DPC SUMMARY REPORT - DESCRIPTION OF WORK TASK TO REDUCE FUEL ELEMENT STORAGE WELL LEAKAGE AT LACBWR

Prepared By:

C. W. Angle
Dairyland Power Cooperative

February 10, 1981

Dairyland Power Cooperative
2615 East Avenue South
La Crosse, Wisconsin 54601

Table of Contents

LIST OF FIGURES

DPC SUMMARY REPORT - DESCRIPTION OF WORK TASK TO REDUCE FUEL ELEMENT STORAGE WELL LEAKAGE AT LACBWR

I. INTRODUCTION

Leakage through the Fuel Element Storage Well (FESW) liner has been evident following construction of the La Crosse Boiling Water Reactor Plant (LACBWR) facility. Early attempts to locate and repair the leaks by welding had not been successful. More recently, the inaccessibility of the liner surface due to the presence of stored irradiated fuel in the 11' x 11' square by 41' deep FESW prevented further repairs by welding.

The leak rate, measured with the FESW filled completely, had increased from 0.2 gallons per hour in 1970 to 14.1 gallons per hour by April 1980. The continuing increase in leak rate was believed to be caused by halogens leached from the wetted concrete interacting with the weld heat-affected-zones in the stainless steel liner and by erosion of larger flow paths through the concrete cold laps, along embedded piping, and along the FESW walls. Assuming continued degradation of the liner, LACBWR engineers projected that future leakage could reach a less tolerable rate. Also considered was the fact that LACBWR was preparing to install new, two-tier fuel storage racks. The new design necessitated maintaining a higher water level in the FESW during plant operation. The head of water in the FESW directly affects the leak rate. Due to the relatively unfavorable predictions, additional methods were sought by LACBWR to reduce or eliminate FESW leakage and retard further liner degradation rates.

II. DESCRIPTION OF WORK

In the course of a joint study of the FESW leakage problem by LACBWR and Southwest Research Institute (SwRI) engineers, it was determined that the most effective method for sealing both the cracks in the FESW liner and the flow paths through the concrete was to inject a slow-setting, water-curable epoxy into the voids between the liner sheet and surrounding concrete. SwRI was contracted to provide engineering consulting services during job preparation, onsite engineering support during job execution, materials, instrumentation, and equipment. After surveying several products, Thermal-Chem, Inc., Injection System Product No. 2 was specified as the epoxy to be used. This epoxy was a special formulation designed to retard the set-time of the standard Thermal-Chem injection epoxy. A construction contractor with experience in use of injection epoxy, was subcontracted to provide consultation, procure the epoxy, and supply drilling and pumping equipment. LACBWR provided coordinating engineering, Quality Assurance, health physics coverage, technical and craft labor, and all other equipment and supplies.

A. Preliminary Testing and Evaluation

To preclude excessive buckling or tearing of the FESW liner during injection of the epoxy, it was necessary to establish the as-built configuration of the liner sheet. The FESW liner was constructed of 16-gauge stainless steel sheet. The sheet was fabricated into panels of differing heights which had vertical corrugations eight inches on center. Each horizontal joint between panels was also formed into an expansion corrugation. Design drawings showed two different anchor strap configurations. SwRI fabricated mock-ups of three anchor strap configurations (including the two shown on drawings) and developed an ultrasonic examination technique for detecting and locating the anchor locations from the water side of the liner.

The FESW water level was lowered to the 680-foot elevation just below the transfer canal gate. Visual inspection revealed areas of discoloration and occasional dimpling of the liner sheet in the attachment weld locations. These locations were verified using ultrasonics. Additional ultrasonic scans were performed in areas not having visible indications of anchor attachments and no ultrasonic indications were detectable. It was also noted during the inspection that these areas of the liner were slightly buckled inward. Hammering on the liner in these buckled areas verified that the liner was tight against the concrete walls in those areas. This indicates that the buckling took place during the placement of the concrete and did not result from trapped water due to prior liner leakage. The results of this inspection and the anchor layout for all accessible panels is presented in the 19-page "Inspection Report" included in Appendix A to the report of Reference 1. A typical panel is shown in Figure 1, attached.

The results of the FESW liner inspection were relayed to SwRI headquarters engineering. Based on the as-built anchor layout, SwRI calculated that the differential pressure across the liner sheet (due to injection of epoxy between the concrete wall and the liner) should not exceed 0.4 psi to preclude excessive buckling of the liner which would exceed the ultimate strength at the anchors.

