Public Service™

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OSCAR R. LEE
VICE PRESIDENT

July 3, 1985
Fort St. Vrain
Unit No. 1
P-85233

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

Docket No. 50-267

SUBJECT: Technical Specifications for Reactivity Control

REFERENCE: (1) PSC Letter, Lee to Johnson, dated June 7, 1985 (P-85180)

(2) PSC Letter, Brey to Johnson, dated June 14, 1985 (P-85199)

Dear Mr. Johnson:

Enclosed are the interim Technical Specifications for Reactivity Control Systems at Fort St. Vrain, including applicable Bases. These Specifications have been revised from our Reference (1) submittal, based on telephone conversations with the NRC (T. King) on June 17 and June 19, 1985.

As discussed in Reference (1), Public Service Company of Colorado (PSC) will use these interim Specifications as the basis for a program to assure control rod drive (CRD) and reserve shutdown system reliability. PSC notes that there are numerous differences between the Specifications in Enclosure 1 and those that are a part of the existing operating license. In these cases, the more restrictive of the two requirements will be adopted.

The enclosed Specifications include a change to the criteria for insertion of reserve shutdown material, which also affects the Backup Reactor Shutdown Procedure commitment provided in Reference (2). A revised commitment is included as Enclosure 2.

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If you have any questions or comments regarding the enclosed Specifications, please contact Mr. M. H. Holmes at (303) 571-8409.

Very truly yours,

Lawrence Brey for

O. R. Lee, Vice President
Electric Production

ORL/SWC/ljb

Enclosures

cc: Tom King, NRC (with enclosures)

Enclosure 1
to P-85233

REACTIVITY CONTROL SYSTEMS

3/4.1.1 CONTROL ROD OPERABILITY

LIMITING CONDITION FOR OPERATION

3.1.1 All control rod pairs not fully inserted shall be OPERABLE with:

A. A scram time less than or equal to 152 seconds,

B. A control rod drive (CRD) motor temperature less than or equal to 250 degrees F.

C. A He purge flow to each CRD penetration when reactor pressure is above 100 psia.

APPLICABILITY: POWER OPERATION, LOW POWER, and STARTUP

ACTION:

A. With one or more rod pairs inoperable due to being immovable (i.e., not capable of being fully inserted) as a result of excessive friction or mechanical interference, immediately initiate a reactor shutdown and be in at least SHUTDOWN within 12 hours.

B. With one rod pair trippable but inoperable due to causes other than addressed by ACTION A. above, operation may continue provided that:

1. The rod is restored to OPERABLE status, or

2. Full insertion of the inoperable rod pair is achieved and verified by OPERABLE rod position indication, or watt meter test, or

3. The SHUTDOWN MARGIN (LCO 3.1.4) is verified to be met with the rod pair considered inoperable in its present position.

If one of the above conditions cannot be met within 24 hours from the time of initial loss of OPERABILITY initiate reactor shutdown and be in at least SHUTDOWN within the subsequent 12 hours.

C. When two or more rod pairs are determined to be inoperable, immediately initiate a reactor shutdown and be in at least SHUTDOWN within 12 hours.

D. The provisions of Specification 3.0.6 are not applicable for changes between STARTUP, LOW POWER, and POWER OPERATION. Prior to entry into STARTUP from SHUTDOWN, all requirements of this LCO must be met, without reliance on provisions contained in the ACTION statements.

SURVEILLANCE REQUIREMENTS

4.1.1 Each control rod pair shall be demonstrated OPERABLE:

A. At least once per 24 hours by:

1. Verifying that all CRD motor temperatures are less than or equal to 250 degrees F.

a. With one or more CRD motor temperature(s) greater than 215 degrees F, the motor temperature of all CRDs whose motor temperatures are greater than 215 degrees F shall be recorded and a partial scram test as described in Specification 4.1.1.B shall be performed on the highest temperature control rod pair at least once per 24 hours. A report on the partial scram test results and the maximum daily temperature of those control rods with motor temperatures above 215 degrees F shall be provided to the NRC at least once every 31 days.

b. If CRD motor temperature instrumentation is not available, an engineering evaluation shall be performed to determine CRD motor temperature by comparison.

2. Verifying that the purge flow is maintained to each CRDM by verifying purge flow in each subheader, when reactor pressure is above 100 psig.

3. Verifying that the purge flow is not carrying condensed water by verifying that the water level in the knock-out pot is less than 6 inches.

B. At least once per 7 days by:

1. Performing a partial scram test of at least 10 inches on all partially inserted and fully withdrawn control rods, except the regulating rod, and verifying that the extrapolated scram time is less than or equal to 152 seconds.

2. Performing a partial scram test of approximately 2 inches on the regulating rod and verifying rod movement.

C. Prior to withdrawal of control rod pairs to achieve criticality (if not performed in the previous week) by performing a partial scram test of at least 10 inches on all OPERABLE rod pairs and verifying that the extrapolated scram time is less than or equal to 152 seconds.

D. During each shutdown with a scheduled duration of 10 days or longer (if not performed during the previous month) by performing a full stroke scram test on all control rod pairs and verifying a scram time less than or equal to 152 seconds.

E. Following any maintenance on a CRD mechanism which could affect the control rod scram time, by performing a full stroke scram test and verifying a scram time of less than or equal to 152 seconds.

F. During each REFUELING CYCLE:

1. By performing a CHANNEL CALIBRATION and a CHANNEL FUNCTIONAL TEST of the eight subheader control rod drive purge flow measurement channels.

2. By performing a CHANNEL FUNCTIONAL TEST of the CRD motor temperature and cavity temperature instrumentation.

3. By performing preventive maintenance on each control rod drive in the scheduling sequence stated below. This shall consist of inspecting and replacing as necessary the CRD gears, bearings, brake pads, cables, and position instrumentation. The sequencing

of this preventive maintenance shall be such that none of the drives installed in the reactor will have gone more than six REFUELING CYCLES without receiving preventive maintenance. During these six REFUELING CYCLES, no CRD shall be in regulating rod service for more than one REFUELING CYCLE.

4. By performing a CHANNEL CALIBRATION of the CRD motor and cavity temperature instrumentation in support of the CRD preventive maintenance described in Specification 4.1.1.F.3 above.

BASIS FOR SPECIFICATION LCO 3.1.1/SR 4.1.1

Control rod OPERABILITY ensures that a minimum SHUTDOWN MARGIN is capable of being maintained.

The rod withdrawal accident analyses described in FSAR Sections 14.2.2.6 and 14.2.2.7 were performed assuming a scram insertion time of 152 seconds and a ramp reactivity insertion of 0.080 delta k.

Requiring the scram time to be less than or equal to 152 seconds will assure that the ramp reactivity rate is consistent with that assumed in the accident analyses. The total calculated reactivity worth of all 37 control rod pairs is 0.210 delta k, which is significantly greater than the value of 0.080 delta k assumed in the accident analyses. Therefore, a single control rod with a scram time greater than 152 seconds, as allowed in ACTION B. of the specifications, will have no impact on the calculated consequences of the rod withdrawal accident.

Temperature Limitation

CRD motor qualification tests were performed in a 180 degree F helium environment. The motor and brake were energized and deenergized in severe duty cycles up to once every 5 seconds for 630,000 jog cycles and 5000 scrams of the CRDM. CRD motor temperatures ranged from 200 degrees F to 230 degrees F with an average of 215 degrees F during these tests. During power ascension testing CRDM temperatures of 213 degrees F were experienced at power levels up to 70%. Using data obtained during power ascension testing, a CRDM temperature of 260 degrees F was predicted for 100% power conditions with an orifice valve fully closed. The minimum predicted open position for an orifice valve at 100% power is about 10% for which the predicted CRDM temperature is 250 degrees F. Tests conducted to 100% power indicated these predictions to be conservative because the maximum measured CRDM temperature was 218 degrees F. The operating temperature of the CRDM is limited by the motor insulation which is rated for 272 degrees F to account for motor temperature rise, frictional torque increase, and winding life expectancy.

CRDM temperatures are monitored to verify that they are less than or equal to 250 degrees F. Any CRDM with a motor temperature greater than 215 degrees F shall be recorded every 24 hours to document that the temperature is less than 250 degrees F. In addition, the partial scram test frequency is increased from once per 7 days to once per 24 hours on the control rod drive motor with the highest temperature. These surveillances ensure that CRD motor temperatures exceeding 215 degrees F do not degrade the CRDM's reliability to perform its design function when required.

If the CRD motor temperature instrumentation is not OPERABLE, an engineering evaluation will be completed within 24 hours or less at the end of each 24 surveillance period to verify that the CRD motor temperature is currently less than 250 degrees F. Additional temperature instrumentation located on the underside primary closure plate and the orifice valve motor plate can be used to infer the CRDM temperature by comparing these temperatures with those on another CRDM in a similar region. Other factors such as orifice valve position and historical temperature data may be used to determine CRD motor temperatures by comparison.

