Babcock & Wilcox

Power Generation Group

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November 1, 1977

BWT-1589
File: T1.2/12B

28B

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Mr. C. R. Domeck
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Toledo Edison Company
Power Engineering & Construction
300 Madison Avenue
Toledo, Ohio 43652

Subject: Toledo Edison Company
REPORT ON DEPRESSURIZATION EVENT
Davis-Besse Unit 1
B&W Reference NSS-14

Dear Mr. Domeck:

By telecon of October 10, you have requested B&W input for a report to NRC regarding the depressurization event of September 24. The NRC exit interview notes dated October 7 summarized the necessary content of the report. B&W is providing write-ups in the following areas in order to substantiate the conclusions of BWT-1578 and BWT-1579 dated October 5 and 7:

A. Description of the event

B. Evaluation of the reactor coolant components

C. Evaluation of RC pumps

D. Evaluation of the fuel

POOR ORIGINAL

In order to expedite submittal of your report, we are sending Sections A, C and D at this time, as agreed in our telecon of October 24. We expect to forward Section B by November 7, and we will try to improve on this date.

Section A describes the sequence of events as reconstructed from computer alarm print-out, reactimeter plots, and control room recorders (Attachment A.1). We have attached pertinent recorder charts of T_{ave}, RC pressure, pressurizer level (Attachments A2, A3 and A4) and reactimeter plots of RC inlet temperature, RCS flow in each loop, RC pressure, pressurizer level, and water level and outlet pressure of each steam generator (Attachments A5 through A13).

Section B will include evaluations of stresses in the pressure boundary, the depressurization transient, boiling the SG dry, jet impingement or the SG, and effect upon fatigue life.

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November 1, 1977
BWT-1589

Section C explains the evaluation which was performed to verify that there was no significant damage to RC pump bearings, seals, or impellers (attachment C1). The transient as it affected the pumps is summarized in Attachment C2. Attachment C3 defines the instrumentation and operational checks applied to the pumps. The results of the operational checks are tabulated in Attachment C4.

Section D evaluates the effect upon the core to determine (1) whether steam was produced in the core (2) the maximum internal fuel rod pressure, and (3) whether maximum lift force exceeded the limit (Attachment D.1). Reactimeter plots are attached for reference Attachments D.2 through D.6.

Very truly yours,

A. H. Lazar
Senior Project Manager

J. A. Lauer
Project Manager

JAL/hj

Attachments

POOR ORIGINAL

22 7 51

Sequence of Events

The event started at time 21:34:20 on September 24, 1977. The plant was in Mode 1 with Power (MWT) = 263. The turbine had been shutdown earlier in the evening to repair a leak in the main steam line at an instrument connection between the turbine stop valves and the high pressure turbine. At this time a half trip of the Steam and Feedwater Rupture Control System (SFRCS) was initiated by an unknown cause. This trip shut the startup feedwater valve to #2 steam generator and stopped all feedwater to this generator (because of the low power level the main feedwater block valve was already shut, isolating the main feedwater control valve). The low level alarm was reached in #2 steam generator at 21:34:44. Before the operator could identify and correct the problem, the low level in #2 steam generator produced a full trip of the SFRCS. This trip shut the main steam isolation valves and feedwater isolation valves in both steam generators (time 21:35:18). SFRCS also started both auxiliary feedwater pumps. The number one pump performed as intended, however, number two auxiliary feedwater pump only came up to 2600 RPM, insufficient to feed its steam generator (#2).

The loss of feedwater, first to one and then both steam generators, caused an increase in primary water temperature, which resulted in an increase in pressurizer level and thus reactor coolant system pressure. At 2255 PSIG the pressurizer electromatic relief valve received an open signal. During the next 40 seconds, it received nine different open and close signals. After one of those signals the valve stuck open. This provided a continuous 2½" vent path from the pressurizer to the quench tank. When pressurizer level got to 290", the operator manually tripped the reactor (time 21:36:07). Energy escaping from the electromatic relief valve and three main steam relief valves caused a rapid cooldown and depressurization of the reactor coolant system. Reactor coolant system pressure dropped to 1600 PSIG (time 21:37:17) initiating the Safety Features Actuation System (SFAS). This started high pressure injection and closed numerous containment isolation valves, including the quench tank cooling lines.

With the electromatic relief valve still open and cooling water isolated to the quench tank, the quench tank rupture disc ruptured (time 21:40) relieving water/steam to the containment building. This discharge damaged a nearby ventilation duct, was deflected off this duct and directed onto #2 steam generator. The steam tore off approximately a 10' high x 20' circumferential section of insulation from #2 steam generator. The paint from the then exposed area of the steam generator was blasted away. The steam in the containment also resulted in two fire alarms (one near RCP 2-2 and one near the pressurizer) and a single channel RPS trip on high reactor building pressure (4 PSIG).

When the main steam relief valves reseated the decrease in reactor coolant system temperature stopped and the high pressure injection pumps started to raise pressurizer level. At time 21:40:34 the operator stopped the high pressure injection pumps. (The operators had been heavily involved before this time in regaining seal injection flow to the reactor coolant pumps. This flow had been stopped by the SFAS actuation. By 21:39:40 the appropriate SFAS signals had been overriden and normal flows restored to the seals of the pumps). Reactor coolant system pressure continued to decrease until saturation pressure was reached and steam began to form in the RCS (approximate time 21:42). This caused an insurge of water into the pressurizer and pressurizer level went off scale high a 320 inches. During this level increase the operator, seeing average reactor coolant system temperature and pressurizer level increasing, stopped one reactor coolant pump in each loop (time 21:43:11).

Due to decreasing pressure in #2 steam generator, the SFRCS system gave a low pressure block permit signal at time 21:48:33. This alerted the opeator to the low level and feed condition of #2 steam generator. He blocked the low pressure trip (time 21:49:38), took manual control of the speed of #2 auxiliary feedwater pump and fed #2 generator (time 21:50). The operator saw the rapid addition of cold feedwater dropping the reactor coolant system temperature and stopped the feedwater addition to this generator.

At approximately 21:55 the operator shut the block valve for the electromatic relief valve on the pressurizer and stopped the venting of the reactor coolant system to the quench tank. At 22:05 pressurizer level came back on scale. At 22:15 the operator started a second makeup pump to try and stop the pressurizer level decrease. This additional cold water started the reactor coolant system on a slow decreasing temperature transient. At 22:17 pressurizer level reached the low level interlock and cut off the pressurizer heaters. At 22:23 the operator started a high pressure injection pump to try and stop the decreasing pressurizer level.

The level and pressure in #2 steam generator again decreased to the point where the SFRCS gave a low pressure block permit signal. The operator again blocked the trip and, through manual speed control of its auxiliary feedwater pump, restored level and pressure in #2 steam generator (time 22:25).

With pressurizer level well on its way to recovering,the operator stopped the high pressure injection pump (time 22:27:44). At time 22:31 he restored RC makeup flow to normal. This stopped the slow decreasing RC temperature transient started at time 22:15. All plant parameters were now fully under control and the plant was brought to a steady state condition and a normal plant cooldown started.

On 10/23/77, the SFRCS again tripped from a spurious signal. The Startup Feedwater Valve on steam generator No. 2 went closed. This ultimately resulted in a valid Steam Generator low level trip input to the SFRCS and the system functioned as intended.

This was the first spurious trip received since the chart recorders had been connected to the SFRCS. All information on the charts could be explained except for a problem on SFRCS logic Channel 4 computer alarm, P680. This particular channel on the recorder was intermittently failing, giving spurious trip indications. Of the 48 total chart recorder channels, this was the only one that had failed.

I&C Technicians "checked out" the bad recorder channel for operation. They found that the channel was sensitive to any mechanical vibration, it did respond to a given input, and that the pens were slightly misaligned. From all of the information gathered it was concluded that the indication on the bad recorder channel was an input from the SFRCS.

The logic point under question then was the computer point ("P680" Low Main Steam Pressure Trip). Examining other charts indicated no change in the input to SFRCS logic Channel 4. Thus it was concluded the problem was internal to the system. In examining the logic control diagram, it was determined 3 IC "chips", 2 input buffers and associated wiring could have caused the fault. I&C personnel replaced all of the above equipment, with the exception of the interconnecting wiring. The wiring and buffer connections were visually inspected, and no faults were observed. A functional logic test was performed and the system responded satisfactorily.

