NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	1 OF 1 1

TITLE (4): High Reactor Pressure Scram & Ensuing Control Rod Automatic Insertion Failures

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 6	2 3	8 4	8 4	— 0 0 8	— 0 0	0 7	2 3	8 4	N/A	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): 0 2 3

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

	20.402(b)		20.405(c)	X	50.73(a)(2)(iv)		73.71(b)
	20.405(a)(1)(i)		50.36(c)(1)	X	50.73(a)(2)(v)		73.71(c)
	20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)		OTHER (Specify in Abstract below and in Text, NRC Form 366A)
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		
	20.405(a)(1)(iv)		50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
	20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER	
	AREA CODE	
Frank Novachek, Technical Services Engineering Supervisor	3 0 3	7 8 5 - 2 2 2 4

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
X	A A	J C	G 0 6 3	Y					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
X YES (If yes, complete EXPECTED SUBMISSION DATE)	NO		1 0	2 3	8 4

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

At 0029 on June 23, 1984, with reactor power at 23%, the Plant Protective System (PPS) initiated an automatic scram upon sensing higher than normal pressure in the Prestressed Concrete Reactor Vessel (PCRV). Prior to the high pressure trip, an orderly shutdown from 40% power was in progress due to high primary coolant moisture levels following an automatic trip action on "A" helium circulator.

As the orderly shutdown and corresponding vessel depressurization were in progress, the normal depressurization flowpath became blocked causing the eventual high pressure trip. The automatic actuation of the PPS scram circuitry is being reported under Section 50.73(a)(2)(iv).

The reactor went subcritical immediately following the automatic scram action, but it was noted that 6 of the 37 control rod pairs had failed to automatically insert. The six rod pairs were manually driven into the core within 20 minutes following the event. The reactor remained subcritical throughout the event and the independently redundant reserve shutdown system was available as designed. The conditions of this event are under investigation to determine the potential impact on the automatic safe shutdown function of the control rod system. Therefore, this event is also being reported under Section 50.73(a)(2)(v) for its potential impact in preventing an automatic safe shutdown.

H005 1/1

<u>BACKGROUND</u>: (Fort St. Vrain FSAR Section 3.8)

The control rod drives are essentially electrically powered winches, which raise and lower the control rods by means of flexible steel cables. Gravitational force acts to propel the control rods into the core during a scram, the free-fall speed being controlled by a velocity limiting system (Figure 1). All control rod drives are of identical design and have the same operating characteristics.

The control rod drive mechanism operates in a helium environment within the PCRV at reactor pressure (Figure 2). Ambient temperature is nominally maintained at approximately 150 degrees Fahrenheit by the refueling penetration cooling system and a thermal barrier between the drive and the reactor core. Shielding, interposed between the drive and the reactor core, limits the radiation level at the control rod drive to approximately 1 rad per hour. A helium purge flow of about 5.5 pounds per hour floods the drive assembly and prevents the ingress of contaminated reactor helium coolant (Figure 3).

The principal components of the control rod mechanism are the drive motor, motor brake, reduction gearing, rod position potentiometer, limit switches, limit switch cams, slack cable indication device, duplex cable drum, control rod guide tubes, and 1/4 inch diameter suspension cables.

The control rod drive raises and lowers the two control rods simultaneously by winding and unwinding the control rod suspension cables from a common drum having two winding grooves. This drum is made up of three plates which are bolted together. The two joints formed by the three plates are machined to form two deep spiral grooves. Each of the two cables is attached to its respective drum groove by an anchor swaged to the cable. The anchor rides in bushings pressed into the drum plates and is therefore able to rotate as required. The spiral grooves are machined such that each successive wrap of cable lies properly on the previous wrap. From their anchor point on the cable drum, the cables pass through a guide pulley assembly consisting of three pulleys mounted approximately 18 inches below the centerline of the drum. The guide pulleys maintain the cables at the current center distance, where they enter the radiation shield below the drive mechanism.

