PEACH BOTTOM 2 & 3

REGENERATIVE HEAT EXCHANGERS

CHEMICAL DECONTAMINATION

AND

SEAL RING REPAIRS

by:

Mark M. Rohner
Philadelphia Electric Company
June 6, 1978

~$4186/MANREM

ABSTRACT

In 1977 and early 1978, Philadelphia Electric Company chemically decontaminated and installed seal rings into the shell to channel joints of all (6) Reactor Water Clean-Up Regenerative Heat Exchangers located in Units 2 & 3 at Peach Bottom Station. The cost to perform this work was approximately $900,000. The radiation exposure accumulated during chemical decontamination and repairs of all (6) heat exchangers was approximately 215 man-rem. This exposure was spread among approximately 300 individuals with individual exposures ranging from .5 to 7 rem over a one year period.

Problems with the Regenerative Heat Exchangers date back to 1974 when Unit 2's heat exchangers began to leak. In 1975, Unit 3 was placed into commercial service and its Regenerative Heat Exchangers also began to leak. Retorquing of the shell to channel bolts was performed with little success. Furmanite compound was injected into the flanged joints of (5) of the (6) heat exchangers during 1976. This temporarily stopped leakage and associated iodine releases. However, continual reinjection of (2) of the heat exchangers became necessary after the Reactor Water Clean-Up System was cycled. Continuing difficulties led to the installation of a bypass line around the Regenerative Heat Exchangers in 1976 and 1977 as an interim solution. Seal ring repairs were then performed.

This report contains the details of the background and history leading up to the repairs including:

1. The Reactor Water Clean-Up System description
2. Sealing the Regenerative Heat Exchangers with Furmanite
3. Installation of a bypass

SEE PG. 9, SECT. II FOR EXPOSURE ANALYSIS

4. Seal Ring design
5. Radiation exposure analysis
6. Seal Ring installation details

The chemical decontamination which was performed for Philadelphia Electric is detailed in a separate paper by The Dow Chemical Company.

I. HISTORY AND BACKGROUND

A. Introduction

The Regenerative Heat Exchangers form an integral part of the Reactor Water Clean-Up (R.W.C.U.) System. They are located in the reactor building just outside the drywell. Their purpose is to cool reactor water before it enters the demineralizers and then reheat it on its way back to the reactor. This regeneration recovers approximately 4.4 MW's worth of thermal energy. Because this system is the reactor's "kidney", removal of the system for more than 48-72 hours cannot be performed without seriously effecting reactor water chemistry. The absence of a clean-up system for this period usually causes the reactor water conductivity to approach limits which require shutdown. Figure 1 shows the relationship of the Regenerative Heat Exchangers to the R.W.C.U. System.

PEACH BOTTOM UNITS 2&3
REACTOR WATER CLEAN-UP SYSTEM

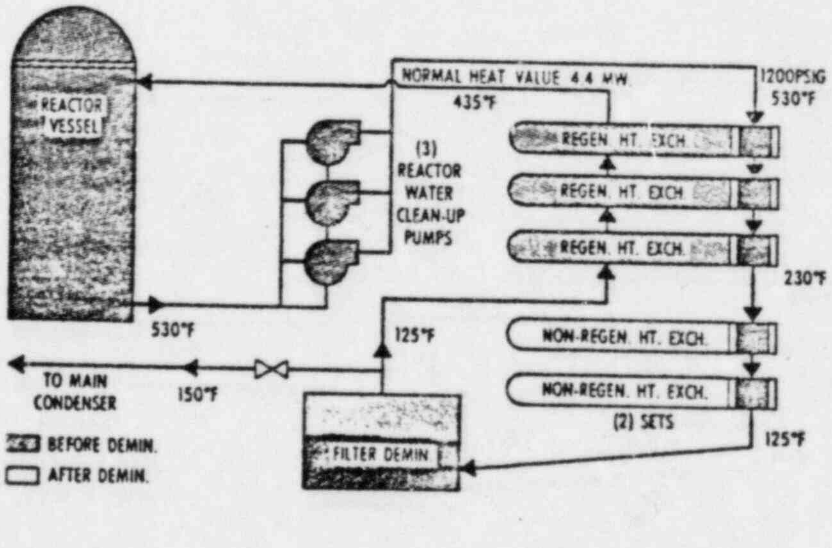


FIG. 1

In August 1974, leakage was observed on one of Unit 2's R.W.C.U. Regenerative Heat Exchangers. Investigation revealed that the stainless steel clad asbestos gasket in the shell to channel joint was leaking. Recommendations from Perfex (the Manufacturer) were that the bolting on all the Regenerative Heat Exchangers be retorqued, including the three heaters in Unit 3 which had not yet been placed in service. Torquing was performed and the leakage in Unit 2 was reduced. In December 1974, Unit 3's reactor was placed into commerical service. Shortly after this, leakage was observed on one of Unit 3's Regenerative Heat Exchangers. During the next 15 months (March 1975 to June 1976), leakage developed in all six Regenerative Heat Exchangers. Retorquing of the shell to channel joint bolting was performed with little success.