Power Engineering had contacted Consolidated Controls Corporation, the manufacturer, and their representative was on site the morning of 10/26/77. The manufacturer also recommended changing the same equipment that TECo I&C personnel had changed.

The manufacturer performed a response time check on both input buffers in question. The response time test showed no defects. TECo I&C personnel continued to monitor one of the two input buffers in a test set. Failure of one input buffer did occur on the test set, which indicates that this was the cause of the half trip.

The manufacturer's representative also took a look at the logic system with an oscilloscope. He was looking for any erratic, noisy points, but everything tested appeared to be trouble free. The two input buffers will remain with TECo for further test and evaluation, while the 3 IC chips were returned to the manufacturer for evaluation.

The manufacturer's representative on 10/27/77 compiled a list of additional points they want monitored. TECo I&C personnel are assisting to connect up the recorders.

After the 10/23/77 event, a study was also conducted to see if any single 120 VAC or 125 V DC fault induced voltage dip could have caused the one-half trip on both MSIV's and closed the SG-2 SU control valve. This study revealed that no single fault on these power supplies could have caused this problem.

The following changes have been made to the design of the SFRCS since the September 24, 1977 incident:

1. Annunciator windows have been added where computer alarms presently exist for:

    a. Steam Generator Level Half/Full Trip for both Channels 1 & 2

    b. Main Feedwater DP Half/Full Trip for both Channels 1 & 2

    c. Loss of 4 Reactor Coolant Pump Trip

2. A new annunciator and computer alarm has been added for a SFRCS Full Trip.

3. The resetting of all SFRCS related alarm will be delayed long enough to allow the computer to record the event.

These changes will be made as soon as possible.

B. Auxiliary Feedpump Turbine Governor

Before describing the modifications made to the auxiliary feedpump turbine (AFPT) governor, the governor action which resulted in the binding will be described. Figure 6-1 is a drawing of the Woodward Governor PG-PL speed setting mechanism, showing the governor in the bound up condition. The sequence of events creating this condition is as follows:

1. When the Bodine motor was at a minimum speed setting, the speed setting shaft nut was fully to the left. The link raised the collar, contacting the base speed setting nut, raising it and the "T"-bar to an idle condition. The pivot bearing would be contacting the floating lever.

2. Because the governor is not rotating, the speed setting servo remains in a fixed position at idle (as shown). It cannot move until oil pressure is available.

3. The thumbscrew is contacting the low speed stop pin.

4. As the Bodine speed setting motor is rotated toward high speed, the following events occur:

   4.1 The speed setting shaft nut moves towards the high speed stop pin.

   4.2 The link allows the collar to move downward.

   4.3 The collar moving downward, allows the base speed setting nut and "T"-bar assembly to move downward.

   4.4 The floating lever is fixed at the speed setting servo piston end.

   4.5 The low speed stop pin end of the link pushes down on the thumbscrew, which pushes down on the speed setting pilot valve until the dashpot land contacts the dashpot plug.

   4.6 Because the floating lever is now fixed on both ends it stops moving.

   4.7 The "T"-bar continues downward following the collar. The pivot bearing leaves the floating lever. The "T"-bar continues downward until the retainer screw contacts the floating lever.

   4.8 The collar separates from the base speed setting nut and continues downward until the stop pin in the speed shaft contacts the stop pin in the speed setting shaft nut.

4.9 Because the Bodine motor continues to rotate the manual speed setting knob, slipping the clutch, a torque is placed on the speed setting shaft nut, link and collar. This torque against the "T"-bar causes friction that locks the "T"-bar in place.

5. When the turbine is started, the speed setting servo piston moves downward with increasing oil flow, increasing the speed setting of the governor. When the floating level contacts the pivot bearing, the speed setting pilot valve begins to raise.

6. When the pilot valve control land covers the metering port, the speed setting servo piston stops moving.

7. Because the torque is still present on the speed setting shaft, the "T"-bar is bound up, and the governor is at 2200-2600 rpm.

8. When the Bodine speed setting motor is backed off from the stop, the "T"-bar falls down to its high speed stop, dropping the pivot bearing. The pilot valve moves downward, increasing oil flow to the speed setting servo until the high speed condition is reached.

9. Any changes in speed setting shaft position are now normally followed by the "T"-bar, pivot bearing, pilot valve, and speed setting servo piston.

When the AFPT governors arrived at the Woodward Governor Company factory, one of the governors was placed on the test stand. While observing the operation of the speed setting linkage, it became evident that a simple link from the speed setting pilot valve (plunger) to the floating lever would allow removal of the bellows, coupling spring, low speed pin, "C" link and dashpot plug in the speed setting pilot valve sleeve (see Figure 2). This would allow the speed setting pilot valve to overtravel when the motor was set in a high speed condition with the speed setting servo at the minimum position (see Figure 6-3).

The required parts were manufactured, the unneeded parts removed and the governors were reassembled. The governors were tested at the Woodward factory and the tests confirmed that the modifications did remove all possibility of the undesired binding of the governors. Surveillance testing at the station has also confirmed that the auxiliary feedpump turbine governors function properly.

