Public Service Company of Colorado

16805 WCR 19 1/2, Platteville, Colorado 80651

February 3, 1985
Fort St. Vrain
Unit #1
P-85046

Mr. Robert Martin, Regional Administrator
U. S. Nuclear Regulatory Commission
611 Ryan Plaza, Suite 1000
Arlington, Texas 76011

Attention: Mr. E. H. Johnson

SUBJECT: Resubmittal of Various CRDOA Related Reports

REFERENCES:
(1) PSC Letter, Lee to NRC RIV Regional Administrator, dated 1/4/85 (P-85003)

(2) NRC Letter, Martin to Lee, dated 1/17/85 (G-85024)

(3) PSC Letter, Lee to NRC RIV Regional Administrator dated 1/28/85 (P-85030)

(4) PSC Letter, Gahm to NRC RIV Regional Administrator dated 1/31/85 (P-85040)

Dear Mr. Martin:

Attached please find a complete resubmittal (including attachments) of our letter P-85040, dated January 31, 1985, concerning Public Service Company of Colorado's response to commitments made in the letters referenced above. Certain pages were erroneously omitted from our original submittal during the reproduction process. Please discard our original submittal and replace with the attached.

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If you have any questions or comemnts regarding the attached documents, please contact Mr. Mike Holmes at (303) 571-8409.

Sincerely,

J. W. Gahm
Manager, Nuclear Production
Fort St. Vrain Nuclear
Generating Station

JWG:FJN/alk

Attachments

Public Service Company of Colorado

16805 WCR 19 1/2, Platteville, Colorado 80651

January 31, 1985
Fort St. Vrain
Unit #1
P-85040

Mr. Robert Martin, Regional Administrator
U. S. Nuclear Regulatory Commission
611 Ryan Plaza, Suite 1000
Arlington, Texas 76011

Attention: Mr. E. H. Johnson

SUBJECT: Submittal of Various CRDOA Related Reports

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(2) NRC Letter, Martin to Lee, dated 1/17/85 (G-85024)

(3) PSC Letter, Lee to NRC RIV Regional Administrator dated 1/28/85 (P-85030)

Dear Mr. Martin:

In response to commitments made in the referenced letters, Public Service Company of Colorado submits the attached reports and procedures for Nuclear Regulatory Commission review. The attachments are summarized as follows:

Attachment 1 - Control Rod System Operability Evaluation Report

Attachment 2 - Control Rod Drive and Orificing Assembly Refurbishment Program Report

Attachment 3 - Control Rod Drive and Orificing Assembly Proposed Preventive/Predictive Maintenance Program Report

Attachment 4 - Control Rod Drive and Orificing Assembly Refurbishment Program Radioactive Waste Handling Analysis Report

Attachment 5 - Control Rod Drive and Orificing Assembly Interim Surveillance Program Report

Attachment 6 - Wattmeter Use to Determine Inserted Absorber String Position Report

Attachment 7 - Exerpt from Issue 15 of SOP 12-01 describing operator actions to prevent overdriving of control rods past the rod-in limit.

Attachment 8 - Operations Order No. 84-17 describing operator actions upon a loss of purge flow and/or detection of high moisture levels in the primary coolant.

Attachment 9 - Current CRD Temperature Data Collection procedure which requires Station Manager notification upon discovery of a measured CRD temperature in excess of 250°F.

If you have any questions or comments regarding these documents, please contact Mr. Mike Holmes at (303) 571-8409.

Sincerely,

J. W. Gahm
Manager, Nuclear Production
Fort St. Vrain Nuclear Generating Station

JWG:FJN/alk

Attachments

ATTACHMENT 1
TO P-85040

CONTROL ROD SYSTEM

OPERABILITY EVALUATION

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

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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 x 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 ΔK/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).

A scram bypass circuit also exists, which provides the capability to power drive a postulated bound or stuck control rod following scram actuation. The bypass circuit is normally open and is closed by actuation of one of four hand switches, HS-93475→93478, which close contacts K61, K62, K63, and K64. These contacts and bypass circuit are considered Class I since they provide for a design safety function. These contactors are manufactured by ITE, Model A103C, and are listed as Subt-499.

B. CONCLUSIONS

All the automatic and manual protective functions, parameters, circuitry, contacts and mechanisms required to achieve scram action are on the Safety Related List. These safety related functions were found to be appropriately tested by plant surveillance procedures except for the rod drive motor de-energizing circuit (K48→K51) and the bypass drive circuit (K61→K64, HS93475→478). These functions are not considered necessary for safe shutdown, nor required by limiting FSAR accident analyses, but appropriate plant procedures are being developed to address these safety related functions.

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.

ATTACHMENT 1

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.

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.

<u>Refurbishment Approach</u>

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.

The refurbishment work will be accomplished utilizing a combination of existing plant equipment and facilities intended for CRDOA refurbishment (i.e., Reactor Building Crane, Auxiliary Transfer Cask, Reactor Isolation Valves, Shield Adapters, Equipment Storage Wells, and the Hot Service Facility), together with special shielding, tooling, fixtures, cranes, and ventilation equipment specifically designed to facilitate the refurbishment program. A list of the special equipment which will be used is provided in Attachment 1.

The following approach will be utilized for refurbishment of the CRDOAs. Detailed procedures have been specifically developed to direct and control the refurbishment work. The approach allows for a number of CRDOAs (up to five assemblies) to be refurbished in parallel through the use of multiple workstations. For clarity, the following steps describe the refurbishment tasks for a single CRDOA.

All steps are to be performed with the reactor shutdown and depressurized.

A. Overall Sequence

1. CRDOA are refurbished sequentially based on the availability of the Hot Service Facility (HSF) for removal and reattachment of the control rods.

2. The first CRDOAs to be refurbished will be the spare assemblies currently stored in the Equipment Storage Wells (ESW).

3. The remaining CRDOAs are removed sequentially from the reactor (within Technical Specification limits for rod removal) and replaced with refurbished assemblies.

B. Refurbishment Procedure

1. Conduct pre-refurbishment testing to establish initial CRDOA performance.

2. Move CRDOA from ESW (or Reactor) to the west end of the HSF (see Attachment 2) using the Auxiliary Transfer Cask (ATC).

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.

b. Reassemble with new cables and rod retract switches. Replace bearings and seals, as necessary. Test shim motor and brake assembly and replace or rebuild, as necessary.

c. Adjust switch and potentiometer setpoints and test the assembly.

7. Refurbish the orifice valve drive shaft assembly, if deemed necessary, based on orifice valve performance and shaft torque measurements.

   a. Pull shaft with bearings.

   b. Clean shaft and bearing cartridge.

   c. Replace bearings, as necessary.

   d. Reassemble.

8. Reassemble the CRDOA.

   a. Attach the refurbished CRD Assembly, upper housing, and shield container to a reassembly fixture on the 10 ton gantry crane.

   b. Attach cable seals and rod test weights to control rod cables.

   c. Lower test weights into guide tubes.

   d. Install cable seals.

   e. Install shield container.

   f. Install upper housing.

   g. Install orifice control mechanism and rod retract switches.

   h. Test orifice drive mechanism.

   i. Install new purge seals.

   j. Install and test CRD Assembly.

9. Move CRDOA from the ESW to the east end of the Hot Service Facility, using the Transfer Shield and 10 ton gantry crane.

10. Replace the Reserve Shutdown System Boron Balls.

    a. Vacuum out balls through fill connections.

    b. Inspect chamber with boroscope.

    c. Replace rupture disk, as necessary.

    d. Refill with new boron balls.

    e. Conduct pressure test. Test DP switch.

    f. Remove rod test weights.

    g. Inspect and repair, as necessary, the secondary seal.

11. Move CRDOA from HSF (East) to HSF (West) using Transfer Shield and 10 ton gantry crane.

12. Reattach Control Rods.

    a. Reassemble clevis using manipulator and clevis bolt wrench.

    b. Disengage clevis holders.

    c. Raise rods.

    d. Rotate carousel to "Test" position.

    e. Perform CRDOA testing.

13. Move CRDOA from HSF (West) to reactor, using ATC. Install in position previously vacated by the removal of a CRDOA of similar boron loading characteristics. Perform final testing in the reactor.

Refurbishment Schedule

The CRDOA refurbishment program is scheduled to begin February 1, 1985 following installation of special shielding and equipment required to support the program and training of personnel who will be performing the refurbishment activities. Refurbishment of 37 CRDOAs (total number of CRDOAs in the reactor) is scheduled to be completed by April 1, 1985.

Attachment 1

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

21. CRDOA Lifting Adapters (for 200 and 600 Assemblies) - ESW

22. CRDOA Reassembly Fixture - ESW

23. Orifice Drive Shaft Puller - ESW

24. Rod Test Weights - ESW

25. CRDOA Electrical Test Panels

26. 200 Assembly Carts with HEPA Unit

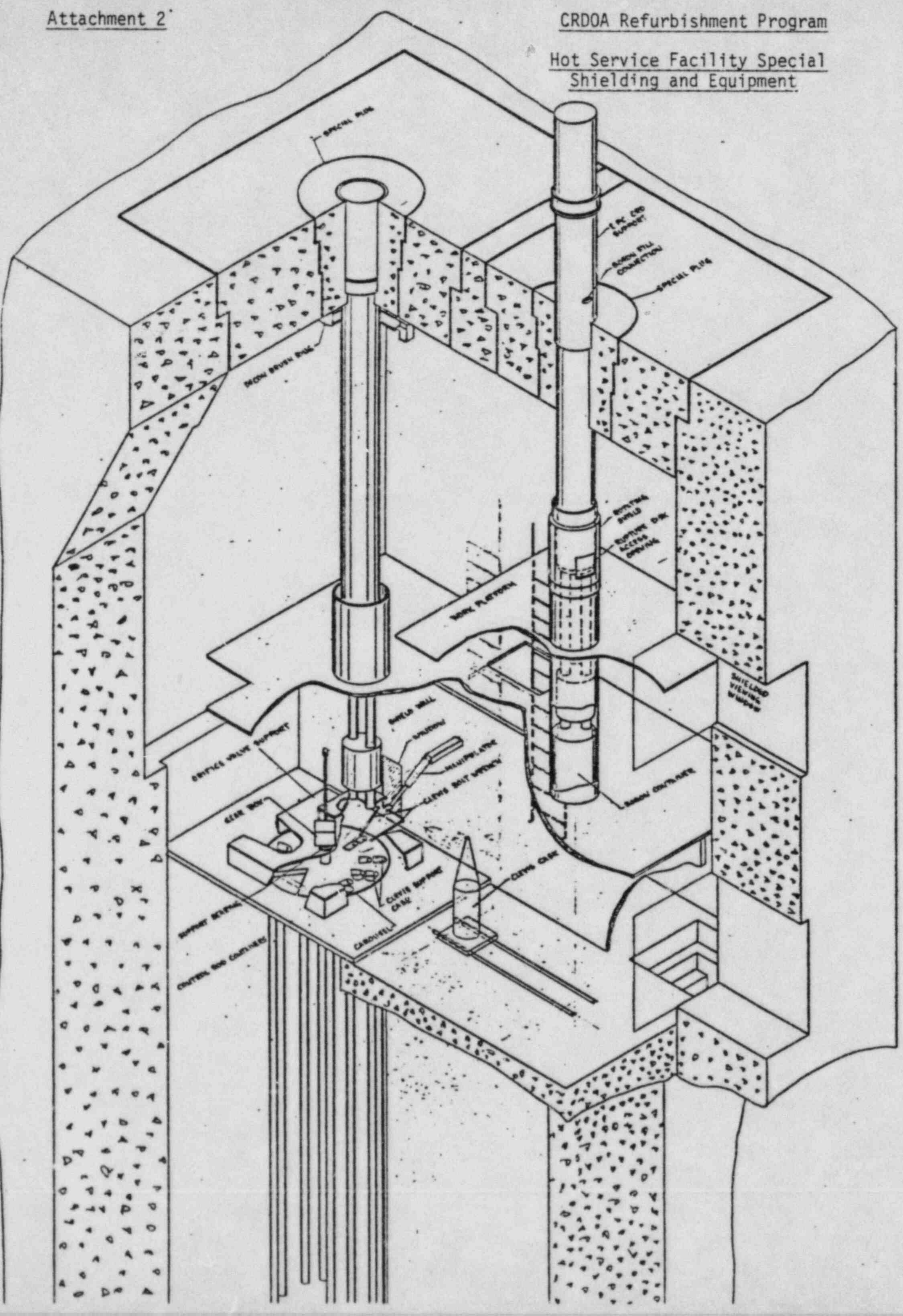
27. Cable Seal Removal and Reinstallation Tools

28. Ultrasonic Cleaners

Attachment 2

CRDOA Refurbishment Program

Hot Service Facility Special Shielding and Equipment



ATTACHMENT 3
TO P-85040

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY PROPOSED PREVENTIVE/PREDICTIVE MAINTENANCE PROGRAM

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I. ABSTRACT

A review of source information to identify potential preventive maintenance activities has been completed, and aspects of that program are being proposed. The detailed implementation of some parts of the program will be dependent upon the results of currently underway Engineering studies. Evidence suggests that a preventive maintenance schedule based on the scheduled refueling cycle for normal service rods (i.e., replacement of rods in refueling regions with refurbished assemblies), and for the regulating rod, in conjunction with predictive maintenance, is appropriate. Of particular importance is the monitoring of shim motor performance, to identify and schedule maintenance other than normally scheduled maintenance.

II. DESCRIPTION OF TECHNICAL REVIEW

A review of a variety of source information on Control Rod Drive and Orificing Assemblies (CRDOAs) has been performed to identify aspects of maintenance for which preventive maintenance consideration would be appropriate. The following sources of information were used:

1. Operations and Maintenance Manual (GA-9806, May 1977)
2. Completed Plant Trouble Reports from the STAIRS database
3. Open Station Service Requests (Plant Trouble Reports)
4. Plant Maintenance Personnel
5. Plant Maintenance Engineering Personnel
6. Proposed Modifications
7. Operational Experience
8. D-1201 Drawings (Design Drawings)
9. Surveillance Requirements
10. Engineering Development Studies

From this variety of information, a set of potential preventive maintenance activities has been identified. Each of these is being subsequently considered individually with regard to component failure history, service life, predictive maintenance (PDM) test potential, and other possibilities, to identify a set of preventive maintenance (PM) activities that is appropriate.

III. PREVENTIVE MAINTENANCE (PM) PROGRAM - GENERAL OVERVIEW OF POTENTIAL PM ACTIVITIES

A. SHIM MOTOR/BRAKE ASSEMBLY

1. Visual Examination

   a. Pinion gear
   b. Motor bearings
   c. Brake pads

2. Test - as left

   a. Dynamometer
   b. Torque to rotate - removed from CRDOA
   c. Torque to rotate - installed on CRDOA
   d. Back-EMF (scram generated braking voltage)

3. Shim Motor Bearings

   a. Clean/replace as required

4. Electrical

   a. Megger motor (insulation test)
   b. Dynamometer (load capability)
   c. Megger brake windings (insulation test)

B. DRIVE TRAIN

1. Visual Examination of exterior

2. Torque - delivered (rods on) measurement

   a. Torque to rotate - motor installed on CRDOA - through shim motor rotor shaft (This is the same as item A.2.c, above)
   b. Back-EMF (scram generated braking voltage)

C. CABLE

1. Visual examination

2. Surface wipe analysis

3. Replace one cable every 3rd refueling cycle to allow:

   a. Detailed visual examination
   b. Metallographic examination
   c. Pull test

D. RESERVE SHUTDOWN SYSTEM

1. Hopper

   a. Visual examination

2. Ma+erial

   a. Sample removal - visual examination
   b. Sample analysis - select CRDOAs

3. Pressure switch

   a. Functional test - Surveillance Requirement

4. Valves

   a. None

5. RSD System

   a. Functional test (blow rupture disk) - Surveillance Requirement

E. POSITION POTENTIOMETERS - ROD PAIR

1. Visual Inspection

2. Test

3. Replace based on service

   a. Number of shims
   b. Rod travel
   c. Anomalous indication
   d. Other service parameters

F. LIMIT SWITCHES (2 each - slack cable, in, out, retract)

1. Visual Inspection

2. Test

3. Replace based on service

   a. Time in reactor
   b. Moisture
   c. Anomalous behavior

G. ORIFICE DRIVE MOTOR ASSEMBLY

1. Visual
2. Bench Test
3. Clean and lube (dry)
4. Replace support nut

H. ORIFICE DRIVE LEAD SCREW

1. Visual - as found
2. Clean - physical
3. Dye Penetrant testing
4. Lubricate and exercise

I. LOWER SEAL

1. Visual
2. Clean - physical, wipe
3. Clean - body housing

J. PRIMARY SEAL - 600 ASSEMBLY

1. Visual - both surfaces
2. Clean - wipe
3. Clean - mating surface, penetration and 600 Assembly
4. Lifetime evaluation - possible replacement

K. PRIMARY SEAL - 200 ASSEMBLY

1. Visual
2. Clean - wipe
3. Clean - mating surface
4. Lifetime evaluation - possible replacement

L. CHECK VALVES - (RSD, CRDOA Purge)

1. Visual
2. Test

M. CABLE SEALS

1. As determined by observed elevated/abnormal housing temperatures

N. ORIFICE MOTOR PLATE SEALS

1. Visual

2. Clean - wipe

O. WINDOW SEALS

1. Visual

2. Clean - wipe

3. Gasket material - evaluate for lifetime

P. MCC CAPACITORS

1. Test

2. Shelf life/service life evaluation

Q. ELECTRICAL - POWER

1. Megger shim motor (test insulation deterioration)

2. Bench test shim motor (load capability)

3. Megger brake windings (test insulation deterioration)

4. Bench test brake solenoid (load capability)

5. Bench test stepping motor (load capability)

R. ELECTRICAL - INDICATION

1. In/Out Limit Switch Function - test redundancy when made up

2. Slack Cable - test redundancy when made up

3. Full retract - N/A - normally not both made up

S. BOLTS - EXPOSED TO PRIMARY COOLANT

1. Visual on selected bolts

T. ABSORBER STRINGS

1. Visual

2. Lifetime evaluation - possible replacement

3. Shock absorber only replacement

IV. PREDICTIVE MAINTENANCE (PDM) PROGRAM

A. SHIM MOTOR/BRAKE ASSEMBLY AND GEAR TRAIN

1. Wattage - outward shims - as found/as left
   inward shims - as found/as left

2. Back-EMF voltages - during scram (and/or equivalent) - as found/as left

3. Delivered torque at motor - as found/as left

   a. After CRD removed from PCRV during PM

   b. Static - complete rotation, both directions

4. Scram times (SR 5.1.1a-A)

   a. Gross performance parameter (really monitors motor variation if done with constant capacitances)

5. Rod drop <u>rate</u> (SR 5.1.1b-M)

   a. More sensitive than Item 4., but less than Item 2.

6. Torque to rotate motor/brake assembly - as found/as left

   a. Removed from CRDOA (hence reflects motor bearings only)

   b. Static - complete rotation

7. "Dynamometer Tests" - as found/as left (Technique under development)

   (Note - this test is not the same test as indicated before - here the object is to apply a known torque input to measure response, especially voltage, such as occurs during scram.)

   a. Simulate driving load of rod pair

   b. Measure response (generated EMF)

   c. Develop correlations

      i.e., applied torque, in oz vs. mean voltage amplitude at nominal motor speeds

   d. Use to <u>trend</u> rate of performance decline

   e. Use for model verification of shim motor

8. Jog counts

   a. Record jog counts

   b. Use to assist PDM Evaluation

B. TEMPERATURE

1. Monitor shim motor temperatures

2. Determine shim motor performance vs. temperature via voltage and wattage measurement.

C. STEPPING MOTOR

1. Monitor stepping motor speed (i.e., determine the rate at which a given change in orifice valve position occurs)

2. Trend

NOTE: Some of the above PDM actions are done while the CRDOAs are installed in the reactor, some while they are being maintained, and some under both conditions.

V. DISCUSSION

The above PM program should be implemented on a refueling basis for CRDOAs that would normally be removed for refueling, and on a more frequent basis for the regulating rod as established from predictive maintenance activities. This would mean that a CRDOA in normal service would be routinely maintained on a refueling cycle rotation, unless predictive maintenance (PDM) indicated a need for more frequent maintenance.

Central to the program is the use of predictive maintenance techniques to monitor the most important aspect of CRDOA performance, scram capability. By monitoring performance parameters indicative of train resistance and motor load, such as wattage and generated voltage or "back-EMF" (amplitude and/or frequency), the level of torque applied to the motor, as well as the resistance torque of the train, could be determined. This, when trended and compared to known values, should allow prediction of times when maintenance will be required. The exact manner in which these tests will be used is currently under development; it is expected that they will be able to provide the indicated information, although complete definition of all aspects of application and use of the tests may require some time after startup. The proposal for certain operational aspects of the PDM program will be implemented on a weekly basis for determination of scram capability and temperature performance during power operation. It would also be desireable to collect this information during shutdown for trending purposes. Other aspects of the PDM program to support this effort would be done during the normal PM activitiy.

Note that the emphasis of predictive maintenance is gear train and motor performance, and the preventive maintenance aspect is on examination and refurbishment of the shim motor/brake assembly. This is consistent with the conclusions obtained from the vast performance testing and analysis performed following the failure to scram incident of June 23, 1984, which identified motor bearings as the most important factor in the incident. Note also, however, that the program is designed so that any overall reduction in mechanism performance will be corrected, regardless of cause. Any degradation in gear train, pulley, or other components will consequently be identified and corrected.

VI. CONCLUSION

The basic schedule for preventive maintenance is proposed as the original refueling basis program which performs PM on non-regulating CRDOAs on a 6 refueling cycle rotation, and a special schedule for the regulating CRDOA subject in all cases to predictive maintenance results suggesting otherwise.

The preventive maintenance proposed herein, in conjunction with current and other projected surveillance requirements, will assure all safety-related aspects of CRDOA performance, as well as many other operational ones. As indicated, many aspects of the proposed program involve collection of data on performance which may ultimately be used to propose changes to this PM program.

ATTACHMENT 4
TO P-85040

FORT ST. VRAIN STATION

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

REFURBISHMENT PROGRAM

RADIOACTIVE WASTE HANDLING ANALYSIS

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

PREPARED BY: Frederick J. Borst
Frederick J. Borst
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FORT ST. VRAIN STATION

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

REFURBISHMENT PROGRAM

RADIOACTIVE WASTE HANDLING ANALYSIS

Introduction

The radioactive waste generated as a result of the Fort St. Vrain Control Rod Drive Refurbishment Program will fall into two general types: relatively low activity, high volume waste such as anticontamination clothing, gloves, wipes, cleaning materials, reserve shutdown material, and the like; and relatively high activity, low volume waste including the control rod clevis bolts, cable and fittings, and control rod cables. The handling methods for each of the two waste types will differ and are described below.

Low Activity, High Volume Waste

For the most part, this waste will be handled in accordance with existing plant procedures relative to collection, transport to the on-site compacting building, compaction, and staging prior to shipment off-site for disposal. At the current time, Fort St. Vrain does not have an approved low level waste disposal program satisfying 10CFR61 requirements. This was identified in NRC Inspection 83-28 as Open Item 04 and is being tracked as Corrective Action Request (CAR) 84-005 by PSC. An approved program will be in place prior to shipment off-site for disposal. Currently the PSC Office of Executive Staff Assistant is evaluating via CAR 84-006 the Fort St. Vrain on-site waste staging facilities (NRC Inspection 83-28, Open Item 05) to determine an acceptable activity content for staging. At no time will the activity placed in the staging area exceed the acceptable quantity as determined in response to CAR 84-006.

Reserve shutdown material will be handled on a case-by-case basis to ensure proper handling and staging techniques are followed.

High Activity, Low Volume Waste

In accordance with the Refurbishment Program, clevis bolts and cable end fittings will be removed from each control rod and placed remotely in a shielded transfer assembly in the Hot Service Facility. The two clevis bolts and two cable ends from one rod pair will comprise a full load for the transfer assembly. The assembly will be removed from the Hot Service Facility with the reactor building crane and moved to the northwest corner of the Refueling Floor. PSC has staged in this area two shielded storage containers with approximately 6.2 inches of lead equivalent shielding which were designed and built by PSC to accomodate a Chem-Nuclear Systems 1-13G Cask Liner. A liner will be placed in the shielded storage container, the clevis bolts and cable ends will be dropped remotely into the liner, and the shielded lid for the container will be put into place. In the event that the liner becomes full prior to completion of the Refurbishment Program, a liner in the second shielded storage container will be utilized. The liners will be removed from the containers, placed in 1-13G or equivalent licensed casks, and shipped off-site for disposal following completion of the Refurbishment Program and development of an approved disposal program. At no time will the storage containers and liners be placed in the staging facility.