The specific gravity of the mixed "Thermal-Chem Product No. 2" epoxy was known to be 1.075 based on manufacturer's test results. It was necessary to inject epoxy sealant between the liner and the concrete from above and below the FESW to coat the liner as completely as possible. The total pressure behind the liner could result from a combined static head of epoxy and leakage water or epoxy only or from the hydraulic head of epoxy being injected against a dead head. The worst case combinations or pressure behind the liner were calculated by Dairyland Power Cooperative engineering and compared with the total head of water in the FESW when flooded to the edge of the FESW overflow gutter which is near the top of the well.

In order to determine the migration paths available for the epoxy sealant from various injection points, it was necessary to inject dyed water behind the liner and inspect for any indications of dye penetration through structures or in leakoff piping. Prior to injection of the dye solution, a color comparison lab test and a turbidity analysis were conducted with known concentrations of dye.

The transit time of the epoxy sealant from injection points to leak pathways was not known. The epoxy material was a special product formulated to retard set-up and provide the most favorable flow properties between the time of mixing and the time of gelling in place. Several tests of the delivered product were tested at LACBWR and in SwRI laboratories to predict the material's behavior in this application.

LACBWR performed acoustical emission tests along accessible surfaces of the FESW surface to identify leak locations before injecting the epoxy. The results of these tests and tests performed after injection for comparison indicated that some, but not all, of the leaks were sealed with the injection of the epoxy. An additional sealant, Dow Corning sealant, Silastic No. 738, was applied from the well side to some areas of the liner where leak paths were believed to exist. The sealant adhered well to the liner areas that had normally been above water-line. The sealant would not adhere, however, in areas that had been submerged below the FESW water line for long periods. This inability to adnere was believed to be due to a fungicidal growth on the walls of the liner or possibly due to an accumulation of a light organic film contaminate. Mechanical scrubbing and cleaning had no effect on the adherence qualities of the silastic sealant in these areas.

B. <u>Repair Procedure</u>

LACBWR performed and documented an Engineering Evaluation in accordance with 10CFR50.59. LACBWR and SwRI jointly prepared a detailed repair procedure which was followed during placement of the epoxy behind the FESW liner. The repair procedure and related data are fully documented as Facility Change No. 58-80-1. Signed originals of the Engineering Evaluation and Facility Change are on file at LACBWR. Copies of the evaluation and procedure texts and figures are provided in the report of Reference 2. Also provided in the report are manufacturers' technical manuals for the injection equipment, photographs of the equipment used, and a chronological presentation of the data taken while executing the repair procedure. Original field data is on file at LACBWR with FC-58-80-1.

Preparation for the repairs included installation of an injection system at the top and bottom of the FESW. Holes were drilled through the FESW liner about 21 inches below the FESW curb between each vertical corrugation in the liner. The holes were tapped and pipe nipples were threaded in. Tubing was run from each nipple to a header which was in turn tubed to a 2-gallon supply tank. Each wall of the FESW was supplied by a separate header and tank. Additional holes were drilled and tubes installed to provide vents and level monitoring stand pipes. This system provided a means for injecting the test dye and the epoxy at a low pressure into the top of the void between the liner and concrete (Figure 3a, b).

An additional injection system was installed below the FESW. The FESW is equipped with a leak collection system which drains into a sample sink located at the grade elevation in the Reactor Containment Building. A pumping system was installed to discharge into the leakoff system drain line. The system included a pressure relief valve, pressure gages, and a standpipe which extended up to the operating floor at Elevation 701'. This system provide a means of injecting the epoxy behind the liner from below the FESW while maintaining precise control over the differential pressure across the liner (Figure 3c).

Two instrumentation systems were installed to measure the deflection of the FESW liner during injection operations. One system consisted of linear potentiometers mounted on brackets and held against the liner at eleven locations along the east and south FESW walls. The detectors were held in position by counterweights acting against legs which protruded into the corners of the FESW. A 500 ohm change in a circuit's resistance reflected a 0.2 inch stroke of the potentiometer (Figure 4).

Another deflection monitoring system consisted of a theodolite surveying instrument positioned to sight along the west wall of the FESW. Targets were installed at six locations on the west wall with suction cups. Each target had a stem marked at 0.125-inch increments which were sighted through the theodolite before, during and after injection operations. Slight movement of a target was easily discernible (Figure 5).