The control rods are electrically controlled by the shim motor and brake assembly. The shim motor and brake assembly is assembled as a unit having a single shaft and can be easily disconnected from the gear train by removing two screws. The shim motor is a 3-phase, 4-pole induction motor operating at 60 cycles, 105 volts, and approximately 1750 rpm. Attached to the motor shaft is an electromagnetic friction disc brake. The brake is spring-released when de-energized. Thus, the brake, when energized and applied, retains the control rods in a withdrawn position. When a scram is initiated, the brake is de-energized and released, allowing the rods to fall into the core under gravitational force.

A 3-phase capacitor array is permanently connected to the motor circuit; thus, when the motor is rotated under the influence of the falling rods, it functions as an induction generator supplying a capacitive-resistive load, the characteristic frequency of which determines the limiting speed of the motor and, consequently, the control rod insertion velocity. The rod velocity during a scram, in this case, is controlled at a value approximately 15% in excess of the shim speed (i.e., scram speed is about 1.25 inches per second). The initial excitation of the motor for operation as an induction generator is provided by residual magnetism built into the motor.

Rod-out and rod-in position indication is provided by cam-actuated switches. The cams are mounted on a drum which is gear-driven by the rod position potentiometer drive shaft. This shaft is directly coupled to the cable drum through a gear train and rotates as required for the full rod travel.

All bearings and gears in the drive assembly are treated with a thoroughly tested dry film lubrication technique which is essentially unaffected by the existing radiation and temperature levels. Bearings and gears are fabricated of materials proved by extensive testing to be suitable for dry film lubrication in a purified helium environment. The bearings are of a special construction compatible with such duty. Motor winding insulation is a high grade material, found by test to be necessary in a low-dielectric-strength gaseous environment; the stator windings are entirely encapsulated as an additional precaution against shorting to the frame and laminations.

With the rods in the inserted position, rod movement is initiated by applying electric power to the drive motor and simultaneously de-energizing the motor brake. The cables then begin to wind onto the drums and withdraw the rods. The limit switch cams release the rod-in switch, causing the "rod in" light on the console to be extinguished. Rod position is transmitted to the console by a potentiometer coupled directly to the drum gearing. As a precaution against loss of rod position indication, both the rod-in and rod-out limit switches and the rod position potentiometer transmitters are duplicated. Also, there are two slack cable sensing switches.

Failure or removal of both AC and DC power from any one drive will allow the rods controlled by that drive to drop into the core under the dynamic braking control of the motor and capacitor system. If the AC motor power fails and DC brake power is maintained (no scram signal), the control rods will retain their position. If DC brake power fails (no scram signal), the rods will drop into the core under dynamic braking control. The DC brake power must be maintained if the rods are to be held steady at any position other than fully inserted.

EVENT DESCRIPTION:

The sequence of events leading up to the high pressure scram began at 1404 hours on June 22, 1984, with the reactor at about 50% power. A rapid rise pressure relay on auxiliary transformer 1 tripped, resulting in a temporary loss of 480V Essential Bus 1 (until the Bus-tie breaker closed). The temporary loss of Bus 1 power resulted in a loss of normal bearing water supply to both helium circulators (A and B) in Loop 1, initiating backup bearing water (BUBW) to be supplied. The surge of BUBW caused an upset in the buffer helium system, which functions as the interface between the high pressure bearing water being supplied to the circulator shaft and the primary coolant helium. The buffer helium upset automatically tripped "A" circulator, but difficulty in setting the shutdown seal was experienced. Reactor power was manually run back to 30%, the Interlock Sequence Switch (ISS) was placed in the "low power" position, and the regulating control rod was returned to automatic control.

Several minutes later, evidence of rising primary coolant moisture levels were seen on both the Plant Protective System (PPS) Moisture Monitors and the analytical system moisture monitor in service. The analytical moisture monitor stabilized in the range of 40→70 ppm, and was subsequently monitored to establish primary coolant moisture levels.