B. <u>Sealing with Furmanite</u>

Through conversation with other utilities, it was learned that Vermont Yankee was having a Company called "Furmanite" inject compound into their leaking shell to channel joints. As a result of these conversations, five Regenerative Heat Exchangers during an eleven month period (November 1975 to September 1976) were injected and sealed. Several of the heat exchangers required reinjection almost every time the R.W.C.U. System was cycled. Others held tight or developed only slight leakage. Although this was not as successful as Vermont Yankee's endeavor (they were reinjected yearly), it did reduce leakage from the heat exchangers. The injection of each heat exchanger required 8 to 10 craftsmen who received radiation exposures of 2.4 rem each after 8 hours of work. This occurred because radiation levels were approximately 2,000 to 3,000 MR/HR on contact with the heat exchanger flanges. The cost to prepare and inject one heat exchanger with Furmanite was about $15,000. Approximately $130,000 was spent over an eleven month period to keep Units 2 & 3 heaters sealed. Travel time and Health Physics training represented a high portion of this expense due to a turnover rate of 2-3 men/shift. Figure 2 illustrates the positioning of injection fittings and a caulking ring used in the Furmanite injection process.

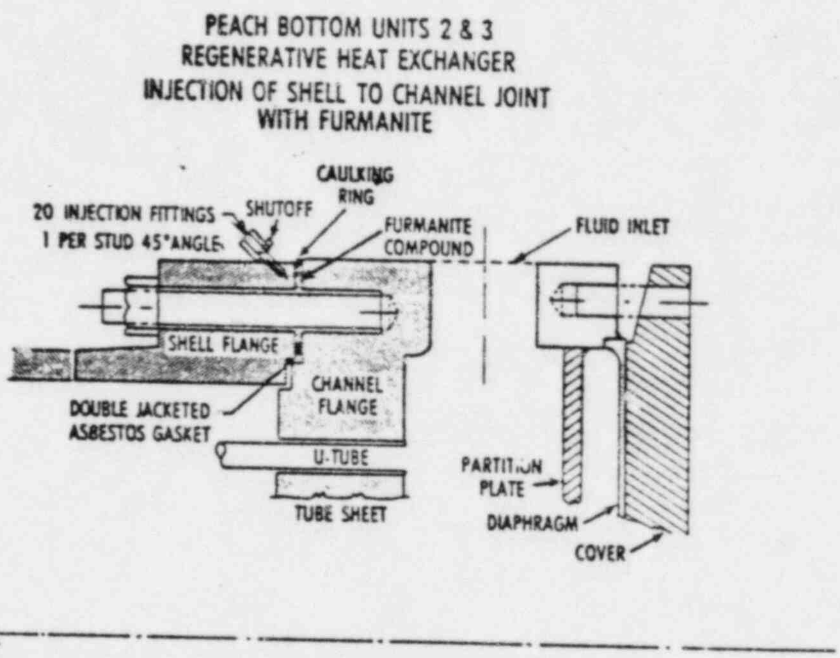


FIG. 2

During 1976, Plant Hatch (Georgia Power & Light) and Brunswick (Carolina Power & Light) developed similar leaks. Plant Hatch had pulled one tube bundle and installed a flexitallic gasket in the early part of 1975. This was done during the first few months of operation when radiation levels were still low. In 1976, both of these Plants had their heaters Furmanited including the one which had a flexitallic gasket installed, as it was found to be leaking also.

C. Installation of a Bypass

Because of the failure of Furmanite compound at Peach Bottom to act as a permanent seal, repair alternatives were studied and a bypass line was installed around the Reactor Water Clean-Up pumps and the Regenerative Heat Exchangers. Mechanical seal problems on the R.W.C.U. pumps necessitated their inclusion in the bypass scheme. Figure 3 illustrates this bypass. The energy loss, due to the loss of regenerative heating, amounted to 4.4 MWt.

PEACH BOTTOM UNITS 2&3
REACTOR WATER CLEAN-UP SYSTEM
REGEN. HT. EXCH. BYPASS (4.4 MW LOSS)

