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

EE-12-0013-REV. B

INTEGRATED SYSTEMS STUDY OF THE CONTROL ROD DRIVE MECHANISM ROD POSITION INSTRUMENTATION

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FORT ST. VRAIN NUCLEAR GENERATING STATION

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CHECK LIST OF DESIGN VERIFICATION QUESTIONS FOR DESIGN REVIEW METHOD

~~CN~~ EE-12-0013 Rev 1

BY L. Marquez

PAGE ______

YES	NO	N/A		
☑	☐	☐	1.	Were the inputs correctly selected and incorporated into design?
☑	☐	☐	2.	Are assumptions necessary to perform the design activity adequately described and reasonable? Where necessary, are the assumptions identified for subsequent re-verifications when the detailed design activities are completed?
☑	☐	☐	3.	Are the appropriate quality and quality assurance requirements specified?
☑	☐	☐	4.	Are the applicable codes, standards and regulatory requirements including issue and addenda properly identified and are their requirements for design met?
☑	☐	☐	5.	Have applicable construction and operating experience been considered?
☐	☐	☑	6.	Have the design interface requirements been satisfied?
☑	☐	☐	7.	Was an appropriate design method used?
☑	☐	☐	8.	Is the output reasonable compared to inputs?
☑	☐	☐	9.	Are the specified parts, equipment, and processes suitable for the required application? only prototypes have been purchased.
☑	☐	☐	10.	Are the specified materials compatible with each other and the design environmental conditions to which the material will be exposed?
☑	☐	☐	11.	Have adequate maintenance features and requirements been specified?
☐	☐	☑	12.	Are accessibility and other design provisions adequate for performance of needed maintenance and repair?
☐	☐	☑	13.	Has adequate accessibility been provided to perform the in-service inspection expected to be required during the plant life?
☐	☐	☑	14.	Has the design properly considered radiation exposure to the public and plant personnel?
☐	☐	☑	15.	Are the acceptance criteria incorporated in the design documents sufficient to allow verification that design requirements have been satisfactorily accomplished?
☑	☐	☐	16.	Have adequate pre-operational and subsequent periodic test requirements been appropriately specified? Prototypes available for testing.
☐	☐	☑	17.	Are adequate handling, storage, cleaning and shipping requirements specified? Not required for prototypes.
☐	☐	☑	18.	Are adequate identification requirements specified?
☑	☐	☐	19.	Are requirements for record preparation review, approval, retention, etc., adequately specified?

NOTE: If the answer to any question is no, provide additional information and resolution below.

RESOLUTION OF DESIGN DEFICIENCIES UNCOVERED DURING THE DESIGN VERIFICATION PROCESS

NDG-88-0208 was added to Appendix H to address concern that Radiation requirement was missing from purchasing specification.

No deficiencies.

Lori K. Marquez
4/6/88

Form (A) 344-22-4086

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1.0 PURPOSE

The Engineering Evaluation (EE) is an integrated system study of the Fort St. Vrain (FSV) Control Rod Position Indication (RPI) system. This study was identified as a long term action item in "Preliminary Report Related To the Restart and Continued Operation of Fort St. Vrain Nuclear Generating Station" dated October 1984 (reference 1). The RPI instrumentation, actuation, indication and associated passive components were evaluated, while addressing all known concerns.

This EE will serve as an input to the Control Rod Drive mechanism temperature requalification plan, the design basis documentation and several FSV action requests.

2.0 SUMMARY

This EE determined that long term upgrades to the RPI system are desirable. Recommendations for improvements may be found in the conclusions section. This study shows the effectiveness of the administrative limits to prevent overdriving the rod pairs. In fact, it is significant to note that subsequent to the establishment of the administrative limits and replacement of the RPI components during 1985, no failures of the RPI instrumentation have occurred. This is believed to be due to improved operator training, replacement with new components, understanding the failure modes and the basic ruggedness of the components. It is anticipated that the components will eventually wear to the point of needing replacement or they may be replaced as a function of planned maintenance. The proposed replacement components will not have the problems associated with mechanical operation. The proposed sensors are non-contact and the potentiometer is designed to operate under postulated abnormal conditions well beyond those required.

3.0 SCOPE

This EE is an evaluation of all RPI components including: instrumentation, ancillary equipment, indication methods and associated passive components. All components and circuits are non-safety related. Each item will be evaluated individually, except where reasons exist to allow typical analysis. The following is a list of all items reviewed, along with a brief description.

3.1 The instrumentation evaluated included (reference Appendix A, sketches 1, 2 and 3):

3.1.1 Position transmitter: potentiometer, *dual gang, 10 turn, 1000 ohm, 1 each per rod pair

3.1.2 Full-in/full-out position: switch, limit, double throw, single pole, 28vdc, 10A, 2 pairs of 2 each per rod pair

3.1.3 Slack cable condition: switch, limit, double throw, single pole, 28vdc, 10A, 2 each per rod pair

3.1.4 Full retract position: switch, limit, double throw, single pole, 28vdc, 10A, 1 each per rod cable, (2 cables per rod pair)

*Two electrically independent potentiometers on a common shaft

3.2 Ancillary equipment evaluated included (reference Appendix A, sketches 4, 1 and 2):

3.2.1 Drive shaft (potentiometer shaft): drives potentiometer directly and cam drum indirectly, 1 each per rod pair

3.2.2 Cam drum: moves cams relative to the full-in/full-out limit switches, 1 each per rod pair

3.2.3 Cams: actuate full-in/full-out limit switches, 2 pairs of 2 each per rod pair

3.2.4 Calibrated counter balancing springs: actuate slack cable switches upon loss of weight of control rod on springs

3.3 Indication methods evaluated included:

3.3.1 Full-in, full-out and slack cable limit lights; color coded, powered thru contact on relays (wired fail safe), 1 each per condition per rod pair

3.3.2 Position indicator; analog, voltage based, indication per position transmitter current output (part 1), 1 each per rod pair

3.3.3 Position indicator; digital, voltage based, indication per position transmitter current output (part 2), 1 set (selectable by rod group)

3.3.4 Relays; energized thru limit switches, provide power thru contact to indicating lights, 1 each per condition per rod pair

3.4 Associated passive components evaluated included:

3.4.1 Power supply: voltage, for limit switch circuits, 24vdc, 1 each

3.4.2 Power supply: current, for all position transmitters, 1 each

3.4.3 Cables, connectors, terminal lugs, terminal blocks, solder connections; as required

3.4.4 Surge protectors: intended to short high inductances caused by relay de-energization to negative side of power supply instead of allowing it thru switch contacts, 1 per relay

4.0 APPROACH

The following is the methodology used in the evaluation of RPI. Each component is evaluated separately unless multiple components and their actuation mechanisms are sufficiently similar to allow typical analysis. In such cases, the basis for similarity will be established within the evaluation.

The general evaluation included:

4.1 Review existing data

4.1.1 Review reference 1 and 2 to determine NRC concerns

4.1.2 Review available design and maintenance documentation

4.1.3 Interview knowledgeable personnel

4.2 Gather new data

4.2.1 Disassemble components and make observations regarding the nature of failures (if any are known), types of damage and other pertinent information for future evaluation

4.2.2 Photograph components for future evaluation (Reference Appendix B) for excerpts of photos

The component specific evaluation included:

4.3 Develop each component's Failure Modes and Effects Analysis (FMEA)

4.3.1 Based on data obtained in 4.2 develop a conceptual FMEA for each component

4.3.2 Consider all data obtained in 4.1 and modify conceptual FMEA as required

4.3.3 Review materials and methods of manufacture of each component and modify conceptual FMEA as required.

4.3.4 Consult appropriate manufacturer's engineering and analytical organizations for evaluation of conceptual FMEA and concurrence (or rejection) of modes and credible causes of failure

4.3.5 Prepare final FMEA

4.4 Identify any component or system weaknesses

4.4.1 Based on FMEA, determine what impact any weakness has on component operation, reliability and mechanisms for failure

4.5 Evaluate operability of components

4.5.1 Based on FMEA, determine level of component operability and reliability

4.6 Evaluate causes of failure

4.6.1 Based on FMEA, determine causes of failure

4.7 Evaluate operational adequacy of the existing system

4.8 Propose interim solutions

4.8.1 Based on causes of failure, propose interim solutions to limit failures by removing as many causes of failure as possible

5.0 EVALUATION

This evaluation is based on the following inputs:

a. The scope of the evaluation is presented in section 3.0 of this study. Exceptions within the specified scope are documented and justified as appropriate.

b. The approach of the evaluation is presented in section 4.0 of this study. Each component or assembly is evaluated on a case by case basis. Failure mode and effect analyses will be presented within the body of the study with references to appendices which contain the technical analysis including the failure tree analysis. An occasional reference by the reader to the appendices containing sketches (A) and photographs (B) will provide additional insight into the assembly or component being discussed.

5.1 A review of existing NRC documentation provides many questions, concerns and an occasional misconception. Table 5.1 will provide a source reference, a basic issue of concern to PSC (from NRC documentation) and a reference to a section of this study. This table should provide the reader immediate access to any specific area of interest.

TABLE 5.1

Reference	Page/Para/Line	Issue	RPI*
G-84392-REF1 (Appendix L)	P3-3,p4,L12	failure mode of pot shaft	C,E
same	P3-3,p4,L14	cam over rotation	C,E
same	P3-3,p4,L16	pot failure modes	E
same	P3-3,p4,L24	single point failure	5.2.6
same	P3-4,p3,L1	circuit redundancy	5.2.5
same	P3-4,p3,L5	single failure undetected	5.2.5
same	P3-6, sect. 3.4	failure modes defined	5.2 E,F,G
same	P3-7,p7,L1	preclude overtravel damage	C,D
same	P3-8,p2	integrated system study	1.0
same	P3-9,table 3.1	anomalies	D
G-87267-REF2 (Appendix M)	P3,p2 and 3	criteria not applicable	3.0p1
same	P4,p3,L1	failure mode of switches	5.2.1 F
same	P4,p3,L6	moisture causes pitting	5.2.1 F
same	P5,p1,L1	corrosion not studied	F
same	P5,p2,L5	design environment	H
same	P5,p3,L3	important to safety	3.0p1
same	P5,p3,L3	design criteria 1 and 13	3.0p1
same	P5,p4,L1	cam damages pot shaft	C
same	P5,p4,L9	pot replacement necessary	C
same	P6,p3,L2	slack cable anomaly	5.2.2
same	P8,p4,L1	maintenance	I
same	P9,p3,L1	inadequate eval of failure	5.2,A BDEFG

*Numbers represent sections of this report.
Letters represent appendices.

5.2 Evaluation Existing RPI

5.2.1 Evaluation of Full-In/Full-out Limit Switches

The evaluation began by researching the application of the limit switches that provide the indicating signals for full-in or full-out position of each rod pair. These limit switches are evaluated simultaneously since the switches, actuation methods and circuitry are identical. The problem identified was binding of the switches. This results in the full-in or full-out indication remaining energized after the rod pair is moved away from the corresponding position. Disassembly of the switches revealed pitting and gouging of the switch shaft and the deposition of the gouged materials onto the switch shaft housing. Further investigation into the cause of the failure revealed the exertion of excessive lateral forces onto the switch shaft by the actuating cam. This was verified by inspection of the disassembled switch, as the degradation occurs primarily on the side of the switch shaft opposite the cam approach. The manufacturer's review of the application confirmed this evaluation. Additionally, the switch manufacturer indicated the balance of the switch to be "in quite satisfactory condition". The manufacturer took specific interest in the condition of the electrical contacts which were found to be in good condition. The technical presentation of the failure modes and effects analysis including the failure analysis tree is presented in Appendix F.

5.2.2 Slack Cable Limit Switches

The slack cable limit switches provide the indicating signals for the control rod pair in the event of a broken cable or a damaged control rod. The principle of operation is very simple. When the rods are suspended by the drive mechanism the limit switch is actuated, resulting in no indication to the control room. In the event of a broken cable or other failure in which weight is removed from the drive, a precision calibrated spring provides a force on the actuating plate. This action results in the change of state in the switch and thus indication in the control room. Contrary to Table 3.1 of reference 1, there has never been a known failure of the slack cable limit switches. The case cited in reference 1 (Table 3.1) was a realistic case of slack cable indication as the cable had broken. The manufacturer's review indicated proper application of the switch. The technical presentation of the failure modes and effects analysis including the failure analysis tree is presented in Appendix G.

5.2.3 Rod Retracted Limit Switch

This switch is not evaluated in this study as it is not a part of the normal control scheme. Instead, it is a maintenance feature to indicate when the rod is properly withdrawn for extraction of the drive assembly from the core. The failure modes for these components are comparable to the full-in/full-out limit switches, however, they have no impact on reactor operation. Therefore, no specific analysis exists. These switches are typically replaced on the same schedule as the full-in/full-out and slack cable switches.

5.2.4 Position Transmitters

The position potentiometers provide two independent and continuous signals for indication of control rod position. Each of the position transmitters completes a current loop from which a voltage drop provides indication on both digital and analog meters. Each section of the potentiometer is evaluated as a separate component as appropriate. Any single failure which presents a dual impact is identified as such. The most common failure mode is breakage of the potentiometer body, coupling or wiper due to overdriving. A secondary possible failure mode is galvanic action. While discoloration (darkening) of the resistive element has been observed, no confirmed account of copper oxide production exists. The technical presentation of the failure modes and effects analysis including the failure analysis tree is presented in Appendix E.

5.2.5 Indicating Methods

The methods utilized to indicate rod position in the control room were reviewed. They include: (1) 37 sets of full-in, full-out and slack cable indicating lights (2) 37 analog gauges for position indication and (3) a series of selectable digital meters for redundant position indication. The indicating lights are low voltage incandescent units wired to energize when the condition is to be indicated. The analog and digital gauges are voltmeters scaled to indicate position. All position indication methods (continuous) use a constant current source to provide a varying voltage dependent on potentiometer resistance which varies with rod position. All limit switches, potentiometers and rod position indicators are redundant. However, one indicating light is provided per pair of limit switches and are therefore not redundant, but are tested at regular intervals. No concerns were identified relative to indication.

5.2.6 Integrated Component/System Review

The movement of the control rod pair (by its drive motor in the inward and outward direction normally or by gravity with capacitive motor speed control during scram) is by a cable connected to a rotating drum. As the drum rotates, the rod pair is moved. This drum, through gearing, is coupled to a shaft which drives a cam wheel for full-in/full-out switch actuation and to a potentiometer for position indication. This common shaft is a single failure point. A review of failures indicates that prior to administrative limits (see note 1) being established, this common shaft in a few instances has sheared resulting in loss of both limit switch and continuous RPI indication. However, subsequent to the establishment of administrative limits, no known failure has occurred.

Note 1: Administrative control has been established in P-85242, 7-10-85 (interim rod indication technical specification) and G-85294, 7-23-85 (supplemental safety evaluation); incorporated into plant procedure SOP-12-01.

The full-in/full-out limit switch failures prior to 1985 refurbishment (Ref. Appendix J) appear to be from excessive operations and wear (from the testing phase). Further, there exists some probability of operator error during June 1984 due to surveillance "testing" of the rods for "full-in" position. Several full-in switches were known to have failed completely, along with others failing intermittently. As a result, the operators (prior to improved training) were likely to attempt to "overdrive" the rods, as observed by the NRC during their June 1984 visit. This doubtlessly contributed to the number of potentiometer failures during this period.

An overall failure rate of .005 (Ref. Appendix J) shows operability of the existing system. This does not influence PSCo's desire to upgrade limit switch and continuous RPI design for improved maintainability and reliability.

6.0 CONCLUSIONS

6.1 General

6.1.1 Limit Switches

A review of the failures occurring after FSV began commercial operation (Appendix J) indicates operability of the existing system. However, based on the FMEA and operational experience, mechanical operation of the components for an extended time period may result in their failure. In the case of the full-in/out switches, actuation of the limit switch plungers by cams results in mechanical wear of the switch shafts. One solution to this problem would be to replace the existing cams with cams having a less severe slope. This would result in improved reliability, but leaves the root cause of failure unchanged (mechanical operation). An improved design would use a sensor that has no moving parts. Such a design in its conceptual stage including FMEA is shown in Appendix K.

6.1.2 Continuous Position Indication

For the potentiometers, an increase in the number of turns (mechanical) will eliminate the concerns associated with "yo-yoing". Furthermore, if an operator was to overdrive the rods in error, the new component will not fail at the point where the existing component does. Improvements in the areas of materials will eliminate all other possible failure modes. This design, including FMEA, is shown in Appendix K.

Both the sensors and potentiometers have been prototyped and are available for testing.

6.2 Specific

6.2.1 Potentiometers

6.2.1.1 Potentiometers can be broken by overdriving (operator error) or by yo-yoing (mechanical rebounding of the rods as they reach the end of travel). This has been observed prior to and after FSV went into commercial operation. The existing administrative limits (Ref. SOP 12-01) do not allow "overdriving". This has resulted in zero failures subsequent to the 1985 refurbishment. To upgrade the potentiometers to the proposed design can only improve their reliability.

6.2.2 Full-in/out Limit Switches

6.2.2.1 The proposed replacement sensors will provide a virtually maintenance free RPI system. These non-contact sensors are capable of function in temperatures up to approximately 500 degrees Fahrenheit at which point the solder connections melt. This limiting factor will not be of concern as the maximum application temperature is approximately 300 degrees Fahrenheit.

6.2.3 Slack Cable Switches

6.2.3.1 No failure modes are known to exist. The manufacturer's review indicates this to be a proper application of the switch.

