

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1) Fort St. Vrain, Unit No. 1 DOCKET NUMBER (2) 050002671 OF 17

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) | | | | | |
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| OPERATING MODE (9) | THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR 5: (Check one or more of the following) (11) | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------|---|--------------------|--|-----------------|----------|-----------------|--------------|-----------------|----------|------------------|--------------|----------------|--|-------------------|----------------|--------------------|--|------------------|-----------------|--------------------|--|-----------------|------------------|-----------------|--|
| N | <table border="1"><thead><tr><th>20.402(b)</th><th>20.408(a)</th><th>20.73(a)(2)(iv)</th><th>73.71(b)</th></tr></thead><tbody><tr><td>20.408(a)(1)(i)</td><td>20.408(a)(1)</td><td>20.73(a)(2)(iv)</td><td>73.71(a)</td></tr><tr><td>20.408(a)(1)(ii)</td><td>20.408(a)(2)</td><td>20.73(a)(2)(v)</td><td>OTHER (Specify in Abstract below and in Text, NRC Form 366A)</td></tr><tr><td>20.408(a)(1)(iii)</td><td>20.73(a)(2)(i)</td><td>20.73(a)(2)(vi)(A)</td><td></td></tr><tr><td>20.408(a)(1)(iv)</td><td>20.73(a)(2)(ii)</td><td>20.73(a)(2)(vi)(B)</td><td></td></tr><tr><td>20.408(a)(1)(v)</td><td>20.73(a)(2)(iii)</td><td>20.73(a)(2)(ix)</td><td></td></tr></tbody></table> | 20.402(b) | 20.408(a) | 20.73(a)(2)(iv) | 73.71(b) | 20.408(a)(1)(i) | 20.408(a)(1) | 20.73(a)(2)(iv) | 73.71(a) | 20.408(a)(1)(ii) | 20.408(a)(2) | 20.73(a)(2)(v) | OTHER (Specify in Abstract below and in Text, NRC Form 366A) | 20.408(a)(1)(iii) | 20.73(a)(2)(i) | 20.73(a)(2)(vi)(A) | | 20.408(a)(1)(iv) | 20.73(a)(2)(ii) | 20.73(a)(2)(vi)(B) | | 20.408(a)(1)(v) | 20.73(a)(2)(iii) | 20.73(a)(2)(ix) | |
| 20.402(b) | 20.408(a) | 20.73(a)(2)(iv) | 73.71(b) | | | | | | | | | | | | | | | | | | | | | | |
| 20.408(a)(1)(i) | 20.408(a)(1) | 20.73(a)(2)(iv) | 73.71(a) | | | | | | | | | | | | | | | | | | | | | | |
| 20.408(a)(1)(ii) | 20.408(a)(2) | 20.73(a)(2)(v) | OTHER (Specify in Abstract below and in Text, NRC Form 366A) | | | | | | | | | | | | | | | | | | | | | | |
| 20.408(a)(1)(iii) | 20.73(a)(2)(i) | 20.73(a)(2)(vi)(A) | | | | | | | | | | | | | | | | | | | | | | | |
| 20.408(a)(1)(iv) | 20.73(a)(2)(ii) | 20.73(a)(2)(vi)(B) | | | | | | | | | | | | | | | | | | | | | | | |
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LICENSEE CONTACT FOR THIS LER (12)
NAME Jim Eggebroten, Technical Services Engineering Supervisor
TELEPHONE NUMBER
AREA CODE 3103 718151-21214

| COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13) | | | | | | | | | | |
|--|--------|-----------|--------------|-------------------|-------|--------|-----------|--------------|-------------------|--|
| CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NRC | CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NRC | |
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SUPPLEMENTAL REPORT EXPECTED (14)
YES (If yes, complete EXPECTED SUBMISSION DATE) NO
EXPECTED SUBMISSION DATE (15) 8 5 0 6 1 2

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 exceeding the floating high pressure trip point 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 driven into the core within 20 minutes following the event. The reactor remained subcritical throughout the event. 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.

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TEXT (If more space is required, use additional NRC Form 388A's) (17)

BACKGROUND: (Fort St. Vrain FSAR Section 3.8)

The control rod drives (CRD) 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 reduces 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.

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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.

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TEXT (If more space is required, use additional NRC Form 388A's) (17)

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.

Following the buffer helium upset, various low range PPS moisture monitors tripped, indicating that moisture levels were greater than 100 ppm. But actuation of the reset circuitry on various monitors cleared the trip, indicating that the moisture level was less than 100 ppm. It was postulated that the low range monitor trips were indicative of spurious sample line water entrainment, and that the homogeneous PCRV moisture level was actually less than 100 ppm. This conclusion has been supported by past monitor performance during this type of moisture ingress event.

The PPS moisture monitor intake sample lines are arranged in a rake configuration located inside of the helium circulator diffuser shroud (Figures 6, 7, and 8). A helium circulator bearing water upset injects water directly into this outlet flow path, thus causing intermittent high moisture indications. The short sample flow path and high driving head allow spurious water entrainment to be cleared. A homogeneous high moisture mixture would not allow the reset circuitry to clear the trip.