Purge Flow

The purge flow into the control rod drive assembly limits the upward flow rate of contaminated primary system helium coolant. Purge flow to each CRD penetration is ensured by verifying that purge flow is available to each subheader and by sealing all the valves between the subheaders and the CRD penetrations in an open position.

A knock out pot, moisture element, and pressure transmitter is installed in the CRD purge line, between the purified helium header and the CRD purge flow valve. Just before the knock out pot, an independent source of dry helium is connectible, in the event the purified helium header becomes unavailable. The pressure in the helium header will be maintained approximately 10 psi above reactor pressure. The knock out pot reduces the probability of moisture in the helium purge header entering the CRD penetrations by trapping any entrained water in the helium. A local alarm indicates that water is collecting in the pot.

The knock out pot is approximately 10 inches deep and verifying that the water level in the knock out pots is less than 6 inches once every 24 hours ensures that the helium purge flow is not carrying condensed water.

Actions

The ACTION to immediately initiate a reactor shutdown if one or more rod pairs are inoperable due to being immovable as a result of excess friction or mechanical interference is implemented because the cause of the problem may be indicative of a generic control rod problem which may affect the ability to safely shutdown the reactor.

The ACTION providing for continued operation with one rod pair trippable but inoperable due to causes other than excess friction or mechanical interference is less restrictive because the SHUTDOWN MARGIN can be met with the highest worth rod fully withdrawn (FSAR Section 3.5.3).

Because the SHUTDOWN MARGIN can be met with the highest worth rod pair fully withdrawn, an exception to 3.0.6 (which prevents moving up to a higher operational MODE while in an ACTION statement) can be made in this case.

Surveillances

The regulating rod is the only control rod with automatic response capability to a change in flux and is used to offset the negative effects of partial scram tests performed on other CRDs. A partial scram test of 2 inches on the regulating rod does not induce unacceptable power transients and demonstrates that the rod is moveable.

Performing a partial scram test prior to achieving criticality ensures control rod OPERABILITY prior to entering into an operational MODE. The full stroke scram test performed during each shutdown is the most accurate method of determining the scram time because the actual scram time is measured over the whole length of the rod versus being extrapolated from a partial distance. Performing a full stroke scram test following any CRD maintenance ensures that the OPERABILITY and scram time of the rod was not affected by the maintenance.

The specified CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST assures that the instrumentation monitoring the eight subheaders providing purge flow to the control rod drive penetrations is OPERABLE and loss of purge flow is detectable.

The specified CHANNEL FUNCTIONAL TEST of the CRD motor temperature and cavity temperature instrumentation will assure that the instrumentation monitoring the CRD temperatures is OPERABLE and capable of detecting any increase in CRD motor temperature.

The preventive maintenance program performed on those CRDs replaced each refueling cycle ensures that by inspecting and replacing as necessary any degraded parts the potential for control rod failure is significantly reduced. Since the regulating rod is used much more than any other rod, it will be substituted with another control rod pair after each REFUELING CYCLE.

REACTIVITY CONTROL SYSTEMS

3/4.1.2 ROD POSITION INDICATION SYSTEMS - OPERATION

LIMITING CONDITION FOR OPERATION

3.1.2 The position indication system for each control rod pair (consisting of a rod-in limit indication, a rod-out limit indication, and analog and digital rod position indication) shall be OPERABLE and capable of determining control rod pair position within 10 inches.

APPLICABILITY: POWER OPERATION, LOW POWER and STARTUP

ACTION:

A. If digital indication and/or rod-out limit indications are inoperable, operation may continue provided that analog indication and a rod-in limit indication are OPERABLE.

B. If analog indication is inoperable, operation may continue provided that one of the following conditions is met:

1. When the rod is fully inserted, a rod-in limit indication is OPERABLE or the full-in position has been established by an independent means of verification (e.g., watt-meter test), or

2. When the rod is in a mid-position, rod position is capable of being indicated by OPERABLE digital position indication, and a rod-in limit indication is OPERABLE, or

3. When the rod is in the full-out position, a rod-out limit indication and a rod-in limit indication are OPERABLE.

C. If rod-in limit indication is inoperable, operation may continue provided that one of the following conditions are met:

1. When the rod is fully inserted, the rod-in position has been established by an independent means of verification (e.g., watt-meter test), or

2. When the rod is in a mid or full-out position, both digital and analog indications are OPERABLE and are known to be accurate at the full-in position, and digital indication is capable of indicating the rod's position.

D. If rod pair position cannot be determined in accordance with A, B, or C above within 12 hours, then be in SHUTDOWN within the subsequent 12 hours.

E. The provisions of Specification 3.0.6 are not applicable for changes between STARTUP, LOW POWER, and POWER OPERATION. Prior to entry into STARTUP from SHUTDOWN, all the requirements of the LCO must be met, without reliance on the provisions contained in the ACTION statement.

SURVEILLANCE REQUIREMENTS

4.1.2 A. Control rod position instrumentation OPERABILITY shall be verified by performing a CHANNEL CHECK on the control rod position instrumentation, as follows:

1. Prior to withdrawal from the fully inserted position.

2. Upon full withdrawal.

3. At least once per 7 days on all control rod pairs except for fully inserted rod pairs which have been disabled by racking out of the drive power.

Each 7 days, during partial scram surveillance or other rod movement, the OPERABILITY of the analog rod position indication shall be verified by confirming that the change in analog indication is consistent with the direction of rod travel. The analog and digital position indications must agree with each other within 10 inches. If a larger difference is observed, it shall be assumed that the analog indication is the inoperable channel, unless the analog indication can be proven to be accurate and OPERABLE by another means.

B. Prior to each reactor start-up, a full-in limit indication for each control rod pair must be verified as OPERATING when the rod is full-in and OPERABLE by virtue of the change in the indication when the rod is withdrawn a short distance. Alternatively, rod-in position indication OPERABILITY shall be similarly verified the first time during or after start-up that a rod is withdrawn from the full-in position.

C. Prior to each reactor start-up, or during the first outward motion of a rod, the analog and digital position indications must be shown to be OPERABLE at the full-in position and be shown to respond appropriately when the rod is withdrawn a short distance. During withdrawal, when the rod-in limit indication clears, the rod position indications must indicate less than 6 inches, to prevent overtravel that could cause damage to the potentiometers and the associated coupling. If the rod position indications indicate 6 or more inches, an engineering evaluation shall be performed to determine the maximum insertion limit for that control rod pair.

BASIS FOR SPECIFICATION LCO 3.1.2/SR 4.1.2

FSAR Section 7.2.2 assumes a long term misalignment of plus or minus 12 inches on control rod position to ensure an acceptable power distribution for core burnup. This allows a 2 foot separation distance for the control rods of any partially inserted shim group. Assuring a position accuracy of plus or minus 10 inches is consistent with this misalignment allowance and provides for a 4 inch margin for operation when manually adjusting the control rods of the shim group. Each shim control rod is normally moved in approximately 2 inch increments during operation to adjust the regulating control rod to its mid operating position. A 10 inch position accuracy for all control rods is also consistent with a reactivity uncertainty of about 0.003 delta k, which allows for detecting core irregularities, such as an inadvertant release of reserve shutdown material within a single core region. Control rod withdrawal procedures require an evaluation if the actual critical control rod position differs from the predicted position during initial criticality by this reactivity worth.

Control rod position indication system OPERABILITY is required to determine control rod positions and to ensure compliance with control rod alignment and position requirements of Specifications 3.1.5 and 3.1.6.

Rod-out and rod-in position indication is provided by cam-actuated switches. The cams are mounted on the same shaft as the rod position potentiometer. The shaft is directly coupled to a cable drum through a gear train and rotates as required for the full length of rod travel. A fully withdrawn rod is indicated by a separate switch which is actuated when the top of the control rod comes in contact with a push rod. When a rod is withdrawn from the fully inserted position, the limit switch cams release the rod in switch causing the rod in light to extinguish. Rod position is transmitted to the console by a potentiometer coupled directly to the drum gearing. The rod-in and rod-out limit switches and the rod position potentiometer transmitters are duplicated to protect against the loss of position indication.

Actions

If analog and rod-in limit indications are OPERABLE but digital and/or rod-out limit indications are inoperable, operation may continue. Since both the analog and digital indications are taken from the same shaft and potentiometer, rod position is still capable of being established with only the analog indication. Rod-in limit indication capability is more critical than rod-out limit indication for the purpose of determining SHUTDOWN MARGIN.