6.2.4 System

6.2.4.1 The existing RPI system is operational, within Technical Specifications limits, and has operated without failure subsequent to the 1985 refurbishment. During the 1985 refurbishment, all limit switches and potentiometers were replaced. After 4.5 million plus hours of availability (Ref. App. J), this system is concluded to be acceptable for continued operation. However, for improved maintainability, it is desirable to proceed with component upgrades consistent with the overall CRDM temperature requalification plan and the CRDM maintenance schedule.

TABLE 6.1

Summary of Component Disposition

Full-In Limit Switches	Recommend replacement with non-contact sensors
Full-Out Limit Switches	Recommend replacement with non-contact sensors
Slack Cable Limit Switches	Leave As-Is; No credible failure modes
Full Retract Limit Switch	Leave As-Is; Not part of control circuitry
Position Potentiometer	Recommend replacement with a unit having more turns and improved design

7.0 REFERENCES

7.1 Reference 1

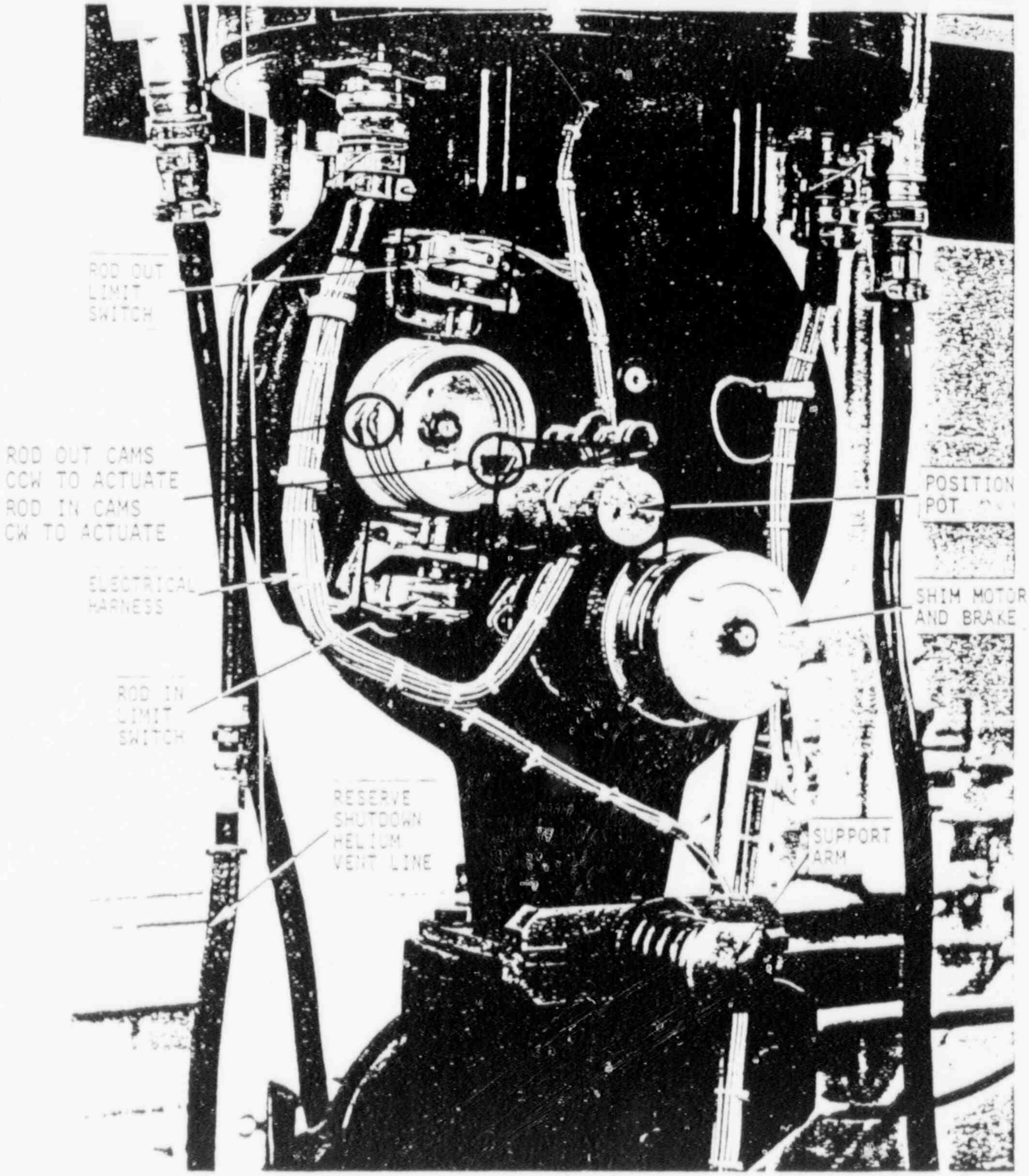
Letter, Denton to Walker
Dated October 16, 1984
and enclosure titled
"Preliminary Report Related to the Restart and Continued Operation of Fort St. Vrain Nuclear Generating Station"

7.2 Reference 2

Letter, Heitner to Williams
Dated July 31, 1987
and enclosure titled
"Evaluation of Integrated Systems Study of Control Rod Drive Mechanism Rod Position Indication Instrumentation for the Fort St. Vrain Nuclear Generating Station"

APPENDIX A

SKETCHES REFERENCED IN SECTION 3.0



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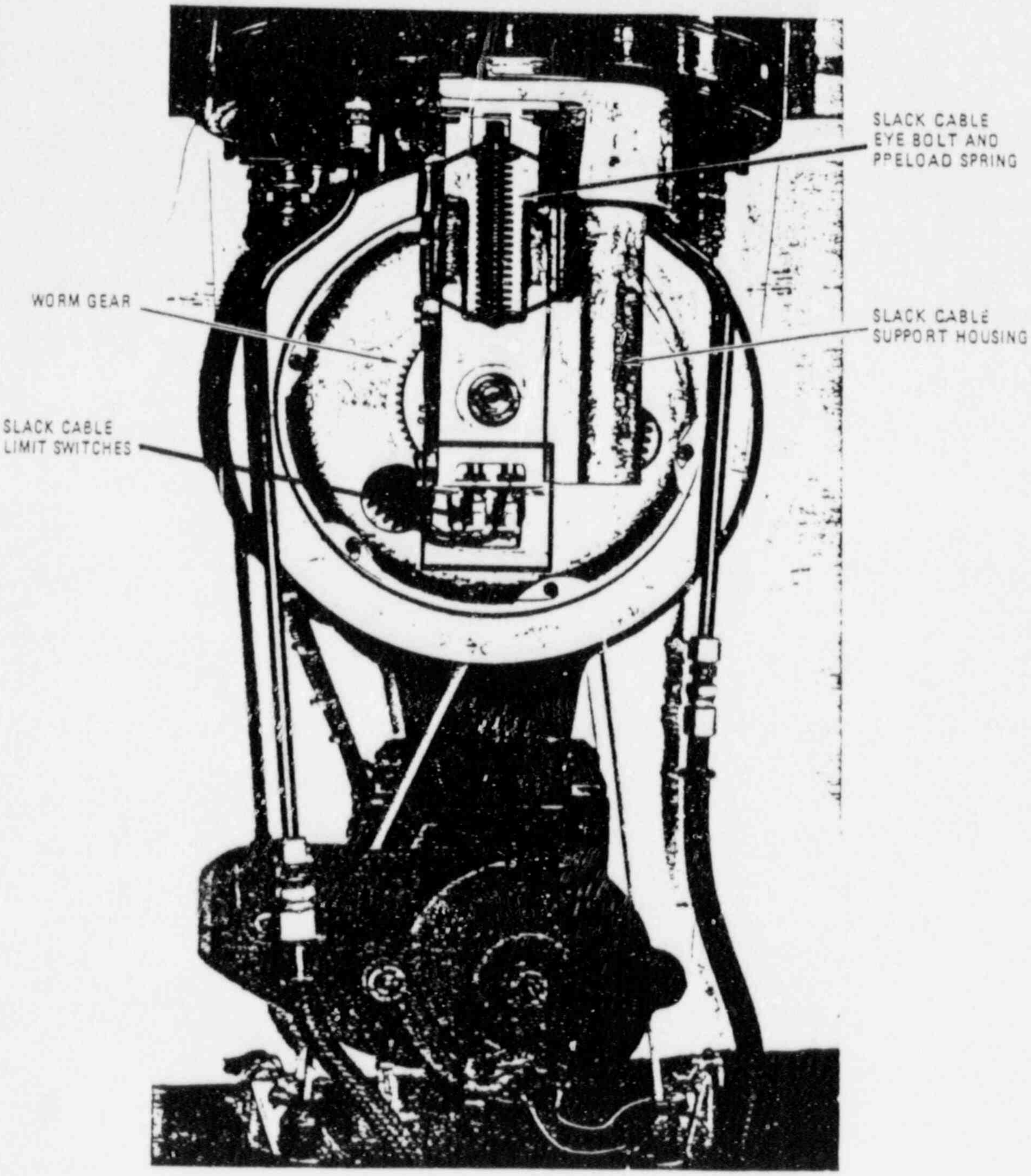
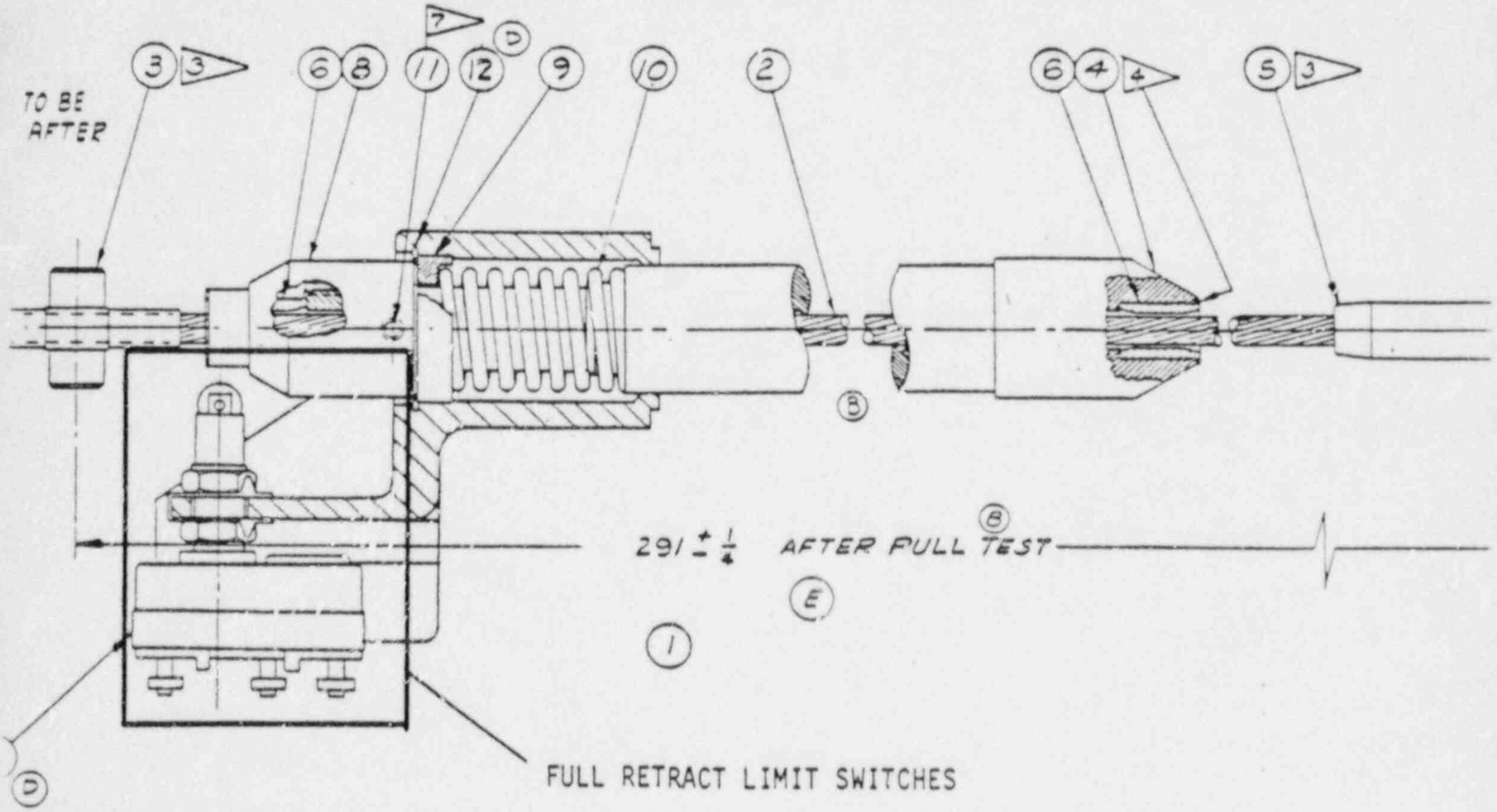
APPENDIX A, SKETCH 1



APPENDIX A, SKETCH 2

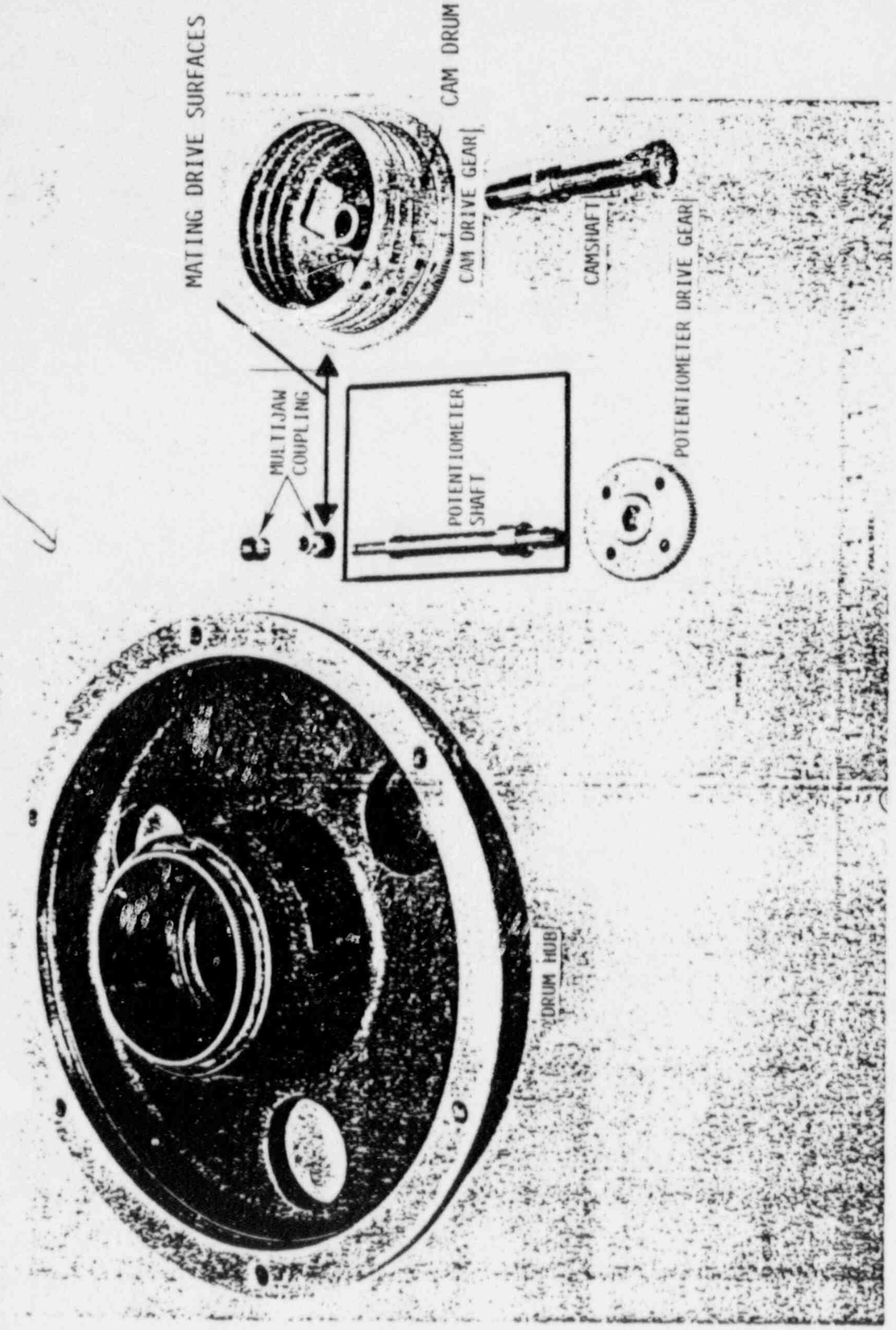
9 ALTERNATIVE PROTECTIVE TREATMENT-
Ⓒ ELECTROLESS NICKEL PLATING .0002 ±.0001
THICK IN ACCORDANCE WITH MIL-C-2607A.
TO BE APPLIED BY KANIGEN PROCESS ONLY.

Ⓓ 10 TRUARC - WALDES KOHINOOR
LONG ISLAND CITY, N.Y.



