U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-412/87-68

Docket No. 50-412

License No. NPF-73

Licensee: Duquesne Light Company
P.O. Box 4
Shippingport, Pennsylvania 15077

Facility Name: Beaver Valley Unit No. 2

Inspection At: Shippingport, PA

Inspection Conducted: November 18-21, 1987

Inspector: C J Anderson 12/16/87
C. J. Anderson, Chief Plant Systems Section, EB, DRS, RI - Team Leader — date

Other Participants:

P. Kang, Engineer, SELB, NRR
S. Pullani, Operations Engineer, OB, DRS, RI
F. Rosa, Chief, Electrical Systems Branch, SELB, NRR
F. I. Young, Senior Resident Inspector, BV-2, PB3, DRP, RI

Approved by: for P. K. Eapen 12/16/87
J. Durr, Chief, Engineering Branch, Division of Reactor Safety — date

Inspection Summary: Inspection on November 18-21, 1987 (Inspection Report No. 50-412/87-68)

Areas Inspected: Fact finding team inspection to followup a loss of offsite power event that occurred at Beaver Valley 2 on November 17, 1987. The inspection scope included: determination of the root cause and safety significance of the event; review of licensee corrective actions; review of precursor events; and review of the potential for similar events at Beaver Valley Unit 1.

Results: The licensee established the root cause of the event. Hardware modifications were made before startup to prevent a recurrence. No violations were identified. One unresolved item was identified.

DETAILS

1.0 Persons Contacted

Duquesne Light Company

D. R. Carothers, Electrical Maintenance Engineer
J. D. Crockett, Sr. Manager-Nuclear Operations
K. Grada, Manager of Nuclear Safety
*W. S. Lacey, Plant Manager
G. Lauck, Electrical Maintenance Engineer
*J. D. Sieber, Vice President Nuclear
R. Zupo, Electrical Maintenance Engineer

U.S. Nuclear Regulatory Commission

*J. Beall, Senior Resident Inspector

*Denotes those present at the exit meeting at the plant site on November 20, 1987.

2.0 Description of the November 17, 1987 Loss of Offsite Power Event

2.1 General Discussion of the Event

On November 17, 1987 at 2:06 p.m., the Beaver Valley Unit 2 tripped from full power after a technician inadvertently tripped a power switch on the turbine rotor position drawer, causing a turbine/reactor trip due to a spuriously generated turbine thrust bearing trip signal. Immediately following the trip, a series of breaker automatic operations resulted in loss of offsite power for approximately seventeen seconds until one of the two offsite power sources was re-energized automatically. In response to the loss of all AC power, both emergency diesel generators (EDGs) automatically started and loaded. Natural circulation was terminated after approximately five minutes when the reactor coolant pumps were restarted. One EDG was secured. The second EDG remained running. It provided power for about eight hours following the trip while the licensee performed a physical inspection of the remaining offsite transformer. No damage was identified, and the second offsite power supply was restored and the second EDG secured at about 10:00 p.m. During the event, the main generator was motorized for a short time by power from the offsite grid through the offsite and onsite transformers.

Because of the potential significance of this event, a team of inspectors from Region I and NRR was sent to the site to independently verify the cause and safety significance of the event. The team also reviewed the licensee's short and long term

corrective actions to ensure that the root cause of this problem was properly identified and corrected. This inspection report summarizes the team's findings and conclusions.

Section 2.2 provides a detailed description of the sequence of events that occurred and is used as a reference throughout the remainder of this report. The remaining sections of this report address the team's findings in the area of event evaluation, licensee corrective actions, and summary of the findings of the team.

2.2 Detailed Sequence of Events

The following is a chronological list of significant events that occurred during the loss of offsite power event. Approximate times are listed for reference only. Exact times may be obtained from the attachments to this report. See Attachment A for the BV-2 One Line Diagram.

- Technician inadvertently de-energized a power switch to the turbine rotor position drawer.

- Technician re-energized the turbine rotor position drawer generating a momentary turbine thrust bearing turbine/generator trip signal. (Time is listed in hour/minutes/seconds/milliseconds: T=14:06:39:302).

- Reactor trip generated due to turbine trip. (T=14:06:39:349).

- Main generator's excitation field breaker and generator output breakers 352 and 362 opened. (T=39:349 Note: Hour and minute have been dropped and are only shown when necessary for clarity).

- 4kV bus 2C Breaker 242D opened. (T=39:408)
  4kV bus 2D Breaker 342D opened.
  4kV bus 2A Breaker 42C opened.
  4kV bus 2B Breaker 142C opened.

- Open indication of reactor trip Breakers noted. (T=39:505)

- 4kV bus 2B system station service transformer Breaker 142A closed. (T=39:449)
  4kV bus 2A system station service transformer Breaker 42A closed.
  4kV bus 2C system station service transformer Breaker 242B closed.
  4kV bus 2D system station service transformer Breaker 342B closed.

- 4kV bus 2C unit station service transformer (USST) Breaker 242D reclosed. (T=39:505)
  4kV bus 2D Breaker 342D reclosed.
  4kV bus 2A Breaker 42C reclosed.
  4kV bus 2B Breaker 142C reclosed.

- Transformer 2C tripped on overcurrent by Breakers 42C & 142C opening (T=39:820).

- Transformer 2A tripped on Z-30 relay device by Breakers 85, 142A, 42A opening.

- Transformer 2D tripped on overcurrent by Breakers 242D and 342D opening.

- Transformer 2B tripped on overcurrent by Breakers 242B and 342B opening.

- Emergency diesel generators 2-1 and 2-2 lit off and output Breakers closed in on respective emergency buses (dead bus) and load. (T=14:06:47)

- 138kV Z-30 relay condition cleared. Offsite Breaker 85 reclosed due to clearing of Z-30 relay circuitry. (T=14:06:56)

- 4kV bus 2B Breaker 142A closed. (T=14:06:56, approx. 17 sec. into the event)

- 4kV bus 2A Breaker 42A closed.

- 2A reactor coolant pump re-energized. (T=14:10 approx. 4 minutes into event).

- 2-1 emergency diesel generator paralleled with the 4kV 2A bus and the loads were transferred from 2-1 diesel back to 2A 4kV bus. (T=15, approx. one hour into event)

- 2-1 diesel generator secured.