Control rod cable will be evaluated on a case-by-case basis, based on radiation levels, to determine whether the cable will be placed in the shielded storage container or the staging facility. In any event, the cable will be cut into manageable lengths as it is removed from the control rod assembly.

Conclusion

All radioactive waste generated as a result of the Control Rod Drive and Orificing Assembly Refurbishment Program will either be placed in the on-site staging facility or remain on the Refueling Floor. No waste will be shipped for disposal until an approved waste disposal program is in place. The activity in the storage area will not exceed the amount contained in the evaluation being performed by the PSC Office of Executive Staff Assistant. Through careful waste management techniques, radiation exposures will remain as low as reasonably achievable.

ATTACHMENT 5
TO P-85040

FORT ST. VRAIN STATION

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

INTERIM

SURVEILLANCE PROGRAM

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

PREPARED BY: [signature]
Charles H. Fuller
Station Manager

FORT ST. VRAIN STATION

CONTROL ROD DRIVE AND ORIFICING ASSEMBLY

INTERIM

SURVEILLANCE PROGRAM

Weekly Surveillance

Objective - Obtain data for analysis and long term trending; exercise the rod; test selected circuitry; verification of FSAR assumed scram time; confirm control rod operability.

Methodology - "Rod Drop" of approximately 10" for selected control rods.

Elements of Tests for Fully Withdrawn Rods

1. Obtain analog and digital position.
2. Verify "Rod Out" light is lit, "Rod In" and "Slack Cable" lights are not lit.
3. Drop the rod approximately 10".
4. During the drop, obtain back EMF data.
5. Verify "Rod Out" light is not lit.
6. Obtain analog and digital position.
7. Withdraw rod to full out position.
8. Verify "Rod Out" light is lit.
9. Obtain analog a.d digital position.

Elements of Test for Partially Inserted Rods

1. Obtain analog and digital position.

2. Verify "Rod Out", "Rod In", and "Slack Cable" lights are not lit.

3. During the drop, obtain back EMF data.

4. Obtain analog and digital position.

5. Withdraw the rod to its previous position.

6. Obtain analog and digital position.

Elements of Test for Fully Inserted Control Rods

1. Obtain analog and digital position.

2. Verify "Rod In" light on; verify "Rod Out" and "Slack Cable" lights off.

Elements of the Test for all Control Rods

1. Obtain CRD motor temperatures.

2. Obtain purge flow if installation on individual rods can be achieved prior to startup.

3. Verify that no "Slack Cable" lights are lit.

Discussion

The obtaining and comparison of analog and digital position indication confirms the satisfactory operation of the associated potentiometers. The acceptable deviation between the indication will be 10" which is well within the deviation assumed in the FSAR for different control rods within a group (2 ± 1 foot per Page 3.6-19, Page 7.2-9, and Section 7.2.2.1). Deviations greater than 10" will be resolved by calibration if possible, or comparison with operable position switch indication. If this is not successful appropriate corrective action will be taken to ensure compliance with Technical Specifications.

A rod drop of approximately 10" is performed by deenergizing the control rod brake for a specified time. This portion of the test confirms that the brake assembly is operating properly, and that deenergization (such as during a scram) will in fact result in brake release.

From the distance dropped and the time of drop, an approximately <u>average</u> scram time can be calculated. Although not strictly representative of a full scram time (the rate of rod drop is position dependent), it is conservative for the near full out position because the rod is accelerating from rest. The acceptance criteria will be 160 seconds, which is the maximum scram time stated in the FSAR. This calculation will provide an early indication to the operator of control rod operability, and can identify those control rods for which priority evaluation (e.g., back EMF) should be given. The control rod will be declared inoperable based on the distance and time rod drop data until more sophisticated analyses or tests can show acceptable rod performance.

Back EMF data will be obtained and analyzed to confirm that the control rod is operable to scram. The data will be compared with previous back EMF data for detection of adverse trends which could result in inoperability.

Verification of "Rod Out" light indication confirms, on a weekly basis, that at least one of these two redundant switches is operable. The withdrawal of the control rod from the "dropped" position confirms proper brake release and motor operation upon withdrawal. Finally, withdrawing the rod to its full out position and obtaining the "Rod Out" light confirms proper operation of the withdrawal circuitry and the interlocks which deenergize the motor upon limit switch actuation.

The obtaining of control drive motor temperature serves a two-fold purpose: (1) to ensure that the tmperatures do not exceed the maximum allowable temperatures of 272°F and; (2) for use in trend analysis and possible correlation with other data collected. In the event that any monitored motor temperature exceeds 272°F, appropriate corrective action will be taken to lower the temperatures below 272°F, or the rod will be declared inoperable. Subsequent testing will be performed to confirm the rod is operable to scram.

<u>Specific Exclusions</u>

The rod drop test will not be performed on the regulating rod. Such testing could result in an unacceptable transient.

Rod drop tests will not be performed on control rods whose testing could result in automatic actuation of Plant Protection System functions such as RWP and scram. Plant conditions at the time of the test will be evaluated to make such determinations. It is not expected that this exclusion will result in frequent exemptions.

Rod drop tests will not be performed on control rods whose testing would result in a violation of the Technical Specifications.

Quarterly Surveillance

Objective - To supplement information obtained on the weekly surveillance; to verify redundancy of selected control rod position limit switches.

Methodology - Check redundancy.

Elements of Test for Fully Withdrawn Rods

1. Determine which of the two redundant "Rod Out" limit switches has actuated.

2. Bypass this switch to allow further rod withdrawal.

3. Withdraw the rod further until the second switch actuates.

4. Confirm operation of rod motor deenergization interlock with second switch actuation.

5. Return rod to original position and remove bypass.

Elements of Test for Partially Inserted Rods

Not Applicable - Partially inserted rods will not have "Rod In", "Rod Out", or "Slack Cable" lights lit. Weekly surveillance will compare analog and digital indication.

Elements of Test for Fully Inserted Rods

Not Applicable - Technical Specifications prohibit the withdrawal of these control rods out of sequence. Such withdrawal would be necessary to confirm limit switch redundancy. The weekly surveillance will compare analog and digital indication, and that the control rod "Rod In" light is lit. Fully inserted rods are already performing their design function.

Refueling Shtudown Surveillance

Objective - Same objective as for the weekly and quarterly surveillance, except data will be obtained over the full scram distance.

Elements of the Test

1. Determine which of the two redundant "Rod In" limit switches has actuated. Jumper this switch out.

2. Withdraw the rod approximately 6" and re-insert to actuate the second "Rod In" limit switch.

3. Confirm operation of the rod motor deenergization interlock with the second switch actuation.

4. Withdraw the rod to the full out position.

5. Confirm "Rod Out" limit switch redundancy.

6. Scram the control rod.

7. During the scram obtain back EMF data and total scram time.

8. During the test, compare analog and digital position indication.

ATTACHMENT 6
TO P-85040

WATTMETER USE TO DETERMINE INSERTED ABSORBER STRING POSITION

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I. ABSTRACT

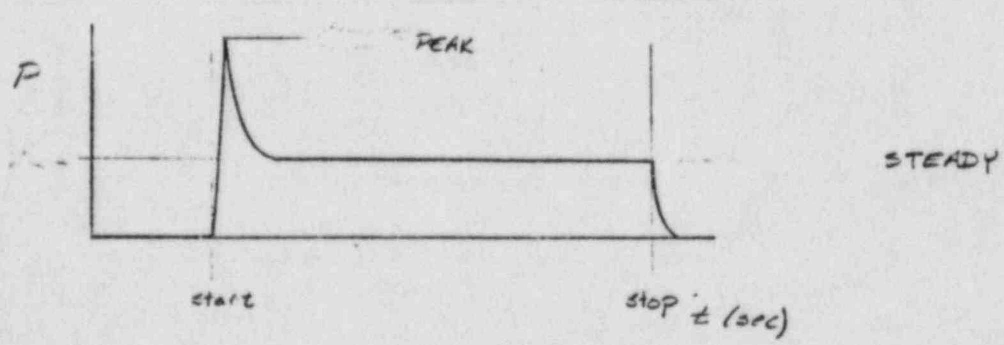
A wattmeter has been used on two occasions to determine "in" rod position and on many other occasions in the recent past to establish conditions such as freedom of motion, high loads, or other abnormal parameters. A request was made in the near past to justify the basis for this test; the following document provides a sound technical basis for the use of this test.

II. BACKGROUND

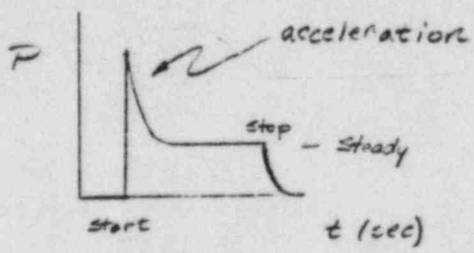
When a control rod is shimmed in either direction, the drive motor is activated which in turn raises or lowers the absorber pair via a gear train and wire rope riding over a drum and guide pulleys to the absorber pair itself. Normal mechanical losses (bearing, gear, pulleys, seal, etc.) in addition to absorber weight represent a load on the motor against which work must be done when the rod pair is raised. In addition, I^2R losses in the motor represent a regular electrical loss. The result of these is that movement of a control rod pair in either direction causes distinctive transients which, to a knowledgable observer, contains a multitude of information that goes far beyond the provided instrumentation (motor overload trip, etc.) and can be used in unusual circumstances to establish condition and location (in some specific cases) of the absorber pair.

III. DESCRIPTION - TRANSIENTS IN/OUT

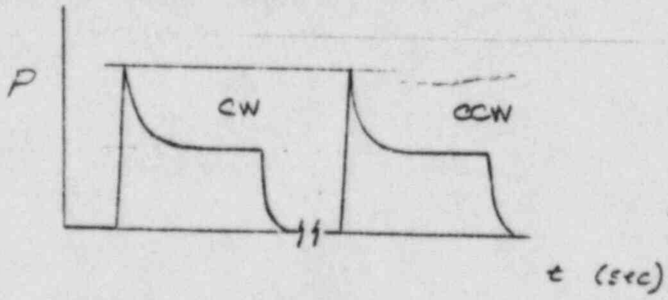
A typical shim wattage transient always includes (in and out) a jump in wattage to a peak as the mechanism accelerates, a reduction to an approximately steady value in 5-10 seconds, and a steady (but slowly varying) wattage for the shim duration as the cable winds or unwinds on the drum sheave. The shim always terminates with a decay in wattage to a zero baseline in 5-10 seconds.



The theory for this behavior is as follows: the shim motor consists of a 4-pole, 3 phase induction motor. A capacitor bank is paralleled across the motor winding phases, but has no effect on torque when the unit is driven from the AC power supply, since the bank's only effect is to change power factors. An induction motor develops torque by the principle of rotor slip; it is assumed that the reader is familiar with this idea. The greater the slip, the larger the induced fields on the rotor, the larger the torque, and the larger the electrical load. Wattage will increase rapidly for a freely-moving mechanism as the transient begins, and the rotor and mechanism acclerate. As the driving torque is developed, the rotor approaches steady speed (corresponding to some steady slip value), and the wattage declines to a steady value.



Note that, for no load on the motor (i.e.; such as during a bench test), a positive power consumption results due to I^2R losses in the stator windings and bearing friction, which should be the same in either direction, i.e.;



This is a useful reference item for the following discussion.

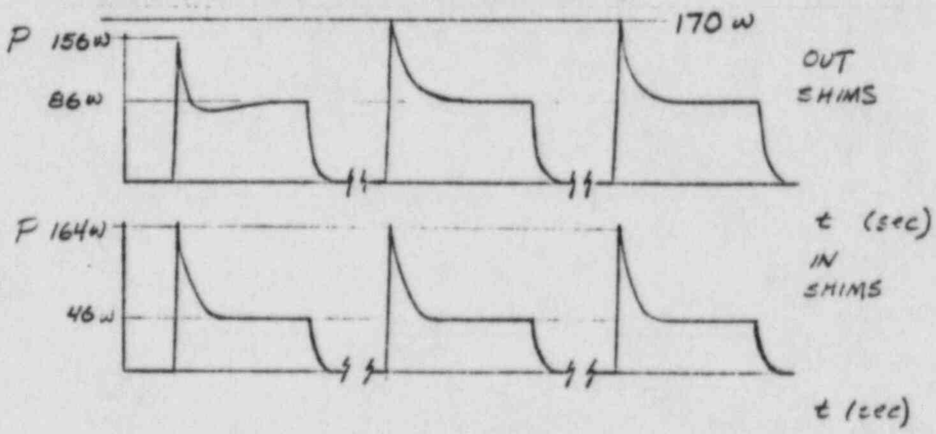
For an outward shim, the opposing weight of the rod pair causes more slip due to the greater rotor load. Hence the rotor-stator field interaction is greater, greater current demand on the stator occurs, and a higher motor load results.

For an inward shim, the assisting weight of the rod pair causes <u>less</u> slip, tending to drive the rod in. (Note that the direction is reversed.) In this case, a reduction in the field interaction occurs, and less motor load results (or equivalently, the operating point is closer to the synchronous speed).

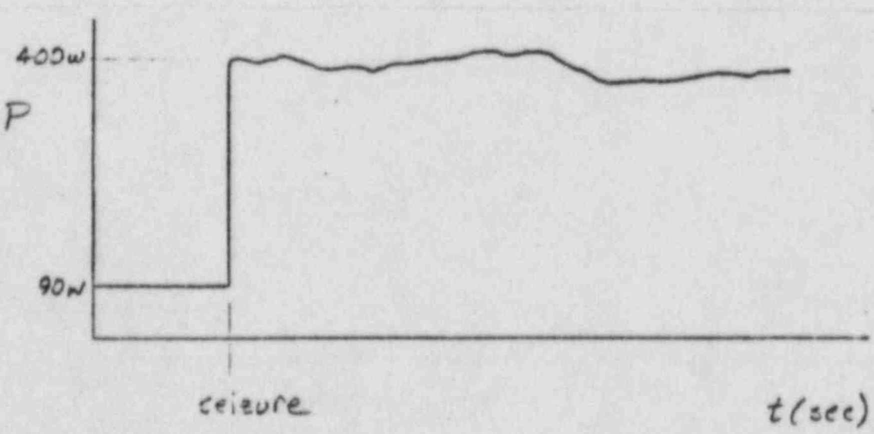
Note that if the motor could be driven externally at exactly synchronous (stator) field speed, no load would result, and any power consumption would represent only the I^2R losses of the stator field.

Also note that physically, one expects a higher load for an outward shim, when the motor must do work against gravity in addition to its own internal losses, than an inward shim, where work is actually done on the motor.

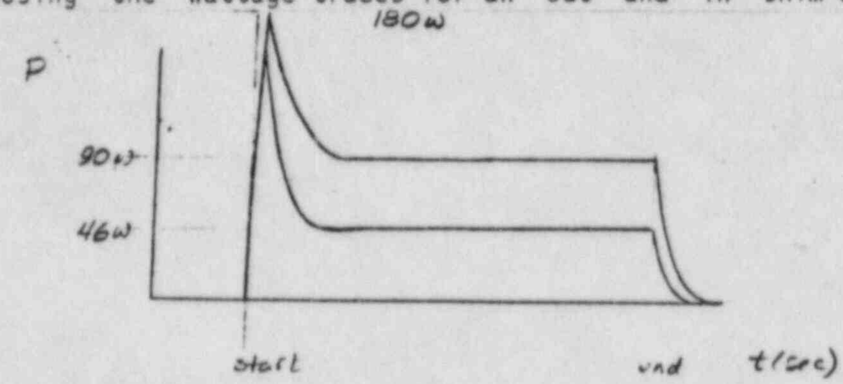
Note also that for an inward shim, again, the mechanism inertia means that instantaneously after the start of the shim, the rotor fields are moving slower than the stator fields. In this case, however, both the gravity torque and the developed torque assist to accelerate the rotor in the "in" direction, so that the transient duration is shorter (i.e.; the "in" shims tend to be more sharply peaked than the "out" ones).



Any sort of impeded mechanism motion shows up as extreme changes in power consumption due to the dramatic slip changes that occur. To some extent, elasticity of the wire rope may mitigate these, however, they are still obvious should any sudden rod pair motions occur.



Superimposing the wattage traces for an "out" and "in" shim we have



Average of nominal in/out steady values;

$$\frac{90 + 46}{2} = \frac{136}{2} \text{ watts or 68 watts.}$$

The work done raising the control rods, neglecting I^2R losses, and neglecting any frictional load (from viscous drag on the absorber pair, drag in the graphite/guide tube channels, and gear train losses), should be less than 90 watts. The following check, assuming <u>no</u> frictional loss in the mechanism confirms this.

Nominal speed 1.05 in/sec $\left(\frac{190 \text{ in}}{180 \text{ sec}} \right)$

$$P = FV \text{ (Physics)}$$

Where F = weight of 2 rods = 240 lbf
and V = 1.05 in/sec

$$P = (240 \text{ lbf}) \quad 1.05 \text{ in/sec} \quad \frac{1}{12} \quad \frac{\text{ft}}{\text{in}}$$

$$= 21.0 \text{ lbf ft/sec} \quad 1.3558 \frac{\text{watt}}{\text{lbf ft/sec}}$$

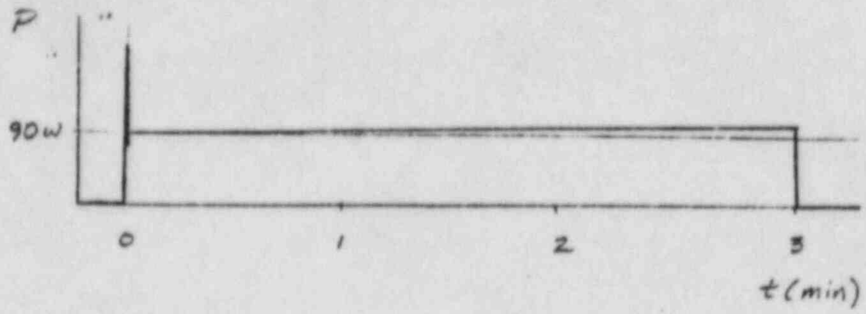
$$= 28.5 \text{ watts}$$

Hence 90 - 29 = 61 watts represent the nominal electrical and mechanical losses in the system. For a mechanical transmission efficiency of 90% per mesh, and a motor efficiency of 80% (both nominal values for similar equipment), the expected out shim power would be

$$\frac{28.5}{0.8 \ (0.9)^4} \text{ watts} = 54.3 \text{ watts.}$$

This compares with an observed range of steady values varying from 80 to 110 watts from all testing, for outward shims.

Finally, note that over a 190 inch rod pull (insertion), the cable drum will wind (unwind), starting from (ending at) the fully inserted position. At this position, the cable drum is completely unwound, i.e.; the rod pair hangs free from the anchor pins.



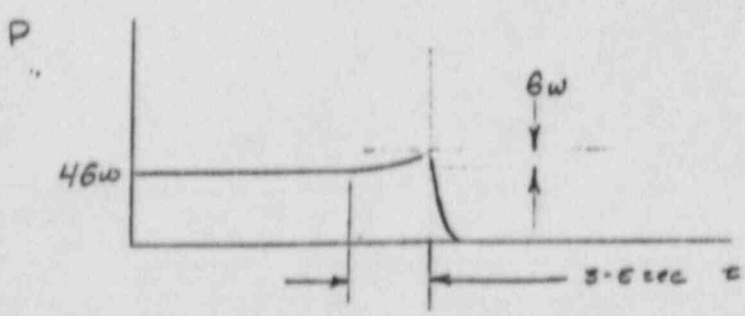
Instantaneously, a shim, since the drum is not wound, does no work against the rod pair weight; i.e., until the drum reaches one-quarter turn, the motor is not working fully against the weight of the rods, as the moment load has not completely developed. The distance travelled by the rods is

$$d = \frac{C}{4} = \frac{2\pi r}{4} = \frac{2\pi(6\ in)}{4} = 9.42 \text{ inches, and}$$

$$t = \frac{9.42 \text{ inches}}{1.05 \text{ in/sec}} \approx 9 \text{ seconds.}$$

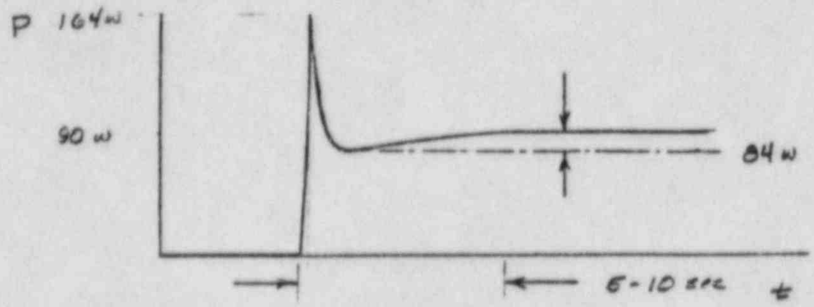
The actual moment load increase functional form is probably a sine-type relation, based on drum rotation.

For the last 5 seconds on an "in" shim, or the first 5 seconds on an "out" shim, a change in the steady wattage value should be seen; this is the observation. All "in" shims terminate with the following:



Note that normally, as the full "in" position is reached, the power to the motor is cut off as the "in" limit switch is activated.

An "out" shim is not so simple, as the initial peak transient must occur. Nonetheless, the same behavior is observed here. The transient peak decays to a value below the steady value and then recovers.



These transient characteristics are <u>unique</u> to the fully inserted position. Many normal rod shim wattage traces have been reviewed and the pattern is entirely consistent.

Finally, note that the direction of drum rotation is irrelevant. If the motor could be driven in beyond the "in" limit switch cutoff position, the rod pair would be raised as the mechanism wound around the drum in the reverse direction. In this case, an "in" shim transient should appear as an "out", and vice versa.

It is on these observations that the wattage verification of rod position incorporated in TSP-30 (proposed) is based.

IV. TSP-30 LOGIC

<u>Objectives</u>

First, the test must verify freedom of rod motion. Second, it must establish position for rods as being in (not just cam drum or equivalent pulley position). Third, it should establish that both rods are supported on the mechanism, if possible (actually, this is only "nice to have").

The wattage test establishes freedom of gear train motion obviously; impeded motion or locked rotor conditions are easy to identify. Rod motion is determined by observing correct nominal values for in/out shims, with the magnitude of the out wattage in excess of 78 watts, (if, in fact, both strings are supported). A steady value of less than 68 watts should be taken as evidence that one rod is not supported, particularly in conjunction with slack cable indication.

Background

TSP-30, Evaluation of Shim Motor Wattage Characteristics, is the culmination of an extensive review of all applications of wattmeter testing performed in the past, particularly that done under T-214, Wattmeter Testing. As a result of an intense examination, a number of clarifications and conclusions can be made.

Refer to Attachments 1-4. These represent a summary of measurements of data on shim transients collected under T-214 in two general time periods. The first was post-third refueling, from about March 11, 1984 to April 15, 1984; the second was post June 23, 1984 Failure-to-scram Event, collected June 23, 1984 to June 25, 1984. There remains additional data collected from July 1, 1984 through November 1, 1984 which was taken on mechanisms in the Hot Service Facility, primarily, and has not been extensively evaluated. It appears, from preliminary review, to be completely consistent with the other data, very similar to that collected in the March 11, 1984 to April 15, 1984 time period.

Results

Evaluation of the data revealed the following qualitative and quantitative results.

1. Normal in/out shims always start with transient peaks occurring over a range from 140 to 200 watts. These decay to a steady value over about 2-4 divisions on the strip chart, where each division is about 2.5 seconds long.

2. "Out" shim transient peaks are higher than "in" shim ones, being about 160-190 watts versus 144-160 watts for "in" shim peaks. On any given CRDOA shim motor, these peaks are distinctive, with a nominal 16-24 watt difference.

3. The rate of decay of "in" shim transient peaks is similar to that of "out" shim peaks, with the exception of the first outward shim from the inserted position.

4. For a continuous shim in the "out" direction from 0 to 192 inches, a very slight wattage increase is seen, of about 6 watts; the nominal steady wattage observed is 90 watts with a range of 80 to 110 watts observed.

5. For a continuous shim in the "in" direction from 192 to 0 inches, a very slight wattage decrease is observed, of about 6 watts; the nominal steady wattage observed is 46 watts, with a range of 30-64 watts observed.

6. An "out" shim transient starting at the fully inserted position is distinctly different from any other "out" shim transient. Two aspects of the transient are different - the peak wattage value and the rate of decay. In almost all cases the rate of the transient decay is so much faster that a pronounced "dip" in wattage below the final steady-state value is observed, due to the winding of the drum sheave phenomena; in every case, the decay to the steady value is significantly faster.