FULL RETRACT LIMIT SWITCHES

APPENDIX A, SKETCH 3



APPENDIX A, SKETCH 4

APPENDIX B

PHOTOGRAPHS

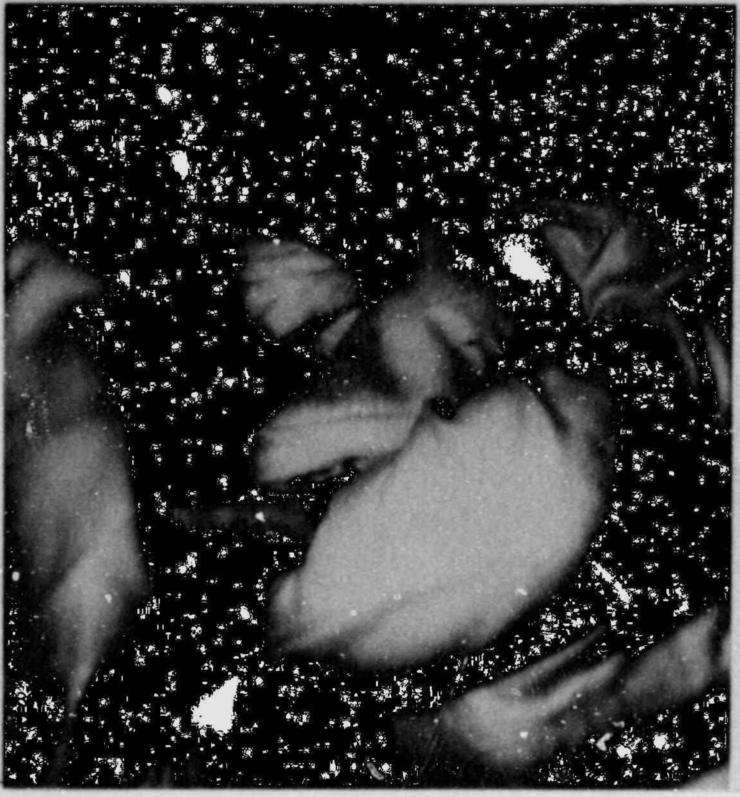


PHOTO OF FULL IN SWITCH SHAFT OF A PARTIALLY FAILED (STICKING) UNIT

CLOSE-UP OF SAME SWITCH SHAFT SHOWING DEGRADATION OF SHAFT ON SIDE OPPOSITE CAM APPROACH

DISASSEMBLED POT WITH SLIDER,SHAFT ETC. VISIBLE*NEW*

AN OLDER POT RESISTIVE ELEMENT VISIBLE FROM A SIMILAR ANGLE*AGE UNKNOWN*

APPENDIX C

NOTES/LETTER REGARDING NRC STAFF VISIT OF 12/04/87

NOTES

Prior to the meeting of Dec. 4, 1987, a tour of the CRDM drive assembly was provided to the NRC staff. It should be noted that specific areas of concern to the staff were reviewed while observing the operation of the CRDM test set-up. One specific concern was the striking of the potentiometer shaft by the cams which presently operate the switches or by the targets which are proposed for use with the new sensors. By visually observing the operation of the cam drum adjacent to the potentiometer shaft on a partially disassembled unit, it was apparent that the targets (which are as large as the cams) do not strike the potentiometer shaft. This point is reiterated by the staff letter of Dec. 15, 1987 Page 1, paragraph 4, last line.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

December 15, 1987

G-87445

Recd 12-22-87

Docket No. 50-267

MEMORANDUM FOR: Jose A. Calvo, Director
Project Directorate - IV
Division of Reactor Projects - III, IV, V and Special Projects

FROM: Kenneth L. Heitner, Project Manager
Project Directorate - IV
Division of Reactor Projects - III, IV, V and Special Projects

SUBJECT: SUMMARY OF MEETING TO DISCUSS CONTROL ROD DRIVE MECHANISM (CRDM) TEMPERATURE REQUALIFICATION AND POSITION INSTRUMENTATION, DECEMBER 4, 1987 (TAC NOS. 61601 AND 62198)

The purpose of this meeting was to discuss the licensee's latest proposals for these licensing actions. The licensee's previous proposals for these areas have been evaluated by the staff in letters dated December 24, 1986, and July 31, 1987. The attendees at this meeting are listed in Enclosure 1.

Position Instrumentation

The licensee presented a preliminary review of the current control rod position instrumentation. The presentation material is in Enclosure 2. The presentation included a failure mode analysis of the present instrumentation. This analysis showed that the current rod-in and rod-out limit switches were strong candidates for replacement. The problems with the current design of the rod position potentiometers were also highlighted.

The licensee stated that improved instrumentation had been selected as follows:

- The rod-in and rod-out limit switches would be replaced by proximity sensors, and
- The rod position indication potentiometer would be replaced by an improved potentiometer.

Both items would be able to withstand the temperature, humidity, radiation, and pressure environment of the CRDM.

The licensee stated that their intent was to submit a new failure mode analysis report. This report would clarify that there was corrosion failure of the rod-in and rod-out limit switches. It would also indicate that there were no credible failures (and need to replace) the slack cable limit switches. There was also not a problem with the proximity switch targets mechanically interfering with the position potentiometer shafts.

The staff noted that the licensee had not addressed other important criteria for the new instrumentation. The staff stated that the new instrumentation should clearly have service life equal to or exceeding that of the current instrumentation. Otherwise, the reactor operation could be constrained by inoperable control rod instrumentation. (The staff also notes that other factors, such as accuracy and long term drift, should be considered.)

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CRDM Temperature Requalification

The licensee reviewed the key steps in his proposed program for CRDM temperature requalification (see Enclosure 3). They are as follows:

- Evaluate the projected maximum CRDM service temperature. The licensee has developed a methodology for correlating the CRDM motor temperature with reactor temperatures and coolant flow parameters. These include the orifice position setting for each refueling region. Projected maximum temperatures for Cycle 4 are about 300°F in Region 12 and 275° F in Region 30. However, the licensee noted that some reductions could be achieved by reducing overall core flow and deliberately mismatching region outlet temperatures through orifice adjustments (within the limits of LCO 4.1.7). There was also some uncertainty about the validity of the correlations at high power, which could result in lower temperatures. Some possibility existed that CRDM temperature requalification would not be needed.
- Evaluate the CRDM system for acceptability at the higher temperature. This would include an evaluation of the materials of construction at higher temperature. The methodologies would be similar to those used to "qualify" materials under 10 CFR 50.49. Specific accepted methodologies would be used for special cases, such as CRDM drive motor insulation.
- Perform an integrated systems test of an entire CRDM assembly. The purpose of this test would be to evaluate potential synergistic and system effects of increased temperature, and
- Evaluate the role of the preventive maintenance program in assuring system performance in the event the "qualified" component life is reduced by the elevated temperatures. This could include more frequent maintenance of CRDMs exposed to higher temperatures

Future Actions

The licensee proposed to submit a proposal for new rod position instrumentation in April 1988, and for CRDM temperature requalification in March 1988. The staff commented that the licensee should give careful attention to applicable and related regulatory requirements and guidance. This included:

- 10 CFR 50.62
- GL 83-28 and related licensee submittals and staff evaluations,
- SRP 3.11, 4.5.1, and 4.6,
- The October 16, 1984 Assessment Report, and
- Subsequent Safety Evaluations on the CRDMs and CRDM position instrumentation.

Kenneth L Heitner

Kenneth L. Heitner, Project Manager
Project Directorate - IV
Division of Reactor Projects - III,
  IV, V and Special Projects

Enclosure:
As stated

cc: See next page

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Commitment Control Program
Coordinator
Public Service Company of Colorado
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Denver, Colorado 80211

Enclosure 1

ATTENDEES
NRC/PSC Meeting
December 4, 1987

NAME	ORGANIZATION
Rick Burrows	PSC/Plant Engineering
Ed Pitchkolan	PSC/Special Projects
M. E. Niehoff	PSC/NED
Greg Bates	PSC/NED
Jim Henderson	PSC/NED
J. R. Reesy	PSC/NED
J. L. Mauck	NRC/NRR/ICSB
Ken Heitner	NRC/NRR/PD-IV
Sam Chesnutt	PSC/Licensing
M. H. Holmes	PSC/Licensing
C. Bomberger	PSC/Licensing
Don Warembourg	PSC/NED
Frank Novachek	PSC/NPD

ENCLOSURE 2

Normal Operating Parameters

1 - Cable length ≈ 240" from Fully Retracted to Full-In Limit.

2 - Cable length ≈ 190" from Full-Out to Full-In Limit.

3 - From Fully Retracted to Full-In ≈ 10 turns on 2-gang potentiometer.

4 - At Full-In 2 each Limit Switches are actuated - wired in series. Actuated by Cam.

5 - At Full-Out 2 each Limit Switches are actuated - wired in series. Actuated by Cam.

6 - On loss of a Rod (Cable Breaks) 2 N/C Limit Switches are actuated by counter balancing spring.

All CRDM Position Instrumentation	Associated Indication	Other Circuitry Components	Anomalies from NRC Inspection Based on Described Component(s) Failure	
			CRDM No./Region	Anomaly
1) Rod-In Limit Switches	Indicating Light (Control Room (CR))	Cable, Connectors, Terminal Lugs, Blocks	13/19	Faulty Rod-In Limit Switch, Incorrect CR analog & digital indication (See 5,6)
		Relays, Surge Protection (Diac), Power Supply	39/23	Incorrect CR Analog position indication, Faulty Rod-In Limit Switch (See 5)
2) Rod-Out Limit Switches	Indicating Light (CR)	Same as Above	6/1	1 of 2 rod-out limit switches inoperable
			26	Faulty Rod-out switch
			29/ESW5	Faulty Rod-out switch
			37/3	Faulty Rod-out switches
3) Rod Retracted Limit Switches	Indicating Light (Test Box)	Cable, Connectors, Terminal Lugs, Blocks		
4) Slack Control Rod Cable Limit Switches	Indicating Light (CR)	Cable, Connectors, Terminal Lugs, Blocks, Relays, Surge Protection (Diode), Power Supply	25/7	Faulty Slack-Cable Switch*
5) Position Potentiometer (2 Gang) Part 1)	Analog Meter (CR)	Cable, Connectors Terminal Lugs, Blocks, Power Supply	12/15	Incorrect CR analog position indication
			13/19	Faulty Rod-In Limit Switch, Incorrect CR analog and digital indication (See 1,6)
			33/16	Faulty analog position indication
			39/23	Incorrect CR analog position indication, Faulty rod-in limit switch (See 1)
6) Position Potentiometer (2 Gang) Part 2	Digital Meter (CR)	Same as Above	13/19	Faulty Rod-In Limit Switch, Incorrect CR analog and digital indication (See 1,5)

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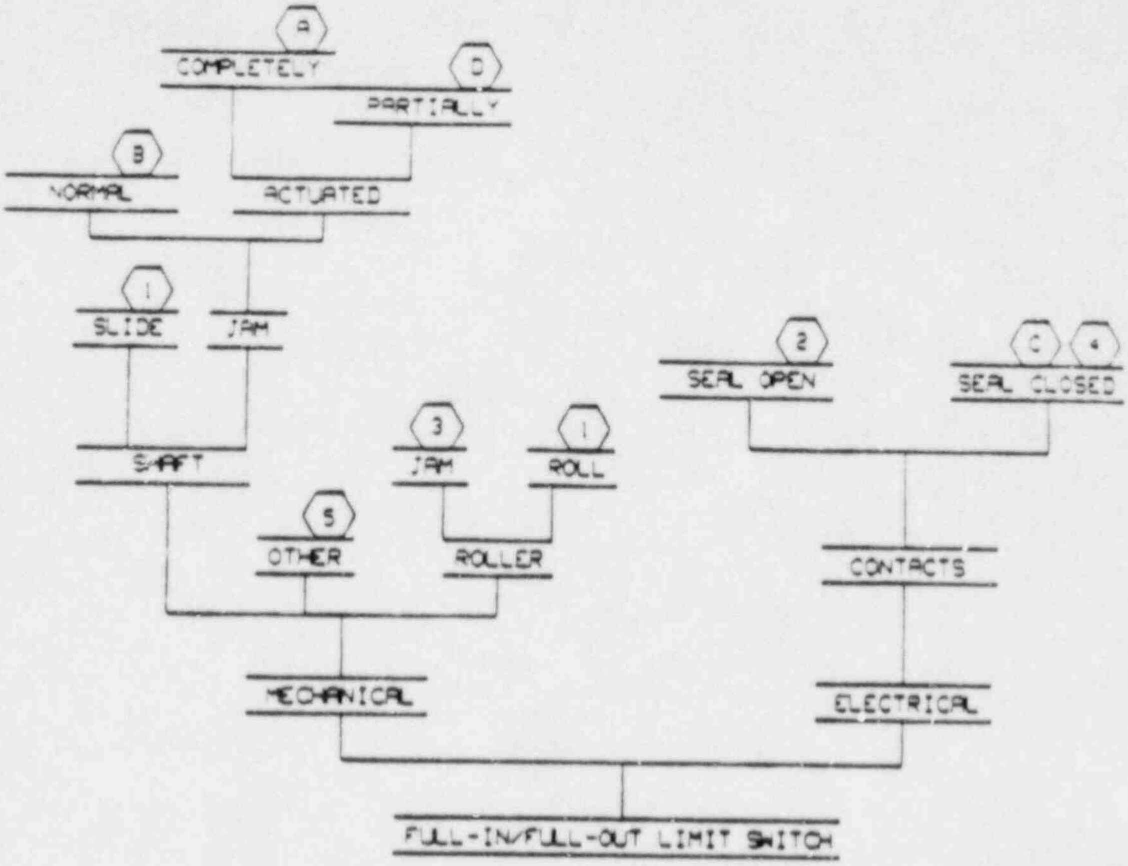
* Note - A known cable failure occurred in this position; therefore, the conclusion of a faulty slack-cable switch is unfounded.

FAILURE ANALYSIS TREE



NOTES

1 - NOT A FAILURE (INTENDED FUNCTION)

2 - NOT A CREDIBLE FAILURE MODE (NO CIRCUIT AVAILABLE)

3 - NOT A CREDIBLE FAILURE MODE (BASED ON MATERIALS 303&440SS)

4 - NOT, BY JUDGEMENT, A CREDIBLE FAILURE MODE (SNAP ACTION SWITCH) SEE 'C'

5 - NOT A CREDIBLE FAILURE MODE (BASED ON STRUCTURAL AND MECHANICAL RUGGEDNESS OF SWITCH)

FAILURE MODE EFFECTS ANALYSIS

A - INDICATING LIGHT ILLUMINATED, REMAINS SO AFTER LOSS OF STIMULUS

B - MECHANICAL FAILURE OF AN UNPREDICTABLE NATURE WILL OCCUR

C - NO INDICATING LIGHT ILLUMINATED UPON ACTUATION - NOT BY JUDGEMENT A CREDIBLE FAILURE - SEE '4'

D - INDETERMINATE - A OR B BASED ON PRECISE POINT OF JAM

Based on Failure Analysis

What Can Fail?

Explain what would cause failure.

Pg. 1 - A - Full-In/Full-Out Switch fails mechanically by jamming the shaft in the completely actuated position.

Cause - Shaft Failure
Investigate cause of shaft failure.

Conclusions: Shaft fails due to high lateral forces caused by Cam angle >15° (recommended max per Mfr). Failure is by erosion, deposition of eroded metal, corrosion until space between shaft and housing is filled and will not allow free movement. To verify: (1) Contact manufacturer for concurrence; (2) Check for corrosion/erosion/deposition on only 1 side of shaft (side opposite Cam approach)
Verify as required.

Pg. 1 - B - Same as "A" above, except position at which final failure occurs.* Cam may fail.*

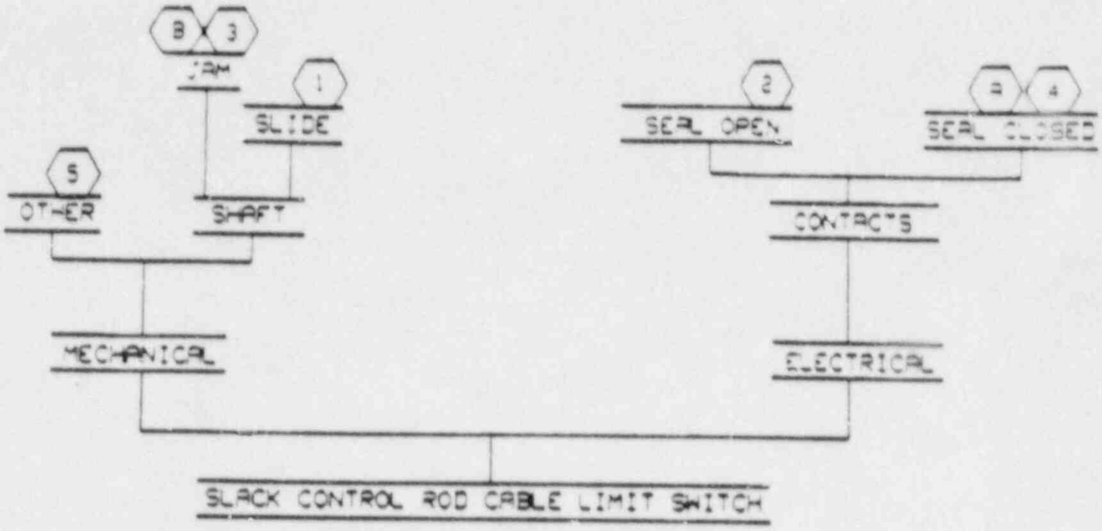
Pg. 1 - D - Same as "A" above, except position at which final failure occurs.

Pg. 1 - C - Full-In/Full-Out Switch fails electrically by sealing the contacts in the closed position. Not credible.

Cause - High inductance discharge from relay coil.

A commitment for testing of surge suppressors is in place.

