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Licensee: GPU Nuclear Corporation
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Parsippany, New Jersey 07054

Facility Name: Oyster Creek Nuclear Generating Station

Inspection At: Forked River, New Jersey

Inspection Conducted: October 5-13, 1988

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Inspection Summary: An Augmented Inspection Team (AIT) was dispatched to review the circumstances surrounding a steaming phenomenon on both Isolation Condensers in late August and September 1988 and an electrical fault associated with the No. 2 Diesel Generator on October 2, 1988. The team's charter was to provide NRC management with a comprehensive review of these events to assess the safety significance and licensee response to the events.

Areas Inspected: See areas listed in AIT Charter (Attachment A).

Results: Results of the inspection are summarized in paragraph 1. With regard to the isolation condenser event, the team concluded that the licensee pursued a prudent action in shutting down the reactor in light of the conditions as they were known on September 29, 1988. Followup actions appear appropriate and comprehensive. For the electrical event, licensee followup was considered appropriate. A number of actions remain to be completed prior to reactor startup following refueling. These actions are summarized on pages 15 and 21 of the report.

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## ATTACHMENTS

## PREFACE

As an aid to the readers' understanding of the steaming phenomenon experienced by the isolation condensers which prompted this inspection, a portfolio of photographs depicting some of the components which were prominently involved in the event has been added at the end of this report. The report details provide overviews of certain areas inspected. Attachments have been added which provide greater detail in several of these areas. Also, the Conclusion/Summary has been placed at the beginning of the report to identify the more important aspects inspected.

## DETAILS

### 1.0 Conclusion/Summary

Certain primary findings resulted from the review of the steaming of the isolation condensers with the condensate return valves closed. In addition, some secondary conclusions were also made.

Primary findings indicate that the "B" Isolation Condenser started spontaneously steaming several hours after being returned to service following being isolated for maintenance for approximately six days. The "A" Condenser started steaming after being out of service for only several hours to perform a surveillance test which had been performed many timesin the life of the plant. This indicates the "B" Condenser being in the steaming mode and interconnected through the common vent system was most probably involved in the initiation of the "A" Condenser steaming.

The vent system includes a single 400 foot run of 3/4 inch carbon steel piping which includes a loop seal and a single manual isolation valve. Any plugging of this line or faulty operation of the manual isolation valve has the potential to make both condensers inoperable.

The design of the isolation condensers coupled with operations or evolutions that were unique, led to conditions not previously experienced or identified. Certain indications involving condenser steam line temperatures had been noted. Region I Inspection Report 88-23 discusses inspector observations relative to unexplained isolation condenser steam line temperatures. The licensee, after the second condenser started steaming, initiated a technical evaluation team review of the occurrence and after determining water to be present in the steam lines promptly isolated the condensers and initiated a plant shutdown.

A secondary finding was that the extended out of service period of the "B" Condenser which preceded its steaming was, in part, due to a maintenance technician using a wrong instrument in backseating a valve which caused a valve operator motor to fail.

A review of strip chart recorder records did not indicate that exactly the same phenomenon had occurred in the past. However, certain anomalous conditions relating to the behavior of the isolation condensers were noted. In the past, steaming of a condenser had always been attributed to condensate return valve leakage.

The investigation of previous operating performance was hampered by chart traces which could not be identified with certainty and by the unavailability of other supporting information during the inspection period. Also, certain records were eliminated by the prolonged jumpering of alarms. The basis for the placement and the alarm setpoint for the isolation condenser steam line thermocouples remains to be determined.

Using the limited data available, a model was postulated which describes a possible mechanism by which abnormal flow in the isolation condenser could be initiated and maintained. The licensee is performing a more detailed thermal-hydraulic analysis of the phenomenon.

The licensee will evaluate and report certain physical effects which resulted from the improper operation of the condensers.

A review of the emergency bus failure shows the plant has underground cables connected to electrical buses which become an extension of these buses. Eight failures of these cables have been experienced, five since 1980. The presence of these underground cables requires an aggressive surveillance program in order to prevent additional failures. The licensee will provide a final report describing proposed corrective action.

## 2.0 Background

The isolation condenser system, designed to remove heat from the reactor vessel during transients when the normal heat sink is unavailable, may have been partially placed in service by a unique set of circumstances that resulted in a steaming phenomenon of the atmospheric side of the isolation condensers. This phenomenon occurred with the condensate return valves shut. Normally, the condensate return valves are opened to initiate the natural circulation flow path from the reactor to the isolation condensers. Attachment E (The Thermal-Hydraulics of the Steaming Isolation Condenser) details one postulated model for heat transfer to the isolation condenser from the reactor to take place with the condensate return valves shut. This phenomenon was first noticed on August 28, 1988, (see Inspection Report 50-219/88-23) while warming up the "B" Isolation Condenser prior to returning it to service from a six-day maintenance period. During the warm-up sequence the shell temperature was observed to increase significantly and seemed to coincide with the operation of the steam inlet isolation valve (see paragraph 5.0, Steaming of "B" Isolation Condenser, August 28, 1988). Following condenser warm-up, an operability surveillance was performed to return the isolation condenser to service. During this surveillance the condensate return valves were not properly sequenced in accordance with the procedure. This resulted in an inadvertent initiation of the isolation condenser for a few seconds, which resulted in a slight reactor power increase of about 1% and a reactor vessel level fluctuation of approximately 1 inch. Subsequently, the isolation condenser steam line temperatures were observed to stabilize at about 300 degrees F and 200 degrees F for the south and north steam lines, respectively. Prior to the isolation condenser maintenance outage during the period August 23-28, 1988, the steam line temperatures indicated approximately 540 degrees F, indicative of the thermocouples sensing a steam environment. During the maintenance outage, steam line temperatures read approximately 100 degrees F, the expected temperature with the isolation condenser valves closed.

On September 26, 1988, during a surveillance of the "A" Isolation Condenser high flow instrumentation, the shell temperature was observed to increase. This particular surveillance closes the three open isolation valves (two steam and one condensate valve) when a simulated high steam or condensate flow signal is inserted. The increase in shell temperature occurred following the valve realignment upon completion of the surveillance without any movement of the condensate return valve (see paragraph 6.0, Steaming of "A" Isolation Condenser, September 26, 1988).

Upon stabilization of conditions, the steam line temperatures for the north and south steam lines indicated about 300 degrees F and 200 degrees F, respectively. This condition represented nearly the same phenomenon experienced with the "B" Isolation Condenser. As a result of a detailed evaluation by September 29, 1988, the licensee determined that, based on the information available, a concern existed whether the isolation condenser system was capable of fulfilling its design function (see paragraph 10.0, Evaluation of Licensee's Review of Events). As a result, the licensee elected to make the isolation condenser system inoperable to avoid any potential water hammer and to proceed to cold shutdown conditions. Cold shutdown was achieved at 9:55 a.m., September 30, 1988.

## 3.0 Isolation Condenser System Configuration

The Isolation Condenser System is an Emergency Core Cooling (ECC) System which can be actuated automatically or manually. It is a standby, high pressure system for the removal of fission product heat from the reactor vessel following a reactor trip with main steam isolation valve closure. It depressurizes the reactor vessel in the event the main condenser is not available as a heat sink. Natural circulation provides the driving head through the isolation condenser tubes. The condensers are horizontal, shell and U-tube heat exchangers with a total rated heat removal capacity of 4.10X10E8 BTU/hr, each rated at 50% of total system capacity. The two isolation condensers are located in the reactor building at elevation 95 ft. The shell side of the isolation condensers contain a water volume which boils off to remove heat transferred from the reactor. The design basis of the Isolation Condenser System is such that its operation in conjunction with the Automatic Depressurization System and the Core Spray System, must be able to maintain peak cladding temperatures below 2200 degrees F for any size LOCA, assuming a single failure occurs in the ECC System.

The Isolation Condenser System is depicted in Attachment E, Figures 23-1 and 23-2, by a simplified drawing of one of the isolation condensers. The system consists of two isolation condensers; each condenser has steam supply isolation valves, condensate return isolation valves, isolation vent valves, and isolation condenser makeup water valves. The steam lines of the isolation condensers have installed thermocouples which extend into wells in the pipes at the inlet to the tube nests. The "A" Isolation Condenser thermocouples on the steam lines have a two foot elevation difference while the steam line thermocouples on the "B" Isolation Condenser are at the same elevation. The shell side of the isolation condensers also have installed thermocouples which sense bulk coolant temperature.

When the isolation condensers initiate, steam flows from the reactor vessel up to the isolation condensers through motor operated steam inlet valves which are normally open. At the 95 ft. elevation the single steam line (one per isolation condenser) splits into a "wye", rises approximately 18 ft. and loops around to the ends of the condensers where they enter the condenser "tube nests." Both condensers have a tube nest at each end. Each tube nest has an effective heat transfer area of approximately 850 sq. ft. The steam condenses and flows back to the reactor through motor operated condensate return valves (1 AC & 1 DC MOV's on each return line) to points on the Reactor Recirculation System pump suction. There is approximately 60 ft. of condensate piping from the condensate return valves to the reactor recirculation loops. The Condensate Transfer System is the normal supply of makeup water to the isolation condenser shell volume. The Demineralized Water Transfer System can supply makeup water to the isolation condensers for day-to-day evaporation. The water can be supplied from the Demineralized Water Transfer System to the condensers through sample connections using a flexible hose; this was accomplished for the events. Fire water can be used as an alternate source of makeup in the event that the Condensate Transfer System is unavailable. The shell sides of the isolation condensers are continuously vented to atmosphere through large vent pipes.

The vent arrangement for the "A" Isolation Condenser is slightly different than the "B". The "A" condenser vents consist of two 20" lines which combine to form a common 28" vent that exits the east reactor building wall north of the two vents for the "B" Isolation Condenser. The atmospheric vents of the "B" Isolation Condenser consist of two 20" pipes that vent directly outside the adjacent reactor building wall (east).

Normally open, small air operated steam line vent valves vent noncondensable gases from the isolation condensers through a common header to the north (B) main steam line. The vent header connects to the "B" main steam line downstream of the outboard main steam isolation valve outside the trunion room at elevation 27 ft. This is 3/4 in. piping largely without insulation. Noncondensables, if allowed to build up in the isolation condenser tubes, would inhibit effective heat transfer from the reactor to the isolation condensers. The common vent header places the "A" and "B" Isolation Condensers in hydraulic communication with one another at their highest elevations. The steam line vent valves isolate during operation of the isolation condensers. The

3/4 in. vent piping follows a lengthy path (approximately 420 ft. of piping) from elevation 115' 6" at the isolation condenser to a low point at elevation 6'6" before turning up and intersecting the B main steam line at elevation 27'. This section of the vent could possibly provide a loop seal if steam is condensed in the vent line and accumulates at this point.

The isolation condensers are placed in standby by placing the steam supply and condensate return valve control switches in the AUTO position. This opens both series steam supply valves and the AC motor operated condensate return valve associated with each condenser. The DC motor operated condensate return valves (in series with the AC MOV's) the only valves normally shut. Upon receipt of an automatic or manual initiation signal, the normally shut DC operated condensate return valves open to initiate flow through the condensers.

4.0 Review of Previous Isolation Condenser Performance

As part of the inspection effort, previous operating performance for the isolation condenser was reviewed to determine if similar or other anomalous conditions have existed in the past and provide some insight into the present phenomenon. This review examined recorder strip charts for the isolation condenser steam line and shell temperatures (i.e., North and South Steam Line and Shell Temperatures). This recorder was replaced in the 1983-1984 outage with an updated model. The review was hampered by unidentifiable traces on some strip charts and unavailability of certain other records which could have supported the traces. In addition, the licensee had bypassed the steam line temperatures for the isolation condensers for certain periods of time to eliminate the annoyance of a constant alarm condition, thereby eliminating these parameters from the recorder strip charts. This was conducted with a safety evaluation (see paragraph 8.0).

The inspectors reviewed selected strip chart traces for the years 1970, 1972, 1974, 1982, 1984, 1985, 1987 and 1988. From this review, it is not clear that this same phenomenon had occurred in the past, but some interesting anomalous conditions were found.

A number of examples existed that indicated that some leakage was occurring past V-14-34 and V-14-35, the normally closed condensate return valves. The charts reflected steam line temperature increases from approximately 120 degrees F and in equilibrium with stabilized shell temperatures, to greater than 500 degrees F, during valve operability surveillances. This could be due to leakage past the condensate return valve. A steam line temperature of approximately 120 degrees F indicates that a significant amount of steam had condensed in the vertical leg of steam line piping where the thermocouple is located. For temperatures to increase from 120 degrees to over 500 degrees F provides an indication that condensate displacement by steam during the valve operability surveillance was larger than normal. Other valve operability surveillances have resulted in only 40-50 degree F increases, as presumably, a small amount of condensate is displaced. Inspection of the valves after an anomalous condition in 1985 revealed that the valve was leak tight with no observable indications of leakage. Having experienced anomalous temperature conditions and during a subsequent valve inspection finding no observable indication of leakage may lead to a conclusion that some type of thermal mechanism associated with the valve cycling may have caused some momentary leakage to occur. The conditions described above were observed with V-14-35, but V-14-34 has displayed some indications of leakage also. In early and late 1987 the "A" Isolation Condenser experienced steam line temperature readings of approximately 548 degrees F with elevated shell temperature readings of between 130 and 160 degrees F while the "B" isolation condenser shell temperatures indicated between 75-115 degrees F and steam line temperature of approximately 548 degrees F for the same time period. This would provide some indication that V-14-34 may have been leaking under certain conditions. V-14-34 internals have not been inspected since these conditions were observed.

### 4.1 Review of the June 12, 1985 Reactor Isolation Scram

A review was conducted of a June 12, 1985 event in which the isolation condenser was initiated to gather information on the isolation condenser operating parameters. The details of this review are presented in Attachment D.

During the actual operation of the condenser the shell and steam inlet temperatures responded as expected and did not correlate to the temperature responses of the recent isolation condenser phenomenon. However, following the initiation of the isolation condenser the steam inlet temperature deviated from the saturation temperature corresponding to reactor pressure. The steam inlet temperature dropped from 350 degrees F to 220 degrees F and then, fifteen minutes later, increased to 300 degrees F. This decrease in temperature and subsequent increase cannot be fully explained. Although there was a limited amount of raw data available, analysis showed that there was a potential to set up conditions in the isolation condenser similar to the August 28 and September 26, 1988 phenomenon. The licensee has been asked to independently review and assess this possibility.

Though postulating that the "A" Isolation Condenser experienced this phenomenon is based on circumstantial evidence, the occurrence of this phenomenon on June 12, 1985 was nevertheless possible. The licensee has been asked to independently review and assess the possibility that the August 28 and September 26, 1988 isolation condenser phenomenon occurred in the "A" Isolation Condenser on June 12, 1985.

## 5.0 Steaming of "B" Isolation Condenser, August 28, 1988

On August 23, 1988, the "B" Isolation Condenser was removed from service and isolated. The isolation valves and vent valves were closed. This alignment remained until August 28, 1988, when it was returned to service. Valve alignment during this period was:

- -- Steam inlet valve (V-14-33). . . . . . . . . . . . . . . closed
- -- Steam inlet valve (V-14-32). . . . . . . . . . . . . . . closed
- -- Condensate return valve (V-14-37). . . . . . . . . . . . closed
- -- Condensate return valve (normally closed) (V-14-35). . closed
- -- Vent Valves (V-14-1, V-14-19). . . . . . . . . . . . . closed
- -- Isolation condenser shell temperature. . . . . . . . . 93 degrees
- -- Temperature between valves V-14-35 & V-14-37 . . . . . 255 degrees

Procedure 307, Isolation Condenser System, section 8, was being used to return the system to operation. During this procedure, the control logic for valve V-14-32 is modified to allow throttling of the valve from the control room. This modification was performed and the valve was opened and closed to verify the ability to throttle.

The process to align system valves and control the rate of isolation condenser heatup is to open the redundant condensate return valve (V-14-37) and a redundant steam supply valve (V-14-33). One steam supply valve is left closed (V-14-32) and the "normally closed" condensate return valve (V-14-35) is left closed. Now, the isolation condenser vent valves (V-14-1 and V-14-19) are opened. Since the two isolation condenser subsystem vents are cross connected, opening the vent valves establishes a flow path from the "A" to the "B" Isolation Condenser, and this would act to pressurize the "B" Condenser. The process also allows for "throttling open" steam inlet valve V-14-32, to admit steam in order to warm-up/pressurize the isolation condenser. Once the isolation condenser is near normal operating temperature and pressure, the steam inlet valve V-14-32 is fully opened, and the control logic modification is removed. The isolation condenser will now initiate when the normally closed condensate return valve, V-14-35, is opened.

