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PDR 6/18

TITLE: ACTION PLAN FOR MAINFEED PUMP CONTROL SYSTEM

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Plan No. 8

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Date Prepared: June 18, 1985

This report has been prepared in accordance with the "Guidelines to Follow When Troubleshooting or Performing Investigative Actions into the Root Causes Surrounding the June 9, 1985 Reactor Trip", Rev. 2.

INTRODUCTORY STATEMENT

This action plan is the first step in addressing Confirmatory Action Letter Item 4a, establishing the cause of main feed pump turbine (MFPT) 1-1 trip. Item 4b will be addressed at a later date.

SUMMARY OF DATA:

The following is a discussion of the events which took place prior to and shortly after the No. 1 MFPT trip on June 9, 1985.

On June 9, 1985 at approximately 1:22:49 computer alarm Q 626 indicated "MFPT 1 Main Oil Pump 1 ON". This indicates the standby main oil pump started approximately 12 minutes before No. 1 MFPT tripped. The Data Trend Table for No.1 MFPT speed indicates that turbine speed increased 29 RPM and then decreased 23 RPM at approximately the same time the standby main oil pump started. This indicates that control valve movement dropped the hydraulic header pressure to <170 psig, therefore starting the standby main oil pump.

Since the MDT 20 control system was installed, valve movement, as described above, has started the standby main oil pump due to the quick response of the unit. Another indication that the control valves moved is the feedwater flow recorders. Approximately 12 minutes before MFPT 1-1 tripped, the charts indicate a change in feedwater flow to both Steam Generators.

The data available concerning No. 1 MFPT trip indicates that the trip was caused by an actual overspeed condition. Recording charts, hooked up after the June 2 problems, show that Limit Switch LS16 was the first indication of a trip. LS16 provides tripped indication of the trip dump valve. Under normal conditions the trip dump valve will trip due to solenoid valve SV-12 energizing, the manual trip lever being actuated, or by the emergency governor plunger due to an overspeed condition. The chart recorders indicate that the hydraulic trip solenoid valve SV-12 did not energize when MFPT 1-1 tripped. Therefore, the trip protection devices associated with SV-12 have been eliminated as possible causes of the turbine trip.

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Using the computer readout of turbine speed as an indication for speed change with respect to time, it can be seen that MFPT 1-1 increased speed by approximately 1591 RPM between 1:34:24 and 1:34:53. This change in speed would be more than sufficient to reach the setpoint for the emergency overspeed plunger to actuate therefore causing the trip dump valve to trip.

The emergency overspeed trip device should actuate between 5866 RPM and 5984 RPM (reference: MFPT Manual GEK 83602). Testing performed after the MDT 20 was installed during the 1984 refueling outage shows that MFPT 1-1 tripped on overspeed at 5920 RPM, 5888 RPM, and 5892 RPM. This testing was performed per PT5136.03, MFPT Overspeed Periodic Test, which requires three consecutive acceptable overspeed trips.

Another indication that MFPT 1-1 speed increased is the feedwater flow charts. At approximately 0135 on June 9, a step increase of approximately 2.5 mpph feedwater flow occurred for total feedwater flow to Steam Generator 1-1 and 1-2. At this time, MFPT 1-1 was in "AUTO" and MFPT 1-2 was in "HAND". This rapid change in feedwater flow indicates that MFPT 1-1 increased speed, therefore increasing total feedwater flow to the Steam Generators. The turbine speed increased until MFPT 1-1 tripped due to an overspeed condition which initiated a plant runback due to a loss of MFPT 1-1 above 55% power.

Following the trip MWO 1-85-1935-00 was initiated on June 9th to attempt to troubleshoot the cause of the MFPT trip. Under this work order voltage readings were taken on MFPT 1-1 and compared to readings taken on MFPT 1-2. No significant differences were noted. All work on this MWO was halted on June 9th.

Maintenance And Test History

The MDT 20 control system for the MFPTs was installed during the 1984 refueling outage. After installation of the MDT 20 control system, Test Procedure TP520.83, Main Feedwater Pump Turbine and Auxiliary Support Systems, was performed to test the equipment.