FAILURE ANALYSIS TREE



NOTES

1 - NOT A FAILURE (INTENDED FUNCTION)

2 - NOT A CREDIBLE FAILURE MODE (NO CIRCUIT AVAILABLE)

3 - NOT A CREDIBLE FAILURE MODE (UPON LOSS OF ROD CABLE, SPRING APPLIES EQUAL FORCE TO AN AREA ~1/4" ø) - IF A JAM OCCURRED AFTER LOSS OF ROD CABLE IT WOULD BE REPLACED DURING REFURBISHMENT TESTING. SEE 'B'

4 - NOT, BY JUDGEMENT, A CREDIBLE FAILURE MODE (SNAP ACTION SWITCH) SEE 'A'

5 - NOT A CREDIBLE FAILURE MODE (BASED ON STRUCTURAL AND MECHANICAL RUGGEDNESS OF SWITCH)

FAILURE MODE EFFECTS ANALYSIS

A - NO INDICATING LIGHT ILLUMINATED UPON ACTUATION - NOT BY JUDGEMENT A CREDIBLE FAILURE - SEE '4'

B - INDICATING LIGHT REMAINS ILLUMINATED. THE ONLY WAY TO REMOVE THE STIMULUS IS TO RE-APPLY THE WEIGHT OF THE CONTROL ROD, VIA THE CABLE. SHOULD THIS FAILURE OCCUR, IT WOULD BE RESOLVED BY SWITCH REPLACEMENT DURING REFURBISHMENT TESTING. SEE '3'

Based on Failure Analysis

What Can Fail?

Explain what would cause failure.

Pg. 2 - A - Slack cable Limit Switch fails electrically by sealing the contacts in the closed position. Not judged a credible failure.

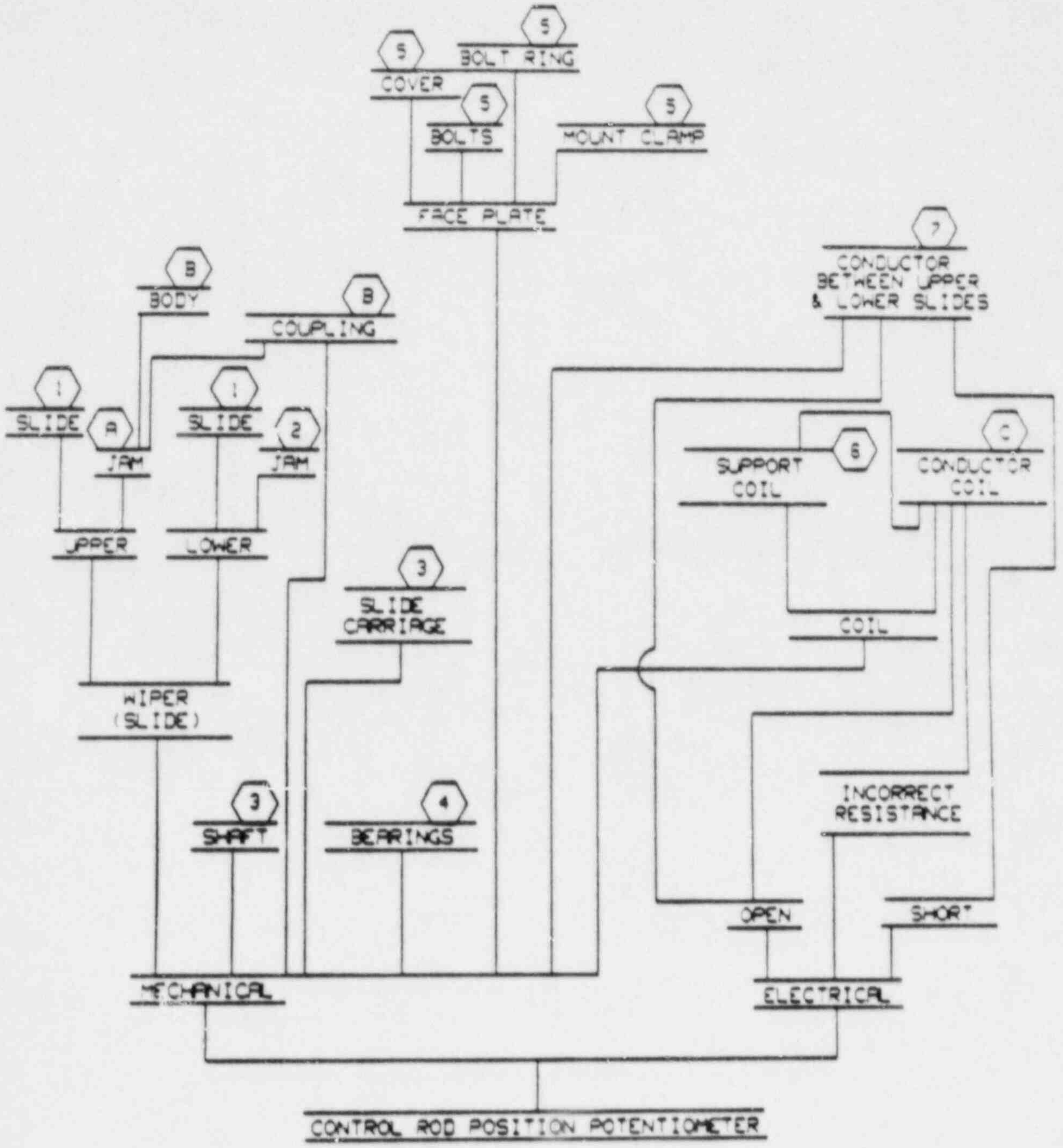
Cause - High inductive discharge from relay coil.

A commitment for testing of surge suppressors is in place.

Pg. 2 - B - Slack cable Limit Switch fails mechanically by jamming the shaft in the completely actuated position. Not a credible failure.

Cause - None known.

FAILURE ANALYSIS TREE



Notes

1 - Not a Failure (Intended Function)

2 - Not a Credible Failure (Failure of some other type required to provide stimuli for this failure). Failure of this type for both analog and digital portions of a single potentiometer simultaneously is not considered credible.

3 - Not a Credible Failure (due to the Structural/Mechanical ruggedness of the Part).

4 - Not a Credible Failure (due to the materials used [non-corroding, presumed a type of magnetic stainless], lubrication, low speed, limited number of operations, and limitations of load applied).

5 - Based on operating experience, no known failures of these parts have occurred.

6 - No known failure modes (Strictly a mechanical support [bobbin] for winding the conductor coil of the potentiometer.

7 - Not a Credible Failure Mode (Neither mechanical [wear] or Electrical [opening or shorting] can occur due to the limited length of conductor and its installed configuration. The conductor is made up of approx. 40 strands which produce an extremely flexible AWG 26 (approx. by measurement). Its length is such that in the installed configuration, this jacketed conductor does not come into contact with the conductor coil of the potentiometer and thus cannot be worn or shorted.

Failure Mode Effects Analysis

A - When the upper wiper (slide) jams (at the top or bottom of the slide carriage) due to being driven beyond its design range, system failure is imminent. One potential failure is the wiper guide (a part of the wiper) is broken, rendering the slide inoperable or at best unpredictable. This failure is particularly likely to occur when the potentiometer is driven very slowly beyond its design limits. When the potentiometer is driven at scram speed (8 turns in approx. 150 seconds, approximately 3.2 rpm), the failure mode is far more likely to be Failure Mode "B". (See Note below.)

B - When the potentiometer is driven beyond design limits, at or near scram speed, the failure mode is most likely to be breakage of the body (housing), the drive coupling, or the drive coupling pin. The result is approximately the same as in failure mode "A" in which the slide is inoperable or unpredictable. (See Note below.)

NOTE: In the event of failure modes "A" or "B", the output and thus the indication in the Control Room becomes unpredictable. Since the 2-gang potentiometer is 2 independent potentiometers, the following may occur:

1 - Each portion may perform adequately.

2 - One portion may be accurate while the other is inaccurate (linearly or non-linearly).

3 - Both portions may perform identically though inaccurately.

Failure Mode Effects Analysis

C - When moisture is introduced into a potentiometer, as in depressurization following a moisture ingress event, an oxide may result. Any uninsulated copper used in the support coil may react electrically with the conductor coil and produce copper oxide. This failure mode is considered unlikely in most potentiometers; yet it has been observed on a limited scale. The result would be to increase the resistance between the wiper and the conductor coil. This would result in erroneous indication in the Control Room. This failure mode may be capable of correction by drying the helium environment prior to depressurization. It is also <u>possible</u> that operation of the potentiometer may remove the oxide once it has formed, correcting to some degree the erroneous indication.

Based on Failure Analysis

What Can Fail?

Explain what would cause failure.

Pg. 3 - A - Control Rod Position Potentiometer fails mechanically by jamming the upper wiper resulting in wiper damage.

Cause - Control Rod Drive Mechanism (CRDM) is overdriven (forced beyond the intended design limit) in an attempt to actuate non-working Limit switches.

An administrative procedure now controls this action to limit this type of damage.

Pg. 3 - B - Control Rod Position Potentiometer fails mechanically by jamming the upper wiper resulting in body or coupling damage.

Cause - Same as "A" above.

Comment same as "A" above.

Pg. 3 - C - Control Rod Position Potentiometer fails electrically by producing copper oxide and thus changing the resistance of the potentiometer. This results in erroneous indication in the Control Room.

Cause - Electrolysis induced by bare copper and other metals in a moist environment. Apparently, the added current of the circuit aids in the electrolysis.

1 - Contact manufacturer for concurrence.

2 - Verify visually.

Contacted and verified as required.

Scope of Review for Replacement Products

For Position Transmitters (sample)

Encoders
- Optical
- Magnetic

Bidirectional BCD
Position Transducers

Motors
- Steppers
- Selsyns

Potentiometers
Off-the-Shelf Custom Design

Companies Contacted (sample):

- Microswitch
- Litton
- Autotech
- Bailey Controls
- General Electric
- Westinghouse
- Beckman
- Many others

For Full-In/Full-Out Position Sensing

Switches
- Roller (Perpendicular to Contact Bar)
- Roller (Longitudinal with Contact Bar)
- Non-roller type with slide actuation

Sensors
- Infrared
- Magnetic
- Proximity - various types including Eddy current killed oscillator for sensor

  - integrated Full-In/Full-Out/Position Transmitters

Selected Replacement Components

1. For Rod-In/Rod-Out

   Proximity Sensor - Eddy Current Killed Oscillator by Microswitch
   Prototype #X82383-FW

   A remotely mounted transmitter receiver is used with this component.

   See Note below.

2. For Position Indication

   2-gang Potentiometer by Beckman
   Prototype #7239-2966-0

   See Note below.

Note: All items designed to operate within the following parameters:

Temp = 300°F min.
Humidity = Approx. 100%
Radiation = 1 Rad per Hour
Pressure = 845 psi.

All parameters encountered simultaneously.

PROPOSED PLAN FOR REQUALIFICATION OF CRDM's

The following integrated plan has been developed for requalification of the CRDMs. The plan consists of the following phases: (1) evaluate temperature profiles obtained from operational data and programs in the area of the CRDM assemblies to establish the temperature to be used for qualification basis; (2) document age-related qualifications of the CRDMs in accordance with the approved FSV EQ program through evaluation using EQ DOR aging criteria; (3) for components which may possess insufficient qualified life at the elevated qualification temperature, perform a failure-modes-and-effects analysis to determine the consequences of component failure during accident and post-accident operation; and (4) perform a type test of a complete CRDM assembly to resolve outstanding concerns, including rod position indication, synergistic effects, moisture ingress, and operation at elevated temperature. NRC Standard Review Plans 3.11 and 4.6 will be reviewed and applicable concerns identified in these SRP's will be incorporated into the integrated CRDM requalification program. Although various phases of this approach have been performed piecemeal to document qualification of the CRDMs, it is PSC's position that this integrated plan will provide a complete qualification approach for qualifying the CRDM's. FSV's EQ program has been audited and approved by the NRC and utilizes a standardized methodology for qualification of these assemblies. The following paragraphs provide additional information related to each of the areas to be investigated.

(1) **DOCUMENTATION OF QUALIFICATION TEMPERATURE:**
Analyze and document available data on the maximum expected motor temperature for which the CRDMs should be qualified. Document (1) recent motor temperatures while operating at power, (2) the program used to estimate maximum temperature, and (3) assumptions used in this program which will require monitoring/review when additional operating data is available. The purpose of the program and analysis is to provide the basis for the qualification temperature to be used in the determination of qualified life.

(2) **DETERMINATION OF QUALIFIED LIFE:**
The qualification will be based on application of the FSV EQ program, which has been reviewed and approved by the NRC, to the qualification of the CRDM's. Qualification will be tailored specifically for the CRDM environment and expected operational requirements The program will have to address the following points as a minimum:

a. description of the applicability of DOR since this component is located inside the PCRV while other EQ items are located outside the PCRV in the Reactor or Turbine Buildings.
b. description of "mild" environment for the CRDMs; define mild and determine worst case accident and post-accident operating environment.
c. evaluate post-accident operability requirements for these components to ensure that, if required to operate, evaluation of the post-accident environment is performed as well as identification of any appropriate testing requirements.
d. identify the functional, operational, and design requirements for the CRDMs to ensure that these characteristics are used as the basis for type testing of the CRDM assembly.

e. qualified life will be established using standard DOR methodology through use of material analysis. Due to the age of the CRDMs, use of this methodology should be acceptable; full thermal aging by type test is not required since it is not required of similar vintage EQ related equipment and the CRDMs are installed in a mild environment. (Type testing is recommended to be performed but is intended to resolve non-aging, synergistic concerns identified by the NRC in their submittals to PSC.)

(3) FAILURE MODES AND EFFECTS ANALYSIS (FMEA):
In addition to determination of the qualified life for degradable components of the CRDM, a FMEA will be needed to justify use of components which are determined to have insufficient qualified life at the elevated temperatures expected. If any such components are identified, the FMEA will determine the consequences of failure of these components or parts. If failure can be proven to cause no adverse effect on the ability of the CRDM to operate or safely shutdown, no action would be required. If, however, the part has inadequate qualified life and its failure has unacceptable consequences, then the recommendation should be made to limit the reactor power level such that an acceptable temperature can be achieved or replace the component prior to the end of its useful life.

(4) TYPE TESTING:
Several pre-1985 documents from the NRC to PSC identify the need to perform type-testing of the CRDM assembly. (See attached page for major comments.) Due to the uncertainty of the results obtained during the last CRDM type test, it is deemed to be prudent to retest the CRDMs to demonstrate suitable performance; the retest will include operability of the rod position indication, operation following moisture ingress, and operation at elevated temperatures. The intent of this test is to demonstrate the operability of the CRDM and to demonstrate that synergistic effects will not adversely affect performance of the CRDMs; it is NOT the intent of this type test to establish the qualified life of the CRDM components.

SUMMARY OF SIGNIFICANT NRC CORRESPONDENCE
RELATED TO THE CRDM QUALIFICATION ISSUE

G-82384:

> "Synergistic effects such as tolerance accumulation, wear induced misalignments, lubricant redeposition, differential thermal expansion etc., mandate reliance on total assembly qualification tests rather than on analysis or tests of individual components."

G-84392:

> "The licensee should determine whether compensating design and/or operational modifications are needed to minimize moisture ingress to the CRDM cavities and minimize temperatures in the vicinity of the rod drives. In the event that temperatures recorded during plant operation prove to be higher than those for which the assembly was initially qualified, perform requalification testing of a CRDM assembly."

Critical comments received from the NRC in the SER for the CRDM Temperature Requalification (G-86664) include the following:

> "The licensee did not develop functional, operational, and design specification based on the environment that the CRDOA's would be expected to operate in. The licensee's submittal did not provide acceptance criteria developed from the functional, operational and design specification against which to evaluate the test results. The tests were not performed under conditions that are representative of conditions in FSV (i.e., tests were performed with dry helium, while moisture is potentially present in the FSV reactor especially if there is a moisture ingress event). The licensee did not provide information on the mechanical and electrical properties of the materials in the CRDOAs as a function of temperature, humidity, pressure, and radiation. The test was performed for a very limited time (i.e., 14 days at 300°F). The licensee's submittal did not explain how the data would be extrapolated to the length of time the CRDOA's would be required to operate at elevated temperatures.

In conclusion, G-86664 stated:

> "the revised submittal should include or consider such items as functional, operational and design specifications, acceptance criteria, material specifications, material properties, test specifications, test operating procedures, test data, and the necessary supporting analyses.

