UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA ST., N.W., SUITE 3100
ATLANTA, GEORGIA 30303

Report Nos. 50-259/80-32, 50-260/80-25 and 50-296/80-26

Licensee: Tennessee Valley Authority
500A Chestnut Street
Chattanooga, TN 37401

Facility Name: Browns Ferry

Docket Nos. 50-259, 50-260 and 50-296

Inspection at Browns Ferry Site near Athens, Alabama

Inspected by: See Section 1 of the Report

Approved by: C. Julian for 8/5/80
H. C. Dance, Section Chief, RONS Branch — Date Signed

SUMMARY

Inspection on June 28 - July 4, 1980

Areas Inspected

This special, announced inspection involved approximately 300 inspector-hours on site in the areas of inspection and evaluation of the licensees investigation of the Unit 3 failure to fully insert control rods following a scram on June 28, 1980.

Results

Of the area inspected, no items of noncompliance or deviations were identified.

8009120 225

DETAILS

1. Persons Contacted

Licensee Employees

*H. L. Abercrombie, Plant Superintendent
*J. L. Harness, Assistant Plant Superintendent
J. B. Studdard, Operations Supervisor
E. Edmondson, Lead Electrical Engineer
J. A. Teague, Maintenance Supervisor, Electrical
M. A. Haney, Maintenance Supervisor, Mechanical
J. R. Pittman, Maintenance Supervisor, Instruments
R. G. Cockrell, Reactor Engineer
B. E. Baggett, Shift Engineer, SRO
J. D. Glover, Shift Engineer, SRO
L. L. Kennedy, Shift Engineer, SRO
M. Gant, Assistant Shift Engineer, SRO
V. Johnson, Unit Operator, RO
R. Champion, Unit Operator, RO
E. Nave, Shift Technical Advisor
R. T. Smith, Quality Assurance Supervisor
L. Parvin, Quality Assurance Staff

Other licensee employees contacted included numerous technicians, operators, mechanics, security force members and office personnel.

NRC Personnel On Site

Individual	Dates
*J. P. O'Reilly, Director, Region II	7/2-4/80
H. C. Dance, Chief, Reactor Projects Section No. 1, Region II	6/30- 7/3/80
*J. Chase, Resident Inspector, Browns Ferry	6/28- 7/4/80
C. Julian, Reactor Inspector, Region II	6/28-29/80
B. Moon, Reactor Inspector, Region II	7/1-3/80
K. Roberts, Senior Resident Inspector, IE	7/2 - 3/80
*R. Sullivan, Senior Resident Inspector, Browns Ferry	6/28- 7/3/80
W. Ruhlman, Reactor Inspector, Region II	7/2 - 4/80
T. Ippolito, Chief, Operating Reactors Branch No. 3, NRR	7/2 - 3/80
W. Minners, Technical Assistant to Director of Safety Technology, NRR	7/2 - 4/80
F. Clemonson, Systematic Evaluation Program, NRR	7/2 - 4/80
S. Rubin, Office of Analysis and Evaluation of Operational Data, NRR	7/2 - 3/80
W. Mills, Senior Specialist, IE:HQ	7/2 - 4/80

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized daily throughout the inspection with those persons indicated in paragraph 1 above.

3. Licensee Action on Previous Inspection Findings

Not inspected.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Summary Of Event

On June 28, 1980, Browns Ferry Unit 3 began a normal shutdown to repair a leak in the 3B reactor feed pump discharge piping. Following established procedure, reactor power was decreased by lowering recirculation loop flows. Power was further reduced by fully inserting 10 control rods in a symmetric pattern. From a reactor power of approximately 400 MWe, the reactor was shutdown by initiating a manual scram at 0131 hours. In response to the scram signal, all rods on the west side of the core fully inserted, but 76 rods on the east side of the core failed to fully insert, halting at various positions ranging from notch 46 to notch 2. Six of these rods stopped at notch 4 or less and thus were effectively fully inserted from a reactivity standpoint. Nuclear instrumentation indicated that the reactor was shutdown and subcritical overall. An OD-8 process computer printout of the Local Power Range Monitor (LPRM) incore detectors was run at 0132 hours and demonstrated no areas of local supercriticality or excessive power generation. The recirculation pumps continued in operation providing sufficient core flow to remove incore heat generation. All indications at this time were that the situation was a controllable one and no prompt drastic emergency action was required.

