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MEMORANDUM FOR: G. Lainas, Chief, Plant Systems Branch, DOR

THRU: D. Tondi, Section Leader, Plant Systems Branch, DOR RB

FROM: R. Scholl, Plant Systems Branch, DOR

SUBJECT: TRIP REPORT OF VISIT TO DAVIS-BESSE UNIT 1 ON OCTOBER 18 AND 19, 1979

The enclosed trip report is forwarded for your information.

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# TRIP REPORT OF VISIT BY DANIEL GARNER AND RAYMOND F. SCHOLL, JR. DAVIS-BESSE UNIT 1 ON OCTOBER 18 AND 19, 1979

## INTRODUCTION

As a result of the confusion surrounding the reactor trip and station blackout of Davis Besse Unit 1 on October 15, 1979, the authors were dispatched on the site on October 18, 1979, to assist in improving communications between Headquarters, Region III personnel on site and Toledo Edison Company (TECO).

## DISCUSSION

Thursday, October 18, 1979, was devoted to traveling from Washington, D.C. to the site in order to interview the Region III personnel. Friday, October 20, 1979, was spent interviewing TECO personnel and returning to Washington. The following are the salient points resulting from our interviews:

1. The basic sequence of events is presented in a draft document, "Unit Trip Report" which is provided as Enclosure 1. This document was prepared by members of the Davis-Besse 1 plant operating crew that were involved in the incident. Although it is a draft, may not be complete, and contains errors; it represents the best available information as of 2:00 PM on Friday, October 19, 1979. Identified errors are discussed below.

2. Three minutes before the event started, the process computer failed. This is one of several unrelated but almost concurrent failures that gave raise to the concern that some common mode failure mechanism had been encountered. The significance of this failure is that the exact sequence of events for the reactor trip is not available. However, the computer was repaired three minutes after trip and was available during the loss of offsite power.

   As best as can be determined, the following plant conditions existed just prior to SCRAM:

   a) the plant was operating under a limiting condition for operation of Technical Specification 3.1.3.3 because of the failure of an absolute rod position indicator;

   b) the high power scram setpoint was 69%;

c) the power level was 60% by heat balance and 64% by nuclear power range indication;

d) the plant was experiencing a low frequency power oscillation which has a peak value of 1.5% of power at this time in core life and occurs between 55 and 65% of power. (This oscillation starts at 35% of power and subsides above 85% of power.) This is not a new phenomena and the Region III inspectors stated that it is common in B&W plants;

e) all switch yard breakers and disconnects were closed and the primary windings of both startup transformers were energized. (The disconnect switches are motor operated. powered from Class IE safety busses and controlled from the control room.) This required alignment is specified in Technical Specification 3.8.1.1; and

f) a capacitor in the interface between the Integrated Control System (ICS) and the Turbine Electro-Hydraulic Control System (EHCS) failed (short circuited).

3. The short circuited capacitor bypassed a control relay contact pair and started to increase the turbine generator load limit. The increased steam demand reduced steamline pressure and resulted in an ICS response to withdraw the control rods to recover pressure. Reactor power level increased and the reactor scrammed on high flux.

4. At this point in the interview, Region III personnel stated that they had a concern with Technical Specification 3.1.3.3.b because it was not clear if, upon declaring a second position indicator inoperable, the licensee had to be out of Mode 2 before the end of 24 hours of if orderly shutdown should be started after 24 hours.

A second problem is that it is not clear when an absolute position indicator is inoperable. The issue here is that a noisy indicator may still be capable of indicating the proper position although the noise is indictive of incipient failure.

Noise was the cause of declaring the position indicator inoperable in this case. TECO has already obtained replacements for the affected cable and connectors from the vessel head. This cable was obtained from Florida Power and has a higher temperature rating. The use of this cable has cured a similar problem for Florida Power.

Finally, it was pointed out that similar capacitor failures have previously occurred. However, in previous events, the 50 psi error limit was reached and the ICS and EHCS automatically transferred to manual before the high scram point was reached. An inspection of the EHCS indicated that a wiring error in the EHCS caused transient voltage on the order of 300 volts. Accordingly, a capacitor with a 1000 volt dielectric rating was used as a replacement and the wiring error corrected.