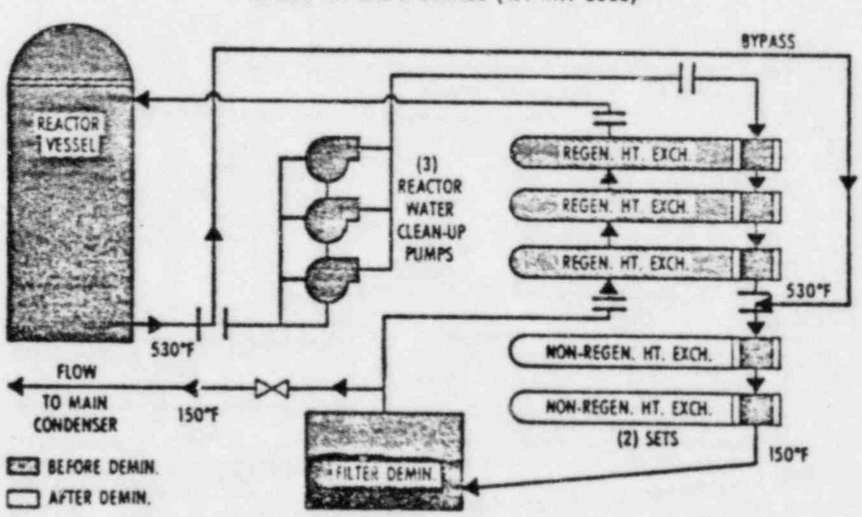


FIG. 3

D. Seal Ring Design

Consultation with Perfex, the heat exchanger designer and General Electric, the system designer, resulted in a recommendation to remove the tube bundles and install flexitallic gaskets. An alternate repair consisting of seal ring installation in place of a gasket was agreed upon by Perfex. This design was proposed by Philadelphia Electric because of previous successes at Fossil Generating Stations. Some of the advantages of this design, which involves the replacement of a gasket with a weldable seal ring, are as follows:

1. It does not have the limitations that a gasket has in thermal cycling applications where "gasket fatigue" can occur.
2. Its installation eliminates the need to remove certain piping and obstructions that are usually removed to change a gasket. In this particular installation, it eliminated the removal of a 48" thick wall and cutting of (2) 4" pipe loops which would have required radiography after rewelding (4 welds). It also eliminated removal of certain 1" connections to which there was limited access.

Perfex indicated that during the original design stages, they tried to eliminate the gasketed shell to channel joints by designing these heaters with welded joints as was done in the case of Non-Regenerative Heat Exchangers. It was found, however, that a difference in code requirements between building the Regenerative Heat Exchangers to Section III and the Non-Regenerative Heat Exchangers to Section VIII were enough to prevent welding of the shell to the channel joint on the Regenerative Heat Exchangers. Radiography would have been required if the Regenerative Heat Exchangers were welded and physical obstructions prevented this.

Based on Perfex's positive response, Maintenance recommended that a seal ring repair be employed. The seal ring design provides a welded joint exempted from the radiography required by code on butt joints. The bolting used for this joint provides the closure strength normally afforded by a butt weld. The seal ring was designed to comply with 1974 ASME Section III, Class ND code requirements. A design change submittal was sent to the Pennsylvania Department of Labor and Industry for a "Pennsylvania State Special" authorization number, to perform the modification as detailed. This was required since modifications were to be made to a National Board vessel by someone other than a "stamp" holder. This design also included the installation of stainless steel bolts in place of the original carbon steel bolting. Stainless steel bolts were specified to help stabilize the clamping force in the joint between hot and cold situations, since it had been determined that carbon steel bolts would be overstressed when the Unit was hot. It is believed that the differential expansion that existed in this joint may have caused the original gasket to fatigue. Calculations indicate that a differential expansion of .015" between the heater flanges and the originally installed carbon steel bolting existed over the change in temperature encountered. Figure 4 illustrates the position of the seal ring in the shell to channel joint.

PHILADELPHIA ELECTRIC COMPANY
PEACH BOTTOM UNITS 2&3 REGENERATIVE HEAT EXCHANGER
SHELL TO CHANNEL JOINT REPAIR-USING SEAL RING

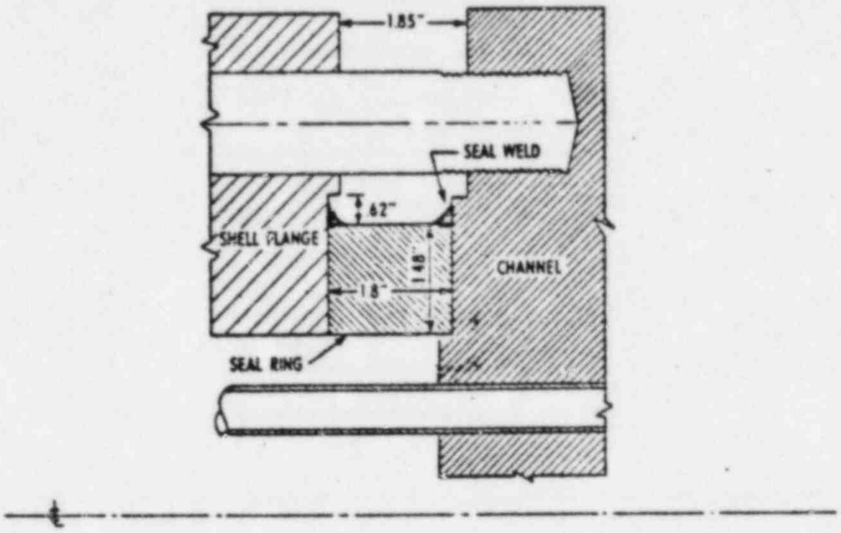


FIG. 4

II. RADIATION EXPOSURE ANALYSIS

Prior to making repairs, Maintenance and Health Physics personnel performed an analysis to predict the radiation exposure and the amount of labor required to perform repairs. The repairs themselves were estimated to take a minimum of 90 shifts/unit. Calculations based on actual radiation exposure data obtained from experience with previous work indicated approximately 1100 man-rem would be required to repair all six heat exchangers. It was estimated that a total of $250,000 would be spent for Welder Qualification Testing ($700/welder) and Health Physics Training. Review showed that it would require 3 days to train and qualify a welder, to the requirements of the ASME Section IX code, only to have him work for 4 hours and then have to be dismissed from the site until the next calendar quarter. These figures indicated that approximately

500-700 craftsmen would be required to perform repairs and that a majority of these individuals would receive radiation exposures equal to 2.5 rem/quarter. This analysis clearly indicated that an alternative arrangement for performing this work was essential.