The problem appeared to be hydraulic rather than electrical in nature. All indications were that all rods had received a normal electrical scram signal. Operators observed that all rods displayed a blue "scram" light on the reactor control panel. These lights are energized only when both the scram water inlet and outlet valves are open for a given rod. Thus it appeared that both the inlet and outlet valves had opened admitting scram drive water below the control rod drive (CRD) piston and allowing above piston water to be exhausted from the CRD mechanism.

Additionally, rods in the west side of the core had performed normally. Rods on the east and west side of the core are controlled by two separate banks of hydraulic control units (HCU) physically located outside the drywell, on the east and west of the reactor respectively. Water exhausted from above the CRD piston collects in two separate scram discharge volume headers (SDVH) located above the east and west HCU banks. Thus the probable failure mode was an inability to exhaust water from the east HCU bank into the east scram discharge volume headers.

After approximately four and one-half minutes operators reset the manual scram. After 94 seconds, the reactor was manually scrammed again. All partially withdrawn rods were observed to drive inward and then halt resulting in 59 rods remaining partially withdrawn.

In approximately one minute the scram was reset again. A[illegible] 33 seconds the reactor was manually scrammed a third time. Again [illegible]ithdrawn rods moved in and halted with 47 rods partially withdrawn. Only 35 of these rods were further than position 04 withdrawn, however.

Approximately three and one-half minutes later, the scram was reset again in preparation for another manual scram. After 160 seconds, the reactor received an automatic scram from high Scram Discharge Volume (SDV) water level. This scram was initiated by the reactor operator moving the SDV high water level scram bypass switch from the "bypass" to the "normal" position. The switch had been placed in "bypass" as a prerequisite for the scram resets.

In response to this scram signal all the remaining rods inserted. The normal shutdown procedures were then resumed and investigations began.

During the efforts to correct the problem, the operators attempted to manually drive the control rods in. This proved impossible as the Rod Sequence Control System (RSCS) would not allow a rod to be selected. The RSCS is designed to enforce a prescribed sequence of rod withdrawal when reactor power is less than 30%. In this case, with numerous rods partially inserted and out of the normal insert sequence, the RSCS acts to prevent selection of any control rod for withdrawal or insertion.

Table I contains a sequence of events derived from the process computer, interviews with the control room operators and plant staff.

6. NRC Actions

Following this event the NRC initiated several actions.

a. The Senior Resident Inspector arrived onsite within 2½ hours of the event and a regional reactor core physics specialist arrived onsite the morning of the event. A total of 13 NRC personnel under the direction of the Region II Director were onsite the following week to review the TVA investigative efforts and to assess the event.

b. Region II issued a Confirmation of Action letter to TVA on June 30, 1980, confirming TVA's investigative plan and an NRC review prior to restart. These actions were verified to have been completed.

c. Preliminary Notification PNO-II-80-119, Failure of Control Rods to Insert During a Scram, was issued on June 30, 1980, alerting all NRC offices to the event. Other BWRs were informed of the event. An update of this PNO was issued on July 3, 1980.

TABLE I

BROWNS FERRY 3

SEQUENCE OF EVENTS

FAILURE TO FULLY INSERT CONTROL RODS FOLLOWING A SCRAM ON 6/28/80

Hour	Min.	Sec.	Event	Comment
01	31	16	Manual Reactor Scram Channel B (half scram)	First Manual Scram
			Manual Reactor Scram Channel A (full scram)	
	31	24	Reactor Trip Actuator, Channel A	Auto Scram Signal from low reactor
			Reactor Trip Actuator, Channel B	Water level after the scram (shrink)
			Reactor Low Water level Channels, A, B, C & D	
			Reactor Feedpump Turbine C Tripped	Manual action
	31	34	Scram Discharge Volume High Level Channel C	
			Scram Discharge Volume High Level Channel D	
	31	37	Scram Discharge Volume High Level Channel B	
	31	40	Scram Discharge Volume High Level Channel A	All SDV scram level switches actuate