- Station transformer 2B meggered and resistance checks performed. (T=20, approx. six hours into the event).

- 2B transformer re-energized by closing breaker 94. (T=22, approx. eight hours into the event)

- 242B and 342B breakers closed re-energizing the C and the D 4kV bus.

- 2-2 emergency diesel generator paralleled with the 4kV bus and loads shifted back; diesel secured.

3.0 Event Evaluation

3.1 Evaluation of the Event Data

The licensee conducted a review of the detailed event data to establish the cause of the loss of off-site power event at Beaver Valley 2 on November 17, 1987. This data consisted primarily of the strip chart recorder traces of the main generator current and the voltages on the 4kV buses 2A, 2B, 2C and 2D. (See Attachment A for the breaker, transformer and bus designations.) The data in the sequence of events log provided additional support to allow a determination of the events and the underlying design deficiencies. However, a greater reliance was placed on the continuous strip chart recorder traces than the sequence of events log, since the events log contains digital information collected with a 100 millisecond sampling interval. Thus, the events log would not provide exact breaker position indication for this fast transient. The detailed event data including the strip chart recorder traces and data from the sequence of events log is provided in Attachment E.

As a result of the licensee's review of this data they arrived at the conclusions discussed below. The inspection team also reviewed this data and concurred with the licensee's conclusions.

- The event was initiated at 14:06:39:302 (i.e., 14 hours, 6 minutes, 39 seconds, 302 milliseconds) on November 17, 1987 by an inadvertent momentary turbine thrust bearing signal. The signal was the result of a technician re-energizing the turbine rotor position drawer.

- The above signal tripped the generator and the reactor. The generator output breakers, the exciter breaker, the Unit Station Service Transformers (USSTs) breakers all opened and the buses fast transferred to the offsite power source through the System Station Service Transformers (SSSTs). This transfer from the unit generator to offsite power bypasses the normal 30 second time delay.

- The USST breakers immediately reclosed due to an unintentional electric breaker contact overlap allowing the tripped generator to be backfed (motorized) from the offsite source through the SSSTs and USSTs. At the time the USST breakers reclosed, the momentary turbine thrust bearing signal was cleared.

- The 138kV Breakers 94 and 85 to the grid tripped. The overcurrent on USST 2D (caused by the motorizing of the generator) caused all four USST breakers to retrip and lock open. (The 138kV Breaker 94, which had tripped on overcurrent, locked out

while the 85 breaker, which had tripped on the Midland feeder phase comparison trip (Z-30), reclosed after the trip signal cleared in approximately seventeen seconds into the event).

- Simultaneous with the above, emergency buses 2AE and 2DF sensed undervoltage and opened their normal supply breakers. The emergency diesel generators (EDGs) started and loaded on to the emergency buses.

- Buses 2A and 2B were recovered when the 85 Breaker reclosed (as noted previously). Reactor Coolant Pump (RCP) 2A which is on bus 2A was restarted approximately four minutes into the event, thus reestablishing forced circulation through the reactor core.

- After bus 2A was recovered as noted above, emergency bus 2AE was re-energized from bus 2A and the associated EDG was secured in approximately one hour. The second EDG continued to power its emergency bus 2DF for about eight hours until it renergized from the offsite source.

The factors contributing to the event were:

1. The thrust bearing failure trip relay (74 TMAAB) does not seal-in.

2. The protective trip relays (62 TMAABX2, 1) for USSTs, generator output and excitor field breakers do not seal-in.

3. There is an unintentional overlap in the 52S closing coil circuit contacts (see Attachment B and C) on the pallet switches of the USST and SSST breakers. These contacts are of an "early b" design to provide fast transfer from the USST to the SSST and vice versa. The intent of the design is to ensure that one set of breakers cannot reclose if the opposite set is closed and to keep to a minimum the time that the unit and system 4kV Breakers are both open with an unpowered bus. However, the design did not function entirely as intended because of the above contact overlap combined with the fast transfer feature in both directions (i.e., fast transfer from the unit generator to the offsite grid or a fast transfer from the offsite grid to the unit generator) and the use of non-seal in type of relays as noted in items 1. and 2. above. When the momentary thrust bearing failure trip signal cleared, the relays reset. This allowed the USST breakers to reclose, although the SSST breakers were closed.

3.2 Design Deficiencies

It was determined that three design deficiencies contributed to the sequence of breaker operations that resulted in the loss of offsite power event. This determination was made by an evaluation of the detailed data collected during the event (see Section 3.1 and Attachment E).

The first design deficiency is in the circuitry which initiates a generator trip and automatic fast transfer of the 4kV buses from the USSTs to the SSSTs on turbine trip which does not include a seal-in feature. (Refer to Attachment A for breaker, transformer and bus designations). The second deficiency is that feature of the design which provides for automatic fast transfer of the 4kV buses in the reverse direction, i.e., from the SSSTs back to the USSTs. The third design deficiency is the overlap closure of the auxiliary "early b" contacts of the 4kV breakers. (See Attachment C for a discussion of electrical breaker "early b" contacts.) When the momentary turbine thrust bearing failure signal reset, this reset the trip signal to the USST breakers (42C, 142C, 242D, 324D) which connect the USSTs to the 4kV buses. But the USST breakers had already started to open and by means of their "early b" auxiliary contact had completed the close circuit for the SSST breakers (42A, 142A, 242B, 342B) which connect the SSSTs to the 4kV buses. The SSST breakers, therefore, had begun to close but their "early b" auxiliary contact which is closed and is in the close circuit of the USST side breakers did not open before the reset of the trip signal to the USST breakers. Therefore, for a momentary interval or overlap, both sets of 4kV bus breakers simultaneously had a close signal.

The result was that both sets of breakers (i.e., the USST and SSST breakers) on buses 2A and 2B were simultaneously closed for approximately 16 cycles and the corresponding breakers on buses 2C and 2D were simultaneously closed for approximately 22 cycles. During these intervals, the main generator with its field deenergized was connected to the 138kV offsite circuits through the intervening USSTs, 4kV buses and the SSSTs. This resulted in motorizing of the main generator. Approximately 6,000 amps of motorizing current was observed on the 22kV generator bus. This indicates that over 20,000 amps current was distributed between the 4kV buses and their transformer windings.