If the analog indication is inoperable, operation may continue with one of the following conditions satisfied:

a. If the rod is fully inserted, the position can be established by the rod-in limit indication or verified by an independent means such as the watt-meter test. Since the rod is fully inserted, any other position indication is not required because its position of being fully inserted can be verified and used in the SHUTDOWN MARGIN calculation.

b. For the case with the rod in a mid-position and the digital and rod-in limit indications OPERABLE, rod position can still be established by digital indication and if the rod were to be fully inserted its position could be verified. Rod-in indication Operability is demonstrated when last tested.

c. For the case with the rod fully withdrawn and rod-out and rod-in limit indications OPERABLE, the rod's position can be established (i.e. fully withdrawn) or if the rod were to be fully inserted, its position could be verified for the SHUTDOWN MARGIN calculation. Again, rod-in indication Operability is demonstrated when last tested.

If rod-in limit indication were inoperable, operation may continue, because a fully inserted rod's position can be established by an independent means such as the watt-meter test. At a mid or fully withdrawn position, the rod's position can be determined by both digital and analog indications.

If rod pair position cannot be determined within 12 hours, reactor shutdown is required within 12 hours. This ACTION is required to satisfy the rod worth and position requirements of Specification 3.1.5 which prevents an unacceptable power distribution.

Surveillances

Rod position indication instrumentation OPERABILITY is verified by performing a CHANNEL CHECK before the rod is withdrawn from the fully inserted position, when it is fully withdrawn, and at least once per 7 days. This surveillance ensures position indication OPERABILITY prior to a reactor startup and during operation.

During the partial scram test (once per 7 days during operation) analog indication is verified OPERABLE by confirming that the change in analog indication is consistent with the direction of rod travel.

If a difference of greater than 10 inches exists between the analog and digital position indications, the analog indication is considered inoperable, unless proven accurate by another means. The analog indication may be proven to be accurate and OPERABLE by fully inserting the rod pair and verifying that the analog indication is more accurate than the digital indication at the full-in limit as determined by the rod-in limit indication or the watt-meter test.

The rod-in limit indication is verified to be OPERATING at the fully inserted position when the rod is withdrawn a short distance. This surveillance ensures that a fully inserted rod's position can be established during operation by verifying OPERABILITY prior to each startup when the rod is first withdrawn from the fully inserted position.

To ensure position indication is capable of being established at mid to fully withdrawn position (during operation) both the analog and digital positions are verified OPERABLE at the full in position when the rod is withdrawn a short distance. This surveillance is performed prior to startup or during the first outward rod motion.

The position indication potentiometers and associated coupling can be damaged by an overtravel of minus 6 inches. This damage is prevented by initially requiring the rod position indication to indicate less than six (6) inches when the rod-in limit indication clears and then by procedurally preventing rod insertion past zero, even if rod-in limit indication is not received. The requirement for position indication to be less than 6 inches when rod-in limit indication is received imposes an enhanced accuracy requirement at this position. The result is that since procedurally the rod pair is not inserted past a zero indication, and if the position indication is within 6 inches of the actual position, then the rod pair will not be inserted beyond the minus 6 inch damage limit, even if the rod-in limit instrumentation fails. Since rod position instrumentation cannot be recalibrated without removing the CRD from the PCRV, the engineering evaluation provides the necessary procedural controls to establish individual rod insertion limits for rods whose position indications exceed 6 inches.

REACTIVITY CONTROL SYSTEMS

3/4.1.3 ROD POSITION INDICATION SYSTEMS - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.3 Sufficient position indication instrumentation shall be OPERABLE to be capable of determining control rod pair position within 12 inches.

APPLICABILITY: SHUTDOWN and REFUELING

ACTION: If the required position indication is not OPERABLE, within 12 hours:

A. The inoperable indication shall be restored to OPERABLE status, or

B. Full insertion shall be verified by other independent means (e.g., watt-meter testing), or

C. The rod pair shall be considered fully withdrawn and the SHUTDOWN MARGIN requirements of Specification 3.1.4 shall be met.

SURVEILLANCE REQUIREMENTS

4.1.3 A. Control rod position instrumentation OPERABILITY shall be verified by performing a CHANNEL CHECK on the control rod position instrumentation, as follows:

1. Prior to withdrawal from the fully inserted position.
2. Upon full withdrawal.
3. At least once per 7 days on all control rod pairs except for fully inserted rod pairs which have had the drive motor power supply disabled.
4. After a MODE change to SHUTDOWN from STARTUP.

B. During each REFUELING CYCLE perform a CHANNEL FUNCTIONAL TEST of the rod pair redundant "in" and "out" limit switches and the analog and digital rod position indication systems.

C. A CHANNEL CALIBRATION of the rod pair redundant "in" and "out" limit switches, and the analog and digital rod position indication systems, shall be performed in conjunction with CRD installation in the PCRV.

D. When in REFUELING, at least once per 7 days, for all control rod pairs that are capable of being withdrawn, the analog and digital position indications must be shown to be OPERABLE at the full-in position and be shown to respond appropriately when the rod is withdrawn a short distance. During withdrawal, when the rod-in limit indication clears, the rod position indications must indicate less than 6 inches, to prevent overtravel that could cause damage to the potentiometers and the associated coupling. If the rod position indications indicate 6 or more inches, an engineering evaluation shall be performed to determine the maximum insertion limit for the control rod pair.

BASIS FOR SPECIFICATION LCO 3.1.3/SR 4.1.3

This specification involves control rods that are either fully inserted or withdrawn, therefore the accuracy requirements are different from those in LCO 3.1.2 for operational considerations. The relative reactivity worth for the total control rod bank as a function of withdrawal position is given in FSAR Section 3.5 (Figure 3.5-2). Experimental results on control rod worth versus withdrawal position have indicated a reduced worth for the first portion of control rod withdrawal. Analyses consistent with those performed in the FSAR have confirmed this, as shown on the attached figures. From this calculated data and a calculated bank worth of 0.210 delta k, it can be shown that a reactivity uncertainty of 0.003 delta k results in the total bank position uncertainty of 17 inches at full insertion and 13 inches at full withdrawal. The reactivity uncertainty of 0.003 delta k is acceptable for the shutdown margin and is consistent with that used to detect core irregularities, such as occasions of inadvertant release of reserve shutdown material within a single core region. Control rod withdrawal procedures require an evaluation if the actual critical control rod position differs from the predicted position during the approach to criticality by the reactivity worth of 0.003 delta k.

If position indication instrumentation is inoperable, a 12 hour ACTION time is allowed because the SHUTDOWN MARGIN requirements have been met prior to position indication instrumentation inoperability.

Rod position indication instrumentation OPERABILITY is verified by performing a CHANNEL CHECK before the rod is withdrawn from the fully inserted position, when it is fully withdrawn, at least once per 7 days, and after a MODE change to SHUTDOWN from STARTUP. This surveillance ensures position indication OPERABILITY when the reactor is shutdown and during any refueling operations.

Each REFUELING CYCLE a CHANNEL FUNCTIONAL TEST will be performed on the rod pair redundant "in" and "out" limit switches and the analog and digital rod position indication systems. This surveillance ensures that the entire position indication system is OPERABLE prior to a reactor startup.

In conjunction with CRD installation in the PCRV, a CHANNEL CALIBRATION will be performed on the rod pair redundant "in" and "out" limit switches, and the analog and digital rod position indication systems. A CHANNEL CALIBRATION on the CRD position indication instrumentation cannot be performed while the control rods are installed in the PCRV, therefore a calibration is performed only on the control rods removed for refueling/repair.

In the REFUELING MODE, the rod "in limit", analog and digital indications will be verified OPERABLE (for those rod pairs capable of being withdrawn) at least once per 7 days.