Hour Min. Sec.	Event	Comment
(Continued)		
01 31 40	Turbine Malfunction Bus Energized	
	Turbine Stop Valve Closure Scram Channel A	
	Turbine Stop Valve Closure Scram Channel C	
	Turbine Stop Valve Closure Scram Channel D	
	Turbine Stop Valve Closure Scram Channel B	
	Turbine Load Rejection Scram Channel B	
	Turbine Load Rejection Scram Channel D	
	Turbine Load Rejection Scram Channel A	
	Turbine Load Rejection Scram Channel C	
	Turbine Tripped	Turbine tripped manually
32 01	Reactor Low Water Level Channel A Clear	
	Reactor Low Water Level Channel C Clear	Reactor vessel level
	Reactor Low Water Level Channel D Clear	recovered following
	Reactor Low Water Level Channel B Clear	shrink
34 45	IRM Channel F High Level Trip	
34 48	IRM Channel D High Level Trip	Alarms caused
	IRM Channel D High Level Clear	by operator down
	IRM Channel D High Level Trip	ranging Intermedi-
	IRM Channel F High Level Clear	ate Range Monitor
	IRM Channel B High Level Trip	(IRM) Channels

Hour	Min.	Sec.	Event	Comment
(Continued)				
01	34	48	IRM Channel B High Level Clear	
			IRM Channel B High Level Trip	
			IRM Channel B High Level Clear	
			IRM Channel B High Level Trip	
			IRM Channel B High Level Clear	
			IRM Channel B High Level Trip	
			IRM Channel D High Level Clear	
			IRM Channel B High Level Clear	
	35	43	Manual Reactor Scram Channel A Clear	Operator resets scram first time
			Manual Reactor Scram Channel B Clear	
	35	46	Reactor Trip Actuator Channel A Clear	auto scram signal
			Reactor Trip Actuator Channel B Clear	reset
	35	59	Scram Discharge Volume High Level Channel B Clear	
			Scram Discharge Volume High Level Channel A Clear	
	36	12	IRM Channel D High Level Trip	Auto half scram
			Reactor Trip Actuator Channel B Trip	from IRM High
			IRM Channel D High Level Clear	with companion
			IRM Channel D High Level Trip	APRM downscale
	36	17	IRM Channel D High Level Clear	
	36	45	Reactor Trip Actuator Channel B Clear	

Hour	Min.	Sec.	Event	Comment
(Continued)				
01	37	20	Manual Reactor Scram Channel B	Operator initiates
			Manual Reactor Scram Channel A	second Manual scram
			Scram Discharge Volume High Level Channel A Trip	
			Scram Discharge Volume High Level Channel B Trip	
	37	33	Scram Discharge Volume High Level Channel B Clear	
			Scram Discharge Volume High Level Channel A Clear	
			Scram Discharge Volume High Level Channel A Trip	
			Scram Discharge Volume High Level Channel B Trip	
	38	19	Manual Reactor Scram Channel A Clears	Operator resets scram
			Manual Reactor Scram Channel B Clears	second time
	38	32	Scram Discharge Volume High Level Channel B Clears	
			Scram Discharge Volume High Level Channel A Clears	
	38	40	Scram Discharge Volume High Level Channel A Trip	
	38	42	Scram Discharge Volume High Level Channel B Trip	
	39	12	Manual Reactor Scram Channel A	Operator initiates
			Manual Reactor Scram Channel B	third Manual Scram
	40	22	IRM Channel F High Level Trip	
			Reactor Trip Actuator Channel B Trips	
			IRM Channel F High Level Clear	
	42	00	Reactor Trip Actuator Channel A Trips	

Hour	Min.	Sec.	Event	Comment
(Continued)				
01	42	37	Reactor Trip Actuator Channel A Clears	
			Reactor Trip Actuator Channel B Clears	Operator rests scram
			Manual Reactor Scram Channel B Clears	third time
			Manual Reactor Scram Channel A Clears	
	45	17	Reactor Trip Actuator Channel A Trips	Fourth reactor scram
			Reactor Trip Actuator Channel B Trips	from SDV High Level scram out of bypass, all rods insert
	45	36	Scram Discharge Volume High Level Channel B Clears	
			Scram Discharge Volume High Level Channel B Trips	
	46	30	Manual Reactor Scram Channel B	Operator inputs fol-
			Manual Reactor Scram Channel A	lowup Manual scram
	47	43	Reactor Trip Actuator Channel A Clears	
			Reactor Trip Actuator Channel B Clears	Operator resets final
			Manual Reactor Scram Channel A Clears	scram per procedure
			Manual Reactor Scram Channel B Clears	
	57	04	Scram Discharge Volume High Level Channel B Clears	
			Scram Discharge Volume High Level Channel A Clears	
	57	34	Scram Discharge Volume High Level Channel D Clears	
			Scram Discharge Volume High Level Channel C Clears	