Prior to injection of epoxy, a test was performed using red dye. Color comparison samples containing varying known concentrations of dye in a solution of FESW leakoff water were prepared. Concentrated dye solution was poured into the injection supply tanks located above the FESW. The tanks were maintained full for approximately 10 hours while liner deflection measurements were recorded and samples drawn from the leakoff system drain line. Fifty-one gallons of dye were injected. No evidence of dye was detected in the FESW leakoff system; however, there was evidence of communication between the injection points and other areas of the surrounding structure. Dye indications were observed on the operating floor (Elevation 701') in the area around the fuel transfer canal curbing, on the outside of the FESW wall around an embedded pipe at Elevation 679', and on the ceiling and walls of a Forced Circulating Pump cubicle below the FESW.

The injection system below the FESW was tested using clean water. Water was pumped into the FESW leakoff drain line while discharge pressure, standpipe level, supply tank volume, and liner deflection were monitored. The change in flow rate was discernible when the leakoff system piping was filled to Elevation 659'-5". The maximum standpipe level achieved (equilibrium between injection flow and flow-through leak paths was reached) at Elevation 682'-9". Approximately 17 gallons of water were drained from the leakoff system before the drain line flow rate again reached equilibrium. It was also observed that the leak collection system had a free volume of less than one gallon, whereas the precalculated volume based on design drawings was almost 21 gallons. It is assumed that the leakoff system was almost filled with grout during construction and that further deposits accumulated during subsequent years of FESW leakage.

The repair procedure specified that epoxy would be injected from the bottom (through the FESW leakoff system) and allowed to set before injecting epoxy from the top. To preclude complete clogging of the leakoff sytem, the procedure called for injecting the epoxy until flow diminished significantly; then injecting 3400 ml of unmixed resin (Component A) to fill and preclude hardening in the leakoff system. A total of 38 gallons of epoxy was injected into the drain line. Only about 950 ml of resin could be injected to backfill the leakoff system. The injection system was shut off and the epoxy allowed to harden for 48 hours prior to opening the leakoff system drain line. None of the resin was recovered and no leakage has been collected from the drain line, indicating that the leakoff system has most probably been sealed off.

After waiting 48 hours for the epoxy to form a permanent seal in those voids accessible from the leakoff system, epoxy was poured into the supply tanks of the injection system located above the FESW. The supply tanks were maintained full for 5 hours. The tanks were emptied and replenished with freshly mixed epoxy at 30-minute intervals. A total of 23 gallons of epoxy was injected from above the FESW before the epoxy began gelling in the injection tubing. After 48 hours, the injection system was disassembled. The injection holes in the FESW liner were covered with stainless steel patches sealed by Dow Corning Silastic 738 Adhesive. The maximum liner deflection observed during any injection operations was 0.1 inch.

C. Final Results

A total of 61 gallons of epoxy sealant was placed into the voids beteen the FESW liner and concrete and into leakpaths through the concrete structure with no damage to the FESW liner. The FESW leakoff system was probably sealed. The FESW leak rate was measured after injection of the epoxy by monitoring FESW water level and found to be 2.04 gallons per hour as compared to 14.1 gallons per hour prior to repairs. Both pre- and post-repair leak rates do not compensate for any evaporation or system leakage not associated with liner integrity. The leak rate measurements were made with the FESW filled to maximum level.

III. CONCLUSION AND EVALUATION

The FESW leak rate was reduced by approximately 85% from a leak rate of 14.1 gallons per hour to 2.04 gallons per hour when the FESW is maintained full at a water level elevation of 700'9". Some minor leaks are still in evidence, specifically in an area along the North wall of the 1B pump cubicle and an area of the wall adjacent to the FESW overflow pipe where a small trace of water emanates. The small amount of water leaking at the present time constitutes less than 4% of typical in-plant water accumulation rates and is considered to be insignificant. There was no measurable increase in leak rate from June 1980 to February 1981, a period of approximately 8 months. It is concluded that many leak paths through the concrete have been coated with the epoxy and further potential for increased leakage rates from the FESW has been significantly reduced.