Shortly following the circulator trip, the analytical system was indicating in the range of 40 to 70 ppm, which was consistent with the reset action on the PPS monitors. However, these monitors are considered very susceptible to entrained water fouling following such an event, due to their intake location and sample line routing. The intake is located above the circulator outlet plenum and the flow path is longer and more tortuous than the PPS monitors. Spurious water entrainment would not be easily cleared due to the lower driving head and longer, more intricate flow path.

Although moisture ingress was evident, the source was known to be characteristically finite and not considered to present the possibility for increasing PCRV pressure above the setpoint of the PCRV Safety Valves, nor for causing reactivity changes due to increased moderation affects. Therefore, plant operation was held steady at approximately 30% power based on the clearing action of the PPS moisture monitors.

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"A" circulator was available for restart about 60 minutes after the incident started and was returned to service around 1620 in an effort to increase the efficiency of the helium purification moisture removal function. Full circulator operation continued until about 2000, at which time the decision was made to begin an orderly shutdown due to the persistent moisture indication. 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 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 $\Delta \rho$ ($K_{eff} = 0.978$) existed even with the above rods not scrammed. The Fort St. Vrain Technical Specifications consider 0.01 $\Delta \rho$ to be an acceptable shutdown margin.

SUMMARY OF SCRAM FAILURES:

Extensive prototype testing, initiated in 1967 to verify operability prior to plant operation, identified and resolved various failures of the control rod scram system. Failures involving the motor bearings, lubricant, cable anchor, and brake discs resulted in several design changes and prolonged demonstration testing (Reference 1).

On February 22, 1982, during routine startup operations, prior to achieving criticality, Operations personnel initiated a manual scram to comply with the requirements of LCO 4.2.11, Loop Impurity Levels. During the scram, it was noticed that the control rod drives in Regions 7 and 28 were not inserting. These rods were driven in with the rod drive motor. This event was reported through Reportable Occurrence 82-007, dated March 8, 1982. Binding or sticking of the control rod drive mechanism was postulated as the most probable cause of the failures and the affects of increased primary coolant contaminants during shutdown conditions including moisture, was noted as a probable contributor. An exercising program was initiated which involved individual full withdrawal and scram of each rod pair. Three other rod pairs exhibited sticking tendencies on the initial exercise only and the control rod in Region 7 inserted freely following several exercises. Corrective action consisted of daily exercising during the shutdown condition, and weekly performance of the normally scheduled monthly scram surveillance test upon resumption of power operation.

Six control rod pairs failed to scram on June 23, 1984, as previously described.

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TEXT (If more space is required, use additional NRC Form 388A's) (17)

Three control rod pairs demonstrated scram failures on January 14, and 15, 1985, during the extensive testing program initiated to investigate the original failures. Control Rod Drive and Orifice Assemblies (CRDOAs) 36, 17, and 15, in Regions 28, 31, and 32 respectively, demonstrated scram failures from partially inserted positions. These rod pairs had all demonstrated successful scrams prior to the experienced failures (References 1 and 2).

ANALYSIS OF EVENT:

The PPS scram circuitry correctly sensed above normal pressure in the PCRV and initiated protective action as designed. However, automatic 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. Automatic actuation of the Plant Protective System moisture monitors was also not considered necessary since the source of the moisture ingress was known to be finite, and not to have the potential for increasing PCRV pressure significantly. Plant operation with higher than normal moisture levels is controlled by Technical Specification LCO 4.2.10, which allows power operation for a period of ten days while impurities are a factor of 10 above normal (10 ppm for H₂O, CO, and CO₂), or for one day while levels are a factor of 100 above normal. The temporary introduction of moisture as a result of various malfunctions of the backup bearing water system, the circulator shutdown seal, and the auxilliary transformer pressure relay were considered operational concerns and have been thoroughly evaluated, with necessary corrective actions initiated.

The icing up of the helium purification system was not abnormal under the observed high moisture conditions. Prior to the trip, the high pressure setpoint was decreasing as programmed with circulator inlet temperature (indicating a power reduction). When the depressurization flow path was blocked, the trip point was exceeded as temperature continued to decrease without a corresponding decrease in pressure (Figure 5).

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 purified helium and mitigates to some extent the upward flow rate of high temperature, contaminated, potentially moisture-laden primary coolant helium. The significance of a loss of purge flow coincident with high primary coolant moisture levels has been investigated with respect to control rod operability through recent evaluation. It has been determined that the migration of moisture from the PCRV into the CRD motor area would not have been prevented even under full design purge flow conditions.