APPENDIX D

ANOMALIES CHART

All CRDM Position Instrumentation	Associated Indication	Other Circuitry Components	Anomalies from NRC Inspection Based on Described Component(s) Failure	
			CRDM No./Region	Anomaly
1) Rod-In Limit Switches	Indicating Light (Control Room (CR))	Cable, Connectors, Terminal Lugs, Blocks	13/19	Faulty Rod-In Limit Switch, Incorrect CR analog & digital indication (See 5,6)
		Relays, Surge Protection (Diac), Power Supply	39/23	Incorrect CR Analog position indication, Faulty Rod-In Limit Switch (See 5)
2) Rod-Out Limit Switches	Indicating Light (CR)	Same as Above	6/1	1 of 2 rod-out limit switches inoperable
			26	Faulty Rod-out switch
			29/ESW5	Faulty Rod-out switch
			37/3	Faulty Rod-out switches
3) Rod Retracted Limit Switches	Indicating Light (Test Box)	Cable, Connectors, Terminal Lugs, Blocks		
4) Slack Control Rod Cable Limit Switches	Indicating Light (CR)	Cable, Connectors, Terminal Lugs, Blocks, Relays, Surge Protection (Diode), Power Supply	25/7	Faulty Slack-Cable Switch*
5) Position Potentiometer (2 Gang) Part 1)	Analog Meter (CR)	Cable, Connectors Terminal Lugs, Blocks, Power Supply	12/15	Incorrect CR analog position indication
			13/19	Faulty Rod-In Limit Switch, Incorrect CR analog and digital indication (See 1,6)
			33/16	Faulty analog position indication
			39/23	Incorrect CR analog position indication, Faulty rod-in limit switch (See 1)
6) Position Potentiometer (2 Gang) Part 2	Digital Meter (CR)	Same as Above	13/19	Faulty Rod-In Limit Switch, Incorrect CR analog and digital indication (See 1,5)

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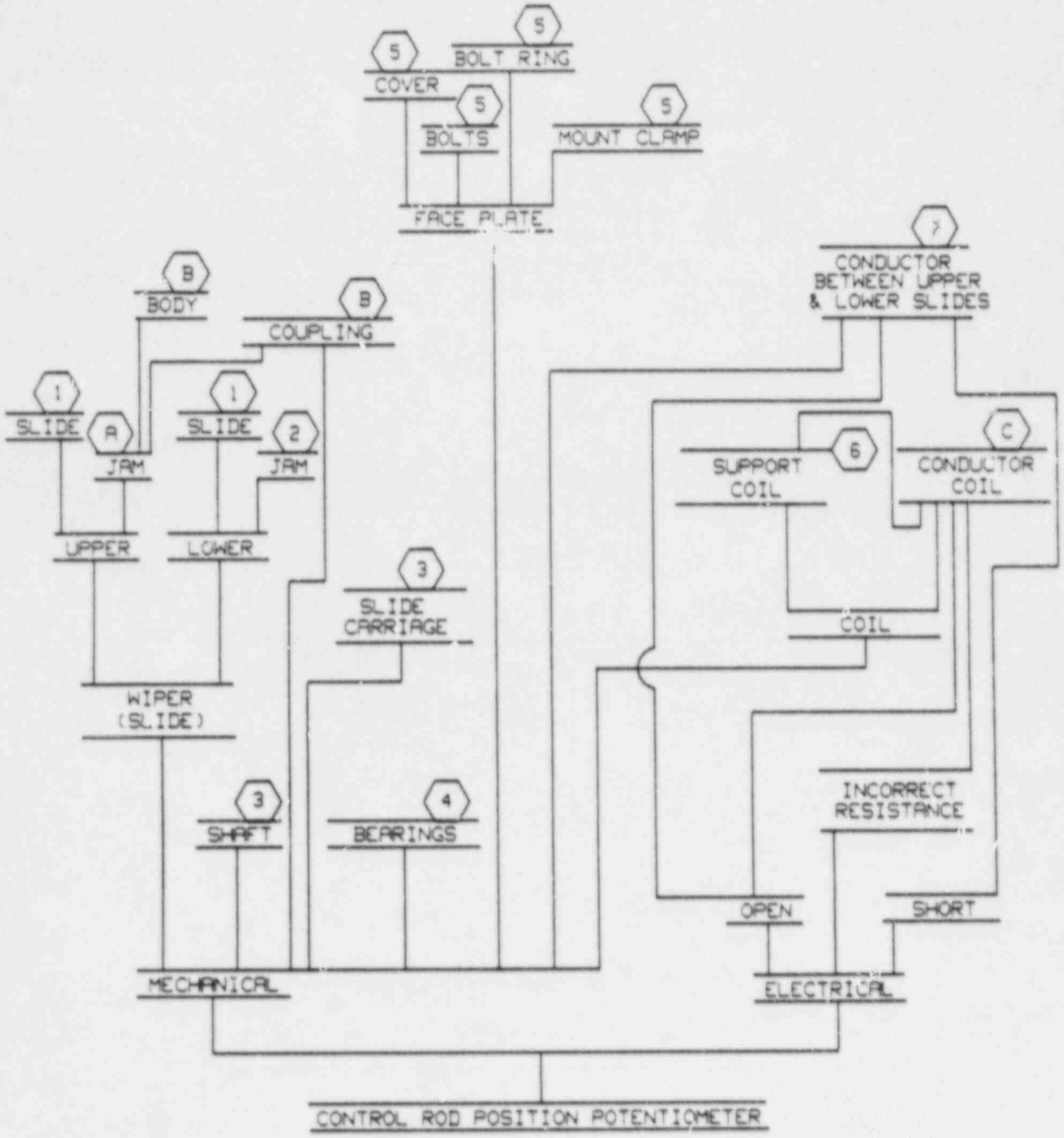
* Note - A known cable failure occurred in this position; therefore, the conclusion of a faulty slack-cable switch is unfounded.

APPENDIX E

FMEA OF POSITION TRANSMITTERS

FAILURE ANALYSIS TREE



Notes

1 - Not a Failure (Intended Function)

2 - Not a Credible Failure (Failure of some other type required to provide stimuli for this failure). Failure of this type for both analog and digital portions of a single potentiometer simultaneously is not considered credible.

3 - Not a Credible Failure (due to the Structural/Mechanical ruggedness of the Part).

4 - Not a Credible Failure (due to the materials used [non-corroding, presumed a type of magnetic stainless], lubrication, low speed, limited number of operations, and limitations of load applied).

5 - Based on operating experience, no known failures of these parts have occurred.

6 - No known failure modes (Strictly a mechanical support [bobbin] for winding the conductor coil of the potentiometer).

7 - No Credible Failure Mode (Neither mechanical [wear] or electrical [opening or shorting] can occur due to the limited length of conductor and its installed configuration). The conductor is made up of approx. 40 strands which produce an extremely flexible AWG 26 (approx. by measurement). Its length is such that in the installed configuration, this jacketed conductor does not come into contact with the conductor coil of the potentiometer and thus cannot be worn or shorted.

Failure Mode Effects Analysis

A - When the upper wiper (slide) jams (at the top or bottom of the slide carriage) due to being driven beyond its design range, system failure is imminent. One potential failure is the wiper guide (a part of the wiper) is broken, rendering the slide inoperable or at best unpredictable. This failure is particularly likely to occur when the potentiometer is driven very slowly beyond its design limits. When the potentiometer is driven at scram speed (8 turns in approx. 150 seconds, approximately 3.2 rpm), the failure mode is far more likely to be Failure Mode "B". (See Note below.)

B - When the potentiometer is driven beyond design limits, at or near scram speed, the failure mode is most likely to be breakage of the body (housing), the drive coupling, or the drive coupling pin. The result is approximately the same as in failure mode "A" in which the slide is inoperable or unpredictable. (See Note below.)

NOTE: In the event of failure modes "A" or "B", the output and thus the indication in the Control Room becomes unpredictable. Since the 2-gang potentiometer is 2 independent potentiometers, the following may occur:

1 - Each portion may perform adequately.

2 - One portion may be accurate while the other is inaccurate (linearly or non-linearly).

3 - Both portions may perform identically though inaccurately.

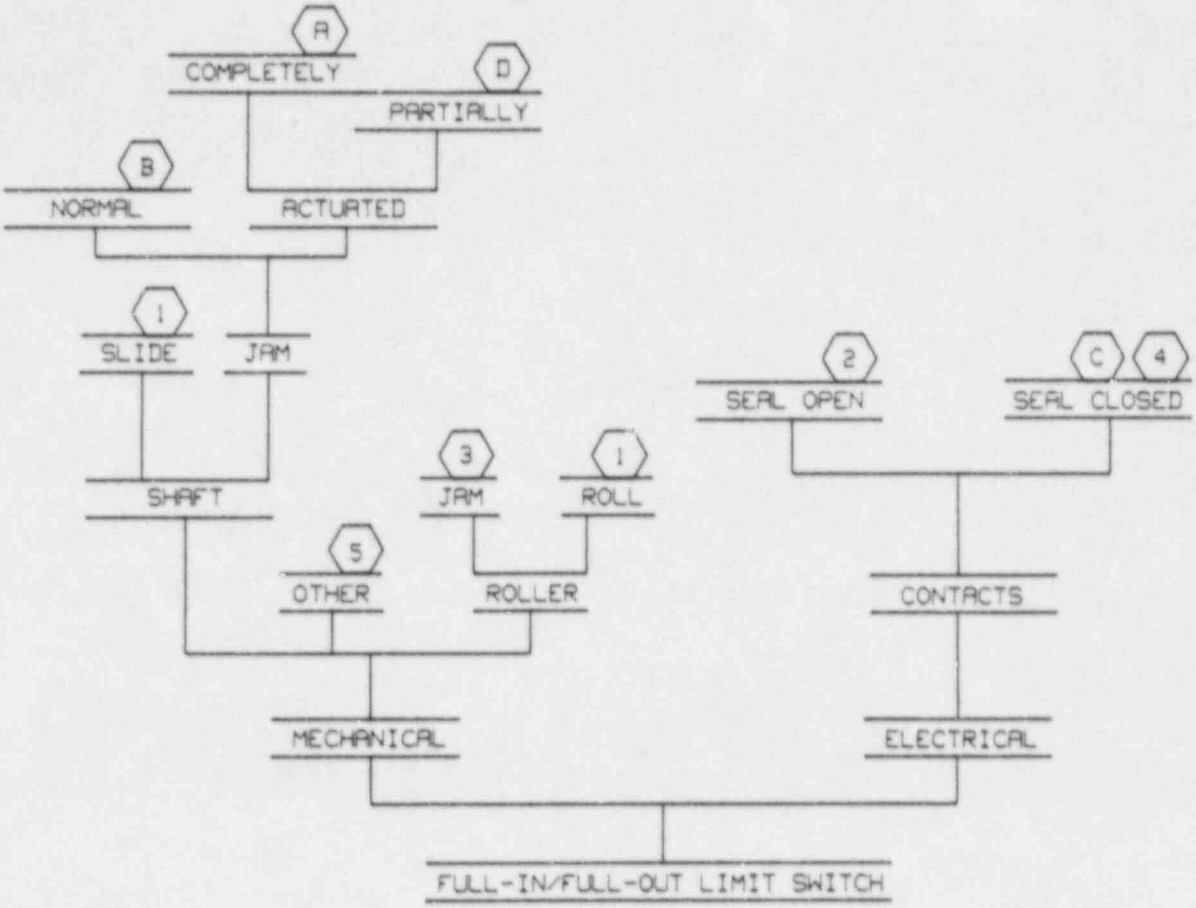
Failure Mode Effects Analysis

C - When moisture is introduced into a potentiometer, as in depressurization following a moisture ingress event, an oxide may result. Any uninsulated copper used in the support coil may react electrically with the conductor coil and produce copper oxide. This failure mode is considered unlikely in most potentiometers; yet it has been observed on a limited scale. The result would be to increase the resistance between the wiper and the conductor coil. This would result in erroneous indication in the Control Room. This failure mode may be capable of correction by drying the helium environment prior to depressurization. It is also possible that operation of the potentiometer may remove the oxide once it has formed, correcting to some degree the erroneous indication.

APPENDIX F

FMEA OF IN/OUT LIMIT SWITCHES

FAILURE ANALYSIS TREE



NOTES

1 - NOT A FAILURE (INTENDED FUNCTION)

2 - NOT A CREDIBLE FAILURE MODE (NO CIRCUIT AVAILABLE)

3 - NOT A CREDIBLE FAILURE MODE (BASED ON MATERIALS 303&440SS)

4 - NOT, BY JUDGEMENT, A CREDIBLE FAILURE MODE (SNAP ACTION SWITCH) SEE 'C'

*5 - NO CREDIBLE FAILURE MODE (BASED ON STRUCTURAL AND MECHANICAL RUGGEDNESS OF SWITCH)

FAILURE MODE EFFECTS ANALYSIS

A - INDICATING LIGHT ILLUMINATED, REMAINS SO AFTER LOSS OF STIMULUS

B - MECHANICAL FAILURE OF AN UNPREDICTABLE NATURE WILL OCCUR

C - NO INDICATING LIGHT ILLUMINATED UPON ACTUATION - NOT BY JUDGEMENT A CREDIBLE FAILURE - SEE '4'

D - INDETERMINATE - A OR B BASED ON PRECISE POINT OF JAM

* REVISED AFTER DECEMBER 4, 1987 MEETING

Based on Failure Analysis

What Can Fail?

Explain what would cause failure.

Pg. 1 - A - Full-In/Full-Out Switch fails mechanically by jamming the shaft in the completely actuated position.

Cause - Shaft Failure
Investigate cause of shaft failure.

Conclusions: Shaft fails due to high lateral forces caused by Cam angle >15° (recommended max per Mfr). Failure is by erosion, deposition of eroded metal, corrosion until space between shaft and housing is filled and will not allow free movement. To verify: (1) Contact manufacturer for concurrence; (2) Check for corrosion/erosion/deposition on only 1 side of shaft (side opposite Cam approach)
Verify as required.

Pg. 1 - B - Same as "A" above, except position at which final failure occurs.* Cam may fail.*

Pg. 1 - D - Same as "A" above, except position at which final failure occurs.

Pg. 1 - C - Full-In/Full-Out Switch fails electrically by sealing the contacts in the closed position. Not credible.

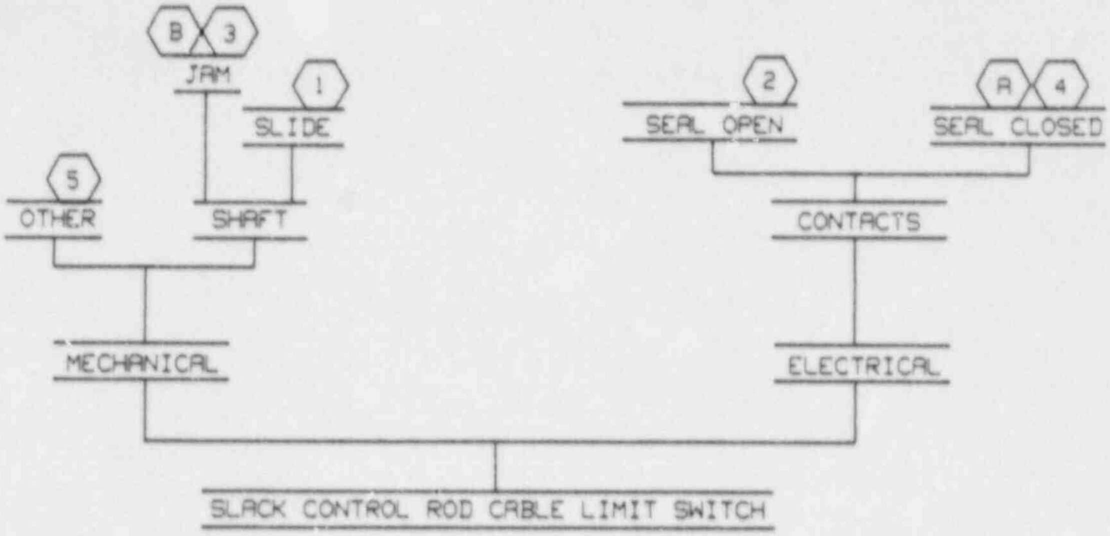
Cause - High inductance discharge from relay coil.

A commitment for testing of surge suppressors is in place.

APPENDIX G

FMEA OF SLACK CABLE SWITCHES

FAILURE ANALYSIS TREE



NOTES

1 - NOT A FAILURE (INTENDED FUNCTION)

2 - NOT A CREDIBLE FAILURE MODE (NO CIRCUIT AVAILABLE)

*3 - NOT A CREDIBLE FAILURE MODE (NO STIMULUS TO PRODUCE THIS FAILURE)

4 - NOT, BY JUDGEMENT, A CREDIBLE FAILURE MODE (SNAP ACTION SWITCH) SEE 'A'

*5 - NO CREDIBLE FAILURE MODE (BASED ON STRUCTURAL AND MECHANICAL RUGGEDNESS OF SWITCH)

FAILURE MODE EFFECTS ANALYSIS

A - NO INDICATING LIGHT ILLUMINATED UPON ACTUATION - NOT BY JUDGEMENT A CREDIBLE FAILURE - SEE '4'

*B - INDICATING LIGHT DOES NOT ILLUMINATE. - NOT A CREDIBLE FAILURE MODE (NO STIMULUS TO PRODUCE THIS FAILURE). SWITCH IS HELD ACTUATED NORMALLY AND CHANGES STATE WHEN WEIGHT IS REMOVED.

* REVISED AFTER DECEMBER 4, 1987 MEETING

Based on Failure Analysis

What Can Fail?

Explain what would cause failure.

Pg. 2 - A - Slack cable Limit Switch fails electrically by sealing the contacts in the closed position. Not judged a credible failure.

Cause - High inductive discharge from relay coil.

A commitment for testing of surge suppressors is in place.

Pg. 2 - B - Slack cable Limit Switch fails mechanically by jamming the shaft in the completely actuated position. Not a credible failure.

Cause - None known.

APPENDIX H

SPECIFICATIONS FOR NEW COMPONENTS

Note that these new components will be specified and procured in accordance with qualification criteria of new qualification program. Material characteristics, temperature limits, expected service life, synergistic effects, FMEA will be performed prior to modification in accordance with established qualification program.

POSITION SENSORS

SPECIFICATION AND CERTIFICATION FOR PROTOTYPES

QUALITY RELATED PURCHASE REQUISITION

INTERNAL CONTROL NUMBER ONLY: Y6148

SELLER NO: 82050

SELLER NAME & ADDRESS:
TESSCO
1489 SO. BROADWAY
DENVER, CO 80210

PURCHASE ORDER NO: Confirming N-6194 Suppl. #1

DATE WRITTEN: 8-6-85

PUBLIC SERVICE COMPANY OF COLORADO

SUBSIDIARY COMPANY

OR

STO: 686

DATE WANTED:

SHIP TO: STOREKEEPER, FORT ST.VRAIN: PLATTEVILLE, COLORADO 80651

1. ☐ SP/FA
2. ☐ COLLECT

SHIPPING POINT INCLUDE CITY & STATE:

SHIP VIA:

TOTAL EST. WEIGHT:

ITEM NUMBER OR STORES CODE NO.	QUANTITY	DESCRIPTION OF MATERIAL OR SERVICES	ESTIMATED UNIT PRICE	ACTUAL UNIT PRICE	AMOUNT

THE FOLLOWING CHANGES PERTAIN TO ITEMS ON THIS P.O.