At about 3:29 a.m., the power was restored to the outboard (normally closed) condensate return valve, V-14-35. This would also supply power to the isolation condenser vent valves, V-14-1 and V-14-19, but they were not opened.

At about 3:46 a.m., the inboard condensate return valve, V-14-37, was opened. With this valve open, the temperature between valves V-14-37 and V-14-35 started to increase from 255 degrees at about 22 degrees/hour. This temperature increase is expected due to convection heating from reactor coolant from the recirculation pump suction.

With steam inlet valve V-14-32 indicating closed, the redundant steam inlet valve, V-14-33, was opened. A sharp increase in isolation condenser steam line temperature was observed (120 to 300 degrees in 2 minutes), and V-14-33 was immediately closed. It was suspected that valve V-14-32 had not been fully closed after the earlier valve operations, and the control room operator cycled the valve open/close to ensure that the valve was fully seated. Valve V-14-33 was then opened with no further heatup of the isolation condenser. Since Procedure 307 limits the heatup rate of the isolation condenser to 90 degrees/hour (average), subsequent heatup was limited to ensure that the average heatup rate was not exceeded.

At 6:15 a.m., the "B" Isolation Condenser vent valves (V-14-1 and V-14-19) were opened. As discussed above, this would allow the "B" Isolation Condenser to be pressurized from the "A" Isolation Condenser. However, unknown to the operators at this time, a manual vent valve on the "A" Isolation Condenser (V-14-6) was closed, isolating the vent path of the "A" Isolation Condenser from the "B". Because of this valve alignment and because the "B" Isolation Condenser was not pressurized, a reverse differential pressure would be established across the isolation vent line, and reverse flow would result from the steam lines back to the isolation condenser. With the isolation condenser isolated and depressurized, it is likely that reverse flow would be established from the main steam line to the condenser via the vent line piping. The isolation condenser vent valves were closed at 6:16 a.m., and were periodically opened/closed from 6:50 a.m. until 9:49 a.m. while attempting to pressurize the isolation condenser.

At 6:50 a.m., valve V-14-32 was "cracked" open to pressurize the isolation condenser. Three minutes later, the control room operator reclosed V-14-32. Temperature in the isolation condenser peaked at 395 degrees F after this valve operation, and began slowly drifting downward.

At 10:00 a.m., valve V-14-32 was again opened (10:00 a.m.)/closed (10:06 a.m.) to heat up the isolation condenser, and, at 10:03 a.m. the isolation condenser shell temperature started to increase. By 10:15 a.m. the shell temperature had increased from 93 degrees to 105 degrees and was steady. It was also during this time frame (10:20 a.m.) that the temperature between V-14-37 and V-14-35 stabilized at 400 degrees, (the normal steady state temperature between V-14-35 and 37 during power operation).

At 10:35 a.m., valve V-14-32 was again opened to heat up the isolation condenser. V-14-32 was closed at 10:50 a.m., and then at 10:55 a.m., valve V-14-32 was fully opened and remained open.

At 11:02 a.m., the isolation condenser shell temperature indicated 107 degrees and was increasing at a rate of 47 degrees/hour. The isolation condenser valve alignment was now:

-- both steam inlet valves open (V-14-32, V-14-33)

-- AC condensate return open (V-14-37)

-- DC condensate return closed (V-14-35)

-- vent valves open (V-14-1, V-14-19)

Before returning to service, surveillance test 609.4.001, "Isolation Condenser Valve Operability and IST," was to be performed. It was during this test that the control room operator inadvertently moved valve V-14-37 in the open direction while valve V-14-35 was open. This effectively resulted in initiation of the "B" Isolation Condenser for about 6-8 seconds. The control room operator immediately closed V-14-37 and closed V-14-35. A minor plant transient resulted. The surveillance was subsequently completed and the isolation condenser returned to service.

Subsequent to the inadvertent initiation, the temperature between valves V-14-35 and V-14-37 fell from 400 degrees to about 275 degrees in a twenty minute period. It then started to rise and eventually returned to about 400 degrees.

By 1:17 p.m., the "B" isolation shell temperature reached 212 degrees. It was suspected that valve V-14-35 was leaking across its seat, so it was cycled open/closed in an effort to "reseat" the valve.

By 1:38 p.m., the low level alarm on the "B" Isolation condenser was received and makeup water was added. Eventually, continuous makeup would be supplied to the "B" condenser shell side, at a rate of 18 gpm.

## 6.0 Steaming of "A" Isolation Condenser, September 26, 1988

During performance of 609.3.002, "Isolation Condenser Isolation Test and Calibration," on the "A" Isolation Condenser on September 26, 1988, the shell temperature of the "A" Isolation Condenser started to increase. This test results in the closing of the two normally open steam supply valves (V-14-30, -31), and the normally open condensate return valve (V-14-36). This was performed at 10:34 a.m., and the valves were reopened at 11:42 a.m. to break for lunch. At approximately 12:30 p.m. the shell temperature on the "A" Isolation Condenser was observed to be 153 degrees F and increasing. Initially shell temperature was approximately 125 degrees.

At 1:32 p.m., the valves were once again closed to complete the testing of the "A" Isolation Condenser. During this period of time, the rise in shell temperature stopped at 179 degrees. When the isolation valves were reopened at 2:30 p.m., the increase in temperature of the "A" condenser shell resumed. At 4:05 p.m., the shell temperature reached 212 degrees and the "A" Isolation Condenser was "steaming" in a manner similar to the "B" Isolation Condenser.

It is significant to note that the normally closed condensate return valve (V-14-34) had not been repositioned. In addition, when the condenser isolation valves were closed, the condenser vent valves (V-14-5 and 20) remained open.

## 7.0 Thermal-Hydraulics of the Steaming Isolation Condensers

This section describes a possible mechanism by which abnormal flow in the isolation condensers could be initiated and maintained, which produces shell side steaming with a condensate return valve on each isolation condenser closed. This section will also provide a basis for interpreting the licensee's model when it becomes available and facilitate the evaluation of corrective and preventive measures required before returning the isolation condensers to service.

When the isolation condenser steaming was first observed, the possibility of a tube leak was investigated and eliminated. Radiation measurements in the shell side fluid were below minimum detectable. Three hypotheses were then advanced for interpretation:

(a) condensate isolation valve leaking,

(b) some kind of level oscillations in the tube side of the isolation condenser which allowed for steam condensation in the coils, and

(c) some unidentified circulation pattern.

The "B" Isolation Condenser was out of service for valve maintenance from August 23 to August 28, 1988, and when returned to standby status started steaming for no apparent reason. Efforts were made to identify the reason for this steaming (Refer to Attachment E, Figure 1 and FSAR Figures 23-1 and 23-2). The licensee drilled through the insulation and recorded the average temperatures shown on Figure 1 in the corresponding locations. These temperatures show that the "south" (left) coil is producing shell side steaming and the "north" (right) is not. This indicates that possibly an internal circulation pattern which promotes steaming was established as indicated in Figure 2. In this postulated circulation pattern, condensate from the south coil goes up through the north coil, descends through the north steam pipe back into the steam supply pipe. Steam ascends through the south steam pipe to the south coil where it condenses. In this model there is practically no evidence that there exists any significant oscillatory pattern, at least not to the extent that the coils change roles in condensing steam. Therefore, attention was given to the identification and quantification of the driving heads (and losses) for this continuous model.

Known facts were used to construct the model where they were available. Where sufficient factual information wasn't known, reasonable assumptions were made. Refer to Attachment E for a discussion of driving heads, and initiation mechanisms involved in the inspectors' model.

The inspectors have concluded, based on this engineering evaluation of the isolation condensers, that:

- the steaming in either isolation condenser takes place only on one tube bundle of each condenser,

- the postulated flow patterns required a very small head and are a combination of gravity, temperature differences, and small flow-induced pressure differences,

- the design of the isolation condensers is such that under certain conditions there is a built-in source of instability,

- there is a possibility that water hammer might have occurred if the isolation condensers were required to operate while steaming,

- there is no reason to believe that the steaming condition would be detrimental to heat removal during system initiation, except for the possibility of water hammer as mentioned above.

As part of the charter of the AIT 88-80, the inspectors collected and reviewed all of the available information regarding the conditions and the causes of steaming in both isolation condensers. The available information is not complete and we hypothesized the flow patterns and temperature distributions in an attempt to find an explanation as to why steaming was initiated and how it attained a steady state condition. The circulation model arrived at incorporates all of the known relevant information, but it is not complete. However, it provides a perspective of one possible circulation model, the magnitude of the required driving heads, and the condition of the condenser steam vent pipe. Similarly, some hypothesis of initiating mechanisms is presented. Besides raising questions, the above models form a framework for the review of the licensee's model when it becomes available.

8.0 Inspection Findings Associated with Isolation Condenser Operation

During the course of the inspection, certain facts associated with the operation of the isolation condensers were identified. These are presented as follows:

-- The safety significance of operating with the isolation condensers in the steaming mode could not be determined. Clearly the shell water volume was being maintained as was the condenser actuating logic.

  The major concern involved in the actuation of the condensers would be the possibility of initiating a water hammer severe enough to cause damage to the isolation condenser system piping or condenser tubes. The pressure differences associated with the operation of the condensers are relatively low generated primarily by the head of water. However, the amount of water in the steam lines and the behavior of this water following condenser initiation could not be determined. Consequently, the generation of a water hammer condition could not be eliminated. Also, the additional water upstream of the tube bundles might briefly delay the condensers' effectiveness. For these reasons the isolation condensers were potentially in an unanalyzed condition and their operability was questionable.

-- The isolation condenser steam lines are provided with well-type thermocouple temperature sensors before they connect to the tube bundles. These temperatures read out and are recorded in the control room. A common temperature alarm is also provided which alarms on high temperature in the steam lines or shell side of the isolation condenser. The alarm setpoint is 225 degrees F. The manual actions specified for the alarm are, "Check position of valves V-14-34 and V-14-35 for system initiation or leakage past valve. Check level at Panel 2F for increasing level indicating tube leaks, or decreasing level, indicating system in operation or isolation valve leaking."

The basis for the alarm setpoint of 225 degrees F could not be found. Some evidence exists which suggests that at one time the alarm had been 350 degrees F. Since the steam line temperature is frequently higher than 225 degrees F the alarm had been identified as a "nuisance alarm" and has been bypassed since May 15, 1987. Other evidence also shows the "A" condenser steam line alarms had been bypassed in 1982.

It is unlikely that a shell side alarm of 225 degrees F would ever be relied upon to indicate isolation condenser initiation. Also, steam line temperature recorder traces show that for extended periods of time (months) these temperatures are above the alarm setpoint. These recorder traces and other temperature records show that steam line temperatures vary from in the low 100's to 540 degrees F. Consequently, it appears a temperature sensor has been installed with an associated alarm for which no basis exists and for which any temperature reading is acceptable. The licensee has been requested to provide a basis for these alarm setpoints.

The FSAR in describing the isolation condenser steam lines where they enter the tube bundles states, "These lines are provided with a five-foot vertical water trap section at the entrance of each tube bundle to prevent condensate drainage from the tubes (which are flooded) into the steam lines, and thus preclude flux steaming during standby." The steam line thermocouples are located in these vertical water trap sections. Perhaps these thermocouples and their associated alarm were intended to provide an indication of condensate level in the vertical section of the steam line. At the time of the inspection the licensee could not provide a design basis for the thermocouple placement or the alarm setpoint.

-- The maintenance histories for the isolation condenser steam and condensate valves were reviewed. These histories as well as discussions with personnel and other documentation indicate that on many occasions the normally closed condensate isolation valves leaked or were suspected of leaking. Outage reports which provided some detail of the maintenance performed in each instances where the normally closed condensate return valves were disassembled and inspected; they showed evidence of leakage and required some repair. These valves have not been inspected since 1985; consequently, it is possible that some leakage past these valves existed. However, any significant leakage would have been identified through elevated shell temperatures. Leak rate determinations associated with these valves is discussed in Inspection Report 50-219/88-23.

-- The isolation condenser steam lines are provided with vents at the high points in the line. These vents are installed to vent noncondensables to the main steam line downstream of the main steam isolation valves. These vent lines are provided with isolation valves and downstream of these valves join together into a single line which extends approximately 400 feet to the main steam line. In traveling these 400 feet the elevations of the line are such that an approximate 18 foot loop seal is established. A single manual isolation valve is provided where the line enters the main steam line.

The vent line is a 3/4 inch schedule 40 carbon steel pipe which has been in service for over 20 years. This line may have rusted and may contain some amounts of debris in the lower portions. This debris may prevent the free flow of steam. In this way a single blockage or valve failure has the capability to adversely affect the operation of both condensers. Records show that in the past the manual valve at the main steam line has been "throttled closed" in an effort to reduce the shell temperature. The licensee has been requested to address the potential of a single failure to adversely affect the operation of both condensers.

9.0 Equipment Effects/Impact

The licensee has initiated steps to evaluate certain concerns which developed as a result of the improper operation of the isolation condensers. The specific concerns to be evaluated are:

-- analyze dead weight stress due to hydraulic loading to ensure there was no overstress on piping or equipment nozzles,

-- ensure no thermal fatigue concerns exist due to any transient conditions,

-- Inspect system hangers and supports, and

-- determine possible effects of water flow in the isolation condenser vent lines on main turbine blades.

Final reports including results of these evaluations will be provided to the NRC.

10.0 Evaluation of Licensee's Review of Events

In response to the unusual occurrences which precipitated the unscheduled shutdown of the facility the licensee has taken actions to evaluate, correct and prevent this situation from recurring. This paragraph provides an independent (NRC) evaluation of the licensee's efforts in this regard.

As indicated in paragraph 3, the "B" Isolation Condenser exhibited unexplained steaming after a brief unintentional initiation of the "B" Isolation Condenser (see Inspection Report 88-23) on August 28. The inspectors expressed concerns regarding the unexplained response of the "B" Isolation Condenser steam line thermocouples. The licensee indicated that their literature research and preliminary analysis did not provide any answers. On September 26, a surveillance of the line break instrumentation on the "A" Isolation Condenser included shutting all four isolation valves. Upon returning the condenser to service, it exhibited the same phenomenon as the "B" Isolation Condenser.

Upon observing steam through the "A" isolation condenser shell side vent, which followed steaming from the "B" isolation condenser shell side, the licensee assembled a team of specialists from Technical Functions and Plant Engineering to investigate the phenomenon. The team evaluated the sequence of events which took place August 23 to September 26, 1988. The beginning of the sequence which set up the thermal-hydraulic conditions in the "B" Isolation Condenser was on August 23, 1988. Events which initiated similar conditions in the "A" Isolation Condenser took place on September 26, 1988 as a result of a routine surveillance test. The licensee at this point was aware of possible safety implications due to inlet/outlet temperatures in the isolation condensers which suggested abnormal flow conditions.

The licensee's initial evaluation of the abnormal operating characteristics in the isolation condensers included the acquisition of temperature data which was in addition to data accumulated from installed thermocouples in the isolation condensers and steam lines. Surface temperature readings on the steam and condensate piping of the "B" Isolation Condenser were taken. As previous noted, this was done by boring holes in the insulation around the piping through to the outside surface of the pipes at four azimuthal locations each on the outlet of the condenser tube bundles and at the "wye" at the bottom of the steam risers (see Figure 1), and utilizing a contact pyrometer to read the temperatures. While performing these temperature measurements at the "wye" section of the steam riser, licensee personnel noted (1) "...low amplitude vibration in the piping...on the order of 5 cycles per second...," (2) "...a rumbling noise...like flow going through a pipe...in sync with the rumbling...," and that (3) "...the intensity (of vibration) felt erratic given...the impression that some turbulent event was occurring in the pipe..." It is through the acquisition of this data that the licensee was able to draw some preliminary conclusions/explanation for the phenomenon in the isolation condensers. Upon concluding an abnormal flow path existed, the condensers were made inoperable and the plant promptly shutdown.

A plant shutdown began on September 29, 1988 due to steaming at an unprecedented rate from the shell side of the condensers and an assumption that water had filled the steam lines. The licensee's decision to shut down the plant was based on the possibility that, if during normal operation of the facility the isolation condensers were called upon to perform their design function, severe water hammer might result upon initiation which could cause damage to the isolation condensers. Since a tube break would result in a direct pathway for primary coolant release to the atmosphere, water hammer needed to be guarded against. The team felt the licensee's action to shutdown was prudent.

