Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

March 10, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Zion Station Units 1 and 2
Response to Generic Letter 82-28
"Inadequate Core Cooling
Instrumentation System"
NRC Docket Nos. 50-295 and 50-304

Reference (a): December 10, 1982, letter from
D. G. Eisenhut to All Operating
Westinghouse and CE PWR's.

Dear Mr. Denton:

Reference (a) transmitted the subject Generic Letter and requested additional information pursuant to 10 CFR 50.54(f). The attachments to this letter provide Commonwealth Edison's response for Zion Station. The following attachments are provided:

Attachment A - References
Attachment B1 - Response to Item 1
Attachment B2 - Response to Item 2
Appendix B2.1 - Table for Subcooling Margin Monitor
Appendix B2.2 - Table for RVLIS
Appendix B2.3 - Table for Core-Exit Thermocouples
Addendum B2.3.1 - Additional Material on Thermocouples.

To the best of my knowledge and belief the statements contained herein and in the attachments are true and correct. In some respects these statements are not based on my personal knowledge but upon information furnished by other Commonwealth Edison and contractor employees. Such information has been reviewed in accordance with Company practice and I believe it to be reliable.

One (1) signed original and forty (40) copies of this letter and ten (10) copies of the attachments are provided for your use.

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PDR ADOCK 05000295
P PDR

Please address any questions you may have concerning this matter to this office.

Very truly yours,

F. G. Lentine

F. G. Lentine
Nuclear Licensing Administrator

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Attachments

SUBSCRIBED and SWORN to before me this 10th day of March, 1983

Rosalie A. Pinta
Notary Public

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ATTACHMENT A

Zion Station Units 1 and 2

Response to Generic Letter 82-28

References

Commonwealth Edison:

(1) October 18, 1979, letter from Cordell Reed to D. G. Eisenhut.
(2) November 21, 1979, letter from Cordell Reed to H. R. Denton.
(3) January 1, 1980, letter from D. L. Peoples to H. R. Denton.
(4) February 22, 1980, letter from D. L. Peoples to H. R. Denton.
(5) April 1, 1981, letter from J. S. Abel to D. G. Eisenhut.
(6) July 30, 1981, letter from L. O. DelGeorge to D. G. Eisenhut.
(7) December 15, 1981, letter from E. D. Swartz to D. G. Eisenhut.
(8) March 1, 1982, letter from E. D. Swartz to D. G. Esienhut.
(9) March 23, 1982, letter from F. G. Lentine to D. G. Eisenhut.
(10) March 24, 1982, letter from E. D. Swartz to D. G. Esienhut.
(11) June 21, 1982, letter from F. G. Lentine to D. G. Eisenhut.
(12) March 10, 1983, letter from F. G. Lentine to H. R. Denton.

NRC:

(13) March 29, 1980, letter from A. Schwencer to D. L. Peoples.
(14) NUREG/CR 2628

Westinghouse:

(15) WCAP 9754
(16) December 9, 1981, letter (NS-EPR-2526) from P. Rahe to L. E. Phillips.
(17) January 13, 1982, letter (NS-EPR-2542) from P. Rahe to L. E. Phillips.
(18) June 28, 1982, letter (SED-SA-0081) from P. Rahe to L. E. Phillips.

Westinghouse Owners Group

(19) November 30, 1981, letter (OG-64) from R.W. Jurgenson to D. G. Eisenhut.
(20) January 4, 1983, letter (OG-83) from O.D. Kingsley to D. G. Eisenhut.
(21) February 17, 1983, letter from J.J. Sheppard to D. G. Eisenhut.

ATTACHMENT B1

Zion Station Units 1 and 2

Response to Generic Letter 82-28

Item 1

> "Within 90 days of the date of this letter, identify to the Director, Division of Licensing, the design for the reactor coolant inventory system selected and submit to the Director, Division of Licensing, detailed schedules for its engineering, procurement, and installation. References to generic design descriptions and to prior submittals containing the required information, where applicable, are acceptable."

Response

Descriptions of our design for the reactor coolant inventory tracking system have been provided in references (1), (3), (5), (6), and (8). As described in reference (6), the system is the generic Westinghouse Reactor Vessel Level Instrumentation System (RVLIS), with certain exceptions. The exceptions are the result of the fact that, in a good faith effort to meet the original installation date specified in NUREG-0578 of January 1, 1981, Commonwealth Edison proceeded with the design and installation of a system in advance of the development of the final Westinghouse generic design. The Zion systems were made operational (in order to gain experience in how the device responds, but not as a basis for operator decisions) on Unit 2 in the Fall, 1980, and on Unit 1 in Spring, 1981.

References (7), (9) and (11) described how the RVLIS systems were removed from service following the occurrence of a high pressure fitting leak on Unit 2 in November, 1981. This leak resulted in damage to control rod drive mechanisms that required a ten day extension of the Unit 2 refueling outage. A review of the design of the high pressure RVLIS connections was undertaken, with the objective of identifying modifications that could be made to reduce the susceptibility of the system to leaks. Design of these modifications (see reference (11)) has been completed, and installation is scheduled for the Spring and Fall, 1983, refueling outages for Units 2 and 1, respectively. Following the completion of these modifications, the RVLIS systems will be capable of being returned to service, as desired, for continued testing.

As stated in reference (6), the major difference between the Zion and the generic Westinghouse systems is the fact that the differential pressure transmitters were installed inside containment for the Zion system. (The hydraulic isolators that were later designed to permit transmitters to be located outside containment were not available at the time of installation of the Zion systems.) As described in reference (8), locating the transmitters inside containment results in the potential for environmentally-induced inaccuracies in the event of adverse containment conditions. Commonwealth Edison is investigating the possibility of obtaining environmentally qualified transmitters for this application. Based on the assumption that a suitable transmitter can be obtained, and consistent with practical design and procurement considerations, it is our expectation that the new transmitters will be available for installation in the 1985 refueling outages.

Generic Letter 82-28 instructed licensees <u>not</u> to turn on the ICC instrumentation system until the task analysis portion of the Control Room Design Review has been completed and instructions in its use and operation have been incorporated in accordance with the Emergency Operating Procedure Guidelines into approved procedures. Detailed schedules for the Control Room Design Review and the implementation of the Emergency Operating Procedure Guidelines are now being prepared in response to Generic Letter 82-33, "Supplement 1 to NUREG-0737". (These schedules will be addressed in our April 15, 1983, response.) Based on our preliminary review, these two efforts are expected to be completed sometime in 1985.

RVLIS will be made fully operational, then, following the NRC's review and approval of (1) the Zion-specific RVLIS design, (2) the Control Room Design Review, and (3) the Emergency Operating Procedure Guidelines related to its use.

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ATTACHMENT B2

Zion Station Units 1 and 2

Response to Generic Letter 82-28

Item 2

"Within 90 days of the date of this letter review the status of conformance of all components of the ICC instrumentation system, including subcooling margin monitors, core-exit thermocouples, and the the reactor coolant inventory tracking system, with NUREG-0737, Item II.F.2, and submit a report on the status of such conformance."

Response

Commonwealth Edison has reviewed the status of the components of our ICC instrumentation system with respect to conformance with NUREG-0737. The tables that follow have been constructed from the checklists of Generic Letter 82-28.

In general, the instrumentation was designed with consideration of the recommendations of NUREG-0737, Appendix B, "Design and Qualification Criteria for Accident Monitoring Instrumentation." Specific details of our designs have been identified in the references cited. It should be noted that in accordance with the guidance of NUREG-0737, Appendix B, Commonwealth Edison installed the "best available equipment" in an effort to meet the implementation dates specified in NUREG-0737. Other than the items specifically identified in this transmittal (RVLIS differential pressue transmitters and core-exit thermocouple system), further upgrading of these systems is not contemplated.