Review of the various methods available to reduce radiation exposure and manpower requirements lead to chemical decontamination as the only alternative. None of the usual methods of reducing radiation exposure (shielding, time and distance) could be employed since it was the heaters themselves which were the principal radiation source in the room and to make repairs, shielding and distance could not be employed. Even with shielding, general area dose rates in the rooms ranged from 200 to 400 MR/HR. With the heaters opened, it was expected that dose rates would have been 1000 to 1500 MR/HR in the area where work was required to be performed. Figure 5 shows an area adjacent to the heaters where a field of 400 MR/HR exists.

FIG. 5

PHILADELPHIA ELECTRIC 5-56918

Contact with Dow Nuclear Services revealed that a solvent was available that could be circulated through the heaters and would chemically remove the radioactive deposits which had plated out on the 3600 sq. ft. of heat transfer surface.

After testing samples taken from Units 2 & 3 (pipe removed during installation of the bypass line), Dow indicated that their solvent (NS-1) would remove a very large percentage of the radioactive contaminants in the Regenerative Heat Exchangers. A proprietary agreement was signed and detailed information regarding the chemicals and their effects on the reactor, piping and valves, etc., was obtained. After reviewing these, a decision was made to contract Dow Chemical to perform decontamination of the heat exchangers. Safety reviews on the process particulars were made and flow diagrams were used to develop piping sketches and drawings necessary for the placement of equipment, etc. Figure 6 shows the simplified flow diagram.

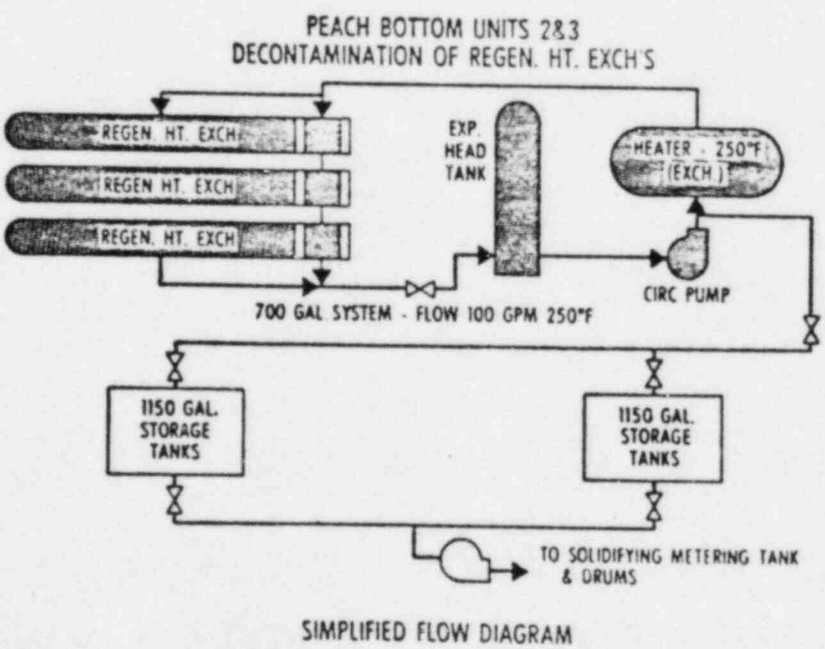


FIG. 6

III. CHEMICAL DECONTAMINATION WITH DOW NS-1

Dow Chemical performed chemical decontamination of Unit 3 Regenerative Heat Exchangers in April, 1977 and Unit 2 heat exchangers in September, 1977. The total cost to perform decontamination of both Units was approximately $450,000. The chemical decontamination and solidification processes required approximately 25 shifts of work, utilizing (4) Dow personnel/shift. Preparation for Unit 3 required two-three months. Unit 2 preparation required approximately one and one-half months.