Since the shutdown the licensee has reorganized and expanded its team of specialists investigating the problem. A task force assigned to evaluate eight areas has been organized and instituted. The task force is charged with investigating the following areas: 1) Explanation of the thermal hydraulics of the phenomenon and construction of a workable computer model; 2) Reconstruction of a detailed sequence of events leading up to the plant shutdown; 3) Stress analysis of related components; 4) Possible operating methods and procedure changes to prevent the abnormal flow phenomenon from recurring; 5) Possible required modifications to the isolation condenser piping network to preclude recurrence; 6) Accumulation of information regarding similar occurrences or events in the industry; 7) Review of outage maintenance plans to assure as-found data important to the operation/evaluation of the isolation condensers is preserved, additionally, consider the effects of water in the steam vent line on the turbine blades; and 8) Preparation of an integrated report on the findings of the task force.

The inspectors reviewed the proposed organization of the task force plan and discussed its charter with the licensee. The licensee has assigned an overall project manager from Technical Functions who is dedicated to the task force as well as a subtask manager for each of the eight tasks. Additionally, team members have been selected for each task and the scope and target completion date of each task has been defined. The licensee has committed to evaluate the event and provide corrective/preventive action before starting up from this outage (see Attachment B). The team concluded that proposed licensee actions are appropriate and comprehensive.

## 11.0 Electrical Event

On October 2, 1988, Oyster Creek Nuclear Station lost power to one half of the safety related electrical system (B) train. This was later determined to be as a result of a cable insulation failure.

### 11.1 Event Summary

The plant was in shutdown with the safety related electrical buses energized from offsite power sources. Reactor temperature was 145 degrees F and the reactor level 162" above the top of active fuel with A and B shutdown cooling pumps in service. On October 2, 1988, at 1:57 p.m. emergency diesel generator 2 locked out and the feeder breaker for 4160 V safety related Bus 1D tripped. The existing shutdown cooling was lost as both running pumps were on the tripped bus. The reactor water temperature increased to 162 degrees F. The licensee promptly reestablished shutdown cooling using the A train power supply and stabilized the temperature at 158 degrees F. The operations department tried to energize the tripped bus by reclosing the breaker but the breaker immediately tripped open. The maintenance department located the fault 7 hours later as being in the cable between diesel generator 2 and 4160 V emergency Bus 1D. The faulted cables were disconnected and Bus 1D was energized from the offsite power source within 8 hours of the event. The emergency diesel generator 2 remained unavailable due to the disconnected bus cable. A detailed chronology of events is provided in Attachment F.

11.2 Plant Status Analysis and Conclusions

An Augmented Inspection Team sent to the site by the NRC management was directed to inspect the following aspects of the electrical event:

- Assess the plant condition with an unavailable emergency diesel generator.
- Develop a chronology of the events.
- Review and assess the logic of diesel generator lockout feature.
- Review the prior history of electrical bus faults.
- Evaluate the adequacy of the licensee's review and corrective actions.

The lockout of the Emergency Diesel Generator (EDG) is a design feature to prevent the EDG from starting and loading on a faulted bus. This signal is generated when the starting and the loading of the EDG is not practical due to an electrical fault on the bus that cannot be isolated or removed by virtue of the installed automatic features on protective relaying.

During the shutdown condition of the plant, emergency train B (Bus 1D) is energized from an offsite source through breaker 1D and Bus 1B. A ground fault was sensed at a relay above breaker 1D (see attached Electrical Power System Sketch, Attachment G) which tripped breaker 1D. This is due to a fault at the 1D Bus or a significant fault at any location below the feeder breakers on Bus 1D which was not isolated by the immediate servicing breaker. Either of these conditions indicate a sustained fault on the bus making it unsafe for the emergency diesel generator to be connected. The setpoint of the ground fault relay is at a reasonable setting to distinguish a ground fault without causing any permanent damage to plant equipment. This condition prompts an EDG lockout. Any other conditions, such as undervoltage, fault on Bus 1B or loss of power to Bus D, would not have caused the diesel lockout. Therefore, this review indicates the diesel lockout was generated only when the fault was confirmed to be on the bus and it functioned in accordance with the Oyster Creek design (see Assessment of Oyster Creek 4160 V Emergency Bus, Section 11.4).

Because of the above event, half of the safety related electrical system (one train) lost power. The licensee design has provisions for cross connecting the safety buses in case of emergency. The team reviewed the instructions documented in procedures 337 and 338. As the plant was in shutdown condition during this event, shutdown cooling was established with the available train "A". The licensee has Station Procedure 2000-OPS-3024.27, Rev. 3, "Shutdown Cooling System-Diagnostic and Restoration Actions," in place for establishing shutdown cooling. This procedure also addresses alternate decay heat removal using the core spray pump and torus water utilizing the relief valves. The team verified the support systems, reactor building closed cooling and service water system to be powered from safety buses. This arrangement permits the establishment of long-term shutdown cooling if any of the safety train is energized with offsite power source or onsite emergency diesel generators.

11.3 Previous Electrical Bus Faults/Losses

Oyster Creek emergency diesel generators (EDG) are located 200 feet away from the turbine/reactor building. The diesel generator, control panel, auxiliary systems and the breaker that connects the generator to the emergency bus are located in the diesel building. This breaker is connected to six single conductor cables (2 per phase) that run underground for 200 feet and another 150 feet inside the building to reach the respective 4160 V emergency bus. The underground cables in this arrangement become an extension of the Class 1E Bus always energized as the part of the bus and there are no breakers in between the safety bus inside the building and the diesel generator building. Any failures on these cables result in power loss to the respective Class 1E train.

Each of the 4160 V buses also feeds the unit substations that service the intake structure through an outdoor underground cable feed of 150 feet. Another underground cable feed is to the dilution plant (water makeup to reduce change in water temperature due to plant use) and it originates from the A startup transformer. Even though the above two cases are not safety related applications, faults on these cables can influence the availability of the safety bus, so the history on failures of these cables are also listed below:

1975 EDG-1, One Phase of the Spliced Cable Section Failed: The team reviewed the test report presented by the Electrical Testing Laboratories dated December 29, 1979. This report indicated the failure was due to a voltage surge. This is consistent with the licensee reported lightning event discussed in a 1973 reportable occurrence. The test laboratory's report recommended periodic high potential testing of power cables at 25KV DC volts, use of heavier wall insulation and an extruded outer semicon shielded cable.

1977 EDG-2, One Phase of the Spliced Cable Section Failed: Observed pinholes in the insulation which could be from a lightning surge resulting from the lightning strike in 1973. All DG cables were replaced.

1978 Ground Fault in Cable Connecting Offsite Power and Startup Transformers (Bank 5) Main Cable Bus: Subsequent review indicated that all outdoor 5KV nonshielded cables have undergone accelerated corona degradation. All cables were replaced with shielded copper cable according to the original Architect Engineer (AE) specification instead of unshielded aluminum.

1980 Dilution Pump Feeder Cable Failed: The licensee inspection found that water completely filled the cable vault. The conduit was reduced from 4" to 3.1/2" just inside the vault wall. This conduit was submerged and filled with water. The cable jacket was found severely cut and damaged (from original construction) in the area of the conduit reducer. Water was found inside the inner conductor and between the out jacket and insulation layer.

The licensee installed a 4" duct to replace the 3.1/2" and 3" sections. Sump pumps were also installed in the cable vault.

1983 Dilution Pump Feeder Cable Terminations were Tested as Water Seepage was Found in Turbine Building Mat: The leakage current was too high for several cables. Determination was made that the cause of the failures were due to a cut in the insulation as well as improper installation methods. Stress cones at cable ends were replaced. Cable was verified to be in good condition.

1983 EDG-1, One Cable of One Phase With a Splice Failed: The failed cable was replaced in February, 1984. The cable inspection by Hanby Associates indicated that the cable with the faulted section (tested adjacent sections to the fault) showed no leakage current at 20 or 30 Kilovolts. The licensee attributes the failure to a manufacturing defect.

1986 Dilution Pump Feeder Cable Failed: Damage to cables indicated that water incursion was the cause of failure. The licensee replaced stress cones and cable was found to be in good condition. Water entrance was due to wicking of moisture along the shield drain wires and up into the stress cone. Drain wires were vented below stress cones to prevent entrance of water into the stress cone area.

1988 USS 1A3 Feeder Failed: Failure of cable did not pierce outer jacket. Failure was small and localized in nature. The copper foil shield was discolored from heat and current within 6 inches of each side of the fault suggesting that ground current was being carried for a long period of time. Review of the original plant high potential tests showed that one of the three phases was high in leakage in 1968 during construction. It was concluded that an original defect was the cause of failure. The corrective action was the replacement of all cables in the feeder.

The licensee's corrective actions in the above failures appear to be reasonable. The team reviewed the records on the testing done on cables after installation. However, in spite of the repeated failures and contrary to the recommendation from the Electrical Testing Laboratories (addressed in 1975 event), the licensee did not institute a surveillance program to monitor the integrity of the safety related electrical cables. The cable failure on October 2 1988 remains to be analyzed when the cable is pulled out of the duct.

11.4 Assessment of Oyster Creek 4160 V Emergency Bus

The emergency diesel generators are located 200 feet away from the turbine building and a total of 350 feet away from the main switchgear inside the building. Two hundred feet of cable run is through outdoor underground ducts that are below the switchyard and a plant service road inside the protected area. The cable failures discussed in paragraph 9.3 indicate the susceptibility of outdoor cables for failure. The diesel generator cables are designed to be an extension of the 1E Bus, always energized, and there are no breakers in between the bus in the turbine building and the diesel generator building. This cable normally serves the diesel generator auxiliary systems and functions as the feeder when diesel generator is supplying the load.

Any potential fault on these cables makes the corresponding safety train immediately unavailable and locks out the diesel generator. The control circuit is designed such that the lockout signal is generated only when a fault is confirmed to be on the safety bus and not isolated by the tripping of the downstream safety grade breakers. Even though locking out a diesel under such bus fault condition is unique to the Oyster Creek station, it appears prudent in this application as the most probable failure is on the cable which can be promptly isolated and the bus recovered in minimum time. As the cables for one EDG are run in two independent raceways, the failure may be limited to one cable and therefore the unfailed cable can be connected back to feed almost 60% of the EDG capacity in case of emergency. The ampacity requirements and the installed size of the conduit in the duct limits any substantial upgrade of the cable insulation (changing to 15KV insulation) while utilizing the existing raceway system.

Substantial improvement (use of 15KV insulation) in cable insulation thickness can be achieved through the use of 3 triplex cables using the existing underground raceway instead of 2 single conductor cables per phase. The licensee considers this option to be prohibitive due to the cost of installing 150 feet of cond 't inside the turbine building to each of the safety train switchgear.

Lightning surges and other switching surges can cause gradual degradation of the insulation and can lead to potential common mode failures, especially when cable insulation for the rated voltage currently installed has exhibited failures in the past. The probability of such cable failures needs to be evaluated when the licensee corrective actions and surveillance program are finalized.

11.5 Licensee Corrective Actions

The opening of breaker 1D deenergized half of the safety related electrical system. The licensee started prompt measures to restore this 4160 V bus. The first alarm that came on was "LKOUT RELAY TRIP". This indicates that EDG-2 has been locked out. The alarm response procedure 2000-RAP-3024.02, Revision 10 has the following confirmatory actions:

> "Verify trip of diesel generator 2 breaker (and Bus 1D if affected). Find any targets at diesel generator and at the Bus 1D in 4160 V room".

Contrary to the above, the licensee personnel looked for targets only at the 4160 V room and elected to close the breaker within 11 minutes from the first alarm. The breaker closed on to the fault and tripped instantaneously.

The electrical maintenance crew started troubleshooting. The maintenance staff made the following observations:

(1) The ground fault relay on D Bus was tripped and the diesel generator was locked out.

(2) The B phase differential relay on diesel generator 2 was tripped.

(3) Two phase shield ground leads on phases B & C in the EDG-2 breaker cabinet (located in the diesel generator building) were detached.

The licensee's investigation is in progress to determine how ground leads became disconnected.

The above indications confirmed the fault to be on the EDG-2 cable and the cable was disconnected at both ends. The 4160 V Bus was subsequently energized by aligning the breakers to the offsite power supply. This activity was complete in 8 hours.

The root cause analysis for the current cable failure will start as soon as the failed cable is available for inspection. However, based on the history of failures the following commitments were made. The immediate corrective actions scheduled before restart are as follows:

(1) EDG-2 cable that failed will be replaced with a cable that has 33% more insulation.

(2) EDG-2 cable that failed will be analyzed by an external specialist and further action will be taken as appropriate.

(3) EDG-2 cable that did not fail will be D-C Hi-Pot tested at a minimum of 15 KV prior to plant restart.

(4) EDG-1 cable(s) will be D-C Hi-Pot tested at a minimum of 15 KV prior to plant restart.

(5) 1B3 Feeder will be tested prior to restart due to the failure of the 1A3 cable in July of 1988.

(6) The need for surge suppression on the offsite feeders to the plant 4160 buses will be evaluated and scheduled if necessary.

(7) Part of the ground system including the ground connection for the EDG switchgear will be tested during 12R.

The licensee's previous practice was to test the cables at 10 KV with the motor connected to it. The industry standards recommend DC high potential test at 25 KV for maintenance testing. The team expressed the need to substantiate the licensee's position for using 15 KV as test voltage. The licensee letter, Attachment B, has committed to provide a final report of the corrective actions for NRC review and resolution of technical issues prior to restart.

Based on the concerns shared by the team, the licensee made the following long-term commitments for the early detection of potential cable problems and to limit the degradation of insulation failure:

(1) Doble Testing and AC Hi-Pot testing will be evaluated as an alternative to DC Hi-Pot testing.

(2) A formalized preventive maintenance program for cables that are important to safety will be developed prior to the 13R refueling outage.

(3) An electrical ground test program will be evaluated to determine its need and scope.

The presence of class 1E 4160 V cable constantly energized in outdoor underground duct warrants an aggressive surveillance program for preserving the availability of the safety bus. The licensee recognizes the safety significance of this program and agreed to provide the details of this program to the NRC for review.

12. Exit Interview

Periodically during the inspection, the team briefed the licensee representatives on the progress of the inspection.

An exit interview was conducted at the conclusion of the inspection to summarize the results of the inspection to Senior Licensee Management. Persons attending the exit meeting are identified in Attachment F of this report.

ATTACHMENTS

ATTACHMENT A

OCT 04 1988

MEMORANDUM FOR: William K. Kane, Director, Division of Reactor Projects

FROM: William T. Russell, Regional Administrator

SUBJECT: AUGMENTED INSPECTION TEAM - INOPERABLE ISOLATION CONDENSERS AT OYSTER CREEK

You are directed to perform a prompt inspection of the causes, safety implications, and associated licensee actions which led to the inoperability of both trains of the isolation condensers on September 29, 1988, and the later loss of a vital electrical bus on October 2, 1988. The inspection shall be in accordance with NRC Manual Chapter 0513, Part III, and additional instructions in this memorandum.

DRP is assigned to conduct this inspection and Curtis J. Cowgill is designated as the Team Leader. The team will also include the provision for participation by the Division of Reactor Safety and NRR.

OBJECTIVE

The general objectives of the AIT are to:

a. Conduct a timely, thorough, and systematic inspection related to the circumstances surrounding the inoperability of the isolation condensers and later loss of a vital electrical bus.

b. Assess the safety significance of the events and communicate to Regional and Headquarters management the facts and safety concerns related to the problems identified.

c. Collect, analyze, and document all relevant data and factual information to determine the causes, conditions, and circumstances pertaining to the events.

d. Evaluate the adequacy of the licensee's internal review of the events.

SCOPE OF THE INSPECTION

The AIT response should identify and document the relevant facts and determine the probable causes and should be limited to the issues directly related to the events the licensee response.

Specifically, the AIT should:

a. Develop a chronology of the events.

b. Determine the scope and quality of licensee's internal review of the events.

c. Develop a history of operability problems with the isolation condensers for the past 3 months.

d. Review prior history of electrical bus faults/losses and logic of diesel generator start.

e. Review the maintenance operations activities leading to the events.

SCHEDULE

The AIT shall be dispatched to the Oyster Creek Nuclear Generating Station no later than October 5, 1988, and shall remain there as long as necessary to accomplish the objectives of this inspection. It is expected that this will take no longer than five working days.

A written report on this inspection will be provided to me by October 30, 1988.