It was also suggested that the Region III inspectors check contacts in Class IE systems to be sure that arc suppression systems are either not present or are clearly shown on plant drawings. The Inspection and Enforcement personnel agreed.

5. Following the reactor trip, the main turbine tripped and the main generator output breakers opened as designed. Because the unit electrical hotel loads have been on startup transformer 1 since late 1978, there was no loss of electrical power at this time.

6. Some 23 minutes after SCRAM the control room operator, in accordance with operating procedures, opened the generator disconnect and attempted to close the generator output breakers. A muffler on one phase of main generator output breaker 34560 blew out and short circuited the "J" bus. This resulted in a loss of electrical power to the emergency busses.

   A similar muffler failed on Thursday, October 18, while a breaker was being opened so that the muffler could be modified by installation of reinforcement straps to reduce the likelihood of future failures. This modification has been recommended by General Electric. Consequently, damaged mufflers are being replaced with an improved model. Region III stated that they will prepare a circular on these mufflers because they have failed several times. (The authors have samples of the internal mesh that were brought back from the Thursday event.)

7. When the station blacked out, both diesel generators started and one successfully picked up all of its loads. The second generator picked up most of its loads automatically. However, Service Water Pump 3 (that had been swung to bus D1 to replace Service Water Pump 2 which was out of service for maintenance) and component Cooling Water Pump 2 had to be manually started. This failure was traced to a faulty weld in a crank rod that mechanically connects the main contacts to the auxiliary contacts in Breaker AD101. As a result the sequencer for these two loads did not start.

There are approximately 28 of this type of breaker in the plant. All will be inspected before the plant is restarted. As of Friday morning, 24 breakers had been inspected and no similar failures were found. (The failure was caused by the fact that one of two fillet welds on a connecting arm was missing.)

8. After the necessary electrical loads were verified to be operating, the operator attempted to parallel the diesels with the secondary of station start-up transformer 02. However, this action was not immediately successful because of an improperly set synchronizing switch (operator error) and failures in the two breakers on the secondary of SST 02 (HX02A and HX02B).

   The cause of the failure of HX02A had not been determined by Friday because it was being used to power the plant while HX02B was under inspection.

   It is believed that HX02A failed for the same reason as HX02B. The specific cause of the failure of HX02B to close on the first try was that the limit switch that detects charging of the trip spring was not actuated. Tapping the mechanism permitted HX02B to close. Prying on a similar mechanism permitted HX02A to close. Westinghouse personnel were onsite to work on these breakers. Six breakers of this type were tested to assure operability to allow the plant to meet Technical Specification requirements. All other similar breakers in the plant will be inspected on a schedule to be issued by TECO. TECO is considering increasing the normal surveillance frequency of these breakers in addition to any Westinghouse recommendations that will result from the Westinghouse work.

   It should be noted that there was no automatic transfer of loads from SST01 to SST02 because of the design that actually only provides a transfer on transformer differential trips. This situation is contradictory to the design presented in previous submittals such as:

   a) the degraded grid report page 8 (TECO letter serial 543 dated October 9, 1979), (Enclosure 2),

   b) FSAR Appendix 3D page 3D-15, last paragraph, and

   c) FSAR Section 8.3.1.1 page 8-6 second paragraph (Enclosure 3).

TECO agreed to submit a letter which clearly identified:

a) the bus transfers that are available now,

b) the bus transfers that will be available after the next refueling outage this spring, and

c) the bus transfers that will be available after a safety grade anticipatory reactor trip system is installed.