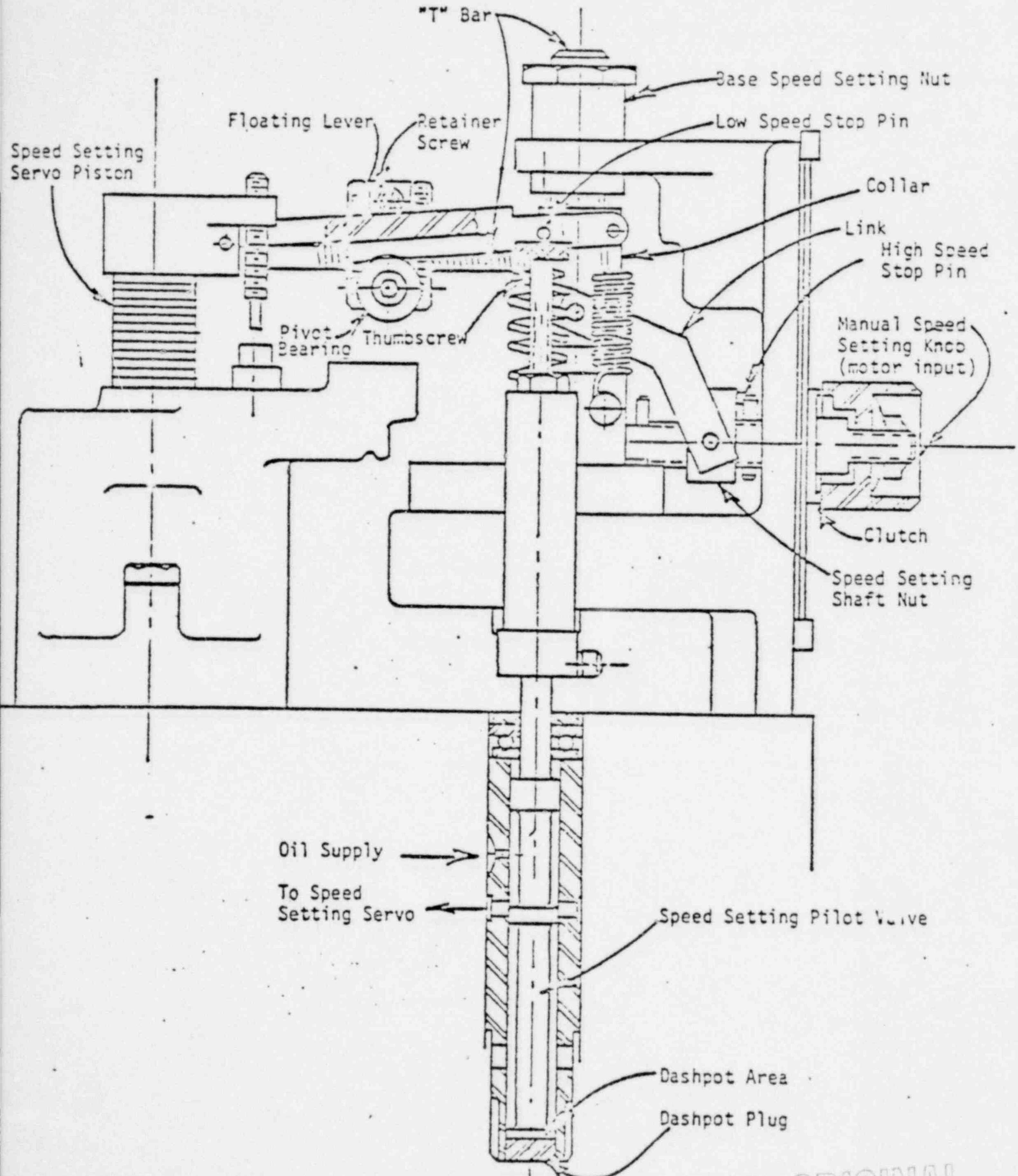

"T" Bar
Base Speed Setting Nut
Floating Lever
Retainer Screw
Low Speed Stop Pin
Speed Setting Servo Piston
Collar
Link
High Speed Stop Pin
Pivot Bearing
Thumbscrew
Manual Speed Setting Knob (motor input)
Clutch
Speed Setting Shaft Nut
Oil Supply
To Speed Setting Servo
Speed Setting Pilot Valve
Dashpot Area
Dashpot Plug

FIGURE 6-1

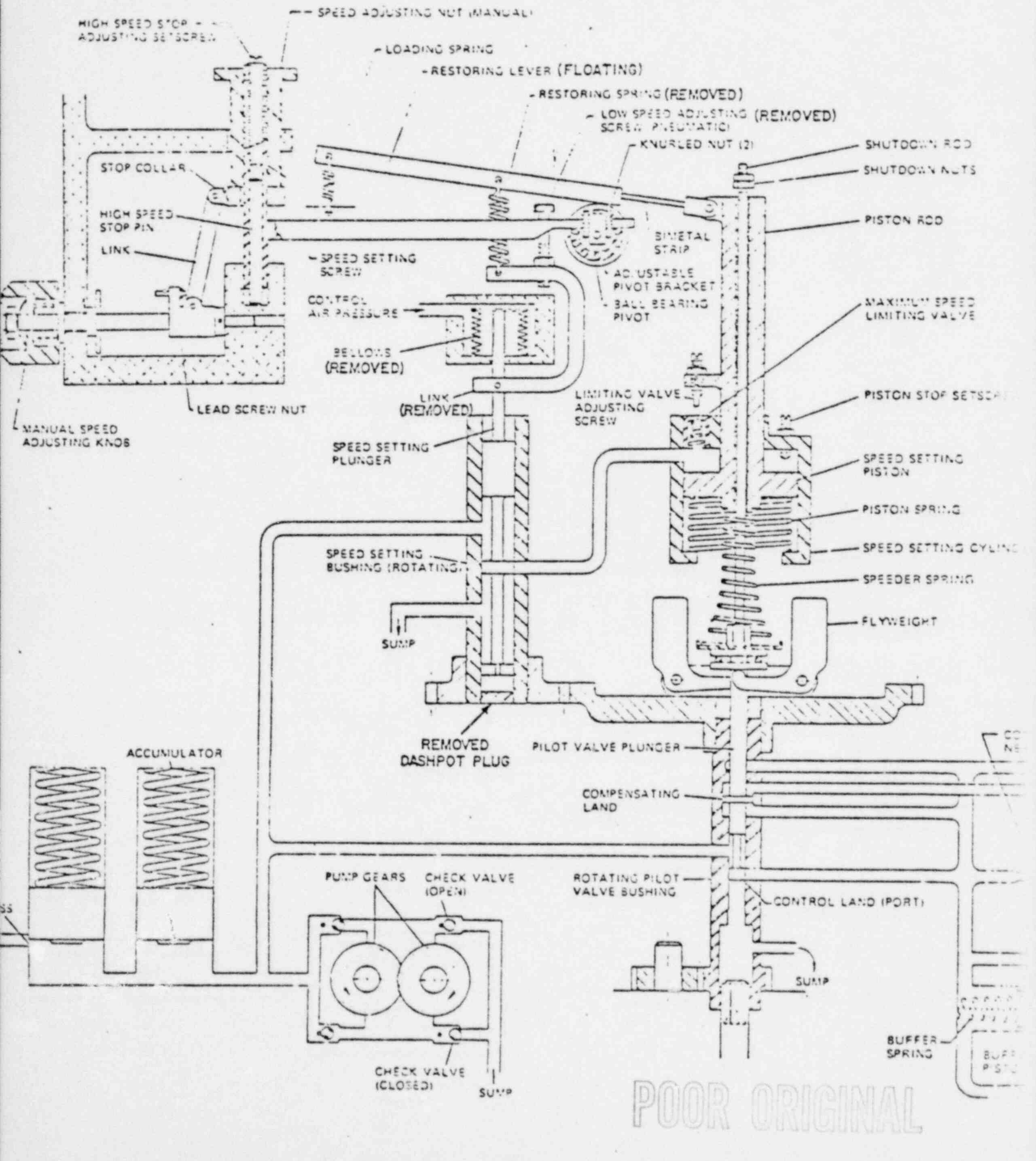

SPEED ADJUSTING NUT (MANUAL)
HIGH SPEED STOP ADJUSTING SETSCREW
LOADING SPRING
RESTORING LEVER (FLOATING)
RESTORING SPRING (REMOVED)
LOW SPEED ADJUSTING SCREW PNEUMATIC (REMOVED)
KNURLED NUT (2)
SHUTDOWN ROD
SHUTDOWN NUTS
STOP COLLAR
HIGH SPEED STOP PIN
LINK
PISTON ROD
BIMETAL STRIP
SPEED SETTING SCREW
ADJUSTABLE PIVOT BRACKET
BALL BEARING PIVOT
CONTROL AIR PRESSURE
MAXIMUM SPEED LIMITING VALVE
BELLOWS (REMOVED)
LINK (REMOVED)
LIMITING VALVE ADJUSTING SCREW
PISTON STOP SETSCREW
LEAD SCREW NUT
MANUAL SPEED ADJUSTING KNOB
SPEED SETTING PLUNGER
SPEED SETTING PISTON
PISTON SPRING
SPEED SETTING BUSHING (ROTATING)
SPEED SETTING CYLINDER
SPEEDER SPRING
SUMP
FLYWEIGHT
REMOVED DASHPOT PLUG
PILOT VALVE PLUNGER
ACCUMULATOR
COMPENSATING LAND
PUMP GEARS
CHECK VALVE (OPEN)
ROTATING PILOT VALVE BUSHING
CONTROL LAND (PORT)
SUMP
BUFFER SPRING
CHECK VALVE (CLOSED)
SUMP
POOR ORIGINAL