The resulting overload on USSTs 2C and 2D and on SSST 2B, and the phase unbalance condition sensed by the Z-30 relay protection for the 138kV line to Midland, caused tripping of all breakers on the four 4kV buses and the tripping of the 138kV breaker 85. The Z-30 relay sensed the phase difference between the 138kV Midland line and the tripped main generator. The different time intervals (16 cycles, 22 cycles) cited above are due to the differences in trip characteristics

or the overcurrents seen by the 4kV bus breakers, i.e., the faulted condition was cleared sooner on buses 2A and 2B.

The licensee determined by tests performed (see Section 3.3) on the 4kV bus breakers that an "early b" contacts closed overlap condition existed in the automatic close circuits of these breakers. This condition would permit simultaneous closure of both supply breakers on each 4kV bus if the trip signal to the USST side breakers were removed before the SSST side breakers had fully closed.

It is noted that the design deficiencies noted above are in the non safety-related portion of the plant electrical system. Also, the Regulations (10 CFR 50 Appendix A GDC 17) only require immediate access to offsite power (i.e., fast transfer to the SSST) in the event of a LOCA. The capability for fast transfer back to the USST is not a design requirement.

One other design feature was reviewed to determine whether it contributed to the fast transfer malfunction which occurred or had the potential for causing a malfunction. This was the design feature that would prevent a fast transfer if the voltage of the 4kV buses was between 30 and 75 percent of normal voltage, which would be the voltage of the power supply to which the bus is being transferred. It was concluded that this feature did not contribute to the malfunction and that it provides equipment protection against the electrical and mechanical stresses that would be produced if two such differing voltage sources, with a probable phase difference due to motors on the isolated bus acting as induction motors were connected (A bus at less than 30% voltage is considered a dead bus, and greater than 75% voltage it is sufficiently close to normal voltage that undue stressing would not occur).

3.3 Followup Tests

As discussed in Section 3.2 above, a design deficiency involving timing of the pallet switches that are a part of the electrical breaker "early b" contacts resulted in simultaneous closure of the 4kV breakers on the unit and the system sides, resulting in motorizing the generator. To confirm this, the licensee performed two followup tests of the pallet switches timing, one on November 19, 1987 for the 2A 4kV bus breakers and another on November 20, 1987 for the 2C 4kV bus breakers. The test results demonstrated that the pallet switches functioned as designed. (i.e., with the design deficiency). The licensee's corrective action for this deficiency was to install knife switches in the closing circuit of the 4kV breakers (see section 4.1). The licensee performed another test on November 20, 1987 to verify that such corrective action would eliminate the design deficiency. This was done by temporarily opening the closing circuit of one of the 4kV breakers (This is equivalent to an open knife switch). The results of the test

verified that the licensee's corrective action would work, i.e., with the set of knife switches on the unit side open and the set on the system side closed, the fast transfer would occur from the unit side to the system side. The unit side breakers would not reclose. This eliminates the possibility of the USST and the SSST breakers being closed at the same time and the resulting potential for motorizing the main generator.

4.0 Corrective Actions

4.1 Description of Modifications

Three design deficiencies were identified by the licensee that contributed to the November 17, 1987 loss of offsite power event. These deficiencies are discussed in Section 3.2.

These deficiencies included (1) the lack of a seal-in of the signal which initiates generator trip and fast bus transfer to the SSST on turbine trip, (2) the capability for automatic fast bus transfer in the reverse direction, i.e., from the SSST back to the USST, and (3) the overlap operation of the "early b" auxiliary contacts of the 4kV bus breakers which enabled a simultaneous closure of the USST side breaker and the SSST side breakers.

Turbine Trip Seal-In Addition

To correct this deficiency, the licensee replaced four Westinghouse MG-6 self-reset relays (they are used as a pair in each of two redundant turbine trip schemes) with two Electro Switch Type LOR lockout type relays which require manual reset. These relays are the final actuation relays for all turbine trip signal inputs and will assure that no turbine trip will self-reset.

Defeat of the Reverse Automatic Bus Transfer

The reverse automatic bus transfer from the SSSTs back to the USSTs was defeated by inserting a knife switch in the auto closure circuit of each 4kV bus breaker. The switches in the close circuit of the USST side breakers will be kept open, which prevents automatic reclosure of these breakers thus defeating the reverse auto transfer of the buses back to the USSTs. The knife switches in the close circuit of the SSST side breakers will be kept closed thus retaining the auto transfer from the USSTs to the SSSTs. The knife switches are physically installed in their respective breaker cubicles and will be maintained in the proper position by administrative controls. Indicator lights in the control room show that each of the eight knife switches are in the correct position. The licensee indicated

his intent to replace these knife switches with more appropriate components at the earliest opportunity. The proper operation of this modification was verified by test. (See Section 3.3)

It was noted that the knife switches for the SSST side breakers were not needed to defeat the reverse auto transfer. The licensee indicated that these switches were installed to provide the plant with flexibility which may be useful during test or maintenance activities during the period prior to replacement of these switches with permanent circuitry.

Elimination of the "early b" Contact Overlap

The defeat of the reverse auto bus transfer by the open knife switches in the close circuit of the USST side breakers effectively eliminated the contact overlap problem. Therefore, no further corrective action was taken.

4.2 Testing and Modification of Electrical System

As described in Section 4.1, the licensee performed two modifications to the electrical system for BV-2. One modified the tripping circuits associated with the transfer scheme of 2A, 2B, 2C, and 2D 4kV buses and the other modified the trip initiation signals from the turbine trip system. Team inspectors reviewed and witnessed the post-modification testing for the changes. Visual observations and walkdowns of the newly installed lockout relays and knife switches were performed as a part of the inspection. Members of the inspection team also discussed the field modifications with personnel installing the hardware to determine whether the individuals were knowledgeable of the modifications that were being implemented. The inspectors found that the personnel installing the modifications demonstrated an acceptable knowledge of the changes. The modification activities were performed in accordance with the applicable procedures.

After the modifications had been functionally tested, the licensee performed an overall system transfer test to ensure that all modifications worked properly. Members of the inspection team witnessed portions of the test and determined that the modifications that the licensee installed worked properly.