7. An "in" shim transient terminating at the fully inserted position exhibits a distinct rise in steady wattage value as the drum sheave unwraps not observed at any other location.

8. Even on mechanisms with poor wattmeter traces, the above behavior is distinct from other transients since the results can be repeated (i.e., spontaneous variations in the wattage record of a poor rod are not duplicatable).

9. A mechanism with only one absorber pair supported will have an "out" steady wattage of about 60 watts, based on Instrumented Control Rod Drive (ICRD) data.

10. Rotor seizure or other erratic mechanism behavior is indicated by erratic wattage recordings exhibiting sudden variations in wattage while shimming.

11. A periodic oscillation of about 4 watts magnitude is commonly seen on "in" shims. This has no significance with regard to mechanism performance.

12. Variations in voltage at the MCC can have a significant effect on the level of all values observed. For effective test results, voltages should be at 105 nominal phase-to-ground RMS volts.

13. Although T-214 did not have provision for voltage measurement and control, cursory examination of applied voltage during drive, performed under T-227 periodically, indicated the nominal phase-to-ground RMS voltage to be close to 105 volts. However, the failure to monitor and record voltage during test presents a significant limitation to data interpretation, except where results are "normalized".

14. When driving the mechanism in beyond the "in" limit, a change in transient behavior does occur; continued shimming in the "in" direction exhibits characteristics of an "out" shim, while shimming out exhibits characteristics of an "in" shim (while the mechanism is still beyond the normal inserted position.).

Operations and Maintenance (O&M) Manual and FSAR

References to shim motor wattage are made in the O&M Manual and FSAR, as indicated on Attachments 14 and 15.

No steady wattage outside the 80-110 watts for outward shims of normal rods has been observed, although that referenced by the O&M Manual is 72 watts. This might be consistent with references to an 18 watt increase being required to cause failure to scram, although there is another reference to 60 watts as the value at which failure to scram is possible (steady out wattage), at 105 volts, which is clearly inconsistent. Operational measurements, indicated nominal values of 90 watts, with the lowest values being 80 watts on a normally configured CRDOA. It must be emphasized that all measurements collected were done without voltage monitoring or control, hence were subject to wide variation.

The FSAR also references 72 watts for normal outward shims, and 90 watts as the steady outward shim wattage beyond which scram capability cannot be assured.

The manner in which a wattage device is hooked up can affect the output. The Fort St. Vrain devices have been carefully checked to verify that they are correctly installed and providing correct output values.

Procedure Logic

Technical Services Procedure (TSP-30) allows measurement of wattage for monitoring purposes, as done in the past, with a clear guide for interpreting the results. This can be used to establish freedom of motion, estimate position from a known position, and verify cable weight. These functions are useful for monitoring purposes during maintenance, trending, and monitoring performance in the PCRV under various operating conditions.

With regard to rod "in" position verification, TSP-30 uses a three-step approach which starts with the most easily identifiable (and obtainable) indication of rod full-insertion, progressing to a second more detailed evaluation if the requirements for the first evaluation are not met, and proceeds to a final, definitive test and evaluation if the first two simpler evaluations cannot meet the test basis requirements. Each step involves repeated step performance so that postulated data collection irregularities should have an almost trivial chance of affecting the conclusion. Note that in the volumes of data reviewed, no data has been observed that would indicate invalidation of these tests.

Because of the repetition requirements, it is possible that a given test performance would not meet the requirements for concluding the rod pair was inserted, even though a preponderance of data indicated that it was. Failure to reach the requirements for certifying insertion does not mean that the rod is not inserted or that additional testing may not be done. In fact, the best approach to the test would be to perform the test, and if there was very marginal indication of insertion based on that step approach, continue on to the next, stronger version of the test. (If the results looked very good except that one data point was not distinct, repetition of that step should allow conclusive results).

Two major points should be made with regard to criticism voiced on these tests in the past. First, the acceptance criteria are now spelled out formally in terms of numerical values and guidelines based on data collected under T-214 on all CRDOAs. There are margins included here that in many instances would invalidate position conclusion from data runs on rods that were known inserted at the time of collection (under T-214). Most data runs would however, allow the correct conclusion without repetition of that test step. Secondly, each test sequence repeats the sequence.

This provides additional assurance that electrical system variations will not yield any transient which could be incorrectly taken to indicate inserted condition. In addition, note that all results are normalized, and absolute levels not used for acceptance criteria, again minimizing any effects of electrical system variations.

For the scrammed condition, for freely-running rod pairs, the rods will be bottomed out. Each test sequence starts from this condition (scrammed), so that presumably the rods are bottomed.

The first test approach merely shims the rod pair "out", then "in", repeating twice, and looks for the dip in wattage on the "out" shim (after the peak) and the rise in wattage at the end of the "in" shim. If these location indicators are observed (within the numerical limits specified), the rods are considered "in".

This second test is based on results observed consistently under depressurized/cooled-down conditions seen in T-214. Its one weakness is that the initial dip is not quite so pronounced under other conditions, so that the requirements might not be met if the test were desired to be used under other conditions. Hence the second test.

This test consists of evaluating the inserted condition again based on shimming "out" from the "in" position, but using the combination of wattage peaks and decay times to discern the difference between the first "out" shim and the subsequent "out" shim characteristics in the sequence of three shims. Again, these two aspects of behavior are easy to discern, and the test, although more complicated to evaluate, is still straightforward with respect to data collection. The possibility occurs, however, that the results will not allow a definite conclusion due to data spread, poor test conditions, or otherwise.

The final test, and most definitive, is the worst to actually perform because it will almost certainly break the multijaws coupling, hence should only be used on a damaged mechanism with a damaged multijaws coupling (no analog/digital indication or inconsistent indication compared to in/out limit switches), with no "in" limit indication. This test involves scramming to establish "in" position (presumably), and then performing an "out"/"in" shim pair, which should approximately return the rod pair to its original "in" position, to establish reference shim values, for normal shims. An "in"/"out" sequence is then performed, which should drive the drum sheave beyond its normal limit, raising the rod pair on the drum in the reverse direction. Hence the characteristic is reversed. The "in" shim is actually lifting the rod pair, while the "out" shim is lowering it. By observing this reversal "in" shim behavior, which is easily discernable so long as the drum wraps to a quarter turn (to develop the moment arm, where the wattage values are nominally 90 watts to raise and 44 watts to lower), the rod pair position is absolutely determined. Again, the sequence is repeated to confirm the behavior.

Finally, the question of the condition of the absorber pair, supported or not, can be addressed in part using data collected from an ICRD (only one supported rod). The nominal wattage observed here was 60 watts for an "out" shim, compared to 90 watts for a normally configured rod (range 80-110 watts for "out" shims). This suggests a limit of between 60 and 80 watts to determine the normal condition with both strings supported. In conjunction with trending, any sudden reduction in nominal steady "out" wattage could probably be used to confirm slack cable indication. A review of the slack cable shimming on Region 7 CRDOA SN 25 done July 20, 1984 indicated a steady wattage value of 76 watts (the same CRDOA, SN 25, exhibited 88 watts on March 13, 1984 and 86 watts on June 25, 1984 for nominal out shim steady wattage), while installed in Region 14).

V. CONCLUSION

The CRDOA wattage test is viable for monitoring motor, train, and rod condition, can extract substantial information under a variety of conditions, and can be used to establish rod pair inserted position. Additional testing should be done under more controlled conditions to confirm results obtained thus far and determine data spreads. Trending of this information should continue to monitor performance. Apparent discrepancies between FSV data and the FSAR and O&M Manual should be resolved and corrected.

Examination of a digital or other wattrecording device to increase the sensitivity of the measurements should be considered, although may not be necessary if voltage variation is found to be the factor limiting test sensitivity. The test is entirely normalized with respect to test values so that absolute levels are not important.

Attachments 1-15

List of Attachments

1. Control Rod Drive and Orificing Assembly

   - Installed in PCRV, rod pair inserted

2. Control Rod Drive Mechanism

   - Shim motor/brake assembly
   - Gear train
   - Cable drum
   - Guide pulleys
   - Slack cable assembly
   - Indication pots/switches

3. Shim Motor/Brake Assembly

Wattmeter Chart Data

Two general time periods for data collection occurred:
Data I - March 11, 1984 - April 10, 1984
Data II - June 23, 1984 - June 25, 1984

All following references to I and II refer to two sets of wattmeter data, each generally consisting of summary data for each of 37 CRDOAs (as available) in the indicated Region.

4. Out Shims Data I

5. Out Shims Data II

   - Summaries of key data values for CRDOAs for outward shim data

6. Out Shims Analysis I

7. Out Shims Analysis II

   - Summaries of key differences used to support position verification by out shim data.

8. In Shims Data/Analysis I

9. In Shims Data/Analysis II

   - Summaries of key differences used to support position verification by in shim data

10. In Shims Transient Decay Time Analysis II

    - Summaries of decay time data for comparison against "out" decay times

11. Individual CRDOA Shim Sequence Variation Analysis

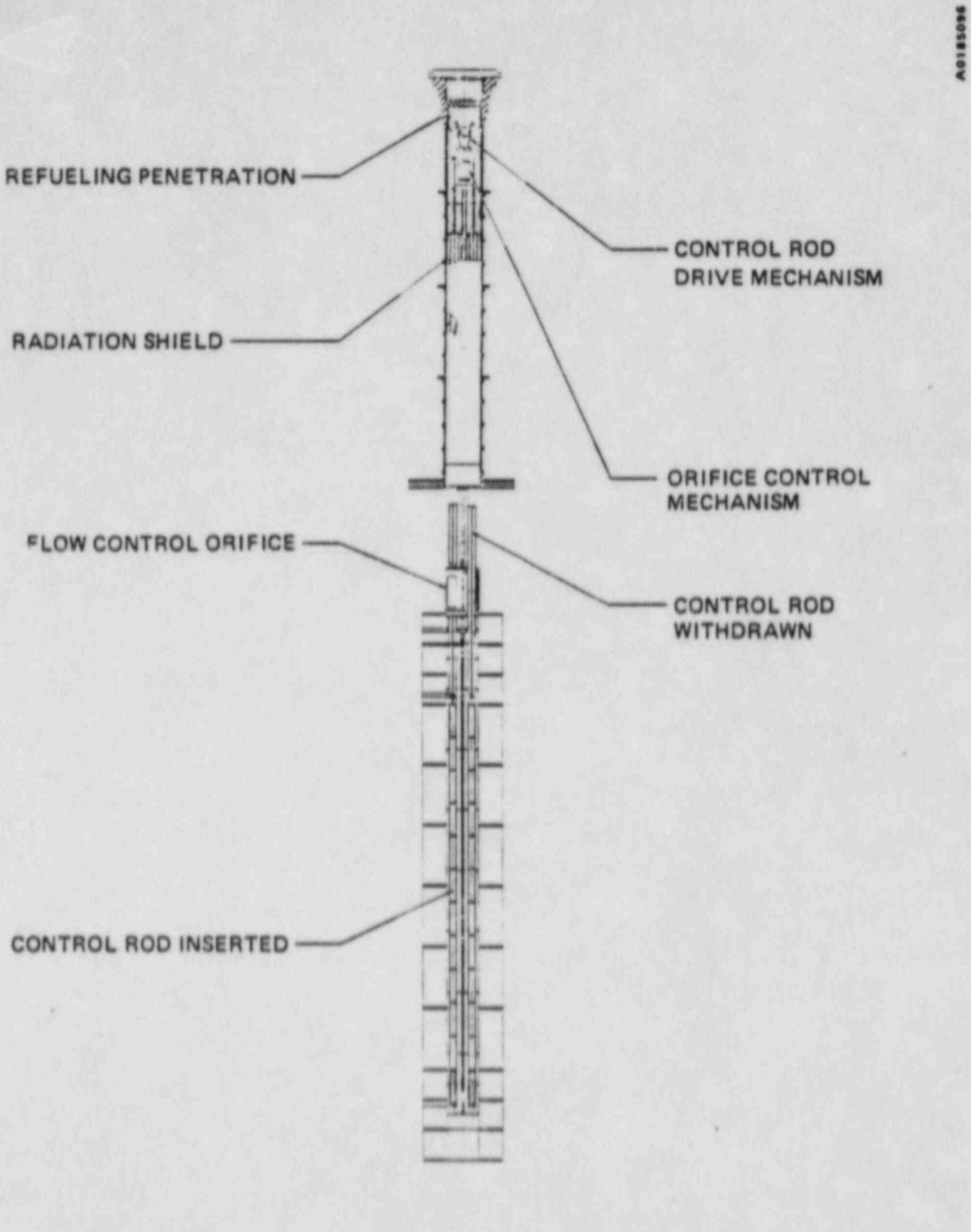
    - Detailed Analysis of discrete values on ten individual CRDOA strip charts that identifies the variation that occurs in key parameters used in the test.

12. Explanation of Wattage Test Evaluation supporting data, items 4-11 above.

13. TECHNICAL SERVICES PROCEDURE NO. 30, EVALUATION OF SHIM MOTOR WATTAGE CHARACTERISTICS (PROPOSED)

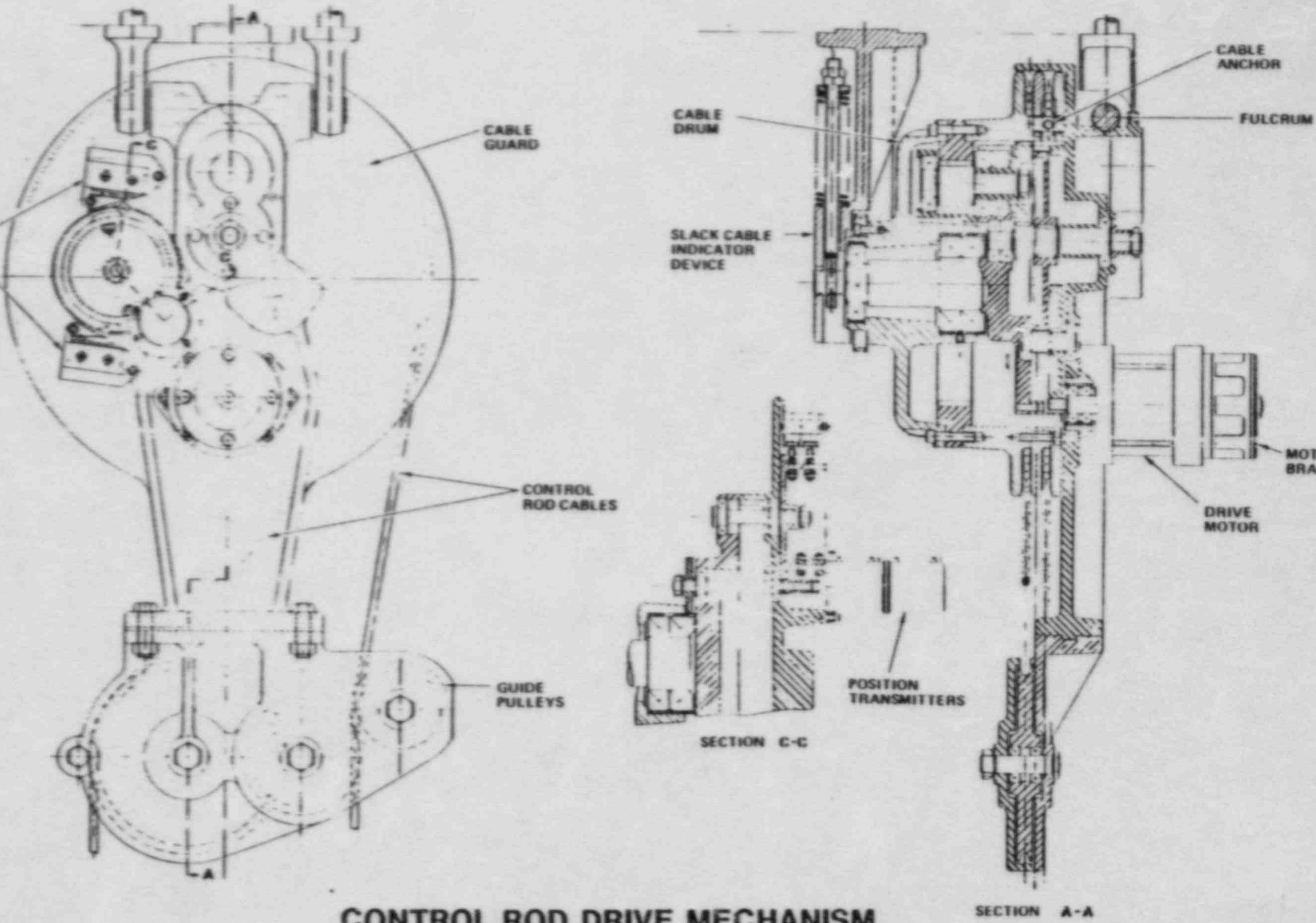
14. O&M Manual Wattage References

15. FSAR Wattage References

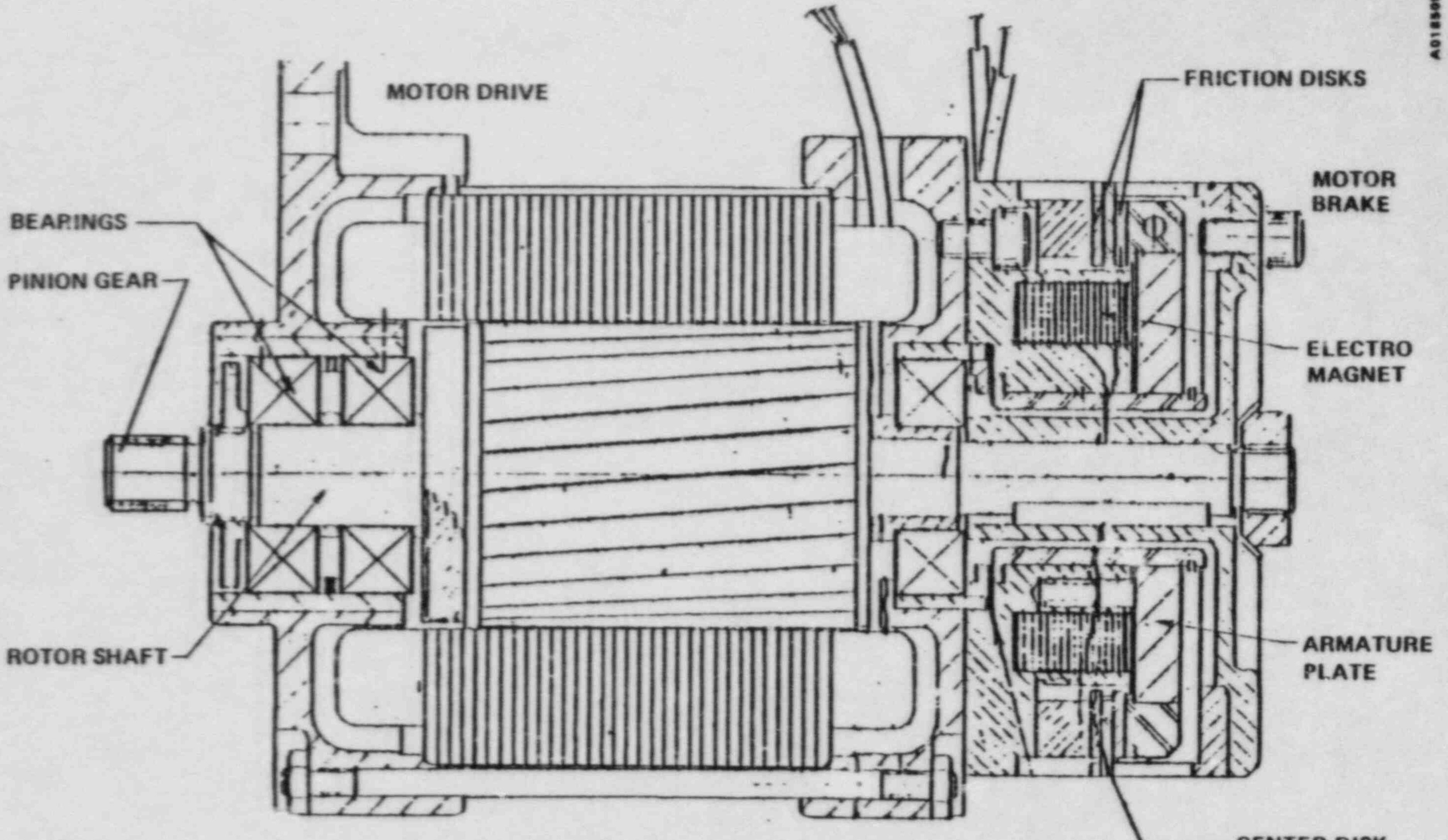


CONTROL ROD DRIVE AND ORIFICE ASSEMBLY

Attachment 2



CONTROL ROD DRIVE MECHANISM



MOTOR AND BRAKE ASSEMBLY

ATTACHMENT 4

OUT SHIMS DATA I

DATE	REGION (SN)	FIRST MINIMUM (X2 WATT)	NOMINAL STEADY VALUE (X2 WATT)	TRANSIENT PEAKS INITIAL VALUE (X2 WATT)	NOMINAL VALUE (X2 WATT)	INITIAL DECAY TIME	NOMINAL DECAY TIME
03/11/84	1(24)	38	44	80	86	0.7	1.5
03/11/84	1(24)	38	43	80	85	0.4	1.5
03/11/84	1(24)	39	42	80	--	0.2	---
03/11/84	1(24)	38	48	80	--	0.2	---
03/11/84	1(24)	37	43	77	--	1.2	---
03/11/84	1(24)	38	42	77	--	0.8	---
03/11/84	1(24)	37	44	78	--	0.8	---
	Mean:	37.86	43.71	78.86	85.5	*	*
--------	2(3)	56	56	82	92	1.0	3.5
03/23/84	3(37)	50	51	80	90	1.0	3.0
03/28/84	4(31)	46	59	80	85	1.2	3.0
03/13/84	5(10)	34	40	80	85	0.7	1.5
03/13/84	6(29)	37	44	80	89	0.7	2.0
--------	7(18)	39	42	80	86	0.7	1.5
03/28/84	8(38)	47	50	82	90	1.2	1.5
03/28/84	9(26)	50	52	84	95	0.8	2.7
03/28/84	10(14)	43	50	84	95	1.5	1.9
03/28/84	11(30)	47	50	83	95	1.2	2.0
04/09/84	12(36)	52	54	83	90	0.8	2.5
04/09/84	13(16)	47	50	80	87	1.6	2.5
03/13/84	14(25)	36	44	80	89	1.0	1.7
--------	15(12)	40	48	80	85	0.9	1.6
--------	16(33)	39	46	80	87	1.0	1.2
--------	17(41)	38	45	78	88	0.8	1.3
--------	18(40)	43	48	80	87	1.0	1.0
--------	19(13)	47	50	85	90	1.3	1.9
04/09/84	20(32)	42	50	81	90	1.0	2.1
04/09/84	21(28)	--	50	82	90	---	2.0
04/09/84	22(5)	46	50	78	88	1.2	2.0
04/09/84	23(39)	47	50	85	91	1.4	1.6

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 4

OUT SHIMS DATA I

DATE	REGION (SN)	FIRST MINIMUM (X2 WATT)	NOMINAL STEADY VALUE (X2 WATT)	TRANSIENT PEAKS INITIAL VALUE (X2 WATT)	NOMINAL VALUE (X2 WATT)	INITIAL DECAY TIME	NOMINAL DECAY TIME
04/10/84	24(23)	48	54	--	89	1.2	2.0
04/10/84	25(7)	45	54	82	90	1.1	1.3
04/10/84	26(1)	46	50	83	90	1.6	1.7
04/10/84	27(2)	45	53	81	90	1.2	2.0
--------	28(44)	44	48	74	80	1.1	1.5
--------	29(35)	43	47	83	89	1.2	1.4
--------	30(11)	43	43	77	87	0.7	1.1
--------	31(17)	40	45	79	87	1.2	1.4
--------	32(15)	37	45	80	88	0.9	1.3
--------	33(34)	42	46	81	88	1.3	1.3
--------	34(22)	37	45	80	86	0.9	1.4
--------	35(21)	38	45	80	86	0.8	1.4
--------	36(8)	Not performed due to motor failure.					
04/10/84	37(4)	50	54	84	94	1.2	2.0
	Mean:	43.48	48.41	80.85	88.71	*	*
	Standard:	5.13	3.87	2.32	3.14	*	*

-- Data Not Available.
* No mean or standard data.
Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 5