d. IE Bulletin No. 80-17 was issued on July 3, 1980 to all BWR licensees specifying requirements to verify that the SDVHs were empty with vent and drain piping unobstructed, plant procedures addressed this concern, special training be conducted, and to demonstrate system operability by conducting a manual and an automatic scram.

e. Region II issued a confirmation of concurrence letter to TVA on July 14, 1980, confirming plans to continuously monitor the SDVH, install an atmospheric vent on the east SDVH similar to that located on the west side, provide instructions to operating personnel that specify actions to be taken when water is detected in the SDV, and to expedite review of modifications required to the SDV, including additional vents on Units 1 and 2.

7. Reactor Physics Investigations

An NRC reactor physics specialist from Region II arrived at the site the morning of the event. The inspector interviewed cognizant Reactor Engineers and plant personnel including all licensed operators present during the event. All available strip chart recorders reflecting plant parameters during the event were examined. Process computer printouts of core parameters prior to and during the event were reviewed.

Indications are that the first manual scram rendered the core subcritical. There is no evidence of a return to criticality during the event. There is no indication of local area power generation in excess of available core cooling capability. Incore neutron detectors indicated that local criticality was possible. A core physics computer code study, modeling the control rod position following the first scram, will be necessary to determine if areas of local criticality actually existed. Licensee representatives stated that their preliminary conclusions were as follows:

a. There was not an accurate estimate of Keff following the scram but the minimum shutdown margin of 0.0038 $\Delta K/K$, required by Technical Specification 4.3.A.1. was not immediately available.

b. Reactor coolant samples taken showed normal activity levels following a scram. There was no evidence of fuel damage as a result of this event.

c. Based on intermediate range monitor nuclear instrumentation following the first scram, heat generation rates in the fuel on the east side of the core were less than one percent of full power heat generation rates.

The inspector found no evidence to dispute these conclusions. The failure to have the required shutdown margin was properly reported to the NRC. No deviations or items of noncompliance were identified in this area.

8. Procedures and Operator Actions

Review of procedures listed below were made by the inspector to determine adequacy and to see that they were followed in this event:

GOI-101, Section V.c., Shutdown by Manual Scram
OI-85, Section IV, Abnormal Operation (Control Rod Drive System)
OI-63, Standby Liquid Control System

The procedures were determined to be adequate but did not specifically cover symptons in this event. Temporary instructions were provided to address the issues on an interim basis. Subsequently, EOI-47, Failure of Control Rods to Fully Insert During Scram, was written to identify the control rod and standby liquid control system restrictions contained in IEB 80-17.

Operator response during this event was judged by the inspectors to be most satisfactory. Rod positions were obtained after each of the scram actions. Deliberate actions and understanding of the system were demonstrated.

No deviations or items of noncompliance were identified in this area.