FIGURE 6-2

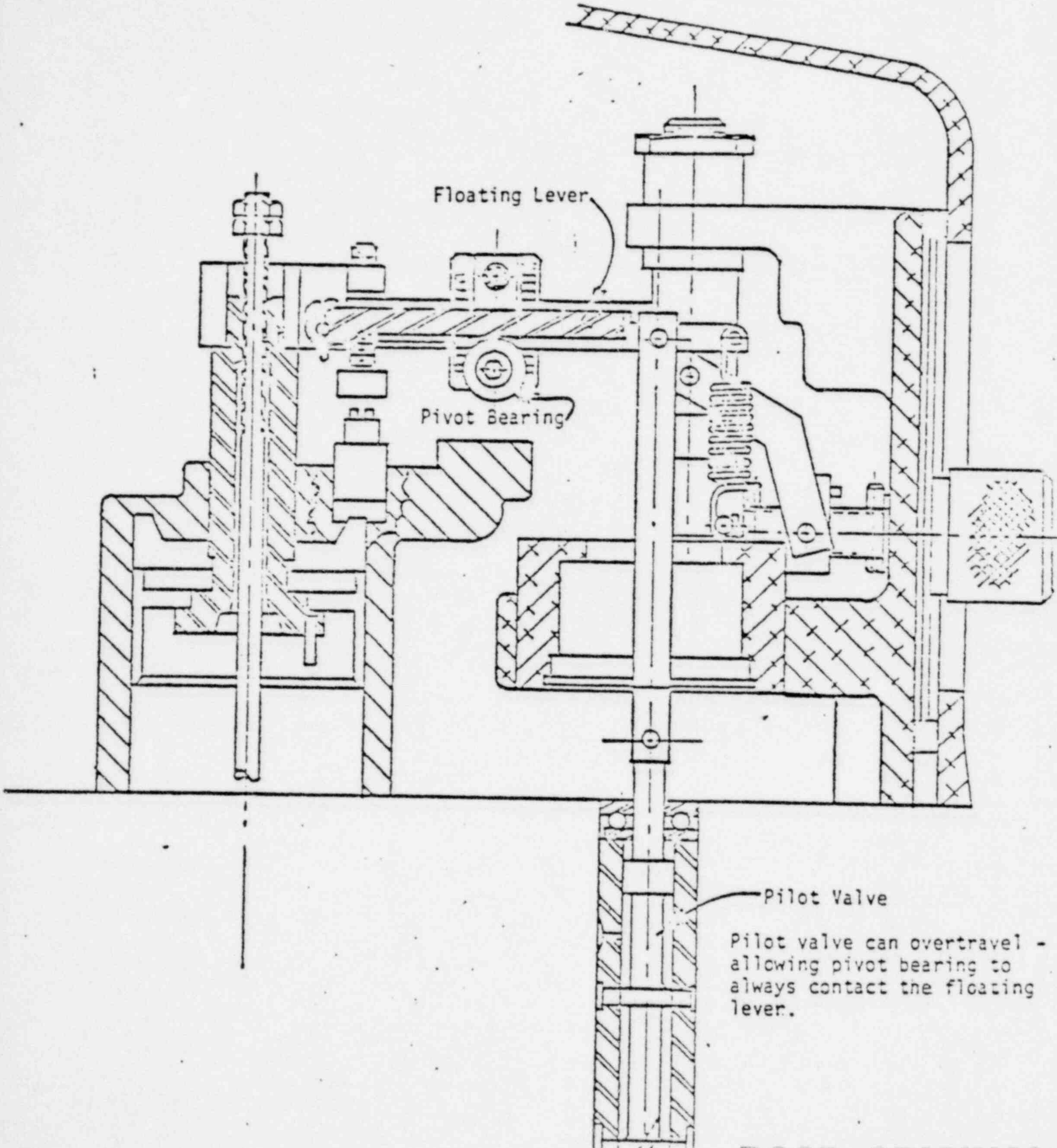

Floating Lever
Pivot Bearing
Pilot Valve
Pilot valve can overtravel - allowing pivot bearing to always contact the floating lever.

FIGURE 6-3

C. Pressurizer Power Relief Valve

On September 28, 1977, the valve was completely disassembled. The main valve was found to be clean. The seats on the nozzle and main valve disc were lapped. The pilot valve was found stuck in the open position and it was thought that the pilot stem was bent so the pilot stem was replaced and the nozzle guide area was cleaned up to remove the marks from the galling of the foreign material. The valve was reassembled and on October 12, 1977, the valve was stroked six (6) times with a pressurizer pressure of approximately 600 psi. During this testing the pilot valve again stuck and the isolation valve had to be closed.

The valve was again disassembled and under closer observation it was found that the pilot valve stem was moving too far (3/8" vs 1/8" desired). It was also found that the clearances between the pilot stem and the nozzle guide were too small (.0005" vs desired minimum of .001"). The clearances were opened up and the stroke of the pilot was shortened by adjustment of solenoid position. The valve was tested again successfully by stroking it twelve (12) times on October 15, 1977, at a pressurizer pressure of approximately 900 psi and one time at a pressure of 2200 psi.

D. Relay/Fuse/Wiring Checks

Because of the missing relay in the pressurizer electromatic relief valve control circuit, an extensive review program of checking all other relay cabinets was performed. All relay cabinets in the plant were inspected for missing plug-in relays and fuses. A detailed review of drawings was made to determine the service of each missing item and its effect on plant operations. The one additional relay and ten fuses found missing were replaced. There were no essential functions affected by the additional missing relay and fuses. The missing fuses and relay were for generator iso phase bus control, alarm and indications; relay cabinets power supply and heater supply circuits; main feed pump turbine lube oil tank level indication; and reactor coolant pump component cooling water return valve control.

Neither the missing relay nor the fuses were controlled under the station jumper and lifted wire control procedure. This indicates the fuses and relay were removed by unknown persons after checkout and testing.

E. Other Actions

Following this incident a training program was developed and presented. This program was approximately eight (8) hours of instruction and discussion covering the events of this incident, including a detailed coverage of the transient and the actions taken by the operators, and a refresher training session covering the operation of the steam and feedwater rupture control system.

The training was presented to all in the operating shift crews, the management and staff level engineers and the QA/QC staff.

7. EXHIBITS

A. Event Chronology

B. Event Variables Plots

C. SFRCS Description

D. 10 CFR Part 21 Letter on Auxiliary Feedpum Turbine Governor

E. Historical Log

7A Event Chronology

21:34:20	Startup Feedwater Valve to OTSG #2 went closed on a "½ trip" of the Steam and Feedwater Rupture Control System (SFRCS).
21:35:18	Received a complete SFRCS trip due to low level in OTSG #2.
21:35:23	Main Steam Isolation Valves went closed.
21:35:26-49	Pressurizer Power Relief Valve cycled 9 times before sticking open.
21:36:04	Auxiliary Feed Pump (AFP) #1 was feeding #1 Steam Generator (SG). AFP #2 did not come up to full speed (3600 rpm), and the discharge pressure was not sufficient to feed #2 SG.
21:36:07	Operator tripped the reactor.
21:37:17	Safety Features Actuation System Incident Levels 1 and 2 were initiated due to reactor coolant system pressure less than 1600 psi.
21:37:33	High Pressure Injection (HPI) Pump 1-2 was on and had normal flow.
21:37:49	HPI Pump 1-1 was on and had normal flow.
21:38:13	Re-established Reactor Coolant Makeup flow.
21:40:22	Containment Normal Sump Pump came on indicating the Quench Tank Rupture Disk had blown.
21:40:36	HPI Pumps were shutdown.
21:43:16	Auxiliary Boiler System was started and at normal conditions.
21:43:41	Tripped Reactor Coolant Pumps (RCP's) 1-1 and 2-2.
21:44:05	Re-established Reactor Coolant Letdown flow.
21:49:57	Put AFP #2 in hand and ran it up to speed (3600 rpm) and then lowered the speed.
21:58:00	Closed block valve to Pressurizer Power Relief Valve.
22:15:22	Started second Reactor Coolant Makeup Pump.
22:22:57	Started #2 HPI Pump.
22:27:24	Brought #2 Main Feed Pump back on with Auxiliary Boiler steam.
22:27:44	Shutdown #2 HPI Pump.
22:33:23	Shutdown #1 Reactor Coolant Makeup Pump.
22:43:54	Shutdown #1 and #2 AFP's.