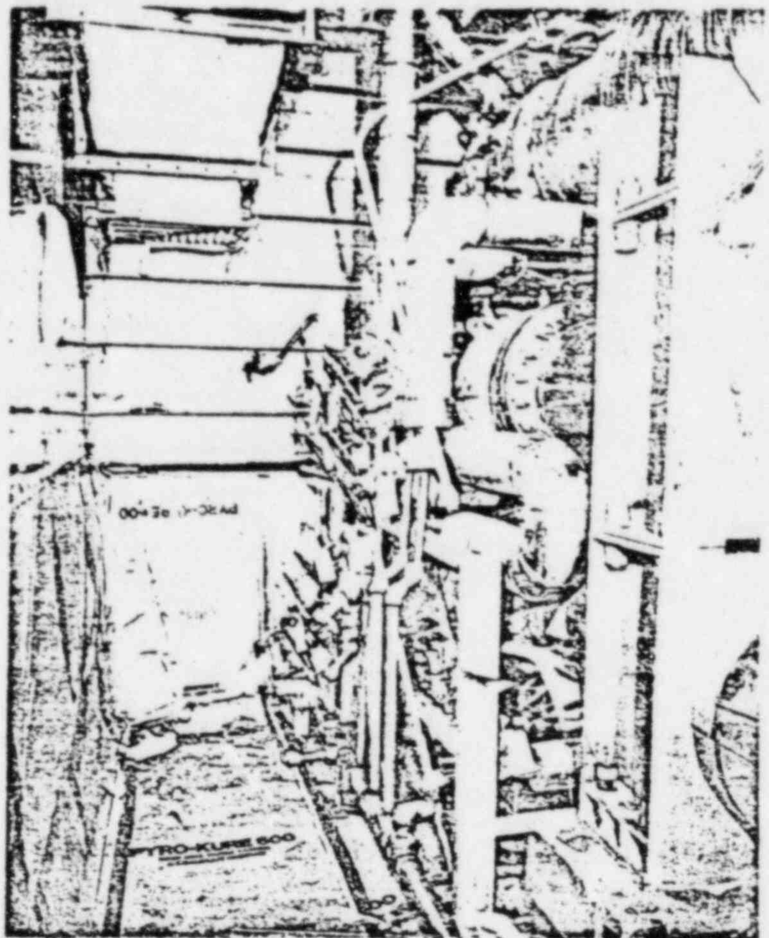
A description of the process (including solidification) is described in a separate paper prepared by The Dow Chemical Company.

Dow's role at Peach Bottom was that of providing; 1) Engineering & Health Physics expertise for the equipment and piping designs, 2) Chemicals and labor to perform chemical decontamination and solidification.

Catalytic Construction Co. was retained to provide necessary labor and equipment needed for the installation of the chemical piping. This included procedures and drawings necessary to effect complete isolation of the heaters from the Reactor Water Clean-Up System and installation of chemical piping.

IV. SEAL RING REPAIRS

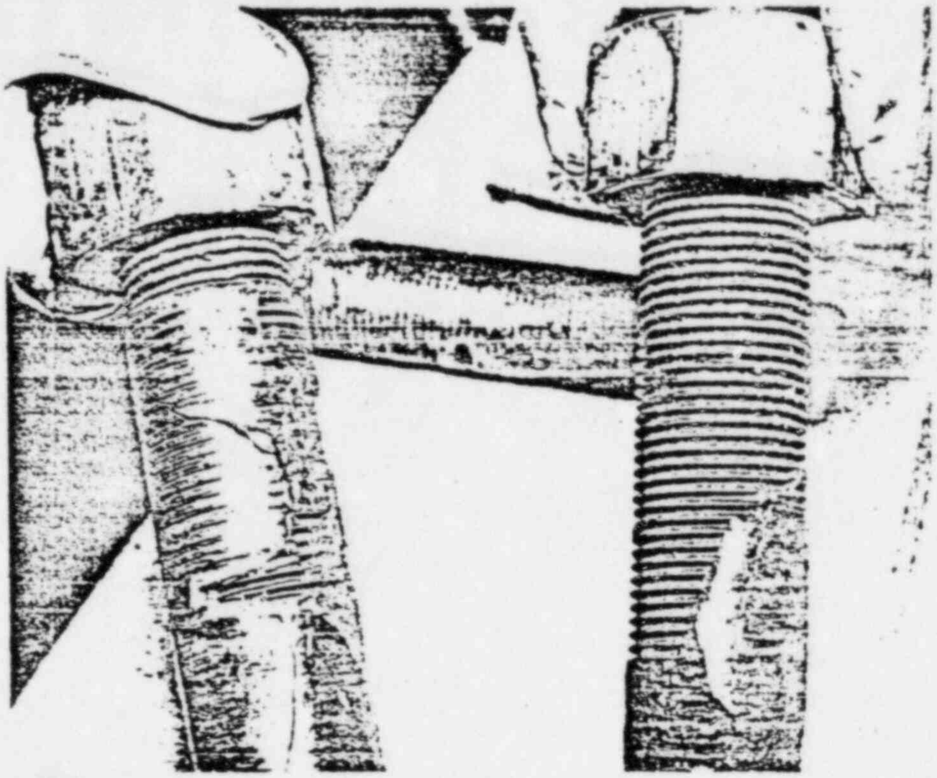
Seal ring repairs consisted of removal of all vent and drain lines, relief valves, piping and piping supports. Shown on Figure 7 is one-half the piping.