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CORRECTIVE ACTIONS:

| Extensive investigations have been initiated since the previous supplement and the following reports have been submitted to the Nuclear Regulatory Commission:

| 1) Control Rod System Operability Evaluation Report

| This report summarized the results of a detailed review of the Fort St. Vrain FSAR, Technical Specifications, and Controlled Documents to determine the impact of the experienced failures on the licensing basis for control rod reliability. Because the recent failures have been identified as due to long term degradation, they are not considered to impact the previous accident analyses, but a control rod drive refurbishment program along with periodic testing/maintenance programs will be implemented (Reference 3).

| 2) Control Rod Drive and Orificing Assembly Refurbishment Program Report

| This program was scheduled to begin February 1, 1985, and refurbishment of all thirty-seven control rod pairs is to be completed (Reference 3).

| 3) Control Rod Drive and Orificing Assembly Proposed Preventive/Predictive Maintenance Program

| This program analyzes each significant component of the control rod system and identifies: a) appropriate preventive maintenance to be performed on the CRDOAs normally taken out of the core for refueling purposes, and b) predictive maintenance techniques to monitor and evaluate control rod drive performance periodically during the cycle (Reference 3).

| 4) Control Rod Drive and Orificing Assembly Interim Surveillance Program Report

| This report describes the specific functions and components which will be tested on a weekly, quarterly, or refueling cycle basis for control rod drives and associated position instrumentation (Reference 3).

| 5) Failures To Scram - Control Rod Drive and Orifice Assemblies

| This report investigates a variety of possible failure mechanisms through qualitative component analyses and quantitative functional testing. The report concludes that internally generated normal wear byproducts in the control rod drive motor bearings is a likely cause of the scram failures. Additional testing is planned to further evaluate and identify this mechanism.

| The report also proposed specific testing and acceptance criteria for use in ensuring reliable control rod operation following the refurbishment process and during power operation. Further operational data and analysis will be required in developing the final testing techniques and acceptance criteria (Reference 1).

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| 6) Control Rod Drive Cable Replacement

| This report outlines the identification, analysis, and resolution of a deficiency discovered in the condition of the control rod drive cables. All control rod cables will be replaced as part of the overall control rod refurbishment program. The replacement cable, Inconel 625, will not be susceptible to the identified degrading mechanism (Reference 5).

| Functional testing of two reserve shutdown hoppers and material examination was completed with unacceptable results on one hopper. The unacceptable discharge was identified by LER 84-012, and the specific failure mechanism analyzed and corrective action proposed in a special report submitted to the Nuclear Regulatory Commission on January 28, 1985 (Reference 4).

| A supplemental report will follow summarizing the status of the refurbishment, surveillance, and maintenance programs.

| References:

- | 1) PSC Letter, D. W. Warembourg to E. H. Johnson, 1/31/85 (P-85037).
- | 2) PSC Letter, O. R. Lee to E. H. Johnson, 1/28/85 (P-85030).
- | 3) PSC Letter, J. W. Gahm to R. Martin, 1/31/85 (P-85040).
- | 4) PSC Letter, O. R. Lee to E. H. Johnson, 1/28/85 (P-85027).
- | 5) PSC Letter, O. R. Lee to E. H. Johnson, 1/30/85 (P-85032).