4.3 Safety Evaluation and 50.59 Review

The licensee performed the required safety evaluations in accordance with 10 CFR 50.59 for the two facility modifications discussed in Sections 4.1, i.e., (1) installation of knife switches in the 4kV breaker closing circuitry and (2) replacement of the existing relays

in the turbine trip circuit with lockout type relays. The licensee's evaluation concluded that no unreviewed safety questions exist for the modifications. The team reviewed the safety evaluations and verified that sufficient bases exist for the licensee's conclusion.

5.0 Precursor Event - October 24, 1987, Partial Loss of Offsite Power

During the performance of the initial startup test program "Net Load Trip Test" on October 24, 1987, Beaver Valley 2 experienced a partial loss of offsite power. This event is discussed in Attachment F and in inspection reports 50-412/87-63 and 87-64. As noted in Attachment F, the licensee noted that immediately after the off-site power source was connected to the 4kV buses, the unit supply breakers attempted to reclose on the 4kV buses. Since the November 17, 1987 event involved a loss of offsite power and a reclosure of the unit supply breakers on the 4kV buses, the inspectors questioned the adequacy of the licensee's initial review of the October 24, 1987 event.

Discussions with licensee management indicated that the October 24, 1987 event was reviewed by engineering to determine the reason these breakers attempted to reclose on an already energized bus. The licensee indicated that using the information that was available at the time of the October 24, 1987 event, the slow bus transfer sequence appeared to allow the transfer attempt to occur. Because of the test initial alignment, the plant had been placed in a unique situation which typically does not occur. From the data, the licensee subsequently concluded that the slow bus transfer sequence was the mechanism that allowed these four additional breakers to attempt to reclose on an energized bus. The review reasonably assured that this was a unique situation and would not occur unless these unique conditions occurred again. Further discussion with the licensee indicated that after reviewing the November 17, 1987 event, engineering went back and reviewed the October 24, 1987 event and determined with the additional data collected from the November 17, 1987 event, that a slow bus transfer did not cause the supply breakers to attempt to reclose on the 4kV buses. The licensee determined that it was in fact the fast transfer scheme that had allowed these breakers to close.

Based on the discussions and an independent review of the data that had been collected from the October 24, 1987 event, the team concluded that the licensee had reasonably reviewed the data and had come to a reasonable conclusion of the October 24, 1987 occurrence. The team concluded that the licensee's review process in this area was adequate to address this type of concern and could adequately resolve technical issues in their review process.

6.0 Beaver Valley Unit 1 Review

As discussed in Section 4.1, several modifications were made to Beaver Valley 2 to correct the design deficiencies that contributed to the November 17, 1987 loss of offsite power event. Discussions were conducted with licensee management to determine if similar design deficiencies existed at Beaver Valley 1 and the potential for a loss of offsite power event at Unit 1 similar to the November 17, 1987 Beaver Valley 2 event.

As discussed in Attachment D, it was determined that a difference exists between the Unit 1 and the Unit 2 thrust bearing trip device signal. The thrust bearing trip signal was the initiating event for the November 17, 1987 event. In Unit 2, an electronic signal is generated which does not lock in. The signal rapidly decays. However, in Unit 1 the thrust bearing trip device signal is not electronic. Rather, it is generated by a hydraulic system that does lock in the trip signal. Therefore, a similar problem is not an immediate concern for Unit 1. However, some aspects of the design deficiencies at Unit 2 (see Section 3.2) are potentially applicable to Unit 1.

The licensee committed in their letter of November 30, 1987 from W. S. Lacey, Duquesne Light to C. J. Anderson, NRC to perform a review of Unit 1 to establish the need and feasibility of design changes. This review is to be conducted at the upcoming BV-1 refueling outage currently scheduled to start on December 11, 1987. The licensee's review of Beaver Valley 1 for potential design deficiencies and the correction of these deficiencies is an unresolved item pending licensee completion and NRC review of these activities (50-412/86-68-01).

7.0 Summary

The team concluded that the licensee identified the primary cause of the short loss of offsite power event that occurred on November 17, 1987. Three design deficiencies that contributed to the event included: lack of a seal-in of the signal which initiates a generator trip and fast bus transfer to offsite power on a turbine trip; capability for fast bus transfer in the reverse direction back to the unit; and overlap operation of the auxiliary contacts of the 4kV bus breakers which allowed simultaneous closure of the USST side and the SSST side breakers. These deficiencies were corrected by two modifications. One of these modifications provided a turbine trip seal-in. The other modification consisted of the insertion of knife switches to the auto closure circuit of each 4kV bus breaker to prevent fast bus transfer in the reverse direction. The insertion of the knife switches eliminated the contact overlap problem.

Prior to startup of Unit 2 after the event, the licensee committed to make the above mentioned modifications to correct the specified deficiencies. This commitment was made by the licensee's management during a telephone call between the licensee and NRC management on November 20, 1987. This commitment was documented in a letter from J. D. Sieber, Duquesne Light to the NRC dated November 25, 1987. These modifications were made and tested prior to restart of Unit 2. In addition, the license committed to review Beaver Valley Unit 1 for similar deficiencies and make any required modifications. The work for Unit 1 is to be done during the refueling outage scheduled to begin on December 11, 1987.

8.0 Unresolved Items

Unresolved items are matters about which more information is required in order to ascertain whether they are acceptable items or violations. An unresolved item identified during this inspection is discussed in Details, Paragraph 6.0.

