CONTROL ROD SYSTEM
OPERABILITY EVALUATION

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CONTROL ROD SYSTEM
OPERABILITY EVALUATION

ABSTRACT:

This report summarizes the results of a detailed review and evaluation of the existing licensing basis for the reliability of the Fort St. Vrain Control Rod System. All FSAR design and safety considerations were reviewed to identify the significant design bases, and the essential safety functions and components required for accident analyses. Once identified, these functions and components were evaluated for consistency with Technical Specification requirements, controlled documents and procedures, and plant operational experience.

In general, the licensing basis was found to be consistent with Technical Specification requirements and design documents. However, specific changes, additions, and evaluations are recommended in maintaining the original level of reliability in view of plant operational experience and continuing engineering investigations.

INTRODUCTION:

This report is organized to highlight the three main areas reviewed in evaluating the licensing basis for control rod reliability:

FSAR REVIEW,
TECHNICAL SPECIFICATION REVIEW, and
CONTROLLED DOCUMENTS REVIEW.

Specific conclusions and recommendations are included following the review of each area.

I. FSAR REVIEW

A. SYSTEM DESCRIPTION

The control rod system functions to control and safeguard the fission process occurring in the reactor. The main components of the control rod system consist of the control rod, the drive mechanism, and the control and position indication circuitry.

The control rod consists of eleven (11) boron carbide cannisters and a tube type shock absorber attached along a metal spine suspended in the core from steel cables. The design considerations are specifically described in FSAR Section 3.8.1.2. The important design considerations are related to boron content, ruggedness of design, and component design life assumptions.

The drive mechanism primarily consists of the drive motor, motor break, reduction gearing and bearings, guide pulleys, cable drum, limit switch cams, position potentiometers, guide tubes, and a velocity limiting three-phase capacitor array. These components are discussed in FSAR Section 3.8.1.1. The drive mechanism is designed to be fail-safe under all postulated accident and operating conditions, allowing for free-fall gravity insertion at all times.

The rod control and position indication system consists of the automatic and manual controls, associated circuitry, interlocks, power sources, sensors, and various relays, which provide for normal reactivity control and indication as well as abnormal reactor protective actions. Reactivity control is described in FSAR Section 7.2.2, and protective actions in Section 7.1.2. The automatic and manual scram capabilities are considered essential.

B. DESIGN BASES

The primary FSAR design bases and major assumptions for ensuring the reliability of the control rod system have been identified as listed. The design bases which are considered essential for performance of the scram safety function, as identified by accident analyses, have been identified by an asterisk (*).

Control Rod

*1. Individual boron loadings are 0.48 gm/cm^3 for the inner nineteen (19) and 0.63 g/cm^3 for the outer eighteen (18) rod pairs, 30 and 40 wt. % respectively (3.8.1.2, 3.5.3.1).

*2. The overall control rod worth and configuration, considering fuel and poison loadings, must be able to ensure subcriticality, with a minimum shutdown margin of 0.01 ΔK, under all conditions with the maximum worth rod pair withdrawn (3.2.2.3, 3.5.3.1, 3.2.3.2). (See Technical Specification LCO 4.1.2.)

*3. The structural integrity, flexibility, and overall dimensions will be maintained while exposed to the normal reactor operating environment, such that satisfactory operation, helium flow, and free fall insertion are sustained (3.2.2.6, 3.8.1.2).

*4. The normal operating environment for the control rod will not exceed 1300°F (3.8.1.2) or 10vpm total oxidant impurities (CO, CO2, H2O) during normal continuous operation (A.9.2.1, 4.2.1, 3.2.3.3, 3.2.3.5). (See LCO 4.2.10, 4.2.11)

*5. The crushable tube-type shock absorber is designed to absorb the energy of a falling control rod, due to cable or spine failure, such that the integrity of the boron cannisters and bottom reflector element is maintained (3.2.2.6, 3.8.1.2).

6. The design life of the control rod is six (6) cycles (1800 effective full power days (EFPD)) of full power operation (3.8.1.2).

*7. The maximum rod pair worth in the event of an accidental rod pair withdrawal, during all anticipated configurations, will result in a transient less severe than the reactivity accidents evaluated in Section 14.2 (3.5.3.1).

*8. Under the design environmental conditions, the clearances, low drag forces, and dry film lubrication make the probability of galling or binding of the cables in the guides extremely unlikely (3.8.2).

9. Cable fatigue life calculations show a life of approximately 1×10^7 jogs.

*10. The control rod is designed to withstand the maximum seismic disturbances, or Design Basis Earthquake, without loss of function (3.8.2).

Drive Mechanism

*1. The control rod drive mechanism provides for free-fall rod insertion under loss of AC motor or DC brake power conditions (3.2.2.6, 3.8.1.1).

2. The CRD motor rotates under the influence of a capacitor array to limit the speed of control rod insertion during gravity driven scram conditions (3.2.2.1, 3.8.1.1).

3. Environmental operating conditions are maintained within acceptable limits based on design thermal barriers, radiation shielding, and normal operation of the penetration purge flow and liner cooling systems (3.8.1.1).

4. Radiation shielding and primary coolant activity levels are designed to limit drive mechanism radiation levels to 1 rad/hr under normal continuous operating conditions (3.8.1.1.1).

*5. The maximum temperature rating of the drive mechanism which might inhibit the scram function is 272°F.

6. The normal penetration purge flow is designed to be approximately 5 lb/hr/penetration.

7. Presence of foreign particles and debris, both metallic and molybdenum disulfide, was observed during the original prototype testing. However, it was specifically evaluated and determined to have no significant effect on drive performance based on design provisions which limit ingress and accumulation.