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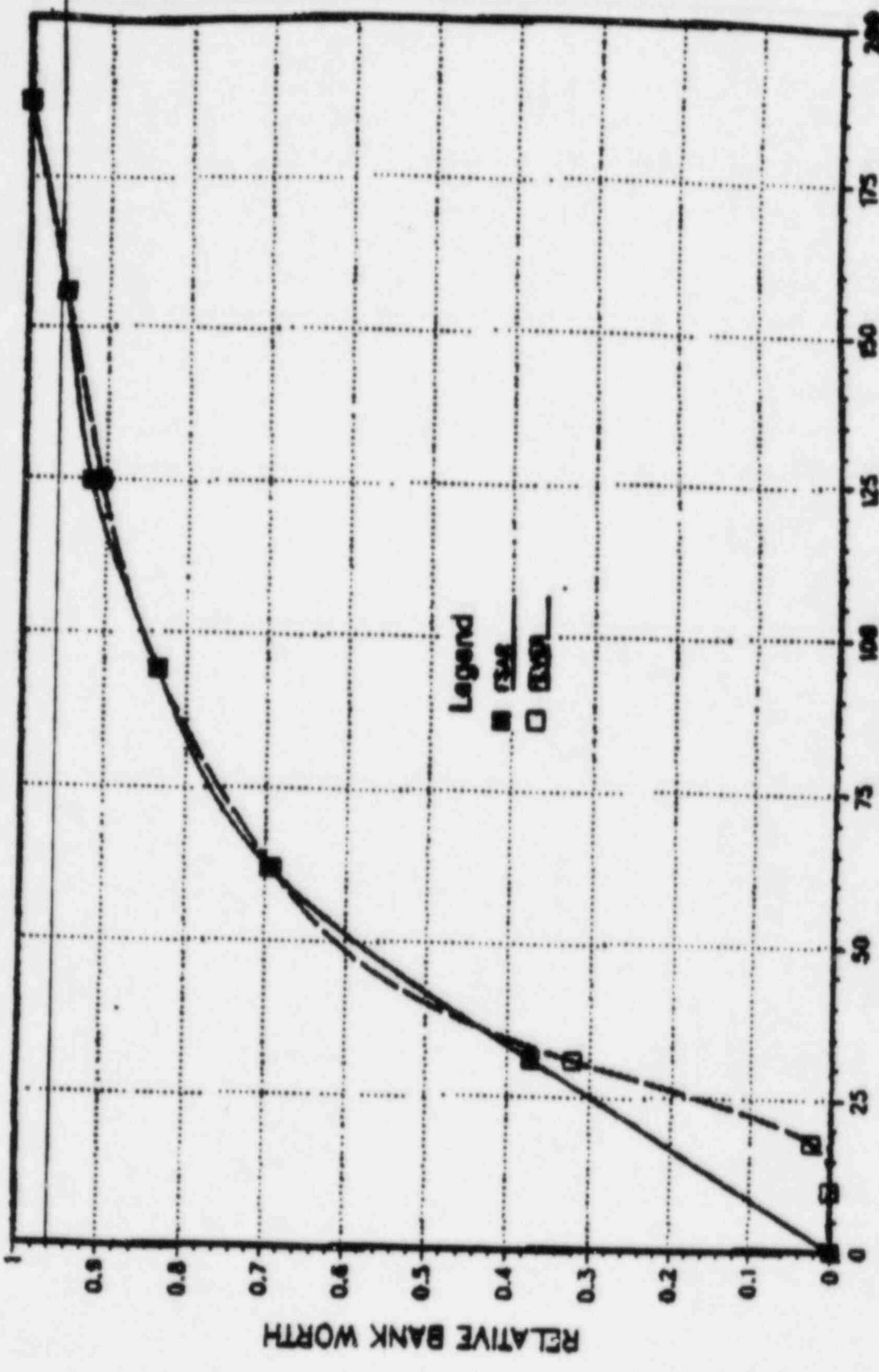
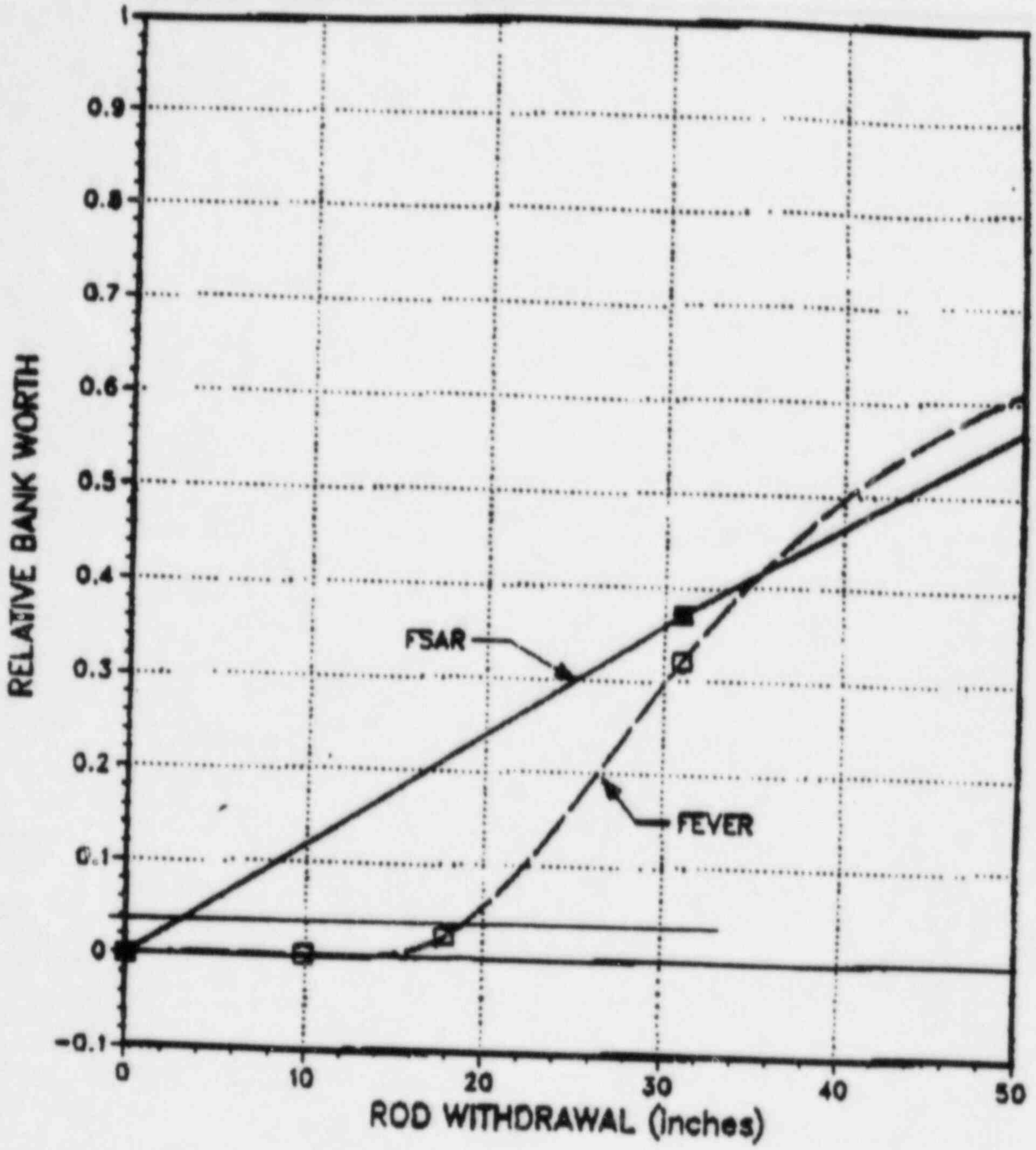
SCRAM WORTH VS WITHDRAWAL DISTANCE
BASIS: FSAR KINETICS CALCULATIONS



SCRAM WORTH VS WITHDRAWAL DISTANCE DETAIL OF BOTTOM FUEL LAYER



REACTIVITY CONTROL SYSTEMS

3/4.1.4 SHUTDOWN MARGIN

LIMITING CONDITION FOR OPERATION

3.1.4 The reactor SHUTDOWN MARGIN shall be greater than or equal to 0.01 delta k.

APPLICABILITY: At all times

ACTION:

A. POWER OPERATION, LOW POWER and STARTUP

With the SHUTDOWN MARGIN less than required, immediately insert sufficient control rod pairs to bring the reactor into compliance with this LCO. If compliance cannot be restored within one hour, initiate a reactor shutdown and be in at least SHUTDOWN within 24 hours.

B. SHUTDOWN

1. With the SHUTDOWN MARGIN less than that required, within 1 hour, either:

   a. Fully insert (as verified by OPERABLE rod position indications per Specification 3.1.3) sufficient control rods to achieve the specified SHUTDOWN MARGIN, or

   b. Actuate sufficient reserve shutdown material to achieve the specified SHUTDOWN MARGIN.

C. REFUELING

1. With the SHUTDOWN MARGIN less than that required:

   a. Immediately suspend all control rod or fuel manipulations involving positive reactivity changes, and

b. Within 1 hour either:

1) Fully insert (as verified by OPERABLE rod position indications per Specification 3.1.3) sufficient control rods to achieve the specified SHUTDOWN MARGIN, or

2) Actuate sufficient reserve shutdown material to achieve the specified SHUTDOWN MARGIN.

SURVEILLANCE REQUIREMENTS

4.1.4 Verification of SHUTDOWN MARGIN shall be performed as follows:

A. When in POWER OPERATION, LOW POWER or STARTUP

1. Once per 7 days.

2. As required by the ACTION statements of LCO 3.1.1.

3. In assessing the SHUTDOWN MARGIN the following conditions shall be assumed:

a. Highest worth rod pair assumed fully withdrawn and not insertable.

b. All OPERABLE rod pairs assumed fully inserted with all inoperable rod pairs in their pre-scram position,

c. A CORE AVERAGE TEMPERATURE of 220 degrees F,

d. No buildup of Xe-135 and Sm-149 and no decay of Pa-233 beyond that present at shutdown (i.e., instantaneous SHUTDOWN MARGIN).