TEAM COMPOSITION

The assigned team members are as follows:

C. Cowgill, DRP, RI
J. Wechselberger, SRI - Oyster Creek
D. Lew, RI - Oyster Creek
W. Baunack, DRP, RI
J. Golla, DRS, RI
L. Lois, NRR
R. Brady, DRP, RI
T. Koshy, DRS, RI

W. T. Russell

William T. Russell
Regional Administrator

cc:
C. Cowgill
Team Members

ATTACHMENT B

Nuclear

**GPU Nuclear Corporation**
Post Office Box 388
Route 9 South
Forked River, New Jersey 08731-0388
609 971-4000
Writer's Direct Dial Number:
October 10, 1988

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555

Dear Sir:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
Isolation Condensers and Emergency Diesel Generators

On September 26, 1988, following a surveillance test of the 'A' Isolation Condenser, it was observed that its shell temperature was increasing which ultimately resulted in steaming of the Isolation Condenser to the atmosphere. Following this event, General Public Utilities Nuclear Corporation (GPUN) initiated an investigation in order to determine the cause of this steaming and also to review the evaluation of the 'B' Isolation Condenser which had been steaming previously. When the 'B' Isolation Condenser had begun steaming, the cause was attributed to leakage through the condensate return valve. After 'A' Isolation Condenser began steaming following the surveillance test, GPUN became concerned that the cause of both occurrences may not have been fully understood.

GPUN established a dedicated evaluation team of Plant Engineering and Technical Functions personnel to perform a detailed review of the Isolation Condenser system and the circumstances leading to steaming. After a few days, the team determined there was a high probability that the steam lines to the Isolation Condensers contained a significant volume of water. Station management, in response to a recommendation from the evaluation team, directed that the isolation condensers be isolated and a plant shutdown be initiated in accordance with the Oyster Creek Technical Specifications. This action was taken due to the industry experience with water hammer events in Isolation Condenser steam lines. Water hammer in these lines has the potential to cause significant damage to the system.

Following reactor shutdown, GPUN commenced the cycle 12 refueling outage and developed a formal plan under the direction of a project manager to address the issues related to the events which have occurred on 'A' and 'B' Isolation Condensers since restart from the last outage. The plan includes:

(1) Development of a thermohydraulic model to assist in the analysis.

(2) Reconstruction of a detailed sequence of events.

(3) A stress analysis of system piping and equipment nozzles.

(4) An evaluation and modification, if necessary, of procedures in order to prevent recurrence, identify the onset of abnormal flow conditions, and to recover should abnormal flow conditions occur.

(5) A determination of those modifications, if warranted, that prevent or minimize abnormal flow conditions and/or that monitor the onset of such conditions.

(6) A review of industry experience as well as maintenance and test activities.

Also following reactor shutdown, an event occurred on October 2, 1988 in which power to the 'D' 4160 volt emergency bus was lost while being powered from the startup transformer. An investigation revealed that the cables from the emergency diesel generator had degraded placing a fault condition on the bus. GPUN is reviewing this occurrence and the circumstances surrounding this event to determine the root cause and any necessary long term corrective actions in conjunction with replacing the faulted cables.

The NRC has established an Augmented Inspection Team (AIT) to review the events associated with the Isolation Condensers and the loss of the 'D' emergency bus. GPUN and the NRC AIT have exchanged information regarding these events and the above GPUN actions which are being taken to address the identified issues. This has proven beneficial in assuring an in-depth review of the events and proper identification of the issues.

GPUN will complete any necessary actions required prior to restart from the 12R refueling outage to assure the Isolation Condensers and Diesel Generators are fully capable of performing their design function. GPUN will continue to advise the NRC inspection personnel of those actions in progress and the results achieved following completion of the identified reviews. Final reports providing the results of the GPUN evaluation and the conclusions reached will be developed. These reports will be provided to the NRC and outstanding issues resolved prior to restart from the 12R refueling outage.

Should you have any questions or comments, please contact Mr. George W. Busch at (609) 971-4909.

Very truly yours,

E. E. Fitzpatrick
Vice President and Director
Oyster Creek

EEF/GB/smz
(0144A:20)

cc: Mr. William T. Russell, Administrator
Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. Alexander W. Dromerick, Project Manager
U.S. Nuclear Regulatory Commission
Division of Reactor Projects I/II
Washington, DC 20555

NRC Resident Inspector
Oyster Creek Nuclear Generating Station
Forked River, NJ 08731

ATTACHMENT C

OYSTER CREEK

CHRONOLOGY OF EVENTS ASSOCIATED WITH ISOLATION CONDENSERS

JULY 5 - OCTOBER 1, 1988

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| July 5<br>1:07 p.m. | Control Room Operator Log (CRO) | Filled the "B" isolation condenser shell to 7'6". Shell level had drifted down over a period of time, and this event was performed to return level to the upper end of the control band. |
| 8:44 p.m. | CRO log and completed test | Performed routine surveillance testing on "A" Isolation Condenser per procedure 609.3.002, "Isolation Condenser Isolation Test and Calibration". This test verifies the ability of the isolation valves to close upon the appropriate isolation signal. During this test, the two steam supply valves close and the redundant condensate return valve closes. This isolates the condenser with the vent valves open. This alignment may exist for an hour or more. |
| July 6<br>10:30 a.m. | CRO log and completed test | Performed routine surveillance testing on "B" Isolation Condenser per Station Procedure 609.3.002.<br><br>Performance of this test isolated the condenser, and returned it to service and did not result in increases in isolation condenser shell temperatures. |
| July 8<br>12:30 p.m. | CRO log | Performed surveillance testing per Station Procedure 609.4.001, "Isolation Condenser Valve Operability and In-Service Test". This test verifies the operability of the isolation condenser valves. The valves are sequenced so each can be opened and/or closed without initiating the isolation condenser. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| July 8<br>12:30 p.m. | (Continued) | Also completed MOVAT's on valves V-14-32, V-14-33, V-14-35 as part of the procedure. (Figure 1 identifies the valves in this discussion. |
| July 9<br>7:37 p.m. | CRO log | Main turbine tripped during plant shutdown. |
| 10:15 p.m. | CRO log | Opened and closed valve V-14-35 at reactor a coolant temperature of 445 degrees during plant cooldown.<br><br>NOTE: V-14-35 has a history of becoming thermally bound in the closed position. In order to minimize these thermal effects during plant cooldown, the valve is cycled every 100 degrees. |
| July 10<br>12:25 a.m. | CRO log | Opened and closed valve V-14-35 at a reactor temperature of 352 degrees. |
| 3:40 a.m. | CRO log | Opened and closed valve V-14-35 at a reactor temperature of 280 degrees. |
| 4:13 a.m. | CRO log | Broke vacuum on the main condenser. |
| 6:00 a.m. | CRO log | Reactor coolant temperature less than 212 degrees. |
| July 13<br>10:35 a.m. | CRO log and switching and tagging log sheet 88-591 | "A" and "B" isolation condensers tagged for maintenance-primarily to repack the steam line vent valves. |
| July 22<br>12:45 p.m. | Switching and tagging log sheet 88-591 | Tags cleared on the "A" and "B" isolation condensers. Manual vent valves V-14-2 and V-14-6 were returned to the open position. V-1-71, the common vent isolation, was left closed. |
| July 31<br>12:00 p.m. | Test documentation | Performed local leak rate test (LLRT) per Station Procedure 665.5.003, "Main Steam Isolation Valve Leak Rate", section 10. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 2 | | |
| 5:00 a.m. | Test documentation | Performed LLRT per Procedure 665.5.003, section 10. |
| August 3 | | |
| 9:40 a.m. | Test documentation | Performed LLRT per Procedure 665.5.003, section 7. V-14-19 failed. |
| August 4 | | |
| 1:20 p.m. | Switching and tagging log sheet 88-707 | Tagout issued to support repairs to vent valve V-14-19. Valves V-14-2 and V-1-71 tagged closed. |
| 9:55 p.m. | Switching and tagging log sheet 88-707 | Tags cleared on "B" isolation condenser. V-14-2 and V-1-71 returned to open position. |
| 10:45 p.m. | Test documentation | Performed LLRT per 665.5.003, section 10 to test valve V-14-19 (this left valve V-14-6 closed). |
| August 5 | | |
| 1:05 p.m. | CRO log and test documentation | Performed isolation condenser valve operability surveillance per Station Procedure 609.4.001, to return condenser to service. |
| August 10 | | |
| 1:40 a.m. | CRO log | Closed reactor head vents. |
| 5:02 p.m. | CRO log | Reactor is critical, temperature 217 degrees. |
| 7:00 p.m. | CRO log | Established condenser vacuum. |
| August 19 | | |
| 9:10-12:52 a.m. | CRO log | Performed routine surveillance testing per Station Procedure 609.3.003, "Isolation Condenser Automatic Actuation Sensor Calibration and Test". This test results in the isolation condenser vent valves being closed for short periods of time. |
| August 23 | | |
| 1:43 p.m. | Licensee Critique | Performed valve operability test for the "A" Isolation Condenser to support work on stem repacking of valve V-14-33 ("B" Isolation Condenser). |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 23 (Continued) | | |
| 6:07 p.m. | CRO log and test documentation | Performed valve operability on V-14-32 using 609.4.001 in preparation to electrically backseat V-14-33. This was being performed in order to repair a packing leak on V-14-33. |
| 6:30 p.m. | CRO log | Three attempts to electrically backseat V-14-33 were unsuccessful. |
| | | NOTE: The electrician then realized the wrong amprobe was being used. The correct probe was obtained and the valve correctly backseated. |
| 10:00 p.m. | CRO log | Mechanical maintenance on V-14-33 completed. |
| 10:43 p.m. | CRO log | V-14-33 fails its post maintenance test and is declared inoperable due to motor failing. "B" isolation condenser removed from service and is isolated (i.e., valves V-14-37, V-14-32, V-14-33 were closed). |
| | | NOTE: Valve V-14-35 was not cycled during this condenser cooldown. |
| August 24 | | |
| 1:55 a.m. | Switching and tagging log sheet 88-772 | Tagout to replace motor on V-14-33 implemented. The "B" isolation condenser vent valves were closed (V-14-1 and V-14-19). |
| 4:11 a.m. | CR Chart Recorder | The temperature between valves V-14-35 and V-14-37 started to fall from 400 degrees after V-14-37 was closed. The temperature eventually reaches 256 degrees. |
| 11:30 a.m. | CRO log | Performed surveillance 609.4.001 on "A" Isolation Condenser while the "B" Isolation Condenser is out of service. (Required to be performed daily.) |
| August 25 | | |
| 11:16 a.m. | CRO log | Performed surveillance 609.4.001 on "A" isolation condenser while the "B" Isolation Condenser is out of service. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 26 11:02 a.m. | CRO log | Performed surveillance 609.4.001 on "A" isolation condenser while the "B" Isolation Condenser is out of service. |
| August 27 9:30 a.m. | CRO log | Performed surveillance 609.4.001 on "A" isolation condenser while the "B" Isolation Condenser is out of service. |
| 6:30 p.m. | Licensee Critique | DC motor for V-14-33 replaced and partial MOVATS completed. Packing leak observed to be increased. Decision made to recheck packing adjustments. Repacking on backseat not acceptable. Decided to assess acceptability of operation with packing leak. When V-14-33 was finally opened, the packing leak significantly decreased. |
| August 28 ---- | Switching and tagging log sheet 88-772 | Cleared tags on "B" isolation condenser. |
| ---- | CRO log | Shell side temperature of "B" Isolation Condenser = 94 degrees |
| 3:45 a.m. | CRO log | Commenced warming "B" Isolation Condenser per Station Procedure 307, "Operation of the Isolation Condensers." |
| 3:58 a.m. | CR Chart Recorder | Temperature between V-14-35 and V-14-37 starts to increase when valve V-14-37 is opened. |
| 4:50 a.m. | CRO log | Opened valve V-14-33. Temperatures and pressures increased in "B" Isolation Condenser Steam Line, and valve V-14-33 was closed. |
| ---- | Operations Engineer Notes | "B" Isolation Condenser Steam Line temperatures went from 120 to 300 degrees in 2 minutes. This temperature is obtained from isolation condenser steam line pressure. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 28 | | |
| 4:55 a.m. | CRO log | Cycled V-14-32 open/closed in an attempt to seat valve. Reopened valve V-14-33; this time no temperature or pressure increases were observed. |
| 6:50 a.m. | CRO log | Opened V-14-32 to heat up "B" Condenser. |
| 6:53 a.m. | CRO log | Closed valve V-14-32 to slow the heatup rate. |
| 6:53 a.m. | | NOTE: Valve position information from the plant computer does not indicate any movement of valve V-14-32 during this time frame (6:50-6:53 a.m.). Discussions with the reactor operator indicate that the valve was "bumped" in the open direction such a small amount, that the "red" open indicating light did not illuminate. If the open light did not illuminate, then the plant computer would not detect valve motion. Plots of isolation condenser heatup show that valve V-14-32 was at least partially open during this time interval.<br><br>Also, the isolation condenser vent valves were cycled open/closed periodically from 6:15 a.m. until 9:49 a.m. |
| 6:58 a.m. | CRO log | "B" Isolation Condenser steam Line temperatures peaked at 395 degrees F and began drifting down slowly. |
| 10:00 a.m. | CRO log | Equalized across "B" Isolation Condenser and opened valve V-14-32. |
| 10:03 a.m. | CR Chart Recorder | "B" Shell Temperature begins to increase. |
| 10:07 a.m. | CRO log | Closed valve V-14-32. |
| 10:15 a.m. | CR Chart Recorder | "B" Shell Temperature steady at 105 degrees. |
| 10:20 a.m. | CR Chart Recorder | Temperatures between valves V-14-35 and V-14-37 steady at 400 degrees. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 28 (Continued) | | |
| 10:55 a.m. | Licensee Critique | Opened valve V-14-32. |
| 11:02 a.m. | CR Chart Recorder | "B" shell temperature begins to increase again. |
| 12:30 p.m. | CRO log | Shell side temperature of "B" Isolation Condenser = 184 degrees.<br><br>During this period of time shell temperature was increasing at the rate of 47 degrees/hour. |
| 12:43 p.m. | Plant computer, licensee critique | During performance of surveillance 609.4.001, CRO inadvertently moves V-14-37 in the open direction while V-14-35 is open. This effectively results in "B" isolation condenser initiation for about 6-8 seconds. A minor plant transient is experienced (IR 50-219/88-23 discusses). V-14-37 is immediately closed.<br><br>During this event, the temperature between valves V-14-35 and V-14-37 decreased from 400 to 270 degrees in about 20 minutes, then slowly started increasing again, eventually to 400 degrees. |
| 1:01 p.m. | CRO log and test documentation | Surveillance 609.4.001 is satisfactorily completed. |
| 1:10 p.m. | CR Chart Recorder | "B" Isolation Condenser shell temperature reaches 212 degrees F. |
| 1:38 p.m. | CRO log | "B" isolation condenser shell side low level alarm received. Shell side temperature is 213 degrees. Initially, the temperature was 94 degrees. At 12:30 p.m. the temperature was 184 degrees. |
| 1:39 p.m. | CRO log | Closed V-14-37. |
| 1:44-3:50 p.m. | CRO log | Added water to "B" isolation condenser 3 times. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 28 (Continued) | | |
| 2:05 p.m. | CRO log | Opened/closed V-14-35. Reopened V-14-37. This was an attempt to seat the suspected leaking valve V-14-35. |
| 3:52 p.m. | CRO log | Making up to "B" isolation condenser using demineralizer water. |
| 5:32 p.m. | CRO log | Closed V-14-37, cycled V-14-35 opened/closed again in an attempt to reseat valve. Reopened V-14-37. |
| 7:32 p.m. | CRO log | "B" isolation condenser shell side activity below MDA. |
| 8:00 p.m. | Licensee Critique | Reactor power reduced by 10 MWt to account for heat removed by the "B" Isolation Condenser. |
| August 29 | | |
| 2:42 p.m. | CRO log and test documentation | Performed "A" Isolation Condenser valve operability per 609.4.001 in preparation to remove "B" from service in order to troubleshoot the suspected leaking condensate return valve, V-14-35. |
| 2:45 p.m. | CRO log | Closed V-14-37, "B" isolation condenser removed from service to troubleshoot V-14-35. |
| 8:30-9:45 p.m. | CRO log | Cycled V-14-35 three times during isolation condenser cooldown. |
| August 30 | | |
| 2:50 p.m. | CRO log and test documentation | Performed surveillance 609.4.001 on "A" isolation condenser while the "B" Isolation Condenser is out of service. |
| 4:21 p.m. | CRO log | Closed V-14-32 to attempt to reseat valve V-14-37. |
| | | Comment: The redundant condensate return valve, V-14-37, had been closed the previous day, yet "B" condenser shell side temperatures remained at 212 degrees, thus leading to the conclusion that both V-14-35 and V-14-37 were leaking at this time. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| August 30 (Continued) | | |
| 4:23 p.m. | CRO log | Cycled V-14-37 opened/closed. |
| 4:25 p.m. | CRO log | Reopened V-14-32. |
| August 31 | | |
| 2:15 p.m. | CRO log and test documentation | Performed surveillance 609.4.001 on "A" isolation condenser while the "B" Isolation Condenser is out of service. |
| 8:07 p.m. | CRO log | Manually closed V-14-35 to measure "leak rate". The valve handwheel moved 9-1/2 turns and the stem moved about an eighth of an inch. |
| | | Comment: During MOVATS testing of V-14-35, the "B" isolation condenser vent valves were closed, yet no observable decrease in the steaming rate was evident. |
| September 1 | | |
| 2:15 a.m. | CRO log | Cycled V-14-35 open/closed manually. |
| 4:50 a.m. | CRO log | Action plan for "B" isolation condenser completed. |
| 2:15 p.m. | CRO log and test documentation | Performed surveillance 609.4.001 on "A" Isolation Condenser while the "B" Isolation Condenser was out of service. |
| 6:51 p.m. | CRO log | Opened V-14-35 electrically. |
| September 2 | | |
| 11:30 a.m. | CRO log | Manual vent valve on "A" Isolation Condenser found closed (V-14-6). The valve was then opened. |
| 1:10 p.m. | Licensee critique | Plant shutdown starts at a rate of 25 MWe/hour as both isolation condensers were out of service. |
| 6:50 p.m. | Licensee critique and Valve Lineup Sheet | Valve lineups complete on both isolation condensers. |
| ----- | Interview | Equipment operator verifies V-1-71 open. Steam observed coming from valve packing. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| September 2 (Continued) | | |
| 7:48 p.m. | CRO log | Surveillance test 609.4.001 completed on both isolation condenser systems. |
| 7:52 p.m. | Licensee Critique | Plant management declared "A" Isolation Condenser operable. Plant shutdown is secured. |
| 8:17 p.m. | Licensee Critique | Plant management declared "B" Isolation Condenser operable. |
| 8:21 p.m. | Licensee Critique | Plant increasing power. |
| September 3 | | |
| 00:00 a.m. | Licensee Critique | Plant reaches full load. |
| September 15 | | |
| ----- | STA data | Steam line temperatures for "A" Isolation Condenser begin to fall from 540 degrees. |
| September 26 | | |
| 10:20 a.m. | CRO log | Performing surveillance 609.3.002 on the "A" Isolation Condenser. |
| 10:34 a.m. | Licensee Critique | Both "A" Condenser steam supply valves and the redundant condensate return valve (V-14-30, 31, and 36) are closed. This isolates the condenser while the vent valves remain open. |
| | | NOTE: The normally closed condensate return valve V-14-34 is not repositioned during performance of this surveillance. |
| 11:42 a.m. | Licensee Critique | Valves V-14-30, V-14-31 and V-14-36 are reopened. |
| | | Performance of the surveillance is suspended for lunch. |
| 12:30 p.m. | CRO log | "A" Isolation Condenser shell temperature observed to increase. |
| 12:45 p.m | Licensee Critique | "A" Isolation Condenser shell temperature indicated 153 degrees. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| September 26 (Continued) | | |
| 1:32 p.m. | Licensee Critique | Valves V-14-30, V-14-31, and V-14-36 are once again closed to complete surveillance. |
| | | Shell temperature stabilized at 179 degrees. |
| 2:30 p.m. | Licensee Critique | Terminated performance of 609.3.002 and opened V-14-36, V-14-31, V-14-30. |
| 2:45 p.m. | CRO log | Performed surveillance 609.4.001 to attempt to reseat valve V-14-34. |
| 2:55 p.m. | Licensee Critique | Shell temperature observed at 185 degrees. |
| 3:30 p.m. | Licensee Critique | Shell temperature observed at 199 degrees. |
| 3:34 p.m. | CRO Log | Secured the performance of the surveillance test after the "A" isolation condenser valve alignment was returned to normal in order to investigate the rising shell temperatures. |
| 4:05 p.m. | Licensee Critique | Shell temperature reached 212 degrees. |
| ---- | STA data | "A" isolation condenser steam line temperatures: North-increase from 230 to 290 degrees; South-falls from 400 to 220 degrees. |
| 5:30 p.m. | Interview | Plant engineer verifies V-1-71 open, water is observed at the valve packing. |
| | | At the same time the technician who supplied makeup water to the isolation condensers noticed water "raining" on the floor from the isolation condenser vent valve area. |
| 7:05 p.m. | CRO log | Performed surveillance 609.4.001 on "B" Isolation Condenser before removing "A" isolation condenser from service. |
| 9:40 p.m. | CRO log | "A" Isolation Condenser removed from service. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| September 27 | | |
| 1:50 a.m. | Licensee Critique | Closed valve V-14-36. |
| 3:15 a.m. | CRO log | Cycled valve V-14-34 open/closed for MOVATS. |
| | | NOTE: During MOVATS on V-14-34, the "A" isolation condenser vent valves clcsed. |
| 1:05 p.m. | CRO log | Received double indications on vent valve V-14-20. |
| 1:24 p.m. | CRO log | V-14-20 open w/o assistance. |
| 1:50 p.m. | CRO log | Performed 609.4.001 on "A" Isolation Condenser. |
| 5:45 p.m. | CRO log | Cycled valves V-14-34 ar d V-14-36 open and closed. |
| 11:07 p.m. | CRO log | "A" Isolation Condenser declared operable. |
| September 29 | | |
| 1:15 p.m. | | The isolation condensers are isolated. All steam supply and condensate return valves are closed, but the vent valves remain open. Plant shutdown commenced due to concerns regarding water in the isolation condenser steam lines. |
| 2:30 p.m. | CRO log | Declared unusual event. |
| September 30 | | |
| 2:27 a.m. | CRO log | Tripped turbine. |
| 3:00 a.m. | CRO log | Manually scrammed reactor. |
| 4:40 a.m. | CRO log | Stroked isolation condenser valves open/closed during cooldown. |
| 5:05 a.m. | CRO log | Stroked isolation condenser valves open/closed during cooldown. |
| 6:20 a.m. | CRO log | Stroked isolation condenser valves open/closed during cooldown. |
| 9:25 a.m. | CRO log | Completed cycling isolation condenser valves at 230 degrees reactor temperature. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| September 30 (Continued) | | |
| 9:35 a.m. | CRO log | Broke main condenser vacuum. |
| 9:55 a.m. | CRO log | Reactor in cold shutdown. Reactor vessel vented. |
| 10:00 a.m. | CRO log | Terminated Unusual Event. |
| 5:25 p.m. | CRO log | Commenced action plan to quantify water in the isolation condenser steam and condensate return lines. Licensee conducted ISO condenser drain down to reactor vessel.<br><br>With the reactor vessel vented and reactor water level steady, the licensee opened the isolation condenser isolation valves to measure the reactor water level increase. This measured volume would be the amount of liquid in the isolation condenser piping. |
| 5:25 p.m. | | Steam valves opened:<br>"B": measured volume=713 gallons calculated volume=744 gallons<br>"A": measured volume=550 gallons calculated volume=665 gallons<br><br>Condensate valves opened:<br>"B": measured volume=676 gallons calculated volume=584 gallons<br>"A": measured volume=1053 gallons calculated volume=662 gallons<br><br>These volume measurements indicated that the isolation condenser piping, including steam piping, was effectively full of water. |
| Night shift interview | | The steam vent line was blown with instrument air into the steam line. To do this valves V-14-98, -99 were used.<br><br>Because of the type of test used to verify flow, it could not be ascertained whether or not there was water in the line. |