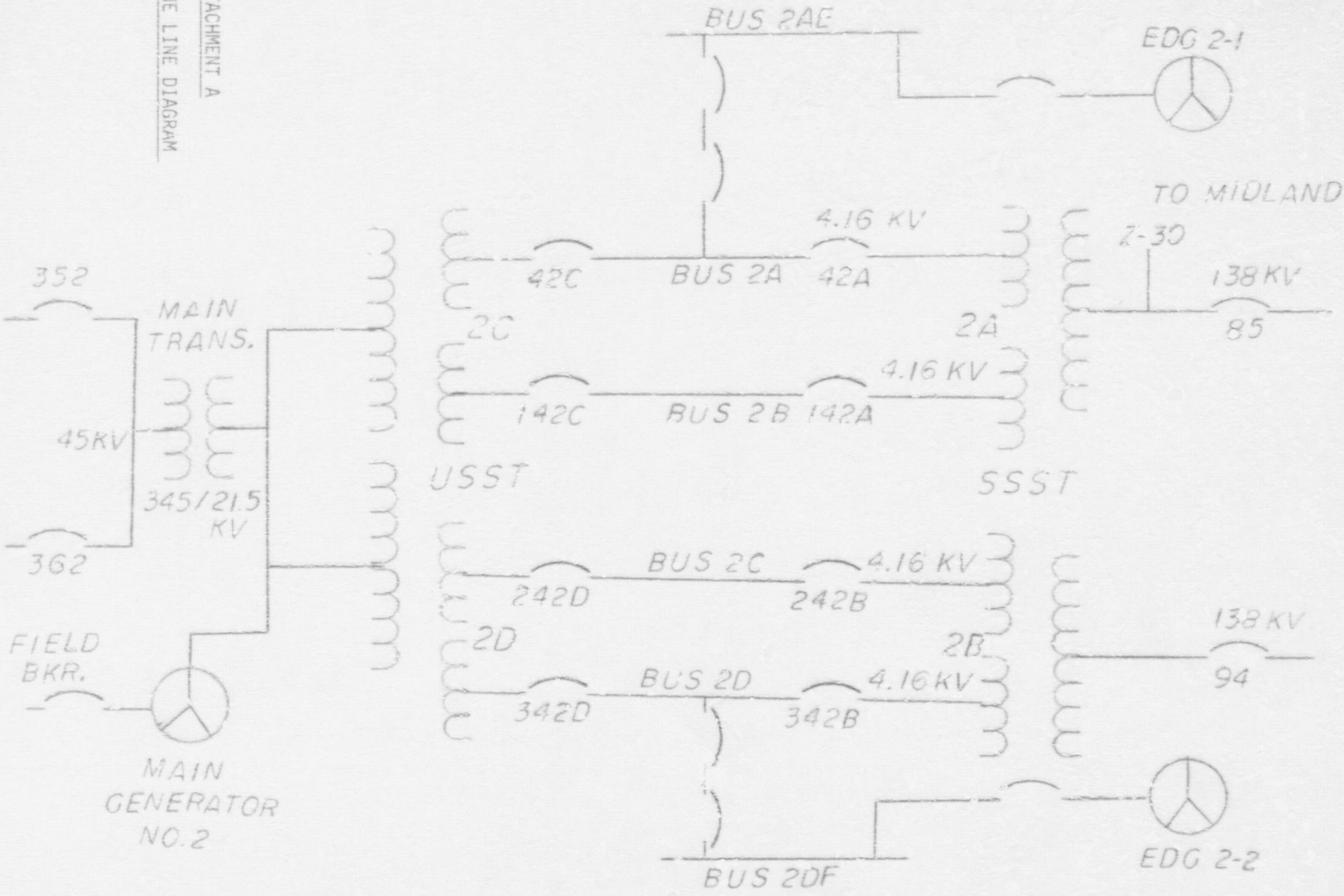
9.0 Exit Meeting

The inspectors met with licensee personnel (denoted in Details, Paragraph 1.0) on November 20, 1987. The inspectors summarized the inspection findings.

At no time during this inspection was written material given to the licensee.

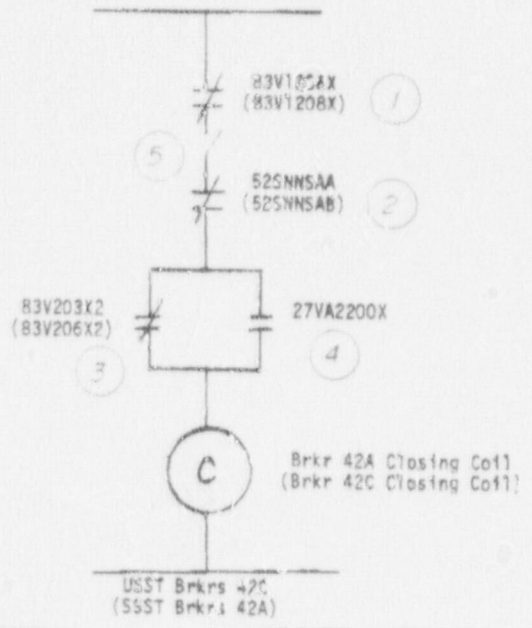
ATTACHMENT A

BV-2 ONE LINE DIAGRAM



Attachment B

4kV Bus Breaker Control Circuit*



*The simplified sketch shown is for the USST breaker 42C and 42A closing coil. However, it is typical of all the USST and SSST breakers (42C, 142C, 242D, 342D, 42A, 142A, 242B and 342B).

Legend

1. 90% voltage relay contact (Device 83V1206X): closes when the USST voltage is above 90%

2. The "early b" contact of each opposite side breaker (e.g., 42A and 42C) when the breaker begins to open is used to initiate closing of its opposite breaker. Thus, when USST breaker 42C starts to open its "early b" contact in the closing circuit of breaker 42A closes initiating closure of 42A before 42C is fully open. Conversely, the "early b" contact of breaker 42A is closed when breaker 42A is open thus providing a close permissive for breaker 42C. This "early b" contact should open when breaker 42A begins to close. The design intent is to provide fast transfer from the USST to the SSST and to prevent reclosing of the USST breaker if the SSST breaker is closed.

3. 75% voltage relay contact (Device 83V208X2) with time delay of 20 cycles: closes when the USST voltage is greater than 75%.

4. 30% voltage relay contact (Device 27VA 2200) closes when the USST voltage is less than 30%.

   NOTE: Items 3 and 4 above permit the operator to close breaker 42C, provided the USST voltage is within permissible limis (>75% or <30%)

5. Knife Switch: added in the circuit as a modification to allow fast transfer only in one direction (i.e., from USST to SSST). The knife switches on the USST side breakers will be kept open and those on the SSST side will be closed to permit such a transfer.

Attachment C

Electrical Breaker "early b" Contacts

Normal contacts associated with the breaker are classified as "a" or "b" contacts. These contacts are mechanically linked to the breaker and open or close with motion of the breaker. When the breaker is closed, the "a" contacts are closed and the "b" contacts are open; when the breaker is open, the "a" contacts are open and the "b" contacts are closed. When the breaker is moving from the closed to open position, all contacts are open because the breaker is not closed and the "b" contacts are open because the breaker is not fully open. Selected breakers at Beaver Valley, Unit 2, are equipped with what is termed as "early b" contacts. The "early b" contacts will close before the normal "b" contact in order to shorten the length of time between the indication the first breaker is being opened and an indication that the opposite breaker should close.