Testing requested by MPR Associates, Inc. was performed by TED personnel on installed equipment in November and December of 1984 which included:

A) A test to establish the dynamic input/output characteristics of the MDT 20.

B) A test to establish the steady state input/output characteristics of the MDT 20 valve positioner.

C) A dynamic response test of the MDT 20 valve positioner.

D) A dynamic response test of the MDT 20 governor during feedwater flush.

Analysis of these tests by MPR concluded that the MDT-20 governor will provide satisfactory feed pump differential control with internal settings as recommended by GE and the Integrated Control System (ICS) settings established prior to the outage with the MHC governor.

Discussion of events concerning April 24th trip:

During operation at 98% full power a flux/delta flux/flow RPS trip occurred. Approximately eight seconds after the Reactor trip, MFPT 1-1 tripped. The cause of the MFPT trip was never positively identified.

Testing was performed to determine if the thrust bearing wear detector trip circuitry could pick up if the standby oil pump is started. Test gauges were installed per MWO 1-85-1442-00 in place of the pressure switches and the standby oil pump was cycled to see if pressure would increase to the trip setpoint. During this testing, pressure did not increase to the trip setpoint. The turbine was also ran through different speed changes to determine if oil pressure could have dropped to trip the turbine. The turbine speed was increased at three different initial speed settings consisting of the following:

1) 3700 RPM to 3900 RPM
2) 3500 RPM to 3900 RPM
3) 3300 RPM to 3900 RPM

This testing indicated that the oil pressure did not decay to the trip setpoints.

Periodic test PT 5136.06, MFPT Emergency Overspeed Governor Tests, was performed to test the overspeed governor. This test was completed successfully.

In addition to the testing which was performed the following instruments were recalibrated:

1) The active and inactivate thrust bearing wear detector pressure switches.
2) The turbine bearing low oil pressure trip switches.
3) The feedpump bearing low oil pressure switches.
4) The main feed pump high discharge pressure trip switches.
5) The MFPT vacuum trip switches.
6) The RFR target speed voltage was adjusted from 4.0090 VDC to 3.6045 VDC.

Discussion of events from June 2nd trip:

During main turbine control valve testing, a high turbine vibration signal tripped the main turbine. The ARTS tripped the reactor. Within four seconds after the turbine/reactor trip, both main feed pump turbines tripped.

Pri. Theory — The theory behind both the MFPT's tripping concerns the following four parameters:

1. Rapid Feedwater Reduction (RFR) target speed being set too high due to not adding in a bias to the RFR setpoint.

   From January, 1985 until April 24, 1985, the RFR target speed was thought to be set at 4800 RPM, when in fact it was actually 5150 RPM.

   Following the April 24 trip, the RFR target speed was thought to be reset to 4600 RPM, when in fact it was actually 5000 RPM. Reference MWO 1-85-1489-00.

   Following the June 2nd trip, it was found that a voltage bias needed to be added to the RFR setpoint. RFR target speed was reset to 4600 RPM. Reference MWO 1-85-1908-00

2. Main steam header pressure increasing to approximately 1070 psig after the reactor tripped causing the MFPT speed to increase.

3. Booster feed pump suction pressure increasing due to increasing deareator level plus deareator pressure. This would cause main feed pump discharge pressure to increase.

4. Feedwater valves partially closing down causing MFP discharge pressure to increase.

   Based on the above four parameters, there is a possibility that the MFPT's tripped on high discharge pressure of 1500 psig, which is one of the trips that could have tripped both pumps almost simultaneously.

Alt. Theory

Quick response time associated with the MDT 20 hydraulic control system could cause hydraulic oil pressure swings which could have activated trip circuitry. This theory is not conclusive based on the following:

Testing indicated that the MFPT's would not trip after the hydraulic control system was subjected to rapid swings by cycling the control valves.