B. When in SHUTDOWN

1. Within 12 hours after each reactor shutdown where all control rods cannot be verified fully inserted, or

2. Prior to control rod withdrawal, if all control rod pairs are not fully inserted prior to withdrawal action, or

3. Prior to control rod withdrawal to achieve criticality, to confirm that upon reaching criticality the SHUTDOWN MARGIN requirement can be met, or

4. As required by the ACTION statement of LCO 3.1.9.

5. In assessing the SHUTDOWN MARGIN the following conditions shall be assumed:

   a. Highest worth rod pair assumed fully withdrawn and not insertable.

   b. All OPERABLE rod pairs assumed fully inserted and inoperable rod pairs in their known position or assumed fully withdrawn.

   c. A CORE AVERAGE TEMPERATURE of 80 degrees F.

   d. Full decay of Xe-135, full buildup of Sm-149, and Pa-233 decay as a function of time after shutdown.

C. When in REFUELING

1. Prior to control rod withdrawal if all control rod pairs are not fully inserted prior to withdrawal action, or

2. Prior to the removal of the control rod pair in a region to be refueled, or

3. As required by the ACTION statement of LCO 3.1.9.

4. In assessing the SHUTDOWN MARGIN the following conditions shall be assumed:

   a. Highest worth rod pair capable of being withdrawn is assumed fully withdrawn and not insertable.

   b. Rod pairs being withdrawn for refueling/repair, for verification of SHUTDOWN MARGIN, or for test purposes are assumed fully withdrawn.

   c. All other OPERABLE rod pairs are assumed fully inserted and incapable of being withdrawn.

   d. Inoperable rod pairs are assumed in their known position or assumed fully withdrawn.

   e. For planned CORE ALTERATIONS, the core shall be in its most reactive configuration.

f. A CORE AVERAGE TEMPERATURE of 80 degrees F.

g. Full decay of Xe-135, full buildup of Sm-149, and Pa-233 decay as a function of time after shutdown.

BASIS FOR SPECIFICATION LCO 3.1.4/SR 4.1.4

A. SHUTDOWN MARGIN - OPERATING

The purpose of this Limiting Condition for Operation is to assure that during operation a sufficient amount of negative reactivity in control rod pairs is capable of being inserted by the automatic and manual scram functions to shutdown the reactor with the highest worth rod pair fully withdrawn. A SHUTDOWN MARGIN of at least 0.01 delta k has been specified at a CORE AVERAGE TEMPERATURE of 220 degrees F. The CORE AVERAGE TEMPERATURE will normally be significantly above 220 degrees F for several days following a scram from power yielding a SHUTDOWN MARGIN greater than 0.01 delta k.

Fission products Xe-135 and Sm-149 are assumed to remain at their current inventory at the time of SHUTDOWN MARGIN determination. For short time periods this is conservative since their immediate inventory change is a buildup due to the decay of precursors. The precursor for Sm-149 has a half-life of a few days, while the decay of Sm-149 occurs over several years, so the builup occurs over a period of several days. For Xe-135, both the precursor and Xenon isotope decay in hours, about 6 and 9 hours respectively, and consequently, Xe-135 initially builds up to a peak value in about 6 hours and then fully decays in a few days. The decay of Pa-233 to fissile U-233 occurs over a period of about 100 days. Therefore, assuming these isotopes to be at their current value is conservative for at least the first 12 hours following a SHUTDOWN.

Any control rod pair that is demonstrated OPERABLE per Specification 3.1.1 will be assumed to be fully inserted and any inoperable control rod pair will be assumed to be at its pre-scram position. This is consistent with FSAR Section 3.5.3, which demonstrates that there is at least 0.014 delta k SHUTDOWN MARGIN with one control rod pair fully withdrawn under any core condition in the equilibrium core and larger for cores prior to the equilibrium core.

Verification of the SHUTDOWN MARGIN requirements at least once per 7 days assures that changes in the core reactivity as a result of burnup have not occured which would make the previous verification invalid. The core reactivity changes as a result of burnup occur slowly and a 7 day surveillance during operation is sufficient. In addition, the ACTION statements of LCOs 3.1.1 and 3.1.2 require more frequent verification if a control rod pair is determined inoperable, or its exact position is uncertain.

B. SHUTDOWN and REFUELING

The purpose of this specification is to assure that during SHUTDOWN and REFUELING a sufficient number of control rod pairs are fully inserted to keep the reactor in a shutdown condition. A SHUTDOWN MARGIN of at least 0.01 delta k has been specified at a CORE AVERAGE TEMPERATURE of 80 degrees F with decay of Xe-135, buildup of Sm-149 and some decay of Pa-233. The CORE AVERAGE TEMPERATURE will normally be significantly above 80 degrees F for many months after shutdown and the decay of Pa-233 occurs over a few months. Therefore, the SHUTDOWN MARGIN immediately after achieving shutdown will normally be larger than the 0.01 delta k specified, and the 12 hour delay in verification of the SHUTDOWN MARGIN is sufficient for the purpose of this specification.

This specification need only require that the rod pair be actually inserted to achieve the specified SHUTDOWN MARGIN. Since full insertion can be verified by either rod position indication or another independent means, such as watt-meter testing per Specification 3.1.3, some additional time has been allowed.

The reserve shutdown system was provided to assure SHUTDOWN even in the event of failure to insert control rods. It is adequate to assure SHUTDOWN even if all control rods fail to insert (FSAR Section 3.5.3). However, the contribution to the SHUTDOWN MARGIN by the addition of reserve shutdown material into a core region already containing an inserted control rod pair is minimal. Therefore, it is sufficient to activate the reserve shutdown material only in those regions whose control rod pairs are not fully inserted.

For SHUTDOWN, the specified SHUTDOWN MARGIN assumes the full withdrawal of the highest worth rod pair. For REFUELING, (which can include either fuel or control rod manipulations) since all control rods are disabled except those involved with the REFUELING operation per Specification 3.1.6, the requirement includes the addition of the highest worth rod pair capable of being withdrawn in the SHUTDOWN MARGIN analysis. Disabling of control rod drives by disabling the electrical supply to the drive motors or placing the reactor mode switch in the "off" position, results in the inability to withdraw the rod pair by action of the drive motor. Therefore, accidental withdrawal of any drive disabled in this manner does not need to be assumed in the evaluation of the SHUTDOWN MARGIN.

The ACTION statements of Specifications 3.1.6 and 3.1.9, Control Rod Position Requirements and Reserve Shutdown System - SHUTDOWN, require completion of the verification of the SHUTDOWN MARGIN within 12 and 24 hours respectively.

Within the first 24 hours after shutdown, the SHUTDOWN MARGIN is significantly larger then specified due to higher core temperatures and the presence of Xe-135 and Pa-233. A 24 hour delay will not compromise the validity of this Specification.

Verification of this LCO prior to any control rod withdrawal, if all control rods are not fully inserted, prior to withdrawal to achieve criticality, or prior to removal of a control rod for refueling/repair, assures that the requirements of this Specification will be met during these actions.

REACTIVITY CONTROL

3/4.1.5 CONTROL ROD WORTH AND POSITION REQUIREMENTS - OPERATION

LIMITING CONDITION FOR OPERATION

3.1.5 A. Control rod pairs (except the regulating rod pair) shall be withdrawn or inserted in groups (3 rod pairs per group) except during scram or rod runback. All control rod pairs shall be either fully inserted or fully withdrawn except that:

1. One shim group and the regulating rod pair may be in any position.

2. Up to 6 additional control rod pairs may be inserted up to two feet.

B. Maximum calculated control rod pair worth shall not exceed:

1. 0.047 delta k with reactor critical at about E-07 percent RATED THERMAL POWER (source power), and

2. At full power, that worth which would result in rod withdrawal accident (RWA) consequences equal to those described for the worst case RWA in the AEC Safety Evaluation of Fort St. Vrain dated January 20, 1972.

APPLICABILITY: POWER OPERATION, LOW POWER and STARTUP

ACTION: A. With any control rod pair or group not in compliance with its position requirements perform the following:

1. Restore the control rods to an acceptable configuration within 4 hours, or

2. Be in at least STARTUP within the subsequent 12 hours, and SHUTDOWN within the following 12 hours.

B. With any control rod pair not in compliance with its worth limits initiate a reactor shutdown and be in at least SHUTDOWN within 24 hours of determination.

SURVEILLANCE REQUIREMENTS

4.1.5 A. Control rod pair positions shall be monitored via OPERABLE rod position instrumentation (LCO 3.1.2) and verified to be in compliance with the above requirements at least once every 8 hours.

B. At the beginning of each REFUELING CYCLE, the reactivity worth of the control rod groups which are withdrawn from LOW POWER to POWER OPERATION, in the withdrawal sequence, shall be measured. The measured group worths shall be compared with the calculated group worths to verify that the calculated criteria upon which the selection of the rod sequence was based has been satisfied. The measured group worth shall agree with the calculated group worth within plus or minus 20% for all groups except groups 4A and 4D, for which the measured group worth shall be within plus 100%, minus 50% of the calculated group worth.