EXHIBIT - B

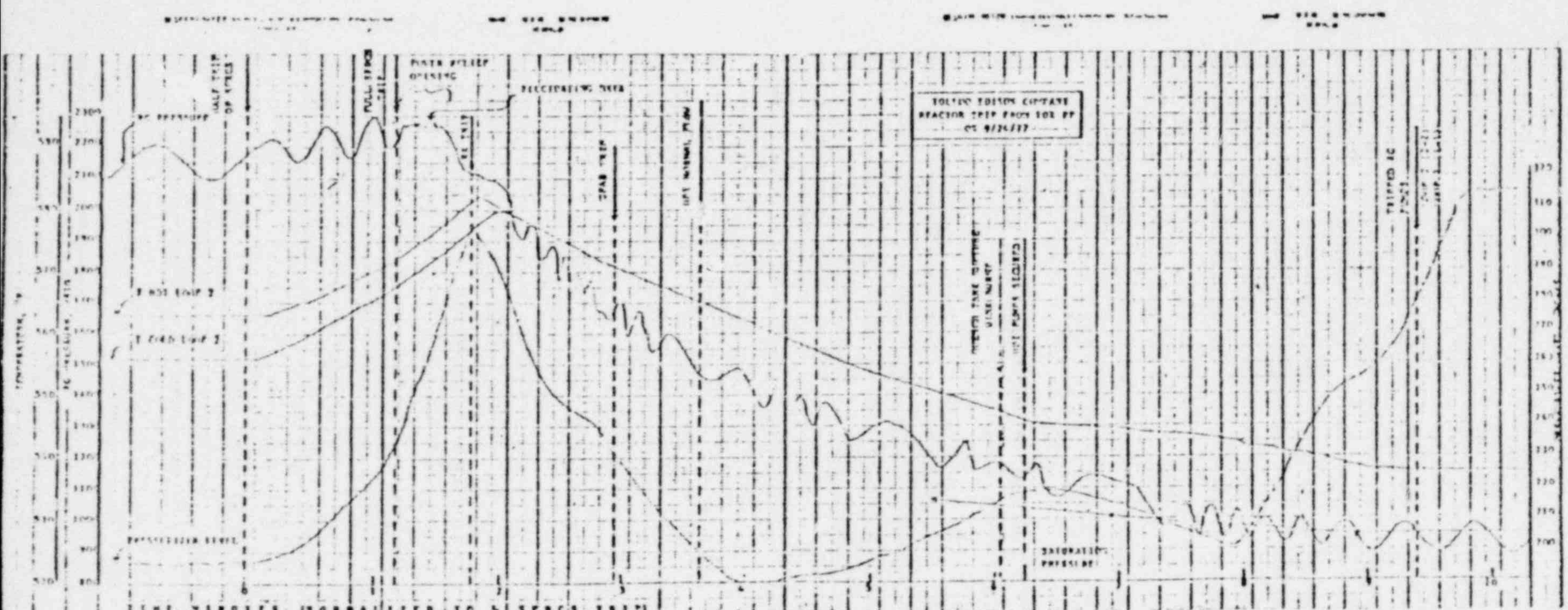


FIGURE 7-1

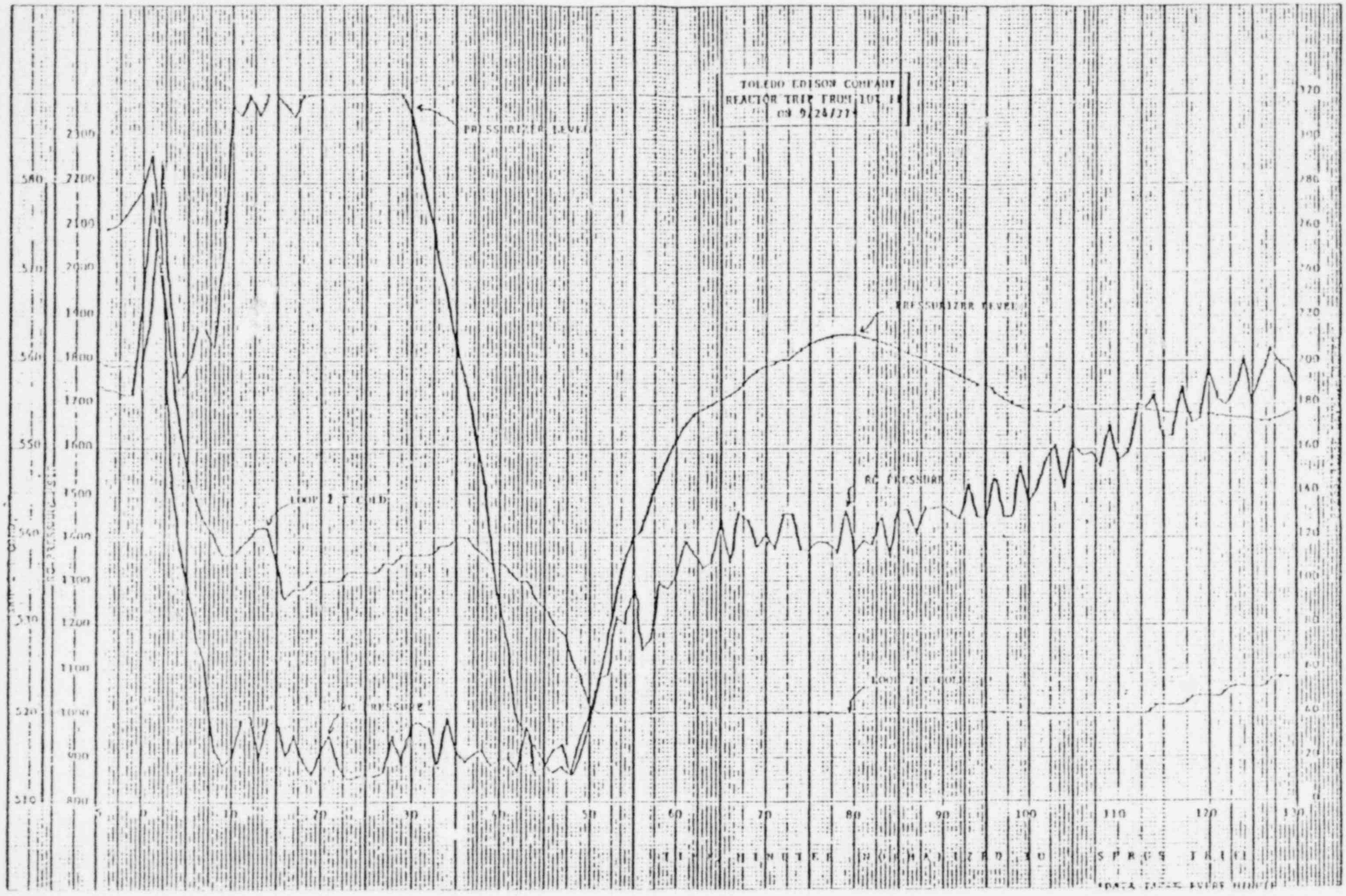
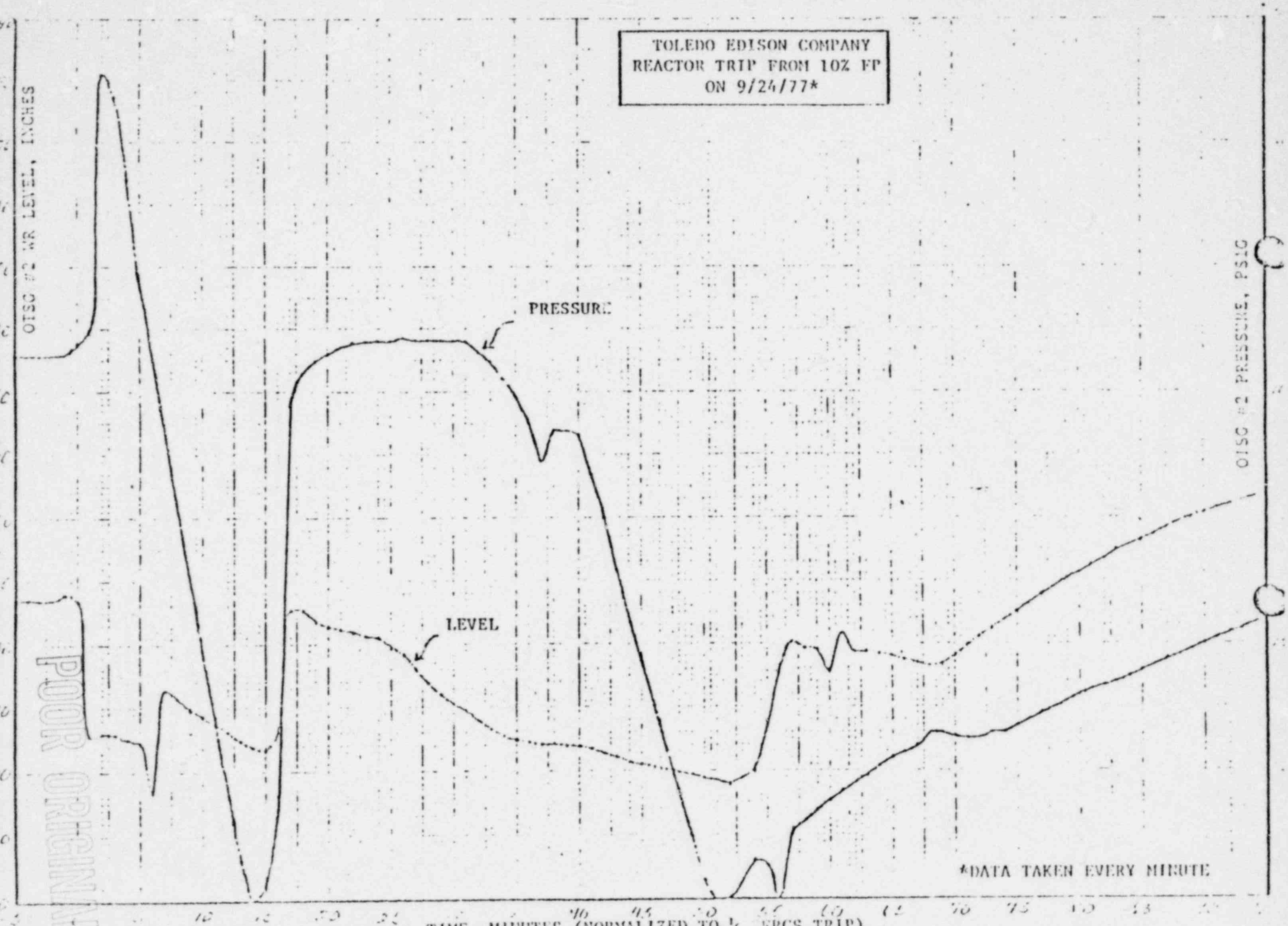
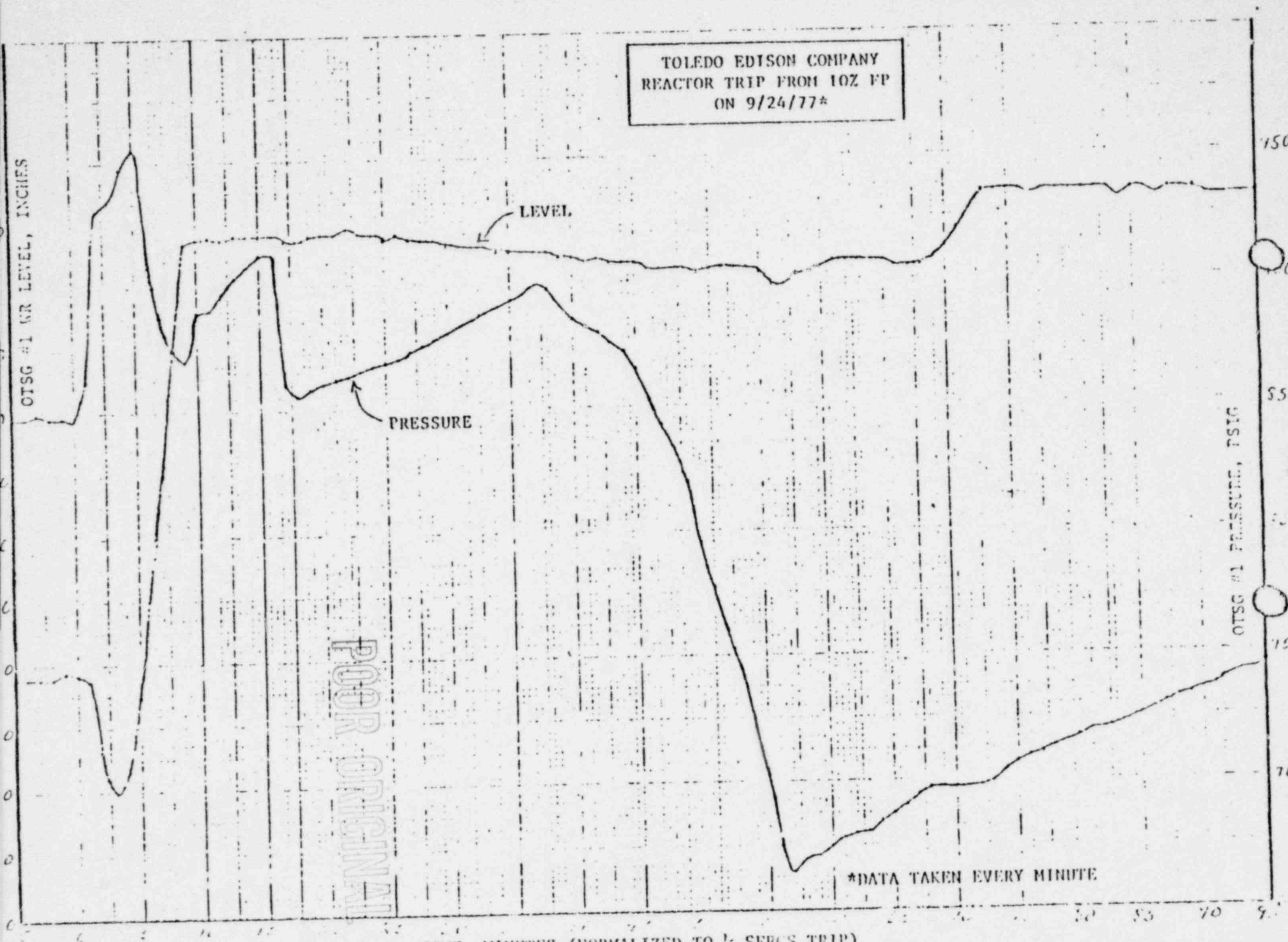