OUT SHIMS DATA II

DATE	REGION (SN)	FIRST MINIMUM (X2 WATT)	NOMINAL STEADY VALUE (X2 WATT)	TRANSIENT PEAKS INITIAL VALUE (X2 WATT)	NOMINAL VALUE (X2 WATT)	INITIAL DECAY TIME	NOMINAL DECAY TIME
06/25/84	1(6)	42	45	74	82	1.0	3.5
06/23/84	2(3)	48	53	80	95	1.6	3.0
06/23/84	3(37)	47	49	75	82	1.4	4.0
06/23/84	4(31)	43	47	74	87	1.5	4.0
06/25/84	5(10)	40	42	74	80	1.5	4.0
06/25/84	6(29)	44	46	74	84	1.0	4.0
06/25/84	7(18)	40	45	71	80	1.3	4.0
06/23/84	8(38)	42	45	74	88	1.6	4.0
06/23/84	9(26)	50	50	83	88	---	3.0
06/23/84	10(14)	46	48	80	88	1.6	3.0
06/23/84	11(30)	44	45	77	84	2.0	3.5
--------	12(42)	47	50	80	87	1.3	2.5
06/23/84	13(16)	43	44	75	81	1.7	4.0
06/25/84	14(25)	42	43	72	81	1.1	4.0
06/25/84	15(12)	47	48	75	81	0.9	2.5
06/23/84	16(33)	47	49	77	84	0.9	2.7
06/25/84	17(41)	47	49	75	85	1.1	4.0
06/25/84	18(40)	46	48	73	83	1.4	5.0
06/23/84	19(13)	44	45	73	75	---	4.0
06/23/84	20(32)	43	45	77	87	1.4	4.0
06/23/84	21(28)	48	49	78	88	1.3	3.4
06/23/84	22(5)	42	45	75	82	1.6	3.0
06/23/84	23(39)	41	44	77	85	1.3	3.0
06/23/84	24(23)	52	52	77	87	1.5	---
06/23/84	25(7)	49	49	77	89	1.3	2.3
06/23/84	26(1)	48	50	80	90	2.0	3.0
06/23/84	27(2)	46	47	78	85	1.3	4.0
06/25/84	28(44)	43	45	72	81	1.0	3.0
06/25/84	29(35)	47	48	77	85	1.4	3.5
06/25/84	30(11)	42	43	74	81	1.0	3.5
06/25/84	31(17)	44	45	74	82	1.2	3.6
06/25/84	32(15)	46	46	76	84	2.5	4.5
06/23/84	33(34)	44	44	74	84	1.2	2.8

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 5

OUT SHIMS DATA II

DATE	REGION (SN)	FIRST MINIMUM (X2 WATT)	NOMINAL STEADY VALUE (X2 WATT)	TRANSIENT PEAKS: INITIAL VALUE (X2 WATT)	TRANSIENT PEAKS: NOMINAL VALUE (X2 WATT)	TRANSIENT PEAKS: INITIAL DECAY TIME	TRANSIENT PEAKS: NOMINAL DECAY TIME
--------	34(22)	43	44	75	82	1.0	2.0
06/25/84	35(21)	42	45	72	81	1.1	2.3
06/25/84	36(8)	42	45	74	83	1.3	3.5
06/23/84	37(4)	44	48	78	89	1.5	2.3
	Mean:	44.73	46.62	75.70	84.32	*	*
	Standard:	2.87	2.62	2.70	3.71	*	*

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 6

OUT SHIMS ANALYSIS I

DATE	REGION (SN)	DIFFERENCE, NOMINAL AVERAGE - FIRST MIN (X2 WATT)	(%)	DIFFERENCE, NOMINAL PEAK - FIRST PEAK (X2 WATT)	(%)	DIFFERENCE, NOMINAL DECAY - FIRST DECAY (TIME)	(%)
--------	1(24)	6	14	6	7	0.8	53
--------	1(24)	5	12	5	6	1.1	73
03/11/84	1(24)	3	7	-	-	---	--
03/11/84	1(24)	10	21	-	-	---	--
03/11/84	1(24)	6	14	-	-	---	--
03/11/84	1(24)	4	10	-	-	---	--
03/11/84	1(24)	7	16	-	-	---	--
	Mean:	5.86	13.43	5.5	6.50	*	*
--------	2(3)	0	0	10	11	2.5	71
03/23/84	3(37)	1	2	10	11	2.0	67
03/28/84	4(31)	4	8	5	6	1.8	60
03/13/84	5(10)	6	15	5	6	0.8	53
03/13/84	6(29)	7	16	9	10	1.3	65
--------	7(18)	3	7	6	7	0.8	53
03/28/84	8(38)	3	6	8	9	0.3	20
03/28/84	9(26)	2	4	11	12	1.9	70
03/28/84	10(14)	7	14	11	12	0.4	21
03/28/84	11(30)	3	6	12	13	0.8	40
04/09/84	12(36)	2	4	7	8	1.7	68
04/09/84	13(16)	3	6	7	8	0.9	36
03/13/84	14(25)	8	18	9	10	0.7	41
--------	15(12)	8	17	5	6	0.7	44
--------	16(33)	7	15	7	8	0.2	17
--------	17(41)	7	16	10	11	0.5	38
--------	18(40)	5	10	7	8	0.0	0
--------	19(13)	3	6	5	6	0.6	32
04/09/84	20(32)	8	16	9	10	1.1	52
04/09/84	21(28)	-	--	8	9	---	--
04/09/84	22(5)	4	8	10	11	0.8	40
04/09/84	23(39)	3	6	6	7	0.2	13
04/10/84	24(23)	6	11	--	--	0.8	40

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 6

OUT SHIMS ANALYSIS I

DATE	REGION (SN)	DIFFERENCE, NOMINAL AVERAGE - FIRST MIN (X2 WATT)	(%)	DIFFERENCE, NOMINAL PEAK - FIRST PEAK (X2 WATT)	(%)	DIFFERENCE, NOMINAL DECAY - FIRST DECAY (TIME)	(%)
04/10/84	25(7)	9	17	8	9	0.2	15
04/10/84	26(1)	4	8	7	8	0.1	6
04/10/84	27(2)	8	15	9	10	0.8	40
--------	28(44)	4	8	6	8	0.4	27
--------	29(35)	4	9	6	7	0.2	14
--------	30(11)	0	0	10	11	0.4	36
--------	31(17)	5	11	8	9	0.2	14
--------	32(15)	8	18	8	9	0.4	31
--------	33(34)	4	9	7	8	0.0	0
--------	34(22)	8	18	6	7	0.5	36
--------	35(21)	7	16	6	7	0.6	43
--------	36(8)	Not collected.					
04/10/84	37(4)	4	7	10	11	0.8	40
	Mean:	4.88	10.30	7.81	8.84	*	*
	Standard:	2.47	5.39	1.98	1.96	*	*

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 7

OUT SHIMS ANALYSIS II

DATE	REGION (SN)	DIFFERENCE, NOMINAL AVERAGE - FIRST MIN (X2 WATT)	(%)	DIFFERENCE, NOMINAL PEAK - FIRST PEAK (X2 WATT)	(%)	DIFFERENCE, NOMINAL DECAY - FIRST DECAY (TIME)	(%)
06/25/84	1(6)	3	7	8	10	2.5	71
06/23/84	2(3)	5	9	15	16	1.4	47
06/23/84	3(37)	2	4	7	9	2.6	65
06/23/84	4(31)	4	9	13	15	2.5	63
06/25/84	5(10)	2	5	6	8	2.5	63
06/25/84	6(29)	2	4	10	12	3.0	75
06/25/84	7(18)	5	11	9	11	2.7	68
06/23/84	8(38)	3	7	14	16	2.4	60
06/23/84	9(26)	0	0	5	6	---	--
06/23/84	10(14)	2	4	8	9	1.4	47
06/23/84	11(30)	1	2	7	8	1.5	43
--------	12(42)	3	6	7	8	1.2	48
06/23/84	13(16)	1	2	6	7	2.3	58
06/25/84	14(25)	1	2	9	11	2.9	73
06/25/84	15(12)	1	2	6	7	1.6	64
06/23/84	16(33)	2	4	7	8	1.8	67
06/25/84	17(41)	2	4	10	12	2.9	73
06/25/84	18(40)	2	4	10	12	3.6	72
06/23/84	19(13)	1	2	2	3	---	--
06/23/84	20(32)	2	4	10	11	2.6	65
06/23/84	21(28)	1	2	10	11	2.1	62
06/23/84	22(5)	3	7	7	9	1.4	47
06/23/84	23(39)	3	7	8	9	1.7	57
06/23/84	24(23)	0	0	10	11	---	--
06/23/84	25(7)	0	0	12	13	1.0	43
06/23/84	26(1)	2	4	10	11	1.0	33
06/23/84	27(2)	1	2	7	8	2.7	68
06/25/84	28(44)	2	4	9	11	2.0	67
06/25/84	29(35)	1	2	8	9	2.1	60
06/25/84	30(11)	1	2	7	9	2.5	71
06/25/84	31(17)	1	2	8	10	2.4	67
06/25/84	32(15)	0	0	8	10	2.0	44
06/23/84	33(34)	0	0	10	12	1.6	57

-- Data Not Available.

* No mean or standard data.

Notes:
1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 7

OUT SHIMS ANALYSIS II

DATE	REGION (SN)	DIFFERENCE, NOMINAL AVERAGE - FIRST MIN (X2 WATT)	(%)	DIFFERENCE, NOMINAL PEAK - FIRST PEAK (X2 WATT)	(%)	DIFFERENCE, NOMINAL DECAY - FIRST DECAY (TIME)	(%)
--------	34(22)	1	2	7	9	1.0	50
06/25/84	35(21)	3	7	9	11	1.2	52
06/25/84	36(8)	3	7	9	11	2.2	63
06/23/84	37(4)	4	8	11	12	0.8	35
	Mean:	1.89	4.00	8.62	10.14	*	*
	Standard:	1.33	2.88	2.49	2.61	*	*

-- Data Not Available.
* No mean or standard data.

Notes: 1. Units of time are in divisions of the strip chart.
2. Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 8

IN SHIMS DATA/ANALYSIS I

DATE	REGION (SN)	NOMINAL STEADY VALUE (X2 WATT)	PEAK AT IN LIMIT (X2 WATT)	DIFFERENCE (X2 WATT)	DIFFERENCE (%)
--------	1(24)	18	22	4	18
--------	1(24)	19	21	2	10
03/11/84	1(24)	20	25	5	20
03/11/84	1(24)	16	20	4	20
	Mean:	18.25	22.0	3.75	17.0
--------	2(3)	22	25	3	12
03/23/84	3(37)	30	34	4	12
03/28/84	4(31)	30	33	3	9
03/13/84	5(10)	15	22	7	32
03/13/84	6(29)	20	27	7	26
--------	7(18)	18	23	5	22
03/28/84	8(38)	32	36	4	11
03/28/84	9(26)	31	34	3	9
03/28/84	10(14)	28	31	3	10
03/28/84	11(30)	27	30	3	10
04/09/84	12(36)	30	33	3	9
04/09/84	13(16)	24	28	4	14
03/13/84	14(25)	19	27	8	30
--------	15(12)	21	25	4	16
--------	16(33)	18	22	4	18
--------	17(41)	20	24	4	17
--------	18(40)	21	24	3	13
--------	19(13)	23	30	7	23
04/09/84	20(32)	26	30	4	13
04/09/84	21(28)	29	31	2	6
04/09/84	22(5)	25	34	9	26
04/09/84	23(39)	24	27	3	11
04/10/84	24(23)	33	34	1	3
04/10/84	25(7)	30	34	4	12
04/10/84	26(1)	25	27	2	7
04/10/84	27(2)	21	24	3	13
--------	28(44)	22	26	4	15
--------	29(35)	22	26	4	15

-- Data Not Available.

Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 8

IN SHIMS DATA/ANALYSIS I

DATE	REGION (SN)	NOMINAL STEADY VALUE (X2 WATT)	PEAK AT IN LIMIT (X2 WATT)	DIFFERENCE (X2 WATT)	DIFFERENCE (%)
--------	30(11)	18	21	3	14
--------	31(17)	20	25	5	20
--------	32(15)	21	26	5	19
--------	33(34)	19	22	3	14
--------	34(22)	16	24	8	33
--------	35(21)	17	20	3	15
--------	36(8)	Data not collected due to faulty motor.			
--------	37(4)	33	36	3	8
	Mean:	23.56	27.69	4.13	15.39
	Standard:	5.21	4.70	1.82	7.20

-- Data Not Available.
Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 9

IN SHIMS DATA/ANALYSIS II

DATE	REGION (SN)	NOMINAL STEADY VALUE (X2 WATT)	PEAK AT IN LIMIT (X2 WATT)	DIFFERENCE (X2 WATT)	DIFFERENCE (%)
06/25/84	1(6)	32	35	3	10
06/23/84	2(3)	39	43	4	10
06/23/84	3(37)	29	34	5	17
06/23/84	4(31)	30	35	5	17
06/25/84	5(10)	22	30	8	36
06/25/84	6(29)	35	38	3	9
06/25/84	7(18)	30	30	0	0
06/23/84	8(38)	26	33	7	27
06/23/84	9(26)	40	42	2	5
06/23/84	10(14)	24	28	4	17
06/23/84	11(30)	24	32	8	33
06/00/84	12(42)	25	30	5	20
06/23/84	13(16)	26	30	4	15
06/25/84	14(25)	29	34	5	17
06/25/84	15(12)	30	32	2	7
06/23/84	16(33)	29	30	1	3
06/25/84	17(41)	30	34	4	13
06/25/84	18(40)	32	35	3	9
06/23/84	19(13)	25	31	6	24
06/23/84	20(32)	28	31	3	11
06/23/84	21(28)	28	33	5	18
06/23/84	22(5)	24	32	8	33
06/23/84	23(39)	25	28	3	12
06/23/84	24(23)	34	35	1	3
06/23/84	25(7)	29	33	4	14
06/23/84	26(1)	28	35	7	20
06/23/84	27(2)	28	33	5	18
06/25/84	28(44)	29	31	2	7
06/25/84	29(35)	30	38	8	27
06/25/84	30(11)	27	31	4	15
06/25/84	31(17)	30	32	2	7
06/25/84	32(15)	31	34	3	10

-- Data Not Available.

Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 9

IN SHIMS DATA/ANALYSIS II

DATE	REGION (SN)	NOMINAL STEADY VALUE (X2 WATT)	PEAK AT IN LIMIT (X2 WATT)	DIFFERENCE (X2 WATT)	DIFFERENCE (%)
06/25/84	33(34)	30	32	2	7
--------	34(22)	No data available.			
06/25/84	35(21)	26	31	5	19
06/25/84	36(8)	29	32	3	10
06/23/84	37(4)	31	34	3	10
	Mean:	29.00	33.08	4.08	14.72
	Standard:	3.86	3.28	2.10	8.70

-- Data Not Available.

Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

ATTACHMENT 10

IN SHIMS TRANSIENT DECAY TIME DATA/ANALYSIS II

DATE	REGION (SN)	TIME TO DECAY
06/25/84	1(6)	3.8
06/23/84	2(3)	2.0
06/23/84	3(37)	2.4
06/23/84	4(31)	2.0
06/25/84	5(10)	2.8
06/25/84	6(29)	3.6
06/25/84	7(18)	4.4
06/23/84	8(38)	3.8
06/23/84	9(26)	1.4
06/23/84	10(14)	3.8
06/23/84	11(30)	2.2
06/00/84	12(42)	3.2
06/23/84	13(16)	4.0
06/25/84	14(25)	3.8
06/25/84	15(12)	1.6
06/23/84	16(33)	1.6
06/25/84	17(41)	2.0
06/25/84	18(40)	3.2
06/23/84	19(13)	2.2
06/23/84	20(32)	3.4
06/23/84	21(28)	1.8
06/23/84	22(5)	2.6
06/23/84	23(39)	2.6
06/23/84	24(23)	1.8
06/23/84	25(7)	2.8
06/23/84	26(1)	2.4
06/23/84	27(2)	4.0
06/25/84	28(44)	4.4
06/25/84	29(35)	4.4
06/25/84	30(11)	4.2
06/25/84	31(17)	2.8
06/25/84	32(15)	2.4
06/23/84	33(34)	1.8
--------	34(22)	1.8

-- Data Not Available.
Note: Units of time are in divisions of the strip chart.

ATTACHMENT 10

IN SHIMS TRANSIENT DECAY TIME DATA/ANALYSIS II

DATE	REGION (SN)	TIME TO DECAY
06/25/84	35(21)	1.8
06/25/84	36(8)	2.0
06/23/84	37(4)	1.6
	Mean:	2.77
	Standard:	0.96

-- Data Not Available.
Note: Units of time are in divisions of the strip chart.

ATTACHMENT 11

INDIVIDUAL CRDOA SHIM SEQUENCE VARIATION ANALYSIS

DATE	REGION/(SN)	OUT SHIM					IN SHIM		
		FIRST PEAK (X2 WATT)	MEAN PEAK* (X2 WATT) (STANDARD DEVIATION)	FIRST DECAY TIME	MEAN DECAY TIME/ (STANDARD DEVIATION)	NO. OF DATA POINTS USED	MEAN PEAK* (X2 WATT) (STANDARD DEVIATION)	MEAN DECAY TIME/ (STANDARD DEVIATION)	NO. OF DATA POINTS USED
08/23/84	HSF/(7)	86.00	92.57 (1.51)	0.4	0.94 (0.10)	7	80.43 (0.53)	0.69 (0.11)	7
08/28/84	HSF/(11)	84.00	94.14 (1.07)	0.2	0.83 (0.08)	7	81.14 (0.38)	1.0 (0.13)	7
09/28/84	HSF/(26)	88.0	97.14 (1.07)	0.4	0.86 (0.10)	7	81.14 (0.69)	0.94 (0.22)	7
08/18/84	HSF/(29)	88.0	96.78 (0.67)	0.2	0.62 (0.16)	9	83.63 (1.51)	0.75 (0.09)	8
03/23/84	3/(37)	80.0	89.47 (1.37)	0.6	1.70 (0.14)	17	79.22 (1.20)	1.36 (0.17)	7
03/28/84	10/(14)	83.0	96.47 (2.21)	0.4	1.27 (0.17)	17	84.14 (1.57)	1.83 (0.36)	7
03/28/84	11/(30	82.0	93.94 (1.14)	0.8	1.40 (0.14)	17	81.14 (0.38)	2.08 (0.38)	7
06/23/84	16/(33)	78.0	87.63 (1.30)	0.6	2.72 (0.81)	8	75.50 (1.77)	1.78 (0.31)	8

*Excludes the first peak.
Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hencc all values should be multiplied by 2.0.

ATTACHMENT 11

INDIVIDUAL CRDOA SHIM SEQUENCE VARIATION ANALYSIS

DATE	REGION/(SN)	OUT SHIM					IN SHIM		
		FIRST PEAK (X2 WATT)	MEAN PEAK* (X2 WATT) (STANDARD DEVIATION)	FIRST DECAY TIME	MEAN DECAY TIME/ (STANDARD DEVIATION)	NO. OF DATA POINTS USED	MEAN PEAK* (X2 WATT) (STANDARD DEVIATION)	MEAN DECAY TIME/ (STANDARD DEVIATION)	NO. OF DATA POINTS USED
06/25/84	35/(21)	76.0	85.0 (1.0)	0.6	1.98 (0.32)	9	73.75 (1.67)	3.35 (0.58)	8
06/25/84	36/(8)	78.0	87.88 (0.83)	0.6	3.0 (0.15)	8	77.63 (0.74)	2.40 (0.21)	8

*Excludes the first peak.
Note: Wattage values were determined on a 0 - 500 scale where the maximum deflection corresponded to 1000 Watt, hence all values should be multiplied by 2.0.

EXPLANATION OF WATTAGE TEST EVALUATION SUPPORTING DATA

This data was collected on either of (2) Esterline Angus Model A 601C Graphic (recording) Wattmeters, rated at 100 volts and 1000 watts, full scale (3 phase, 3 wire, 60 Hz), serial numbers 182698, 182699, calibrated July 7, 1984, with a guaranteed accuracy of 1% full scale (10w). Precision, as indicated by peak and nominal values reached over many shims at approximately the same drum condition, appears to be about 1 watt. This means, provided voltage conditions are kept constant, the readings can be compared between shims on a given chart, so that very precise conditions can be achieved, which is important for the use of the wattage test done here (Note - variations in voltage over the time required to perform the test will generally not pose a problem, as these are typically slight). All wattage values are recorded assuming a precision of 1 watt. Also note that voltage variations have no effect on the watt recorder's ability to accurately determine wattage; rather, they change the motor operating point so that power consumption, for the same load, will be different. Finally, note that absolute determinations of power in watts, for comparison against FSAR, O&M, and other values, are admittedly a problem because the test did not include voltage data; the proposed procedure corrects this problem. Consequently, these comparisons and any conclusions should be very tentative. Remember the guaranteed accuracy is only ±10w, even if the precision is 1w.

All data values were recorded on a 0-500 scale where 500 corresponded to 1000w. Hence the reading in watts is that recorded times two. Also, the two wattmeters were adjusted for different chart speeds on the slow speed scale, as follows:

SN 182698 (East Rx) 5 sec/minor division
SN 182699 (West Rx) 2.5 sec/minor division

Because the speeds for various charts were different, evaluation of overall mean decay times for reference purposes was intentionally not done. This has no effect on the proposed test, as any given determination of position is done on a single wattrecorder.

Out Shims Data I, II

These list values for minimum wattage during the transient, peak wattage during the transient, and decay time (chart division units) for the two general transient types: (1) those starting at the in limit, and (2) subsequent transients with the drum wrapped. Note that with the drum wrapped, the nominal steady value is the minimum value, since no dip occurs.

Out Shims Analysis I, II

These compute differences, and express these in percent for comparison against test requirements. One observes that in a few instances, actual "in" conditions would not be met by the test requirements, even though limit switch behavior indicated that in fact, the rod pairs were "in".

In Shims Data/Analysis I, II

These list values for steady final wattage for in shims leaving the drum wrapped, and final peak wattage for shims that terminate at the "in" position, as well as the differences and percentage difference.

In Shims Transient Decay Time Data/Analysis II

This has no relevance to the test, but was included to show typical in shim decay time variation, for information.

Individual CRDOA Shim Sequence Variation Analysis

This is the summary of detailed evaluation of shim sequences on individual CRDOAs to determine the variation in nominal values for out peak (drum wrapped), out decay, in peak, and in decay. The purpose is to illustrate the mean and variation in these parameters, to allow comparison against the tested value, to examine the significance of the variation:

First Peak vs. Mean Peak
First Decay vs. Mean Decay

In shim data is again provided for information.

Note that 10 shim sequences from 10 different mechanisms tested on various dates were selected. Selection was random, with the exception that several charts could not be used due to incomplete or multiple shim activations during the transient periods, which required elimination because peak or other values could not be clearly defined. The proposed test also eliminates this possibility by requiring complete repition of the sequence, should this occur.

Attachment 13

TITLE: TECHNICAL SERVICES PROCEDURE NO. 30, EVALUATION OF SHIM MOTOR WATTAGE CHARACTERISTICS

ISSUANCE AUTHORIZED BY			
PORC REVIEW			EFFECTIVE DATE

1.0 PURPOSE

This procedure describes the methods used to obtain wattage recordings, review the recordings, identify anomalies, establish "in" rod position and document the recordings.

2.0 APPLICABILITY

This procedure applies to the Technical Services Department's periodic responsibilities with regard to monitoring shim motor performance. All in-reactor rod movement will be done by the Reactor Operator with the Shift Supervisor's concurrence as indicated in SOP 12. Technical Services' responsibility will include monitoring of the watt recorder on the MCC and requesting the desired rod motion per SOP 12 through the Reactor Operator/Shift Supervisor. Adequate shutdown margins must be maintained at all times as indicated in the Cycle Safety Analysis or by GAUGE calculation.

3.0 OBJECTIVES

To establish a data base of shim motor characteristics. To establish condition of absorber strings and/or drive mechanism under anomalous conditions. To determine rod "in" position in the event analog and digital ("in" limit switches or position potentiometers) indication is lost, or to verify existing indication.

4.0 PROCEDURE

4.1 Initial Conditions

4.1.1 Recording wattmeter is connected to the CRDMCC with the region(s) to be tested.

4.1.2 If the wattmeter is not connected to the desired CRDMCC obtain a TCR through the Results Department and request an electrician to connect as required.

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4.1.3 Insure the wattmeter is operational. (Turn power "on", check to see pen is correctly set and inking, and adequate chart paper is installed, or perform other checks as appropriate for the instrument.)