PHILADELPHIA ELECTRIC 5-56941

FIG. 7

Approximately 25 shifts utilizing 10 craftsmen/shift were required to remove 60 (1-5/8") flange bolts and to remove Furmanite from the flange faces and bolt holes. Figure 8 illustrates Furmanite adhering to the bolting.



PHILADELPHIA ELECTRIC 5-57563

FIG. 8

A jacking assembly, consisting of a "T" beam fastened across the three channel heads and two 9 ton jacks, capable of jacking all three heat exchanger bundles (20,000 lbs.) apart simultaneously was utilized. This was done by mounting the jacking assembly around the middle shell and jacking the middle channel forward. Double acting jacks were used so that opening and closing operations could be performed with minimum set-up time. Jacking in this manner permitted repairs to be made without cutting the loop piping (2 loops) between heaters. The jacking collar and one jack is shown on Figure 9.

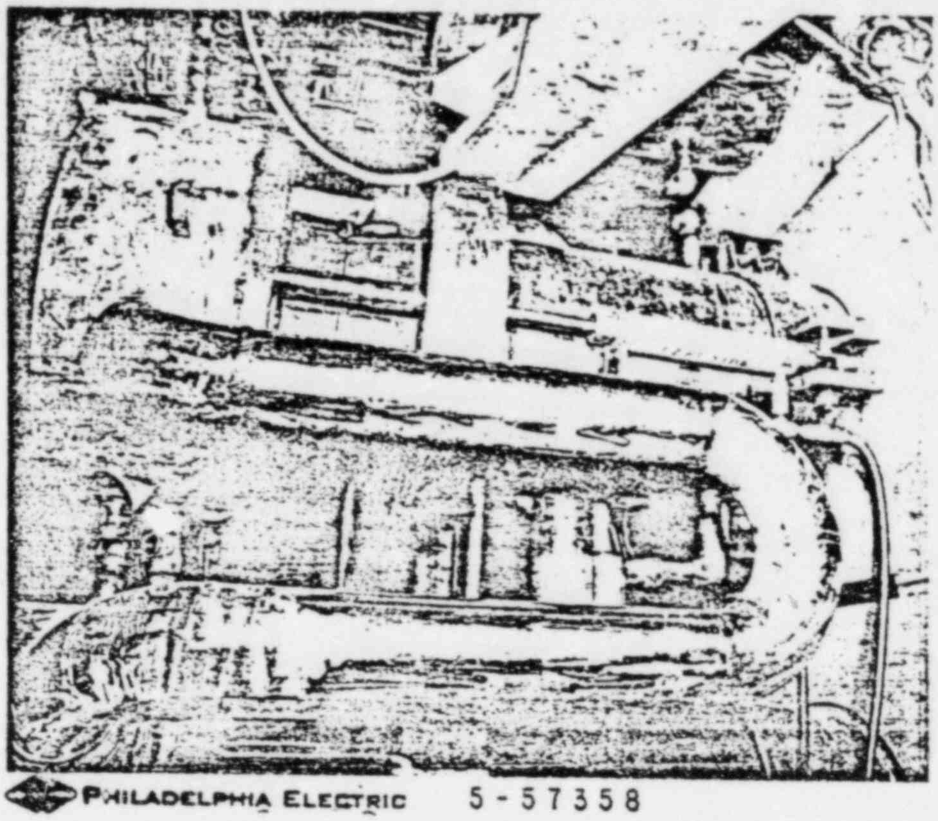


FIG. 9

Once the heaters were apart, split seal rings were mounted on each channel flange. A copper ring was temporarily used to protect the flange face. A stainless steel clamping ring with six clamps was used to prevent warpage during welding. See illustration in Figure 10.