"A" circulator was available for restart about 60 minutes after the accident started and was returned to service around 1620. Reactor power had been returned to about 40%, and full circulator operation at this level continued until about 2000 at which time the decision was made to begin an orderly shutdown on account of moisture. At this time, it became evident that the helium purification train, which is used in decreasing vessel pressure in accordance with power level, was icing up due to the high moisture levels. The turbine was tripped at 2144 with power at about 30%.

At 0029, with reactor power at 23% and being decreased, the reactor automatically scrammed on programmed vessel pressure high. Although the reactor was verified subcritical following the automatic scram, it was noted that 6 of the 37 control rods (in Regions 6, 7, 10, 14, 25, and 28) had failed to automatically insert and these were manually driven in over the following 20 minute interval (see Figure 4). A subsequent calculation using a computer code analysis (Gauge) verified that a shutdown margin of 0.0225 delta ρ (Keff = 0.978) existed even with the above rods not scrammed. The Fort St. Vrain Technical Specifications consider 0.01 delta ρ to be an acceptable shutdown margin.

ANALYSIS OF EVENT:

The PPS scram circuitry correctly sensed above normal pressure in the PCRV and initiated protective action as designed. However, protective action was not necessary during this condition since the high pressure was not the result of a steam generator tube or subheader rupture which would have the potential for increasing reactor pressure beyond the setting of the PCRV safety valve resulting in an unplanned radiological release. The temporary introduction of moisture through a malfunction of the backup bearing water system and the circulator shutdown seal is considered an operational concern and is under investigation.

The icing up of the helium purification system is not considered an abnormal occurrence under the observed high moisture conditions and would likely have resulted in the observed mismatch between programmed PCRV pressure and core temperature (decreasing with power level) initiating a programmed high reactor pressure scram via the plant protective system.

The blockage of the on-line helium purification train caused a loss of the helium purge flow which normally provides the control rod drive assembly with a supply of clean helium and limits the upward flow rate of contaminated or moisture laden primary coolant helium. The significance of a loss of purge flow coincident with high primary coolant moisture levels is under investigation with respect to control rod operability.

The failure of the six control rod pairs to automatically insert is considered to have possible significant safety implications and an extensive investigation is in progress to ascertain possible causes and identify any necessary corrective actions to prevent reoccurrence. Although the reserve shutdown system was available and was designed to provide an independent, alternate means of achieving shutdown conditions from any operating condition without any movement of the control rods, the ability of the control rod system to safely shut down the reactor under postulated abnormal conditions should be maintained.

CAUSE DESCRIPTION:

The automatic scram was initiated by the PPS upon sensing higher than normal pressure in the PCRV caused by ice blockage in the on line helium purification train coincident with a reduction in power which correspondingly reduced the programmed high primary coolant pressure setpoint.

At the present time, it has not been definitely determined what the actual cause of the observed control rod system failures was. The visual examinations thus far have revealed evidence of minor oxidation of the carbon steel components, previous moisture condensation, and small quantities of unidentified particualte matter. But there has been no evidence of excessive wear, pitting, improper lubrications, gear misalignment, or other conditions which could have resulted in CRDOA inoperability. No evidence of brake seizure or locking has been found either.

The event appears to be due primarily to the specific plant conditions that existed immediately prior to the observed failures: high primary coolant moisture levels and loss of CRDOA purge flow and subsequent effects of these environmental conditions on the CRDOA shim motor rotor bearings. However, the investigation will continue as outlined and these observations and ideas should be considered preliminary and not conclusive.

CORRECTIVE ACTIONS:

The actions to date, along with those that have been planned to date include the following:

1) Motor power consumption profiles have been obtained and scram verifications have been made for all 37 control rod drive and orifice assemblies (CRDOAs) resident in the core on June 23, 1984.

2) Examination of the control rod drives from Regions 7 and 14 is complete.

3) Examination of the control rod drive from Region 10 is currently in progress.

4) Investigations into the effects of purge flow loss coincident with high primary coolant moisture levels are continuing.

5) Collection of particulate matter found in the CRDOA subassemblies is in progress, and analysis for constituent parts will be performed. (NOTE: Successful analysis is contingent upon sufficient particulate being available for collection).