*8. All bearing and gear materials, fabrication, and special dry film lubrication have been proven through extensive testing to maintain satisfactory operation in the purified helium environment (3.8.1.1.1).

*9. Gravity free fall capability is based on an initiating load of 120 lbs. per cable (Page 3.8-5).

*10. The drive mechanism is designed to withstand the maximum seismic disturbance or Design Basis Earthquake without loss of function (3.8.2).

*11. The total scram insertion time is approximately 152 seconds (3.5.3.1).

*12. The maximum reactivity insertion rate is about 0.001 $\Delta K/ft$, based on a normal complete rod pair withdrawal time of approximately 180 seconds (3.5.3.1, 3.6.7).

13. Operation of the control rods by the control rod drive system, including representative numbers for scram operations, is possible for at least the six cycle (1800 EFPD) minimum life of the control rods (3.2.2.6).

14. The prototype testing, initiated to ascertain the reliability of the control rod system, simulated the expected long term operating conditions of temperature and helium, with less than 10 VPM oxidant impurities, and no radiation effects. In the shim mode, the prototype demonstrated some 200 years of service life or 33 times its <u>expected</u> service life (6 years) (A.9.2.2).

15. The rod drives were to receive inspection and refurbishment as necessary (A.9.2.2).

Rod Control And Position Indication

*1. A rod withdrawal sequence interlock prevents rods from being withdrawn out of sequence at power levels between 1 and 5% rated power (3.5.3.1, 7.1.2.2, 7.2.2.1). (See Technical Specification LCO 4.1.3)

2. The control and position indication system is utilized to establish and measure the core power level (7.2).

*3. Partial control rod insertion is required to prevent endangering fuel particle integrity for region peaking factors greater than 1.83 (3.2.3.1). (See Technical Specification LCO 4.1.3)

4. The runback controller is allowed to insert rods only (7.2.1.2).

5. Rod control actuator switch interlocks and power supply load sensors ensure that not more than one rod pair may be moved simultaneously outward (7.2.2.1, 7.2.2.3).

6. Each of the thirty-seven (37) control rod drives is equipped with two (2) potentiometer type position transmitters, one providing continuous analog indication for each rod and one providing digital indication on a selective basis in the control room (7.2.2.3, 7.2.2.1).

7. In addition to Item 6 (above), each rod pair is equipped with three pairs of limit switches which provide control room indication of individual full in/full out position, outward/inward rod motion, and slack cable (7.2.2.1, 7.2.2.2, 3.2.2.6, C.13).

*8. Means must be included in the control room to monitor and control the reactivity status of the reactor (7.2.2.1, C.13.1). (See Technical Specification LCO 4.1.8)

9. Excessive deviation between rod pairs in a group is alarmed for rod deviations greater than 2 ± 1 ft (Page 3.6-19, Page 7.2-9 and Section 7.2.2.1).

*10. To prevent undesirable flux and temperature distributions, partial rod insertion, with the exception of the regulating rod pair, shall be limited to two groups at any position (separated by at least 10 ft), six pairs up to 2 ft, and the two runback groups (six pairs) at any position not to exceed 4 hours (3.2.3.1). (See Technical Specification LCO 4.1.4)

*11. The automatic scram circuitry provides three independent sensing circuits for each scram parameter, and is based on a general 2 of 3 logic system up to the final trip logic (7.1.2.1).

*12. Direct DC brake power supply interruption is provided through Manual Scram capability, independent of the automatic system (7.1.2.1).

13. Relays in the rod brake circuitry deenergize contactors in the rod motor circuit to ensure scram functions (7.1.2.1).

14. Manual push-button bypass circuitry is provided to allow powered insertion of a bound rod following a scram (7.1.2.1).

*15. Remote manual scram capability is provided in the switchgear room to effect plant shutdown in the event the control room becomes uninhabitable (7.1.2.3).

*16. The reactor mode switch (RMS) is provided as a backup to manual scram (7.1.2.3).

*17. The automatic scram parameters are defined as shown in Attachment 1 to this report (Table 7.1-2).

C. ESSENTIAL SAFETY FUNCTIONS AND COMPONENTS

Through review of the FSAR accident analyses, with respect to the previously listed design bases, essential safety functions and components have been identified along with general conclusions regarding accident evaluations.

Environmental Disturbances

(Sections 14.1, 1.4, and 10.3)

Of all the FSAR accident evaluations, the environmental disturbance accidents are probably the most significant in terms of the impact on equipment requirements. All plant structures, systems, and components have been divided into two groups, Class I and Class II, based on their importance to safety during environmental accidents. Of the environmental accidents, the Design Basis Earthquake and Maximum Tornado were considered limiting.

Class I equipment was specifically defined through evaluation of an encompassing accident involving a Design Basis Earthquake or Maximum Tornado, which are evaluated to include the failure or loss of: outside electric power, main turbine, deaerator, all three boiler feedpumps, all condensate pumps, auxiliary boiler and backup auxiliary boiler feed pumps, main condenser, main and service water cooling towers, and piping and equipment downstream of the main steam bypass valves. Under these conditions, items whose failure or damage could have resulted in:

i) Release of abnormal quantities of radioactivity,
ii) Interference with safe reactor shutdown, or
iii) Interference with adequate removal of decay heat,

were designated Class I. The Class I list included certain considerations for redundancy, accident mitigation, and single failures where considered appropriate (10.3.10). The minimum requirements for cooldown of the plant under these conditions have been defined by another list of equipment items termed Safe Shutdown, which is a subset of the Class I List (10.3.9 and 14.4.2). Thus, all Class I items, with the exception of the fuel handling machine, are designed to withstand both the Design Basis Earthquake and the Maximum Tornado without unsafe damage or loss of safety function. (See Design Documents SR 6-1 and SR 6-2)

All other plant structures, systems, and components were designated Class II.