Zero the instrument or otherwise identify "zero" level, once the wattrecorder is on. <u>All following references to wattage are with respect to this "zero" level, if the wattrecorder is not exactly zeroed.</u>

4.1.4 Verify the wattmeter calibration date and record on TSP-30A.

4.1.5 Obtain a calibrated stopwatch and record calibration date if a timed shim sequence is to be performed.

4.1.6 Attach a voltmeter (multammeter) in the voltage measurement mode across the individual phase-ground terminals for phases A, B, and C. Record voltages on TSP-30A (see diagram TSP-30C).

4.2 <u>Procurement of Data</u>

4.2.1 Request Shift Supervisor's permission to perform shim motor wattage test. Identify Region involved and reason. Testing will normally only be done while shutdown. For normal CRDOA configurations the requirements of SOP 12-02 must be met:

Not more than 2 CRDOA absorber pairs at positions other than fully inserted, including those of any CRDOA removed from the reactor (i.e., if any CRDOA is removed, its absorber pairs must be considered fully withdrawn).

For other configurations (examples, (1) low CRDOA in a high region, (2) ICRD reinstalled, etc.) not explicitly covered by the cycle SAR, a GAUGE run verifying the shutdown margin (≥ 0.01) must be performed prior to rod movement.

Review Attachment B to become familiar with watt recorder interpretation.

4.2.2 Request Reactor Operator to notify Shift Supervisor and then exercise or shim the desired control rod pair in reactor. If monitoring is to be done on a CRDOA in the HSF, request the Maintenance Refueling Supervisor or designee to exercise control rods.

4.2.3 For each CRDOA to be monitored for trending/monitoring purposes, it is desired to obtain recordings of one full in and one full out movement. Record control rod position at start, finish, and at appropriate places deemed necessary. Additional recordings, such as running the control rods "out" and "in" in twenty inch increments may also be obtained. All position information may be marked on the recording chart.

4.2.4 To establish "in" rod position with watt recorder perform the following while obtaining watt recordings:

Sequence a

a) Scram the rod pair (pull the fuse, scram the Reactor, etc., as appropriate).

b) Obtain a calibrated stopwatch and prepare to time. Shim "out" for 15 seconds. (This will not have a significant effect on core reactivity since the total rod travel will be about 16 inches.)

Record time of "out" shim:

________ ________ ________
a b c

c) Shim "in" for the exact time recorded above. The rod pair should again be at the fully inserted position.

d) Scram the rod pair.

Sequence b

e) Repeat steps 4.2.4 b)-4.2.4 d) above.

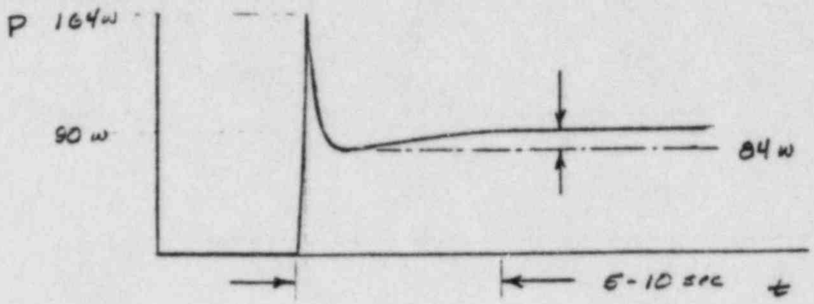
Sequence c

f) Repeat steps 4.2.4 b)-4.2.4 d) above.

4.3 Evaluation of Data

4.3.1. "In" Position Evaluation

a` For an inserted rod pair, the cable drum must wrap to raise the rod pair. As this occurs motor load will increase. For the "out" shims above, observe a wattage trace which shows an increasing 'steady' value after the starting peak occurs, as seen below.



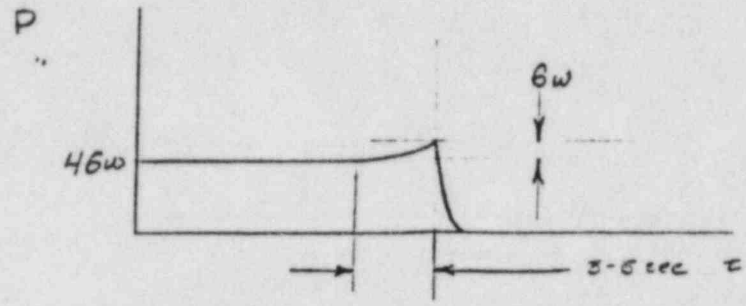
Record the minimum wattage for each "out" shim:

____ 1a ____ 1b ____ 1c

Record final wattage for each "out" shim:

____ 2a ____ 2b ____ 2c

b) For the "in" shims, observe an increase in the steady wattage towards the end of the shim as the drum unwraps, as seen below:



Record the nominal wattage after the starting peak for each "in" shim:

____ 3a	____ 3b	____ 3c

Record the final wattage for each "in" shim:

____ 4a	____ 4b	____ 4c

c) If the above observations are made, and if for items 1 and 2, cases a through c,

$$5 = \frac{2 - 1}{2} \times 100\% > 5\%, \text{ and}$$

for items 3 and 4, cases a through c

$$6 = \frac{4 - 3}{4} \times 100\% > 5\%,$$

the rod maybe considered "in"; continue to step 4.6 below.

Record:

____ 5a	____ 5b	____ 5c	(> 5%)
____ 6a	____ 6b	____ 6c	(> 5%)

d) An exact repetition of the above sequences, 4.2.4 a)-f) and 4.3.1 a)-c) may be done as many times as desired. Any sequence for which the above conditions are met may be used to conclude that the rod pair is "in".

4.4 Detailed "In" Rod Position Test and Evaluation

a. Theory

Both the peak wattage and decay time for an outward shim starting at the fully inserted position varies from those of a shim starting with the drum sheave wrapped. This is due to the decreased power to establish motion, in conjunction with a quicker decay to the final steady value due to the more rapid acceleration when the rods are not immediately required to rise upon shim initiation. Decay time is the time to reach a minimum wattage value during the shim, or the time to reach a value within 2 watts of the final extrapolated steady value, or the time of the shim, whichever is shorter.

b. Data Procurement

NOTE: Any RWP or incomplete shim will require repeating the test sequence.

Sequence a

i) The control rod pair is scrammed; reset the scram breaker. Start the wattrecorder when ready.

ii) Shim outward for 15 seconds; wait 10 seconds.

iii) Perform ii) again, exactly.

iv) Perform ii) again, exactly.

v) Shim inward for 15 seconds; wait 10 seconds.

vi) Perform v) again, exactly.

vii) Perform v) again, exactly.

Sequence b

viii) Repeat steps i) - vii) above.

Sequence c

ix) Repeat steps i) - vii) above.

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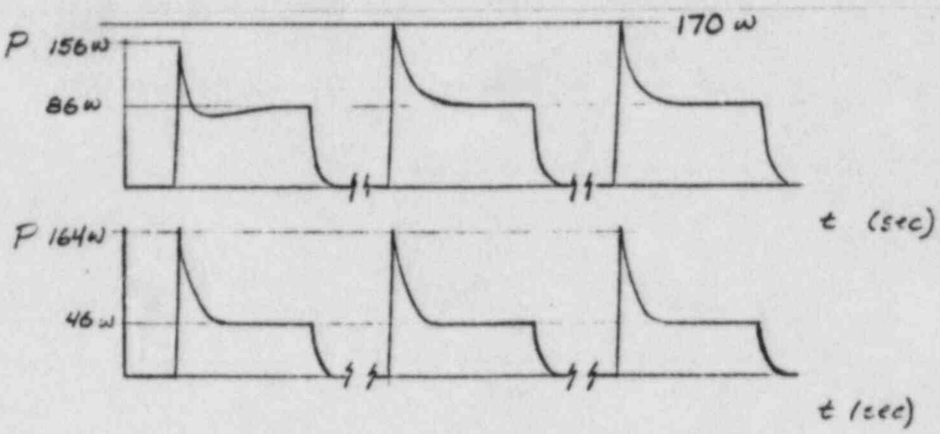
c. Evaluation

i) The wattage record will indicate three sequences, each a series of 3 "out" shims and 3 "in" shims, of exactly the same duration.



ii) Record the wattage peaks of each shim, consecutively, below:

Sequence a

"out" shims

shim 1 ________ 1a   shim 2 ________ 2a   shim 3 ________ 3a

"in" shims

shim 4 ________ 4a   shim 5 ________ 5a   shim 6 ________ 6a

Sequence b

"out" shims

shim 1 ________ 1b   shim 2 ________ 2b   shim 3 ________ 3b

"in" shims

shim 4 ________ 4b   shim 5 ________ 5b   shim 6 ________ 6b

Sequence c

"out" shims

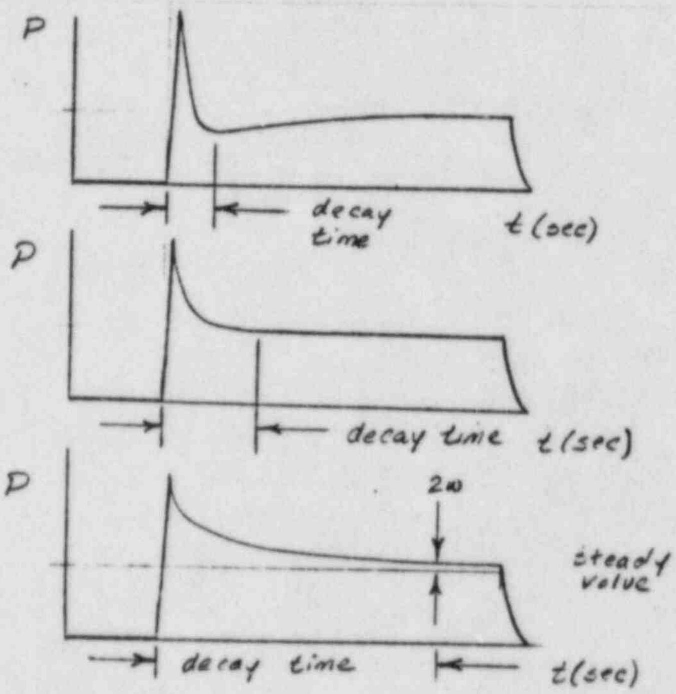
shim 1 ______ 1c   shim 2 ______ 2c   shim 3 ______ 3c

"in" shims

shim 4 ______ 4c   shim 5 ______ 5c   shim 6 ______ 6c

iii) Record the decay time of each shim, consecutively.

Decay time: time to reach a minimum or stable value (within 2 watts of extrapolated final steady value), or time of the shim, whichever is smaller.



Sequence a

"out" shims

shim 1 ______ 1'a   shim 2 ______ 2'a   shim 3 ______ 3'a

"in" shims

shim 4 ______ 4'a   shim 5 ______ 5'a   shim 6 ______ 6'a

Sequence b

"out" shims

shim 1 ________ (1'b) shim 2 ________ (2'b) shim 3 ________ (3'b)

"in" shims

shim 4 ________ (4'b) shim 5 ________ (5'b) shim 6 ________ (6'b)

Sequence c

"out" shims

shim 1 ________ (1'c) shim 2 ________ (2'c) shim 3 ________ (3'c)

"in" shims

shim 4 ________ (4'c) shim 5 ________ (5'c) shim 6 ________ (6'c)

iv) For each sequence,
average ii) items 2-3 $\frac{2 + 3}{2} = 7$

and average iii) items 2'-6' $\frac{2' + 3' + 4' + 5' + 6'}{5} = 8$

Sequence a

Record 7 and 8: ________ (7a) ________ (8a)

Sequence b

Record 7 and 8: ________ (7b) ________ (8b)

Sequence c

Record 7 and 8: ________ (7c) ________ (8c)

v) If for each sequence,

$$9 = \frac{7 - 1}{7} \times 100\% \geq 5\%$$

and

$$10 = \frac{8 - 1'}{8} \times 100\% \geq 50\%,$$

the rod pair may be considered "in"; continue to step 4.6.

Sequence a

Record 9 and 10: ________ (>5%) ________ (≥50%)
9a 10a

Sequence b

Record 9 and 10: ________ (>5%) ________ (≥50%)
9b 10b

Sequence c

Record 9 and 10: ________ (>5%) ________ (≥50%)
9c 10c

If the result is negative, notify the Shift Supervisor and Technical Services Engineering Supervisor that "The control rod pair in Region (give Region) cannot be considered inserted"; continue to step 4.5 if directed.

4.5 Absolute "In" Position Evaluation

NOTE: This test should only be performed if both the analog/digital position pots are not correctly indicating and the "in" limit switches are not picking, or there is evidence that the multijaws coupling connecting these indicating devices is failed, causing readings inconsistent with the rod motion, or if there is an absolute need for independent verification of rod pair position.

Because this activity places a high risk on breaking the multijaws coupling, Station Manager approval is required to proceed.

Approval to proceed:

__________________________ ____________________
Station Manager Date/Time

This is the most definitive wattage test for determining "in" position.

a. Theory

A shim in which the motor raises the control rod pair, nominally referred to as outward shim, performed by shimming in the "out" direction, differs from an inward shim due to the differences in the peak and steady wattages, for the case where the cable drum is wound approximately ¼ turn so that the moment arm is developed.

At the fully inserted position, the moment arm is zero, as the rod pair hangs free from the drum attached by the anchor ends. At this point, the transient peak for an "out" or "in" shim is the same, although under normal conditions only an "out" shim may be accomplished, as the picking of the "in" limit switches precludes shimming in the inward direction.

Note that if the "in" limit switches fail or are opened up, shimming in the inward direction is again possible, except that now the cable is wrapping around the drum sheave in the reverse direction. Hence the shim motor is essentially performing a raising transient, which requires more wattage than an insertion transient.

Thus the shim motor wattage transient will appear as if an "out" shim is being performed, even though the shim is in the "in" direction.

The crux of this test is to observe the change in the motor transient performance that will occur if the rods are at the fully inserted position.

b. Data Procurement

NOTE: Any RWP or incomplete shim will require repeating the test sequence.

WARNING: The following sequence must be performed exactly to minimize risk of jamming the assembly.

Sequence a

i) The control rod pair is scrammed; reset the scram breaker. Start the wattrecorder when ready.

ii) Shim "out" for 10 seconds; wait ≥ 10 seconds.

Shim time: ________ a ________ b ________ c

iii) Shim "in" for 10 seconds; wait ≥ 10 seconds.

Shim time: ________ a ________ b ________ c

iv) Shim "in" for 10 seconds; wait ≥ 10 seconds.

Shim time: ________ a ________ b ________ c

v) Shim "out" for 10 seconds; wait ≥ 30 seconds.

Shim time: ________ a ________ b ________ c

Sequence b

vi) Repeat i) through v), exactly.

Sequence c

vii) Repeat i) through v), exactly.

c. Analysis

i) Determine the final wattage values for the shims in item b. ii); if no steady value was obtained, note.

________ 1a ________ 1b ________ 1c

ii) Determine the steady wattage for the shims in item b. iii). This will correspond to the minimum wattage seen during those shims.

________ 2a ________ 2b ________ 2c

iii) Calculate for i) and ii), items a through c above

$$3 = \frac{1 - 2}{1} \times 100\%$$

iv) Determine the final wattage for the shims in item b. iv); if no steady value was obtained, note.

______ 4a ______ 4b ______ 4c

v) Determine the steady wattage for the shims in item b. v). This will correspond to the minimum wattage seen during these shims.

______ 5a ______ 5b ______ 5c

vi) Calculate for iv) and v) items a through c.

$$6 = \frac{4 - 5}{4} \times 100\%$$

vii) If for items a through c,

3 > +25%

and

6 > +25%

Record 3 and 6, items a through c, below:

______ 3a ______ 3b ______ 3c (>+25%)

______ 6a ______ 6b ______ 6c (>+25%)

Then the rod pair may be considered "in"; continue to step 4.2.5 a 5).

If the result is negative notify the Shift Supervisor and Technical Services Engineering Supervisor that "The control rod pair in Region (give Region) cannot be considered inserted"; continue to step 4.6.

4.6 Disable Rod Motion

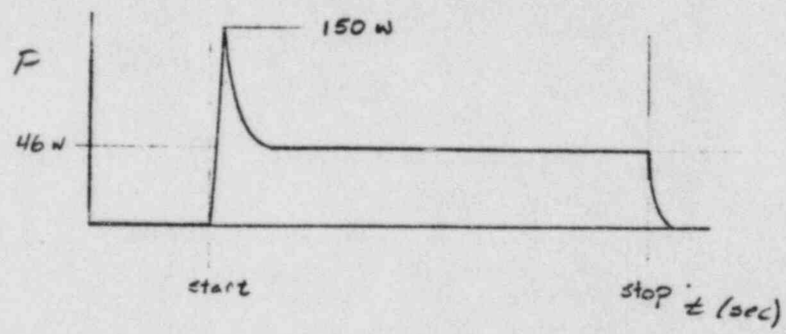
To insure no rod motion for shutdown margin purposes, instruct the Reactor Operator to pull the fuses on that Region and write a System Status Tag precluding rod motion for that rod pair.

4.7 Transient Evaluation

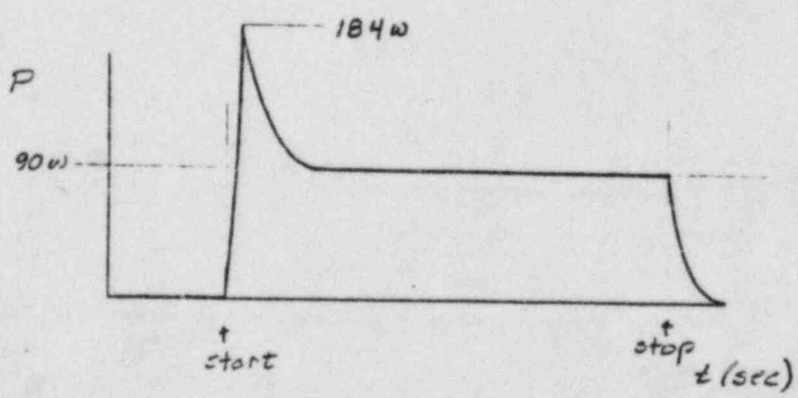
4.7.1 Normal Operation

a) For shims that begin/end at more than 10 inches position, the wrapping/unwrapping behavior in a. is not observed.

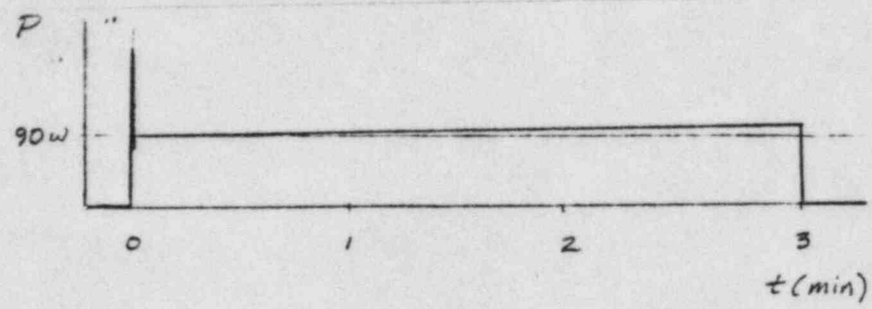
b) For the "in" shims, observe an increase in wattage at the initiation followed by decay to a steady value over the next 10 seconds. Nominally the wattage should peak at 140-150 watts and decay to 40-50 watts.



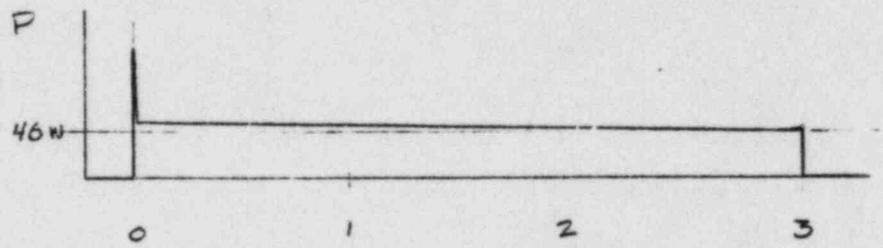
c) For the "out" shims, observe an increase in wattage at the initiation followed by decay to a steady value over the next 10 seconds. Nominally the wattage should peak at 160-180 watts and decay to 80-100 watts.



d) Over the duration of a continuous "out" shim from the fully inserted position, a gradual rise in wattage is seen of ~6 watts, due to the spiral wrapping of the drum sheave slightly changing the sheave moment arm.

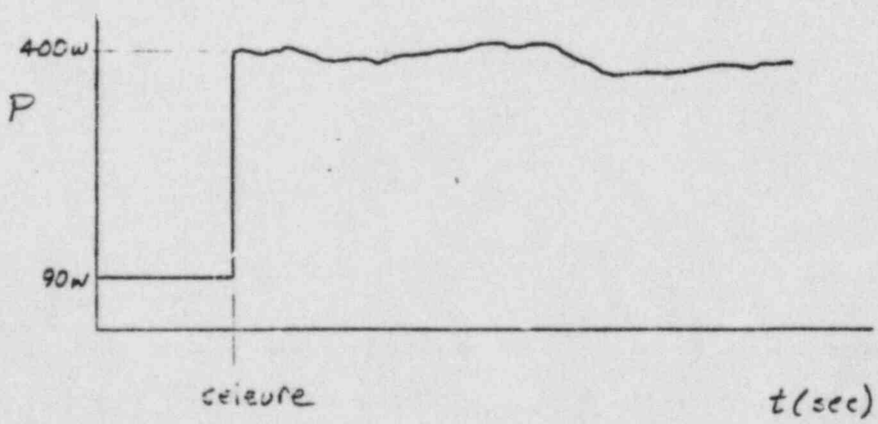


e) Over the duration of a continuous "in" shim from the fully withdrawn position, a gradual decline in wattage is seen of ~6 watts due to the unwrapping of the drum sheave.



4.7.2 Rotor Seizure

a) Rotor (hence drive mechanism) seizure is indicated by nearly instantaneous changes in wattage of very large magnitude. Should these be observed, rod motion should be stopped and evaluation of circumstances performed.



4.8 Documentation

Upon completion of monitoring, record the region that was tested or indicate HSF if conducted there, the CRDOA serial number, primary coolant temperature and moisture level as available. This information can be recorded on the wattage recording. Sign and date the chart recording and attach to this procedure. This information is recorded on Attachment TSP-30A.

4.9 Review

Review the recordings for unusual wattage. Normal steady readings are 90 watts during withdrawal and 44 watts during insertion; transient peaks should be 70 to 95 watts.

Normal readings are 90 ± 20 watts out
44 ± 20 watts in

4.10 Notification

If abnormal readings are obtained notify the Technical Services Engineering Supervisor.

4.11 Historical CRDOA Data

File copies of anomalous chart recordings with the Technical Services Control Rod Historical Information. Complete the Evaluation Summary and forward to the Technical Services Engineering Supervisor for review.

4.12 Records

Transmit the original attachment and chart recordings to Record Storage; retain copies in Technical Services files for review. Also transmit completed evaluations and recordings for any position evaluations.

5.0 REFERENCES

SOP 12

GA-9806, Operation and Maintenance Manual, CRDOA

WATTMETER USE TO DETERMINE INSERTED ABSORBER STRING POSITION, Engineering Analysis by Jim Eggebroten

6.0 ATTACHMENTS

Attach. TSP-30A, Evaluation Summary Sheet

Attach. TSP-30B, Typical Transient Analysis Sheet

Attach. TSP-30C, Sample Transient Records

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

EVALUATION SUMMARY SHEET

Engineer/Technician: ____________________ Date: ______________

QC Representative: ____________________

Wattmeter Identification: ____________ Calibration Date: __________

Stopwatch Identification: ____________ Calibration Date: __________

Voltmeter (Multameter)
Identification: ____________________ Calibration Date: __________

Location (check) Reactor ____ HSF ____

If Reactor: Region ________

Moisture (if available) ______ ______ppm ______°F

Inst (MM9305, MM9306, MM9307) ________

T Circ Inlet ____________°F

CRDOA SN (if available) ____________

Phase-to-ground voltages during shim: A ______ B ______ C ______
(Not required for position determination.)