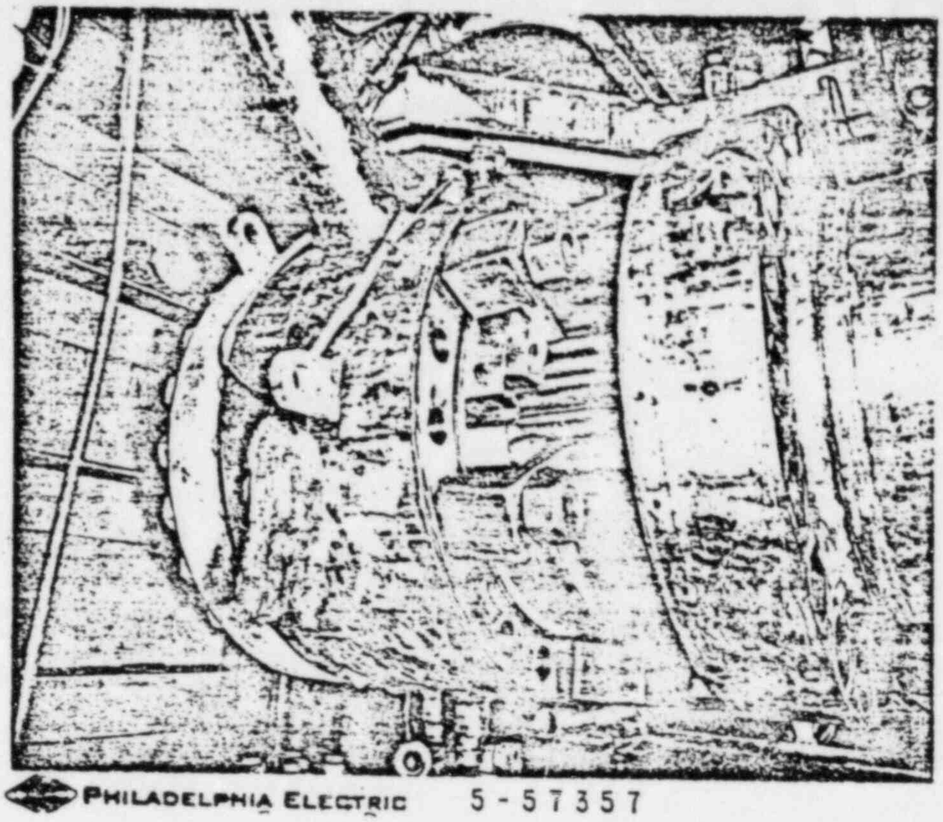


FIG. 10

Butt welding of the rings was performed using both the tig and electric arc welding processes. Fiberglass backing tape was used as a backing band during root welding. Surface grinding and penetrant testing of all welded surfaces (including the root I.D.) was performed. During the joining process, the welder alternated between each of the three rings so that the 300-350°F maximum interpass temperature limit required for 304 stainless steel would not be exceeded. Distortion during welding was controlled by utilizing a peening process between weld passes. The performance of the six butt welds required approximately 30 shifts, utilizing 10 craftsmen/shift. Figure 11 shows the ring with a partially made butt weld.

FIG. 11

A ½" fillet weld was utilized to seal weld the rings to the shell and channel flanges. Accurate positioning of the rings against the flanges was required due to the limited clearance that existed between the ring I.D. and existent steps on the flange faces. New SA 453 GR 660 stainless steel bolting was installed and torqued. This bolting was designed to hold the ring in compression at all times. Seal welding of three rings to the shell and channel flanges required approximately 15 shifts, utilizing 10 craftsmen/shift. Figure 12 shows the finished joint.

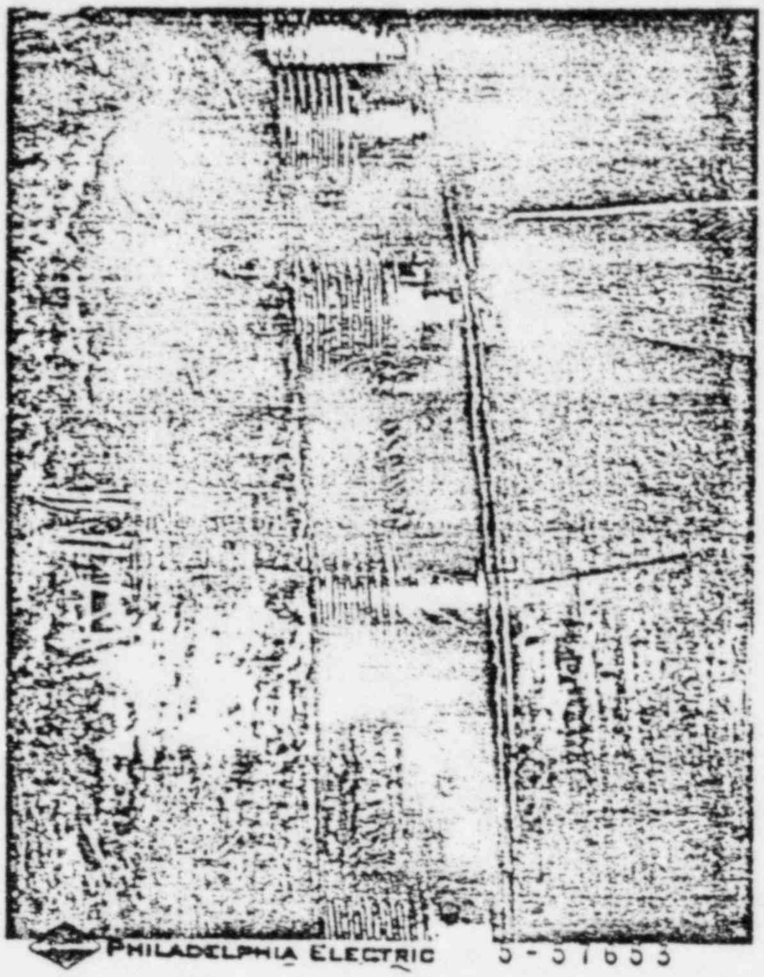


FIG. 12

Following completion of the job, all drain and vent piping was re-installed and insulated (See Figure 13). Approximately 40 shifts, utilizing 10 craftsmen/shift, were required for piping and insulation work. Repositioning of some of the piping was required to compensate for the 1-3/4" change in length caused by substituting a seal ring for a gasket. Prior to this, all valves (approximately 42) were repacked and repaired. Inspection of the tube sheet and channel boxes indicated all internal parts to be in good condition with the exception of an internal weld between the channel box and the channel pass cover which was cracked. This was repaired. Hydrostatic testing to 2180 PSIG was performed and performed and witnessed by an Insurance Inspector.