9. After offsite power was restored via SST02 it was decided to restart the reactor coolant pumps. One pump started, but the other three were discovered to have blown fuses in the loss of pump cooling interlock circuitry. The fuses were replaced and two additional pumps were started. The last pump blew the new fuses. Further investigation revealed some welded relay contacts in the interlock circuitry. The relay was replaced, new fuses installed and the pump started. TECO has reviewed the fuse sizing because the event indicated that the fuses may be too small (and therefore blew as a result of currents induced by the electrical transient) and too large (therefore resulted in relay contact damage). The review determined that the fuses and relays were all sized correctly. Further inspection of the Component Cooling Water interlock cabinet in the Auxiliary Building revealed corrosion of many of the pins on the backs of the relays. The corrosion allowed a shunt path to ground and this is the most likely cause of the overcurrent that blew the fuses. The relay associated with the RCP that encountered no problem in started showed no corrosion. On overall inspection of the cabinet, it appears that it had been sprayed by water (presumably during construction). Further investigation will be pursued to determine why the failure did not occur until this event.

   The fact that SST01 was not in service complicated the start of these pumps because of voltage drop problems. In order to start the reactor coolant pumps, it was necessary to remove the under voltage bus protection relays. (Normally one transformer is used to start these pumps while the rest of the hotel loads are on the other transformer).

   The seismic qualifications of such plug-in relays were discussed. The Region III and TECO personnel were sure that letters of certification of seismic qualification were available on site for the switchgear.

At this point, a draft I&E Bulletin on plug in relays was discussed. TECO stated that they would object strongly to a request for failure data on relays that were not used in safety systems.

Finally, TECO reported that the revised automatic transfer scheme will provide push buttons to bypass the undervoltage relays, and that a Technical Specification change to allow the use of the bypass had been submitted to the NRC for approval.

10. The next failure to be reported was the failure of the base plate for a main steamline support in the turbine building approximately halfway between the turbine centerline and a moisture separator/reheater. This was being repaired while the authors were on site. The plant trip had resulted in the shearing of base plate bolts on the support. The corresponding support on the other main steamline was inspected and base plate bolts were found loose. Both supports were upgraded by adding a third support member, by increasing the size of the base plate, and by increasing the size and number of base plate bolts.

11. The final equipment failure was reported by the local telephone company. It seems that the "red 'phone" showed up on the trouble board during the event but, by the time the telephone company checked out the lines, they could not find any problem. TECO investigated the loss of the telephone and determined that the 'phone requires 110 VAC power in order to function. The loss of all offsite power will render the 'phone inoperable. At the present time, the indication is that this problem may not be peculiar to the Davis-Besse Plant. I&E is investigating the situation.

CONCLUSION

1. Enclosure 1 is the best available statement of the sequence of events.

2. The numerous failures that occurred are not the result of a common cause but several were triggered by the stresses associated with the loss of offsite power (except for the loss of the red 'phone which was directly caused by the loss of offsite power).

3. The program that has been agreed to between Region III and TECO appears to be both reasonable and prudent.

4. Electrical transients were initially responsible for the blown fuses in the reactor coolant pump interlocks but the low voltage associated with the heavy loading of SST02 may have caused the failure of the relay contacts in the four pumps.

5. The present design satisfies GDC 17.

## RECOMMENDATIONS

1. The low frequency power oscillations in B&W plants should be investigated further.

2. The Technical Specifications should be modified to clarify:

   a) the definition of operable; and

   b) the action statement of 3.1.3.3.b.

3. The degraded grid study evaluation should be delayed until TECO clarifies the design of the automatic bus transfers.

4. Region III should follow the resolution of the concerns listed below and advise DSS and DOR of the results of their investigations:

   a) pump interlock fuses;

   b) Westinghouse "mechanical relay" limit switches; and

   c) General Electric muffler problems.

5. The Executive Director should be advised of the failure of the red telephone and advised of the final resolution. He should also be requested to consider if a set of standards on emergency telecommunications needs to be developed.

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# UNIT TRIP REPORT

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DATE OF TRIP: October 15, 1979

FACILITY: Davis-Besse Unit 1

IDENTIFICATION OF OCCURRENCE: Reactor Trip and Station Blackout

INITIAL CONDITIONS: The unit was in Mode 1, with Power (MWT) = 1665, and Load (Gross MWE) = 530.