This arrangement is typically used when a fast transfer of electrical power is needed within a few cycles of the first breaker actually tripping open. With this scheme, the first breaker would be tripped and the second breaker could start to go closed before the first breaker has fully opened by use of "early b" contact. During normal travel under a non-fast transfer, the second breaker would not be allowed to start to go closed until the first breaker had truly indicated open by a "b" contact. By use of an "early b" contact, which is typically 22 to 33 degrees ahead of a "b" contact, the second breaker can start to close early on in the actual open cycle of the first breaker.

At Beaver Valley, these "early b" contacts are designed in an arrangement which is known as pallet switches.

Attachment D

Thrust Bearing Trip Description

The thrust bearing trip device is designed to measure the axial positioning of the main turbine shaft. The thrust bearing trip control system detects motion of the thrust bearing in either direction. The sensing device for Unit 2 is a linear variable transformer (LVT) type arrangement that generates an electrical signal which is directly proportional to the thrust bearing motion. This signal is sent to the plant computer and to the turbine rotor position module in the control room. With this circuitry, a turbine trip signal and two control room alarms are generated. The turbine thrust bearing wear alarm, a precursor alarm, is generated when a predetermined setpoint is reached. This alarm is designed to allow the operator to take immediate action to unload the unit prior to reaching a thrust bearing failure. This circuitry also provides a signal to the Westinghouse emergency cabinet for turbine trip circuitry and annunciator window 3F, turbine thrust bearing failure turbine trip. The Westinghouse emergency cabinet circuitry, upon receipt of this signal, is designed to automatically shut down the unit and immediately open generator output breakers 352, 362, and the field excitation breaker.

The Unit 2 thrust bearing trip device does not lock-in the trip signal. Therefore, when the electronic signal decays away, the trip signal will clear. The Unit 1 thrust bearing trip device signal is generated by a hydraulic system that does lock in the trip signal. Therefore, a similar problem is not an immediate concern for Unit 1. The above Unit 2 trip device is duplicated, thus incorporating a one out of two trip coincidence. The Westinghouse emergency trip cabinet allows for individual circuit testing without causing a turbine trip.

Attachment E

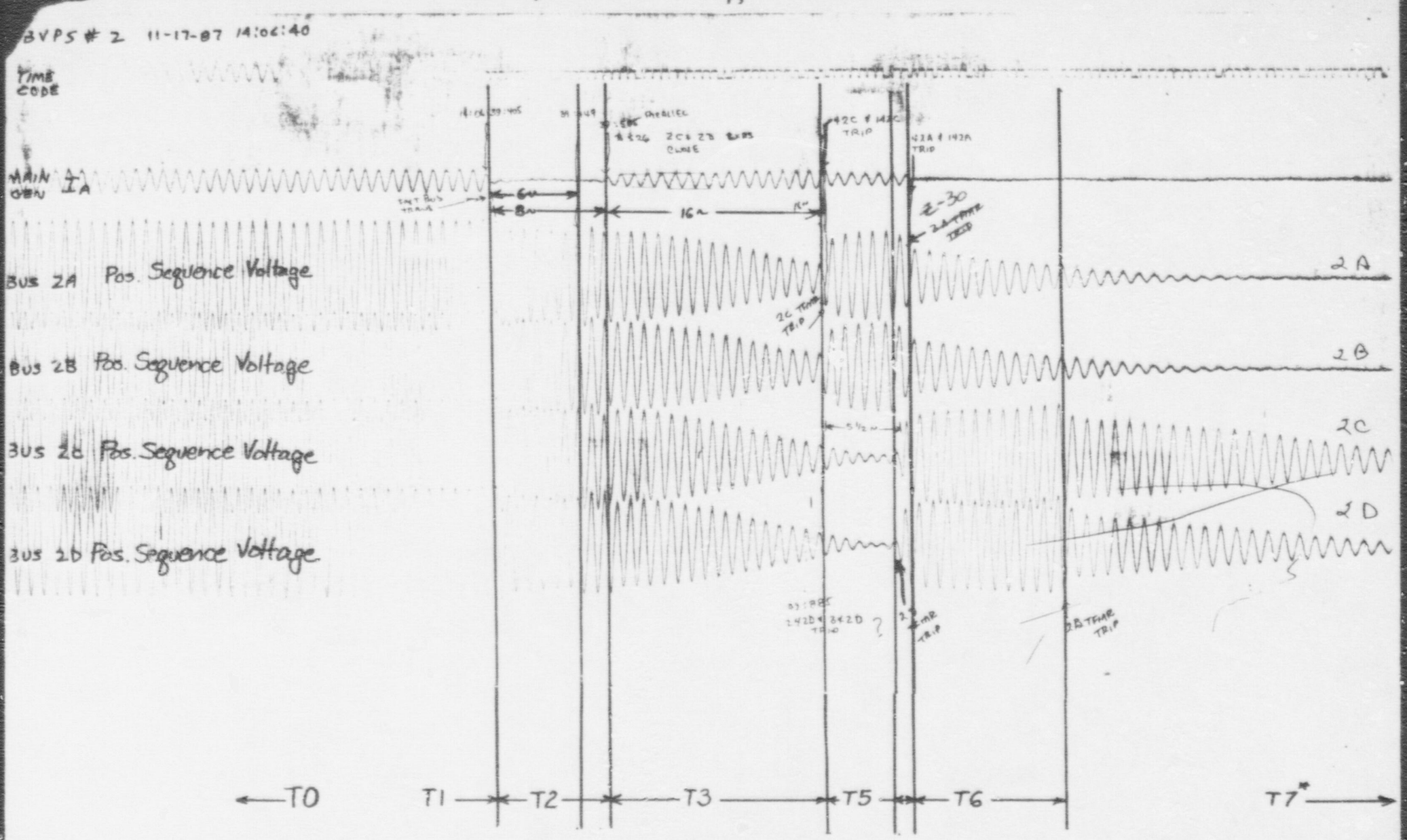
Event Data

E.1 Oscillograph Strip Chart Recorder Traces

E.2 Sequence of Event History

E.3 Sequence of Events Log (Handwritten Summary of Key Events)