TOLEDO EDISON COMPANY
REACTOR TRIP FROM 103 [illegible]
ON 9/24/77
PRESSURIZER LEVEL
PRESSURIZER LEVEL
RC PRESSURE
LOOP 1 T COLD
LOOP 2 T COLD
RC PRESSURE
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TIME, MINUTES NORMALIZED TO SPRAY TRIP

FIGURE 7-2



TOLEDO EDISON COMPANY
REACTOR TRIP FROM 10% FP
ON 9/24/77*
OTSC #2 WR LEVEL, INCHES
OTSC #2 PRESSURE, PSIG
PRESSURE
LEVEL
*DATA TAKEN EVERY MINUTE
TIME, MINUTES (NORMALIZED TO ½ FRCS TRIP)

FIGURE 7-3


TOLEDO EDISON COMPANY
REACTOR TRIP FROM 10% FP
ON 9/24/77*
LEVEL
PRESSURE
OTSG #1 WR LEVEL, INCHES
*DATA TAKEN EVERY MINUTE
TIME, MINUTES (NORMALIZED TO ½ SFRCS TRIP)

C. System Description

Steam and Feedwater Rupture Control System

1. General

The steam and feedwater rupture control system (SFRCS) is an automatic system designed to protect against the following incidents:

a. Main steam line rupture, either upstream or downstream of main steam isolation valve (MSIV). This condition, if allowed to proceed, could rapidly blow down both steam generators, resulting in a rapid RCS cool down and therefore a rapid reactivity insertion under certain core conditions.

b. Main feedwater line rupture. If on the steam generator side of the feedwater check valve, this is approximately the same accident as the steam line rupture; on the feedwater side of the feedwater check valve this results in a total loss of feedwater.

c. Loss of all feedwater. This (as well as the above incidents) could result in boiling both steam generators dry. If this happens, there would be no steam available for running auxiliary feedwater pumps to remove decay heat.

d. Loss of 4 reactor coolant pumps (RCP). This results in loss of reactor coolant flow and therefore auxiliary feedwater is needed to establish reactor coolant natural circulation flow.

The SFRCS, upon indication of conditions a, b and c above will isolate both steam generators (close the main feedwater valves and main steam line valves and trip the turbine) and start the auxiliary feedwater system. Auxiliary feedwater is initiated to keep steam available for the auxiliary feed pump turbines and to remove decay heat from the reactor coolant system. Once this is accomplished, the operator will have time to begin a cool down in an orderly manner.

2. Design Criteria

The design criteria for the SFRCS and the auxiliary feedwater system are as follows:

a. The system must perform its safety function after a single active failure has occurred. This means that the single failure of any power supply, pump, turbine, instrument or control system logic channel will not prevent the system from removing decay heat from the reactor coolant system.

b. A main steam line break upstream of the MSIV or a main feedwater break downstream of the main feedwater isolation valve will disable one steam generator. After this event both auxiliary feed pumps and turbines will be aligned to the remaining intact steam generator. This remaining steam generator has adequate capacity to remove the decay heat from the reactor coolant system.