BASIS FOR SPECIFICATION LCO 3.1.5/SR 4.1.5

The specification of a rod pair withdrawal sequence and position requirements during STARTUP and LOW POWER operation is required to:

a. Assist in evaluating the reactivity worth of rods withdrawn during the approach to criticality by indicated changes in the multiplied source neutrons.

b. Ensure that an acceptable power distribution is maintained (peaking factors within design limits) for the condition when many control rods are still inserted.

c. Ensure that the calculated maximum worth rod in STARTUP and LOW POWER operation, if assumed accidentally withdrawn, would result in a transient with consequences no more severe than the rod withdrawal accident analyzed in the FSAR (Sections 3.5.3.1 and 14.2.2.7).

The specification of a rod pair withdrawal sequence and position requirements during POWER OPERATION is required to yield an acceptable power distribution. In addition, the sequence ensures that the combination of maximum single rod pair worth and available core temperature coefficients, in the event of an accidental rod withdrawal, will result in a transient with consequences less severe than those analyzed in the FSAR. The rod withdrawal accident (RWA) analyzed in the FSAR is consistent with the RWA evaluation in the AEC Safety Evaluation of Fort St. Vrain dated January 20, 1972.

The rod withdrawal accident analysis at rated power, as described in the FSAR, was based on a maximum rod pair worth of 0.012 delta k, using temperature coefficients equivalent to a reactivity defect from refueling (220 degrees F) to operating temperature (1500 degrees F) of 0.028 delta k. For operation in the range from 0 to 100 percent power, the fuel temperature may be lower than the full power operating fuel temperature of 1500 degrees F. This results in a greater number of control rod pairs inserted for the critical configuration, and a larger maximum single rod pair worth. In addition, since the temperature coefficients are greater at the beginning of the cycle, a single control rod pair worth as much as 0.016 delta k is acceptable i.e., the consequences of a rod withdrawal accident are less severe, FSAR Section 14.2.1. A value larger than .012 delta k for a single rod pair can be safely accommodated if fuel temperatures are lower than 1500 degrees F and/or the temperature defect between refueling temperature (220 degrees F) and operating temperature (1500 degrees F) is greater than .028 delta k (FSAR Section 14.2.1.1).

The specified range of power peaking factors given in Specification 5.3, REACTOR CORE, was used in developing the Reactor Core Safety Limit of Specification 2.1 since the limiting combinations of core thermal power and core coolant flow rate are a function of the region, intra-region, and axial power peaking factors. Specifying a control rod withdrawal sequence for each REFUELING CYCLE which has peaking factors within these power peaking factor limits assures that the criteria upon which Specification 2.1 is based, are met.

The presence of too many partially inserted rod pairs in the core will tend to push the flux into the bottom half of the core and raise the fuel temperatures. The intra-region and axial power peaking factors used in determining the rod withdrawal sequence for each REFUELING CYCLE will be maintained during normal operation if the rods are inserted and withdrawn in sequence and if partially inserted rods are limited as noted above (See FSAR Section 3.5.4).

The 6 additional rod pairs which may be inserted up to two feet into the core will permit the operator to move rods to assist in regulating the core region outlet temperatures to those specified in Specification 3.2.2. This has a minimal effect on the axial power distribution, resulting in an increase in the average power density in the lower layer of fuel of less than 5 percent.

The runback function inserts two pre-selected groups of three rod pairs during rapid load reduction (see FSAR Section 7.2.1.2). The partial insertion of these control rod pairs, (FSAR Section 3.5.4.3) in addition to those noted above would increase the average axial power peaking factor in the lower layer of fuel to about 0.85. Negligible fuel particle migration (See Specification 2.1) would occur with this condition in the core for up to four hours.

The ACTION requirement which specifies to be in at least STARTUP within the subsequent 12 hours is prudent, since the core temperatures are significantly reduced at lower power levels. In STARTUP, negligible fuel particle migration would occur as long as the minimum helium flow requirements (Specification 3.2.4) are maintained. It is desirable to reduce plant load and temperatures in a controlled manner.

The measurement of control rod group worths in the normal withdrawal sequence at the beginning of each REFUELING CYCLE will provide an evaluation of calculational methods in determining the control rod group worths in the core configuration for that cycle. The criteria used in selecting the control rod sequence is based on calculated data for the maximum worth for any individual rod pair as well as the calculated peaking factors, (region, intra-region, and axial) in the normal operating control rod configuration. Since the core configuration changes for each REFUELING CYCLE (a new segment includes approximately one sixth of the total core) this evaluation confirms the ability to predict control rod worths in that specific configuration.

The acceptance criteria for the comparison of measured versus calculated control rod group worth within plus or minus 20% includes an allowance for the calculated uncertainty of plus or minus 10% (FSAR Section 3.5.7.4) and uncertainty in the measurement. A larger acceptance criteria is needed for control rod groups 4A and 4D because of a larger uncertainty in the calculated values. Groups 4A and 4D are five column regions located at the core reflector interface, and the analytical model for control rod worth calculations was developed for seven column regions. In addition, since the control rods are located in the central column and this column for a five column region is immediately adjacent to the reflector, their reactivity worth is substantially less than the other control rod groups. These groups are typically worth less than 0.010 delta k. Because of the low worth and the analytical uncertainty, a larger range for the acceptance criteria is required.

REACTIVITY CONTROL SYSTEM

3/4.1.6 CONTROL ROD POSITION REQUIREMENTS - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.6 A. All control rod pairs shall be fully inserted except:

1. Up to two control rod pairs may be withdrawn for refueling/repair, and

2. Additional control rod pairs may be withdrawn for SHUTDOWN MARGIN verification or tests.

B. All fully inserted control rod pairs shall be made incapable of being withdrawn by:

1. Placing the reactor mode switch in the "off" position, or

2. Disabling the electrical supply to the drive motors.

C. The SHUTDOWN MARGIN requirements of Specification 3.1.4 shall be maintained during all of the above control rod pair configurations.

APPLICABILITY: SHUTDOWN AND REFUELING

ACTION: A. After each reactor shutdown, if more than 2 control rod pairs are not verified to be fully inserted, within 1 hour either:

1. Insert at least all but 2 control rod pairs to the full-in position, or

2. Insert reserve shutdown material in those regions where control rod pairs are not verified fully inserted, beyond the allowable 2.

B. Subsequent to having achieved full insertion of all control rod pairs with the reactor shutdown, with less than the above requirements:

1. Immediately suspend all control rod or fuel manipulations involving positive reactivity changes, and

2. Within 12 hours:

   a.) Insert any rod pair capable of being inserted and verify the SHUTDOWN MARGIN requirements are met (LCO 3.1.4), or

   b). Actuate sufficient reserve shutdown material to achieve the specified SHUTDOWN MARGIN.

SURVEILLANCE REQUIREMENTS

4.1.6 A. Control rod pair positions shall be monitored via OPERABLE rod position instrumentation (LCO 3.1.3) for compliance with this LCO at least every 12 hours.

B. Following each reactor shutdown, each rod pair shall be verified to be at the full-in position by one of the following means:

1. The agreement of the analog position indication and the full-in position indications; or

2. The agreement of the analog and digital position indications (that were known both to be OPERABLE prior to the shutdown and to be accurate at the full-in position); or

3. The use of an independent rod position verification method (e.g., watt-meter test).

Rods that were known to be fully inserted into the reactor prior to the shutdown may be excluded from the above verifications.

C. Prior to removal of any control rod drive assembly from the reactor for refueling/repair, the SHUTDOWN MARGIN shall be explicitly calculated per the requirements of LCO 3.1.4.

D. Upon full withdrawal of a control rod pair selected for removal from the PCRV, and prior to disabling its scram capabilities, the SHUTDOWN MARGIN shall be verified by withdrawing one or more additional control rod pairs with a calculated worth greater than or equal to 0.01 delta k plus any calculated positive worth of the planned CORE ALTERATION, verifying subcriticality, and then reinserting.

BASIS FOR SPECIFICATION LCO 3.1.6/SR 4.1.6

This specification ensures that a sufficient number of control rods are fully inserted to keep the reactor in a shutdown condition (SHUTDOWN MARGIN greater than or equal to 0.01 delta k) in the SHUTDOWN and REFUELING MODES.

Prior to refueling a region, the control rod in that region and the control rod in the region next in sequence to be refueled will be withdrawn. Additional predesignated control rods will also be withdrawn and subcriticality will be verified. The minimum reactivity worth of the additional predesignated control rods is 0.01 delta k plus the reactivity difference between the new and spent fuel in the region to be refueled, plus the temperature defect between the refueling temperature and 80 degrees F. After subcriticality has been verified, the predesignated control rods will be fully reinserted. Withdrawal of the predesignated control rods ensures a SHUTDOWN MARGIN of greater than or equal to 0.01 delta k at 80 degrees F with new fuel loaded into the refueled region.