| DATE/TIME | SOURCE | DESCRIPTION |
|---|---|---|
| October 1 | | |
| 2:15 a.m. | CRO log | Closed all MSIV's. |
| 3:35 a.m. | CRO log | Closed reactor head vents V-25-21 and V-25-22. |

## ATTACHMENT D

## REVIEW OF THE JUNE 12, 1985 REACTOR ISOLATION SCRAM

A review of a June 12, 1985 event in which a reactor isolation scram occurred was conducted to gather information on the isolation condenser operating parameters following actuation. The event was initiated at 9:36 a.m. by a malfunction in the electrical pressure regulator which caused a turbine bypass valve to open. As a result, reactor pressure dropped rapidly and the main steam isolation valves closed on low reactor pressure. A reactor scram from 100% power occurred.

The "A" Isolation Condenser was manually initiated to control reactor pressure at 10:15 a.m. The two temperature strip charts which were available for the isolation condensers were the "A" Isolation Condenser shell temperature and the "A" Isolation Condenser steam inlet temperature (north steam line). The initial "A" Isolation Condenser shell temperature and steam inlet temperature were 102 degrees F and 117 degrees F, respectively. The 117 degrees F steam inlet temperature was indicative that the thermocouple was submerged in condensate. After the initiation of the isolation condenser, the shell temperature increased to 212 degrees F in approximately 11 minutes. The steam inlet temperature was observed to increase to 540 degrees in approximately 40 seconds, which was indicative of the condensate level on the tube-side falling below the level of the thermocouple. During the operation of the "A" Isolation Condenser to control reactor pressure, the steam inlet temperature followed changes in reactor pressure.

During the operating period in which the "A" Isolation Condenser was utilized to control reactor pressure, the shell and steam inlet temperatures responded as expected and do not correlate to the temperature responses of the recent isolation condenser phenomenon.

Later in the event, at approximately 2:00 p.m., the "A" Isolation Condenser steam inlet temperature deviated from the saturation temperature corresponding to reactor pressure. The steam inlet temperature dropped from 350 degrees F to 220 degrees F. Fifteen minutes later, steam inlet temperature increased to approximately 300 degrees F and remained at this temperature until approximately 6:00 p.m. when the reactor was vented through the isolation condensers. This decrease in temperature and subsequent increase cannot fully be explained from the available plant operating data and information during this period.

Although there was a limited amount of raw data available on this event, analysis showed that there was a potential to set up conditions in the isolation condensers similar to the August 28 and September 26, 1988 isolation condenser phenomenon. The following are facts gathered in the assessment of this event which may be pertinent to the evaluation of the isolation condenser performance.

-- Shutdown Cooling System was placed in service at approximately 12:17 p.m. When no recirculation pumps operating, reactor level was raised above 185" above top of active fuel (TAF) to facilitate natural circulation through the reactor. Raising the level to 185" provides for spillover from the core region to the annulus area and thus prevent thermal stratification when the Shutdown Cooling System is placed in service without recirculation pump operation.

-- Plant System Procedure 307, "Isolation Condenser System," and Abnormal Procedure 2000-ABN-3200.01, "Reactor Scram," require that the DC condensate return valve V-14-34 and V-14-35, are placed in the closed position when reactor level is above 180" above TAF, but does no address the closing of the DC steam inlet valve, V-14-31 and V-14-33. The Emergency Operating Procedures in 1985 similarly addressed closing only the DC condensate return valves and not the DC steam inlet valves. A change to the Emergency Operating Procedures to include closing the DC steam inlet valves did not occur until 1987. To resolve the inconsistency with Emergency Operating Procedures, the licensee is currently making changes the Plant System Procedure 307 and Abnormal Procedure 2000-ABN-3200.01. These changes will require the closure of valves V-14-31 and V-14-33 when reactor level reaches 180" above TAF.

-- The "A" Isolation Condenser was initiated at 10:15 a.m. When the isolation condenser is initiated by opening the DC condensate return valve, an automatic interlock shuts the isolation condenser vent valves. The vent valves, however, do not automatically reopen when the DC condensate return valve is shut. The operator is required to reset the isolation condenser vent valves to reopen them.

-- The reactor pressure at approximately 2:30 p.m. was 150 psig.

-- The isolation condenser steam inlet temperature dropped to 220 degrees F at 2:00 p.m. which may be indicative that the water in the tube side of the isolation condenser had risen above the thermocouple level. This temperature drop occurred while the DC condensate return valve was shut. As indicated above, the DC isolation condenser return valves would have been shut prior to raising reactor level above 180" above TAF for placing the Shutdown Cooling System in service.

-- The steam inlet temperature increased from 220 degrees F to 300 degrees F with no operation or initiation of the isolation condensers. This was the approximate temperature noted on one of the steam inlet temperatures for the isolation condensers during the August 28 and September 26, 1988 phenomenon.

Based on the above information and discussions with operators, the following could be postulated.

-- The isolation condenser DC condensate return valves were shut before 12:17 p.m. when the Shutdown Cooling System was placed in service. This assumption is based on the above procedural information and discussions with operational personnel who stated that they would expect these valves to be shut when reactor level is above 180" above TAF.

-- The isolation condenser vent valves were shut at 10:15 a.m. and remained shut until approximately 6:00 p.m. when the reactor was vented through the isolation condenser. This assumption is based upon the above interlock description between the DC condensate return valve and the vent valves, and interviews with operations personnel who stated that normally there would be no requirement to reopen the vent valves once the isolation condenser was initiated.

With the given information and assumptions, a possible mechanism to fill the "A" Isolation Condenser existed. As reactor level is raised to 185" above TAF, the isolation condenser steam line penetrations which are located in 183" above TAF may have been covered with water. Since the vent valves and the DC condensate return valves were probably shut and the steam inlet valves probably opened, the isolation condensers communicated with reactor vessel hydraulically. As the steam in the isolation condensers condenses thus reducing pressure, water will be drawn up into the isolation condenser (reactor pressure was at approximately 150 psig) and thus fill it. This is one possible interpretation for the steam inlet temperature drop which occurred at 2:00 p.m.

Assuming that the isolation condensers were filled as described above and the vents valves were shut, the "A" Isolation Condenser experienced circumstances similar to those in which the August 28 and September 26, 1988 phenomenon occurred. Although the reactor was shutdown, decay heat was adequate to provide the energy to sustain the recently observed phenomenon. Postulating that the "A" Isolation Condenser experienced this phenomenon after being filled with condensate would account for the steam inlet temperature rise from 220 degrees F to 300 degrees F which occurred fifteen minutes after the steam inlet temperature drop.

The postulate that the "A" Isolation Condenser experienced this phenomenon is based on circumstantial evidence. The licensee has been asked to independently review and assess the possibility that the August 28 and September 26, 1988 isolation condenser phenomenon occurred in the "A" Isolation Condenser on June 12, 1985.

## ATTACHMENT E

## THE THERMAL-HYDRAULICS OF THE STEAMING ISOLATION CONDENSER

The "B" Isolation Condenser was out of service for valve maintenance from August 23 to August 28, 1988, and when returned to standby status started steaming for no apparent reason. Efforts were made to identify the reason for this steaming. (Refer to Attachment C, Figure 1 and FSAR Figures 23-1 and 23-2). The licensee drilled through the insulation and recorded the average temperatures shown on Figure 1 in the corresponding locations. These temperatures show that the "south" (left) coil is producing shell side steaming and the "north" (right) is not. This indicates that possibly an internal circulation pattern which promotes steaming was established as indicated in Figure 2. In this postulated circulation pattern, condensate from the south coil goes up through the north coil, descends through the north steam pipe back into the steam supply pipe. Steam ascends through the south steam pipe to the south coil where is condenses. In this model there is practically no evidence that there exists any significant oscillatory pattern, at least not to the extent that the coils change roles in condensing steam. Therefore, attention was given to the identification and quantification of the driving heads (and losses) for this continuous model.

### Thermal Head on the North Side Bundle

The condenser is supplied with makeup water through a 4 inch diameter opening at the bottom of the shell. Two approximately 22 foot tube bundles enter the shell from both ends and extend for almost all of the 12 ft. diameter of the lower portion of the shell. From the temperatures shown in Figure 1 it is concluded that only the south side is steaming. Therefore, it is reasonable to conclude that the shell side circulation is as shown in Figure 2. This means that the north bundle is exposed to a driving thermal head from the shell which delivers a temperature difference as high as 160 degrees F. This model also suggests that the north side tube is receiving heat from the shell. A quantification of this effect (see Calculation 1) shows that for DT=80 degrees F. the north side will develop about 2 ft. of water driving head. For 100 or 120 degrees F it may be as high as 3 ft.

This conclusion is inconsistent with the measured temperatures at locations D and E of Figure 2, i.e., the north side tube bundle outlet temperature (Point E, which under normal flow patterns is the tube inlet) should be higher than its inlet (Point D). However, there are a number of possible explanations:

(a) the measured temperatures may be inaccurate. For both locations a hole was drilled through the insulation and outside pipe temperatures measured. Any film on the pipe skin would yield a lower temperature measurement. Also, instrument accuracy is ± 3 degrees F.

(b) there may be internal (tubeside) circulations which could explain the inconsistent pipe skin temperatures. It is evident from the measured temperatures that the north side does not steam. However, they do not support the supposition of the model that heat is being transferred from the shell side to the north bundle tube side.

Static Head in the South and North Le[illegible]

This examines the segments AB and DC in Figure 2. The relative lengths and elevations are the same (Reference 2) and so are the temperatures. Thus, static head in these two segments should be approximately the same.