CHANGE CERTIFICATION PARAGRAPH

FROM: MANUFACTURER'S CERTIFICATE OF CONFORMANCE THAT MATERIALS FURNISHED MEET OR EXCEED THE REQUIREMENTS OF LETTER NDG-85-0277 (ATTACHED).

TO: MANUFACTURER'S CERTIFICATE OF CONFORMANCE THAT MATERIALS FURNISHED MEET OR EXCEED THE REQUIREMENTS OF PAGE 2 OF THIS PURCHASE ORDER.

EXCEPT FOR THE ABOVE CHANGE, ALL OTHER DOCUMENTATION, PARTS, AND PRICES REMAIN UNCHANGED.

SEE ATTACHED SHEET FOR QUALITY AND DOCUMENTATION REQUIREMENTS.

SPEC. NO. ________ EQUIP. NO. ________

QUALIFIED SOURCE REQUIRED:
☐ MANUFACTURER
☐ SUPPLIER
☐ SERVICES

QA REVIEW ____________________

ACCOUNTS TO BE CHARGED

INDICATE ITEM NUMBER FROM ABOVE WHEN MORE THAN ONE ACCOUNT NUMBER IS USED

CORRESPONDING ITEM NUMBER AND OR	PERFORMED	CONTROLLED	RESRCE	CHRGD	ORDER CODE	MCS REPORT DESCRIPTION ONE LINE PER ACCOUNT

LOCATION OF USE: FORT ST. VRAIN

APPROVED CAPITAL BUDGET ITEM

L. ARAGON

571-8556

DATE

DATE

NOTES

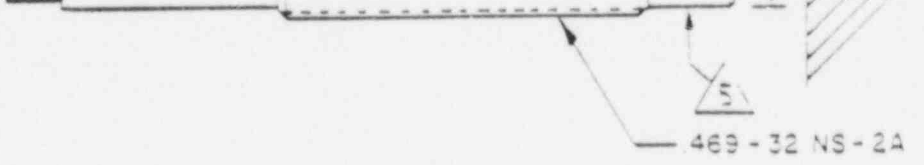
1 - ELECTRICAL CONNECTIONS - THREE 20 GAGE WIRES PER MIL-W-22759/43 "RED" TO TERMINAL 3 OF 405FW504-B SWITCH CARD, "BLUE" TO TERMINAL 6, AND "YELLOW" TO GROUND. WIRE LENGTH 72 INCHES MINIMUM.

2 - ACTUATION: WHEN OPERATED WITH THE 405FW504-B SWITCH CARD OPERATE POINT FOR A TARGET OF 15-5PH STEEL, .625 DIAMETER BY .062 THICK IS BETWEEN .060 AND .080 INCHES, RELEASE POINT IS BETWEEN .003 AND .012 INCHES OVER THE OPERATE POINT DISTANCE.

3 - MINIMUM OPERATING TEMPERATURE OF THE SENSOR IS -77°C.

4 - SENSOR IS DESIGNED AND MANUFACTURED TO MEET OR EXCEED THE FOLLOWING ENVIRONMENTAL PARAMETERS:
   a) TEMPERATURE @ +155°C
   b) PRESSURE @ 845 P.S.I.
   c) HUMIDITY @ 100%
   d) RADIATION @ 1 RAD/HOUR
   e) ALL THE ABOVE ENCOUNTERED SIMULTANEOUSLY

△5 - PART MARKING THIS SURFACE



D = .435 $^{+.000}_{-.005}$

MICRO SWITCH
FREEPORT ILLINOIS 61032
A DIVISION OF HONEYWELL INC.

CERTIFICATION

THAT GOODS CONFORM TO SPECIFICATIONS

This will certify that MICRO SWITCH catalog listing X82383-PW (Customer Part Number Reference None) furnished Public Service of Colorado on its Confirming Purchase Order N6194 and Supplement #1 to TESSCO (MICRO SWITCH A.D.), Contract (None) conforms to the dimensional, performance and environmental requirements of referenced purchase order.

By: HK Hinkley
Harlan K. Hinkley, Supervisor
Approvals Engineering
13 August 1985

POTENTIOMETER

SPECIFICATION AND CERTIFICATION FOR PROTOTYPES

Public Service

2420 W. 26th Avenue Suite 100-D Denver, CO 80211

Public Service Company of Colorado
P.O. Box 840
Denver, CO 80201 - 0840
(303) 571 - 7511

February 8, 1985
Fort St. Vrain
Unit No. 1
NDG-85-0081

Beckman Industrial Corp.
901 Oxford Street
Toronto, Ontario
Canada M8Z 5T2
Attn: Dan McBride

Dear Mr. McBride:

Below listed are our revised requirements for the quantity of potentiometers shown on the attached requisition. Please note this letter is specification for construction of required potentiometers.

Requirements:

1 - 10 Turn 3600° Elect. 5400° Mech., Elec. Turns Centered in Mechanical Turns
2 - Mounting Same as Bechman 7603
3 - 2 Gang - Electrically Independent
4 - 1000 OHMS ± 5%
5 - Linearity @ 1/10 of 1% Error
6 - High Reliability Seal - Per Item 10
7 - High Temperature Reliability - 300°F Min.
8 - Power Rating, Watts 5 @ 70°F, Derating to 0 @ Maximum Temperature Rating
9 - Taps - Conductors or Terminals Penetrating "Can" (May Be Axial)
10 - Direct Water Ingress Resistance to Maximum Level Reasonably Attainable Maintaining Torque ≤ 10 In. Oz.
11 - Seismic Qualification - STD for Series 7600
12 - Shock - - - - - - - - - STD for Series 7600
13 - Standard Tests Not Named Above
14 - Hydrolizable Chlorides Subject to Item 16
15 - Copper may be used only if it is sealed completely away from other parts.
16 - Due to the atmosphere involved, all materials require approval prior to their application.
17 - Pressure = 845 P.S.I.
18 - Voltage Tracking Sect. 1 to Sect. 2 = .25%.

Should you have any questions or desire further information, please do not hesitate to contact me at (303) 571-7134.

Very truly yours,

James G. Henderson

JGH/dh
Attachment

Beckman Industrial™

ELECTRONIC TECHNOLOGIES DIVISION
BECKMAN INDUSTRIAL CORPORATION
901 OXFORD STREET, TORONTO, ONTARIO, CANADA M8Z 5T2
TELEPHONE (416) 251-5251 TWX 610-492-1301

January 8, 1985

Public Service of Colorado,
2420 West 26th Avenue,
Suite 100D,
Denver, Colorado,
U.S.A. 80211

Attention: Jim Henderson

Re: C of C For Model 7239-2966-0

This is to certify that the components supplied on our P/S 08993P, your order #N6113 were designed to withstand 845 P.S.I. and manufactured, inspected, tested and conform to your letter NDG-85-0081, February 8, 1985.

Yours very truly,

BECKMAN INDUSTRIAL CORPORATION
ELECTRONIC TECHNOLOGIES DIVISION

Edward Smith

ES/cc

Edward Smith,
Quality Control Manager

EMERSON

BECKMAN INDUSTRIAL CORPORATION
A SUBSIDIARY OF EMERSON ELECTRIC CO

Beckman® INSTRUMENTS

Helipot®

Potentiometer Type 7239-2966-0

Serial Number Unit A

Insulation ✓

V.B.T. ✓

Insulation ✓

Noise Less than	10 M/V	25 M/V	50 M/V	100 M/V	250 M/V
" " " 1				X	
" " " 2				X	

Total Resistance 1 1000·75Ω

" " 2 1000·15Ω

" " 3

Linearity Type	Independent	Zero Based	Terminal Based	Absolute	Special
	X				

Linearity Error 1 ± 0·042%

" " 2 ± 0·064%

Electrical Rotation 1 3599°30' ±

Electrical Rotation 2 3599° ±

Tap 1		7	
" 2		8	
" 3		9	
" 4		10	
" 5		11	
" 6		12	

Phasing Within 1° at CCW

Front Shaft Extn. 0.625

Rear " " N/A

Face Run-Out 0.003

Diameter Run-Out 0.0015

Shaft Run-Out 0.001

Shaft End Play 0.005

Radial Play 0.002

Starting Torque 10 MAX In. ozs.

Burrs ✓

Finish ✓

Other Features

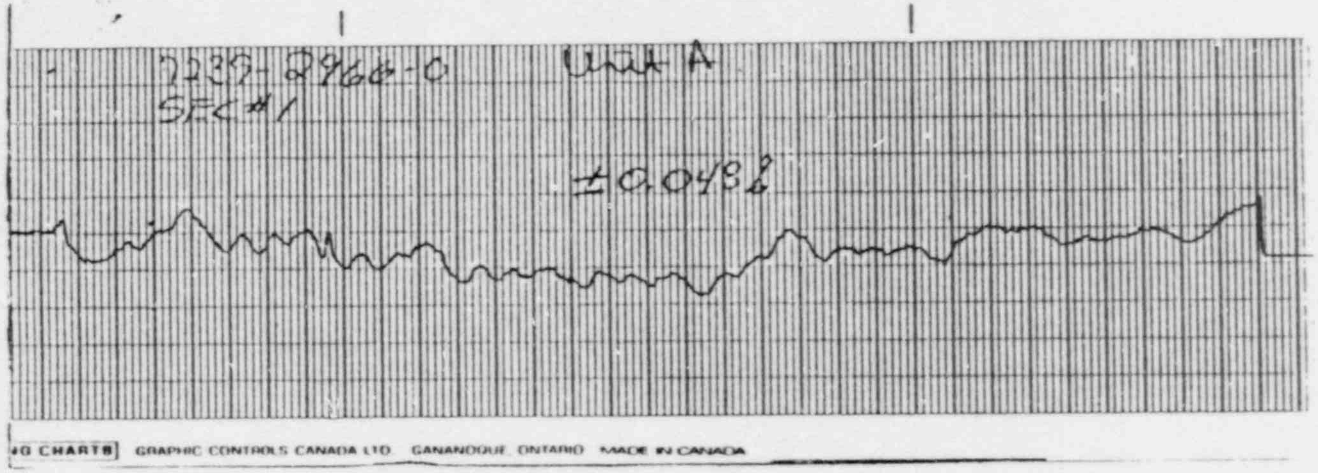
Mechanical Rotation 5400°30'

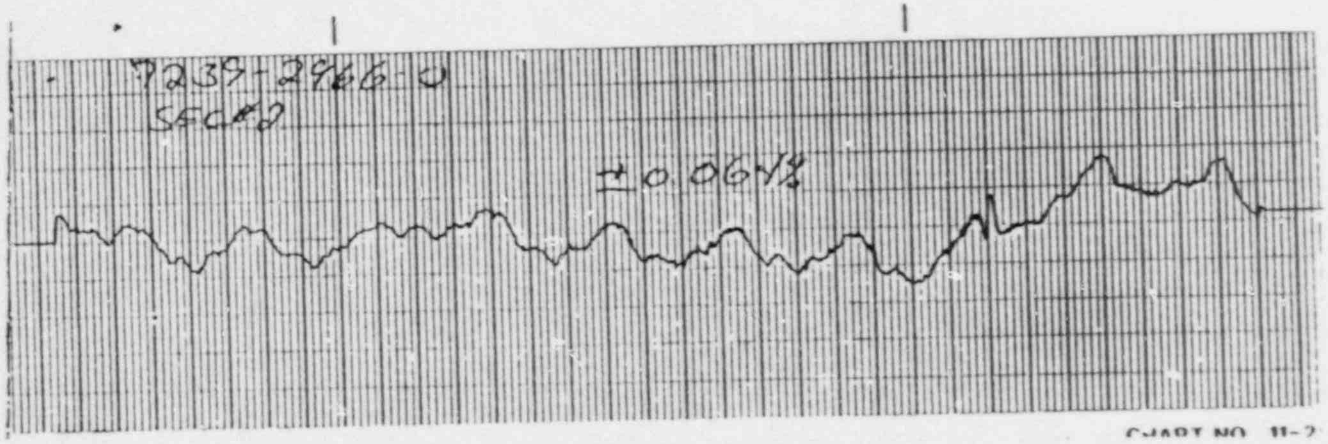
Electrical Overtravel
as per Spec

Inspected By C

Approved By P.S.

Form No. C/1-2


7239-2966-0
Unit A
SEC#1
±0.048%
G CHARTS GRAPHIC CONTROLS CANADA LTD GANANOQUE, ONTARIO MADE IN CANADA


7239-2966-0
SEC#2
±0.064%
CHART NO 11-2

Beckman® INSTRUMENTS

Helipot®

Potentiometer Type 7239-3966-0
Serial Number Unit B
Insulation ✓
V.B.T. ✓
Insulation ✓

Noise Less than

	10 M/V	25 M/V	50 M/V	100 M/V	250 M/V
1				X	
2				X	

Total Resistance 1 1004Ω
" " 2 1004·1Ω
" " 3

Linearity Type

Independent	Zero Based	Terminal Based	Absolute	Special
X				

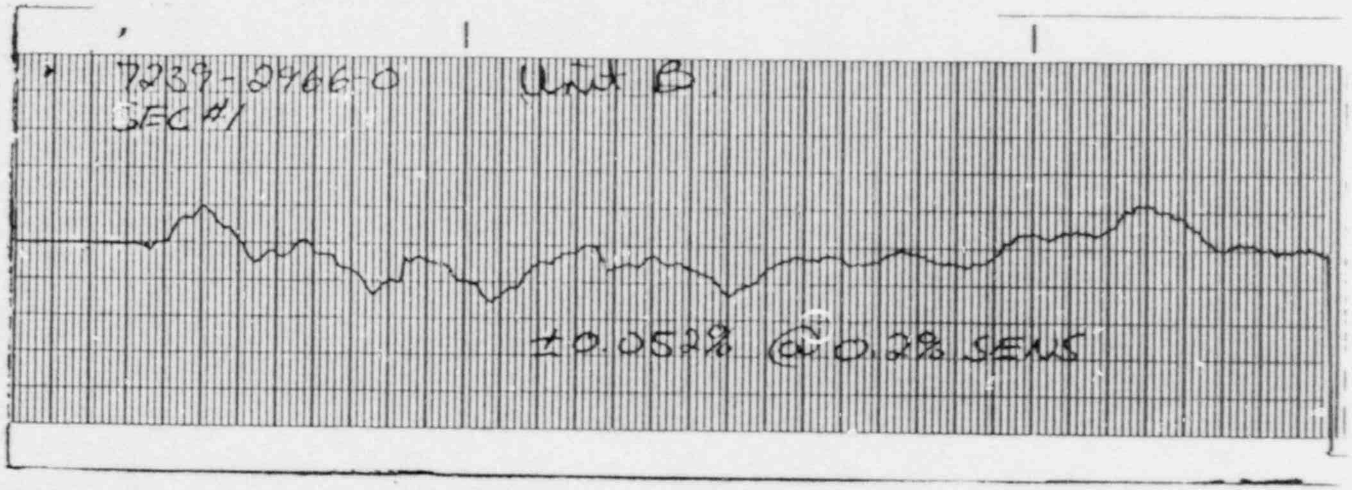
Linearity Error 1 ± 0·052%
" " 2 ±0·064%
Electrical Rotation 1 3599°45' ±
Electrical Rotation 2 3601° ±

Tap 1 7
" 2 8
" 3 9
" 4 10
" 5 11
" 6 12

Phasing Within 1° at ccw
Front Shaft Extn. 0.625
Rear " " N/A
Face Run-Out 0.003
Diameter Run-Out 0.0015
Shaft Run-Out 0.001
Shaft End Play 0.005
Radial Play 0.002
Starting Torque 10 MAX In. ozs.
Burrs ✓
Finish ✓
Other Features
Mechanical Rotation 5400°
Electrical Overtravel
as per spec

Inspected By C 101
Approved By

Form No. C/1-2


7239-2966-0
SEC #1
Unit B
±0.052% @ 0.2% SENS


7239-2966-0
SEC #2
±0.064% @ 0.22 SENS
CHART NO. 11-2012-22

Public Service™
Public Service Company of Colorado

Interoffice Memo

NDG-88-0208

Date March 10, 1988

To L. Marquez Department or Division

From J. Henderson Department or Division

Attn.

Subj. Lack of Radiation Specification in Letter #NDG-85-0081

While the radiation requirements are not specifically addressed, they were covered in discussions with the manufacturer. This does not appear to be a significant concern, as these components are prototypes only (not for permanent installation). The permanent plant components must have the 1 rad per hour specification included.

James G. Hend

J. G. Henderson

JGH/dh

APPENDIX I

MAINTENANCE INFORMATION

Public Service®

FORT ST. VRAIN NUCLEAR GENERATING STATION Page 1 of 29

PUBLIC SERVICE COMPANY OF COLORADO

TITLE: CRDOA PREVENT MAINTANENCE

DEPARTMENT: MAINTENANCE

RESPONSIBLE FOR				
AUTHORIZED BY				
PORC REVIEW	PORC 746 OCT 6 - 1987		EFFECTIVE DATE	10-9-87
DCCF NUMBER (S)	87-1012			

MQC Review J. JACKSON BY James W. OToole

Do not start test before________ Week # _____

and must be completed by________ Sch. Clerk

FORT ST. VRAIN
NON - CONTROLLED
COPY
VERIFY ISSUE
STATUS WITH
DOCUMENT CENTER
PRIOR TO USE
FORM 372-22-3587

FORM (D) 372 - 22 - 3642

5.46 IF inspection and/or test acceptance criteria(s) are not met,

THEN initiate SSR to refurbish components as required and indicate extent of refurbishment below.