Making all of the fully inserted control rods incapable of being withdrawn ensures that an un-analyzed core configuration which might result in criticality will not exist.

A SHUTDOWN MARGIN of greater than or equal to 0.01 delta k after reactor shutdown (automatic scram or controlled) is ensured by the 1 hour ACTION to either fully insert all but 2 control rod pairs or insert reserve shutdown material in those regions where control rod pairs cannot be verified to be fully inserted, beyond the allowable two. Control rod pairs may be verified fully inserted by rod-in indication, by both digital and analog indications less than 12 inches, or by other independent means (e.g., watt meter test) as time permits. The 12 inch limit assures reactivity control, as discussed in the Bases for LCO 3.1.3. Experience has shown that a control rod pair which is not fully inserted by a scram may still be fully inserted manually with its control rod drive motor. If the control rod pair cannot be fully inserted with its drive motor, then reserve shutdown material will be inserted into that region, ensuring a SHUTDOWN MARGIN of greater than or equal to 0.01 delta k.

If any requirements of the LCO are not met while the reactor is shutdown or in refueling, any control rod or fuel manipulations which would result in a positive reactivity addition will be suspended immediately and within 12 hours any withdrawn control rod pairs will be fully inserted. If a SHUTDOWN MARGIN of greater than or equal to 0.01 delta k is not met by fully inserting the control rods, sufficient reserve shutdown material will be inserted to achieve the specified SHUTDOWN MARGIN. This ACTION ensures a SHUTDOWN MARGIN of greater than or equal to 0.01 delta k during reactor shutdown or refueling operations.

The reserve shutdown material is an effective form of reactivity control when inserted into core regions where the control rods have not been fully inserted. Because of the proximity to the control rods, it has almost no additional worth when inserted in regions where the control rods are inserted. Therefore, to insure an adequate SHUTDOWN MARGIN, it need only be inserted into those core regions where full insertion of the control rods cannot be demonstrated.

Verifying control rod position indication instrumentation OPERABILITY every 12 hours ensures that control rod position can be monitored during control rod manipulations performed in refueling operations.

After each shutdown, verifying that each rod pair is at the full in position ensures that the position of each control rod is known and that the SHUTDOWN MARGIN calculation is accurate.

Verifying that a SHUTDOWN MARGIN of greater than or equal to 0.01 delta k exists prior to removing any control rod drive assembly from the reactor ensures that criticality will not be achieved and the SHUTDOWN MARGIN requirements will be maintained after the rod is removed.

REACTIVITY CONTROL SYSTEMS

3/4.1.7 REACTIVITY CHANGE WITH TEMPERATURE

LIMITING CONDITION FOR OPERATION

3.1.7 The reactivity change due to a CORE AVERAGE TEMPERATURE increase between 220 degrees F to 1500 degrees F, shall be at least as negative as 0.031 delta k but no greater than 0.056 delta k throughout the REFUELING CYCLE.

APPLICABILITY: POWER OPERATION, LOW POWER and STARTUP

ACTION: With the reactivity change outside the range specified, the reactor shall be placed in SHUTDOWN within 12 hours of determination.

SURVEILLANCE REQUIREMENTS

4.1.7 At the beginning of each REFUELING CYCLE the reactivity change as a function of CORE AVERAGE TEMPERATURE change (temperature coefficient) shall be measured and integrated to verify that the measured reactivity change is within the above limits.

BASIS FOR SPECIFICATION LCO 3.1.7/SR 4.1.7

The negative temperature coefficient is an inherent safety mechanism that tends to limit power increases during temperature excursions. It is a stabilizing element in flux tilts or oscillations due, for example, to xenon transients.

Fuel temperatures during a power excursion beginning from a high power level are well within design limits regardless of the magnitude of the negative temperature coefficient, provided protective action is initiated by a power level signal. However, if protective action occurs much later, such as from a manual scram or activation of the Reserve Shutdown System, peak fuel temperatures will be sensitive to the magnitude of the negative temperature coefficient.

Requiring a reactivity change at least as negative as 0.031 delta k for a CORE AVERAGE TEMPERATURE increase from 220 degrees F to the 1500 degree F temperatures associated with the nominal RATED THERMAL POWER value, ensures temperature coefficients at least as negative as those used in the FSAR accident analysis. All rod withdrawal transients assume a reactivity temperature defect of 0.028 delta k which when combined with an uncertainty of plus or minus 10%, yields the specified defect of 0.031 delta k.

The maximum reactivity temperature defect of 0.056 delta k (0.062 delta k minus 0.006 delta k for uncertainty) assures that there is sufficient reactivity control to ensure reactor SHUTDOWN in the unlikely event that all control rod pairs cannot be inserted and the reserve shutdown system has been activated.

The reactivity worth of the reserve shutdown system was calculated to be 0.120 delta k in the equilibrium core (FSAR Section 3.5.3). From calculated excess reactivity data in Table 3.5-4 of the FSAR it is seen that the maximum excess reactivity in the equilibrium core with the CORE AVERAGE TEMPERATURE of 220 degrees F, Xe-135 decayed, and some Pa-233 decay, is 0.097 delta k (1 week of Pa-233 decay) and 0.102 (2 weeks of Pa-233 decay). The calculated reactivity temperature defect for that cycle is 0.044 delta k and the excess SHUTDOWN MARGIN allowing 2 weeks of Pa-233 decay is 0.018 delta k. Therefore, if the reactivity temperature defect were as large as 0.062 delta k (0.044 delta k plus 0.018 delta k) reactor SHUTDOWN could be ensured for at least 2 weeks even for the unlikely event that all control rods failed to insert, and the reserve shutdown system was activated.

The major shifts in reactivity change as a function of core temperature change will occur following refueling. The specified frequency of measurement following each refueling will assure that the change of reactivity as a function of changes in core temperature will be measured on a timely basis to evaluate the limit provided in Specification 3.1.7.

The maximum value of reactivity temperature defect occurs at the beginning of the cycle and slowly decreases through the cycle to a minimum value at the end of the cycle. Since the measurement is made at the beginning of a cycle and the minimum value occurs at the end of a cycle, a direct evaluation cannot be made. However, by comparing the calculated value at the beginning of the cycle with the measured value, an evaluation for compliance can be made using the calculated value at the end of cycle.

REACTIVITY CONTROL SYSTEMS

3/4.1.8 RESERVE SHUTDOWN SYSTEM - OPERATION

LIMITING CONDITION FOR OPERATION

3.1.8 All reserve shutdown (RSD) units shall be OPERABLE with:

A. At least 1500 psig pressure in their individual He gas bottle supplies.

B. At least 500 psig pressure in the ACM nitrogen bottles which provide a backup means of actuating the RSD hopper pressurization valves.

APPLICABILITY: POWER OPERATION, LOW POWER and STARTUP

ACTION: A. With one RSD unit inoperable, operation may continue provided that the RSD unit is capable of being made OPERABLE within 14 days following a reactor shutdown.

B. With two or more RSD units inoperable, or if the provisions of ACTION A cannot be met, restore the inoperable equipment to as a minimum meet the conditions of ACTION A within 24 hours, or be in at least SHUTDOWN within the next 12 hours.

C. The provisions of Specification 3.0.6 are not applicable for changes between STARTUP, LOW POWER, and POWER OPERATION. Prior to entry into STARTUP from SHUTDOWN, all the requirements of this LCO must be met, without reliance on the provisions contained in the ACTION statements.

SURVEILLANCE REQUIREMENTS

4.1.8 The reserve shutdown system shall be demonstrated OPERABLE:

A. At least once per 7 days by verifying that the pressure of the individual hopper He gas bottles is at least 1500 psig.

B. At least once per 7 days by verifying that the pressure of the ACM nitrogen bottles is at least 500 psig.

C. At least once per 92 days by:

   1. Pressurizing each of the 37 reserve shutdown hoppers above reactor pressure, as indicated by operation of the hopper pressure switch. OPERABLE reserve shutdown hoppers shall be capable of pressurization.

   2. Operating the ACM quick disconnect couplings.

   3. Performing a CHANNEL FUNCTIONAL TEST of the instrumentation which alarms at low pressure in the reserve shutdown actuating pressure lines.

D. At least once per 365 days by performing a CHANNEL CALIBRATION of the gas pressure instrumentation.

E. Following entry of condensed water into any reserve shutdown system hopper(s), by performing the surveillance requirements identified in Specification 4.1.9.D.4.

BASIS FOR SPECIFICATIONS LCO 3.1.8/SR 4.1.8 and LCO 3.1.9/SR 4.1.9

The reserve shutdown system must be capable of achieving reactor shutdown in the event that the control rods fail to insert.