6) Disassembly and inspection of the motor-brake assemblies of the CRDOA's that failed to scram on June 23, 1984 is continuing.

7) A functional test of two reserve shutdown hoppers, along with a physical examination of the material is planned.

8) The disassembled components of the CRDOAs inspected will be cleaned as appropriate, using wet or dry wiping, nitrogen blowdown, or alcohol solution methods.

9) A test to determine the sensitivity of the motor bearing assembly to moisture relative to free rotational torque will be performed.

10) A test to determine the effects of exercising a CRDOA to ascertain the self cleaning characteristics of the assembly will be performed.

11) Disassembly and inspection will be performed on the motor-brake assemblies of two additional CRDOAs which properly scrammed on June 23, 1984. In addition, one of the selected CRDOA's will undergo disassembly and inspection of its 200 Assembly gear train.

The specific cause of the observed control rod scram failures continues to be investigated. The results of such investigations will be provided in a supplemental report.

Related Reports: RO 82-007

NRC Form 366A (9-83)

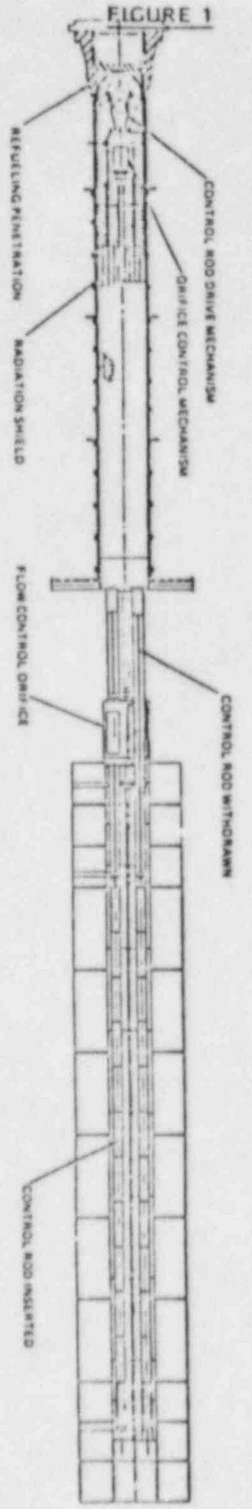
LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	8 4	— 0 0 8	— 0 0	0 7 OF 1 1

TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 1



NRC Form 366A
(9-83)