DESCRIPTION OF OCCURRENCE: At approximately 1227 hours on October 15, 1979, a capacitor failed in the Integrated Control System (ICS) pulser circuit to the turbine electro-hydraulic control system. This capacitor failure caused the turbine control valves to open which lowered the main steam line header pressure. The ICS responded to the low header pressure by increasing both reactor power and feedwater which resulted in a reactor protection system reactor trip at the reduced high flux setpoint of approximately 68.8 percent of full power.

Main steam safeties 1, 2, and 4 on number one main steam line and main steam safeties 1 and 2 on the number two main steam line lifted to relieve pressure. The lowest safety valve reset pressure recorded was 970 psig on Main Steam Line 1-1 and 963 psig on Main Steam Line 1-2. Pressurizer level dropped to a low of 42 inches and Reactor Coolant System (RCS) average temperature dropped to 553°F. Feedwater flow reduced to the minimum flow within one minute of the trip. RCS pressure recovered to its normal value within five minutes and the plant responded normally to the transient.

While reclosing the generator output breaker 34560 at approximately 1250 hours, "J" bus tripped which resulted in a de-energization of the startup transformer 01 and a station blackout. Both emergency diesel generators automatically started. The Steam and Feedwater Rupture Control System (SFRCS) actuated from the loss of all four reactor coolant pumps, and natural circulation was established in the RCS. The loss of the reactor coolant pumps placed the unit in violation of Technical Specification 3.4.1 and the loss of "J" bus placed the unit in the Action Statement of Technical Specification 3.8.1.1.

The Component Cooling Water (CCW) Pump 2 and Service Water (SW) Pump ~~2~~ 3 failed to automatically start when the diesels were started. The operators manually started both pumps to provide cooling to the Diesel Generator 2.

Manual control of the auxiliary feedpumps was utilized to increase the steam generator levels and reduce RCS temperature and therefore pressure since the turbine bypass valves and the pressurizer spray were not available. When manual control of the atmospheric vents was available, the setpoint of the atmospheric vents was lowered to control the increasing RCS pressure. The highest RCS pressure recorded was 2232 psig. Difficulty was experienced in re-energizing "A" and "B" bus from Startup Transformer 02. This was caused by sticking relays which required several attempts at closure for bus "A" and a slight tap for bus "B". Therefore, it was not until 1316 hours that bus "A" was re-energized and at 1333 hours bus "B" was re-energized from Startup Transformer 02. The diesel generators were shutdown and restoration of the non-essentially powered systems began.

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Reactor Coolant Pump 1-2 was restarted at 1415 hours. Due to difficulties with blown fuses in the CCW interlock, the remaining reactor coolant pumps could not be restarted until 1915 hours (Pump 2-2), 2000 hours (Pump 1-1), and 0135 hours on the next day (Pump 2-1).

ANALYSIS OF OCCURRENCE: The cause of the trip was the failure of the capacitor in the ICS pulser circuit at the reduced Reactor Protection System trip setpoint (the plant trip setpoint was limited to less than 70% of full power by Technical Specification 3.1.3.3 since an absolute position indicator was inoperable.)

The cause of the station blackout was a blowing out of the internals of the muffler on generator output breaker 34560 which caused a fault to ground when the breaker was reclosed.

The cause of the failure of the CCW and SW Pump 2 to automatically start was due to a failure of the linkage rod assembly in the Diesel Generator 2 outlet breaker AD101.

The cause of the blown fuses in the CCW interlock to the reactor coolant pump start circuit is still under investigation.

Adequate core cooling existed throughout the occurrence and at no time did RCS conditions approach the saturation point.

CORRECTIVE ACTION: The failed pulser circuit was repaired and proper operation of the ICS was verified. Since this was the third occurrence of problems with the capacitors, B&W is investigating the cause of the failures. No previous failures resulted in unit trips.

The mufflers on both generator output breakers will be replaced if damaged and a reinforcing band installed to strengthen the mufflers.

The linkage rod in the Diesel Generator 2 will be replaced. The linkage rod on Diesel Generator 1 as well as several other breaker linkage rods will be inspected.

The sticking "A" and "B" bus relays were cleaned and adjusted.