9. Mechanical System Review

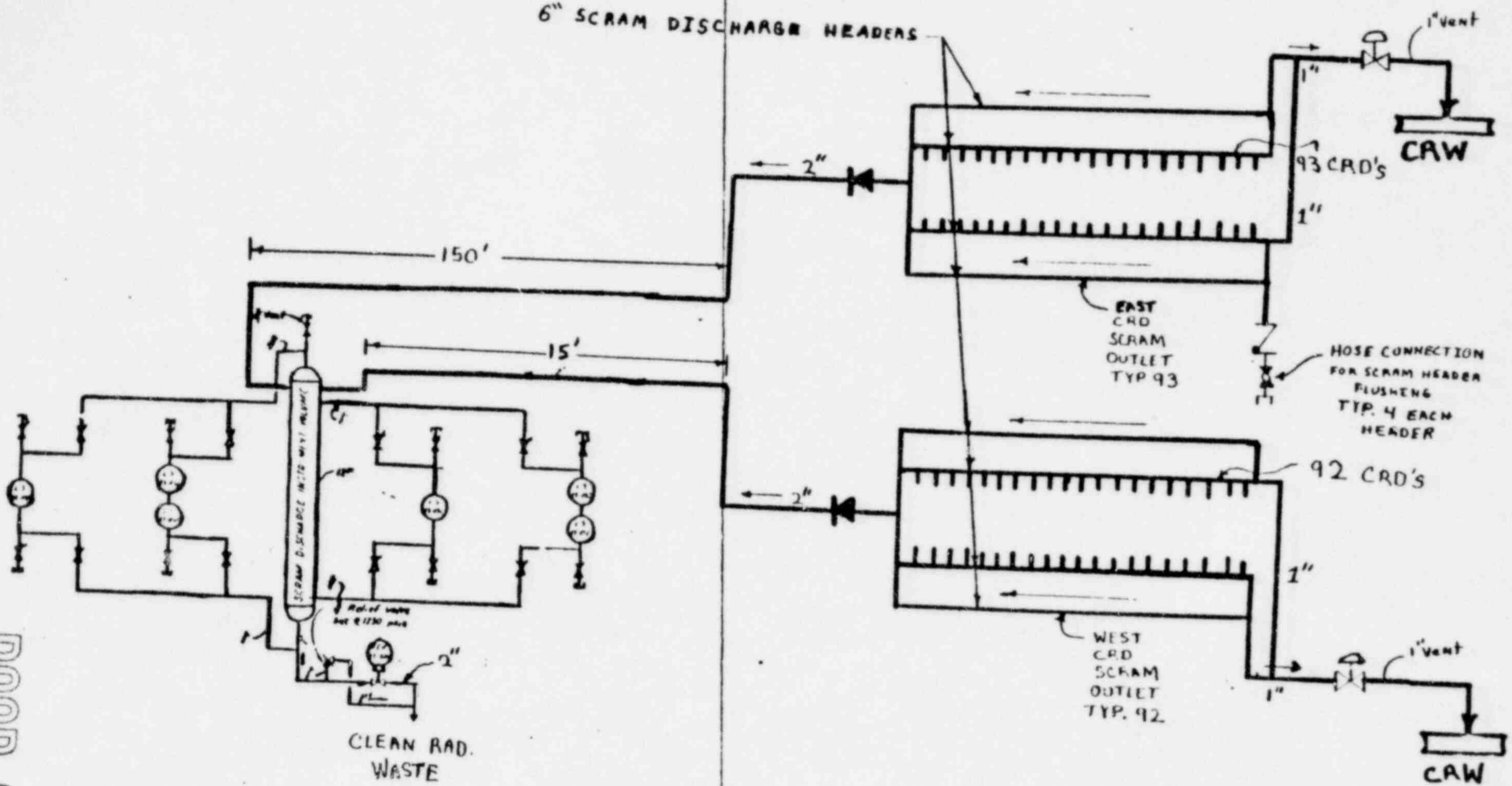
The apparent cause of the control rods on the east side of the reactor to insert is the east scram discharge volume header (SDVH) was partially filled with water prior to the scram. This is also supported by the SDV Hi level (scram) switch which activated in 18 seconds after the initial scram. Review of 12 previous scrams indicated normal times of 42-56 seconds. Figure 1 is a schematic of the system. The design intent is that the SDV system remains empty, with vent and drain valves open, during normal operation. Upon a scram, the vent and drain valves close, and the scram discharge water from above the CRD piston empties rapidly into both SDVH chambers. With the east SDVH partially filled, the pressure quickly equalized to that of the CRD scram inlet water, and the CRD's stopped motion and settled into the nearest notch.

Upon reset of the scram signal, the scram outlet valves from the CRD's close, the vent and drain valves of the SDV open, and water begins to drain from the SDV providing free volume. When the reactor was scrammed again, scram discharge water again flowed into the SDV and all partially withdrawn rods drove in. When pressure equalized above and below the CRD pistons, the rods not fully inserted again stopped and settled into the nearest notch. By repeating this process of reset and scram, three times, the rods were finally able to fully insert. The periods of reset, during which the SDV was allowed to drain, were 94, 53, and 160 seconds. The amount of control rod insertion after each scram signal roughly corresponds to the relative length of drain times. The fact that the final scram which fully inserted the remaining rods was initiated from the automatic circuitry is apparently not significant. At that point, the SDV had been allowed to drain for 160 seconds and a manual scram at that point would have accomplished the same results.