APPENDIX B 2.1

Subcooling Margin Monitor

Checklist
for Plant Specific Review of
Inadequate Core Cooling (ICC) Instrumentation System

For Zion Units 1 and 2 **Docket No.** 50-295
50-304

Operated by: Commonwealth Edison Company

The following items for review are taken from NUREG-0737, pp II.F.2-3, and 4. Responses should be made to full requirements in NUREG-0737, not abbreviated forms below. Applicants should provide reference to either the applicant's submittal or the generic description under the column labled "Reference." These items are required to be reviewed on a plant specific basis by NUREG-0737 for all plants. Differences from the generic descriptions provided by Westinghouse, the Westinghouse Owner's Group, Combustion Engineering, or Combustion Engineering Owner's Group must be indicated by "yes or no" in the column labled deviations and must be justified. Under the Column labeled schedule, either indicate that your documentation of the item is complete or provide a proposed schedule for your submittal.

	Reference	Deviations	Schedule
1. Description of the proposed final system including: a. a final design description of additional instrumentation and displays; b. detailed description of existing instrumentation systems. c. description of completed or planned modifications.	(1), (2), (3), (4), (6), (13)		Completed
2. A design analysis and evaluation of inventory trend instrumentation, and test data to support design in item 1.	Not applicable		
3. Description of tests planned and results of tests completed for evaluation, qualification, and calibration of additional instrumentation.	Not applicable		

4. Provide a table or description covering the evaluation of conformance with NUREG-0737: II.F.2, Attachment 1, and Appendix B (to be reviewed on a plant specific basis)*	See Page 3.
5. Describe computer, software and display functions associated with ICC monitoring in the plant.	See item 1.
6. Provide a proposed schedule for installation, testing and calibration and implementation of any proposed new instrumentation or information displays.	Installation Completed.
7. Describe guidelines for use of reactor coolant inventory tracking system, and analyses used to develop procedures.	Not applicable
8. Operator instructions in emergency operating procedures for ICC and how these procedures will be modified when final monitoring system is implemented.	(19), (20), (21) Schedule by 4/15/83
9. Provide a schedule for additional submittals required**	See item 8.

*II.F.2 Attachment 1 (for Core Exit Thermocouples)

In response to item 4 in the above checklist, the following materials should be included to show that the proposed system meets the design and qualification criteria for the core exit thermocouple system.

1. Provide diagram of core exit thermocouple locations or reference the generic description if appropriate.
2. Provide a description of the primary operator displays including:
   a. A diagram of the display panel layout for the core map and description of how it is implemented, e.g., hardware or CRT display.
   b. Provide the range of the readouts.
   c. Describe the alarm system.
   d. Describe how the ICC instrumentation readouts are arranged with respect to each other.
3. Describe the implementation of the backup display(s) (including the subcooling margin monitors), how the thermocouples are selected, how they are checked for operability, and the range of the display.
4. Describe the use of the primary and backup displays. What training will the operators have in using the core exit thermocouple instrumentation? How will the operator know when to use the core exit thermocouples and when not to use them? Reference appropriate emergency operating guidelines where applicable.

5. Confirm completion of control room design task analysis applicable to ICC instrumentation. Confirm that the core exit thermocouples meet the criteria of NUREG-0737, Attachment 1 and Appendix B, or identify and justify deviations.

6. Describe what parts of the systems are powered from the 1E power sources used, and how isolation from non-1E equipment is provided. Describe the power supply for the primary display. Clearly delineate in two categories which hardware is included up to the isolation device and which is not.

7. Confirm the environmental qualification of the core exit thermocouple instrumentation up to the isolation device.

Appendix B (of NUREG-0737, II.F.2)

Confirm explicitly the conformance to the Appendix B items listed below for the ICC instrumentation, i.e., the SMM, ~~the reactor coolant inventory tracking system, the core exit thermocouples and the display systems~~.

	Reference	Deviations
1. Environmental qualification	(4)	
2. Single failure analysis	(4)	
3. Class 1E power source	(4)	
4. Availability prior to an accident	(4)	
5. Quality Assurance	(4)	
6. Continuous indications	(4)	
7. Recording of instrument outputs	(4)	
8. Identification of instruments	(4)	
9. Isolation	(4)	

APPENDIX B.2.2

RVLIS
Checklist
for Plant Specific Review of
Inadequate Core Cooling (ICC) Instrumentation System

For Zion Units 1 and 2 **Docket No.** 50-295
50-304

Operated by: Commonwealth Edison Company

The following items for review are taken from NUREG-0737, pp II.F.2-3, and 4. Responses should be made to full requirements in NUREG-0737, not abbreviated forms below. Applicants should provide reference to either the applicant's submittal or the generic description under the column labled "Reference." These items are required to be reviewed on a plant specific basis by NUREG-0737 for all plants. Differences from the generic descriptions provided by Westinghouse, the Westinghouse Owner's Group, Combustion Engineering, or Combustion Engineering Owner's Group must be indicated by "yes or no" in the column labled deviations and must be justified. Under the Column labeled schedule, either indicate that your documentation of the item is complete or provide a proposed schedule for your submittal.

	Reference	Deviations	Schedule
1. Description of the proposed final system including: a. a final design description of additional instrumentation and displays; b. detailed description of existing instrumentation systems. c. description of completed or planned modifications.	(1), (3), (5), (6), (8), (12)	yes See Ref. (6)	Report on Xmtr upgrade prior to installation
2. A design analysis and evaluation of inventory trend instrumentation, and test data to support design in item 1.	(8), (14), (15) (16), (17), (18)		Completed
3. Description of tests planned and results of tests completed for evaluation, qualification, and calibration of additional instrumentation.			See item 2.

4. Provide a table or description covering the evaluation of conformance with NUREG-0737: II.F.2, Attachment 1, and Appendix B (to be reviewed on a plant specific basis)*	See page 3.	
5. Describe computer, software and display functions associated with ICC monitoring in the plant.	See item 1.	
6. Provide a proposed schedule for installation, testing and calibration and implementation of any proposed new instrumentation or information displays.	(12)	Completed
7. Describe guidelines for use of reactor coolant inventory tracking system, and analyses used to develop procedures.	(19), (20) (21)	Completed
8. Operator instructions in emergency operating procedures for ICC and how these procedures will be modified when final monitoring system is implemented.	(19), (20) (21)	Schedule by 4/15/83
9. Provide a schedule for additional submittals required**	See items 1 and 8.	

*II.F.2 Attachment 1 (for Core Exit Thermocouples)

In response to item 4 in the above checklist, the following materials should be included to show that the proposed system meets the design and qualification criteria for the core exit thermocouple system.

1. Provide diagram of core exit thermocouple locations or reference the generic description if appropriate.

2. Provide a description of the primary operator displays including:

   a. A diagram of the display panel layout for the core map and description of how it is implemented, e.g., hardware or CRT display.
   b. Provide the range of the readouts.
   c. Describe the alarm system.
   d. Describe how the ICC instrumentation readouts are arranged with respect to each other.

3. Describe the implementation of the backup display(s) (including the subcooling margin monitors), how the thermocouples are selected, how they are checked for operability, and the range of the display.

4. Describe the use of the primary and backup displays. What training will the operators have in using the core exit thermocouple instrumentation? How will the operator know when to use the core exit thermocouples and when not to use them? Reference appropriate emergency operating guidelines where applicable.

5. Confirm completion of control room design task analysis applicable to ICC instrumentation. Confirm that the core exit thermocouples meet the criteria of NUREG-0737, Attachment 1 and Appendix B, or identify and justify deviations.

6. Describe what parts of the systems are powered from the 1E power sources used, and how isolation from non-1E equipment is provided. Describe the power supply for the primary display. Clearly delineate in two categories which hardware is included up to the isolation device and which is not.