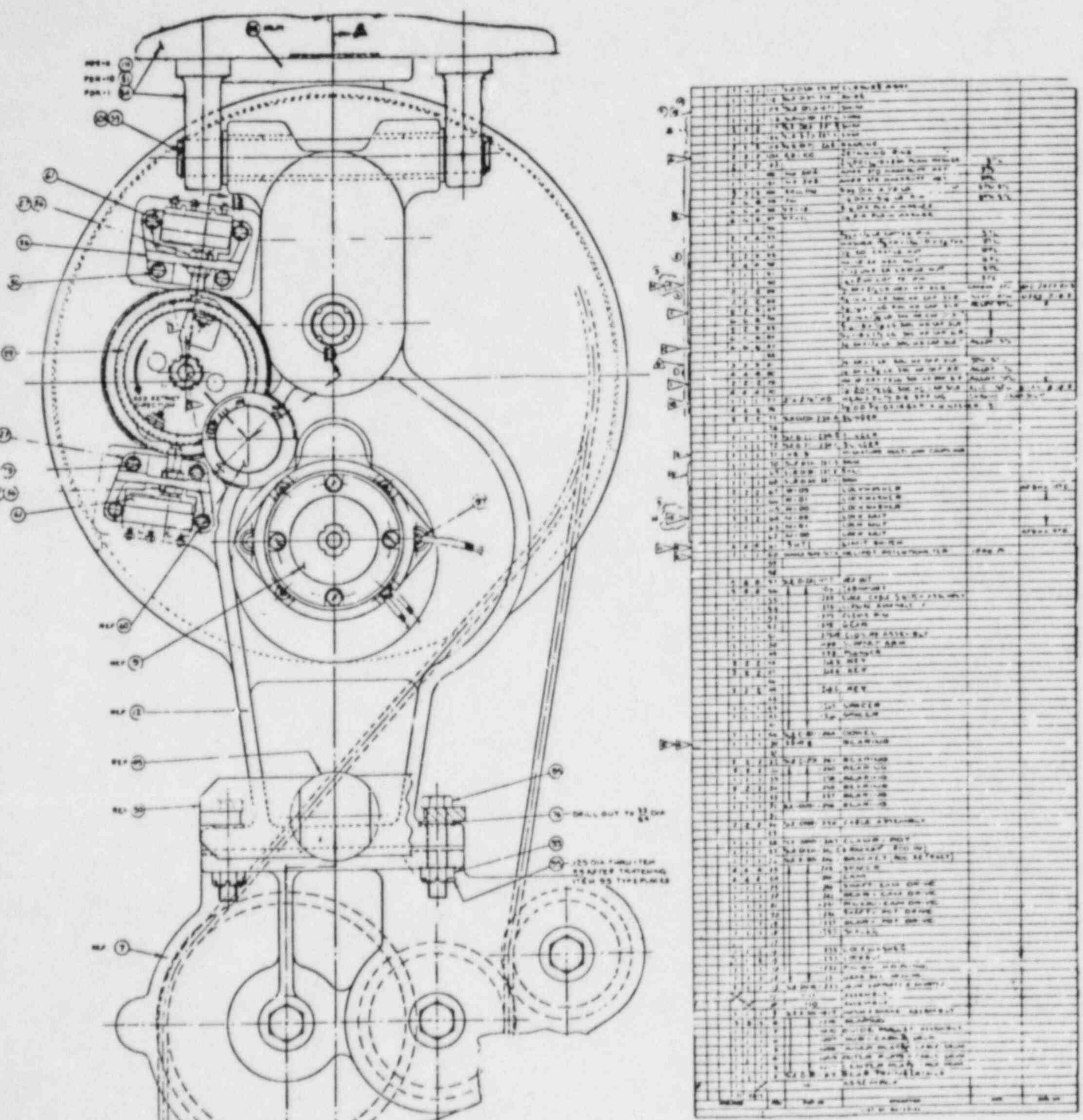
U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	8 4	— 0 0 8 —	0 0	0 8 OF 1 1

TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 2



NRC Form 366A (9-83)