Flow Losses in Segment BC and Bundle Exit and Ent[illegible]

To obtain an estimate of the magnitude of flow related head losses we must estimate the velocity of the condensate in ABCDEF Figure 2. The l[illegible] estimate for the "B" condenser is that it required 18 gpm makeup. This equates to about 9,000 lbm/hr. Using a single bundle as a heat exchanger, the heat transfer (bundle to shell) required to boil off this amount would be about 10.2x[illegible]/hr. The required amount of primary steam (heat input to the tube side to boil the shell side) is 1,900 gal/hr.

Estimated velocities in the BC segment are so low that it is reasonable to ignore head losses due to skin friction, pipe diameter changes, and bundle entrance-exit losses.

Comments on the Validity of the Steady State Model

There are several uncertainties in the model described. We shall attempt to list some of them and take the opportunity to comment on alternate models.

One of the difficulties is that we cannot account explicitly for the required driving head. For example, under the steady state conditions assumed by this model, steam at the "wye" formation between the north and south vertical steam pipes (Figure 2a) may create a lower pressure at BB relative to AA. This is possible due to the venturi effect produced from steam going up the south steam leg and tending to pull the head of the north leg. However, the amount of driving head produced by this effect is unquantifiable. Another is the inconsistency of the temperatures at D and E of the north leg, i.e., measured Td>Te. The model requires that Te>Td. There may be an explanation in terms of the uncertainty of the contact skin temperature readings or another model. Due to possible errors in temperature measurement it could be that the real temperatures are such that Te>Td.

However, if it is accepted that Tc>Td, the model should include some form of level oscillation. Any such oscillation to be sustainable would require another motive force like condensation in the south bundle. No such phenomenon is identifiable from the known facts.

Another model could be constructed by assuming leakage in the condensate isolation valves. Large leakage cannot be justified from observed parameters. However, small amounts of leakage could be present and the model could be appropriately modified. No information exists to indicate the condensate valves were leaking slightly.

We conclude that based on the known facts the proposed model is the most plausible among the alternatives.

Initiation Mechanisms

As pointed out earlier the steady state phenomenon was separated from the initiation mechanism. The following discusses some mechanisms which are suggested by the observed facts, conditions and plant parameters but does not arrive at a conclusive model because (a) the steady state model is not conclusive and (b) parameters required for model validation are not known.

The vent line which vents noncondensables from the high point of the condensate steam line to the main steam line extends approximately 400 ft. and includes an approximate 20 foot loop seal. The DP across this line under full power is about 40 psi. It was assumed the loop seal or other possible restriction to free flow existed, consequently the pressure difference from this line was not accounted for in the model.

In addition there is experimental evidence to support this assumption:

(a) water has been observed to leak from the stem and the packing of the condenser steam isolation valve V-1-71,

(b) shell side steaming continued with the vent valves closed,

(c) in the model the required DP to overcome the 20 ft. of water head in the loop seal does not exist, and

(d) even if there is some flow it is so small that it does not affect the steaming conditions.

The normal operating flow pattern in the isolation condensers is depicted in Figures 23-1 and 23-2 of the FSAR (attached). If, for any reason the flow through the vent line is seriously impeded and there exists some imbalance in the system then the steam will preferentially condense on one side of the vertical steam lines (in this case on the south side) and the steaming flow pattern will initiate.

Another initiation mechanism (which has been proposed by the licensee) supposes that after the isolation of the "B" condenser for maintenance a relative underpressure was created resulting in suction of water from the reactor recirculation loop (Figure 23-2) through a possibly leaking condensate return valve such that it filled the entire system including the vertical portions of the condenser steam supply pipes. The presence of the water in these pipes created the asymmetry when the steam valves were reopened. Likewise the "A" Condenser was assumed to have filled, while it was isolated for a surveillance test, by flow from the "B" Condenser through the vent lines.

FIG. 1 - ISOLATION CONDENSER

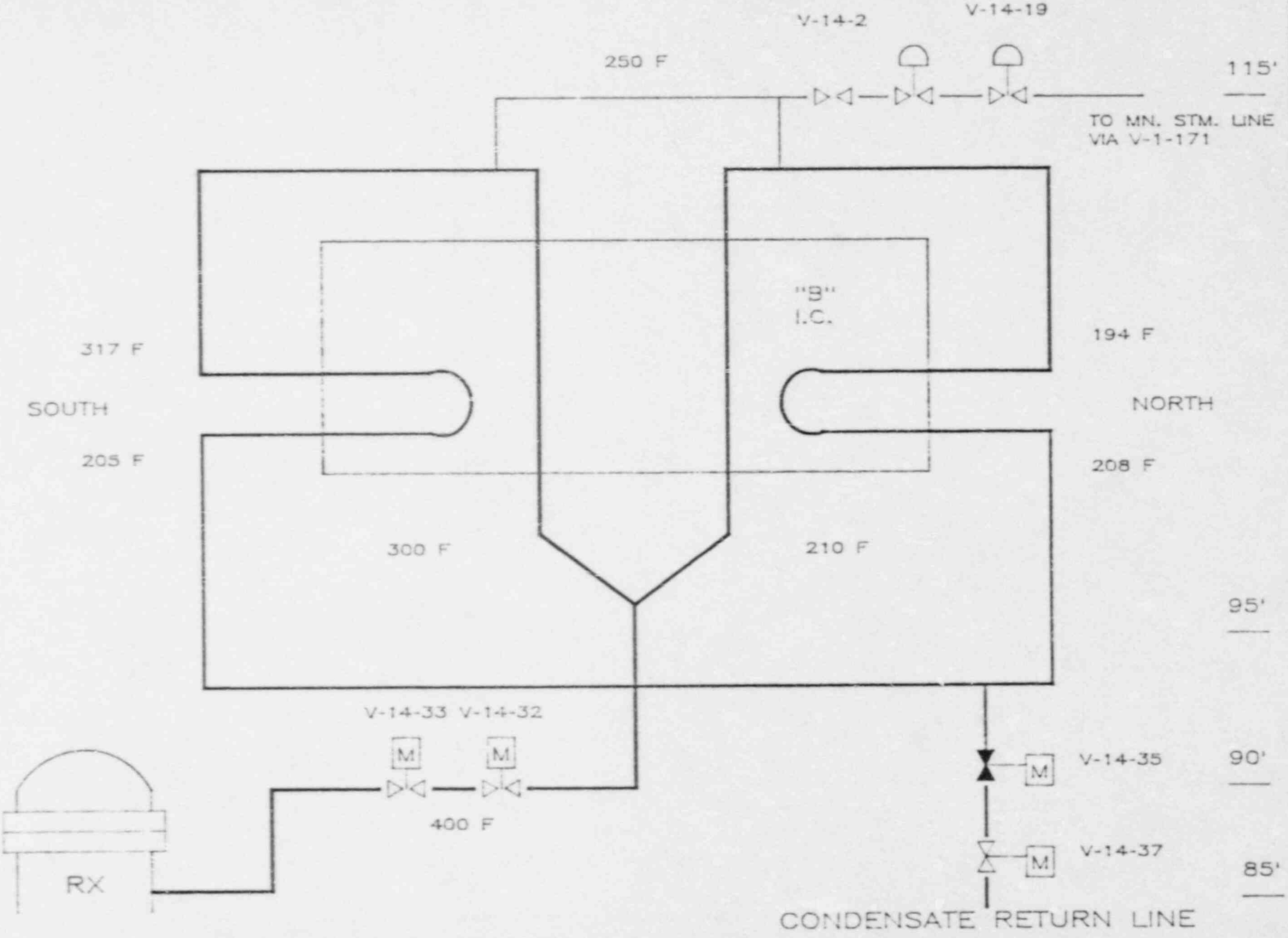


FIG. 2 - THERMAL HYDRAULIC MODEL

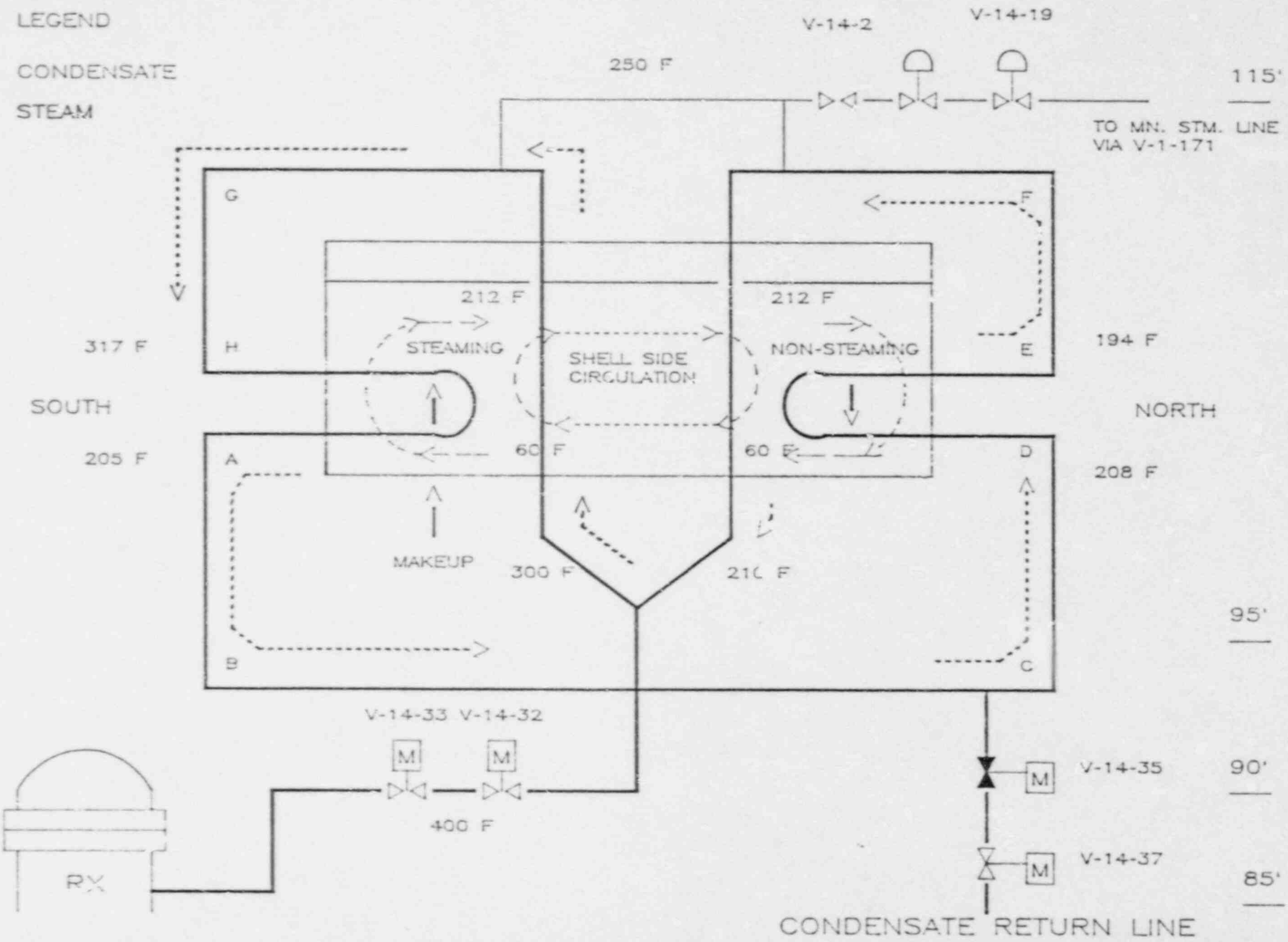
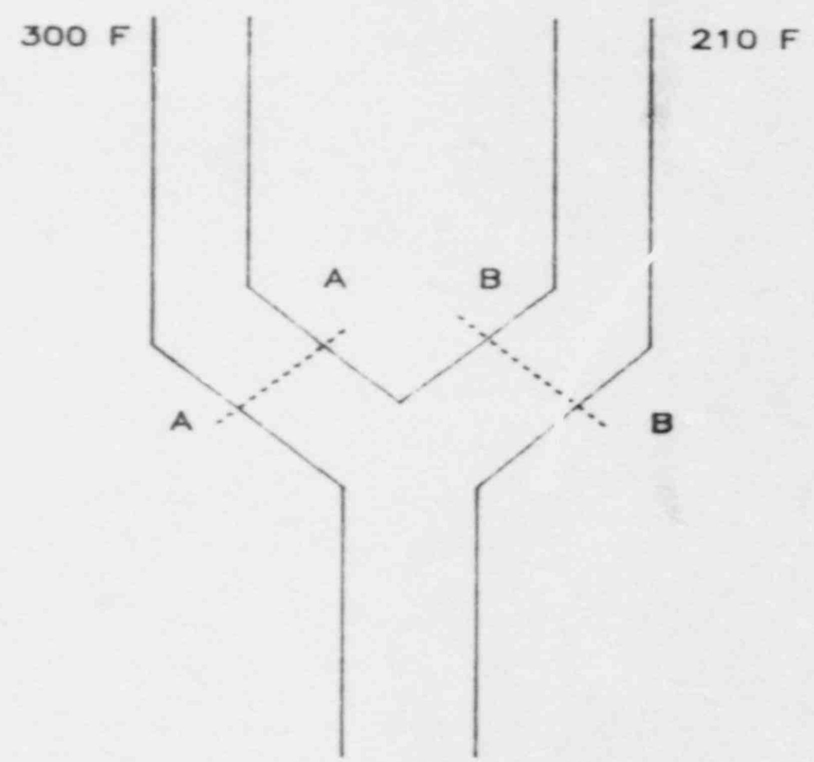