Breaker Operational Sequence



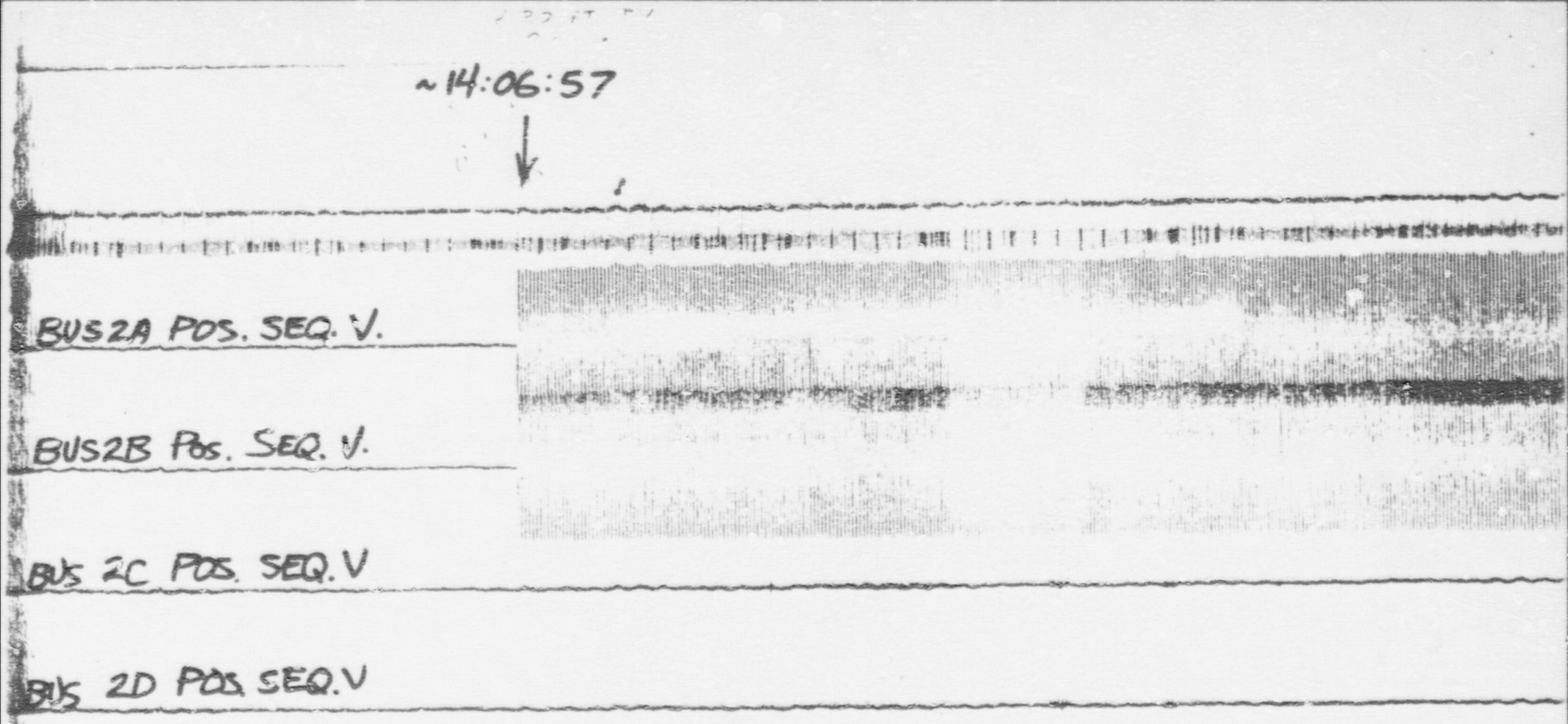
*17 sec. Later

Attachment E.1

Oscillagraph Strip Chart

Recorder Traces

~14:06:57



T7

Attachment E.1 (Continued)

Oscillagraph Strip Chart

Recorder Traces

SEQUENCE OF EVENT HISTORY

T = 0	STATUS	REMARKS
PCB 352, PCB 362	CLOSED	T/G RUNNING PUTTING POWER TO 345KV GRID SYSTEM
ACB 42C, 142C, 242D, 342D	CLOSED	"
ACB 42A, 142A, 242B, 342B	OPEN, FBT	"
T = 1		
TURB THRUST BRG FAIL	TRIP	ACCIDENTAL TURBINE TRIP INITIATES GENERATOR & REACTOR TRIPS
TURB OIL LOW PRESS	TRIP	"
GEN TRIP FROM TURB	TRIP	"
RX TRIP FROM TURB	TRIP	"
T = 2		
ACB 42C TC1	TRIP	USST 4KV BKRS TRIP DUE TO T/G TRIP
ACB 142C TC1	TRIP	"
ACB 242D TC1	TRIP	"
ACB 342D TC1	TRIP	"
FAST BUS TRANSFER INITIATED		
ACB 42A	CLOSE	SSST 4KV BKRS CLOSE AS A RESULT OF FAST BUS TRANSFER
ACB 142A	CLOSE	"
ACB 242B	CLOSE	"
ACB 342B	CLOSE	"
T = 3		
UNEXPECTED EVENT BEGINS		
ACB 42C	RECLOSE	USST 4KV BKRS RECLOSE UNEXPECTEDLY. MALFUNCTION UNDER INVESTIG.
ACB 142C	RECLOSE	"
ACB 242D	RECLOSE	"
ACB 342D	RECLOSE	"

T = 4	STATUS	REMARKS
PROTECTION DEVICES ACTIVATED		
GEN MOTORING PILOT WIRE SYSTEMS ACTIVATED TFMR 2D, TFMR 2B, OC OCCURS		GENERATOR DRAWS CURRENT AND ACTIVATES PILOT WIRE AND O/C PROTECTION SCHEMES TO INITIATE TRIPPING.
T = 5		
ACB 42C, 142C, 242D, 342D ACB 42A, 142A, 242B, 342B	TRIP CLOSE	USST 4KV BKRS TRIP VIA P.W PTOTECTION TO BREAK CURENT PATH SSST 4KV BKRS REMAIN CLOSED
T = 6		
ACB 42A, 142A, 242B, 342B OCB 85 (Z30 LINE)	TRIP TRIP	SSST 4KV BKRS TRIP VIA P.W PROTECTION TO DE-ENERGIZE BUSES
T = 7		
138KV OCB 85 (Z30 LINE)	RECLOSED	P.W PROTECTION TRIPS OCB 85 AND INITIATES RECLOSURE