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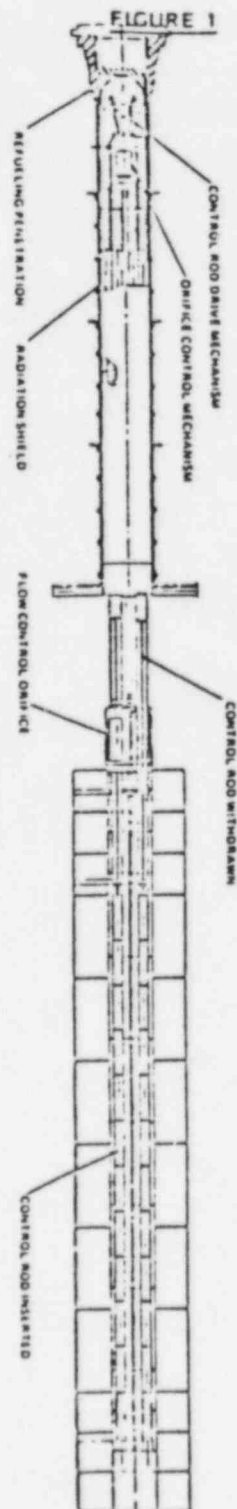
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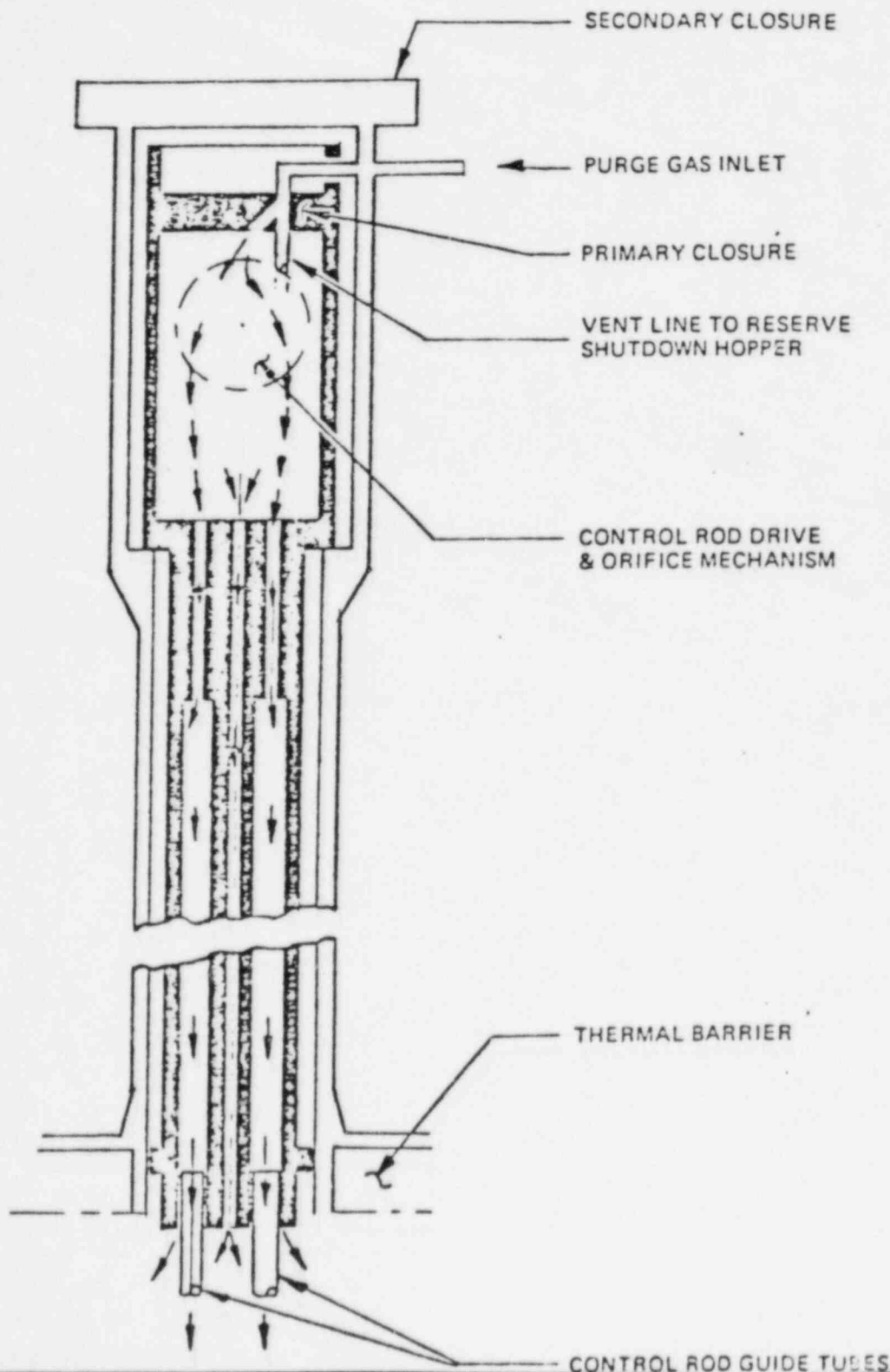
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FIGURE 3