Based on the above theory, the MFPT 1-1 control valves were cycled repeatedly through full stroke cycles as fast as possible with the GE representative. This was performed to try to decrease the oil pressure to activate trip circuitry associated with the hydraulics. No MFPT 1-1 trips were activated. The testing indicates that the MDT 20 hydraulic control system responds from the valves

crack point to full open in approximately 0.6 seconds.

Continued testing by GE identified that the #1 MFPT could be tripped when stopping the #2 Main Oil Pump (MOP). If the #2 MOP was left in-service for a period of time and then turned off, the #1 MFPT would not trip. It was recommended by GE not to turn off the #2 MOP on #1 MFPT until after it had run for awhile. This was only a short term solution to the problem. Long term solution will be to inspect both MOP discharge check valves along with PRV3 during a major outage.

While increasing power and performing PT5136.01, MFPT Stop Valve Periodic Test, on #1 MFPT, #2 MOP came on during stroke valve testing. The operators left #2 MOP on for approximately 20 minutes as instructed and then shut-down the #2 MOP after which the #1 MFPT tripped. At 0155 the plant was at approximately 56% power and experienced a runback to 55% power.

Repeated testing after the 6-5-85 0155 MFPT 1-1 trip:

0630 After stopping the #2 MOP MFPT1-1 would trip.

0800 After stopping #2 MOP the MFPT tripped two out of six times.

1400 After stopping #2 MOP the MFPT would not trip. This was performed numerous times with the MFPT on turning gear and at speeds of approximately 4000 RPM's.

1900 Broke vacuum to install additional instrumentation to monitor the active thrust bearing pressure switches.

6-6-85 Additional testing was performed and the MFPT would not trip when either #1 or #2 MOP was stopped.

GE Factory Personnel and Representative felt that the #2 MOP discharge check valve was sticking open and remained open momentarily after stopping #2 MOP. Under this condition, #1 MOP would pump oil back into the #2 MOP impeller and the 55 psig header pressure would decrease. It is possible that the check valve remained open long enough to have the pressure control valve that reduces pressure from 250 to 55 psig (PRV3) to open to maintain header pressure at 55 psig. After the #2 MOP discharge check valve seated, preventing back flow, with PRV3 open the 55 psig header could experience a pressure surge picking up the thrust bearing wear detector trip circuitry. Based on repeated testing, the cause for the check valve to remain open evidently cleared itself.

Strip chart recorders were connected to monitor particular electrical signals and oil system pressures after the June 2 trip to determine the

cause of MFPT 1-1 trip which initiated the reactor trip. The recorders were hooked up to monitor the following information for MFPT 1-1.

CTRM Cabinet Room:

1. Lube Oil Pressure to feed pumps (PS25)
2. Bearing Header Pressure (PS19)
3. Thrust Bearing Wear (PS 2 & 12)
4. Main Feed Pump Discharge pressure (Q628)
5. Speed Reference Signal (TP111)

Locally at MFPT 1-1:

1. Limit switch LS16
2. Solenoid valve SV12
3. Hydraulic header pressure
4. Control oil pressure
5. Thrust bearing wear detective (Active)

FAILURE HYPOTHESES SUMMARY

On the April 24th and June 2nd trips, the reactor tripped and the MFPT(s) tripped shortly afterwards. On the June 9th trip, the MFPT initiated the transient which caused the reactor trip. On the April 24th and the June 2nd trips there was no apparent MFPT overspeed condition. On the June 9th trip we very clearly saw an indication of a MFPT overspeed condition. As a result, we feel that the June 9th trip is unrelated to the previous trips. We will continue to monitor electrical and oil pressure signals.

On June 9, the chart recorder monitoring the speed reference signal shows that demanded speed for MFPT 1-1 was steady until actual turbine speed increased and the main feedwater control valves began to close due to the increased feedwater flow. The ICS speed control for the MFPTs is derived from the pressure drop across the feedwater control valves and from the feedwater demand signal. Due to a developed feedwater flow error signal, the main feedwater control valves closed down and the pressure drop across the valves increased. The ICS turbine speed control circuitry responded properly by reducing the speed reference signal (demanded turbine speed). This indicates the ICS input signal and the MDT 20 electronic circuitry which produces the speed reference signal did not cause the overspeed condition. This also rules out an inadvertent RFR initiation.