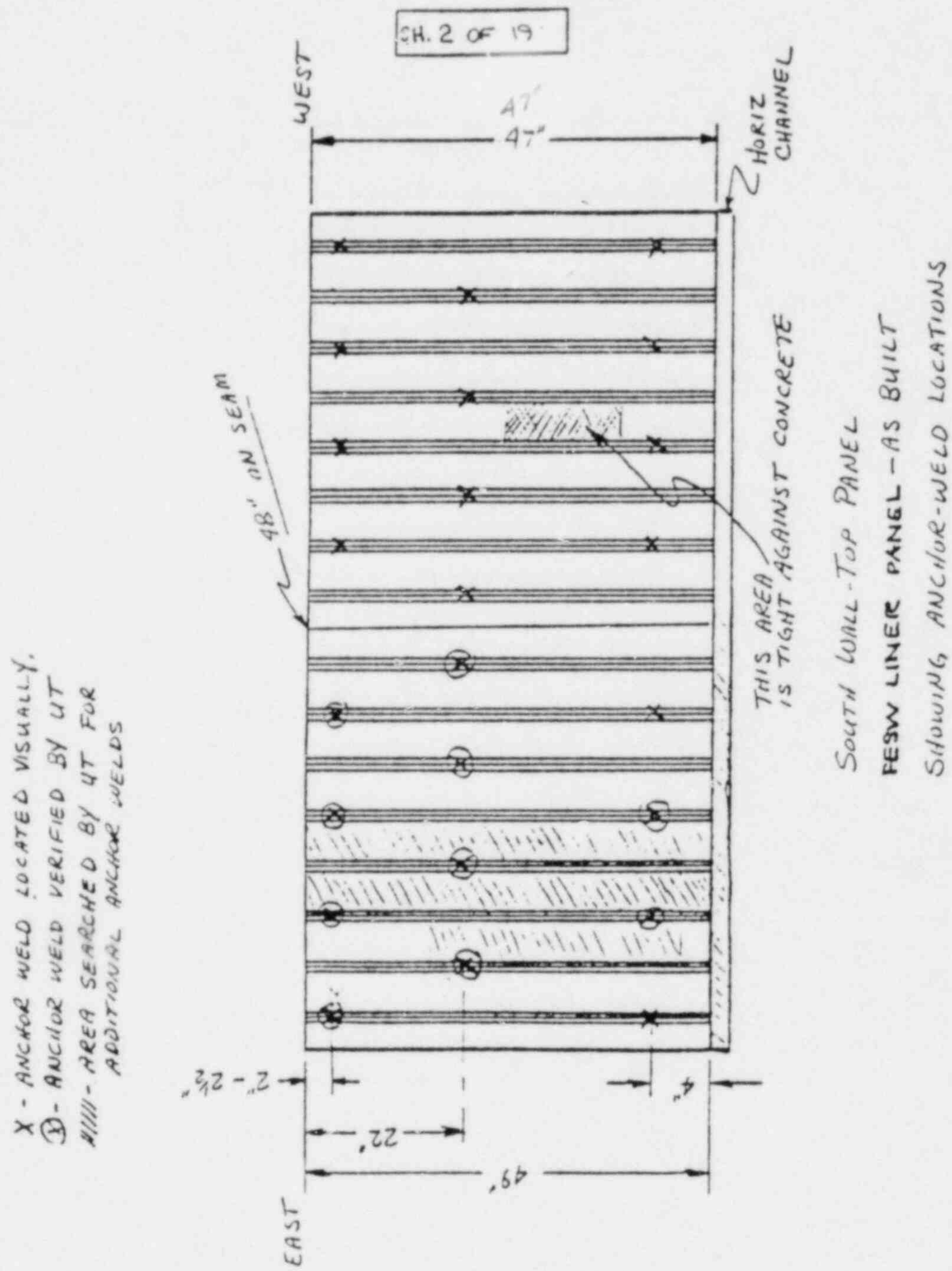
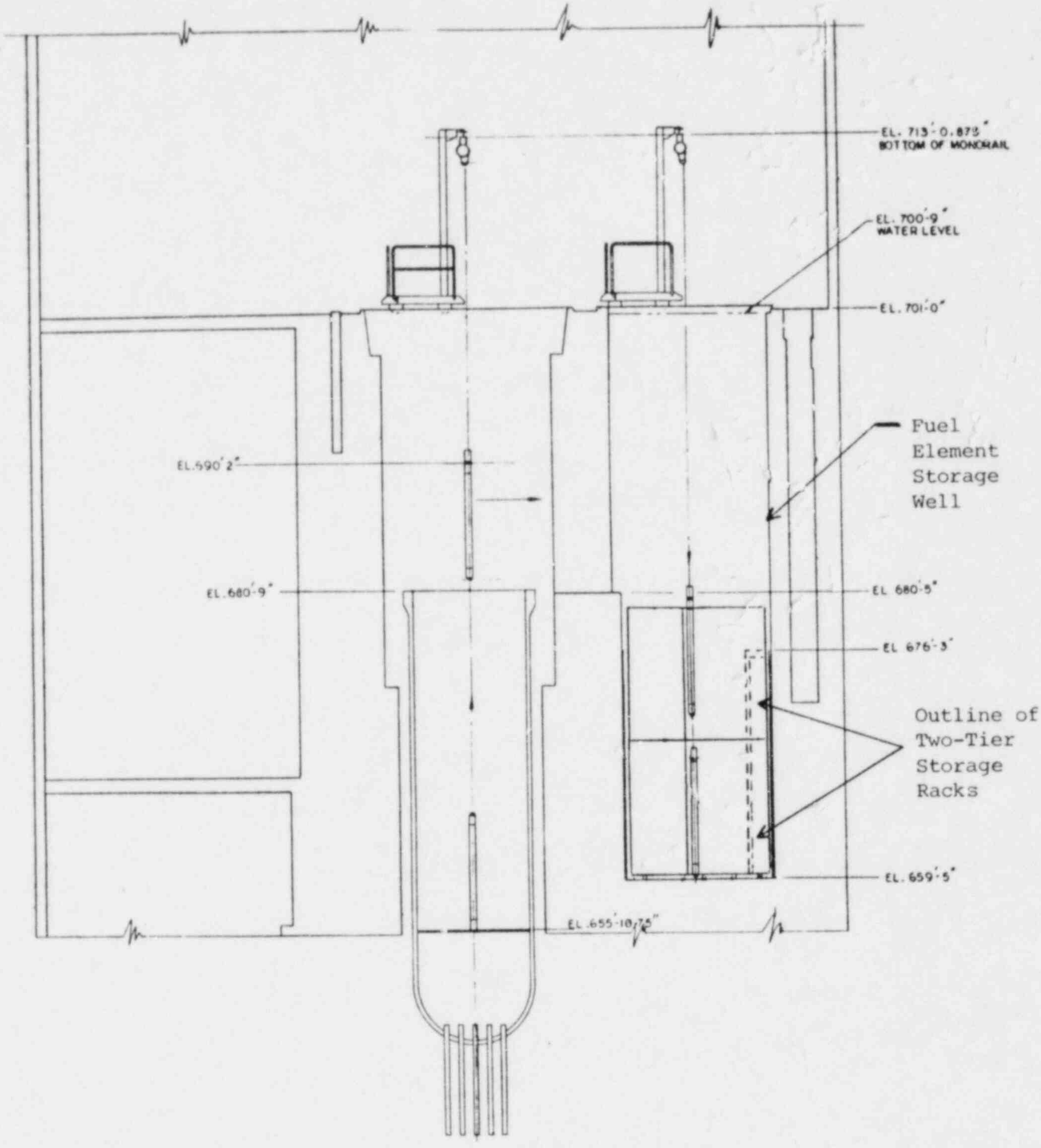