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FIGURE 4

CORE MAP

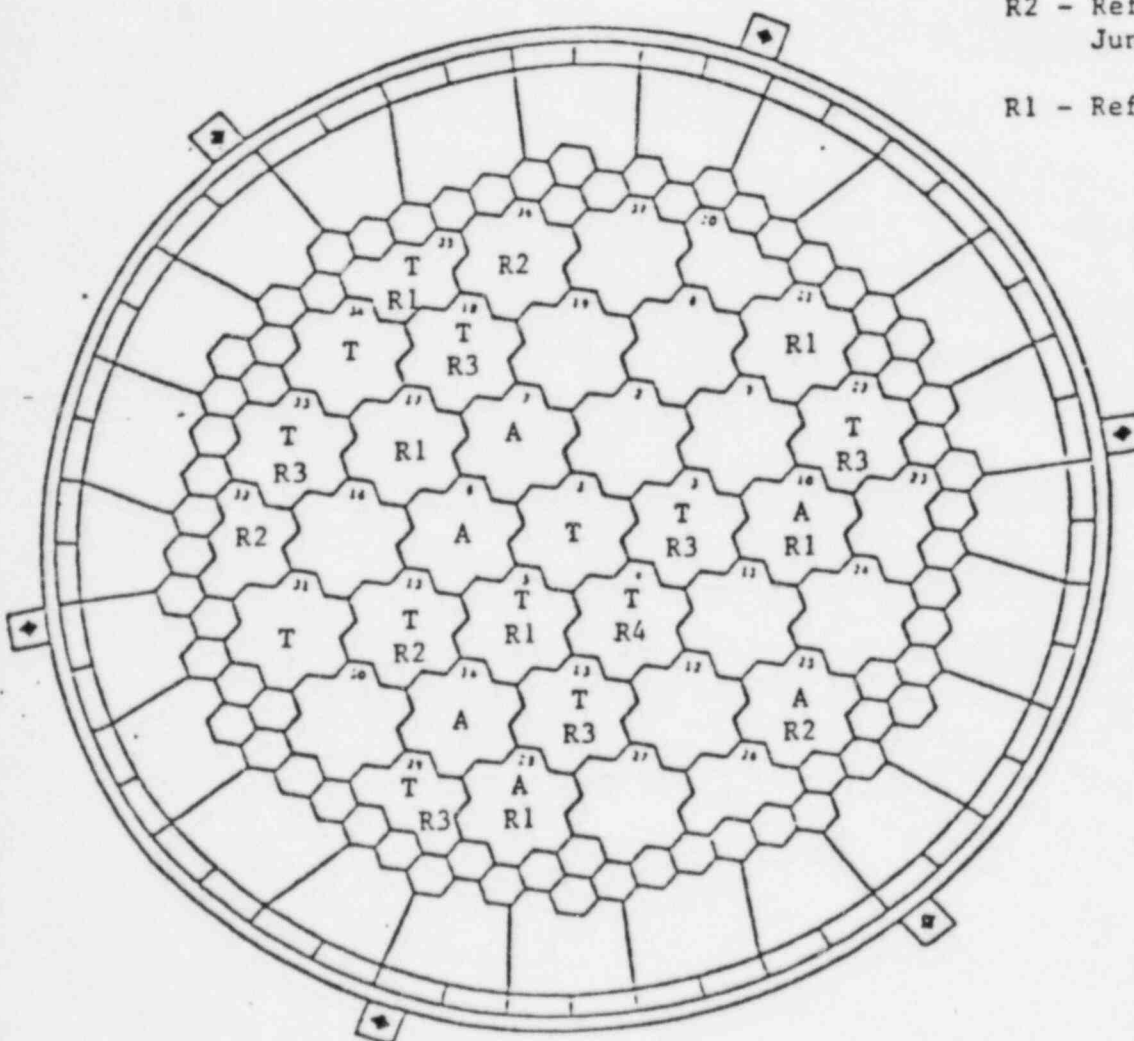
A - Affected Regions

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

R3 - Refueled,
February-March, 1984

R2 - Refueled,
June-July, 1981

R1 - Refueled 1979



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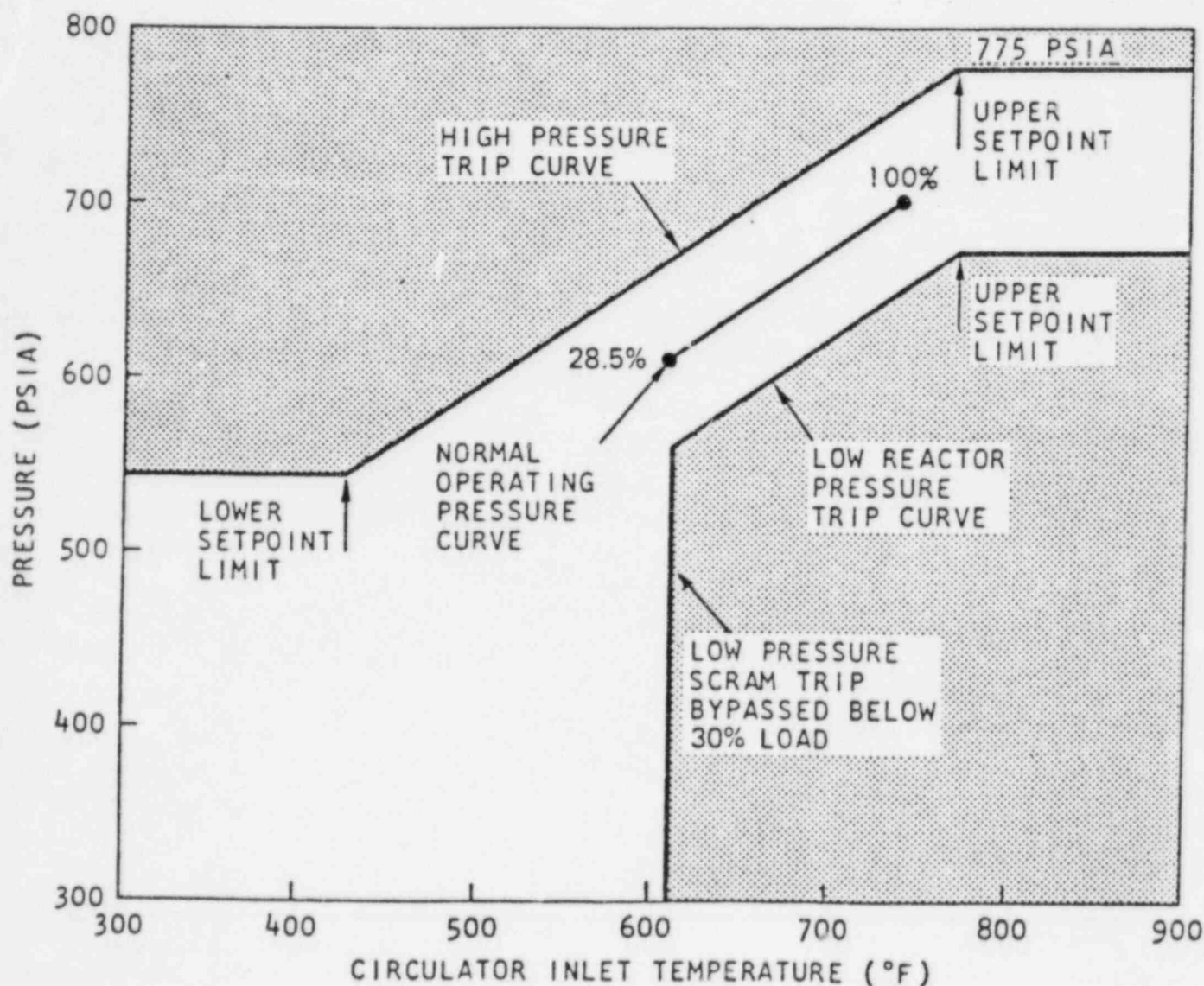
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FIGURE 5