SSR #_______________ N/A_______

Remarks___________________________

____

____

____

5.47 Replace orifice position potentiometer per approved procedure.

Procedure(s) used: _______________

____

NOTE: Rod potentiometer and limit switch replacement should be performed during drive train refurbishment, if refurbishment is required.

5.48 Replace rod position potentiometer per approved procedure.

Procedure(s) used: _______________

____

5.49 Replace slack cable, rod in, rod out, and rod retract limit switches (2 each) per approved procedure(s).

Procedure(s) used: _______________

____

_______________________ _______
Test Conductor Signature Date

** TOTAL PAGE.03 **

APPENDIX J

FAILURE STUDY OF RPI COMPONENTS
FROM COMMERCIAL OPERATION TO DATE

EVALUATION OF FAILURES OF ROD POSITION INDICATION COMPONENTS SUBSEQUENT TO COMMERCIAL OPERATION

By J. G. Henderson

February 7, 1988

REVIEW OF MAINTENANCE DATA*

DATE	COMPONENT	SER#	DISPOSITION
821229	In/Out	34	Type 1
811117	In	R4	Type 2
810325	Relay	16	Type 3A
791107	Retract	17	Type 3
811110	Pot	17	Type 3
791107	Retract	17	Type 3
791103	Analog Ind	25	Cleaned Meter Case
791114	Pot	27	Zero Pot Adjusted
810706	Pot	31	Type 1
821018	Pot	5	Type 3
800804	Pot	R23	Type 3
791107	In	1	Type 3(Assume In)
791109	In	17	Type 3
840217	In	19	Type 3(Assume In)
801031	Pot	27	Cancelled
840719	Slack	7	Not a Failure
821008	In	8	Type 1
840516	In	3	Type 1
830625	Pot	35	Type 3
790801	Pot	35	Type 2

No Failures 8507 thru 8802

Disposition Types:

1. Work description indicates no work required
2. Adjusted Component
3. Replaced Component
3A. Replaced component (mounted outside core)

Note: Sources of data include:

a) '79 thru '84 component tracking report #5597
b) '8507 thru '8802 data from system engineer

EVALUATION OF PERIOD BETWEEN FAILURES

DATE	COMP	SER#	MONTHS	HOURS(THOUSANDS)***
791107	In	1	---	---
791109	In	17	.066	8.9
800804	Pot	R23	9	1,216.2
811110	Pot	17	15	2,029.1
821018	Pot	5	11	1,486.5
830625	Pot	35	8	1,081.1
840217	In	19	8	1,081.1
8406XX	Misc	Misc	4	540.5*
8802XX	----	----	33	4,459.7**

* Multiple failures assumed to occur at same time (as the purpose of this document is to show period between failures, no benefit is gained by showing specific data)

** Calculated from July, 1985 (end of refurbishment)

*** Hours of availability/year = 365.25 x 24 hours x 37 rods x 5 components (Note 1)

Note 1 Five components is conservative as (2) rod-in and (2) rod-out switches are considered while the potentiometer (dual-gang) is considered as (1) component. The slack cable switches are not considered as no failure of this component has has ever occurred.

CONCLUSIONS

APPROX. AVERAGE NUMBER OF FAILURES PER CALENDAR YEAR:

POTS:<1

SWITCHES:<1

1) Some of the components which failed thru the years prior to and during the '84 incident were part of the original installation.

2) Multiple failures during June, 1984 point to the high probability of operator error. The operators (as observed and reported by the NRC) tended to overdrive the rods in an attempt at obtaining correct indication from nonoperational limit switches and thus damaged the potentiometers as well.

3) The zero failure rate from refurbishment of 1985 (approximately July) thru February 1988 shows that enhanced operator training in operation of the control rod drives has been effective. Furthermore, the availability of the new equipment for 4.5 million hours indicates the replacement parts have served well.

4) The reliability rate of the existing RPI system (based on a failure rate of 1 component per year) is:

$$\left(\frac{\text{1 failure per year}}{\text{37 rods x 5 components}}\right) = .005$$

Based on conclusion 2, above, 1984 failures are not included in failure calc as the data is not considered valid for the reason indicated.

APPENDIX K

FMEA OF NEW DESIGNS

FMEA of Proposed Replacement Sensors

(1) **Non-Contact Sensing for Full-In/Out Position**

Failure Modes Analyzed	Credible?	Comments
Jamming (mechanical)	No	Non-Contact, Double Nutted into place.
Sensor Failure	Yes	Per Mfr. Calc: MTBF @ 257°F = 2 million hrs/8766 hrs/yr = 228 yrs Life MTBF @ 300°F = 1.5 million hrs/8766 hrs/yr=171 yrs.

(2) **Extended Range Potentiometer**

Failure Modes Analyzed	Credible?	Comments
Jamming (Mechanical)	Yes	If rod is driven approx. 30% beyond Full-In or Full-Retract, the potentiometer will jam and fail like the existing component.
Galvanic Corrosion	No	All materials are isolated from the copper winding core.
Disparity in Output	No	.1% linearity .25% Tracking Phase 1 to Phase 2.

APPENDIX L

(REF. 1)

Preliminary report related to the restart and continued operation of Fort St. Vrain Nuclear Generating Station (excerpt from)

2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OCT 16 1984

G-84-392

Mr. R. F. Walker, President
Public Service Company of Colorado
P. O. Box 840
Denver, Colorado 80201

Dear Mr. Walker:

In early July I directed my staff, with assistance from Region IV, to perform an audit of Fort St. Vrain operations including problem areas associated with the June 23, 1984 event regarding the failure of a number of control rods to insert.

A preliminary report (copy attached) has been developed by the staff which documents the results of our assessment. The report contains findings that the staff believes should be implemented before and after station restart. These findings are contained in the Executive Summary and at the end of each section in the body of the report. The report is preliminary in that various options to solve staff's findings are available to the licensee and need to be discussed prior to final resolution.

Public Service Company of Colorado should review and evaluate the report and determine what followup actions are appropriate. We intend to schedule a meeting to discuss your proposed actions to resolve these findings and will be in contact with you to schedule such a meeting.

Sincerely,

HR Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc: See next page

~~8410240115~~ 4p

3 CONTROL ROD INSTRUMENTATION ANOMALIES

3.1 Introduction

On July 30, 1984, the NRC was informed of numerous and various control rod instrumentation anomalies in several refueling regions in the reactor. The eleven anomalies included: simultaneous rod-in and rod-out indications, out-limit switch lights remaining lighted, indications of partial rod withdrawal, no position signals, disparity between analog and digital rod position information, and a slack-cable indication. A team of NRC technical personnel and their consultants from Los Alamos National Laboratory, visited the plant site on August 1-3, 1984, to review the instrumentation problems.

This Section reports the results of that plant visit. This Section includes a description of the Control Rod Drive instrumentation characteristics and the anomalies observed, a preliminary evaluation of the anomalies and their effect on verifying control rod position, and recommendations. The results are included in the assessment report because they relate to the overall performance of the CRDMs.

3.2 Control Rod Instrumentation

As described in Section 2 of this report, the principal mechanical components of the CRDM are the shim motor and motor brake assembly, the reduction gearing to the cable drum, and the control rod pair suspended by cables from the drum. Integrated into the CRDM and used to determine control rod positions are the instrumentation-related components that include the rod position potentiometers, rod-in and rod-out limit switches, limit switch cams and gear reducer, and the slack-cable indication device. The relative locations of these components are shown on Figure 3.1.

The control rod potentiometers are intended to provide continuous monitoring of control rod position. As shown in Figure 3.2, both of the ten-turn, potentiometers are directly coupled to the rotation of the cable drum. The coupling is provided by connection of the potentiometer shaft to the cable drum hub. The potentiometer shaft passes through the drum support, and a pinion gear on the shaft drives the limit switch cam wheel. Beyond the pinion, a multi-jaw coupling drives the two potentiometers. Output from the potentiometers is provided to the operator through separate analog and digital readouts in the control room.

As previously mentioned, "rod-in" and "rod-out" position indication is provided by cam-actuated limit switches (the potentiometer shaft shown in Figure 3.2 also drives the cam wheel). At the full rod-in position, the cable anchor on the cable drum and the cam are at the 6 o'clock position, and both rod-in limit switches are actuated. Full rod travel (190 ± 1 inches) to the rod-out position causes the cam wheel to rotate clockwise 3/4 turn, actuating the pair of rod-out limit.switches. Limit switch actuation is indicated by steadily-lighted lamps in the control room.

The slack-cable switch assembly shown in Figure 3.3 is provided for monitoring the tension in the cables supporting the control rod pair. The spring plunger exerts an upward force on the underside of the cable drum spindle, which counteracts the downward force caused by the control rod weight. In the event a control rod cable becomes slack, the upward force overcomes the control rod weight, and microswitches are actuated. Slack cable indication is signalled in the control room by both an alarm and a light.

3.3 Control Rod Drive Instrumentation Review

In response to the information received about instrumentation anomalies the NRC staff and Los Alamos personnel reviewed the overall control rod assembly as it relates to control rod drive performance and control rod position indication. The team requested and received extensive, detailed information on the CRDM and interfacing instrumentation. The major items discussed were:

1. the instrumentation anomalies currently being experienced;

2. the CRDM mechanical interface to the rod position instrumentation, which includes the potentiometer drive gear and shaft acting as the

pinion for the cam wheel drive and the rod-in and rod-out limit switches, a multi-jaw coupling, and the two potentiometers; and

3. the electrical capabilities of the CRDM instrumentation to determine control rod position under normal and adverse conditions.

The instrumentation anomalies observed at the time of the plant visit are summarized in Table 3.1.

From a mechanical perspective, the CRDM instrumentation is indeed directly coupled to the motion of the cable drum, which dictates the movement of the control rods. However, under certain conditions, the mechanical aspects can actually inhibit the performance of the instrumentation. The common shaft controlling both the rod position potentiometers and the limit switches is susceptible to damage by overdriving the control rod pair past the rod-in position. This problem has been encountered when, for some reason, a given control rod pair, when supposedly fully inserted, may not actuate the rod-in limit switch. In an attempt to actuate the switch, the operator would typically try to overdrive the control rods to attain full insertion (even though the operation manuals (Ref. 1) strongly advise against such a maneuver). In this case, the in-limit cam can rotate past the in-limit switch, and the out-limit cam can rotate to interfere with other mechanical components resulting in damage to potentiometer shaft. This damage can occur because neither a positive stop is provided to restrict cam wheel overrotation nor is there sufficient clearance for the cam to overrotate. If the shaft is damaged by overtorquing or shearing, or the multi-jaw coupling is displaced, the two rod position potentiometers at the end of the shaft can give: the same erroneous signal about the actual position of the control rods on both readouts, different analog and digital outputs for the same rod position, or no output signals at all. On the other hand, if the control rods are overdriven by 1/4 turn of the cable drum (about 10 inches), the cable anchor can become wedged in the cable groove of the drum, and then upon withdrawal, the control rod cables may not feed onto the drum correctly, or can become entangled. It is clear that this type of integration of mechanical and instrumentation components can result in a single point failure, can potentially result in damage to the instrumentation, and does not provide an independent indication of control rod full-in position.

Discussions were held with the licensee regarding the electrical interfacing and control of the CRDM and instrumention. Electrical schematics from the "Rod Control System Equipment I-9303, Operation and Maintenance Manual", Ref. 1 and the "Installation, Operation and Maintenance Manual for the Control and Orificing Assembly for the Fort St. Vrain Reactor" Ref. 2, were reviewed by the staff. The licensee stated that none of the control and indication circuitry for the CRDM is classified as safety-related, except for the bypass circuitry used during a scram to energize the shim motor to drive in the control rods.

A number of questions were raised as to the effective redundancy in circuits such as rod-in and rod-out limit switch indications. According to the electrical schematic (Figure 3.4), the rod position limit switches may not be, in effect, redundant, because the loss of one switch of the pair is not detectable. In other words, a single circuit switch failure would go undetected. If this occurs the loss of the second switch will result in complete loss of full-in or full-out indication. The rod-in and rod-out limit switches are integrated into the mechanical aspects of the CRDM to the extent that the same switches are used for both rod drive control and rod position indication.

Purchase specifications were reviewed to determine how the CRDM instrumentation should be expected to perform in normal and adverse environmental conditions. That review indicated that all CRDM instrumentation is of commercial grade, and that no special quality or safety-related specifications are required. No housing or shielding is provided to protect CRDM instrumentation from the existing environment.

Under relatively normal operating conditions, such as just prior to the control rod insertion failure, control rod position instrumentation had been generally operable. Within two days after the control rod insertion failure, all control rods were exercised, and rod position instrumentation was operable. Some two weeks after the insertion failure event the core was depressurized. It was after the depressurization that the broad array of instrumentation anomalies were observed during subsequent control rod exercising. The staff, therefore, believes that the rod position instrumentation is quite likely to become unreliable when subjected to depressurization following exposure to a hot, moist environment. It is likely that condensation of moisture and wetting of electrical components occurred after reactor pressure was reduced.

The staff focused its attention on the specific problems regarding the CRDM located in Region 19, where both the analog and digital readouts indicated that the control rod was withdrawn about 40 inches. When asked if the instrumentation should be believed, the PSC responded that they did not believe the installed rod position readouts, but that they had verified to their satisfaction that the control rod was indeed fully inserted. This conclusion was based on signature traces from watt-meter testing of the shim motor. According to PSC, at some point after depressurization, the Region 19 control rod pair was being exercised, and when the rod pair was fully inserted, the rod-in limit switch indication did not come on. The operator drove the rod pair in further so as to make contact with the limit switch. Again, no contact was indicated. At some point during this attempt to get full rod-in indication, the 40-inch offset was noticed. Therefore, a watt-meter test was performed on the Region 19 shim motor. The wattage reading of the shim motor was recorded as the rod pair was "yo-yo-ed," i.e., a repetitive withdrawal and insertion sequencing. Based on past experience and the Region 19 traces, PSC concluded that the control rod pair was fully inserted. However, when the staff examined the Region 19 traces, the evidence was inconclusive. The inconclusive watt-meter traces in conjunction with analog/digital indications prompted the staff to request that a more definitive verification of the Region 19 control rod position be performed.

The verification technique selected by the licensee consisted of manually retracting the control rod pair from the region, as if in preparation for refueling removal--i.e., the control rods are completely drawn up into the refueling penetration housing. A completely separate limit switch, indicates full control rod retraction to the refueling position. If the control rod were completely inserted, then full retraction would require an additional 50 inches of travel over the normal 190 inches of rod travel (for a total of 240 inches) from the rod-in position, corresponding to a total of 330 turns of the manual rewind tool. On the night of August 2, 1984, the Region 19 control rod pair was withdrawn 330 turns when the full retract position indication was obtained, proving that indeed the rod had been fully inserted. However, it also demonstrated that the installed rod position instrumentation alone is insufficient to determine control rod positions under adverse conditions, such as when mechanical damage may have occurred to rod position instrumentation.

It is evident that control rod analog and digital position indications can be in agreement without reflecting the true rod pair position.

Statistically, no particular instrumentation anomaly [illegible] to be prevalent under these adverse circumstances. A summary of the current status of the control rod drives, instrumentation and orificing, as prepared by PSC, shows that the anomalies tend to be evenly distributed among rod limit switching problems, digital and/or analog readout problems from rod position potentiometers, with the exception of the single slack-cable related problem. This pattern is in contrast to the historical distribution, where rod position potentiometer problems had been dominant. In reviewing past instrumentation anomalies as recorded on PTRs (Plant Trouble Report) since plant startup, approximately 47% of the anomalies are rod position petentiometer problems, about 17% are limit-switch related, less than 2% are related to slack-cable indication, 17% are connected to orifice valve problems that are not germaine to this review, and 19% are related to motor/brake and other anomalies. In a majority of the cases, the "faulty" component was simply replaced.

3.4 SUMMARY

In general, the instrumentation anomalies are believed to be the result of mechanical damage or exposing the CRDMs to a hot, moist atmosphere and a subsequent core depressurization. As stated in Ref. 1, proper CRDM and instrumentation performance requires maintaining purge flow into the CRDM cavity, and maintaining drive mechanism temperatures below 250°F. Loss of purge flow certainly contributed to the ingress of moist helium into the CRDM cavities. The effects of depressurization on instrumentation performance are not well understood, but there is significant evidence that depressurization in conjunction with a moist environment can tend to increase instrumentation problems. These problems are likely caused by condensation of moisture on electrical components. In contrast, the Region 19 instrumentation anomalies were most likely caused by overdriving the control rods, thereby damaging the potentiometer shaft, and resulting in ambiguous and erroneous position instrumentation readings.

3.5 CONCLUSIONS

The following conclusions are based on the possibility of unreliable performance of the CRDM rod position instrumentation under adverse conditions and/or mechanical damage from overdriving, questions concerning instrumentation redundancy, and the lack of independent rod full-in position verification.

The staff has determined that the following actions must be completed prior to restart:

1. To prevent CRDM damage and to protect rod position potentiometers and limit switches, plant procedures should be changed to prevent overdriving the control rods past the rod-in limit (yo-yo-ing).

2. Periodic surveillance of rod position potentiometers and switches should be developed and implemented in interim procedures and be proposed for inclusion in the plant Technical Specifications. This surveillance should include verification of limit switch operability and confirmation that redundancy has not been lost.