After extended power operation, the reserve shutdown system must add sufficient negative reactivity to overcome the temperature defect between 1500 and 220 degrees F, the decay of Xe-135, the buildup of Sm-149, and some decay of Pa-233 to U-233.

The core reactivity increase due to core cooldown and Xe-135 decay occurs within a few days and was calculated to be between 0.089 delta k and 0.081 delta k, at the beginning and end of the initial cycle, respectively, and about 0.076 delta k for the mid cycle of the equilibrium core. The reactivity increase is largest in the initial core where the thorium loading is high and reduces through the first six cycles to a minimum value for the equilibrium core. The reactivity increase due to Sm-149 buildup and Pa-233 decay occurs over several weeks to months and increases the core excess reactivity for the equilibrium core by about 0.007 delta k during the first 14 days and by about 0.024 delta k after a few months, including full Pa-233 decay. Therefore, the reactivity control requirement for the reserve shutdown system, including an allowance of 0.01 delta k for SHUTDOWN MARGIN, in the absence of any control rods being inserted is 0.098 delta k for the initial core and 0.093 delta k for the equilibrium core after 14 days of Pa-233 decay and 0.121 delta k and 0.110 delta k after full Pa-233 decay. This data is summarized in more detail in FSAR Section 3.5.3.

The calculated worth for the reserve shutdown system as noted in FSAR Section 3.5.3 is at least 0.13 delta k in the initial core and 0.12 delta k in the equilibrium core. Although not summarized in the FSAR, the calculated worth for an inoperable RSD unit is about 0.020 delta k which reduces the total worth to 0.110 delta k in the initial core and 0.100 delta k in the equilibrium core, which is sufficient to ensure SHUTDOWN during the first 14 days of Pa-233 decay.

Generally, inoperable RSD units are capable of being made OPERABLE within 24 hours. However, in the unlikely event that an inoperable RSD unit cannot be made OPERABLE within this time, there is adequate time (at least 14 days due to the slow Pa-233 decay as discussed in the Basis for Specification 3.1.4) following a shutdown using the reserveshutdown system, to allow for corrective action of changing out a CRD assembly.

The SHUTDOWN requirement of at least 0.01 delta k, with a CORE AVERAGE TEMPERATURE greater than or equal to 220 degrees F, was selected to minimize the reactivity control requirements for the reserve shutdown system and also provide for changing out a control rod drive (CRD) assembly, if necessary. Refueling condition requirements are given in Specification 3.9.1 which requires the CORE INLET TEMPERATURE to be less than 165 degrees F. Under normal conditions when the reactor has been operated for several months (which is required for Pa-233 buildup), a CORE AVERAGE TEMPERATURE greater than 220 degrees F is retained for a period of 2-4 weeks even with the CORE AVERAGE INLET TEMPERATURE as low as 100 degrees F. This is adequate time for the replacement of a CRD assembly.

A minimum pressure of 1500 psig in the individual helium gas bottle supplies is adequate because the minimum pressure required to burst the rupture discs is 1100 psig (FSAR Section 3.8.3). The rupture discs are designed and have been tested to burst at a differential pressure of 165 plus or minus 50 psi.

A minimum pressure of 500 psig in the ACM nitrogen bottles is adequate because the minimum required set pressure is 220 psig. A set pressure of 220 psig is based on stroking a bank of 10 reserve shutdown valves one time and keeping the regulator full open. This value also compensates for minor line losses and system leakages.

Each of the 37 reserve shutdown hoppers shall be pressurized above reactor pressure at least once per 92 days. Two redundant pressurizing valves will be opened using local test switches and the corresponding hopper pressure observed to increase. To prevent releasing absorber material, the high pressure gas cylinder is isolated and the pressurized actuating line is vented prior to the test. Pressurization is accomplished using test gas at a pressure differential of approximately 40-70 psi above reactor pressure, which is below the 115 psi differential pressure required to rupture the disc. The hopper pressure should increase at least 10 psi above reactor pressure, as indicated by the hopper high pressure alarm.

A CHANNEL FUNCTIONAL TEST will be performed on the low pressure alarm instrumentation at least once per 92 days to ensure that the minimum require rupture gas pressure can be monitored.

A CHANNEL CALIBRATION will be performed on the gas pressure instrumentation at least once per 365 days to ensure reliable monitoring of the helium and nitrogen gas supplies.

In the event that condensed water enters into any reserve shutdown system hoppers, (and during each refueling outage) two RSD hoppers shall be functionally tested out of the core. One assembly will contain 20 weight percent and the other 40 weight percent boronated material. The RSD hopper will be pressurized to the point of rupturing the disc and releasing the poison material. The material will be visually examined for boric acid crystallization and chemically analyzed for boron carbide and leachable boron content.

Specification 3.1.9, RSD hoppers in the SHUTDOWN and REFUELING modes, only requires RSD units to be OPERABLE for those control rod pairs capable of being withdrawn because the worth of the control rod pair(s) removed for refueling/repair has been accounted for in the SHUTDOWN MARGIN and the worth of the RSD material in regions whose control rods are inserted adds little to the SHUTDOWN MARGIN.

The ACTION time of 24 hours is adequate because the reactor has already been shutdown and the SHUTDOWN MARGIN requirements met, versus verifying SHUTDOWN MARGIN requirements immediately after a shutdown.

At each refueling, each group of pressurizing valves will be actuated from the Control Room to verify that the valves open.

At each refueling, the RSD hopper pressure switches which measure the pressure differential between the hoppers and the reactor will be calibrated as individual control and orifice assemblies are removed from the reactor for servicing and maintenance. These switches alarm high hopper pressure for pressurization testing or actual system operation.

The refueling penetration pipe sections will be visually examined for deformation and corrosion following disassembly for refueling or maintenance.

REACTIVITY CONTROL SYSTEMS

3/4.1.9 RESERVE SHUTDOWN SYSTEM - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.9 Reserve shutdown (RSD) units on control rod drive assemblies whose control rod pairs are capable of being withdrawn shall be OPERABLE (except RSD units in any control rod drive assemblies removed for refueling/repair) with:

A. At least 1500 psig pressure in their individual He gas bottle supplies.

B. At least 500 psig pressure in the ACM nitrogen bottles which provide a backup means of actuating the RSD hopper pressurization valves.

APPLICABILITY: SHUTDOWN and REFUELING

ACTION: With less than the required RSD units OPERABLE, within 24 hours:

A. Return all control rod pairs (except the ones removed for refueling/repair) to the full-in position, or

B. Verify SHUTDOWN MARGIN requirements are met (LCO 3.1.4), or

C. Insert sufficient RSD material to maintain SHUTDOWN MARGIN requirements.

SURVEILLANCE REQUIREMENTS

4.1.9 The reserve shutdown system shall be demonstrated OPERABLE:

A. At least once per 7 days by verifying that the pressure of the individual hopper He gas bottles is at least 1500 psig.

B. At least once per 7 days by verifying that the pressure of the ACM nitrogen bottles is at least 500 psig.

C. At least once per 365 days by performing a CHANNEL CALIBRATION of the gas pressure instrumentation.

D. At each refueling outage by:

1. Demonstrating that each subsystem is OPERABLE by actuating each group of pressurizing valves from the Control Room and verifying that the valves open. The capability of pressurizing the corresponding hoppers need not be demonstrated during this test.

2. Performing a CHANNEL CALIBRATION of the reserve shutdown hopper pressure switches at the time of control rod drive preventive maintenance (Specification 4.1.1).

3. Visually examining the pipe sections which require disassembly and reassembly within the refueling penetrations, after they have been disassembled for preventive maintenance (Specification 4.1.1), and verifying that there is no deformation or corrossion that could affect RSD system OPERABILITY.

4. Functionally testing two reserve shutdown assemblies out of core. One assembly shall contain 20 weight percent boronated material and the other 40 weight percent boronated material. The tests consist of pressurizing the reserve shutdown hopper to the point of rupturing the disc and releasing the poison material.

   The absorber material from the tested hoppers shall be visually examined for evidence of boric acid crystal formation and chemically analyzed for boron carbide and leachable boron content. Failure of a reserve shutdown assembly to perform acceptably during functional testing or evidence of extensive boric acid crystal formation will be reported to the Commission within 30 days per Specification 6.9.

E. Following entry of condensed water into any reserve shutdown system hopper(s), by performing the surveillance requirements identified in Specification 4.1.9.D.4.

Enclosure 2
to P-85233

Backup Reactor Shutdown Procedure

The requirements outlined in Reference (1) will be incorporated into plant operating procedures, including the necessary steps to be taken for reserve shutdown system (RSD) actuation. These procedures will require insertion of RSD material within one hour into any regions (beyond an allowable two regions) where control rod pairs have not been verified fully inserted after a shutdown.