7. Confirm the environmental qualification of the core exit thermocouple instrumentation up to the isolation device.

Appendix B (of NUREG-0737, II.F.2)

Confirm explicitly the conformance to the Appendix B items listed below for the ICC instrumentation, i.e., ~~the SMM~~, the reactor coolant inventory tracking system, ~~the core exit thermocouples and the display systems~~.

	Reference	Deviations
1. Environmental qualification	(6), (10)	
2. Single failure analysis	(6), (8)	
3. Class 1E power source	(6), (8)	
4. Availability prior to an accident	(6)	
5. Quality Assurance	(6)	
6. Continuous indications	(6)	
7. Recording of instrument outputs	(6)	
8. Identification of instruments	(6)	
9. Isolation	(6)	

**For the users of either Combustion Engineering Heated Junction Thermocouple (HJTC) System or Westinghouse Differential Pressure (dp) system a detailed response to the plant specific items stated below should be provided.

	Reference	Deviations From generic design
A. Westinghouse dp System		
1. Describe the effect of instrument uncertainties on the measurement of level.	(8)	Yes
2. Are the differential pressure transducers located outside containment?	(6) No	Yes
3. Are hydraulic isolators and sensors included in the impulse lines?	(6) No	Yes
B. CE HJTC System		
1. Discuss the spacing of the sensors from the core alignment plate to the top of the reactor vessel head. How would the decrease in resolution due to the loss of a single sensor affect the ability of the system to detect an approach to ICC?		

APPENDIX B.2.3

Core-exit Thermocouples

Checklist
for Plant Specific Review of
Inadequate Core Cooling (ICC) Instrumentation System

For Zion Units 1 and 2 **Docket No.** 50-295
50-304

Operated by: Commonwealth Edison Company

The following items for review are taken from NUREG-0737, pp II.F.2-3, and 4. Responses should be made to full requirements in NUREG-0737, not abbreviated forms below. Applicants should provide reference to either the applicant's submittal or the generic description under the column labled "Reference." These items are required to be reviewed on a plant specific basis by NUREG-0737 for all plants. Differences from the generic descriptions provided by Westinghouse, the Westinghouse Owner's Group, Combustion Engineering, or Combustion Engineering Owner's Group must be indicated by "yes or no" in the column labled deviations and must be justified. Under the Column labeled schedule, either indicate that your documentation of the item is complete or provide a proposed schedule for your submittal.

	Reference	Deviations	Schedule
1. Description of the proposed final system including: a. a final design description of additional instrumentation and displays; b. detailed description of existing instrumentation systems. c. description of completed or planned modifications.	(3), (4), (6), (12) - Addendum B 2.3.1		Report on E Q upgrade by 7/10/83
2. A design analysis and evaluation of inventory trend instrumentation, and test data to support design in item 1.	Not applicable		
3. Description of tests planned and results of tests completed for evaluation, qualification, and calibration of additional instrumentation.	(8), (15)		Completed

4. Provide a table or description covering the evaluation of conformance with NUREG-0737: II.F.2, Attachment 1, and Appendix B (to be reviewed on a plant specific basis)*	See below and page 3.
5. Describe computer, software and display functions associated with ICC monitoring in the plant.	See item 1.
6. Provide a proposed schedule for installation, testing and calibration and implementation of any proposed new instrumentation or information displays.	Installation completed.
7. Describe guidelines for use of reactor coolant inventory tracking system, and analyses used to develop procedures.	Not applicable.
8. Operator instructions in emergency operating procedures for ICC and how these procedures will be modified when final monitoring system is implemented.	(19), (20) (21) Schedule by 4/15/83
9. Provide a schedule for additional submittals required**	See items 1 and 8.

*II.F.2 Attachment 1 (for Core Exit Thermocouples)

In response to item 4 in the above checklist, the following materials should be included to show that the proposed system meets the design and qualification criteria for the core exit thermocouple system.

1. Provide diagram of core exit thermocouple locations or reference the generic description if appropriate. See (12) Addendum B 2.3.1
2. Provide a description of the primary operator displays including: (4), (8), B 2.3.1
   a. A diagram of the display panel layout for the core map and description of how it is implemented, e.g., hardware or CRT display.
   b. Provide the range of the readouts.
   c. Describe the alarm system.
   d. Describe how the ICC instrumentation readouts are arranged with respect to each other.
3. Describe the implementation of the backup display(s) (including the subcooling margin monitors), how the thermocouples are selected, how they are checked for operability, and the range of the display. (4), (8), B 2.3.1
4. Describe the use of the primary and backup displays. What training will the operators have in using the core exit thermocouple instrumentation? How will the operator know when to use the core exit thermocouples and when not to use them? Reference appropriate emergency operating guidelines where applicable. (8), (19), (20), (21)

5. Confirm completion of control room design task analysis applicable to ICC instrumentation. Confirm that the core exit thermocouples meet the criteria of NUREG-0737, Attachment 1 and Appendix B, or identify and justify deviations. Schedule by 4/15/83

6. Describe what parts of the systems are powered from the 1E power sources used, and how isolation from non-1E equipment is provided. Describe the power supply for the primary display. Clearly delineate in two categories which hardware is included up to the isolation device and which is not. (4), B.2.3.1

7. Confirm the environmental qualification of the core exit thermocouple instrumentation up to the isolation device. (3), (4), Report by 7/10/83

Appendix B (of NUREG-0737, II.F.2)

Confirm explicitly the conformance to the Appendix B items listed below for the ICC instrumentation, i.e., ~~the SMM, the reactor coolant inventory tracking system,~~ the core exit thermocouples and the display systems.

	Reference	Deviations
1. Environmental qualification	(3), (4), Report by 7/10/83	
2. Single failure analysis	(4)	
3. Class 1E power source	B.2.3.1	
4. Availability prior to an accident	B.2.3.1	
5. Quality Assurance	(4)	
6. Continuous indications	B.2.3.1	
7. Recording of instrument outputs	(4)	
8. Identification of instruments	B.2.3.1	
9. Isolation	(4), B.2.3.1	

INCORE THERMOCOUPLE SYSTEM

CHAPTER NO. 7b

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION AND GENERAL DESCRIPTION

A. SYSTEM PURPOSE

The Incore Thermocouple System monitors reactor coolant outlet temperatures of selected fuel assemblies in the reactor core for Control Room indication and Plant Computer analysis.

B. SYSTEM DESCRIPTION

The Incore Thermocouple System consists of 65 identical thermocouples positioned to measure fuel assembly reactor coolant outlet temperatures. The temperatures sensed by the thermocouples are continuously monitored by the Plant Computer and may be read individually in the Control Room.

Each thermocouple is sealed in a stainless steel sheath that is positioned at the outlet of a preselected fuel assembly. The thermocouple leads extend up through instrument guide tubes to the reactor vessel head where they exit through an instrument port column penetration and terminate in a connector at the head. The thermocouple leads then go to temperature controlled reference junction boxes near the seal table room. The temperature signal is sent to the Plant Computer and the incore thermocouple control cabinet.

C. SYSTEM ARRANGEMENT/SIMPLIFIED DRAWING

A thermocouple is a temperature measuring device consisting of two electrical conductors of dissimilar metals jointed together at a point, termed the measurement junction. When the measurement junction is exposed to an increased temperature, an electrical voltage potential is produced that is proportional to the temperature difference between the measurement junction and the reference junction which is kept at a constant temperature. A simplified drawing of a thermocouple channel as used in the Incore Thermocouple System is shown in Figure 7b-I-C1. The dissimilar metals used for monitoring the core coolant outlet temperatures are chromel and alumel. The measurement junctions are located on the upper core plate above the core fuel assemblies where the reactor coolant flow exits as indicated in Figure 7b-I-C2. The other ends of the dissimilar chromel-alumel wires are maintained at a constant reference temperature of 160°F in junction boxes near the seal table room. Normal copper wire is used to bring the signal voltage to the temperature indicator in the Control Room.