The "control and orificing assemblies" are considered Class I and the "control rod drives" are considered required for safe shutdown cooling, as designated in Table 1.4-1 and 1.4-2 respectively. The ability of the control rod to drop freely into the core under worst case core misalignment conditions following an earthquake, is specifically evaluated in Section 14.1.1. The conclusions of Section 14.4.2 regarding acceptable safe shutdown cooling, assume that a scram is achieved immediately following the event. This is consistent with Section 7.3.9, which requires immediate reactor shutdown following seismic instrument indication that a disturbance of the magnitude of the Design Basis Earthquake, 0.10g, has occurred.

The critical safety functions, for these conditions, would be those responsible for the scram functions. Scram, under the postulated conditions, can be assumed to occur automatically or manually within ten minutes after the event, as evaluated in Sections 10.3.3 and 10.3.1, respectively. (See Technical Specification LCO 4.4.1)

Reactivity Accidents

(Section 14.2)

The FSAR evaluated reactivity accidents initiated by any of the following conditions:

1. Excessive removal of control poison,
2. Loss of fission product poisons,
3. Rearrangement of core components,
4. Introduction of steam into the core, and
5. Sudden decrease in reactor temperature.

From these evaluations, it is concluded that the accidental withdrawal of control poison results in the worst reactivity accidents. Ten specific protective actions or lines of defense against the rod withdrawal accidents are provided, of which nine are considered effective during a startup accident, and five effective during power operation. The inherent protective design features considered are the maximum reactivity addition rate of 0.00009 ΔK/sec., and the available scram reactivity, which is always sufficient to achieve subcriticality with a 0.01 ΔK shutdown margin with due regard for inoperable rod pairs. (See Technical Specification LCO 4.1.2)

Three main rod withdrawal accidents are specifically reviewed: i) Maximum Worth Control Rod Pair Withdrawal at Full Power, ii) Maximum Worth Control Rod Pair Withdrawal at Source Power, and iii) Simultaneous Withdrawal of All Thirty-Seven Rod Pairs.

i) The power range accident assumed three sequential lines of defense: automatic scram at 140% rated power as initiated by the power range channels, manual scram after 60 seconds, and hot reheat steam temperature automatic scram at 1075°F after 105 seconds. Only when protective action is not initiated prior to the 1075°F reheat steam temperature limit is fuel failure assumed to occur. However, it is concluded that the 2% fuel particle failure would result in less than design primary coolant activity levels, and core shutdown/cooldown and PCRV integrity would not be impaired. (See Technical Specification LCO 4.4.1)

ii) Assuming the sequential failure of four specified lines of defense,the source power accident was assumed terminated by a scram at 140% rated power. The consequences of a 0.047 ΔK source power insertion was evaluated with no fuel particle failure expected. (See Technical Specification LCO 4.1.3)

iii) The simultaneous rod pair withdrawal accident (37) was considered incredible due to the specific protective design features including control rod acutator switch interlocks, and rod motor power supply line load sensors. For the limiting conditions of 0.0029 Δk/sec. reactivity insertion, 180 second total withdrawal time, and 150 second rod insertion time, a scram initiated at 140% power will not lead to fuel failure nor any other condition endangering the safety of the plant. (See Technical Specification Surveillance Procedures SR 5.1.1a-A/5.4.1.4.4.b-R-Load Sensor, Scram and Withdrawal Rate, and 5.4.1.4.4.a-P-Hand Switch Interlocks)

Design Basis Accidents

(Sections 14.10 and 14.11)

For Design Basis Accident No. 1, permanent Loss Of Forced Circulation, the FSAR assumes an automatic scram on "two loop trouble" occurs upon initiation of the event. Following scram, the core fission product afterheat is expected to result in peak temperatures of 2980°C for the center of the active core. The boron compact loadings of 30 and 40 wt %, for inner and outer rods, were specifically evaluated and determined to maintain the structural integrity of the boron compacts thus ensuring that no major loss of poison material would occur (D.3.3).

The analysis of Design Basis Accident No. 2, Rapid Depressurization, assumes that automatic scram is initiated by the load programed PCRV pressure - Low, 50 psig below normal or 650 psig from full load. Neither the event initiation nor conditions following the event are considered to impair the reactor shutdown systems, control rods and reserve shutdown material. (See Technical Specification LCO 4.4.1 Scram Parameters snd Settings)

Steam Leak Accidents

(Section 14.5)

For the various limiting steam generator leaks analyzed in the FSAR, automatic scram is assumed to occur following correct operation of any one of three safeguards: high moisture (2 inputs), high pressure, or manual steam generator dump and scram. These scram parameters are assumed to be operable to initiate corrective action within approximately 100 seconds following the event. (See Technical Specification LCO 4.4.1)

Other Accidents

Other abnormal conditions such as loss of purge flow (14.6.1.1), cable failure (3.8), and loss of power have been evaluated and determined not to impair the shutdown function of the control rod system.

In the incredible event of total inoperability of the control rod system, the reserve shutdown system is adequate and independently redundant to achieve shutdown conditions from any operating condition (3.8.3). (See Technical Specification LCO 4.1.6 and SR 5.1.2)

D. CONCLUSIONS

1. Although the control rod system was adequately evaluated to remain fail-safe under loss of purge flow conditions, purge flow was a design consideration for normal, continuous power operation for minimizing the effects of primary coolant in the CRD motor area. Therefore, the proposed orifice motor plate and window seals will be installed to reduce purge flow requirements.

2. Due to the concerns regarding control rod temperature, control rod temperature will be monitored on a regular basis.

3. The control rod cable failure and corrective actions should be evaluated for impact on FSAR design life and operating environment assumptions. A 10CFR50.59 Safety Evaluation has been written for changeout of the material.