SUMMARY OF OBSERVATIONS

____

____

____

____

____

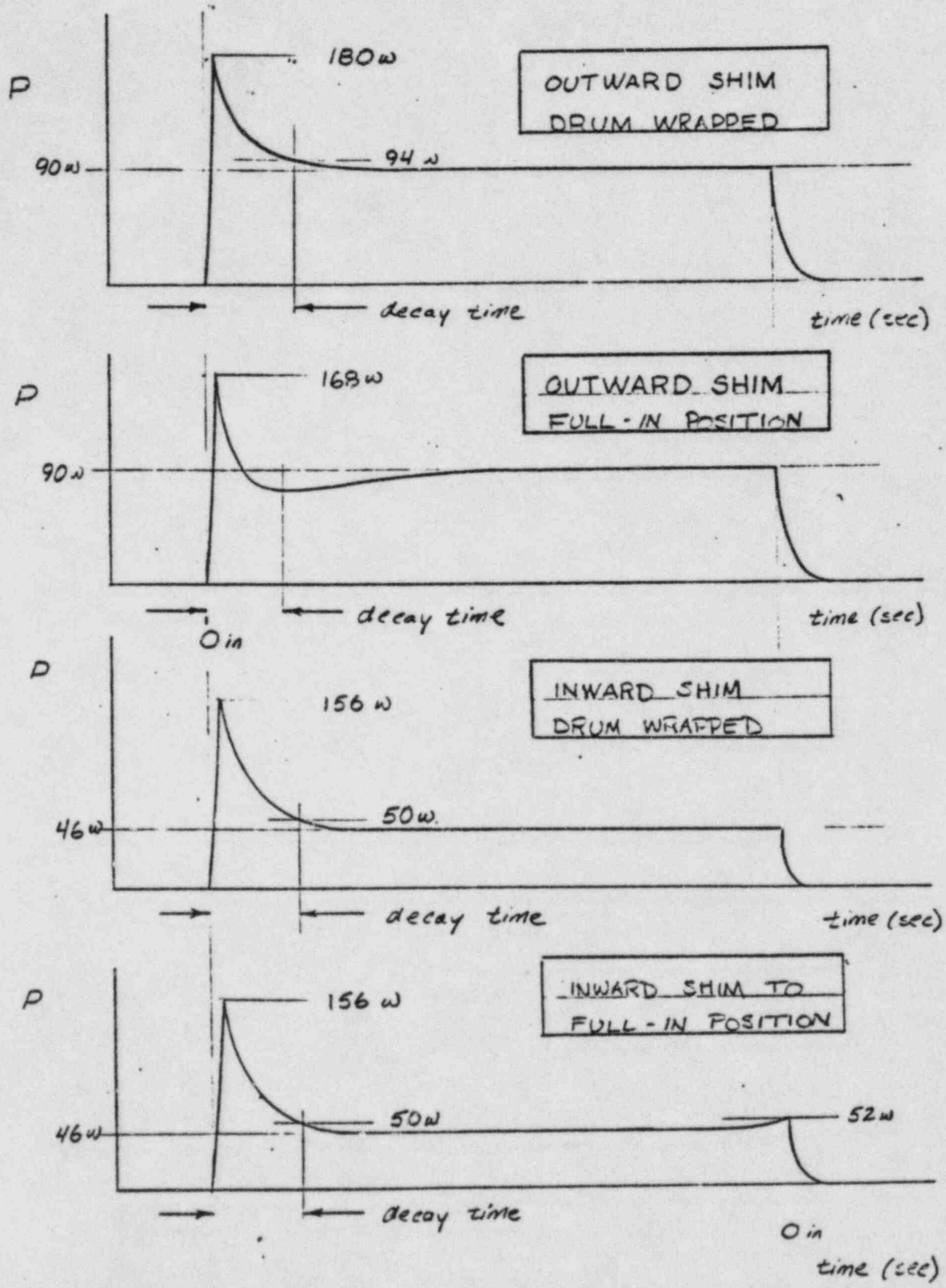
Completed By: ____________________ Date: ____________

____________________ Date: ____________
Technical Services
Engineering Supervisor
("In" position verification and abnormal readings, only.)

Make a copy for Technical Services files and forward criginals to Records Storage.

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

WATTMETER INTERPRETATION



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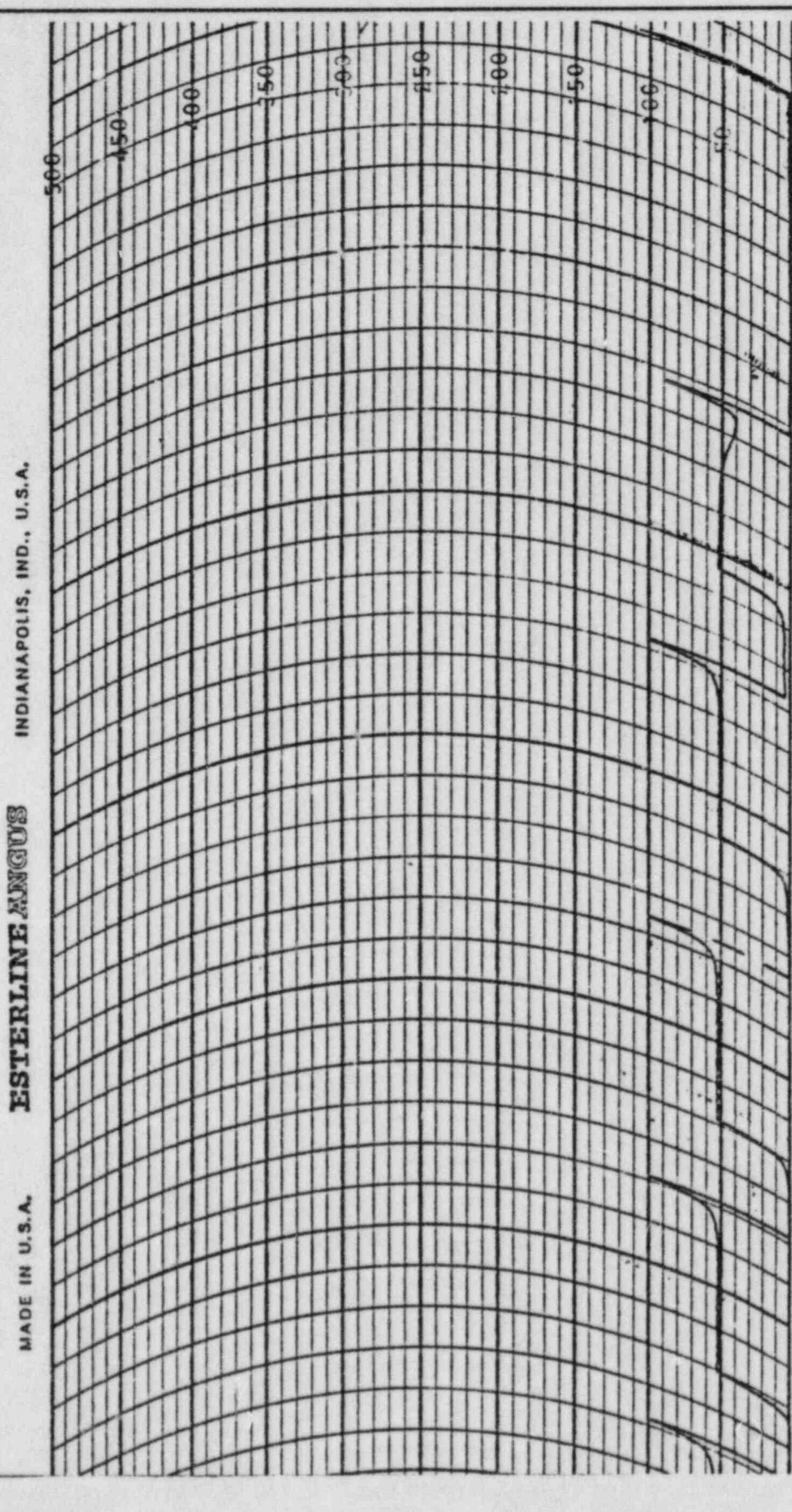
PUBLIC SERVICE COMPANY OF COLORADO