FIG. 2a STEAMLINE BRANCH CONNECTION



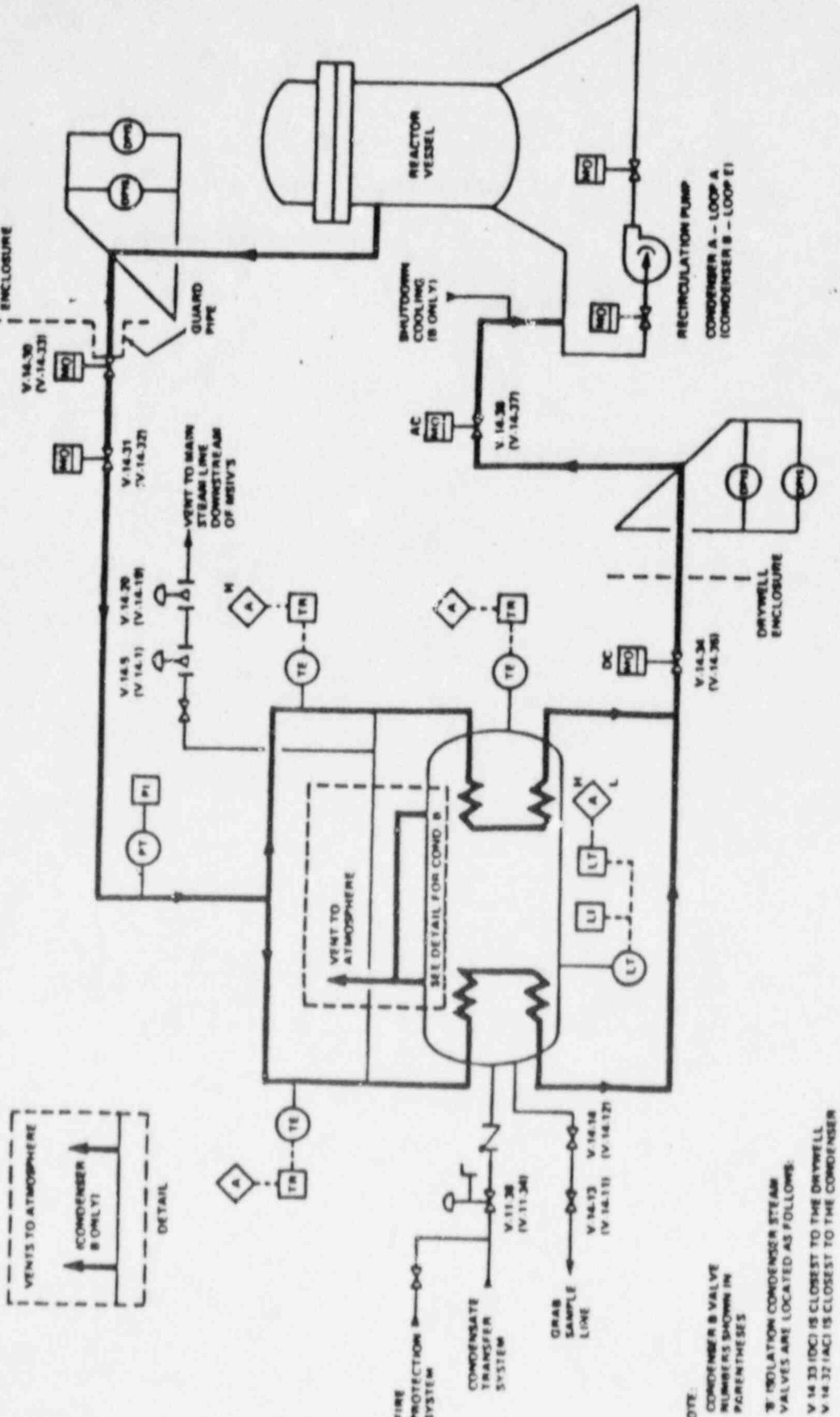



FIGURE 23-1: ISOLATION CONDENSER SYSTEM

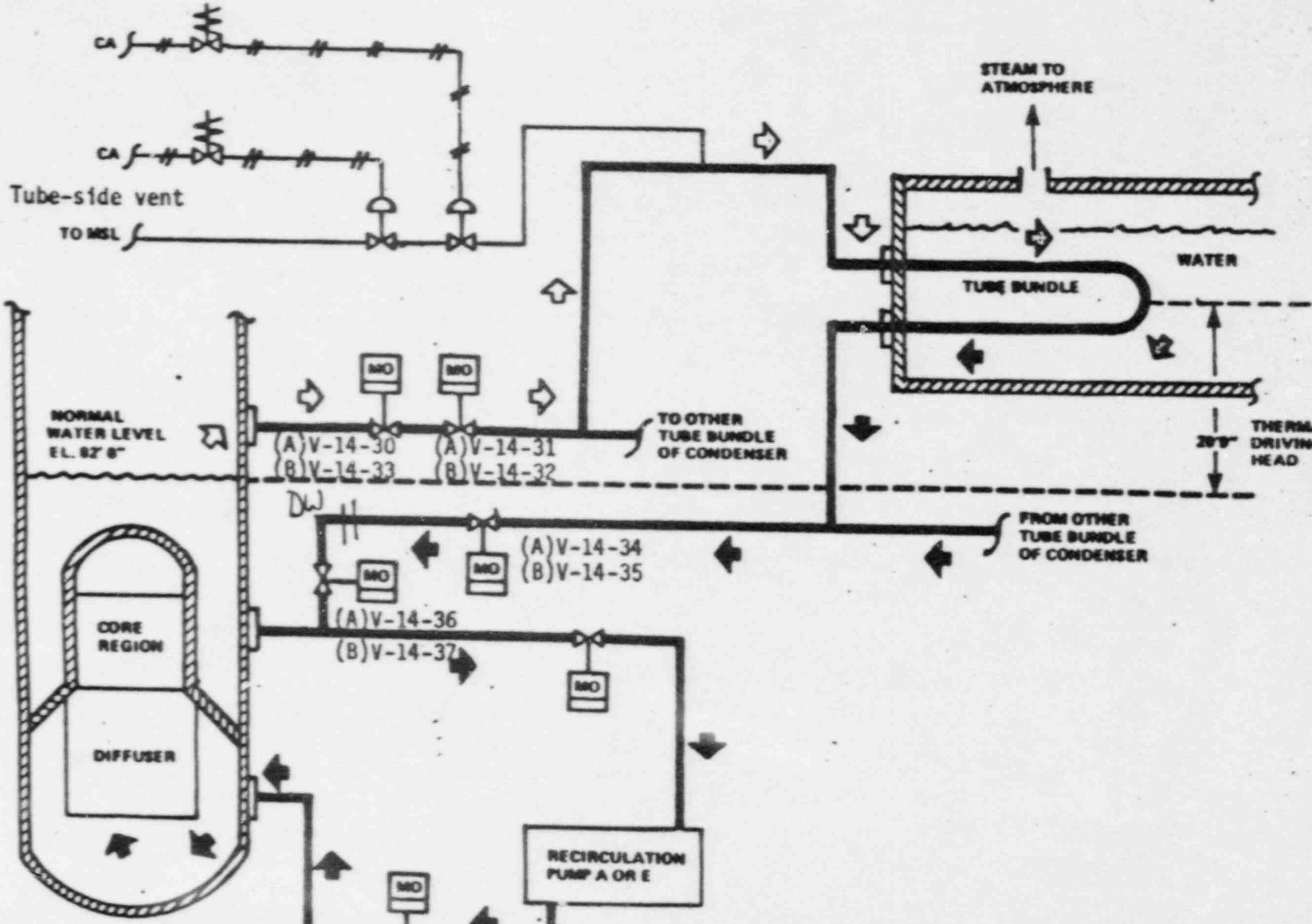



FIGURE 23-2: ISOLATION CONDENSER NATURAL CIRCULATION FLOW PATH

## CALCULATION 1

Approximate quantification of the thermal head in the north bundle.

At P=1000 psig from the steam tables:

| Temperature Degrees F | ft/lbm | lbm/ft** |
|---|---|---|
| 210 | .01665 | 60.060 |
| 220 | .01672 | 59.801 |
| 230 | .01679 | 59.559 |
| 240 | .01687 | 59.277 |
| 250 | .01694 | 59.032 |
| 260 | .01703 | 58.720 |
| 270 | .01711 | 58.445 |
| 280 | .01720 | 58.140 |

Sum=.006944X(60.060+59.801+ ... +58.140)=4.095 lbm/sq.inch.

For 210 degree F water under the same conditions:

Sum=.0069444X60.060X8=3.337 lbm/sq. inch.

Dm=4.095-3.337=1.368 lbm/sq. inch > .837 psi > 2 ft of water

Thus 80 degrees F > 2 ft. water.

120 degrees F > 3 ft. water.

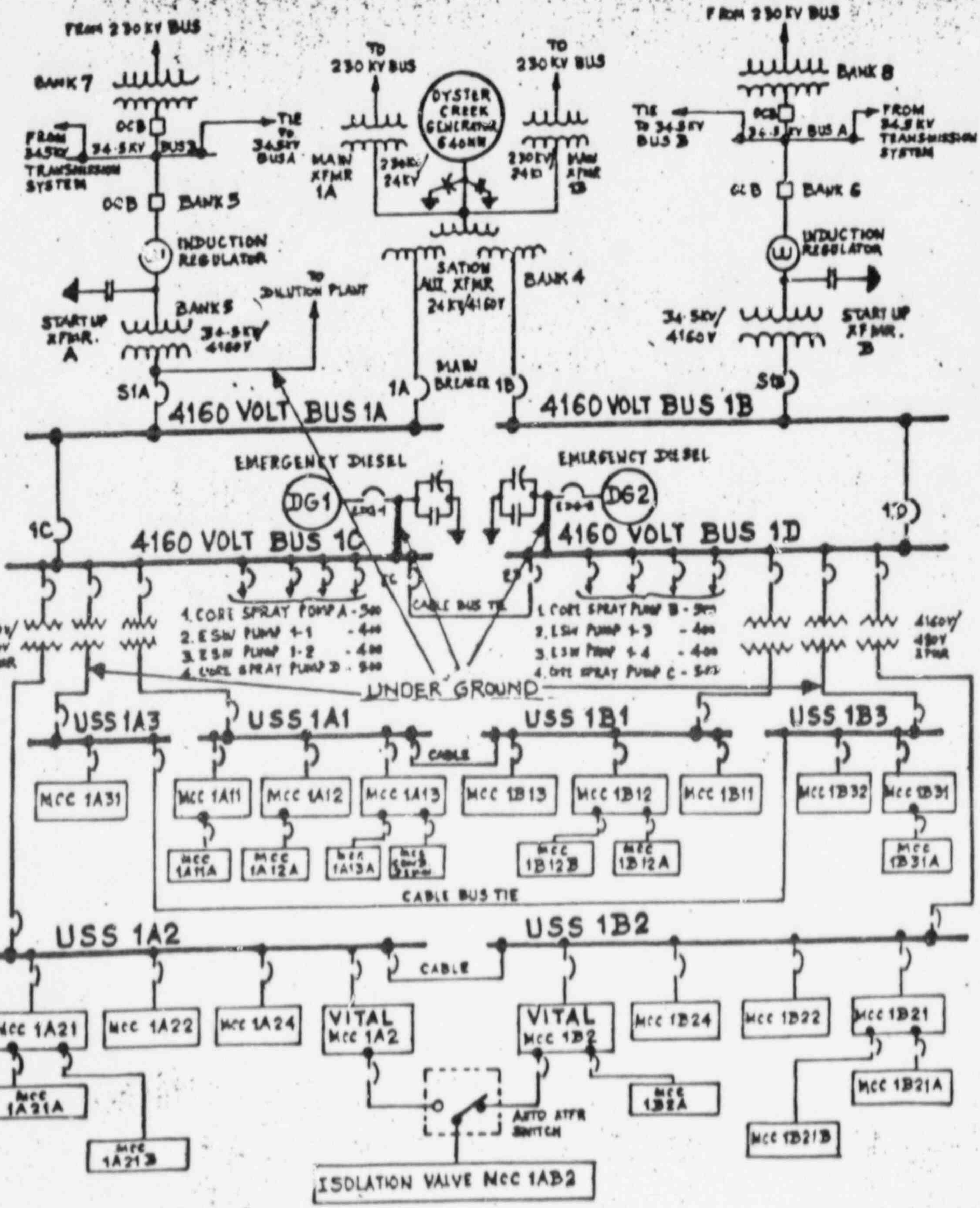
## ATTACHMENT F

## ELECTRICAL EVENT ON OCTOBER 2, 1988

| TIME | SOURCE OF INFORMATION | DESCRIPTION |
|---|---|---|
| 1:57 p.m. | Sequence of Alarm Recorder (SAR) | Diesel generator 2 locked out. |
| 1:57 p.m. | SAR | Main breaker 1D tripped. Last half of Safety Related Electrical System RPS Motor generator tripped. This resulted in full reactor scram due to RPS Bus #2 trip. |
| 1:57 p.m. | Control Room Operator Log (COL) | All power lost to unit substations 1B1, 1B2 and 1B3 which were fed from Bus 1D. |
| 1:57 p.m. | COL | Instrument air was lost due to loss of the "B" train 480 V Bus and vital AC panel (VACP-1) power supply transfer. |
| 1:57 p.m. | COL/SAR | Containment high range radiation monitoring system was lost and caused the drywell and torus isolation. |
| 1:57 p.m. | COL | The main steam isolation valves received an isolation signal. |
| 1:57 p.m. | COL | Reactor water cleanup system tripped due to loss of MCC1B21 |
| 1:57 p.m. | COL | #2 Reactor building closed cooling water pump was lost (lost MCC1B2). |
| | COL | #2 service water pump was lost (lost MCC1B3). |
| | COL | Shutdown cooling pumps B & C tripped (lost MCCB2) |
| | COL | Fuel pool cooling system tripped (lost MCC1B21). |
| | COL | Control rod drive system tripped (lost MCC1B2) |
| | COL | Condensate transfer system tripped (lost MCC1B32). |

| TIME | SOURCE OF INFORMATION | DESCRIPTION |
|---|---|---|
| 1:57 p.m. (Continued) | COL | 1AB2, VACP-1 and IP4 transferred to their alternate power supplies as designed. |
| | COL | Core spray main pumps B & C were unavailable due to loss of 4160 V Bus 1D. Core spray booster pumps B & C were unavailable due to loss of 4160 V Bus 1D. |
| 2:08:30.576 | SAR | 1D Breaker Closed. |
| 2:09:22.528 | SAR | 1D Breaker Tripped. |
| 2:15 p.m. | COL | Manually started standby gas treatment system. |
| 2:58 p.m. (approx.) | Interview and Computer Data | Reestablished shutdown cooling with A train and adjusted service water flow. Stabilized the reactor temperature at 162 degrees F. |
| 3:05 p.m. | COL | Power was restored to Reactor Protection System #2 by transferring the power feed to the transformer powered from VMCC 1A2. The drywell and torus ventilation isolation was reset. The MSIV isolation signal was cleared. |
| 6:30 p.m. | Diesel Surv. Test | Commenced EDG-1 load test. |
| 7:43 p.m. | COL | Opened EDG-1 breaker. Completed load test. |
| 9:30 p.m. | COL | Source of fault located at EDG-2 cable to Bus 1D. Disconnected cable at both ends. |
| 10:15 p.m. | SAR | 1D Bus energized. Diesel remained unavailable. |

# OYSTER CREEK NUCLEAR GENERATING STATION
## SIMPLIFIED SKETCH OF ELECTRIC POWER SYSTEMS




ATTACHMENT G

## ATTACHMENT H

## DOCUMENTS REVIEWED

A. Drawings

| | | |
|---|---|---|
| EM8397907 | Revision 1 | Electro Motive Decision schematic Drawing |
| E1164 | Revision 6 | Elementary Diagram Diesel Generator 2 |
| 223R0173 | Sh. 22, Rev 12 | Elementary Diagram Tie Breaker to Switchgear 1B |
| 223R173 | Sheet 14 | Elementary Diagram Alternate Source Startup Transformer S1B Breaker Power and control circuit |
| BR3002 | Revision 22 | Auxiliary One Line Diagram |
| GE148F711 | Revision 20 | Piping and Instrumentation Diagram Reactor Shutdown Cooling System |
| JCP-19433 | Sheets 1-6 Rev. 2 & 3 | Piping Isometric Drawings |
| DWC No. 21413 | | Emergency Condenser Piping Plans, Section and Details in Reactor Building - As Built |
| DWG No. H0101 | Rev. 2 | Existing 3/4" Emergency Condenser Vent to Main Steam - Reactor Building Pipe Support location. |

B. Procedures

635.2.001, Revision 4, "Switchgear Buses (A, B, C, D) and Circulating Water Pump Protective Relay Surveillance"

2000-OPS-3024.27, Revision 3, "Shutdown Cooling System Diagnostic and Restoration Actions"

2000-OPS-3024.10b, Revision 1, "Electrical Distribution 460 VAC Diagnostic and Restoration Actions"

Station Procedure 337, Revision 21, "4160 Volt Electrical System"

Station Procedure 338, Revision 15, "460 Volt Electrical System"

Surveillance Test 609.3002, "Isolation Condenser Isolation Test and Calibration"

Surveillance Test 609.4.001, "Isolation Condenser Valve Operability and In-Service Test"

Surveillance Test 609.3.003, "Isolation Condenser Automatic Actuation Sensor Calibration and Test"

Surveillance Test 605.5.00?, "Main Steam Isolation Valve Leak Rate Test"

System Operating Procedure 307, "Isolation Condenser System"

C. Other Documents

OCMGS, FSAR, Chapter 8

OCMGS, FSAR, Chapter 6

Cable Test Data, ANACONDA, dated April 13, 1977

Cable Corporation specification for Unshielded EP Cable

IEEE Guide for Mailing High Direct Voltage Tests on Power Cable Systems in the Field. ANSI/IEEE 400-1980

OCMGS, Operations Plant Manual

Safety Evaluation for installation of jumpers on "A" isolation steam inlet temperature points 2 and 5 on recorder IF/2F, Dated June 25, 1982.

Records Associated with the failure of V-14-35 to open on February 7, 1985.

Safety Evaluation for temporary variation EJ-87-66 which by-passed isolation condenser inlet pipe high temperature alarms, dated May 15, 1987.

Memorandum A020-88-040, Is. Condensers Unusual Event, Dated October 3, 1988.

Preliminary results of isolation condenser steam valve leak rate tests.

Outage reports for 1974, 1977, 1978, 1980 1981, 1982, 10 M outage, 10 R outage, and 11 R outage.

Records of isolation condenser piping temperatures obtained on September 29, 1988.

Maintaining Histories of isolation condenser steam and condensate return valves.

Isolation condenser temperature recorder charts.

Operations Critique 88-07, Inadvertent Isolation of the "A" Isolation Condenser"

Switching and Tagging Addendum Sheet, Form 108-2A dated September 2, 1988.

Isolation Condenser System Valve Check-Off Sheet dated September 2, 1988.

Control Room Operator log books.

Switching and Tagging Log Sheets numbers 88-591, 88-707, 88-585, 88-588, 88-590, 88-613, 88-714, and 88-772.

ATTACHMENT I

PERSONS ATTENDING EXIT MEETING

OCTOBER 13, 1988

Oyster Creek Nuclear Generating Station (OCNGS)
General Public Utilities - Nuclear (GPUN) Corp.