Figure 1

SCRAM DISCHARGE VOLUME

DATE: 7/14/80



The exact cause for the east SDVH being partially full is not known. The licensee performed many tests and inspections in accordance with approved procedures to determine the cause in the days following the events. Many of these evaluations were witnessed by NRC inspectors and the results of the tests were evaluated by the NRC. Table II lists these efforts.

Only two anomalies were found as a result of the tests and inspections.

a. When a vacuum pump was first connected to the east vent line on the drainage side, a vaccum of 8" of mercury was pulled for a short period which dropped sharply to 2". The reason for this temporary vacuum was not determined and the transient vacuum was not observed during repetition of the test.

b. The low level (3-Gallons) and rod block (25-Gallons) level switches did not activate during the first calibration fill after the scram. Operator observations did indicate that these two switches worked at least during part of the event. The third protective level, 50-Gallons level scram, composed of four separate switches worked properly. IE Bulletin 80-14, Degradation of BWR Scram Discharge Volume Capability, addresses the operability of these switches.

It was hypothesized that the water in the west SDVH prior to the scram either failed to drain after the prior unit 3 scram on June 7, 1980, was forced in through the vent line from the clean rad waste (CRW) vent and drain header system, or accumulated from leakage from the CRD's through one or more leaking scram outlet valves. No abnormality in the CRW was observed between June 7 and 28 of a magnitude to force water up into the SDV system. If such an abonormality had occurred, the water should have emptied back out of the SDV via the drain line. Leakage of thermally hot water from the CRD's through the scram outlet valves would have caused a high temperature alarm in the control room on the leaking CRD and no such alarm was observed.

Potential blockage in the 2 inch drain line connecting the east SDVH with the instrument volume and the drain valve was investigated. This piping was cut at six locations and inspection yielded no evidence of blockage. The east SDVH was flushed and inspected with a boroscope from the cut made in the 2" drain line. The instrument volume was also inspected with a boroscope. No anomalies were noted.

Tests indicate that a failure of the vent valve to open or a blockage of the vent line to the CRW system indeed inhibits draining of the east SDVH. Except for the transient vacuum observed during the first test, no evidence of a plug exists. Tests and inspection after disassembly proved the vent valve to be normal. Subsequently, five cuts were made in the east SDVH vent piping. The piping was clear. A 1.3 cfm vacuum pump attached to the vent pipe was unable to establish a vacuum after fifteen minutes.

No deviations or items of noncompliance were identified in this area.

TABLE II

BROWNS FERRY UNIT 3 INVESTIGATIONS AND TESTS COMPLETED

1. VERIFIED CORRECT HYDRAULIC CONTROL UNIT VALVE ALIGNMENT
2. EAST BANK VENT VALVE VERIFIED OPERABLE
3. FRICTION TESTF' ,5 RODS - PERFORMED NORMAL
4. VERIFIED CALIBRATION OF 3-GALLON, 25-GALLON, AND 50-GALLON LEVEL SWITCHES ON INSTRUMENT VOLUME
5. COMPLETED RADIATION SURVEY OF DRAIN LINES TO DETERMINE IF HOT SPOTS EXIST INDICATING BLOCKAGE
6. COMPLETED RADIATION SURVEY OF #3 EQUIPMENT DRAIN SUMP
7. SAMPLED #3 EQUIPMENT DRAIN SUMP
8. SAMPLE REACTOR COOLANT SYSTEM - FOUND NORMAL
9. VERIFIED THAT OFF GAS RADIATION LEVELS WERE NORMAL
10. COMPLETED VISUAL AND MECHANICAL INSPECTIONS OF VENTS AND DRAINS IN SCRAM DISCHARGE VOLUME
11. VERIFIED THAT NO MAINTENANCE OR MODIFICATIONS IN PROGRESS OR RECENTLY PERFORMED THAT WOULD AFFECT CONTROL ROD DRIVES
12. REVIEWED SCRAM HISTORY FOR PREVIOUS FAILURES
13. PERFORMED PRESSURE, FLOW AND DRAIN TIME TESTING ON EAST AND WEST HEADERS
14. GE ENGINEERS PERFORMED EXTENSIVE EVALUATIONS AND INSPECTIONS.
15. CUT AND INSPECTED 2-INCH LINE AND VENT HEADER PIPING WITH BOROSCOPE INSPECTION OF 6-INCH HEADERS AND SCRAM DISCHARGE INSTRUMENT VOLUME
16. GE ISSUED TWO SERVICE INFORMATION BULLETINS