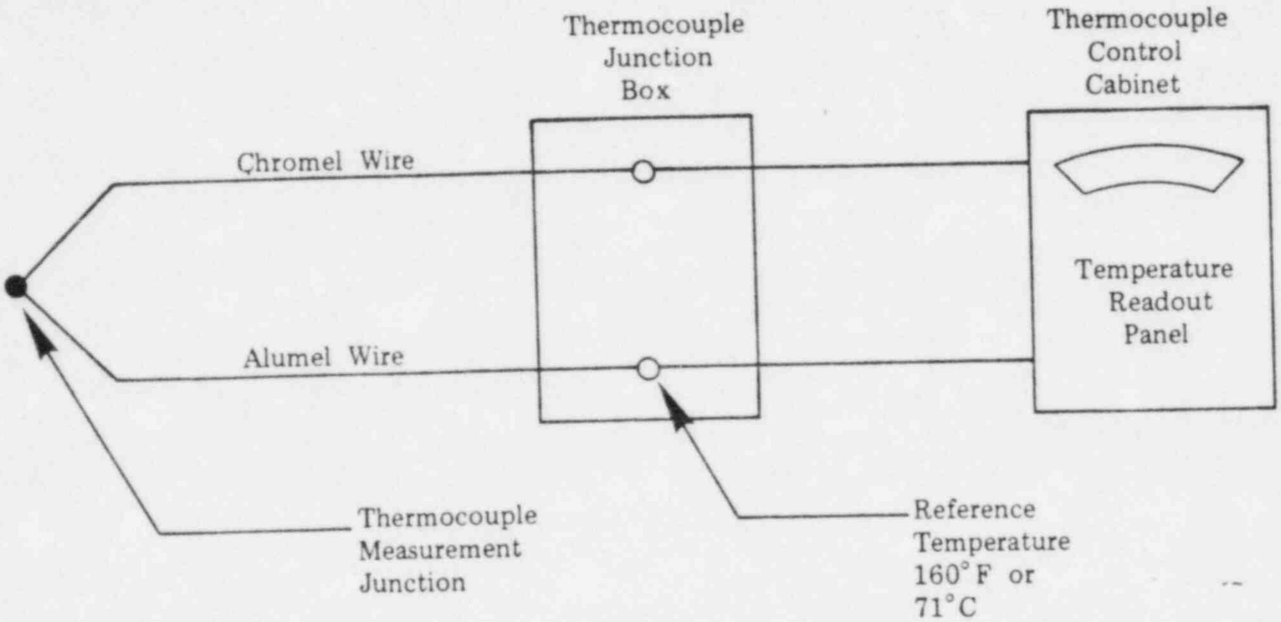


Figure 7b-I-C1

Simplified Incore Thermocouple System

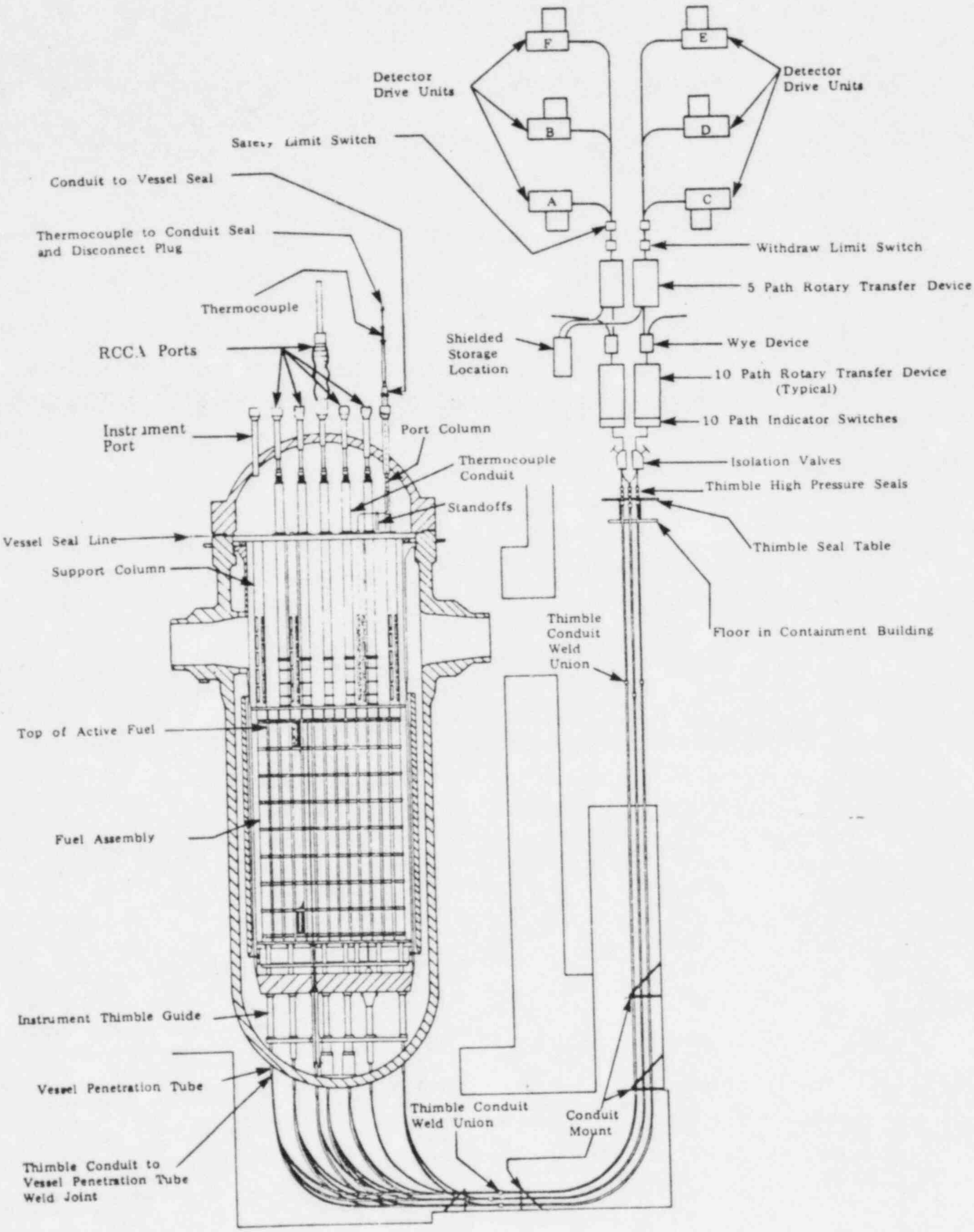


Figure 7b-I-C2
Reactor Vessel Cross Section Showing
Incore Instrumentation System

D. COMPONENT DESCRIPTION AND LOCATION

The major components of the Incore Thermocouple System are:

1. Thermocouples
2. Stainless Steel Sheaths
3. Thermocouple Guide Tubes
4. Instrument Port Columns
5. Seal Assembly
6. Reference Junctions
7. Incore Thermocouple Control Cabinet

1. Thermocouples

The Incore Thermocouple System utilizes 65 chromel-alumel thermocouples. The measurement junction where the wires are welded together is shown in Figure 7b-I-D1. The thermocouple offers a simple and versatile method for measuring temperature as it requires no power supply and is usable over a wide temperature range. The thermocouple and its lead wire can be replaced or interchanged. A distance of several hundred feet exists between a thermocouple and the indication circuits. The chromel-alumel thermocouple is more resistant to oxidation than other base-metal combinations. Chromel-P is an alloy of approximately 90% nickel and 10% chromium. Alumel is approximately 94% nickel, 3% manganese, 2% aluminum and 1% silicon. The dynamic response of the thermocouple is faster than any other commonly applied temperature sensor, with a response time constant of 60 milliseconds and an accuracy of $\pm 2^oF$ being typical. It is important that these thermocouples be protected from the reactor coolant and the water chemistry which increases the thermocouple corrosion rate. Protection is accomplished by means of a stainless steel sheath. In addition, each thermocouple is insulated with aluminum oxide.