4. The FSAR specifically considered both the ability to differentiate between rod motor withdrawal and insertion characteristics, and the ability to identify bound rods by measuring rod motor characteristics. The proposed watt-meter and Back-EMF testing capabilities are being evaluated and formalized for use in predictive/preventive maintenance programs.

5. Control Rod Drive refurbishment efforts have specifically identified as left acceptance criteria for design considerations related to position indication, primary and secondary penetration seal leakage and scram time.

6. CRDOA serial numbers will be verified and tracked to assure inner and outer ring boron loadings are maintained in accordance with the DBA-1 analysis.

7. Recent investigations have determined that the major consideration in the observed failures to scram was long term control rod drive degradation. From FSAR design life considerations, the control rod absorber section was considered the limiting factor. The control rod shock absorber was later defined as the limiting component of the control rod, due to neutron embrittlement. Once the design life of the control rod shock absorber was identified (1800 EFPD), the drive mechanism was then prototype tested for performance over this expected service life. However, actual operating experience has shown that normal degradation of the drive occurs independently of EFPD accumulation. Periodic CRDOA performance monitoring will be implemented to provide adequate information to detect significant degradation.

8. Since all limiting accident analyses assume that automatic or manual scram is initiated early in the accident, performance degradation type failure would not need to be addressed provided that periodic testing and preventive/predictive maintenance programs are implemented. Therefore, accident reanalysis is not necessary.

9. The reserve shutdown system was designed to provide an alternate, independent means of shutting the reactor down from any operating condition without movement of the control rods. To ensure this capability, examination of reserve shutdown material will be included as a part of the CRDOA preventive maintenance program to verify that material bridging or agglomeration is not occurring.

II. TECHNICAL SPECIFICATION REVIEW

A. LCO, SR OVERVIEW

The Technical Specification requirements and corresponding procedures related to the control rods and the reserve shutdown system were reviewed to ensure that the identified FSAR analyses limits are incorporated, that the existing limits are consistent with FSAR analyses, that LCO's have appropriate SR requirements, and that SR requirements are maintained through appropriate SR procedures.

The LCO, SR, and SR procedure matrix was identified as follows:

LCO 4.1.2 Operable Control Rods

SR 5.1.1 Control Rod Drives Surveillance

SR 5.1.1a-A/ 5.4.1.4.4.b-R	Control Rod Scram Test/Multiple Rod Pair Withdrawal Check
SR 5.1.1b-M	Control Rod Operability
SR 5.1.4-W-P	Core Reactivity Status Check

LCO 4.1.3 Rod Sequence

SR 5.1.5 Withdrawn Rod Reactivity Surveillance

SR 5.1.5-RX	Control Rod Reactivity Worth

LCO 4.1.4 Partially Inserted Rods

LCO 4.1.8 Reactivity Status

SR 5.1.4 Reactivity Status

SR 5.1.4-W-P Core Reactivity Status Check

LCO 4.4.1 Plant Protective System Instrumentation

See Attachment 2

SR 5.4.1 Reactor Protective System

See Attachment 3

SR 5.4.1.1.1.a-RP	Manual (Control Room) Scram Test
SR 5.4.1.1.2.a-MP	Manual (I-49) Scram Test

SR 5.4.1.1.3.b-P/ 5.4.1.4.1.b-P	Startup Channel Scram Test
SR 5.4.1.1.3.c-R	Startup Channel Scram Calibration
SR 5.4.1.1.4.b-M/ 5.4.1.4.2.b-M	Linear Power Channel Scram Test
SR 5.4.1.1.4.c-D/ 5.4.1.4.2.c-D	Linear Power Channel Heat Balance Calibration
SR 5.4.1.1.4.d-R/ 5.4.1.4.2.d-R	Linear Power Range Channel Calibration
SR 5.4.1.1.5.b-P/ 5.4.1.4.3.b-P	Wide Range Power Channel Test
SR 5.4.1.1.5.c-M/ 5.4.1.4.3.c-M	Wide Range Channel Heat Balance Calibration
SR 5.4.1.1.5.d-R/ 5.4.1.4.3.d-R	Wide Range Power Channel Calibration
SR 5.4.1.1.6.c-R	Primary Coolant Moisture Scram Calibration
SR 5.4.1.1.6.e-M	Primary Coolant Moisture Instrumentation Sample Flow Alarm Functional Test
SR 5.4.1.1.7.a-M	Primary Coolant Moisture Scram Test
SR 5.4.1.1.8.b-M	Reheat Steam Temperature Scram Test
SR 5.4.1.1.8.c-R	Reheat Steam Temperature Scram Calibration
SR 5.4.1.1.9.b-M/ 5.4.1.2.9.a-M	Primary Coolant Pressure Scram Test
SR 5.4.1.1.9.c-R	Primary Coolant Pressure Scram Calibration
SR 5.4.1.1.10.b-M	Circulator Inlet Temp. Scram Test

SR 5.4.1.1.10.c-R Circulator Inlet Temp. Scram Calibration

SR 5.4.1.1.11.a-M Hot Reheat Header Pressure Scram Test

SR 5.4.1.1.11.b-R Hot Reheat Header Pressure Scram Calibration

SR 5.4.1.1.12.a-M Main Steam Pressure Scram Test

SR 5.4.1.1.12.b-R Main Steam Pressure Scram Calibration

SR 5.4.1.1.13.a-M Two Loop Trouble Scram Test

SR 5.4.1.1.13.b-R Two Loop Trouble Scram Test

SR 5.4.1.1.14.a-M Plant 480V Power Loss Scram Test

SR 5.4.1.1.15.b-M High Reactor Building Temperature (Pipe Cavity) Scram Test

SR 5.4.1.1.15.c-R High Reactor Building Temperature (Pipe Cavity) Scram Calibration