17. GE PERFORMED TEST ON CONTROL ROD DRIVE AND PRESSURE VESSEL MOCKUP IN SAN JOSE
18. PERFORMED TESTS TO CONFIRM ADEQUACY OF ULTRASONIC TESTING TO MEASURE WATER LEVEL IN SCRAM DISCHARGE VOLUME 6-INCH HEADERS
19. PERFORMED DRAIN TEST TO DEMONSTRATE THAT THE SYSTEM WILL DRAIN IN A PREDICTABLE MANNER FROM A NORMAL ALIGNMENT
20. PERFORMED VACUUM HOLD TEST TO DEMONSTRATE THAT A BLOCKED VENT PATH WILL RESTRICT DRAINAGE OF THE SIX-INCH SCRAM DISCHARGE PIPING
21. FRICTION TEST - DEMONSTRATE NORMAL INSERT - WITHDRAWAL OPERATION OF THE DRIVES IN THE EAST BANK
22. SCRAM TESTING

    A. FULL SCRAM TEST AT RATED CONDITIONS FROM ZERO POSITION TO VERIFY PROPER OPERATION OF ELECTRIC COMPONENTS AND HYDRAULIC CONTROL UNITS

    B. INDIVIDUAL ROD SCRAMS AT VARIOUS CONDITIONS FROM POSITION 48 TO VERIFY SCRAM CAPABILITY WITHIN TECH SPECS TIMES (EAST BANK RODS)

23. PERFORMED SCRAM TIME TEST OF FIVE RODS THAT FULLY INSERTED AND FIVE THAT DIDN'T ON THE EAST BANK - NO DIFFERENCE
24. CHECKED FOR SCRAM DISCHARGE VALVE LEAKAGE EVERY 200 POUNDS WHILE INCREASING REACTOR PRESSURE
25. GE RECOMMENDED RESTART OF REACTOR TO PERFORM SCRAM TESTS
26. TVA ON-SITE SAFETY REVIEW COMMITTEE RECOMMENDED RESTART
27. TVA NUCLEAR SAFETY REVIEW COMMITTEE RECOMMENDED RESTART
28. NRC ISSUED IE BULLETIN 80-17
29. LICENSEE PERFORMED ACTIONS OF IE BULLETIN 80-17
30. NRC ISSUED CONFIRMATION OF CONCURRENCE LETTER TO ALLOW RETURN TO POWER

10. Electrical System Review

NRC inspectors on site reviewed the licensee's efforts and performed independent inspections to determine if the cause of the failure to fully insert control rods was of electrical origin.

The inspector reviewed the referenced Reactor Protection System (RPS) drawings and inspected the installation to determine whether possibilities of a common mode failure exist within the system. In addition, the inspector traced some of the licensee's post incident trouble shooting efforts.

References:

- Browns Ferry Unit 3 Reactor Protection System Drawing, 730E915 sh 8, 11, 13, 15 and 16.
- Browns Ferry Unit 3 Manual Control System Drawing, 730E321 sh 4.
- Browns Ferry Unit 3 CRD Hydraulic System, 47W616-85.
- Browns Ferry Unit 1, 2, and 3 Sequential Event Recording Wiring Diagrams, 45N621.
- Browns Ferry Unit 3, Sequence of Event Recording on 6/28/80.

Findings:

a. Scram Valve/Vent and Drain Valve Control - The RPS logic for this control is designed such that loss of instrument air to the hydraulic Control Modules (HCU) will result in a scram. Instrument air is needed to keep the inlet and outlet scram valves closed. A full scram removes air from these valves, causing them to open. Each scram valve has a position switch associated with it to show that it actually changed position. Both inlet and outlet scram valves for each control rod must be in the open position to illuminate a blue scram indicator light for the individual control rod. The licensee stated that their operators verified illumination of all blue lights following the first manual scram. This confirms that all the scram valves responded to the manual scram signal.