Programmed Reactor Pressure High-Low Trip Points

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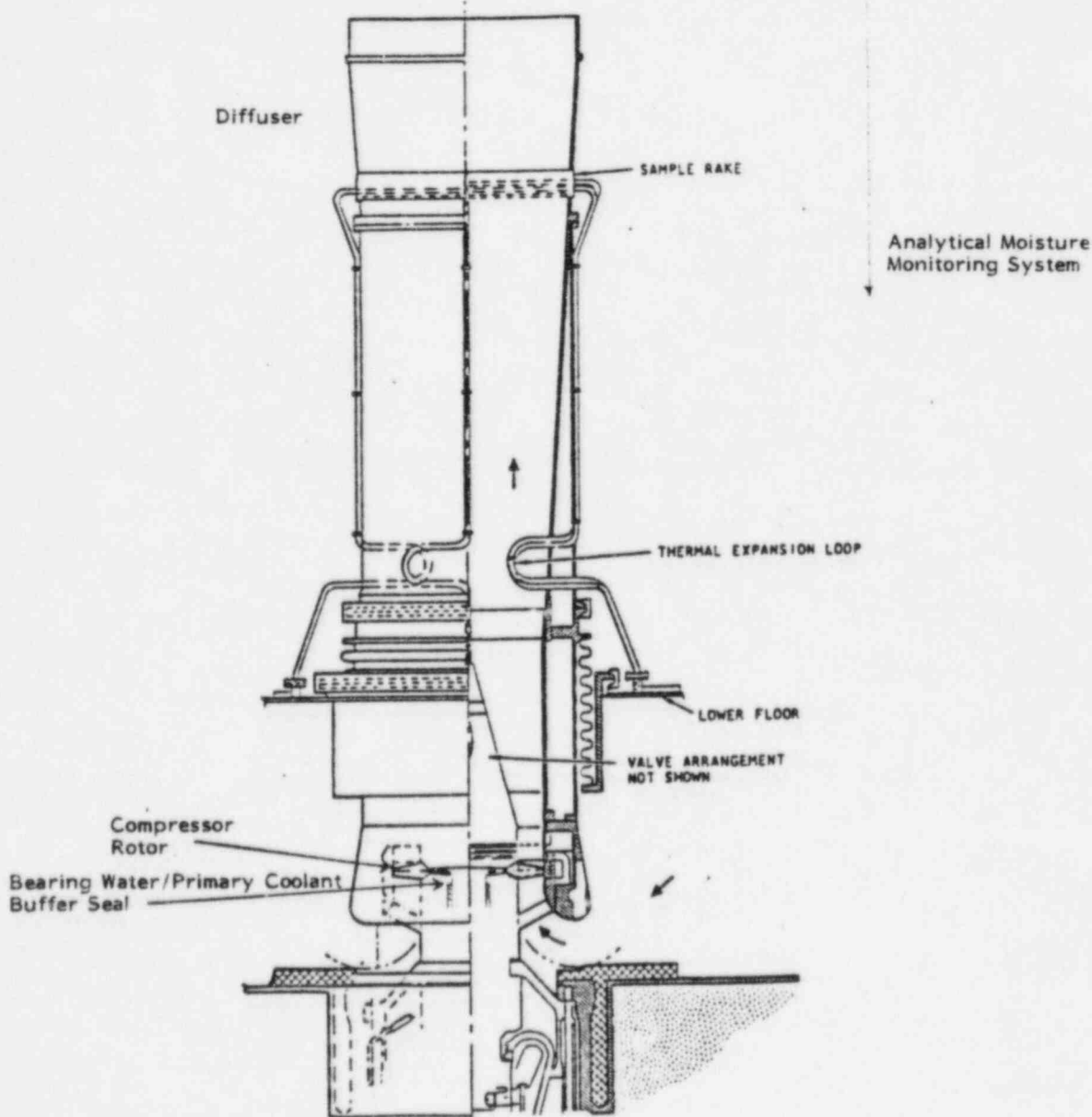
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FIGURE 6

Core Outlet Plenum

Circulator Outlet Plenum

UPDATED FSAR
Revision 2



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FACILITY NAME (1)

Fort St. Vrain, Unit No. 1

DOCKET NUMBER (2)

0 5 0 0 0 2 6 7 8 4 - 0 0 8 - 0 2 1 5 OF 1 7

LER NUMBER (8)

PAGE (3)

YEAR

SEQUENTIAL NUMBER

REVISION NUMBER

TEXT (If more space is required, use additional NRC Form 386A s) (17)