LCO 4.1.6 Reserve Shutdown System

SR 5.1.2 Reserve Shutdown System

SR 5.1.2ad-Q Reserve Shutdown Hopper Pressure Test

SR 5.1.2a-W ACM Nitrogen Backup Bottle Pressure

SR 5.1.2bd-A Reserve Shutdown Hopper Low Pressure Calibration

SR 5.1.2c-X Reserve Shutdown Assembly Functional Test

SR 5.1.2e-X Reserve Shutdown Hopper Pressure Switch Calibration

SR 5.1.2f-X Refueling Penetration Examination

SR 5.1.2g-R Reserve Shutdown Valve Operability Test

LCO's 4.1.2 and 4.4.1 ensure that the available scram reactivity worth and automatic/manual initiating actions respectively, are maintained functional in accordance with the accident analyses of the FSAR. The scram parameters of LCO 4.4.1 and associated surveillance requirements are attached.

LCO's 4.1.3 and 4.1.4 define design startup and power operation requirements which must be verified to ensure safe power assention and continuous power operation.

LCO 4.1.4 is controlled administratively and thus does not have a specific surveillance requirement.

B. CONCLUSIONS AND RECOMMENDATIONS

The recommendations made below will be evaluated as a part of the Technical Specification Upgrade Program.

1) LCO 4.1.2 basically requires that control rods be "operable" or "fully inserted" to verify available shutdown margin. Although the LCO states that these conditions must be met during power operation, the basis and the FSAR clearly require that they be met at all times. Therefore, a change to the applicability of the LCO is recommended to make it consistent with the FSAR. The allowable actions in LCO 4.1.2 when withdrawn and partially inserted control rods are determined to be inoperable should be stated, along with the requirement to verify compliance within a certain period following rod inoperability. Per the basis of LCO 4.1.2, a control rod is considered operable if it demonstrates scram capability or is fully inserted.

2) SR 5.1.1 should be revised to adequately address the determination of scram capability for both withdrawn rods and partially inserted rods and position verification of fully inserted rods. Control rod position indication is also necessary to verify compliance with LCO 4.1.4, LCO 4.1.8, and the basis for LCO 4.1.2. It is therefore recommended that indication discrepancies and requirements be specified in SR 5.1.1 as well.

3) Provisions for acceptable alternate scram capability testing and rod-in position verification testing should be added to the Technical Specifications.

4) Provisions should also be added to include periodic checks of a representative sample of the control rod drive temperature indicators to ensure that the maximum temperature rating of 272°F is not exceeded during power operation.

5) The criteria defined in the basis for LCO 4.1.3 are actually design safety requirements and should be contained in the Specification section so that it is clear that these limits are not to be exceeded.

6) SR 5.1.5 , for the measurement of control rod worths during cycle startup, should clearly state that a comparison of measured and predicted rod worths is required and that a 20% discrepancy is acceptable as specified in the procedure. The ±20% acceptance criteria should be explained in the bases.

7) LCO 4.1.4 is controlled administratively and thus does not have an applicable surveillace requirement. This LCO should specify appropriate actions for exceeding limits and allow specific time periods for achieving compliance.

8) All FSAR scram parameters are adequately controlled and tested per LCO 4.4.1 and SR 5.4.1.

9) The reserve shutdown system LCO, SR, corresponding procedures, and anticipated corrective actions are considered adequate to demonstrate and ensure the operability of the system. However, recent problems with this system suggest the need for periodic examination of the material to monitor and detect long term degradation. Technical Specifications should be developed to require that one low and one high boron content hopper be functionally tested on a refueling cycle basis and that the material collected undergo visual and chemical examination.

III. CONTROLLED DOCUMENTS REVIEW

A. SAFETY RELATED LIST

Control Rod Assembly

The control and orificing assembly, as specified in FSAR Table 1.4-1, is equipment item D-1201 on the Safety Related Equipment List (see Dwg. D-1201-940). The Safety Related List includes all components which have been designated Class I. This assembly is designated seismic type 2, and environmental I.D. 5, meaning that the item must function only following a seismic event, and that it is required for safe shutdown (Dwg. D1200-100).

Drive Mechanism

The control rod drive mechanism is not separately listed in the Safety Related List, even though it is specifically listed as safe shutdown in FSAR Table 1.4-2. This is due to the fact that the whole assembly is listed as Class I, Safe Shutdown. However, for FSAR purposes, it is clear that the only part of the assembly required to remain operable for scram capability and Safe Shutdown, is the drive train assembly. The control rod absorber sections and power supplies are considered fail-safe. (See Surveillance Procedure SR 5.1.16-M)

The rod motors are powered directly from the Control Rod Drive Motor Control Centers 1 and 2 (N-9225, N-9226), through Reactor MCC's 1 and 3, (N-9229A, N-9231) which are all on the safety related list.

Scram Circuitry

The protective Scram Circuitry is based on hindrance logic; the protective action is caused by loss of signal.