SEQUENCE OF EVENTS 11/17/87

Time		Remarks
14:06:39:302	Turbine Thrust Brg Failure	Initiating Event
:343	Gen. Trip From Turb Trip	
:349	Rx Trip From Turb Trip	
:404	Main Gen Out Brks and Exciter Brk Open	
:408	Turbine Thrust Brg Normal	
:405	4KV Bus 2C ACB 242D Open	Bus transfer from Unit to System Service
:409	4KV Bus 2D ACB 342D open	
:410	4KV Bus 2A ACB 42C open	
:426	4KV Bus 2B ACB 142C open	
:449	4KV Bus 2B ACB 142A close	
:455	4KV Bus 2A ACB 42A close	
:456	4KV Bus 2C ACB 242B Close	

Time		Remarks
14:06:39:458	4KV Bus 2D ACB 342B close	
:505	4KV Bus 2C ACB 242D close	Unit Service Brks close back in
:509	4KV Bus 2D ACB 342D close	
:510	4KV Bus 2A ACB 42C close	
:526	4KV Bus 2B ACB 142C close	
:820	UAS Serv Tfmr 2D OC	Overcurrent condition from back feeding main Generator from 4KV buses. Unit Service brks for 2C and 2D buses trip. Buses still energized from system.
:884	4KV Bus 2D ACB 342D open	
:887	4KV Bus 2C ACB 242D open	
:901	4KV Bus 2A ACB 42C open	Unit Service Brks for 2A and 2B buses trip- overcurrent. Buses still energized from system.
:915	4KV Bus 2B ACB 142C open	
40:034	4KV Bus 2DF Volts Low (27-VF2200)	
:044	4KV Bus 2AE Volts Low (27-VE2200)	

Time			Remarks
14:06:40:087		D6-2-2 Auto Start	
:092		D6-2-1 Auto Start	
:092	I100	4KV Bus 2D ACB 342B open	System Service Brks for 2C and 2D buses trip due to overcurrent trip on 2B ss Tfmr (OCB-92 trips open) - 2C and 2D buses de-energized
:093		4KV Bus 2C ACB 242B open	
:425		4KV Bus 2A ACB 42A open	Phase comparison between Midland and BYss takes out 2A ss Tfmr - Z-30 trips and Sys. Service Brks for 2C and 2D buses open - 2A and 2B buses de-energized.
:451		4KV Bus 2B ACB 142A open	
:06:56:829		4KV Bus 2B ACB 142A close	Z-30 brk Re-closes and Recloses ss supply - 2A and 2B buses Re-energized.
:843		4KV Bus 2A ACB 42A close	

Attachment F

October 24, 1987 Partial Loss of Offsite Power Event

The Main Generator output breakers were opened with the unit at full power for the performance of the initial startup test program "Net Load Trip Test". A reactor trip signal was received approximately 6 seconds later from a Low-Low Steam Generator level signal followed by a Turbine Trip from Reactor Trip. As per design following a turbine trip, a main generator trip and fast bus transfer to offsite power is initiated 30 seconds after the turbine trip. Therefore, the main generator continued to supply the station 4kV buses for 30 seconds after the turbine trip. During this time, the main generator speed decreased below 1800 RPM and approximately 11 seconds into the event the Reactor Coolant Pumps tripped on underfrequency (57.5 Hz). Thirty (30) seconds after the turbine trip, the generator trip signal opened the main generator exciter breaker and a fast bus transfer was initiated. The unit supply breakers to the 4kV buses opened (42C, 142C, 242D, 342D) and the offsite power system supply breakers (42A, 142A, 242B, 342B) closed in on the 4kV buses. About 50 msecs. after the system supply breakers closed in the unit supply breakers for three of the four 4kV buses (42C, 242D, 342D) attempted to reclose in on the buses and then reopened about 50 msecs. later. After the fast bus transfer to offsite power, the 2A System Station Service Transformer developed an undervoltage condition and tripped the system supply to the 2A and 2B buses. This undervoltage was a result of the transfer of the 4kV buses and the unit to the offsite supply while in a degraded voltage and frequency condition caused by the main generator speed coastdown. The offsite supply breaker for the 2A bus reclosed in about 1.5 seconds after opening and the 2B bus supply breaker reclosed about 16.5 seconds after opening.

The plant was stabilized on natural circulation. The 2A Reactor Coolant Pump was later restarted.

Attachment G

List of Documents Reviewed

	Doc. No.	Title	Revision
1.	**Elementary Diagrams**		
	12241-E-5A	Bus 2A Supply ACB 42C	16
	12241-E-5B	Bus 2A Supply ACB 42A	19
	12241-E-5AA	Bus 2B Supply ACB 142C	14
	12241-E-5AB	Bus 2B Supply ACB 142A	13
	12241-E-5BA	Bus 2C Supply ACB 242D	12
	12241-E-9A	Turbine Controls	14
	12241-E-9B	Turbine Controls	14
	12241-E-5K	SSST 2A Undervoltage	9
	12241-E-5BL	USST 2C Undervoltage	8
2.	**Event Data**		
	NA	Sequence of Event Log for Tuesday 11-17-87, 14:06:09:200	NA
	NA	Sequence of Events 11-17-87 (Handwritten summary)	NA
	NA	Oscillograph Chart of the Event	NA
3.	**Followup Test Results**		
	NA	Results of Followup Tests on timing of pallet switches, performed on November 19, 1987	NA
	NA	Result of test by temporary opening (inserting paper in relay contact) of the closing circuit of a 4KV breaker, performed on November 20, 1987	NA
4.	**Miscellaneous Documents**		
	872005 thru 872012	4 Work Request and Failure Report packages for 8 knife switch installations including their 10 CFR 50.59 safety evaluations	0
	872013 872014	Work Request and Failure Report packages for replacement of Turbine Thrust Bearing Trip Relay 62-TMAABX1, X2 including their 10 CFR 50.59 safety evaluations	