An electrical connection problem/malfunction may have developed in the MDT 20 circuitry (excluding the circuitry producing the speed reference signal).

Another possible explanation for the overspeed trip is a hydraulic/mechanical control system malfunction which drove the steam control valves open therefore causing an overspeed condition.

Another possible cause for the overspeed condition could have been a mechanical coupling failure betwen the pump and turbine. Since feedwater flow increased as turbine speed increased, this possibility was ruled out.

An industry poll by MPR revealed that an overspeed failure occurred in an Indiana power station due to a faulty MDT-20 speed circuit. A former G.E. Service Representative was contacted, and he recalled troubleshooting a high speed failure due to a faulty frequency to voltage integrated circuit.

There is indication from the feedwater flow recorders that the problem may be intermittent, which may make it extremely difficult to locate the problem. This fact is also recognized by G.E.

CHANGE ANALYSIS

1. Until the 1984 refueling outage, the MFPT's were equipped with mechanical/hydraulic speed governors (General Electric Model MHC). These MFPT's were replaced with more modern electrical/hydraulic speed governors (General Electric Model MDT-20) installed per FCR 81-075.

   After the April 24, 1985 trip, the following work (Items 2 through 9) were performed:

2. Installed Test gauges on 4-24-85 in place of the active and inactive thrust bearing wear trip pressure switches PS 2715 and PS 2717. Disconnected the test gauges and reconnected PS 2715 and PS 2717 on 4-25-85 per MWO 1-85-1442-00.

3. Recalibrated PS 2715, Active thrust bearing wear trip pressure switch, per MWO 1-85-1451-00.

4. Recalibrated PS 2717, Inactive thrust bearing wear trip pressure switch, per MWO 1-85-1451-01.

5. Recalibrated PSL 1161, MFPT 1-1 turbine bearing low oil pressure trip switch, per MWO 1-85-1451-02.

6. Recalibrated PSL 1192, BFP 1-1 bearing low oil pressure trip switch, per MWO 1-85-1451-03.

7. Recalibrated PSH 506, MFPT 1-1 discharge high pressure trip switch, per MWO 1-85-1451-04.

8. Recalibrated PS 2535A and PS 2535B, MFPT 1-1 low vacuum pressure trip switches, per MWO 1-85-1451-05.

9. Recalibrated the Rapid Feedwater Reduction (RFR) Target Speed Setpoint from 4.0090 VDC to 3.6045 VDC which was thought to correspond to 4600 RPM.

After the June 2, 1985 trip, the following work (Items 10, 11, 12 and 13) were performed:

10. Additional MFPT System test points were monitored and recorded by field mounted strip chart recorders installed per MWO 1-85-1887-00 and 01.

11. Again recalibrated the RFR Target Speed Setpoint from 3.6045 VDC to -2.000 VDC which corresponds to 4600 RPM per MWO 1-85-1908-00.

12. Operational change: #1 Main Oil Pump was changed from primary to backup service and #2 Main Oil Pump was changed from backup to primary service.

13. Operational change: #2 MFPT was placed in ICS manual operation from automatic operation. #1 MFPT was left in automatic operation.

HYPOTHESES INVESTIGATION

Based on the information gathered, it appears that several conditions could have caused MFPT 1-1 to overspeed:

1. Loose connections associated with the electrical circuitry for the MDT 20 system.

2. A circuit board component malfunction.

3. Hydraulic/Mechanical control problem.

ACTION PLAN

TITLE: MFPT 1-1 Control System Problem

Rev. 0

ACTION PLAN NUMBER: 8 | DATE PREPARED: 6-18-85 | PAGE 1 of 4

PREPARED BY: J. E. Blay, D. E. Missig, A. S. Topor, T. R. Isley

SPECIFIC OBJECTIVE:

To determine the root cause of MFPT 1-1 overspeed trip on 6-9-85

STEP NUMBER	ACTION STEPS	PRIME RESPONSIBILITY	ASSIGNED TO	START DATE	TARGET DATE	DATE COMPLETED
	All steps of this Action Plan are to be performed in accordance with the latest revision of "Guidelines to Follow When Troubleshooting or Performing Investigative Actions Into the Root Causes Surrounding the June 9, 1985, Reactor Trip". Action plan steps will be performed in the sequence listed.					
1	Loose connections: Visual inspections and troubleshooting will be performed locally at the pump and at the control cabinet. A log will be maintained to document the troubleshooting performed and the findings. A DVOM or an oscilloscope will be used to monitor connections while performing these checks.	J. Blay				

ACTION PLAN

ED 6408

TITLE

MFPT 1-1 Control System Problems

Rev. 0

PLAN NUMBER	PAGE
8	2 of 4
DATE PREPARED	PREPARED BY
6-18-85	J. E. Blay D. E. Missig ~~A. S. Topor~~ T. R. Isley

SPECIFIC OBJECTIVE

To determine the root cause of the MFPT 1-1 overspeed trip on 6-9-85

STEP NUMBER	ACTION STEPS	PRIME RESPONSIBILITY	ASSIGNED TO	START DATE	TARGET DATE	DATE COMPLETED
2	Circuit board component malfunction:	J. Blay				
	Under the direction of a GE representative, using a check-list per the MWO, an electrical check of the circuits will be performed and no adjustments will be made. A log will be maintained to document the tests performed and the findings.					
	Particular boards of interest are:					
	i) Redundant Speed Pickup Circuitry					
	ii) Speed Summation & Valve Lift Reference Circuitry					
	iii) Operator & Pilot Valve Position Feedback Circuitry					
	iv) Servo Amplifier Circuitry					
	Function signal generators may be used for input signals					

ACTION PLAN

TD 040B

TITLE

MFPT 1-1 Control System Problem

Rev. 0

PLAN NUMBER	PAGE
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DATE PREPARED	PREPARED BY
6-18-85	J. E. Blay D. E. Missig ~~A. S. Topor~~ T. R. Isley

SPECIFIC OBJECTIVE

To determine the root cause of MFPT 1-1 overspeed trip on 6-9-85

STEP NUMBER	ACTION STEPS	PRIME RESPONSIBILITY	ASSIGNED TO	START DATE	TARGET DATE	DATE COMPLETED
3	Hydraulic/Mechanical Control System:	J. Blay				
	a) Testing of the hydraulic and mechanical control system will be performed per GE recommendations. Tests such as cycling the valves through full stroke may be performed along with other GE recommended tests. While moving the valves, testing of appropriate electrical signals may also be performed.					
	b) Sample oil and inspect filters for contamination.	J. Blay				
4	If the root cause is not determined from steps 1,2, or 3, then an Aux Steam/Main Steam run of MFPT 1-1 will be performed to obtain data to compare to previous information gathered earlier by MPR. GE may also perform additional checks.	J. Blay				

ACTION PLAN

ED 6408

TITLE

MFPT 1-1 Control System Problem

Rev. 0

PLAN NUMBER	PAGE	PREPARED BY
8	4 of 4	J. E. Blay D. E. Missig ~~A. S. Topor~~ T. R. Isley
DATE PREPARED 6-18-85		

SPECIFIC OBJECTIVE

To determine the root cause of MFPT 1-1 overspeed trip on 6-9-85

STEP NUMBER	ACTION STEPS	PRIME RESPONSIBILITY	ASSIGNED TO	START DATE	TARGET DATE	DATE COMPLETED
5	a) If the root cause is not determined from steps 1,2,3 or 4, then the circuit boards will be sent to GE at Fitchburg for stress tests in an attempt to locate a failure.	J. Blay				
	b) If the root cause is not determined from steps 1,2,3, or 4, then a field wiring check will be performed, such as a megger test.	J. Blay				