The control rod brake power supply from Instrument Buses 1 and 2 (N-9237, N-9238), is normally supplying power to the control rod brakes, and can be interrupted by one of the following actions:

1. A scram signal from the PPS circuitry grounds out or de-energizes control power to the relay coils in the brake power supply lines, which causes the contacts to open, disconnecting the brake power supply and releasing the brake mechanism (Dwgs. IB-93-6 and D169-2951). The PPS contacts in the brake power supply are XM93125-1, -2, XM93126-1, -2, and XM93127-1, -2. The manufacturer is Square D, Model #CL7002-TG-2. They are listed on the safety related subtier component list as Subt-313, seismic type 1 (function both during and following a seismic event), environmental I.D.-3 (required for safe shutdown-located in three room control complex). (See Technical Specification Surveillance Requirement SR 5.4.1)

2. Numerous manual scrams may be initiated as a backup to the automatic scrams. The three predominant methods for manual scram are: actuation of the manual scram switch, HS-9330 on I-03; positioning the Reactor Mode Switch to OFF, HS-1216 on I-03; and depressing 2 of 3 pushbuttons in the switchgear room, HS93372, HS93373, and HS93374, on I-49. These hand switches are all on the safety related list and are classified as seismic type 1, environmental I.D.-6 (Class I but not required for safe shutdown cooling-environmental qualification required for loss of air conditioning). (See Surveillance Procedure SR 5.4.1.1.1a-RP and SR 5.4.1.1.2a-MP)

In addition to de-energizing the brake circuit, the brake power supply also supplies control power to a set of relays and contacts in the power supply circuit to the control rod drive motors. When the brake circuit is de-energized, control power to contactors K48, K49, K50, and K51 is lost, which causes their associated contacts to open, disconnecting power (120V) to the control rod drive motors. This causes any control rods which were being driven in or out, at the moment the scram occurred, to fall into the core. Contactors K48→K51 are manufactured by ITE, Model A103C. They are listed in the safety related subtier component list as Subt-499, seismic type 1, and environmental I.D. 1 (Class I not required for safe shutdown).

Table 7.1-2
Scram Parameters

	Sensed Variable[a]	Type and Number of Input	Detector Location	Basic Logic	Normal Full Load Value	Absolute[d] Trip Level
1a.	Manual	Hand switch (1)	Control Room Board (I-03)	1 of 1	--	--
1b.	Manual	Hand switches (3)	Control Board I-49	2 of 3	--	--
2.	Neutron countrate - high (use only at Fuel Loading)[a]	Nuclear Channels I, II	PCRV Well	1 of 2		10^5 counts/sec
3.	Rate of neutron flux rise - high (use only at Startup)[a]	Nuclear Channels III, IV, V (wide range)	PCRV Well	2 of 3	< 2 decades per min	5 decades/min
4.	Neutron flux - high	Nuclear Channels III, IV, V, VI, VII, VIII	PCRV Well	2 of 3 2 of 3	100% power	140% power
5.	Primary coolant moisture - high	Dewpoint monitor[b] (8)	PCRV Penetration	2 of 3 plus 1 of 2 or 2 of 2 high level	< -58°F dewpoint	67°F dewpoint
6.	Reheat steam temperature - high (4 thermocouples are combined for 1 scram channel)	Thermocouples (12)	Reactor Building	2 of 3	1002°F	1075°F
7.	Primary coolant pressure - low (use only at Power)[a]	Pressure Transmitters[b] (3)	PCRV Penetration	2 of 3	700 psia	50 psi below rated programmed with load
8.	Primary coolant pressure - high	Pressure Transmitters[b] (3)	PCRV Penetration	2 of 3	700 psia	7-1/2% above normal pressure programmed with load
9.	Hot reheat line pressure - low (use only at Power)[a]	Pressure switches (3)	Turbine Building	2 of 3	610 psig	35 psig
10.	Superheat line pressure - low (use only at Power)[a]	Pressure switches (3)	Turbine Building	2 of 3	2500 psig	1500 psig
11.	Plant electrical system power - loss	Undervoltage relays (9)	480V SWGR No. 1A, 1B, & 1C	2 of 3	480 volts	480V buses 1A, 1B, & 1C (2 out of 3 phases on (2 out of 3 buses) loss of voltage for 35 seconds
12.	Two-loop trouble[c]	Loop shutdown logic	Control Room (Board I-10)	2 of 3 (both loops)	--	--
13.	Reactor building temperature - high	Thermocouples (3)	Reactor Building	2 of 3	95°-110°F	325°F

[a]Notation in parenthesis refers to Interlock Sequence Switch or Reactor Mode Switch positions.

[b]The same transmitters are used for steam/water dump.

[c]"Two-loop trouble" is a condition whereby one steam generator loop is shutdown and trouble that would normally cause a loop shutdown is sensed in the other steam generator loop.

[d]Actual trip setpoints are more conservative to allow for instrument inaccuracy.

Specification LCO 4.4-1

TABLE 4.4-1

INSTRUMENT OPERATING REQUIREMENTS FOR PLANT PROTECTIVE SYSTEM, SCRAM

NO.	FUNCTIONAL UNIT	TRIP SETTING	MINIMUM OPERABLE CHANNELS	MINIMUM DEGREE OF REDUNDANCY	PERMISSIBLE BYPASS CONDITIONS
1a.	Manual (Control Room)	—	1	0	None
1b	Manual (Emergency Board)	—	2 (f)	1	None
2.	Startup Channel-High	≤ 10^5 cps	2	1	Reactor Mode Sw. in "RUN"
3a.	Linear Channel-High, Channels 3, 4, 5	≤ 140% power (a)	2 (f)	1	None
3b.	Linear Channel-High, Channels 6, 7, 8	≤ 140% power (a)	2 (f)	1	None
4.	Primary Coolant Moisture High Level Monitor Loop Monitor	 ≤67°F Dewpoint ≤27°F Dewpoint	 1 (f,t) 2/Loop (f,t)	 1 (c) 1/Loop	None (h) Rev No. 13
5.	Reheat Steam Temperature - High (b)	≤ 1075°F (a)	2 (b) (f)	1	None
6.	Primary Coolant Pressure - Low	≤ 50 psig below normal, load programmed (a)	2 (f) (k)	1	Less than 30% rated power
7.	Primary Coolant Pressure - High	≤ 7.5% above normal rated, load programmed (a)	2 (f) (k)	1	None
8.	Hot Reheat Header Pressure - Low	≥ 35 psig	2 (f)	1	Less than 30% rated power
9.	Main Steam Pressure - Low	≥ 1500 psig	2 (f)	1	Less than 30% rated power
10.	Plant Electrical System-Loss	(d)	2 (e) (f)	1	None
11.	Two Loop Trouble	—	2	1	Reactor mode switch in "Fuel Loading"
12.	High Reactor Building Temperature (Pipe Cavity)	≤ 325°F	2 (f)	1	None