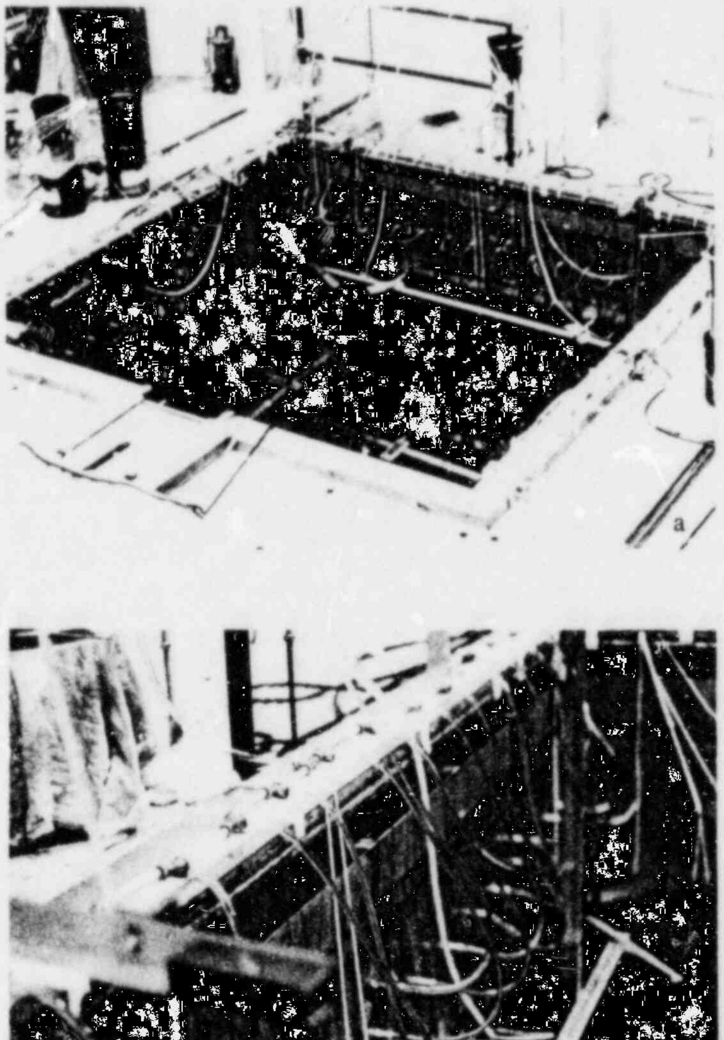