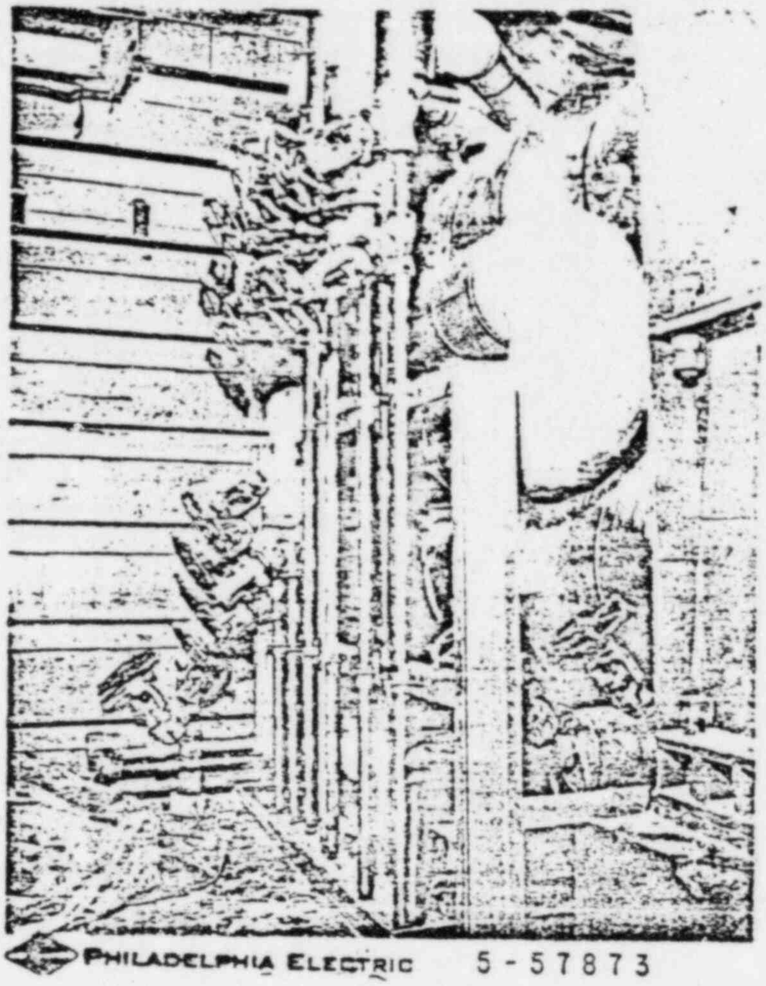


FIG. 13

V. SUMMARY

Installation of seal rings into each of the shell to channel joints was in some ways easier than chemical decontamination. Approximately 135-150 shifts/unit were spent to perform the repairs, which included 25 shifts for channel box inspection and tube testing that had not originally been planned. This was about 30% more time than was estimated for the planned work.

For the most part, 10 men/shift were used on a 2 shift/day, 5 day per week basis. The principal problems that seemed to exist which caused reductions in labor output were:

1. High temperature in the Regenerative Heat Exchanger room during periods when the Plant had normal ventilation turned off and stand-by gas turned on. Unit 2 repairs were performed with a temporary air conditioner installed. (The change in temperature was small but the psychological benefits were large.)
2. Health Physics problems such as a lack of anti-contamination equipment (during the refueling outage), personnel contamination and inflexabilities in the dose extension system.

Since these repairs, a change in our dose extension system has been implemented and has worked out quite well.

From data dept during the job, it was found that approximately 110 man-rem was expended to decontaminate Unit 2 and Unit 3 heat exchangers. For the most part, this includes piping installation and removal, plus Engineering and Testing. It also includes the 7 man-rem which Dow Company Personnel received during the decontamination process. An additional 105 man-rem (extrapolated from data taken during work on one unit) was expended to install the seal rings. The total radiation expenditure was approximately 215 man-rem, as opposed to the originally estimated 1100 man-rem without decontamination. Thus, an estimated total of 900 man-rem of radiation exposure was saved by chemical decontamination.

If chemical decontamination had not been available, it is estimated that an additional $350,000 would have been added to the repair cost due to the increased crew size, welder qualification and Health Physics training that would have been necessary. Thus, the estimated cost to reduce radiation exposure by chemical decontamination was approximately $115/man-rem after applying the $350,000 potential increase in the repair cost had decontamination not been performed.

In retrospect, had chemical decontamination not been available at the time repairs were performed, the only viable alternative available would have been to scrap the Regenerative Heat Exchangers and purchase replacements without gasketed joints. It is estimated that the cost for these installed replacements would have been approximately $1,000,000 and 300 man-rem of radiation exposure.