Amendment No. 22

Table 5.4-1

MINIMUM FREQUENCIES FOR CHECKS, CALIBRATIONS, AND TESTING OF SCRAM SYSTEM

Channel Description	Function	Frequency (1)	Method
1. Manual (Control Room)	a. Test	R	a. Manually trip system
2. Manual (1-49)	a. Test	M	a. Manually trip each channel
3. Start-Up Channel	a. Check	D	a. Comparison of two separate channel indicators
	b. Test	P	b. Internal test signal to verify trips, and alarms
	c. Calibrate	R	c. Internal test signal shall be checked and calibrated to assure that its output is in accordance with the design requirements. This shall be done after completing the external test signal procedure by checking the output indication when turning the internal test signal switch.
4. Linear Power Channel	a. Check	D	a. Comparison of 6 separate channel indicators
	b. Test	M	b. Internal test signal to verify trips, and alarms
	c. Calibrate	D	c. Channel adjusted to agree with heat balance calculation
	d. Calibrate	R	d. Internal Test signals to adjust trips and indications
5. Wide Range Power Channel	a. Check	D	a. Comparison of three separate indicators
	b. Test	P	b. Internal Test signals to verify trips and alarms
	c. Calibrate	M	c. Channel adjusted to agree with heat balance calculation
	d. Calibrate	R	d. Internal Test signals to adjust trips and indications
6. Primary Coolant Moisture (all channels)	a. Check	D	a. Comparison of two separate high level channel mirror temperature indications
	b. Check	D	b. Comparison of six separate low level channel mirror temperature indications

Table 5.4-1

MINIMUM FREQUENCIES FOR CHECKS, CALIBRATIONS, AND TESTING OF SCRAM SYSTEM (Continued)

Channel Description	Function	Frequency (1)	Method
6. Continued	c. Calibrate	R	c. Inject moisture laden gas into sample lines
	d. Check	D	d. Verification of eight separate monitor's sample flow, per Item (t) of Notes for Tables 4.4-1 through 4.4-4.
	e. Test	M	e. Verify that each of the eight monitors will alarm on low and high sample flow.
7. Primary Coolant Moisture (High Level Channels)	a. Test	M	a. Trip one high level, one low level channel, pulse another low level channel.
8. Reheat Steam Temperature	a. Check	D	a. Comparison of the averaged thermocouple channel input indications
	b. Test	M	b. Trip channel, verify alarms and indications. Internal test signal to verify trips and alarms.
	c. Calibrate	R	c. Compare each thermocouple output to an NBS traceable standard. Internal test signal to adjust trips and indicators.
9. Primary Coolant Pressure	a. Check	D	a. Comparison of six separate channel indicators.
	b. Test	M	b. Trip channel, internal test signal to verify trips and alarms.
	c. Calibrate	R	c. Known pressure applied to sensor. Internal test signal to adjust trips and indicators.
10. Circulator Inlet Temperature	a. Check	D	a. Comparison of eight separate indicators.
	b. Test	M	b. Trip channel, internal test signal to verify trips and alarms.
	c. Calibrate	R	c. Compare each thermocouple output to an NBS traceable standard. Internal test signal to adjust trips and indicators.

Table 5.4-1

MINIMUM FREQUENCIES FOR CHECKS, CALIBRATIONS, AND TESTING OF SCRAM SYSTEM (continued)

Channel Description	Function	Frequency (1)	Method
11. Hot Reheat Header Pressure	a. Test	M	a. Reduce pressure at sensor to trip channel, verify alarms and indications.
	b. Calibrate	R	b. Known pressure applied at sensor to adjust trips.
12. Main Steam Pressure	a. Test	M	a. Reduce pressure at sensor to trip channel, verify alarms and indications.
	b. Calibrate	R	b. Known pressure applied at sensor to adjust trips.
13. Two Loop Trouble	a. Test	M	a. Special test module used to trip channel by energizing each of four appropriate pairs of two-loop trouble relays.
	b. Test	R	b. Trip logic to cause two loop trouble scram.
14. Plant 480 V Power Loss	a. Test	M	a. Trip each channel by applying simulated loss of voltage signal; verify alarms and indications
15. High Reactor Building Temperature (Pipe Cavity)	a. Check	D	a. Comparison of three separate channel indicators.
	b. Test	M	b. Trip channel, verify alarms and indications. Internal test signal to verify trips and alarms.
	c. Calibrate	R	c. Compare each thermocouple output to a NBS traceable standard to adjust temperature trip point.

NOTE 1: D - Daily when in use
M - Monthly
R - Once per refueling cycle
P - Prior to each start-up if not done previous week

ATTACHMENT 2
TO P-85040

FORT ST. VRAIN

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

REFURBISHMENT PROGRAM

PUBLIC SERVICE COMPANY OF COLORADO
FORT ST. VRAIN NUCLEAR GENERATING STATION

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FORT ST. VRAIN STATION

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

REFURBISHMENT PROGRAM

PROGRAM DESCRIPTION

Introduction

This report describes the program currently being undertaken at Public Service Company of Colorado's Fort St. Vrain Generating Station to refurbish the reactor control rod drive and orificing assemblies (CRDOA). The report includes both a description of the CRDOA components to be inspected, tested, and refurbished or replaced, as necessary, as a part of the program and a description of the procedure to be used for disassembly and reassembly of the CRDOAs.