2. Stainless Steel Sheaths

The thermocouples are enclosed in stainless steel sheaths. The sheaths, which are removable, are routed in guide tubes which position the thermocouple end at the selected core location. The guide tubes extend the entire distance from the core location on the seal assemblies and are supported as described in Reactor Vessel and Internals System, Chapter 3a. Figure 7b-I-D2 shows a sketch of the sheath which encloses each thermocouple.

3. Thermocouple Guide Tubes

The thermocouple leads, which are sheathed in stainless steel, are routed inside guide tubes. The guide tubes are then routed up through the upper internals to thermocouple port columns which exit the reactor vessel head with thirteen guide tubes exiting from each of the five port columns. A sealing arrangement is provided for each of the guide tubes and is a Reactor Coolant System pressure boundary.

4. Instrument Port Columns

The individual thermocouple guide tubes are enclosed in a thermocouple port column which protrudes through the reactor head instrument port. The individual thermocouple guide tubes are sealed to the thermocouple port column. The thermocouple sheath is sealed to the guide tube by means of a swagelock seal.

The sealing between the head and the instrument port column is accomplished by the use of two conoseals. During normal head removal only these seals must be broken. Refer to Figure 7b-I-D3 which shows details of the thermocouple guide tubes, instrument port columns and reactor vessel head sealing arrangment for the Incore Thermocouple System.

5. Seal Assembly

The sealing assembly consists of the conoseals and seats, male flange, jack screw assembly, reactor head penetration adapter, and the carbon steel clamp.

After the head is in place the thermocouple port column protrudes through the reactor vessel head. The conoseals are placed on the seating surfaces and the male flange is slipped down over the thermocouple port column. A hydraulic ram is then used to seat the conoseals. With the ram in place, the carbon clamp is installed and tightened. The ram is then removed and the carbon steel clamp is then holding the assembly together. The jack screw plate is then installed by removing a split ring and sliding the jack screw plate down over the thermocouple, the jack screw plate replaces the split ring and is tightened by jack screws.

6. Reference Junction Boxes

The individual thermocouple wires are separated and routed to either of two reference junction boxes. The selection of the thermocouples to be connected to each reference junction box was made to eliminate the possibility that a single failed reference junction box would totally negate the value of the readings received from the thermocouple system. In the event a reference junction box does fail, the thermocouples connected to the remaining reference junction box have been chosen so as to provide a meaningful representation of the core temperature. The reference junction boxes are located in the containment on the 603' elevation outside of the missle barrier, and they are maintained at 160^{o}F by an electric heater in the box.

Each reference juntion box contains three platinum resistance temperature detectors (RTD's). Two of the RTD's provide input to the Plant Computer while the third is an installed spare. The reference junction temperature signal is used by the Plant Computer to correct the measured temperature for reference junction temperature deviation from the nominal 160°F.

Each thermocouple reference junction is electrically insulated and embedded in a thermally insulated aluminum block which is maintained at 160°F $\pm$0.1°F by a resistance bridge-magne ic amplifier heater system. Aluminum block temperature is monitored by manganin and copper windings connected directly to a wheatstone bridge circuit. The wheatstone bridge in conjunction with a magnetic amplifier will control the operation of fine and course heaters to maintain block temperature. The fine heater will normally cycle on and off to maintain 160°F with the course heater being available for larger deviations from the set temperature of 160°F.

7. Incore Thermocouple Control Cabinet

A multipoint precision indicator has been provided to indicate the temperature sensed by the thermocouples. Only one thermocouple at a time can be connected to the indicator. Toggle switches have been provided on the front of and above the indicator to select the thermocouple desired. (refer to Figure 7b-I-D4 and 7b-I-D5.) The indicator provides a local readout of temperature from 0 to 2500°F. The thermocouple outputs are also applied to the Plant Computer.