FIGURE 1 - TYPICAL FESW PANEL INSPECTION DATA



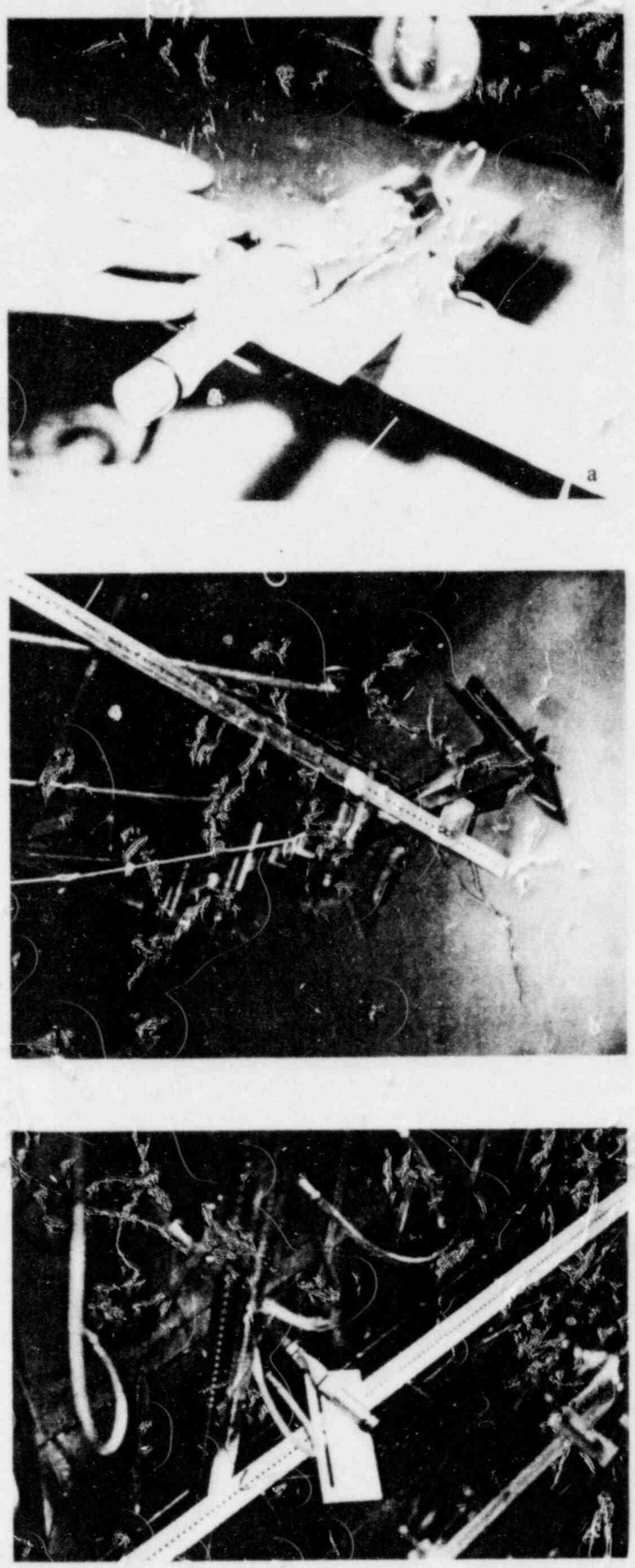
LACBWR SPENT FUEL TRANSFER DIAGRAM

FIG. 2



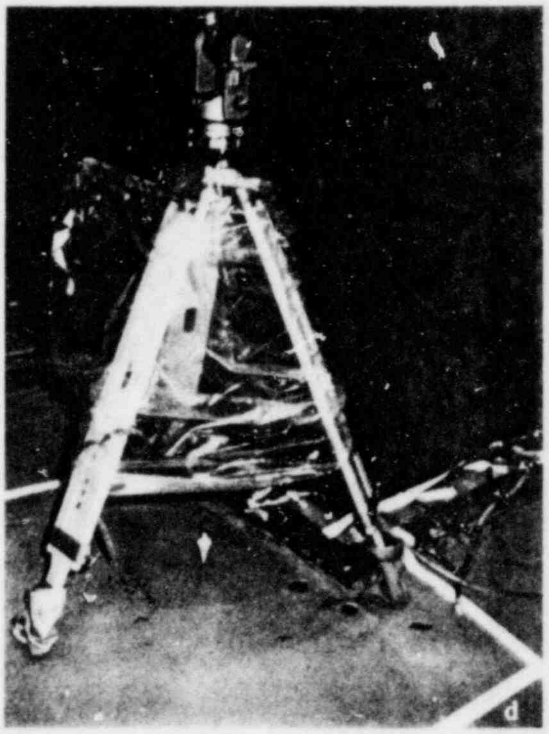
(a) and (b) show reservoirs, tubing manifolds, branch lines, and vents used to inject epoxy behind the liner panels at the top of the FESW. (c) shows the pumping system used to inject epoxy into the FESW leakoff drain line from below.

FIGURE 3. EPOXY INJECTION SYSTEMS
(FESW is the Fuel Element Storage Well)



(a) and (b) show components of the linear potentiometer system prior to their installation on