Replacement parts to be used will either be manufactured to the original equipment specifications or be an upgraded design to resolve problems which have been experienced or anticipated. Where upgraded parts are to be used, the changes in design have been demonstrated to be suitable for the intended applications and documented by existing design change procedures.

The overall purpose of the CRDOA refurbishment program is to ensure both that the CRDOAs will perform their intended safety functions and that potential operability problems with the CRDOAs will not limit plant availability.

SPECIAL EQUIPMENT FOR CRDOA REFURBISHMENT

1. Carousel with Rod Tubes, Clevis Holders, and Valve Support Stand - HSF(W)
2. Shield Wall with Lead Glass Windows, Manipulator, and Clevis Wrenches - HSF(W)
3. Hydraulic Cable Cutter - HSF(W)
4. Clevis Cask and Cart with Track - HSF
5. TV Cameras - HSF(W)
6. Decon Brush Ring - HSF(W)
7. Rotatable Shield - HSF(E)
8. Access Platforms - HSF(E)
9. Special Lighting and Power Supplies - HSF
10. Communications System - HSF
11. Special Ventilation: HEPA Unit and Ducting - HSF
12. Airlock and Special Access Door - HSF
13. CRDOA Support Stand for Boron Ball Removal - HSF(E)
14. Boron Ball Container - HSF(E)
15. Alignment Fixture for SA - HSF(W)
16. Boron Ball Removal and Fill Tools, including Air-Driven Vacuum Cleaner - HSF(E)
17. 10-Ton Gantry Crane with Rails
18. 1-Ton A-Frame Hoist
19. Transfer Shield with Bellows, Lifting Frame, and HEPA Unit
20. CRDOA Support Stands (upper and lower) for Disassembly - ESW

CRDOA Components Involved in the Refurbishment Program

The following CRDOA components will be inspected, tested, and refurbished or replaced, as necessary, as a part of the refurbishment program:

Component	Refurbishment Activities
1. Control Rod Drive Assembly (200) Assembly	
a. Shim Motor & Brake Assembly	Test and rebuild or replace, as necessary
b. Bearings	Clean or replace, as necessary
c. Gears	Clean, as necessary
d. Limit Switches/ Potentiometers	Test and replace, as necessary (Replace components previously identified to be faulty.)
e. Control Rod Cables	Replace
f. Seals	Inspect and replace, as necessary
2. Orifice Control Mechanism	
a. Orifice Control Motor	Test and rebuild or replace, as necessary
b. Bearings	Clean or replace, as necessary
c. Potentiometer	Test and replace, as necessary
d. Gears	Clean, as necessary
e. Drive Shaft & Nut	Clean, as necessary
f. Drive Shaft Housing	Clean, as necessary
3. Rod Retract Switches	Replace (with cables)
4. Cable Seals	Clean, as necessary
5. Control Rods	Verify serial numbers
a. Clevis Bolts	Replace with Inconel bolts
6. Primary Seal Ring	Inspect and replace, as necessary
7. Reserve Shutdown System	
a. Boron Balls	Replace
b. Rupture Disk	Replace, as necessary
c. DP Switch	Test and replace, as necessary

8. Helium Purge Check Valves	Test and replace, as necessary

In addition, the following design modifications will be made to CRDOAs as a part of the refurbishment program:

a. Installation of new purge seals on the orifice control mechanism mounting plate to improve control of helium purge flow into the upper housing of the CRDOA.

b. Use of Inconel in lieu of stainless steel for control rod cables, cable end fittings, and cable clevis bolts to eliminate the potential for stress corrosion cracking in these components.

c. Installation of RTDs in all CRDOAs to monitor temperatures in the vicinity of the control rod drive assembly and orifice control mechanism.

d. Installation, when required, of replacement seal material for seals internal to the 200 Assembly and the primary seal.

Refurbishment Approach

The approach which will be used to refurbish the CRDOAs was developed to meet the following program objectives:

a. Ensure that safe shutdown capability is not affected during refubishment work.

b. Minimize personnel radiation exposure and Refueling Floor contamination levels.

c. Ensure proper quality control and documentation.

d. Minimize the potential for problems.

3. Remove the control rods and deposit in carousel, as follows:

   a. Lower rods into carousel rod tubes.

   b. Engage rod clevis holders.

   c. Rotate clevis and remove clevis bolts.

   d. Cut swaged eye from each cable and deposit in cask.

4. Move the CRDOA from HSF (West) to ESW using 10 ton gantry crane with Transfer Shield and position on ESW stands. (Upper stand raises CRDOA sufficiently to allow access to openings in the side of the upper housing for removal of control rod drive assembly. Lower stand supports the orifice valve assembly during disassembly of the CRDOA.)

5. Disassemble the CRDOA.

   a. Disconnect electrical connectors and tubing through access openings.

   b. Remove CRD Assembly (200 Assembly) and place in cart. Move to CRD Refurbishment Area.

   c. Remove and dispose of control rod cables.

   d. Remove rod retract switches.

   e. Remove orifice control mechanism. Inspect, test, clean and refurbish the mechanism, as necessary.

   f. Remove the upper housing. Inspect and replace the primary seal, as necessary.

   g. Remove the shield container.

   h. Remove cable seals. Disassemble and clean for reuse.

6. Refurbish the Control Rod Drive Assembly (200 Assembly).

   a. Disassemble and clean parts.

Attachment 2

CRDOA Refurbishment Program

Hot Service Facility Special Shielding and Equipment