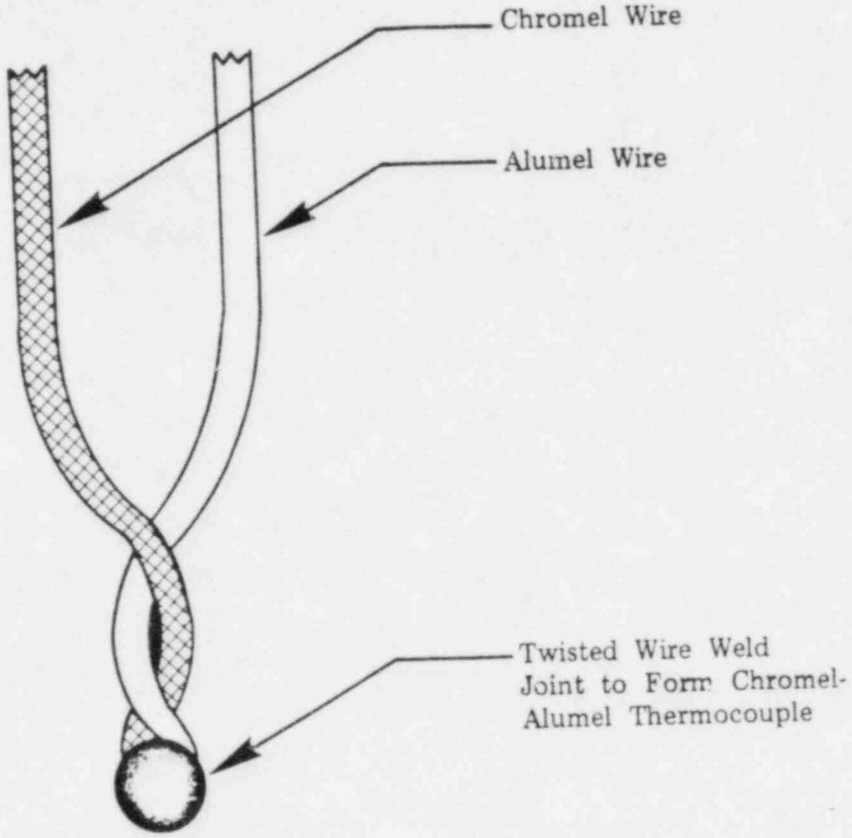


Figure 7b-I-D1

Typical Measurement Junction Weld

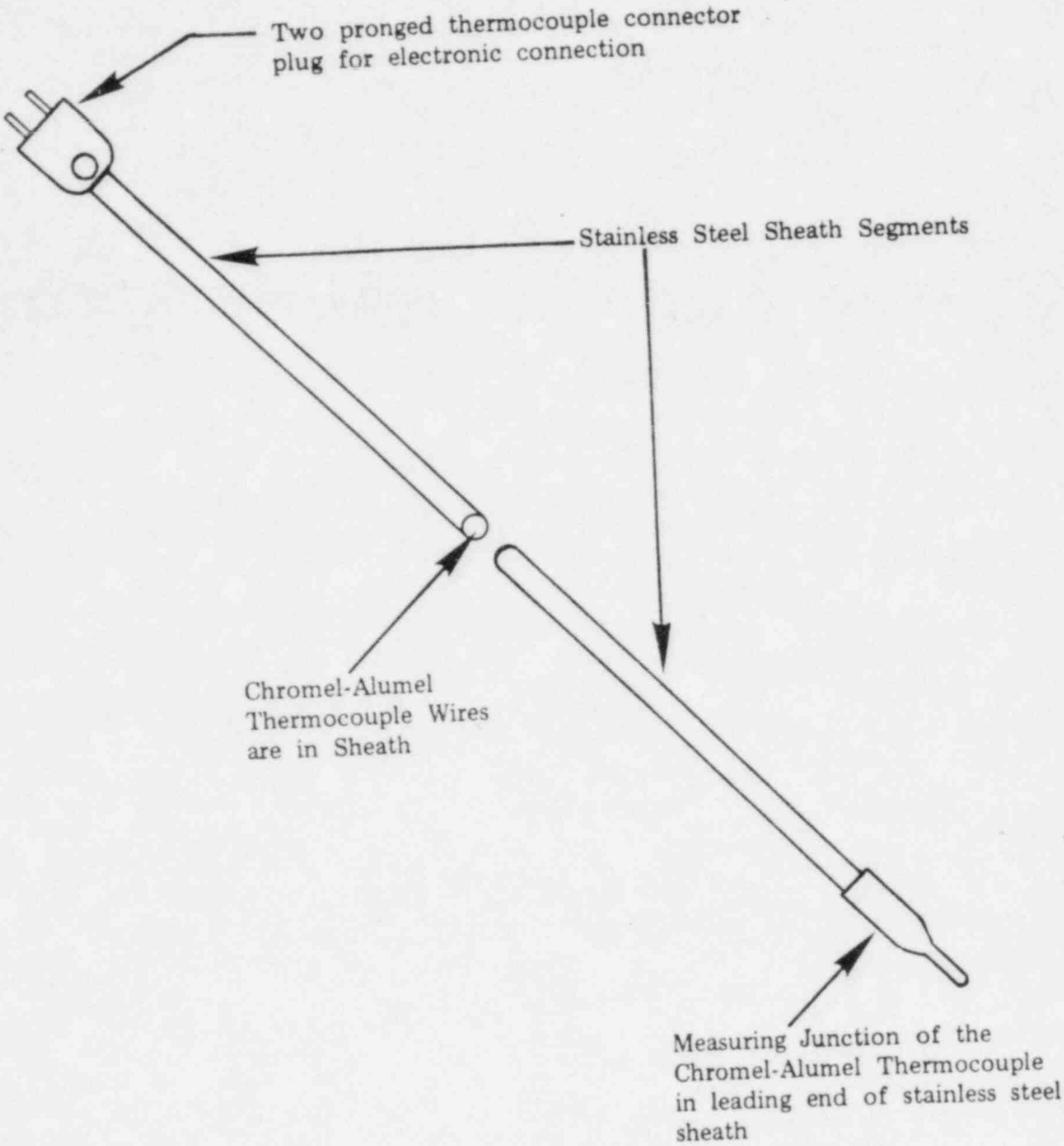


Figure 7b-I-D2

Thermocouple Sheath Segments

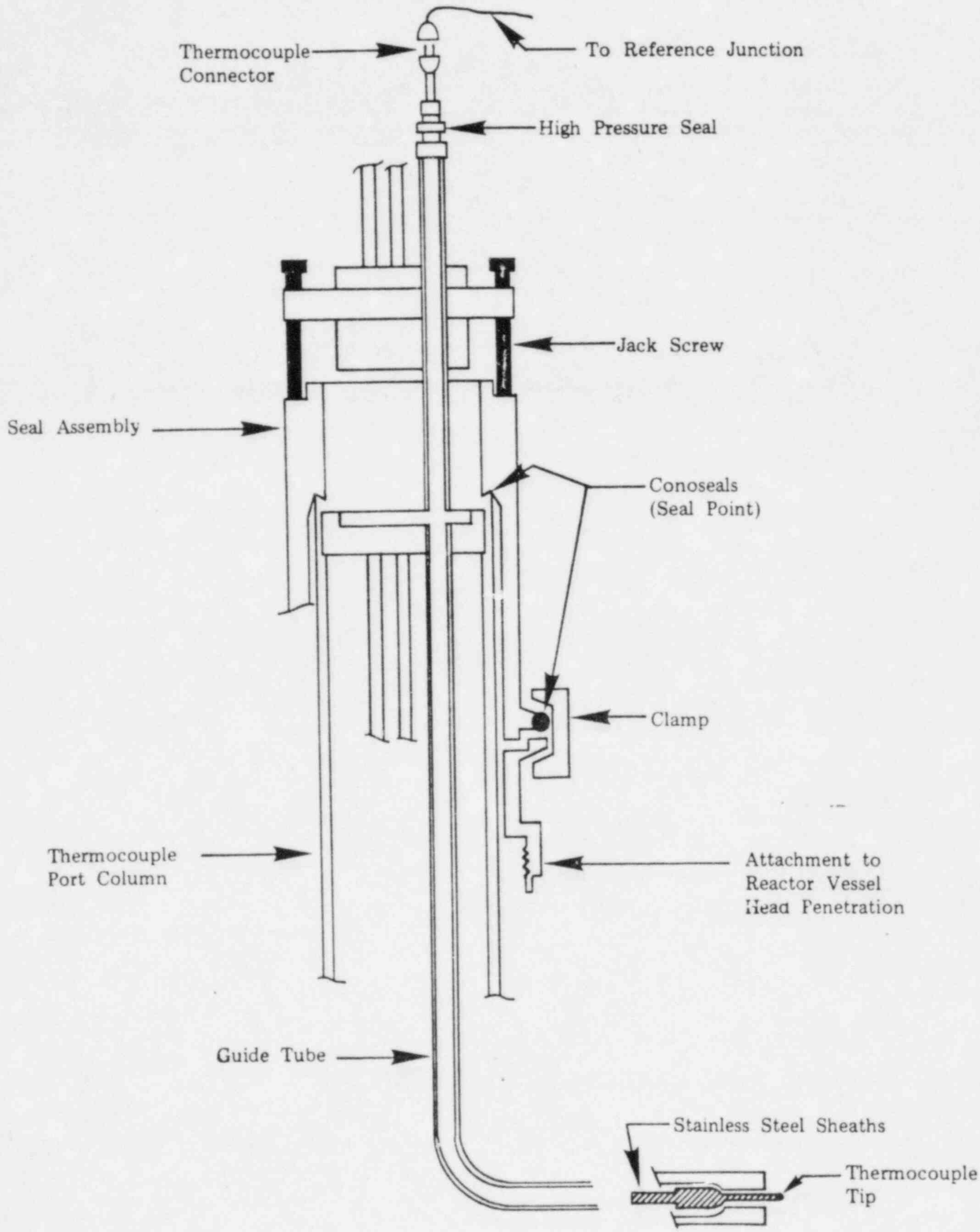


Figure 7b-I-D3
Thermocouple Routing General Arrangement

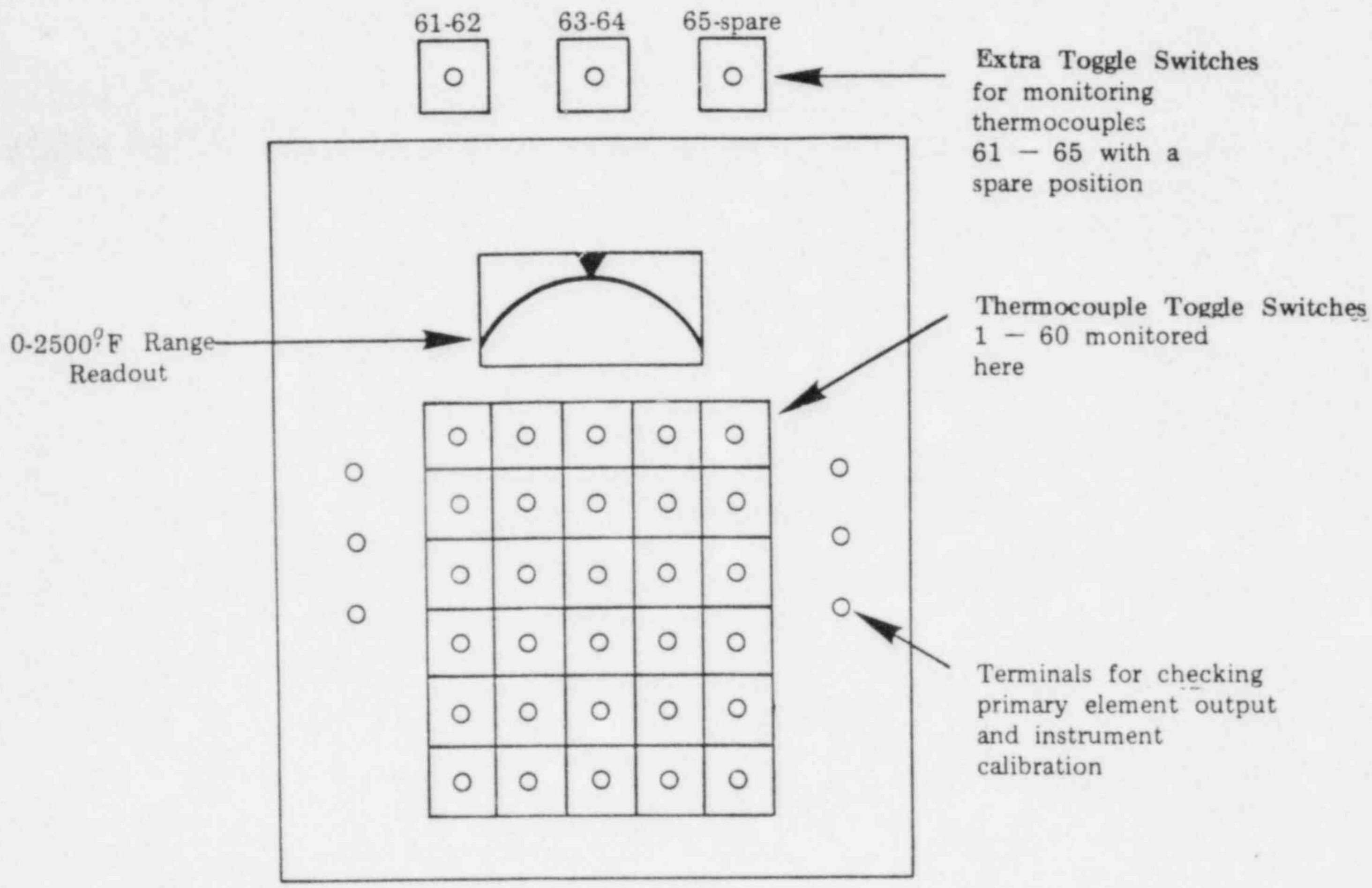


Figure 7b-I-D4

Thermocouple Indicator and Control Panel

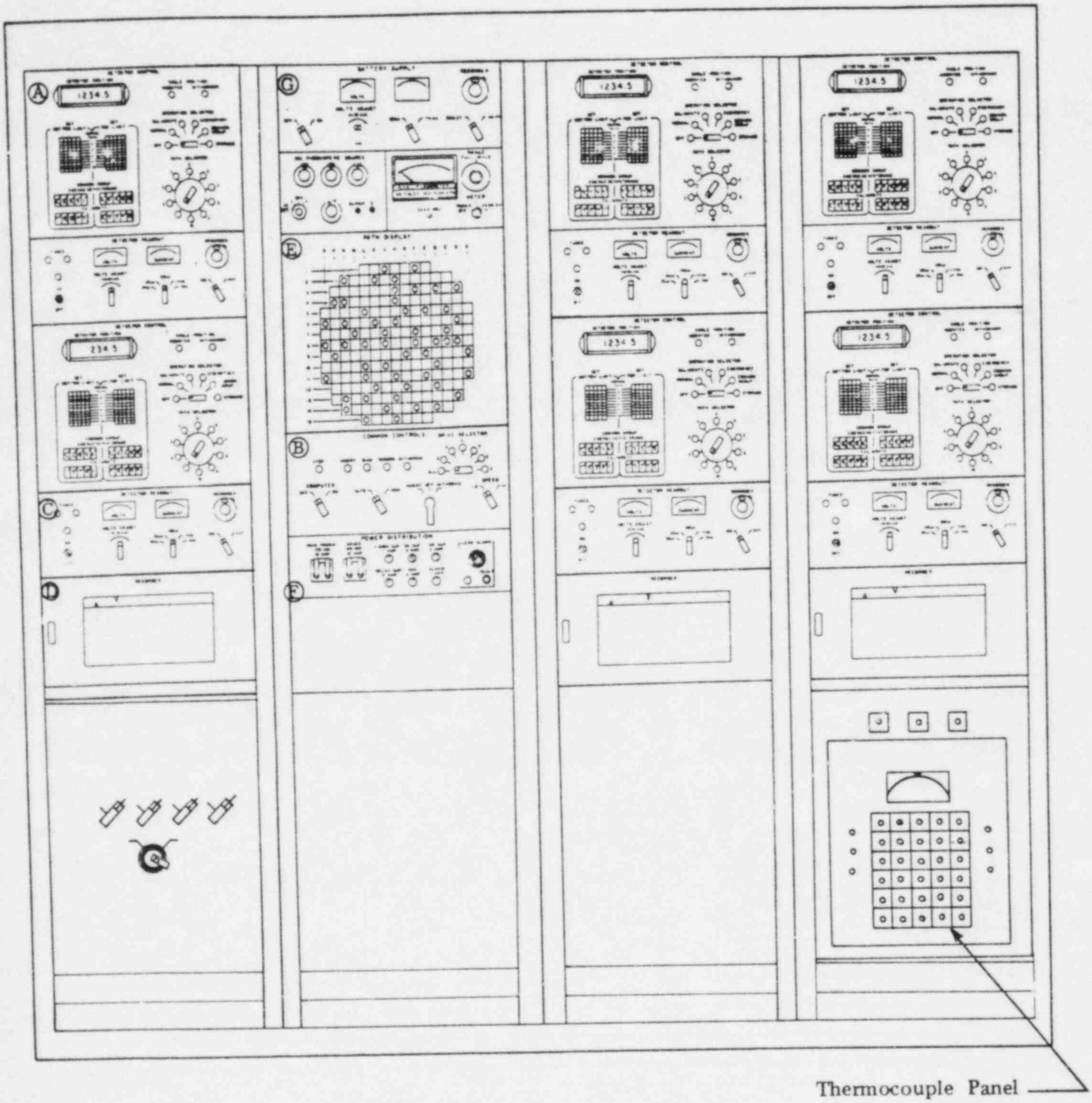


Figure 7b-I-D5

Control Console, Front View

Thermocouple Indicator and Control Panel

E. SAFETY DESIGN BASES

The Incore Thermocouple System does not have a safety design basis as such but it is used to provide reactor core fuel assembly coolant outlet temperatures. In this manner, it provides an independent means of measuring the balance of power among the core quadrants. If one excore power channel is out of service, it is required to have available an independent means of determining the quadrant power balance. It is, therefore, an additional source of monitoring instrumentation to help ensure reactor operational safety.