FIGURE 7

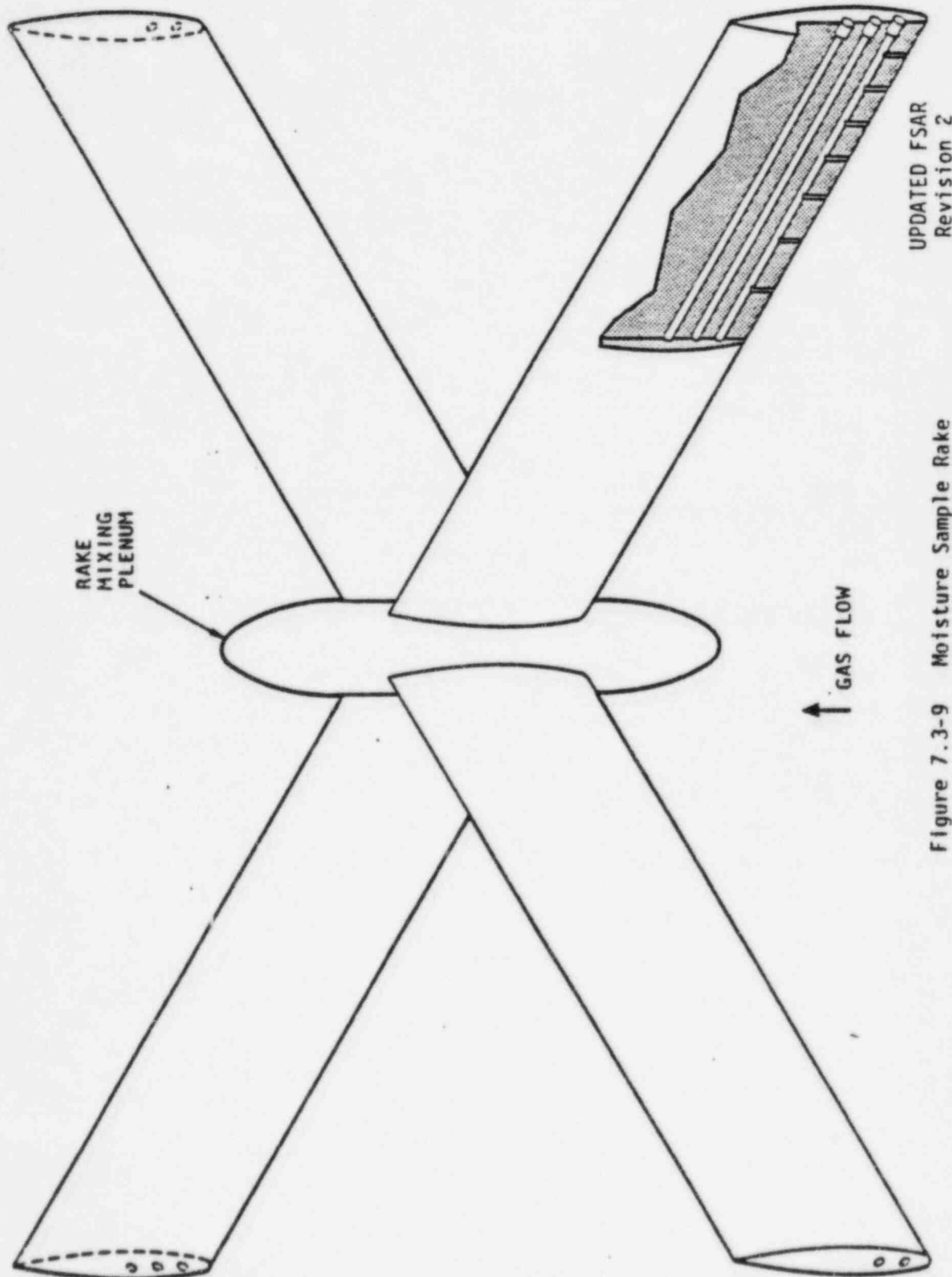


Figure 7.3-9 Moisture Sample Rake

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME (1)

Fort St. Vrain, Unit No. 1

DOCKET NUMBER (2)