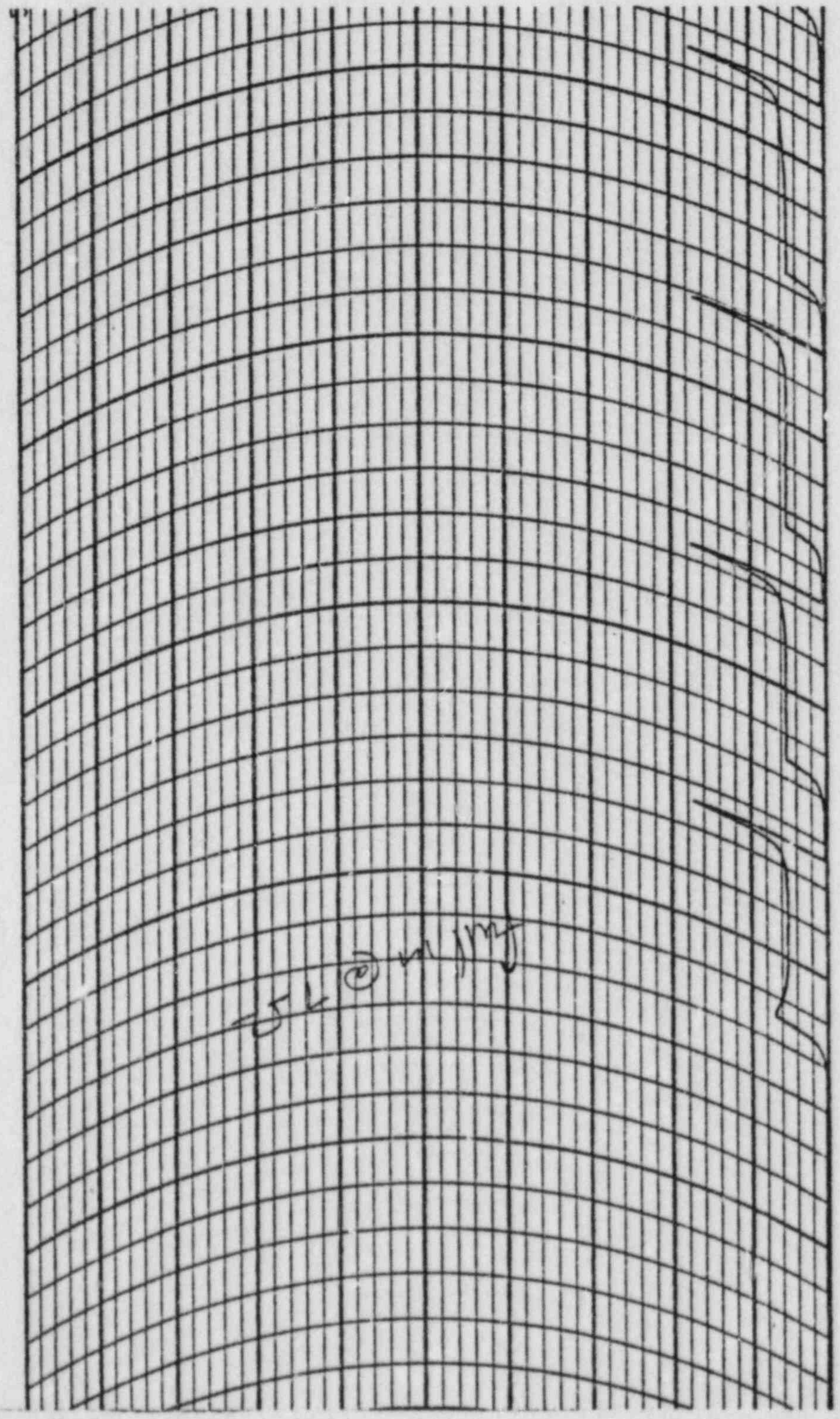


"Out" Shims Starting from "In" Limit

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

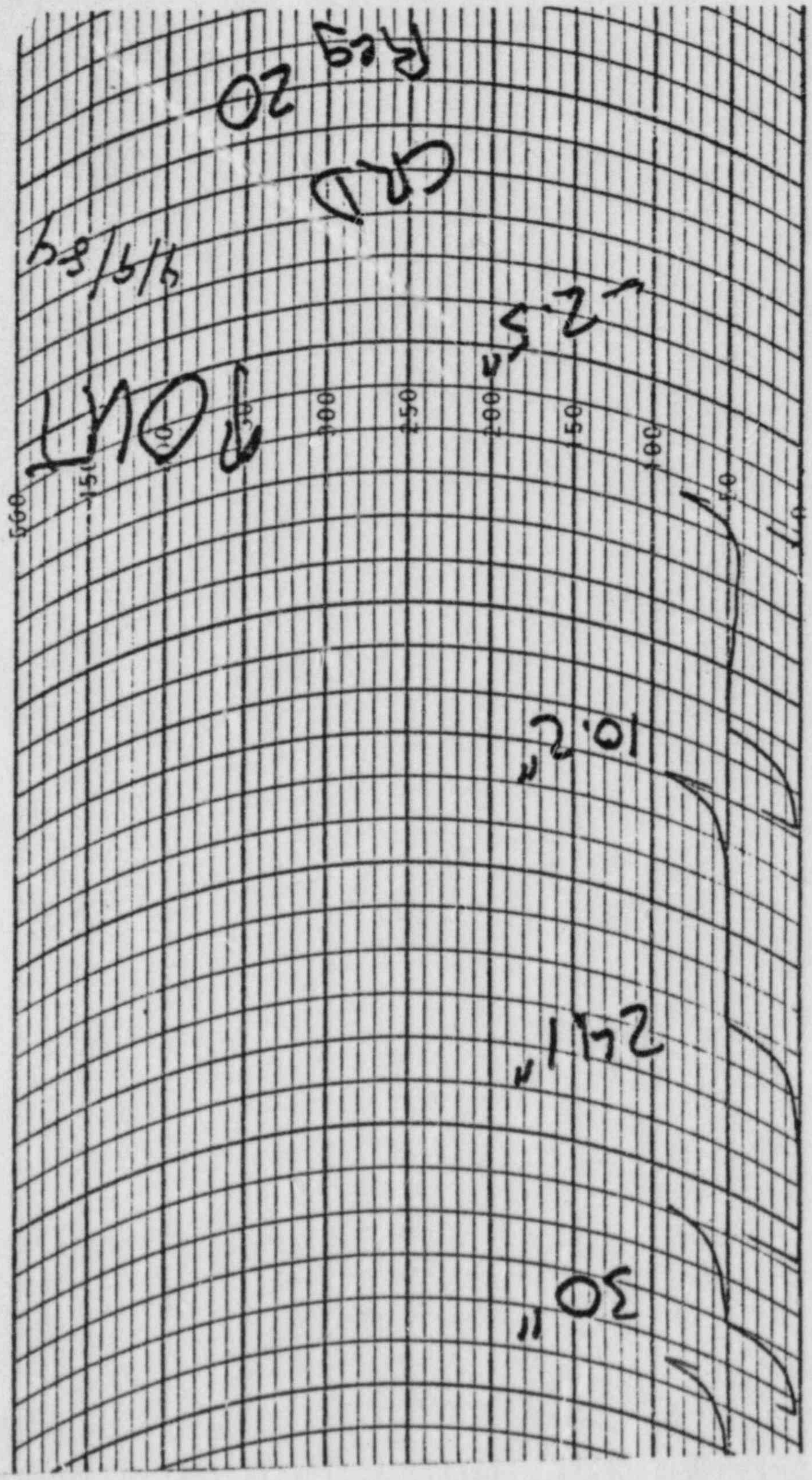


"In" Shims Ending at the "In" Limit

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

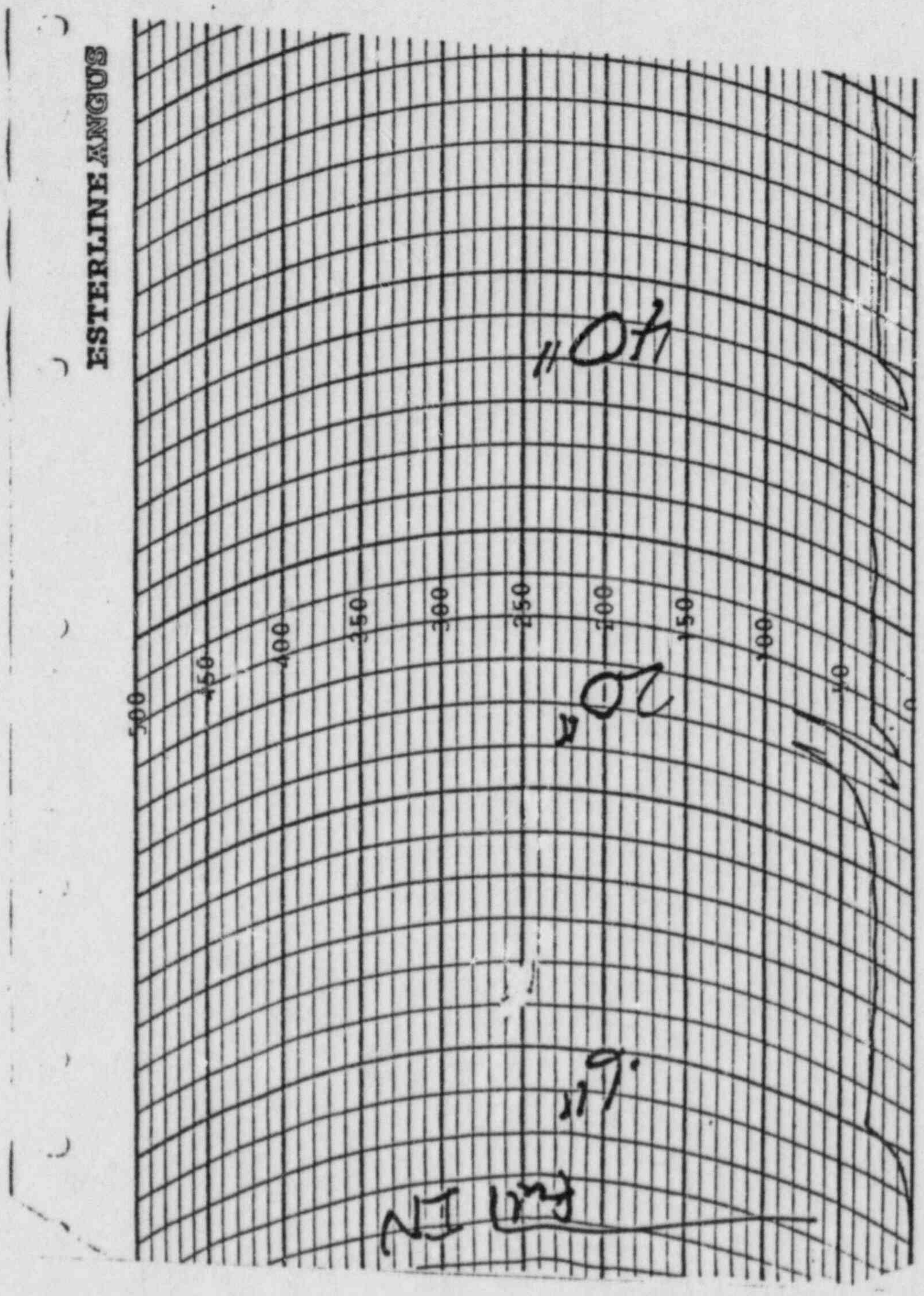


"Out" Shims Starting From "In" Limit - Deteriorated

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

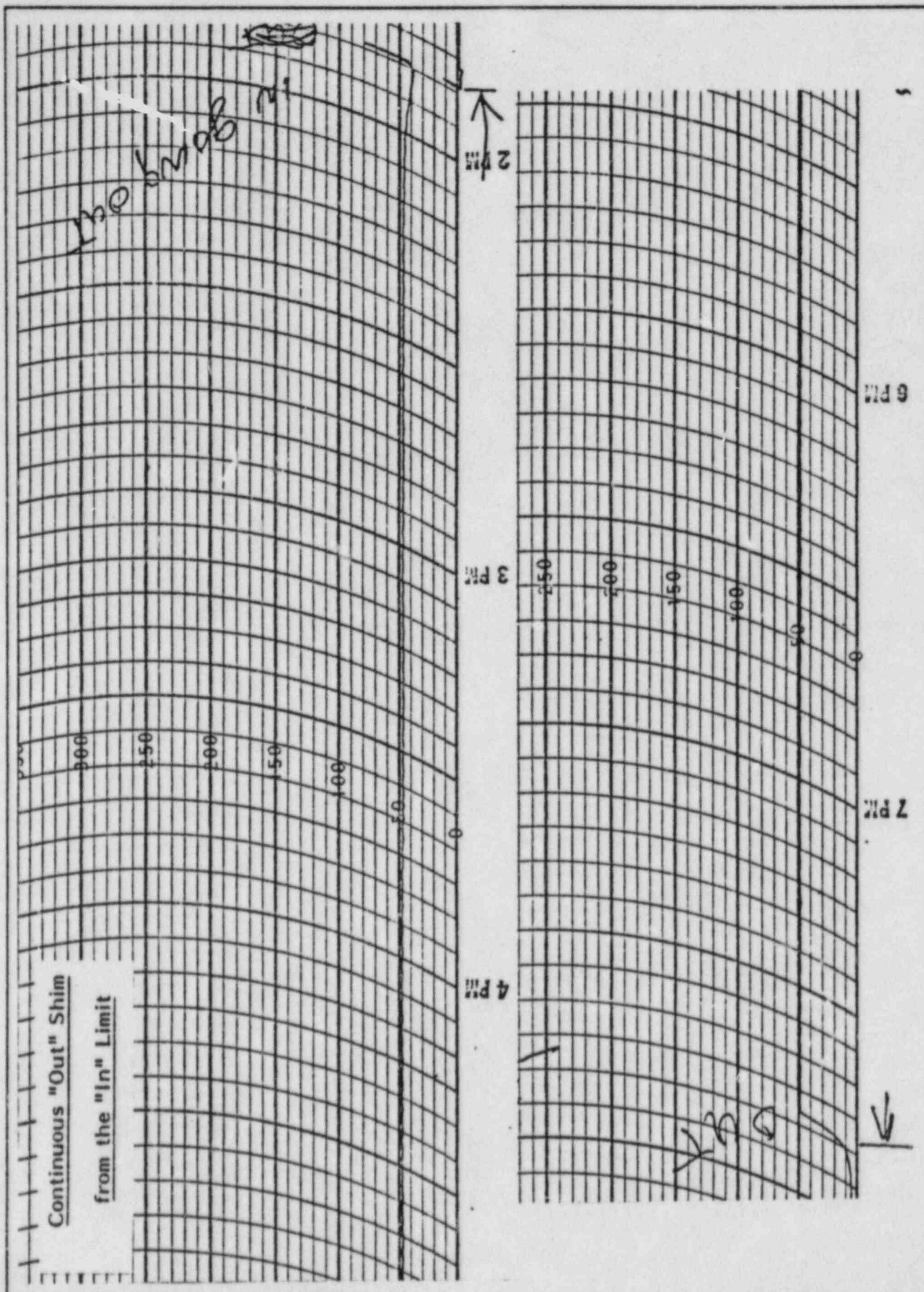


"In" Shims Ending at "In" Limit - Deteriorated

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

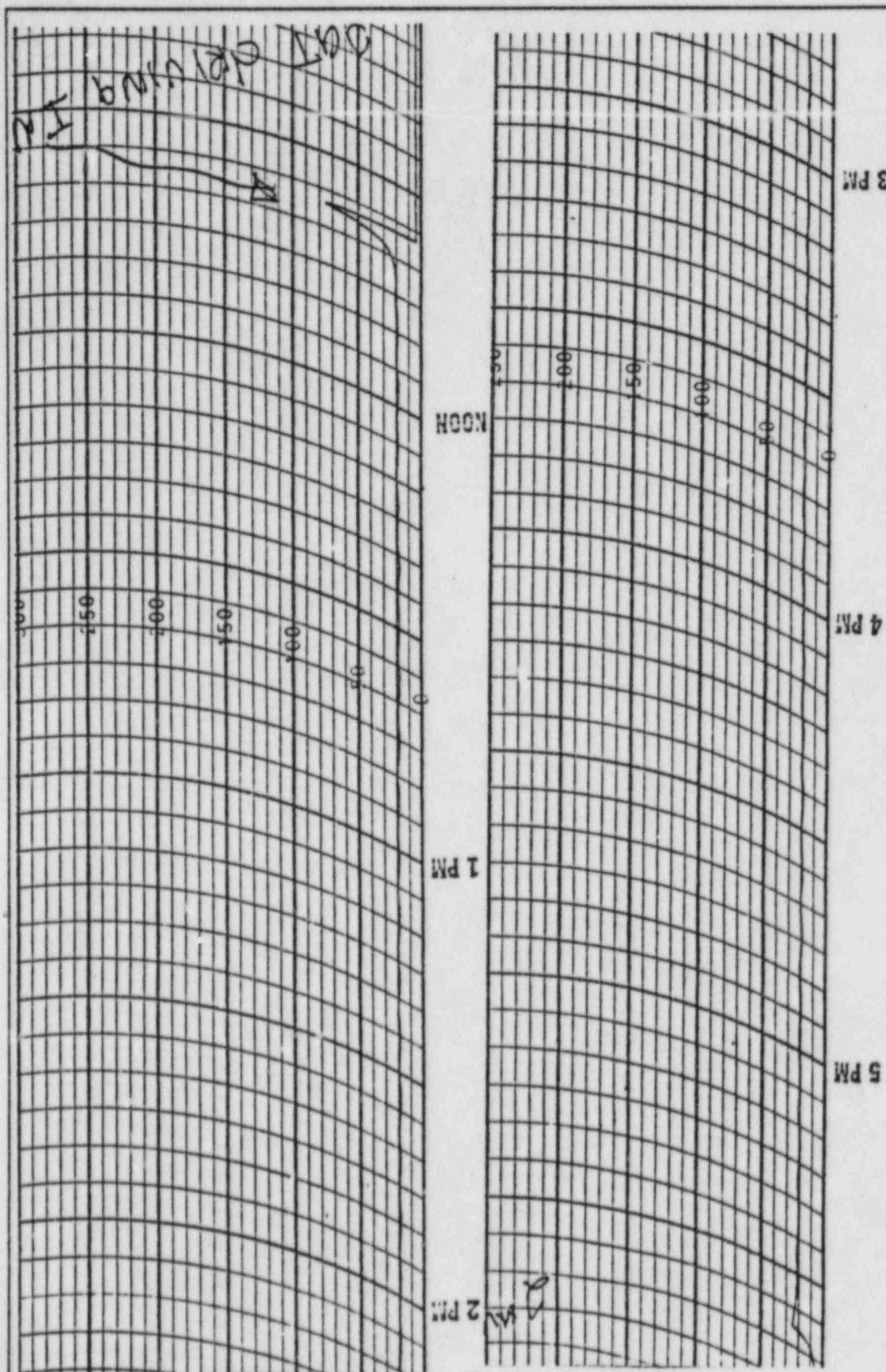


FORM (C) 372 - 22 - 3643

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO



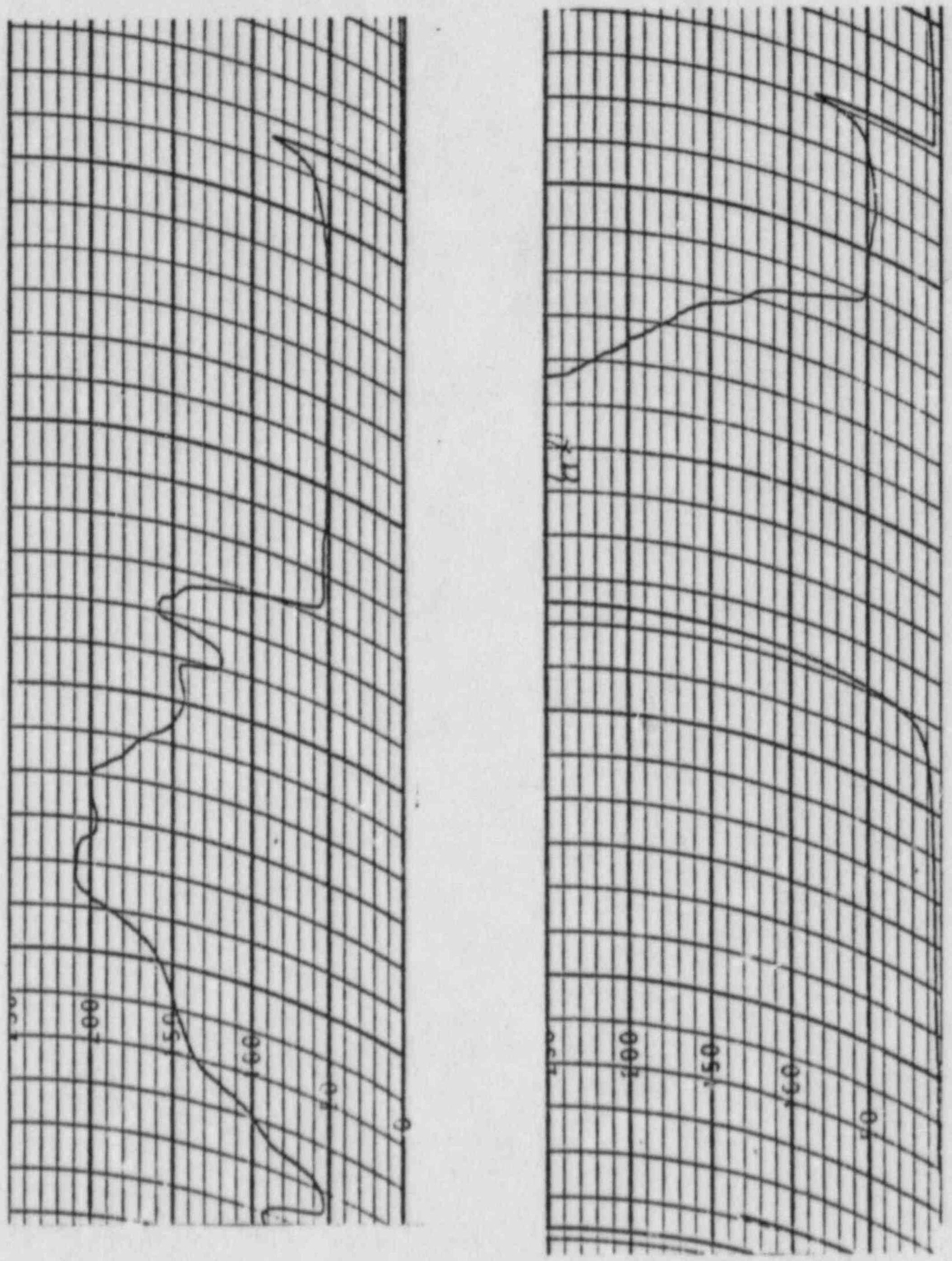
Continuous "In" Shim Ending at "In" Limit

FORM (C) 372-22-3843

Public Service™

FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

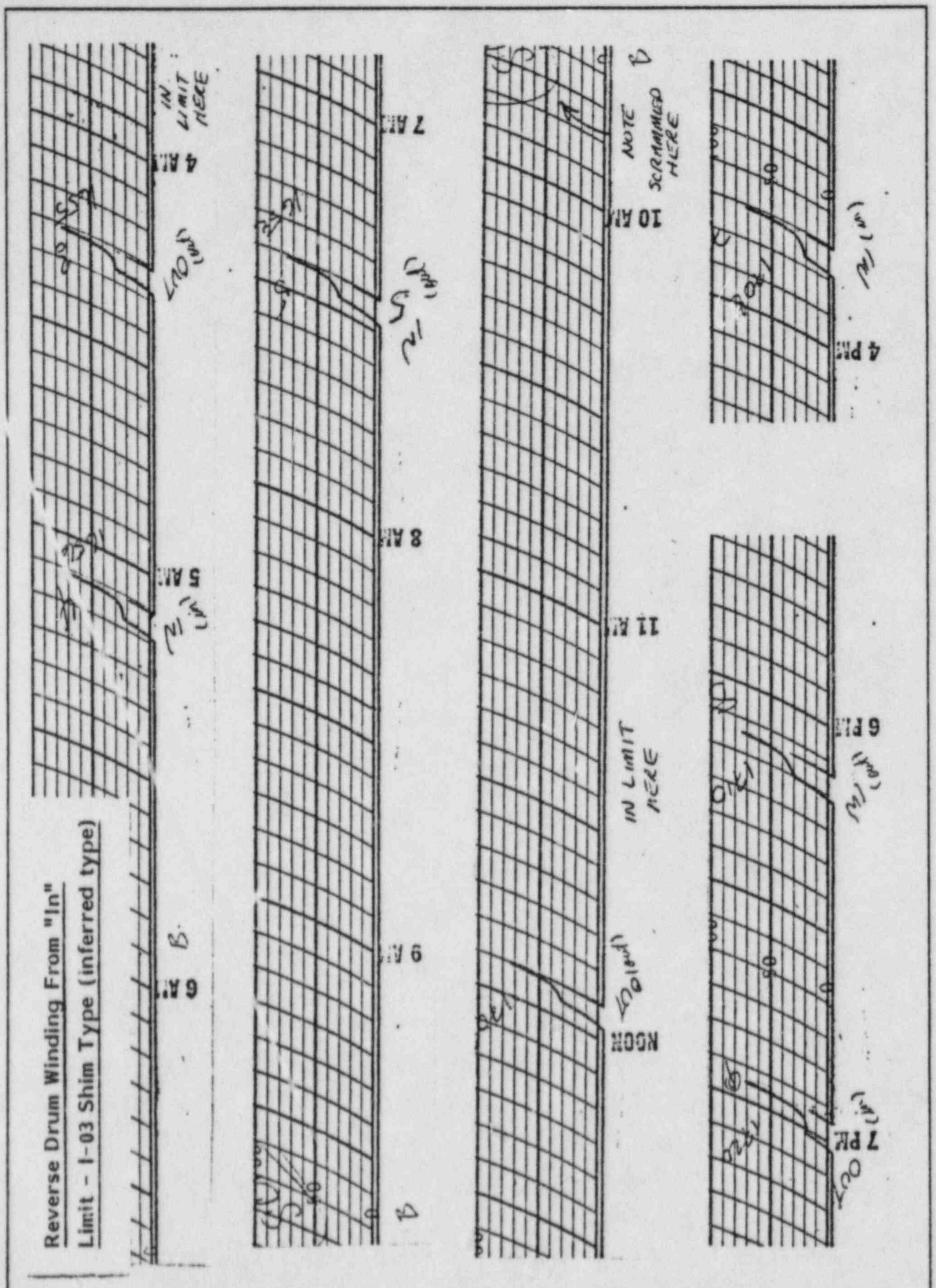


Rotor Seizure and Erratic Motion

Public Service™

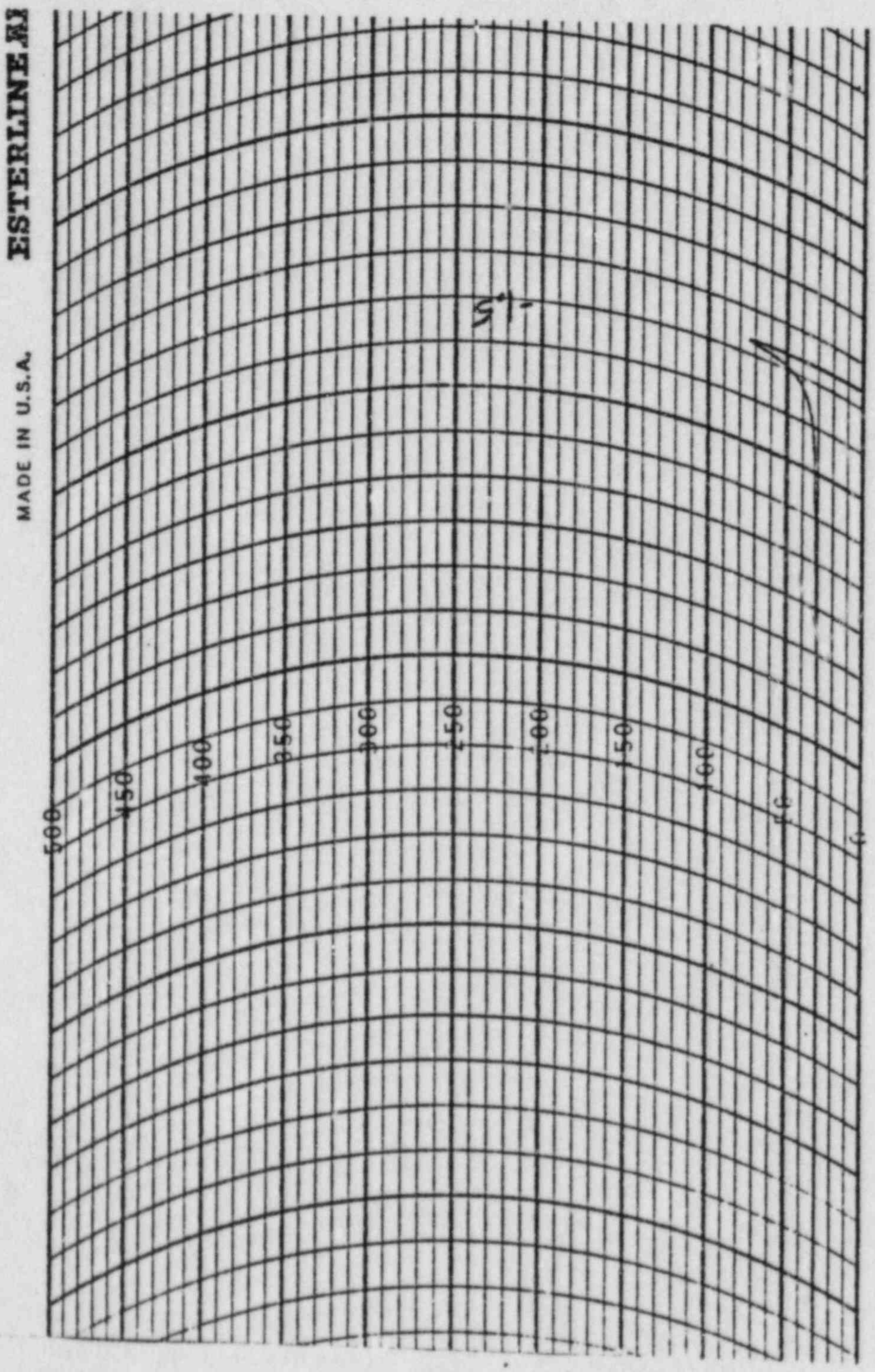
FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO



Reverse Drum Winding From "In"
Limit - I-03 Shim Type (inferred type)

Public Service™



ICRD Continuous Outward Shim (Reference)

O&M REFERENCES TO MOTOR WATTAGE

Page 47: 60 watts - maximum normal out wattage beyond which reliable scram capability not assured.

Page 64: At motor supply voltage of 105V:

22 watts - normal insertion wattage

72 watts - normal withdrawal wattage

Page 75: At motor supply voltage of 105V:

72 watts - normal withdrawal wattage

18 watts - difference between normal and value beyond which scram may not occur due to high friction.

FSAR REFERENCES TO WATTAGE

The rod withdrawal reading, with the additional 1.0 to 1.3 in-lb torque applied to the motor, was 90w compared to a normal (i.e., "as built") wattage reading of 72w.

Page 3.8-5

5.6.11 Bypass the rod out limit.

5.6.12 Obtain Reactor Operator permission and withdraw rod to full retract limit. ~ 1000 Ω.

*#*Section 5.7 is the result of an NRC commitment. Reference G-84392 and responses. DO NOT DELETE without issuance of comparable controls.*#*

5.7 No "In Limit" Light On Fully Inserted Rod.

5.7.1 Verify there is no slack cable indication.

5.7.2 Reset Scram per Section 3.2

5.7.3 First withdraw affected rod pair to a digital indication of ~6". Do not first insert the rod, since damage to position potentiometers could occur.

5.7.4 Manually insert rod until rod motion stops or a digital indication of 0.0", whichever occurs first.

5.7.5 Verify "In Limit" light is lit. If not, initiate SSR.

ATTACHMENT 8
TO P-85040

NUMBER #84-17

ISSUE 2

DATE 1/31/85

SYSTEM 11

OPERATIONS ORDER

ATTENTION:

XXXXXX	XXXXXX	XXXXXX	XXXXXX
S S	R O	E O	A T

Note:
Initial when order is read

CRD PURGE FLOW LOST

The loss of Control Rod Drive (CRD) purge flow is alarmed in the Control Room. The intended response to a low purge flow alarm is:

1. Review purified helium flow, pressure and temperature indications for abnormal indications.

2. Verify by local indication that flow alarm is valid.

3. Attempt to recover purge flow.

PORC 806 JAN 31,1985

NUMBER #84-17

ISSUE 2

DATE 1/31/85

SYSTEM 11

4. If available, switch to the standby helium purification train.

If the above steps do not restore purge flow, reactor power will be reduced to less than 2% by following established operating procedures.

High Moisture in Primary Coolant

1. Average core outlet temperature ≥ 1200°F and chemical impurities ≥ 10 ppm as determined by Health Physics. Reduce core outlet temperature to < 1200°F. Further reduction of core outlet temperature may be necessary to remain in the limited acceptable range on Figure 4.2.11-1 in the Technical Specifications.

2. Average core outlet temperature ≤ 725°F.

   a. If primary coolant dew point temperature is equal to or greater than 60°F, scram reactor per EP B-1 and notify Superintendent of Operations.

William [signature]
Superintendent, Operations
(or) Station Manager

PORC 606 JAN 31, 1985

TITLE: CRD TEMPERATURE DATA COLLECTION

DEPARTMENT: RESULTS

ISSUANCE AUTHORIZED BY	Milt McBride		
PORC REVIEW	PORC 549 DEC 27 1983	EFFECTIVE DATE	12-30-83

Do not start test before________ Week # _____

and must be completed by________ Sch. Clerk

This procedure cannot be run in its entirety for the following reasons:

___ 1. This system is not operating.

___ 2. This system is not required to be operating and has a frequency of one month or less (reference Technical Specification, paragraph 2.18).

___ 3. Reactor is in "scrammed" condition.

___ 4. Loop I is in "Loop Shutdown" condition.

___ 5. Loop II is in "Loop Shutdown" condition.

___ 6. 1A Helium circulator is in "tripped condition".

___ 7. 1B Helium circulator is in "tripped condition".

___ 8. 1C Helium circulator is in "tripped condition".

___ 9. 1D Helium circulator is in "tripped condition".

___ 10. Other____________________________________

____

____

___ 11. Reschedule test for__________________________

____
Department Supervisor

8502060557

1.0 PURPOSE

The purpose of this test is to provide for regular temperature recordings of the CRD assemblies that are equipped with temperature devices.

2.0 PRECAUTIONS, LIMITATIONS, AND SPECIAL ASSISTANCE

None.

3.0 PREREQUISITES

3.1 Test Equipment

Name	Identification No.	Last Calibration Date
DVM		

3.2 References ______________________________

____

4.0 AUTHORIZATIONS

4.1 Departmental Approval ______________________________
Dept. Supervisor Date

4.2 Mech/Elec Clearance Issued, if required: Number Not Required

4.3 Radiation Work Permit Issued, if required: Number Not Required

4.4 Permission to initiate test ______________________________
Shift Supervisor Date

5.0 PROCEDURE

5.1 PRELIMINARY CHECKS

5.1.1 The temperatures are to be read when the reactor power level is ≥ 50% or the core Δp is ≥ 3 psid and,

a) As soon as possible after weekly control rod drop tests (SR 5.1.1b-M) have been performed.

b) When the reactor steady-state power level is changed ± 10% or more. This test can be done at the same time that the linear power channels are calibrated because of the change in the power level.

____

5.2 TEST PROCEDURE (FOR DATA COLLECTION ONLY)

5.2.1 The temperatures to be read are the CRD motor, orifice valve motor plate and upper helium environment temperatures of the CRD's which have had RTD's (Resistance Temperature Devices) installed in the aforementioned areas. RTD's will eventually be installed in all the CRD assemblies as the CRD's are pulled out for maintenance and refueling over the next few years. (See data sheets for recording of temperatures.)

5.2.2 All temperatures should be less than 250°F, if not, contact Station Manager.

____

Test Conductor Signature   Date

DATA SHEET

Reactor POWER _______ %

Average Core Inlet Temp. _______ °F

Core ΔP PSID _______

Primary Coolant Flow ________ %

REGION	ORIFICE POSITION (% OPEN)	CRD POSITION (INCHES)
15		
31		
34		
4		
5		
35		

Test Conductor Signature   Date

DATA SHEET (continued)

	Back of MCC Terminals	Upper Helium Environment		Back of MCC Terminals	Orifice Valve Motor Plate		Back of MCC Terminals	CRD Motor Temp.	
		Ω	°F per Table		Ω	°F per Table		Ω	°F per Table
Region 15	5			7			14		
	6			8			17		
Region 4	13			6			5		
	14			12			4		
Region 34	5			7			14		
	6			8			17		
Region 31	5			7			14		
	6			8			17		

	Back of MCC Terminals	Orifice Valve Motor Plate		Back of MCC Terminals	CRD Motor Temperature	
		Ω	°F per Table		Ω	°F per Table
Region 5	7			5		
	8			6		
Region 35	7			5		
	8			6		

NOTE: Reactor Power, Avg. Core Inlet Temp., Core ΔP and Primary Coolant Flow information are found on the data logger. Orifice position and CRD position are found on I-04.

Regions 15, 4, 34, 31: resistance reading is converted to °C per Table XVIII.

$$\frac{C \times 9}{5} + 32 = 32\,°F$$

Regions 5, 35:

