. Stouky, R. J., and E. J. Kohler, "Planned Decommissioning of the Peach Bottom Unit 1 High Temperature Gas Cooled Reactor," paper presented at the ASME Winter Annual Meeting, Detroit, Michigan, November 11-15, 1973, ASME Publication 73-WA/NE-7.
2. "Metallurgical Examination of Primary Circuit Components from the Peach Bottom HTGR," General Atomic Report GA-A14506, to be published.
3. Yang, L., N. L. Baldwin, and W. A. Baugh, "Tritium Permeation Tests on Peach Bottom Steam Generator Tubes," ERDA Report GA-A14376, General Atomic Company, June 1977.
4. Hanson, D. L., N. L. Baldwin, and W. E. Selph, "Gamma Scanning the Primary Circuit of the Peach Bottom HTGR," paper presented at the American Nuclear Society/European Nuclear Society 1976 International Meeting, Washington, D.C., November 14-19, 1976 (General Atomic Report GA-A14161).
5. Iacono, J. V., et al., "Removal of Primary Circuit Components from the Peach Bottom HTGR," Catalytic, Inc., Subcontract Final Report, General Atomic Report GA-A14369, April 1977.
6. "Decommissioning Plan and Safety Analysis Report - Peach Bottom Atomic Power Station Unit 1," submitted by Philadelphia Electric Company to NRC, August 1974.