3. Functional Description (Refer to Enclosures 1 and 2)

The SFRCS is divided for redundancy, diversity, and testability into four logic channels. Logic channels 1 and 3 form channel 1, and logic channels 2 and 4 form channel 2. In one cabinet one logic channel has an AC power supply, the other a DC supply:

Logic Channel	Cabinet	Power Supply
1	C5762A	Y1 (120V AC)
2	C5792	Y2 (120V AC)
3	C5762A	D1P (125V DC)
4	C5792	D2P (125V DC)

Each logic channel receives the following inputs which will cause it to trip:

a. Six pressure switches, two on <u>each</u> main steam line set at 600 psig decreasing and one on each main steam line set at 650 psig decreasing.

b. Two main feedwater pressure differential switches, one from each main feedwater line (see Enclosure 1 for sensing points) set at 177 psid steam generator pressure higher than main feedwater line pressure.

c. Two level transmitters with bistables, one on each steam generator set at 17" decreasing level on the startup range.

d. A contact from RPS pump power sensing circuit; contact opens on loss of all four RCP's.

The SFRCS cabinets consist basically of an AC and a DC power supply, input buffers, logic modules, and output relays. The output relays de-energize to actuate their associated equipment. They also turn out a light on the cabinet when in the tripped state.

Each input to SFRCS has a test switch and light so that a trip of that input can be initiated for testing purposes.

The outputs from the SFRCS are contacts from the output relays. These contacts are in the control circuits for the SFRCS actuated equipment. Most components require <u>two</u> SFRCS logic channels to trip to actuate. See Enclosure 2 for a listing of actuated equipment.

There is a block feature associated with the low steam pressure trip. To prevent the system from actuating on cooldown, each logic channel has a "block" pushbutton on C5721 and on the SFRCS cabinet. When steam pressure goes below 650 psig a block permissive light is received on C5721 along with annunciator and computer alarms. When the block button is pushed, the channel will not trip on low steam pressure and a "MN STM LOW PRESS TRIP BLKD" light is actuated on C5721 as well as annunciator and computer alarms. On a heatup [illegible] automatically removed when the steam generator

There is another block which is utilized on cooldown. If the decay heat system suction valves from the reactor coolant system (DH11 and 12) are open, this block will prevent the opening of the steam inlet valves to the auxiliary feed pump turbines. This prevents the SFRCS from starting the auxiliary feed pumps when all reactor coolant pumps are secured on shutdown. This "block" is automatically removed when the decay heat system is shut down on startup.

4. System Logic

a. The response of the actuated components depends on the type of trip: (refer to Enclosure 2)

1. On low steam pressure on one main steam line, both steam generators are isolated. In addition, both auxiliary feed pumps are aligned to the steam generator which is above 600 psig.

   If both steam generators go below 600 psig, both steam generators are isolated and no auxiliary feedwater is initiated.

   If any other trip (such as low steam generator level) accompanies a low steam pressure trip, the valves will align per low steam pressure trip logic.

2. On high feedwater pressure differential or low steam generator level on one steam generator, both steam generators are isolated and each auxiliary feedwater pump is aligned to feed its respective steam generator (1 to 1 and 2 to 2).

3. On loss of all four reactor coolant pumps, each auxiliary feedwater pump is aligned to its respective steam generator. The steam generators are not isolated.

4. On all of the above events, the turbine is tripped by the SFRCS.

b. The auxiliary feedwater pump governor control switch in the control room bus has 3 positions:

   Auto-Essential (SFRCS)
   ICS
   Manual

   In the auto-essential position, the auxiliary feedwater pump is in auto-essential level control. In the ICS position, the auxiliary feedwater pump is on level control from the ICS; via the Hand-Auto station. In manual, the auxiliary feedwater pump is controlled by the operator with the Raise-Lower switch.

c. The SFRCS starting of the auxiliary feedwater pumps will automatically reset once the trip condition on the input is removed. None of the valves, however, will return to their original position until operated individually from the control room or a new trip condition occurs.

5. System Operation

In order to understand the operation of the SFRCS system, it is best to follow the various system actions under several accident conditions. The following cases will be considered:

a. Steam Line Rupture
b. Feedwater Line Rupture
c. Loss of Feedwater Pumps
d. Loss of Four Reactor Coolant Pumps

Enclosures 1 and 2 should be used as an aid to understanding the description. All discussions assume 100% FP operation at start. Some non-SFRCS actions are considered to aid in understanding the transient.

(1) Steam Line Rupture - Assume steam line 1 shears downstream of MSIV. Steam pressure will rapidly drop. When either steam generator reaches 600 psig, all four logic channels will trip, isolating both steam generators. (See Enclosure 2 for specific valves.) The MSIV takes five seconds to shut, the main feedwater isolation valve 15 seconds. Both steam lines will probably drop below 600 psig, therefore, auxiliary feedwater will not start until one steam generator recovers to above 600 psig. Auxiliary feedwater pumps will align as described in Section 3 above to feed the steam generator that first recovers to 600 psig, with both auxiliary feed pumps. The SFRCS will trip the turbine. The reactor will trip on low pressure.

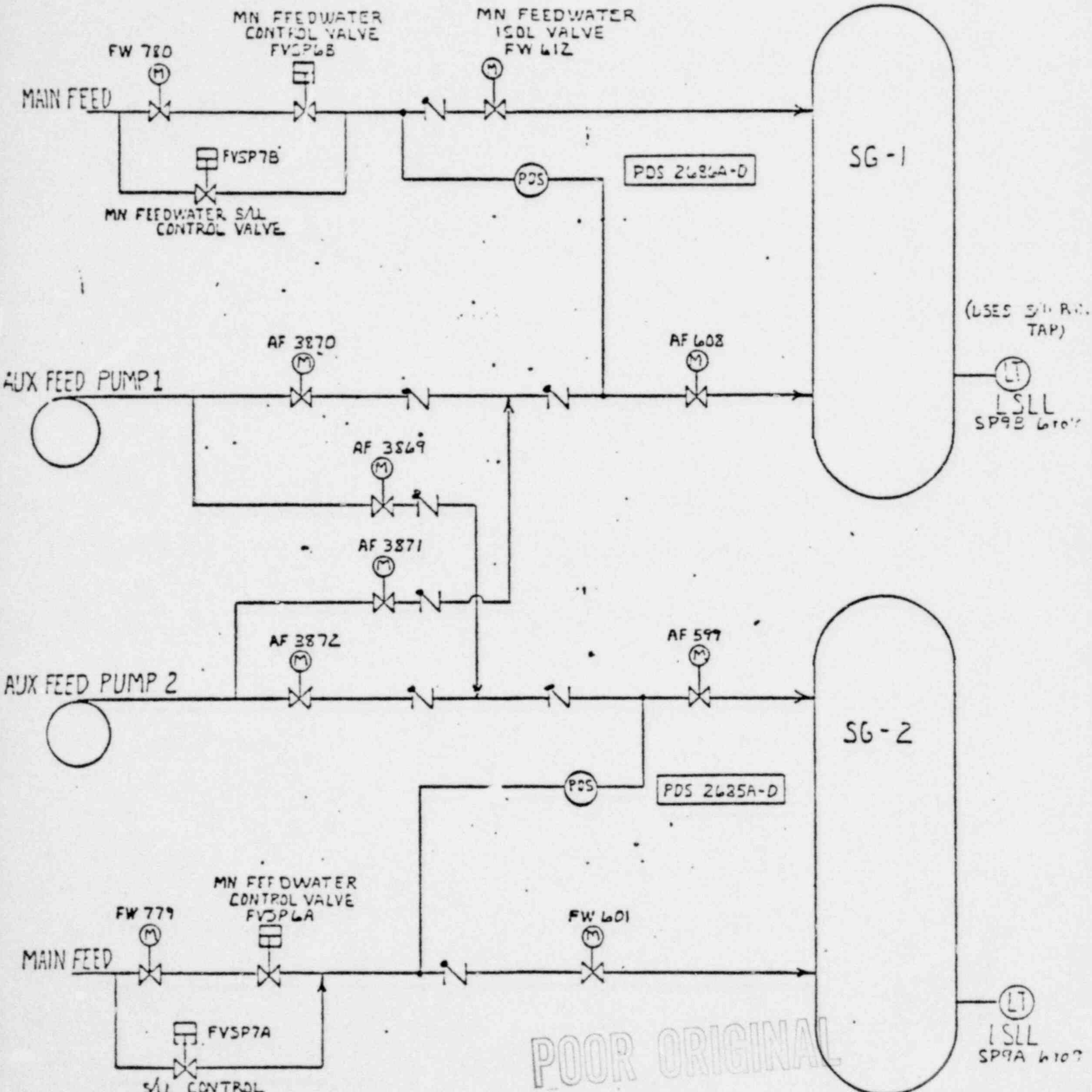
When both steam generators are above 600 psig, the trip condition automatically clears and the atmospheric vent valves may be used for pressure control cooldown if required and provided no other trips are present.