the wall of the FESW. (c) shows the monitoring instruments in place. (Eleven such detectors were utilized to measure FESW liner deflection during injection of the epoxy.)

FIGURE 4. LINER DEFLECTION MONITORING SYSTEMS
(FESW is the Fuel Element Storage Well)



(d) shows the theodolite surveying instrument aligned with the west wall of the FESW. (e) shows one of six theodolite targets installed on the west wall panels. (Movement of the targets was measured during epoxy injection.)

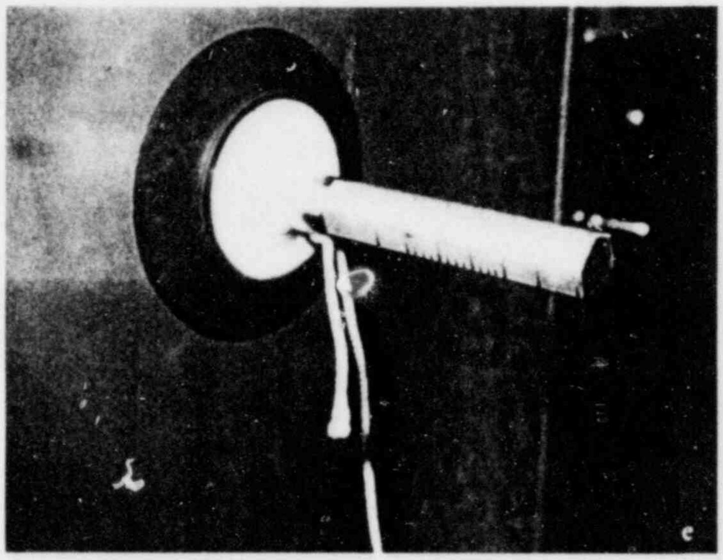


FIGURE 5. LINER DEFLECTION MONITORING SYSTEMS (CONT'D)