R. Barrett, Plant Operations Director
J. Barton, Deputy Director
R. Blouch, Manager, Technical Support
R. Brown, Manager, Plant Operations
G. Busch, Licensing
J. Camire, Manager, Plant Analysis
P. Cervenka, Plant Engineering
T. Dempsey, Reactor Plant Manager-Engineering & Design
E. Fitzpatrick, Vice President/Director Oyster Creek
V. Foglia, Technical Functions Site Manager
T. Gaffney, Supervisor I & C Material Assessment
M. Godknecht, Plant Engineering
R. Hewari, Vice President/Director, Maintenance, Construction & Utilities
J. Kowalski, Licensing Manager
D. MacFarlane, Site Audit Manager
T. Quintenz, Manager, Material Assessment
D. Ranft, Manger, Plant Engineering
J. Rogers, Licensing
A. Rone, Plant Engineering D. ector
P. Smith, Engineer, Systems Engineering
E. Scheyder, Maintenance, Construction and Facilities Director
N. Trikouros, Manager, Safety Analysis/Plant CL

State of New Jersey

M. Jacobs, Bureau of Nuclear Engineering (NJ DEP/BNE)

United States Nuclear Regulatory Commission (USNRC)

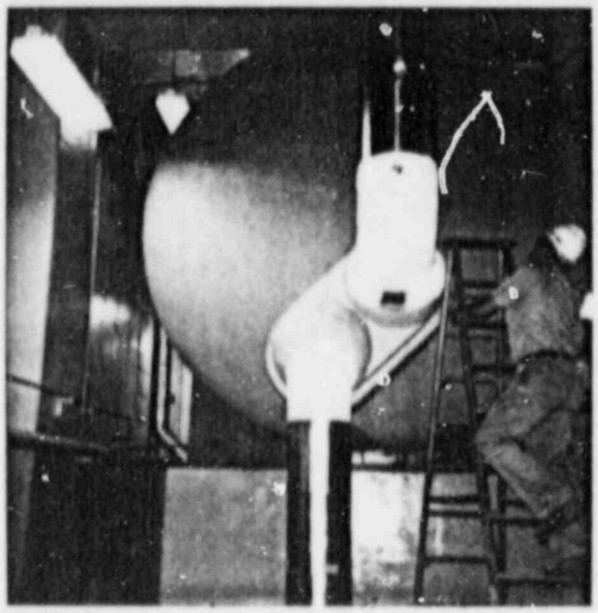
W. Baunack, Project Engineer
L. Bettenhausen, Chief, Projects Branch No. 1
E. Collins, Resident Inspector, Oyster Creek
C. Cowgill, Chief, Reactor Projects, Section 1A
J. Golla, Reactor Engineer
T. Koshy Senior Reactor Engineer
L. Marsh, Chief, Mechanical Engineering Branch, Region I
J. Wechselberger, Senior Resident Inspector, Oyster Creek

PHOTOGRAPHS OF THE

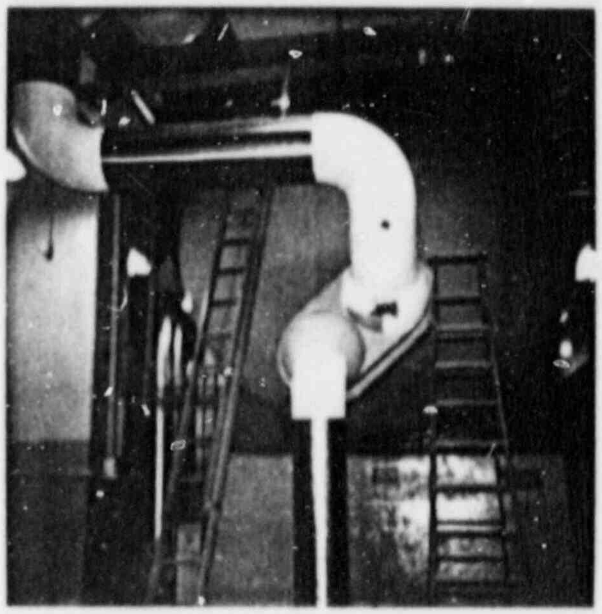
ISOLATION CONDENSER SYSTEM

# LIST OF PHOTOGRAPHS

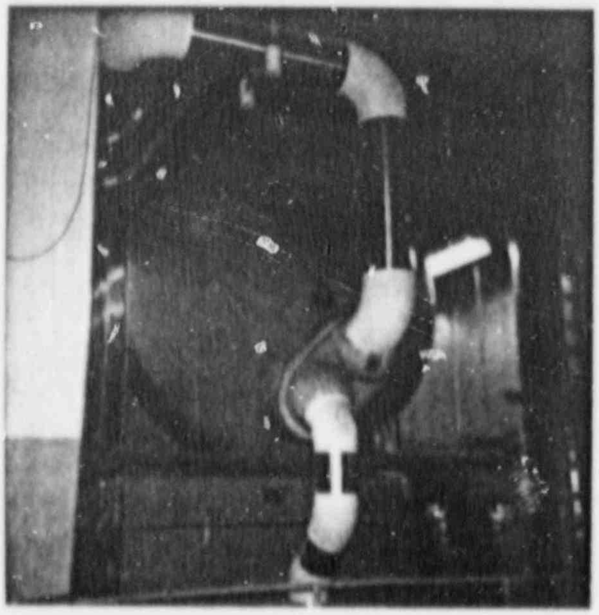
PHOTOGRAPHS 1-4



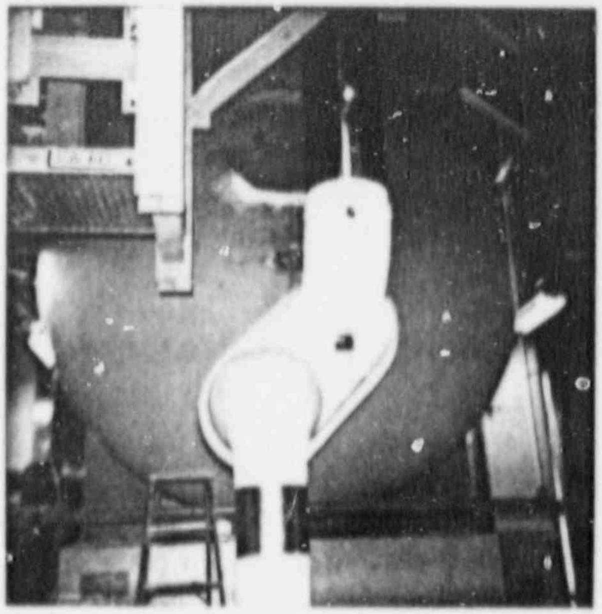
"B" ISOLATION CONDENSER
NORTH END 1



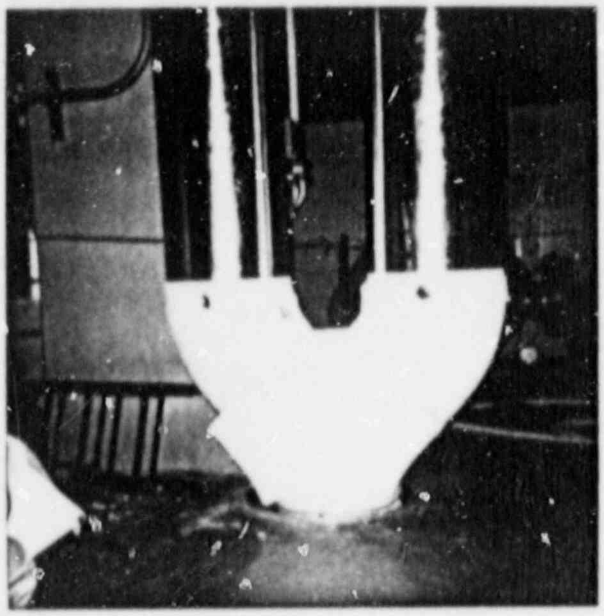
"A" ISOLATION CONDENSER
NORTH END 2



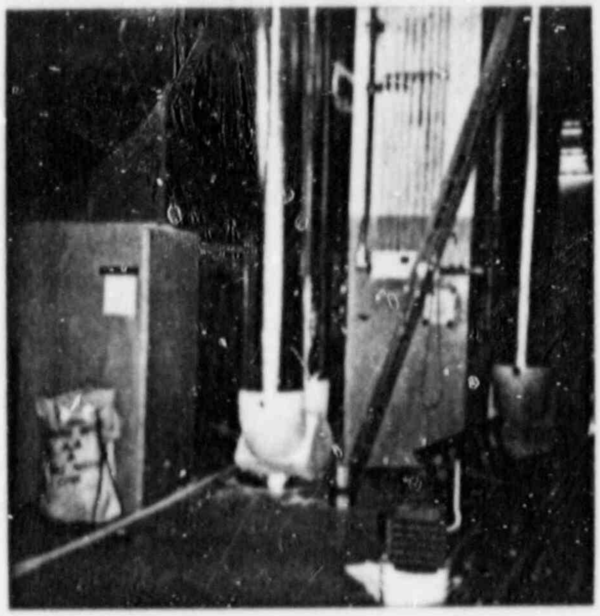
"B" ISOLATION CONDENSER
SOUTH END 3



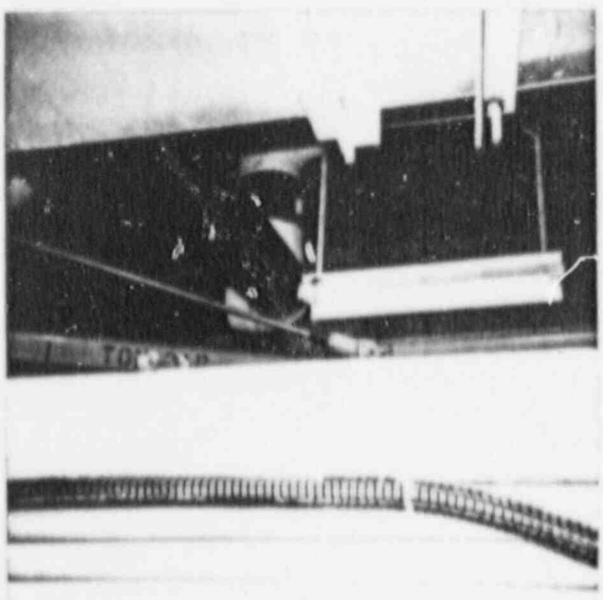
"A" ISOLATION CONDENSER
SOUTH END 4



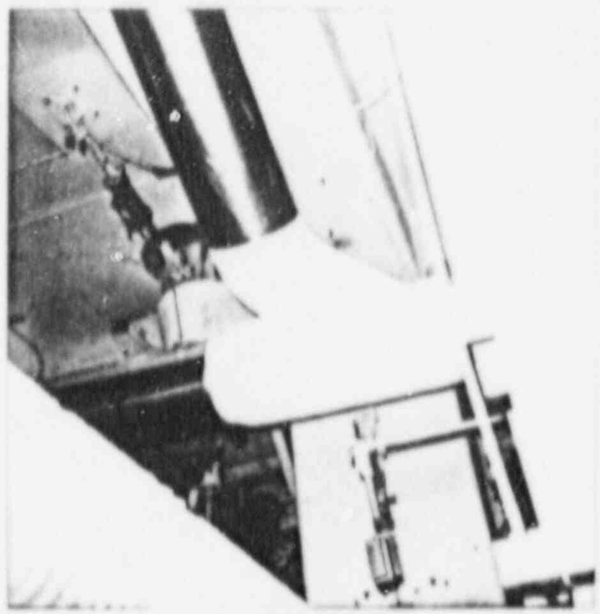
"A" CONDENSER STEAM WYE 5



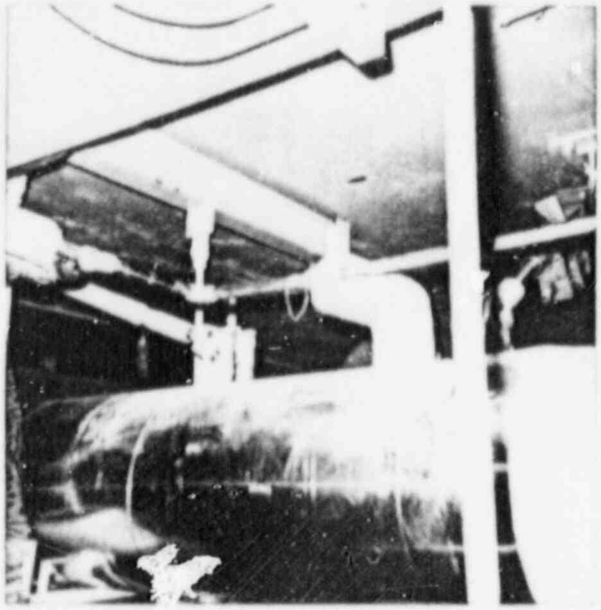
"B" CONDENSER STEAM WYE ON LEFT; "A" CONDENSER STEAM WYE ON RIGHT 6



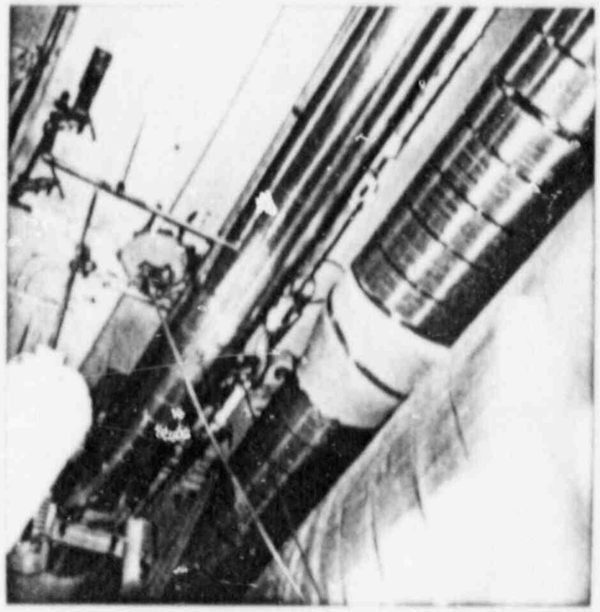
"B" ISOLATION CONDENSER CONDENSATE RETURNS 7



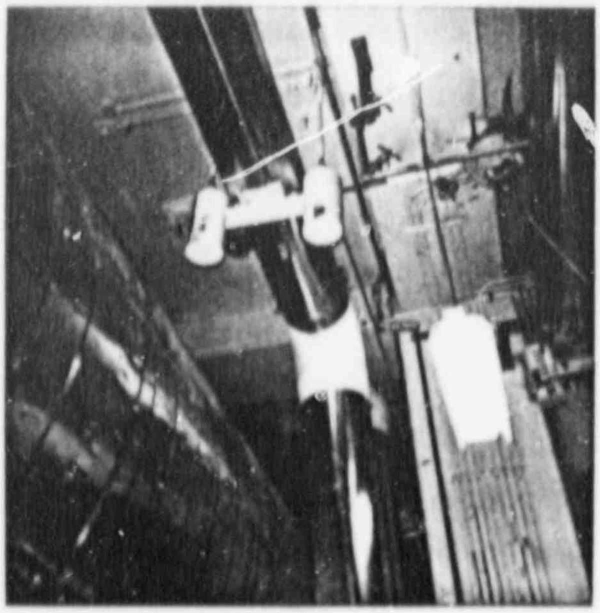
"A" ISOLATION CONDENSER CONDENSATE RETURN BOTH LEGS JOINING 8



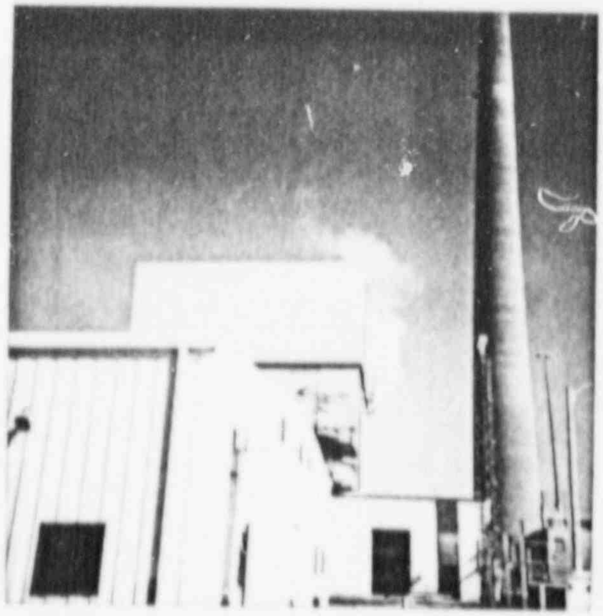
TYPICAL STEAM LINE VENT CONNECTION 9



STEAM LINE AND VENT 10



"B" ISOLATION CONDENSER NORTH STEAM LINE AND VENT 11



"B" ISOLATION CONDENSER STEAMING, SEPTEMBER 11, 1988 12