The following actions should be taken in the long-term:

1. Damage due to overtravel should be precluded either by the installation of a positive mechanical stop or by providing sufficient clearance to prevent damage.

2. An appropriate, independent and definitive means of verification of control rod full-in position should be provided because the installed rod position instrumentation can be inadequate to verify control rod position. In the present form, Watt-meter testing of the shim motor is considered inadequate to verify full insertion of control rods. It is therefore concluded that the Watt-meter method be refined or an alternate method be developed to achieve sufficient resolution of rod position and then formalized into a plant procedure.

3. Conduct an integrated systems study to resolve rod position indication maintenance and operability questions.

3.6 REFERENCES

1. "Installation, Operation, and Maintenance Manual for the Control and Orificing Assembly for the Fort St. Vrain Reactor", GA-9806, May 1977

2. "Rod Control System Equipment I-9303. Operation and Maintenance Manual", E-115-265 (REV. 3), August 1979.

Table 3.1 Current CRDM and Instrumentation Anamalies

CRDM No.	Current Region	Instrumentation Problem
6	1	1 of 2 rod-out limit switches inoperable.
12	15	Incorrect Control Room (CR) analog position indication.
13	19	Faulty rod-in limit switch, incorrect CR analog and digital indication.
25	7	Faulty slack-cable switch.
26		Faulty rod-out switch.
29	ESW5*	Faulty rod-out switch.
33	16	Faulty analog position indication.
37	3	Faulty rod-out switches.
39	23	Incorrect CR analog position indication, faulty rod-in limit switch.

* Equipment Storage Well

APPENDIX M

(REF. 2)

Evaluation of integrated systems study of control rod drive mechanism position indication instrumentation for the Fort St. Vrain Nculear Generating Station.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 31, 1987

G-87262
Recd. 8-10-87

Docket No. 50-267

Mr. R. O. Williams, Jr.
Vice President, Nuclear Operations
Public Service Company of Colorado
P. O. Box 840
Denver, Colorado 80201-0840

Dear Mr. Williams,

SUBJECT: EVALUATION OF INTEGRATED SYSTEMS STUDY OF CONTROL ROD DRIVE MECHANISM POSITION INDICATION INSTRUMENTATION FOR THE FORT ST. VRAIN NUCLEAR GENERATING STATION (TAC NO. 62198)

We have completed our review of your submittal dated August 15, 1986 (P-86522), which contained an integrated systems study of the control rod drive mechanism (CRDM) position instrumentation at Fort St. Vrain (FSV). This review was performed by our contractor EG&G, Idaho, Inc. Their Technical Evaluation Report (TER) is enclosed.

The staff has reviewed this TER and concurs with the EG&G, Idaho, Inc. conclusion that Public Service Company of Colorado has not provided an acceptable proposal to upgrade the control rod position instrumentation system for Fort St. Vrain. Section 4 of the TER gives the reasoning for this conclusion. We are forwarding this TER to you to allow for another proposal for the upgrading of the control rod position instrumentation system.

We request that you provide a new schedule for completing this proposal within 30 days of the date of this letter. The new proposal should be provided within the following 120 days after your schedule is established.

The information request in this letter affects fewer than 10 respondents; therefore OMB clearance is not required under P.L. 96-511.

Sincerely,

Kenneth L. Heitner

Kenneth L. Heitner, Project Manager
Project Directorate - IV
Division of Reactor Projects - III,
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As stated

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EGG-NTA-7705
May 1987

Enclosure

Idaho
National
Engineering
Laboratory

Managed
by the U.S.
Department
of Energy

INFORMAL REPORT

EVALUATION OF INTEGRATED SYSTEMS STUDY OF CONTROL ROD DRIVE MECHANISM ROD POSITION INDICATION INSTRUMENTATION FOR THE FORT ST. VRAIN NUCLEAR GENERATING STATION

D. E. Jackson
C. L. Nalezny

EG&G Idaho

*Work performed under
DOE Contract
No. DE-AC07-76ID01570*

Prepared for the

U.S. NUCLEAR REGULATORY COMMISSION

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EGG-NTA-7705

EVALUATION OF INTEGRATED SYSTEMS STUDY OF CONTROL ROD DRIVE MECHANISMS ROD POSITION INDICATION INSTRUMENTATION FOR THE FORT ST. VRAIN NUCLEAR GENERATING STATION

Docket No. 50-267
TAC No. 62198

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ABSTRACT

This EG&G Idaho, Inc., report presents the results of an evaluation of an integrated systems study (engineering evaluation) of the control rod drive mechanism rod position indication instrumentation for the Fort St. Vrain Nuclear Generating Station which was submitted to the Nuclear Regulatory Commission (NRC) by the licensee, Public Service of Colorado (PSC). The evaluation by EG&G Idaho, Inc., concludes that PSC has not complied with the NRC directive to prepare an engineering evaluation of the problems experienced with the control rod drive rod position indication because it does not adequately address the problems that were experienced at the Fort St. Vrain Nuclear Generating Station, and does not propose acceptable component replacements. In addition, the proposed replacement instruments that are important to safety (full-in limit swithch and rod position potentiometer) do not comply with the quality standard and instrumentation requirements of General Design Criteria No. 1 and 13 of Appendix A to 10CFR50.

Docket No. 50-267
TAC No. 62198

FOREWORD

This report is supplied as part of the "Review of Plant Specific Licensing Actions for Operating Reactors," Task 1-14 being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of PWR Licensing-B, by EG&G Idaho, Inc., NRR and I&E Support Branch.

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Docket No. 50-267
TAC No. 62198

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EVALUATION OF INTEGRATED SYSTEMS STUDY OF CONTROL ROD DRIVE MECHANISMS ROD POSITION INDICATION INSTRUMENTATION FOR THE FORT ST. VRAIN NUCLEAR GENERATING STATION

1.0 BACKGROUND

Following a scram on the morning of June 23, 1984, at the Fort St. Vrain Nuclear Generating Station (FSV), 6 of 37 rod pairs failed to scram. As a result of this event, the Director of Nuclear Reactor Regulation (NRR) ordered that an audit of the overall operation of FSV be performed. This audit was to include problem areas associated with the June 23 scram.

The Control Rod Drive Mechanism (CRDM) is comprised of the shim motor and motor brake assembly, the gear reduction to the cable drum and the control rod pairs suspended by cables from the drum. Instrumentation-related components, integrated into the CRDM, used to determine control rod positions include the rod position potentiometers, rod-in and rod-out limit switches, limit switch cams and gear reducers, and the slack-cable indication devices.

On July 30, 1984, the NRC was informed of numerous and varied control rod instrumentation anomalies in several refueling regions in the reactor (Refence 1, section 3.1). The eleven anomalies included: simultaneous rod-in and rod-out indication, out-limit switch lights remaining lighted, indications of partial rod withdrawal, no position signals, disparity between analog and digital rod position information, and slack cable indication.

The results of the NRC audit were documented in a preliminary report which was issued on October 16, 1984, (Reference 1). The report contains findings to be addressed both before and after plant restart. The NRC staff noted that a number of deficiences need to be corrected on a long-term basis following restart. The licensee was directed to submit schedules within 60 days of restart for completing these items. One of the items listed under "Actions Required Following Restart" is "Conduct an integrated systems study (engineering evaluation) to resolve rod position indication, maintenance and operability questions."

On August 15, 1986, Public Service Company of Colorado (PSC) issued a report entitled "Integrated Systems Study (Engineering Evaluation EE-12-0013) of the Control Rod Drive Mechanism Rod Position Indication Instrumentation" (Reference 2). This Engineering Evaluation by PSC was in response to the requirement listed in Section 4.e of the Executive Summary of Reference 1, and is the subject of this staff evaluation.

2. DESIGN BASIS CRITERIA

The following General Design Criteria (GDC) of Appendix A to 10 CFR 50 were applied to the evaluation of the Fort St. Vrain Integrated Systems Study of Control Rod Drive Mechanisms Rod Position Indication instrumentation.

Criteria 1 - Quality Standards and Records. Structures, systems, and components important to safety shall be designed, fabricated, erected and tested to quality standards commenserate with the importance of the safety function to be performed.

Criteria 13 - Instrumentation and Control. Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

3. EVALUATION

The PSC response to the NRC preliminary report, specifically addresses the requirement for an integrated systems study (engineering evaluation) to resolve rod position indication (RPI) maintenance and operability questions. It was issued in the form of an Engineering Evaluation (EE-12-0013) and documents the evaluation of several active and passive electrical components in the RPI system to identify any potential design deficiencies. These components included the control rod-pair full-in and full-out limit switches, slack cable limit switches and rod-pair position potentiometers. In addition the associated lights and meters in the control room were evaluated. The EG&G evaluated the integrated systems study by PSC to determine if the root causes of the anomolies had been identified, if PSC had proposed design changes that would correct them, and if the proposed design changes were in compliance with General Design Criteria (GDC) 1 and 13. The results of the EG&G evaluation follow.

3.1 Control Rod-Pair Full-In and Full-Out Limit Switches

The most common problem observed with the full-in and full-out limit switches was pitting, errosion and corrosion of the switch shafts which caused binding of the switchs which resulted in inaccurate indications in the control room. PSC stated that the pitting and erosion of the shafts, and the deposition of shaft metal on switch housings was due to the high angle at which the actuating cams contact the switch shafts exerting excessive lateral force on the shaft thereby causing binding and or breakage of the switch.

The conclusion that the high angle of the cams is responsible for the high lateral loads which caused the switches to bind is not supported. The NRC preliminary report stated that the instrumentation anomalies are believed to be the result of mechanical damage or exposure of the CRDMs to a hot, moist atmosphere and a subsequent core depressurization which resulted in condensation of moisture. It is very likely that moisture caused pitting of the plunger and contributed to the failure of the rod position instrumentation. The study by PSC does not include an evaluation of corrosion of the switch components, and the effect corrosion would have on the mechanical operation of the switches.

PSC proposes to replace these switches with proximity sensors which are specially designed for their application and environment. This is an acceptable solution if the sensors are designed to satisfy appropriate functional, and operational requirements, and are qualified for the environment in which they must operate. However, the statements "designed for FSV's application and environment" and "capable of operation at several hundred degrees Fahrenheit above the requirements" are vague and do not adequately specify the operating conditions and functional requirements for the design, fabricaton, and procurement of the sensors.

The full-in limit indications can be classified "important to safety" because they are the primary means of verifying that the control rod drives (CRDs) have fulfilled their reactor scram safety function. The proposed changes to the full-in limit switch does not comply with the design standards requirement of GDC 1, or the instrumentation requirement of GDC 13.

The concern that the out-limit cam being overdriven and damaging the potentiometer shaft is not addressed in the PSC engineering evaluation (Reference 2). It is stated that, "targets for the sensors will be provided by replacing the existing cams with stainless steel cubes. These targets are the same size as the existing cams and will not cause any new mechanical interference problems." They will therefore have the same potential to damage the potentiometer drive coupling and shaft, due to overdriving, as the original cams. It is stated that administrative limits have been imposed to prevent overdriving the system. However, if it is still necessary to provide replacement potentiometers with additional turns to avoid being damaged when overdriven, it should also be necessary to address the fact that the stainless steel targets will damage the potentiometer shafts when the system is overdriven.

Since the analog position indicators are "important to safety," the out-limit cam must be designed so that overdriving it will not damage the potentiometer shaft, or so that they can not be overdriven.

Therefore, it is concluded that PSC has not performed a satisfactory engineering evaluation of the problems associated with the full-in/full-out switches, has not proposed solutions which will correct the problems, and has not complied with the requirements of GDC 1 and 13.

3.2 Slack-Cable Limit Switches

In Reference 2, PSC states that the engineering evaluation of the slack-cable limit switches revealed no known failures and the switch manufacturer confirmed this to be an acceptable application of the switch. However, the list of anomalies in section 3.1 and table 3.1 (Reference 1) indicate a slack-cable switch failure which was not addressed by the licensee. The statement that the manufacturer confirmed this to be an acceptable application of this switch is not acceptable because it does not resolve the question of why the switch failed. The engineering evaluation should have included a comparison of the design requirements for the switch with the known operating conditions to determine if the failure was design, fabrication, or maintenance related. Therefore, it is concluded that PSC has not performed a satisfactory engineering evaluation of the slack-cable limit switches and has not proposed any solution to correct the problem.

3.3 Position Potentiometers

The engineering evaluation of the position potentiometers by PSC revealed that resistivity changes were caused by moisture intrusion into the case and that driving these potentiometers past their limits had caused broken bodies and drive gears. The changes in resistivity caused some measurement uncertainty. Section 3.3.3 of the NRC preliminary report (Reference 1) states that overdriving the potentiometers can result in the out-limit cam rotating around to the point that it can interfere with and cause damage to the potentiometer shaft coupling.

PSC proposes to replace these potentiometers with new ones specifically designed and fabricated for this application. The replacement potentiometers are to be built with a 10 turn electrical section centered on a 15 turn mechanical section and mounted the same as the Bechman Model 7603s which are currently used. These and other specifications are included in "Specification for Prototype Potentiometers," Appendix D, of Ref. 2. The proposed replacement potentiometers are an improvement. However, because they provide the operator with continuous position information for all the rods during operation and following a scram, they are considered "important to safety." Therefore, they must be designed, fabricated and procurred to the requirements of the appropriate GDCs. The specifications for the potentiometers presented in Reference 2 are appropriate for a commercial grade component, but did not comply with the quality standards and reporting requirements of GDC 1, which are necessary for a component that must comply with GDC 13. For instance, the requirements for a quality assurance program were not called out. Environmental conditions such as minimum and maximum temperatures, and maximum moisture content of the Helium atmosphere were not specified. If PSC procures commercial grade potentiometers for this application, they should develop a formal program to qualify the components. In developing the qualification program, PCS should apply the applicable guidance contained in Chapters 3.11 and 4.6 of the NRC Standard Review Plan (Reference 3) which deal with environmental qualification of mechanical and electrical equipment, and the functional design of control rod drive systems.

3.4 Results of Evaluation of Proposed Control Rod Drive Temperature Limits

Since the RPI instrumentation is an integral part of the CRDM, it is subject to the same design and functional requirements as the CRDMs. In this context, reference is made to the NRC Safety Evaluation Report (SER), dated December 24, 1987 (Reference 4). Reference 4 is an evaluation of a PSC proposal to increase the operating temperature limits of the FSV Control Rod Drive and Orifice Assemblies (CRDOAs) to 300°F. The findings and deficiencies identified in Reference 4 are generally applicable to the CRDM rod position instumentation. The operating environment of the CRDMs and the rod position instrumentation is the same. Therefore, the important to safety instrumentation should be subject to the same requirements. The deficiencies in the CRDM submittal (Reference 4) that are applicable to the safety related rod position instrumentation are listed below.

1. PSC did not provide acceptance criteria developed from the functional, operational and design specifications against which to evaluate the proposal.

2. PSC did not provide information on the mechanical and electrical properties of materials in the RPI components as a function of temperature, humidity, pressure, and radiation.

3. PSC did not address maintenance of RPI instrumentation.

4. CONCLUSIONS

The licensee for the Fort St. Vrain Nuclear Power Station, Public Service of Colorado, has not provided an acceptable proposal to upgrade a selected number of Control Rod Position Instrumentation Systems. The rational for this conclusion is given below.

The submittal was reviewed for compliance with the NRC requirement that PSC conduct an integrated systems study to resolve rod position indication maintenance and operability questions, and the applicable requirements of the General Design Criteria (Appendix A to 10 CFR 50) for "important to safety" instrumentation.

① The licensee did not perform a thorough evaluation of the failures that were identified in the NRC preliminary report. ② The contribution of corrosion of the full-in limit switches was not evaluated, ③ the design of the relacement targets for the full-in/full-out limit switches did not consider the potential for damaging the rod position potentiometers when the control rods are overdriven, ④ the failure of the slack cable limit switches was not evaluated, and ⑤ the specification for the replacement rod position potentiometers did not include all the environmental conditions that the components could be exposed to and did not define how the potentiometers would be qualified. In addition, ⑥ the proposed replacement instruments that are important to safety (full-in limit switch and rod position potentiometer) did not comply with the quality standard and instrumentation requirements of GDC 1 and 13 of Appendix A to 10 CFR 50.

4.0 REFERENCES

1. NRC Letter, Denton to Walker, Preliminary Report Related to Restart and Continued Operatin of Fort St. Vrain Nuclear Generating Station, (G-84392) dated October 16, 1984.

2. PSC Letter, Warembourg to Berkow, Fort St. Vrain Rod Position Instrumentation Integrated Systems Study, (P-86522) dated August 15, 1986.

3. U. S. Nuclear Regulatory Commission, Standard Review Plan, NUREG-0800, Rev. 2, July 1981.

4. NRC letter, Heitner to Williams, Control Rod Drive and Orifice Assembly 300°F Temperature Limits Fort St. Vrain Nuclear Generating Station, G-86664, December 24, 1986.

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13. ABSTRACT (200 words or less)

This EG&G Idaho, Inc., report presents the results of an evaluation of an integrated system study (engineering evaluation) of the control rod drive mechanism rod position indication instrumentation for the Fort St. Vrain Nuclear Generating Station which was submitted to the Nuclear Regulatory Commission (NRC) by the licensee, Public Service of Colorado (PSC). The evaluation by EG&G Idaho, Inc., concludes that PSC has not complied with the NRC directive to prepare an engineering evaluation of the problems experienced with the control rod drive rod position indication because it does not adequately address the problems that were experienced at the Fort St. Vrain Nuclear Generating Station, and does not propose acceptable component replacements. In addition, the components of the rod position instrumentation that are "important to safety," are not in compliance with General Design Criteria 1 and 13 of Appendix A to 10 CFR 50.

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