   During a scram, the scram pilot valves de-energize and block the flow of instrument air to the scram valves. The scram pilot valves are designed fail-safe since a loss of power to the solenoids, due to an initiation of a scram (manual or automatic), causes a loss of instrument air. The inspector verified from the sequence of events that the loss of power occurred during the first manual scram. Subsequently, automatic scrams occurred from reactor process instrument signals such as Lo Reactor Water Level and Scram Discharge Instrument Volume High Water Level. These scrams as well as the initial manual scram positively interrupted power to the solenoids in the HCUs located in both the east and west division. The referenced drawing showed that this power interruption of a given CRD group should occur simultaneously at both the east and west locations because a common scram contactor supplies power to both of the solenoids. The drawing also shows that 4 CRD electrical groups are dispersed evenly throughout the core in both the east and west divisions. This confirms that the scram pilot valves assigned to both divisions de-energized following the first manual scram.

The inspector verified from the sequence of event parameters such as Discharge Volume High Water Level and Group 1 Scram Contactors, that RPS scram discharge volume vent and drain valves operated throughout the entire event, providing relief in the dicharge volume.

b. Layout Inspection - The inspector examined, on July 2,1980, 8 fuse boxes (4 in each division) and 2 scram contactor cabinets located in the Auxiliary Instrument Room, for any physical degradation of components or layout modifications. There was no apparent sign of degradations or alternations.

c. Scram Relay Response Times - The inspector reviewed a test record of SMI 150, RPS Scram Solenoid Relay Response Times, conducted on 6-28-80, right after the event. This confirmed that the scram contactor relays were operated (de-engerized) within specified time limits.

No deviations or items of noncompliance were identified in this area.

11. GE Tests

General Electric Company conducted tests in San Jose in days following the event to try to simulate responses observed at Browns Ferry. Tests were witnessed by a Region V inspector. The tests demonstrated on the one control rod prototype that 0.9 gallons were discharged from a scram stroke, 1.6 gallons per minute per drive continued into the SDV following a scram, and that a control rod would stop at an intermediate position if the space available in the SDV were limited. Initial data on varying CRD leakage rates were inconclusive. These results appeared consistent with conditions observed during this event.

12. Additional Information

a. Unit 2 tripped midmorning on June 28 due to loss of condenser vacuum. Control rod response was normal.

b. Three additional GE engineers arrived onsite on July 1 to assist TVA in the investigation.

c. The NRC task force was provided a detailed briefing of the event, investigations to date and status on July 2, 1980.

13. Summary

The most likely cause of this event was due to water accumulation in the scram discharge volume east header before the scram. The exact cause of this accumulation was not definitely established. There is good reason to think that the cause was a failure of the east scram discharge volume header to drain following the previous scram or from other inleakage that failed to drain. This appears to have been caused by a blockage of either the 2" drain line or the vent line to the clean rad waste system. There is no evidence of fuel damage as a result of this event. There was no abnormal release of radioactivity during this event. The event served to point up several apparent design deficiencies in the SDV system at Browns Ferry. These items have been referred to IE Headquarters and NRR for evaluation.

Items identified included the following:

a. The east and west SDV headers do not have positive redundant vents to atmosphere. They are vented to the Reactor Building Equipment Drain Tank via a large closed volume of piping which receives water drainage from many sources throughout the plant. Thus venting of the SDVH may be impaired by the actions of other systems.

b. The six level switches on the SDV system failed to detect water levels in the east SDVH which prevented rods on the east side of the core from fully inserting. These switches are all located on a single instrument volume which is remote from the east SDVH. Improved monitoring is necessary. An ultrasonic technique of monitoring the SDVH was refined during the inspection. Verification by this method that Unit 1 and 2 SDVH were empty was first made on July 1, 1980.

c. Electrically the control rods are divided into four groups dispersed throughout the core. This event demonstrates that due to the hydraulic piping all the rods on one side of the core could be commonly affected.

d. During this event, the Rod Sequence Control System prevented the operators from selecting a control rod to manually insert.