0 5 0 0 0 2 6 7 8 4 - 0 0 8 - 0 2 1 6 OF 1 7

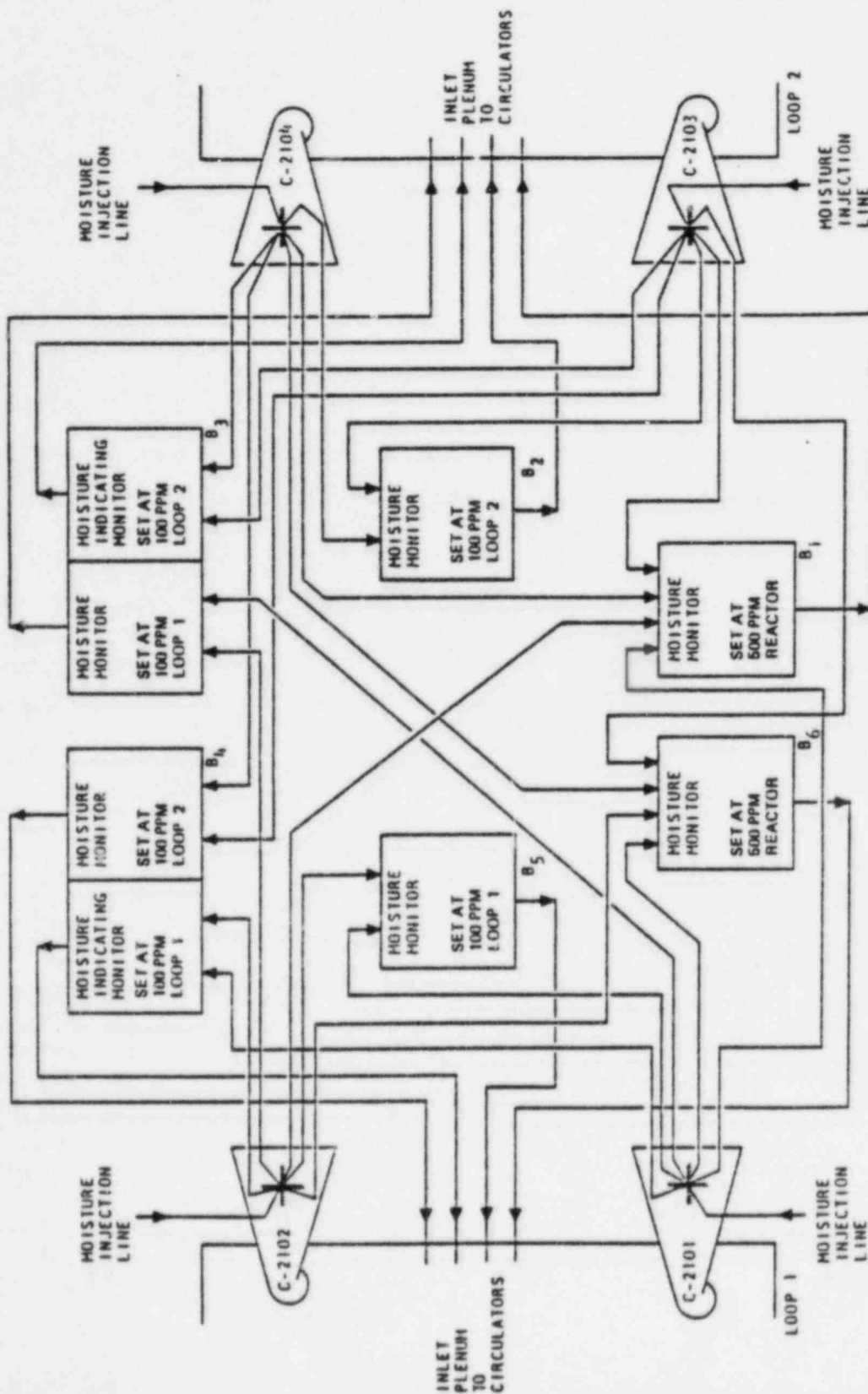
LER NUMBER (6)

| YEAR | SEQUENTIAL NUMBER | REVISION NUMBER |
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| 84 | 008 | 02 |

PAGE (3)

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FIGURE 8



S-228
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Revision 2

Figure 7.3-2 Moisture Sampling System

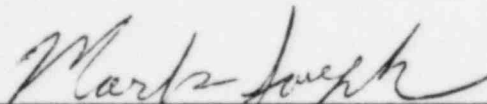
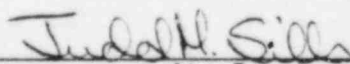
LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

APPROVED OMB NO. 3150-0104

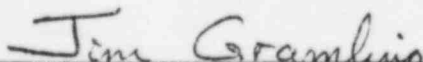
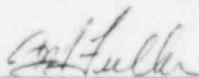
EXPIRES 8/31/85

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| FACILITY NAME (1) Fort St. Vrain, Unit No. 1 | DOCKET NUMBER (2) 0 15 0 0 0 2 6 7 8 4 | LER NUMBER (6) | | | PAGE (3) | | |
| | | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | | | |
| | | 0 0 8 | 0 0 8 | 0 2 | 1 7 | OF | 1 7 |

TEXT (If more space is required, use additional NRC Form 305A's) (17)

Mark Joseph
Technical Services EngineerJim Eggebroten
Technical Services Engineering Supervisor

Licensing Review By:

Jim Gramling
Nuclear Licensing-Operations SupervisorC. H. Fuller
Station ManagerJ. W. Gahm
Manager, Nuclear Production



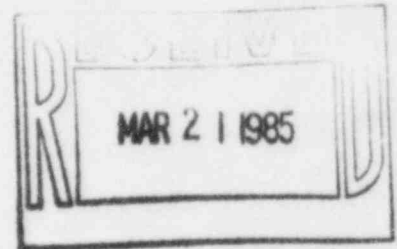
Public Service Company of Colorado

16805 WCR 19 1/2, Platteville, Colorado 80651

March 12, 1985
Fort St. Vrain
Unit #1
P-85073

Regional Administrator
Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, TX 76011

ATTN: Mr. E. H. Johnson



Docket No. 50-267

REFERENCE: Facility Operating
License No. DPR-34

SUBJECT: Licensee Event
Report 84-008,
Supplemental Report

Dear Mr. Johnson:

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

Sincerely,

J. W. Gahm
Manager, Nuclear Production

Enclosure

cc: Director, MIPC

JWG/djm

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