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104

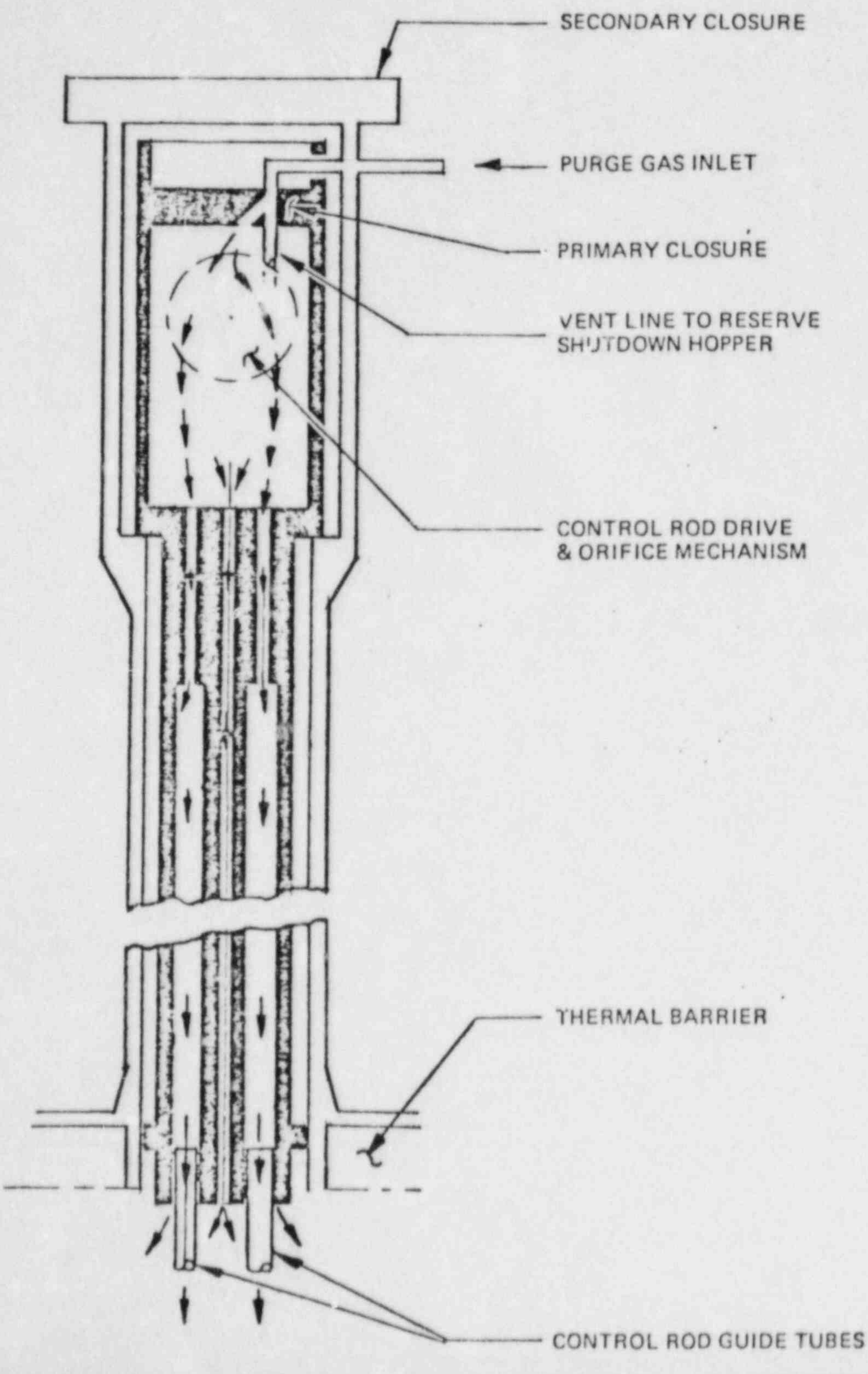
EXPIRES 8/31/85

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Fort St. Vrain Unit No. 1	0 5 0 0 0 2 6 7	8 4	— 0 0 8	— 0 0	0 9 OF 1 1

TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 3



FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	8 4	— 0 0 8 —	0 0	1 0 OF 1 1

TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 4

CORE MAP

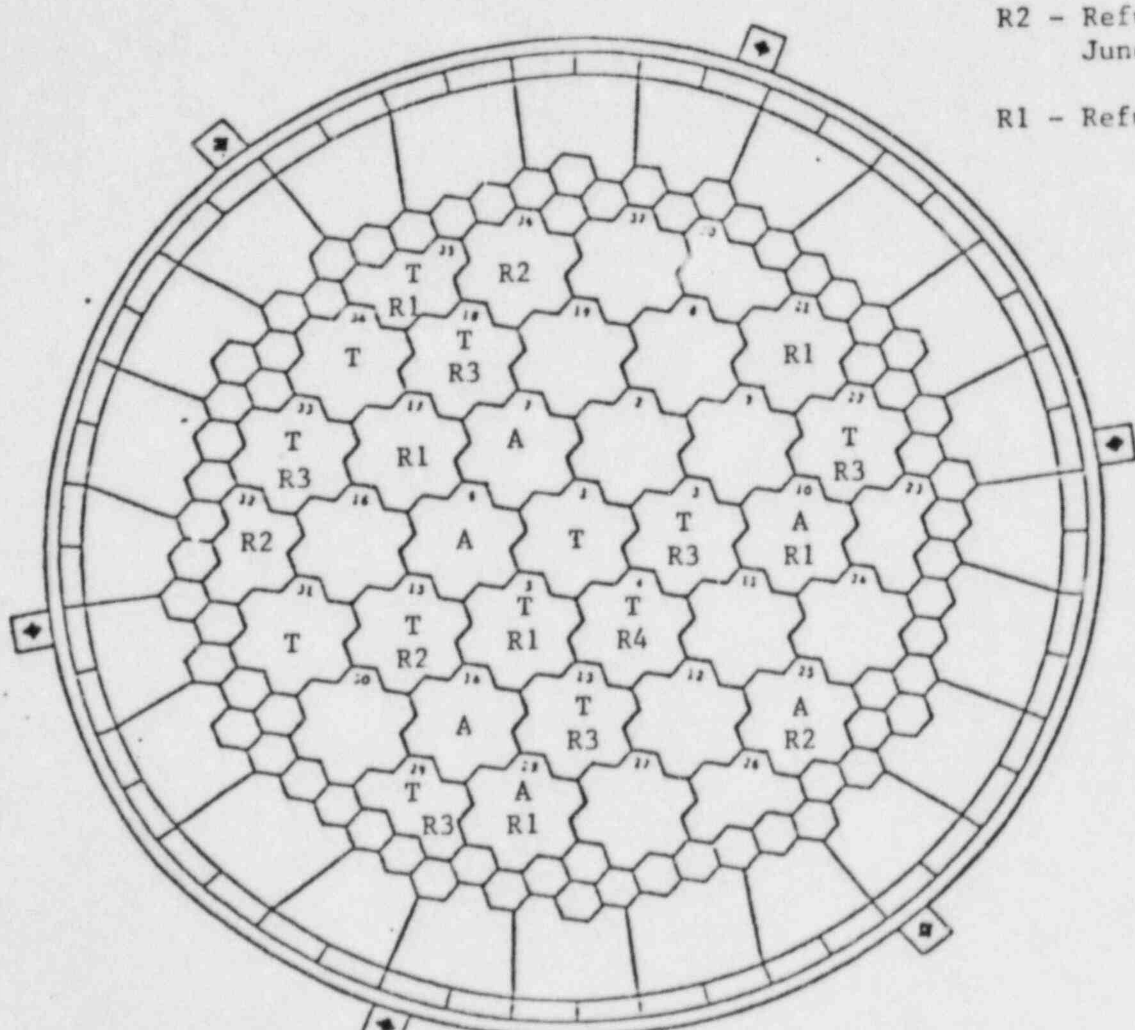
A - Affected Regions

T - Temperature Indication (as of 6-22-84)

R3 - Refueled, February-March, 1984

R2 - Refueled, June-July, 1981

R1 - Refueled 1979



LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	8 4	— 0 0 8 —	0 0	1 1 OF 1 1

TEXT (If more space is required, use additional NRC Form 366A's) (17)

Mark A. Joseph
Mark A. Joseph
Techical Services Engineer

Frank J. Novachek
Technical Services Engineering Supervisor

L. Milton McBride
L. M. McBride
Station Manager

Don Warembourg
Don Warembourg
Manager, Nuclear Production

Public Service Company of Colorado

16805 WCR 19 1/2, Platteville, Colorado 80651

50-267

RECEIVED
JUL 25 1984

July 23, 1984
Fort St. Vrain
Unit #1
P-84228

Mr. E. H. Johnson, Chief
Reactor Project Branch 1
Region IV
Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, TX 76011

REFERENCE: Facility Operating License No. DPR-34

Docket No. 50-267

Dear Mr. Johnson:

Enclosed please find a copy of Licensee Event Report No. 50-267/84-008, Preliminary, submitted per the requirements of 10 CFR 50.73(a)(2)(iv) and (a)(2)(v).

Very truly yours,

Don Warembourg

Don Warembourg
Manager, Nuclear Production

DWW/djm

Enclosure

cc: Director, MIPC

H005 1/1