$$\frac{(\text{resistance reading} - 400)}{157} \times 180 + 32 = °F$$

Test Conductor Signature

Date

TABLE XVIII (Cont.) Temperature Vs. Resistance Table

For European Curve, Alpha = .00385 — 1° Celsius Increments

°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.
480	274.25	0.34	542	294.81	0.32	604	314.93	0.32	666	334.60	0.31	728	353.84	0.31	790	372.62	0.30
481	274.59	0.34	543	295.14	0.33	605	315.26	0.33	667	334.92	0.32	729	354.14	0.30	791	372.92	0.30
482	274.92	0.33	544	295.47	0.33	606	315.58	0.32	668	335.23	0.31	730	354.45	0.31	792	373.22	0.30
483	275.26	0.34	545	295.80	0.33	607	315.90	0.32	669	335.55	0.32	731	354.76	0.31	793	373.52	0.30
484	275.60	0.34	546	296.12	0.32	608	316.22	0.32	670	335.86	0.31	732	355.06	0.30	794	373.82	0.30
485	275.93	0.33	547	296.45	0.33	609	316.54	0.32	671	336.17	0.31	733	355.37	0.31	795	374.12	0.30
486	276.26	0.33	548	296.78	0.35	610	316.86	0.32	672	336.49	0.32	734	355.67	0.30	796	374.41	0.29
487	276.60	0.34	549	297.10	0.32	611	317.18	0.32	673	336.80	0.31	735	355.98	0.31	797	374.71	0.30
488	276.93	0.33	550	297.43	0.33	612	317.50	0.32	674	337.11	0.31	736	356.29	0.31	798	375.01	0.30
489	277.27	0.34	551	297.76	0.33	613	317.82	0.32	675	337.43	0.32	737	356.59	0.30	799	375.31	0.30
490	277.60	0.33	552	298.08	0.32	614	318.14	0.32	676	337.74	0.31	738	356.90	0.31	800	375.61	0.30
491	277.93	0.33	553	298.41	0.33	615	318.46	0.32	677	338.05	0.31	739	357.20	0.30	801	375.91	0.30
492	278.27	0.34	554	298.74	0.33	616	318.77	0.31	678	338.36	0.31	740	357.51	0.31	802	376.21	0.30
493	278.60	0.33	555	299.07	0.33	617	319.09	0.32	679	338.68	0.32	741	357.81	0.30	803	376.50	0.29
494	278.93	0.33	556	299.39	0.32	618	319.41	0.32	680	338.99	0.31	742	358.12	0.31	804	376.80	0.30
495	279.27	0.34	557	299.72	0.33	619	319.73	0.32	681	339.30	0.31	743	358.42	0.30	805	377.10	0.30
496	279.60	0.33	558	300.05	0.33	620	320.05	0.32	682	339.61	0.31	744	358.73	0.31	806	377.40	0.30
497	279.93	0.33	559	300.37	0.32	621	320.37	0.32	683	339.92	0.31	745	359.03	0.30	807	377.70	0.30
498	280.26	0.33	560	300.70	0.33	622	320.69	0.32	684	340.23	0.31	746	359.33	0.30	808	377.99	0.29
499	280.60	0.34	561	301.03	0.33	623	321.01	0.32	685	340.55	0.32	747	359.64	0.31	809	378.29	0.30
500	280.93	0.33	562	301.35	0.32	624	321.33	0.32	686	340.86	0.31	748	359.94	0.30	810	378.59	0.30
501	281.26	0.33	563	301.68	0.33	625	321.65	0.32	687	341.17	0.31	749	360.25	0.31	811	378.89	0.30
502	281.59	0.33	564	302.00	0.32	626	321.96	0.31	688	341.48	0.31	750	360.55	0.30	812	379.18	0.29
503	281.93	0.34	565	302.33	0.33	627	322.28	0.32	689	341.79	0.31	751	360.85	0.30	813	379.48	0.30
504	282.26	0.33	566	302.65	0.32	628	322.60	0.32	690	342.10	0.31	752	361.16	0.31	814	379.77	0.29
505	282.59	0.33	567	302.98	0.33	629	322.92	0.32	691	342.41	0.31	753	361.46	0.30	815	380.07	0.30
506	282.92	0.33	568	303.30	0.32	630	323.24	0.32	692	342.72	0.31	754	361.77	0.31	816	380.37	0.30
507	283.25	0.33	569	303.63	0.33	631	323.56	0.32	693	343.03	0.31	755	362.07	0.30	817	380.66	0.29
508	283.59	0.34	570	303.95	0.32	632	323.87	0.31	694	343.34	0.31	756	362.37	0.30	818	380.96	0.30
509	283.92	0.33	571	304.28	0.33	633	324.19	0.32	695	343.66	0.32	757	362.68	0.31	819	381.25	0.29
510	284.25	0.33	572	304.60	0.32	634	324.51	0.32	696	343.97	0.31	758	362.98	0.30	820	381.55	0.30
511	284.58	0.33	573	304.93	0.33	635	324.83	0.32	697	344.28	0.31	759	363.29	0.31	821	381.85	0.30
512	284.91	0.33	574	305.25	0.32	636	325.14	0.31	698	344.59	0.31	760	363.59	0.30	822	382.14	0.29
513	285.25	0.34	575	305.58	0.33	637	325.46	0.32	699	344.90	0.31	761	363.89	0.30	823	382.44	0.30
514	285.58	0.33	576	305.90	0.32	638	325.78	0.32	700	345.21	0.31	762	364.19	0.30	824	382.73	0.29
515	285.91	0.33	577	306.23	0.33	639	326.09	0.31	701	345.52	0.31	763	364.50	0.31	825	383.03	0.30
516	286.24	0.33	578	306.55	0.32	640	326.41	0.32	702	345.83	0.31	764	364.80	0.30	826	383.32	0.29
517	286.57	0.33	579	306.88	0.33	641	326.73	0.32	703	346.14	0.31	765	365.10	0.30	827	383.62	0.30
518	286.91	0.34	580	307.20	0.32	642	327.04	0.31	704	346.45	0.31	766	365.40	0.30	828	383.91	0.29
519	287.24	0.33	581	307.52	0.32	643	327.36	0.32	705	346.76	0.31	767	365.70	0.30	829	384.21	0.30
520	287.57	0.33	582	307.85	0.33	644	327.67	0.31	706	347.06	0.30	768	366.01	0.31	830	384.50	0.29
521	287.90	0.33	583	308.17	0.32	645	327.99	0.32	707	347.37	0.31	769	366.31	0.30	831	384.80	0.30
522	288.23	0.33	584	308.49	0.32	646	328.31	0.32	708	347.68	0.31	770	366.61	0.30	832	385.09	0.29
523	288.56	0.33	585	308.82	0.33	647	328.62	0.31	709	347.99	0.31	771	366.91	0.30	833	385.39	0.30
524	288.89	0.33	586	309.14	0.32	648	328.94	0.32	710	348.30	0.31	772	367.21	0.30	834	385.68	0.29
525	289.22	0.33	587	309.46	0.32	649	329.25	0.31	711	348.61	0.31	773	367.51	0.30	835	385.98	0.30
526	289.55	0.33	588	309.78	0.32	650	329.57	0.32	712	348.92	0.31	774	367.81	0.30	836	386.27	0.29
527	289.88	0.33	589	310.11	0.33	651	329.89	0.32	713	349.22	0.30	775	368.12	0.31	837	386.57	0.30
528	290.21	0.33	590	310.43	0.32	652	330.20	0.31	714	349.53	0.31	776	368.42	0.30	838	386.86	0.29
529	290.54	0.33	591	310.75	0.32	653	330.52	0.32	715	349.84	0.31	777	368.72	0.30	839	387.16	0.30
530	290.87	0.33	592	311.07	0.32	654	330.83	0.31	716	350.15	0.31	778	369.02	0.30	840	387.45	0.29
531	291.20	0.33	593	311.40	0.33	655	331.15	0.32	717	350.46	0.31	779	369.32	0.30	841	387.74	0.29
532	291.53	0.33	594	311.72	0.32	656	331.46	0.31	718	350.76	0.30	780	369.62	0.30	842	388.04	0.30
533	291.86	0.33	595	312.04	0.32	657	331.78	0.32	719	351.07	0.31	781	369.92	0.30	843	388.33	0.29
534	292.19	0.33	596	312.36	0.32	658	332.09	0.31	720	351.38	0.31	782	370.22	0.30	844	388.62	0.29
535	292.52	0.33	597	312.68	0.32	659	332.41	0.32	721	351.69	0.31	783	370.52	0.30	845	388.92	0.30
536	292.84	0.32	598	313.01	0.33	660	332.72	0.31	722	351.99	0.30	784	370.82	0.30	846	389.21	0.29
537	293.17	0.33	599	313.33	0.32	661	333.03	0.31	723	352.30	0.31	785	371.12	0.30	847	389.50	0.29
538	293.50	0.33	600	313.65	0.32	662	333.35	0.32	724	352.61	0.31	786	371.42	0.30	848	389.79	0.29
539	293.83	0.33	601	313.97	0.32	663	333.66	0.31	725	352.92	0.31	787	371.72	0.30	849	390.08	0.29
540	294.16	0.33	602	314.29	0.32	664	333.98	0.32	726	353.22	0.30	788	372.02	0.30	850	390.38	0.30
541	294.49	0.33	603	314.61	0.32	665	334.29	0.31	727	353.53	0.31	789	372.32	0.30			

Test Conductor Signature ______ Date ______

TABLE XVIII **Temperature Vs. Resistance Table**

For European Curve, Alpha = .00385 — 1° Celsius increments

°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.
-220	10.41		160	35.48	0.42	-100	60.20	0.41	-40	84.21	0.40	±0	100.00	0.39	+60	123.24	0.38
219	10.81	0.40	159	35.90	0.42	99	60.61	0.41	39	84.61	0.40	+1	100.39	0.39	61	123.62	0.38
218	11.20	0.39	158	36.31	0.41	98	61.01	0.40	38	85.00	0.39	2	100.78	0.39	62	124.01	0.39
217	11.60	0.40	157	36.73	0.42	97	61.42	0.41	37	85.40	0.40	3	101.17	0.39	63	124.39	0.38
216	11.99	0.39	156	37.15	0.42	96	61.82	0.40	36	85.79	0.39	4	101.56	0.39	64	124.77	0.38
215	12.39	0.40	155	37.57	0.42	95	62.23	0.41	35	86.19	0.40	5	101.95	0.39	65	125.16	0.39
214	12.78	0.39	154	37.98	0.41	94	62.63	0.40	34	86.59	0.40	6	102.34	0.39	66	125.54	0.38
213	13.18	0.40	153	38.40	0.42	93	63.04	0.41	33	86.98	0.39	7	102.73	0.39	67	125.92	0.38
212	13.57	0.39	152	38.82	0.42	92	63.44	0.40	32	87.38	0.40	8	103.12	0.39	68	126.30	0.38
211	13.97	0.40	151	39.23	0.41	91	63.85	0.41	31	87.77	0.39	9	103.51	0.39	69	126.69	0.39
210	14.36	0.39	150	39.65	0.42	90	64.25	0.40	30	88.17	0.40	10	103.90	0.39	70	127.07	0.38
209	14.78	0.42	149	40.07	0.42	89	64.65	0.40	29	88.57	0.40	11	104.29	0.39	71	127.45	0.38
208	15.19	0.41	148	40.48	0.41	88	65.06	0.41	28	88.96	0.39	12	104.68	0.39	72	127.83	0.38
207	15.61	0.42	147	40.90	0.42	87	65.46	0.40	27	89.36	0.40	13	105.07	0.39	73	128.22	0.39
206	16.03	0.42	146	41.31	0.41	86	65.86	0.40	26	89.75	0.39	14	105.46	0.39	74	128.60	0.38
205	16.45	0.42	145	41.73	0.42	85	66.27	0.41	25	90.15	0.40	15	105.85	0.39	75	128.98	0.38
204	16.86	0.41	144	42.14	0.41	84	66.67	0.40	24	90.55	0.40	16	106.23	0.38	76	129.36	0.38
203	17.28	0.42	143	42.56	0.42	83	67.07	0.40	23	90.94	0.39	17	106.62	0.39	77	129.74	0.38
202	17.70	0.42	142	42.97	0.41	82	67.47	0.40	22	91.34	0.40	18	107.01	0.39	78	130.13	0.39
201	18.11	0.41	141	43.39	0.42	81	67.88	0.41	21	91.73	0.39	19	107.40	0.39	79	130.51	0.38
200	18.53	0.42	140	43.80	0.41	80	68.28	0.40	20	92.13	0.40	20	107.79	0.39	80	130.89	0.38
199	18.96	0.43	139	44.21	0.41	79	68.68	0.40	19	92.52	0.39	21	108.18	0.39	81	131.27	0.38
198	19.38	0.42	138	44.63	0.42	78	69.08	0.40	18	92.92	0.40	22	108.57	0.39	82	131.65	0.38
197	19.81	0.43	137	45.04	0.41	77	69.48	0.40	17	93.31	0.39	23	108.95	0.38	83	132.03	0.38
196	20.23	0.42	136	45.45	0.41	76	69.88	0.40	16	93.71	0.40	24	109.34	0.39	84	132.41	0.38
195	20.66	0.43	135	45.87	0.42	75	70.29	0.41	15	94.10	0.39	25	109.73	0.39	85	132.80	0.39
194	21.08	0.42	134	46.28	0.41	74	70.69	0.40	14	94.49	0.39	26	110.12	0.39	86	133.18	0.38
193	21.51	0.43	133	46.69	0.41	73	71.09	0.40	13	94.89	0.40	27	110.51	0.39	87	133.56	0.38
192	21.93	0.42	132	47.10	0.41	72	71.49	0.40	12	95.28	0.39	28	110.89	0.38	88	133.94	0.38
191	22.36	0.43	131	47.52	0.42	71	71.89	0.40	11	95.68	0.40	29	111.28	0.39	89	134.32	0.38
190	22.78	0.42	130	47.93	0.41	70	72.29	0.40	10	96.07	0.39	30	111.67	0.39	90	134.70	0.38
189	23.21	0.43	129	48.34	0.41	69	72.69	0.40	9	96.46	0.39	31	112.06	0.39	91	135.08	0.38
188	23.63	0.42	128	48.75	0.41	68	73.09	0.40	8	96.86	0.40	32	112.44	0.38	92	135.46	0.38
187	24.06	0.43	127	49.16	0.41	67	73.49	0.40	7	97.25	0.39	33	112.83	0.39	93	135.84	0.38
186	24.49	0.43	126	49.57	0.41	66	73.89	0.40	6	97.64	0.39	34	113.22	0.39	94	136.22	0.38
185	24.92	0.43	125	49.99	0.42	65	74.29	0.40	5	98.04	0.40	35	113.61	0.39	95	136.60	0.38
184	25.34	0.42	124	50.40	0.41	64	74.68	0.39	4	98.43	0.39	36	113.99	0.38	96	136.98	0.38
183	25.77	0.43	123	50.81	0.41	63	75.08	0.40	3	98.82	0.39	37	114.38	0.39	97	137.36	0.38
182	26.20	0.43	122	51.22	0.41	62	75.48	0.40	2	99.21	0.39	38	114.77	0.39	98	137.74	0.38
181	26.62	0.42	121	51.63	0.41	61	75.88	0.40	1	99.61	0.40	39	115.15	0.38	99	138.12	0.38
180	27.05	0.43	120	52.04	0.41	60	76.28	0.40				40	115.54	0.39	100	138.50	0.38
179	27.47	0.42	119	52.45	0.41	59	76.68	0.40				41	115.93	0.39	101	138.88	0.38
178	27.90	0.43	118	52.86	0.41	58	77.07	0.39				42	116.31	0.38	102	139.26	0.38
177	28.32	0.42	117	53.27	0.41	57	77.47	0.40				43	116.70	0.39	103	139.63	0.37
176	28.74	0.42	116	53.68	0.41	56	77.87	0.40				44	117.08	0.38	104	140.01	0.38
175	29.17	0.43	115	54.09	0.41	55	78.27	0.40				45	117.47	0.39	105	140.39	0.38
174	29.59	0.42	114	54.49	0.40	54	78.66	0.39				46	117.86	0.39	106	140.77	0.38
173	30.01	0.42	113	54.90	0.41	53	79.06	0.40				47	118.24	0.38	107	141.15	0.38
172	30.43	0.42	112	55.31	0.41	52	79.46	0.40				48	118.63	0.39	108	141.52	0.37
171	30.86	0.43	111	55.72	0.41	51	79.85	0.39				49	119.01	0.38	109	141.90	0.38
170	31.28	0.42	110	56.13	0.41	50	80.25	0.40				50	119.40	0.39	110	142.28	0.38
169	31.70	0.42	109	56.54	0.41	49	80.65	0.40				51	119.78	0.38	111	142.66	.038
168	32.12	0.42	108	56.94	0.40	48	81.04	0.39				52	120.17	0.39	112	143.04	0.38
167	32.54	0.42	107	57.35	0.41	47	81.44	0.40				53	120.55	0.38	113	143.41	0.37
166	32.96	0.42	106	57.76	0.41	46	81.83	0.39				54	120.94	0.39	114	143.79	0.38
165	33.38	0.42	105	58.17	0.41	45	82.23	0.40				55	121.32	0.38	115	144.17	0.38
164	33.80	0.42	104	58.57	0.40	44	82.63	0.40				56	121.70	0.38	116	144.55	0.38
163	34.22	0.42	103	58.98	0.41	43	83.02	0.39				57	122.09	0.39	117	144.93	0.38
162	34.64	0.42	102	59.39	0.41	42	83.42	0.40				58	122.47	0.38	118	145.30	0.37
161	35.06	0.42	101	59.79	0.40	41	83.81	0.39				59	122.86	0.39	119	145.68	0.38

Test Conductor Signature ____________ Date ______

TABLE XVIII Temperature Vs. Resistance Table

For European Curve, Alpha = .00385 — 1° Celsius Increments

°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.	°C	Ohm	Diff.
→120	146.06	0.38	→180	168.47	0.37	→240	190.46	0.36	→300	212.03	0.36	→360	233.19	0.35	→420	253.93	0.34
121	146.44	0.38	181	168.84	0.37	241	190.82	0.36	301	212.39	0.36	361	233.54	0.35	421	254.27	0.34
122	146.81	0.37	182	169.21	0.37	242	191.18	0.36	302	212.74	0.35	362	233.89	0.35	422	254.61	0.34
123	147.19	0.38	183	169.58	0.37	243	191.55	0.37	303	213.10	0.36	363	234.23	0.34	423	254.95	0.34
124	147.56	0.37	184	169.95	0.37	244	191.91	0.36	304	213.45	0.35	364	234.58	0.35	424	255.29	0.34
125	147.94	0.38	185	170.32	0.37	245	192.27	0.36	305	213.81	0.36	365	234.93	0.35	425	255.64	0.35
126	148.32	0.38	186	170.68	0.36	246	192.63	0.36	306	214.16	0.35	366	235.28	0.35	426	255.98	0.34
127	148.69	0.37	187	171.05	0.37	247	192.99	0.36	307	214.52	0.36	367	235.63	0.35	427	256.32	0.34
128	149.07	0.38	188	171.42	0.37	248	193.36	0.37	308	214.87	0.35	368	235.97	0.34	428	256.66	0.34
129	149.44	0.37	189	171.79	0.37	249	193.72	0.36	309	215.23	0.36	369	236.32	0.35	429	257.00	0.34
130	149.82	0.38	190	172.16	0.37	250	194.08	0.36	310	215.58	0.35	370	236.67	0.35	430	257.34	0.34
131	150.20	0.38	191	172.53	0.37	251	194.44	0.36	311	215.94	0.36	371	237.02	0.35	431	257.68	0.34
132	150.57	0.37	192	172.90	0.37	252	194.80	0.36	312	216.29	0.35	372	237.37	0.35	432	258.02	0.34
133	150.95	0.38	193	173.27	0.36	253	195.17	0.37	313	216.65	0.36	373	237.71	0.34	433	258.36	0.34
134	151.32	0.37	194	173.63	0.37	254	195.53	0.36	314	217.00	0.35	374	238.06	0.35	434	258.70	0.34
135	151.70	0.38	195	174.00	0.37	255	195.89	0.36	315	217.36	0.36	375	238.41	0.35	435	259.05	0.35
136	152.07	0.37	196	174.37	0.37	256	196.25	0.36	316	217.71	0.35	376	238.76	0.35	436	259.39	0.34
137	152.45	0.38	197	174.74	0.37	257	196.61	0.36	317	218.07	0.36	377	239.11	0.35	437	259.73	0.34
138	152.82	0.37	198	175.10	0.36	258	196.98	0.37	318	218.42	0.35	378	239.45	0.34	438	260.07	0.34
139	153.20	0.38	199	175.47	0.37	259	197.34	0.36	319	218.78	0.36	379	239.80	0.35	439	260.41	0.34
140	153.57	0.37	200	175.84	0.37	260	197.70	0.36	320	219.13	0.35	380	240.15	0.35	440	260.75	0.34
141	153.95	0.38	201	176.21	0.37	261	198.06	0.36	321	219.48	0.35	381	240.50	0.35	441	261.09	0.34
142	154.32	0.37	202	176.57	0.36	262	198.42	0.36	322	219.84	0.36	382	240.84	0.34	442	261.43	0.34
143	154.70	0.38	203	176.94	0.37	263	198.78	0.36	323	220.19	0.35	383	241.19	0.35	443	261.77	0.34
144	155.07	0.37	204	177.31	0.37	264	199.14	0.36	324	220.54	0.35	384	241.53	0.34	444	262.11	0.34
145	155.45	0.38	205	177.68	0.37	265	199.50	0.36	325	220.90	0.36	385	241.88	0.35	445	262.45	0.34
146	155.82	0.37	206	178.04	0.36	266	199.86	0.36	326	221.25	0.35	386	242.23	0.35	446	262.78	0.33
147	156.20	0.38	207	178.41	0.37	267	200.22	0.36	327	221.60	0.35	387	242.57	0.34	447	263.12	0.34
148	156.57	0.37	208	178.78	0.37	268	200.58	0.36	328	221.95	0.35	388	242.92	0.35	448	263.46	0.34
149	156.95	0.38	209	179.14	0.36	269	200.94	0.36	329	222.31	0.36	389	243.26	0.34	449	263.80	0.34
150	157.32	0.37	210	179.51	0.37	270	201.30	0.36	330	222.66	0.35	390	243.61	0.35	450	264.14	0.34
151	157.69	0.37	211	179.88	0.37	271	201.66	0.36	331	223.01	0.35	391	243.96	0.35	451	264.48	0.34
152	158.07	0.38	212	180.24	0.36	272	202.02	0.36	332	223.36	0.35	392	244.30	0.34	452	264.82	0.34
153	158.44	0.37	213	180.61	0.37	273	202.37	0.35	333	223.72	0.36	393	244.65	0.35	453	265.15	0.33
154	158.81	0.37	214	180.97	0.36	274	202.73	0.36	334	224.07	0.35	394	244.99	0.34	454	265.49	0.34
155	159.19	0.38	215	181.34	0.37	275	203.09	0.36	335	224.24	0.35	395	245.34	0.35	455	265.83	0.34
156	159.56	0.37	216	181.71	0.37	276	203.45	0.36	336	224.77	0.35	396	245.68	0.34	456	266.17	0.34
157	159.93	0.37	217	182.07	0.36	277	203.81	0.36	337	225.12	0.35	397	246.03	0.35	457	266.51	0.34
158	160.30	0.37	218	182.44	0.37	278	204.16	0.35	338	225.48	0.36	398	246.37	0.34	458	266.84	0.33
159	160.68	0.38	219	182.80	0.36	279	204.52	0.36	339	225.83	0.35	399	246.72	0.35	459	267.18	0.34
160	161.05	0.37	220	183.17	0.37	280	204.88	0.36	340	226.18	0.35	400	247.06	0.34	490	267.52	0.34
161	161.42	0.37	221	183.54	0.37	281	205.24	0.36	341	226.53	0.35	401	247.40	0.34	461	267.86	0.34
162	161.79	0.37	222	183.90	0.36	282	205.60	0.36	342	226.88	0.35	402	247.75	0.35	462	268.19	0.33
163	162.16	0.37	223	184.27	0.37	283	205.95	0.35	343	227.23	0.35	403	248.09	0.34	463	268.53	0.34
164	162.53	0.37	224	184.63	0.36	284	206.31	0.36	344	227.58	0.35	404	248.44	0.35	464	268.87	0.34
165	162.91	0.38	225	185.00	0.37	285	206.67	0.36	345	227.94	0.36	405	248.78	0.34	465	269.21	0.34
166	163.28	0.37	226	185.36	0.36	286	207.03	0.36	346	228.29	0.35	406	249.12	0.34	466	269.54	0.33
167	163.65	0.37	227	185.73	0.37	287	207.39	0.36	347	228.64	0.35	407	249.47	0.35	467	269.88	0.34
168	164.02	0.37	228	186.09	0.36	288	207.74	0.35	348	228.99	0.35	408	249.81	0.34	468	270.22	0.34
169	164.39	0.37	229	186.46	0.37	289	208.10	0.36	349	229.34	0.35	409	250.16	0.35	469	270.55	0.33
170	164.76	0.37	230	186.82	0.36	290	208.46	0.36	350	229.69	0.35	410	250.50	0.34	470	270.89	0.34
171	165.13	0.37	231	187.18	0.36	291	208.82	0.36	351	230.04	0.35	411	250.84	0.34	471	271.23	0.34
172	165.50	0.37	232	187.55	0.37	292	209.17	0.35	352	230.39	0.35	412	251.19	0.35	472	271.56	0.33
173	165.87	0.37	233	187.91	0.36	293	209.53	0.36	353	230.74	0.35	413	251.53	0.34	473	271.90	0.34
174	166.24	0.37	234	188.28	0.37	294	209.89	0.36	354	231.09	0.35	414	251.87	0.34	474	272.23	0.33
175	166.62	0.38	235	188.64	0.36	295	210.25	0.36	355	231.44	0.35	415	252.22	0.35	475	272.57	0.34
176	166.99	0.37	236	189.00	0.36	296	210.60	0.35	356	231.79	0.35	416	252.56	0.34	476	272.91	0.34
177	167.36	0.37	237	189.37	0.37	297	210.96	0.36	357	232.14	0.35	417	252.90	0.34	477	273.24	0.33
178	167.73	0.37	238	189.73	0.36	298	211.32	0.36	358	232.49	0.35	418	253.24	0.34	478	273.58	0.34
179	168.10	0.37	239	[illegible].10	0.37	299	211.67	0.35	359	232.84	0.35	419	253.59	0.35	479	273.91	0.33

Test Conductor Signature ________________ Date ________

6.0 TEST CONDUCTOR'S REPORT

6.1 Were any procedure changes or deviations made to the test and DCCF/PDR initiated? (Attach copies if applicable)
Yes____ No____

6.2 Were all steps successfully completed as stated in test?
Yes____ No____

6.3 If the answer to 6.2 is NO, notify Department Supervisor and list conditions and/or PTR number(s):

____

6.4 Test completed except for items noted in 6.3

______________________ ______________________
Test Conductor Date

6.5 Test sheets and data sheets reviewed and approved except for items noted in 6.3

______________________ ______________________
Department Representative Date

7.0 DEPARTMENT SUPERVISOR'S/TEST CONDUCTOR'S REVIEW
(If the answer to 6.2 is YES, sections 7.0 and 8.0 are not applicable go to Section 9.0)

7.1 Does the failure described in 6.3 require any action or impose any limit to operation per the applicable LCO(s)?
Yes____ No____ N/A____

7.2 Applicable LCO(s)______________________________

Action or Limit______________________________

7.3 Is the reason test is not being completed at this time due to plant or equipment status?
Yes____ No____ N/A____

7.4 If the answer to 7.3 is YES, list condition(s) and/or PTR number(s):

____

7.5 Is retest necessary for items listed in 6.3 and/or 7.4?
Yes____ No____ N/A____

7.6 If the answer to 7.5 is YES; list specific section(s) or step(s) to be retested.

____

Dept. Supervisor/Test Conductor — Date

8.0 RETEST SECTION
(If the answer to 7.5 is NO go to Section 9.0)

8.1 Verify satisfactory retest of section(s) or step(s) listed in 7.6

Retest Conductor — Date

8.2 Retest reviewed.

Department Representative — Date

9.0 APPROVALS

9.1 Test results approved. Satisfactory results confirm compliance with applicable LCO(s).

Department Supervisor — Date

9.2 Notification of satisfactory test results and test conclusion:

Shift Supervisor — Date

9.3 Requires Station Manager evaluation:

Department Supervisor — Date

9.4 Station Manager — Date

10.0 DATA SHEETS RECEIVED, VERIFIED SECTION 9.0 COMPLETE, AND SURVEILLANCE TEST RECORDS UPDATED.

Scheduling Technician — Date