All blown fuses were replaced in the CCW interlock circuit.

TRANSIENT CLASSIFICATION: This transient was classified as an 8B transient by station personnel.

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DATA PACKAGE:

1. Alarm printout (note: computer was inoperable for several minutes before and after the trip)
2. Post trip review and sequence of events
3. Reactimeter printout and graphs
4. Control Room charts (later - in master file only)
5. ICS response strip charts (later - in master file only)

select an alignment of either startup transformer 01 or 02 to bus A and likewise for bus B. The reserve source selector switches can be set so that only one startup transformer is aligned to both 13.8 kV buses A and B. When power is being supplied to a 13.8 kV bus by a startup tranformer, the reserve source selector switch for that bus can preselect the alternate startup transformer source. This permits a fast bus transfer to the alternate startup transformer source should the original source fail.

Only true for Xfmr Fault

The fast bus transfer scheme from the unit auxiliary transformer 11 to the startup transformers 01 and/or 02 is further enhanced by fast acting synchrocheck relays. Opening of the 345 kV breakers 34560 and 34561 during normal power operation with the electrical auxiliary systems being supplied power from the unit auxiliary transformer X11 will result in these relays monitoring the phase angle difference between the secondary voltage of the unit auxiliary transformer 11 and the startup transformer(s) secondary voltage during the 6 cycle bus transfer. Should the angle exceed 35 degrees the transfer will be blocked to prevent out of phase reenergization and the associated overvoltage stresses on the plant's electrical auxiliary system. These fast acting synchrocheck relays are also functional during the 30 second delayed transfer scheme described in Section II.E.1.

3. 4.16 kV System

During normal operation and accident conditions without a loss of offsite power, the safety related 4.16 kV buses C1 and D1 are supplied power from the bus tie transformers AC and BD (Ref. Figure No. 3). Each safety related 4.16 kV bus is provided with a fast transfer (6 cycles) scheme which will transfer the bus from its normal source to an alternate source of power. As an example, the normal supply of power to the 4.16 kV

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# 8.3 ONSITE POWER SYSTEMS

## 8.3.1 AC POWER SYSTEM

### 8.3.1.1 Description

The station distribution system consists of various auxiliary electrical systems designed to provide reliable electrical power during all modes of station operation and shutdown conditions (See Figures 8-4a and 8-4b). The systems are designed with sufficient power sources, redundant buses and required switching, to ensure reliability. Engineered safety feature circuits are arranged so that a loss of a single bus section, for any reason, results in only single losses of auxiliaries leaving redundant auxiliaries to perform the same function.

The station distribution system is capable of starting and accelerating the largest required drive with the remainder of the connected motor loads in service. The system will have a fast transfer to the reserve power source following a turbine generator or reactor trip, without the loss of auxiliary load.

Protective relaying is arranged for selective tripping of circuit breakers, thus limiting the loss of power to the affected area.

#### 8.3.1.1.1 Unit Auxiliary and Startup Transformers

During normal operation of the station, the 52/69 MVA unit auxiliary power transformer, connected to the generator isolated phase bus, provides the normal source of electrical power for station auxiliaries.

Two startup transformers, each 39/52/65 MVA, are supplied from different 345 kV switchyard bus sections. Each startup transformer provides power for startup, shutdown, and post shutdown requirements. The two transformers will also serve as a complete reserve power source for the station auxiliaries in the event of failure of the unit auxiliary tranformer supply.

Normally each startup transformer is the reserve power source of only one 13.8 kV bus. However, if either transformer is out of service, the remaining startup transformer is available (by manual preselection) to automatically supply both 13.8 kV buses should the normal source (auxiliary transformer) fail.

The secondaries of all three transformers are of low-resistance grounded, wye connected construction.

#### 8.3.1.1.2 13800 Volt Auxiliary System

During normal operation each 13.8 kV bus is fed from one of the 13.8 kV secondary windings of the unit auxiliary transformer. During startup and shutdown, each bus is fed from the 13.8 kV secondary winding of either startup transformer No. 01 or No. 02.

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