(2) Feedwater Rupture Line - Assume feedwater line 1 shears upstream of the feedwater line check valve. Feedwater pressure will rapidly drop. When either feedwater heater drops to 177 psig less than steam generator pressure, the SFRCS will isolate both steam generators and align the auxiliary feed pumps to their respective steam generator (1 to 1; 2 to 2). The reactor will trip on high pressure and the SFRCS will trip the turbine.

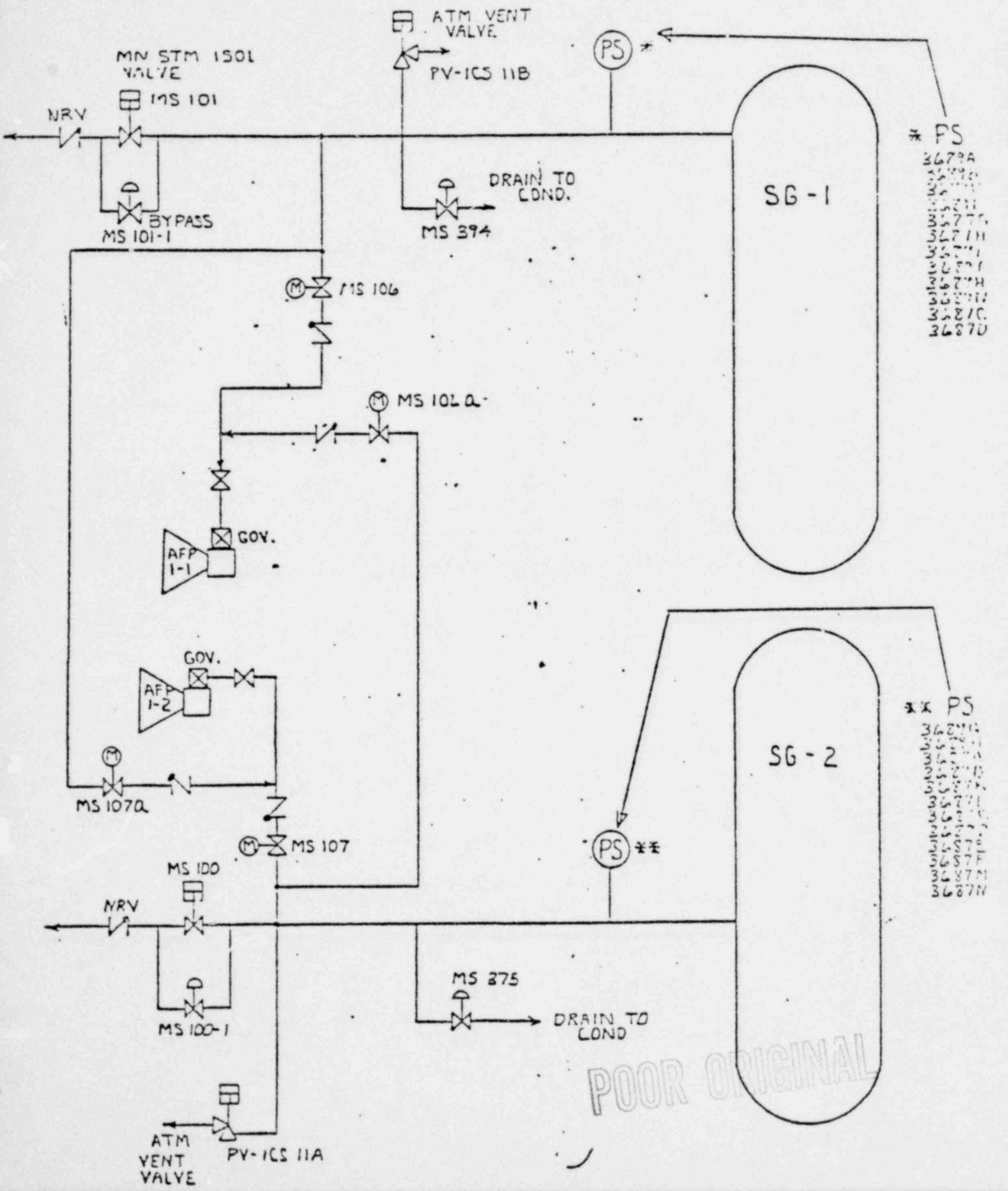
(3) Loss of Four Reactor Coolant Pumps - If all four reactor coolant pumps trip, the turbine will be tripped by the SFRCS and the reactor protection system will trip the reactor. The SFRCS will initiate auxiliary feedwater. The steam generators will not be isolated.

ENCLOSURE 1 SFRCS ACTUATED EQUIPMENT (FEEDWATER)

(FOR STEAM VALVES SEE NEXT PAGE)



ENCLOSURE 1 SFRCS ACTUATED EQUIPMENT (STEAM)



CLOSURE 2

STEAM-FEEDWATER RUPTURE CONTROL SYSTEM ACTUATION

ANNEL 1 (5767A) / ANNEL 2 (5792)	MS 101	MS 100	MS101-1 NOTE 3		MS 394 NOTE 3		ICS 11B NOTE 3		FW 612		FW 780		SP 7B NOTE 3	
	MS 101	MS 100		MS100-1 NOTE 3		MS 375 NOTE 3		ICS 11A NOTE 3		FW 601		FW-799		SP 7A NOTE 3
W PRESSURE MAIN eam Line 1 (<600#)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
W PRESSURE MAIN eam Line 2 (<600#)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
H. - FW ΔP SG 1 GH (>177 PSID)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
H. - FW ΔP SG 2 GH (>177 PSID)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
W LEVEL SG 1 17" SUR)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
W LEVEL SG 2 17" SUR)	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT	SHUT
SS OF 4 RC PUMPS														

ANNEL 1 (5767A) / ANNEL 2 (5792)	SP 6A		MS 106		MS 106A		AF3870		AF 3869		AF 608		MAIN TURBINE
		SP 6B		MS 107		MS107A		AF3872		AF3871		AF 599	
W PRESSURE MAIN EAM LINE 1 (<600#)	SHUT	SHUT	SHUT	OPEN NOTE 1	OPEN NOTE 1	SHUT	SHUT	OPEN NOTE 1	OPEN NOTE 1	SHUT	SHUT	OPEN	TRIP
W PRESSURE MAIN EAM LINE 2 (<600#)	SHUT	SHUT	OPEN NOTE 1	SHUT	SHUT	OPEN NOTE 1	OPEN NOTE 1	SHUT	SHUT	OPEN NOTE 1	OPEN	SHUT	TRIP
H-FW ΔP SG 1 GH >177 PSID	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	TRIP
H-FW ΔP SG 2 GH >177 PSID	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	TRIP
W LEVEL SG 1 17" SUR)	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	TRIP
W LEVEL SG 2 17" SUR)	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	TRIP
SS OF 4 RC PUMPS			OPEN NOTE 2	OPEN NOTE 2	SHUT	SHUT	OPEN	OPEN	SHUT	SHUT	OPEN	OPEN	TRIP

TES:

If both main steam lines are <600#, these valves shut.

These valves will not open if DH 11 and DH 12 (DH Suction from RCS) are open.

These valves are closed on a ½ channel trip.