F. TABLES

1. Component Ratings

a. Chromel-Alumel Thermocouples

• Number	65
• Diameter	0.125 inch
• Sheath	Stainless Steel
• Insulation	Aluminum Oxide
• Accuracy (0^oF-530^oF)	$\pm 2^oF$
• Accuracy (530^oF-700^oF)	$\pm 3/8$%

b. Thermocouple Reference Junction Boxes

• Transition Wiring	Chromel-Alumel to Copper
• Reference Temperature	160^oF (71^oC)
• Reference Temperature Monitor Type	Platinum RTD
• Cyclic Temperature Excursion	$\pm 0.1^oF$

c. Thermocouple Indicator

• Measurement Range	0-2500°F
• Thermocouple Selection	Made by Non-Locking Toggle Switches on Front of Indicator
• Supply Voltage	Recommended Instrument Voltage Limits are Between 107 and 127 VAC
• Operating Frequency	60 Hz

2. System Ratings

• Thermocouple Readout Range	0-2500°F
• Thermocouple Sheath Design Pressure	2500 psig

3. Normal System Parameters

• Thermocouple Operating Temperature (Based on Hot-Leg Temperature)	619°F
• System Operating Pressure (Outside Thermocouple Sheath)	2250 psig

4. Power Supplies

Component	Power Supply
• Thermocouple Reference Junction Box #1	120 VAC Instrument Power - Inverter 113
• Thermocouple Reference Junction Box #2	120 VAC Instrument Power - Inverter 114

II. INSTRUMENTATION AND CONTROL

A. PRINCIPLES OF OPERATION

The instrumentation important to the Incore Thermocouple System for both operation and system readiness is:

1. Thermocouples
2. Thermocouple Reference Junction Boxes
3. Thermocouple Indicator

1. Thermocouples

The thermocouple consists of two dissimilar metal wires which, when welded together at one end, will develop a millivoltage at the other end dependent upon the temperature difference between the two ends. The junction where the wires are joined together is called the "measurement junction". The other terminal is called the "reference junction".

a. Basic Considerations

A thermocouple, as shown in Figure 7b-II-A1, is a device that generates a small voltage (millivolts) almost directly proportional to the temperature difference between its "reference" and "measurement" junctions. The correspondence between temperature difference and voltage depends on the materials used in the thermocouple.

b. Thermocouple Lead Wire

The reference junction of a thermocouple circuit is almost always located at the indicating or controlling instrument itself or there is a means for automatically controlling the reference junction temperature. The indicating instrument and sensor are separated by substantial distances. The thermocouple leads are made long enough to extend from the reactor to the reference junction box. Lead (or extension) wires of less expensive copper have thermoelectric characteristics matching the thermocouple over a limited temperature range. This range is based on the ambient temperature expected at the point where the thermocouple extension wires connect to the thermocouple and the Control Room.

c. Thermocouple Materials

The Incore Thermocouple System employs a chromel-alumel type of thermocouple which is used over a temperature range of 0 to 2500°F.

Figure 7b-II-A2 shows how the electromotive force (emf) expressed in millivolts (mV) varies as a function of measuring temperature for the chromel-alumel thermocouple. Note the linearity of this thermocouple output for the temperature range between 100°F and 650°F, the typical hot-leg output temperature range experienced between cold shutdown and hot full power conditions.

The Incore Thermocouple System thermocouples are positioned at the core locations shown in Figure 7b-II-A3.

The philosophy used in selecting these thermocouple locations is based on the concept if all thermocouple positions were reflected back to one reference quadrant, then each position in this quadrant would be monitored at least once by means of a thermocouple. Assuming this quarter-core symmetry, all positions in one quarter of the core may not have a thermocouple, but a symmetric position on another quarter of the core is monitored.

Incore thermocouples have the advantage of rapidly providing data which is easily converted to power in the Plant Computer by determining the enthalpy rise (delta H) across the nuclear fuel axially using thermocouple temperature and reactor inlet temperature. The enthalpy rise at various locations can be compared and a radial power distribution map can be generated. The Plant Computer uses this data to compute the nuclear enthalpy rise hot channel factor, $F^N_{\Delta H}$ for the core.

As opposed to the incore flux detectors discussed in Chapter 7a, which are operated on an intermittent basis, the thermocouples are directly applicable to on line radial power sharing measurements. However, they have the disadvantage of larger measurement errors due to flow patterns and mixing problems at the detector location. To reduce the uncertainty in the thermocouple measurements and provide an accurate radial power measurement for on-line monitoring, the incore thermocouple outputs are compared to incore flux detector data. Figure 7b-II-A3 shows a composite distribution of the thermocouple locations for the reactor core.

2. Thermocouple Reference Junction

Thermocouples are widely used in industry and research as a convenient and accurate means of measuring temperature in terms of an analog low level voltage. In a typical thermocouple temperature probe, the measuring tip, a junction of two appropriate metals (such as chromel and alumel), forms one end of a loop in which a thermoelectric voltage is developed when a temperature difference exists between the probe end and the remote end where the loop is completed. When measuring an unknown temperature with the thermocouple, it is not sufficient to determine the millivoltage produced; it is also necessary to know the temperature of the reference junction.

Figure 7b-II-A4 illustrates a typical measuring circuit in which the thermocouple loop is opened at the reference end by making two separate junctions with copper in a constant temperature location.

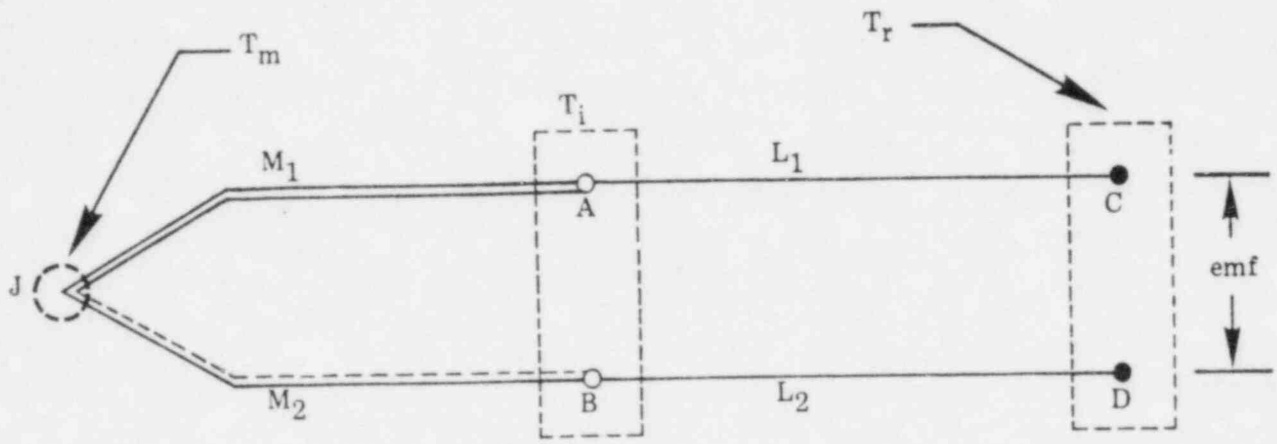
This arrangement allows the introduction of a millivolt potentiometer or other meter for measurement of the thermoelectric voltage.

The thermocouple reference junction boxes contains heaters which provide a precisely controlled stable temperature reference for multi-channel thermocouple systems.

Each reference junction is electrically insulated and embedded in a thermally insulated aluminum block which is maintained at a constant 160^{O}F temperature. At the control temperature, the cyclic temperature excursion is less than $\pm$0.1^{O}F, and the maximum deviation of any junction from the mean is within $\pm$1/5^{O}F of the setpoint.

3. Thermocouple Indicator

The circular scale precision indicator presents a continuous measurement of the selected fuel assembly coolant outlet temperature. As many as 60 points can be measured with the multipoint instrument. A total of 65 thermocouples are utilized and,therefore, 3 additional switches are necessary. Each Toggle Switch can monitor 2 thermocouples depending upon whether the switch is positioned to the right or left. The concentric rotating scale, illuminated by incandescent lamps, features a stationary, double hairline which eliminates parallax errors. Terminals for checking the primary element output and instrument calibration are located on the door.



$T_h > T_i > T_c$

$T_m > T_i > T_r$

Basic principle of thermocouple operation. M_1 and M_2 are dissimilar metals jointed at J (measurement junction) and connected at A and B to lead (extension) wires L_1 and L_2. The lead wires are connected to a potential-measuring device at C and D (reference junction). The electromotive force (Seebeck emf) across C and D depends on M_1, M_2, and on $T_m - T_r$ provided: (1) C and D are at the same temperature, (2) A and B are at the same temperature.

Figure 7b-II-A1

Basic Thermocouple Circuit

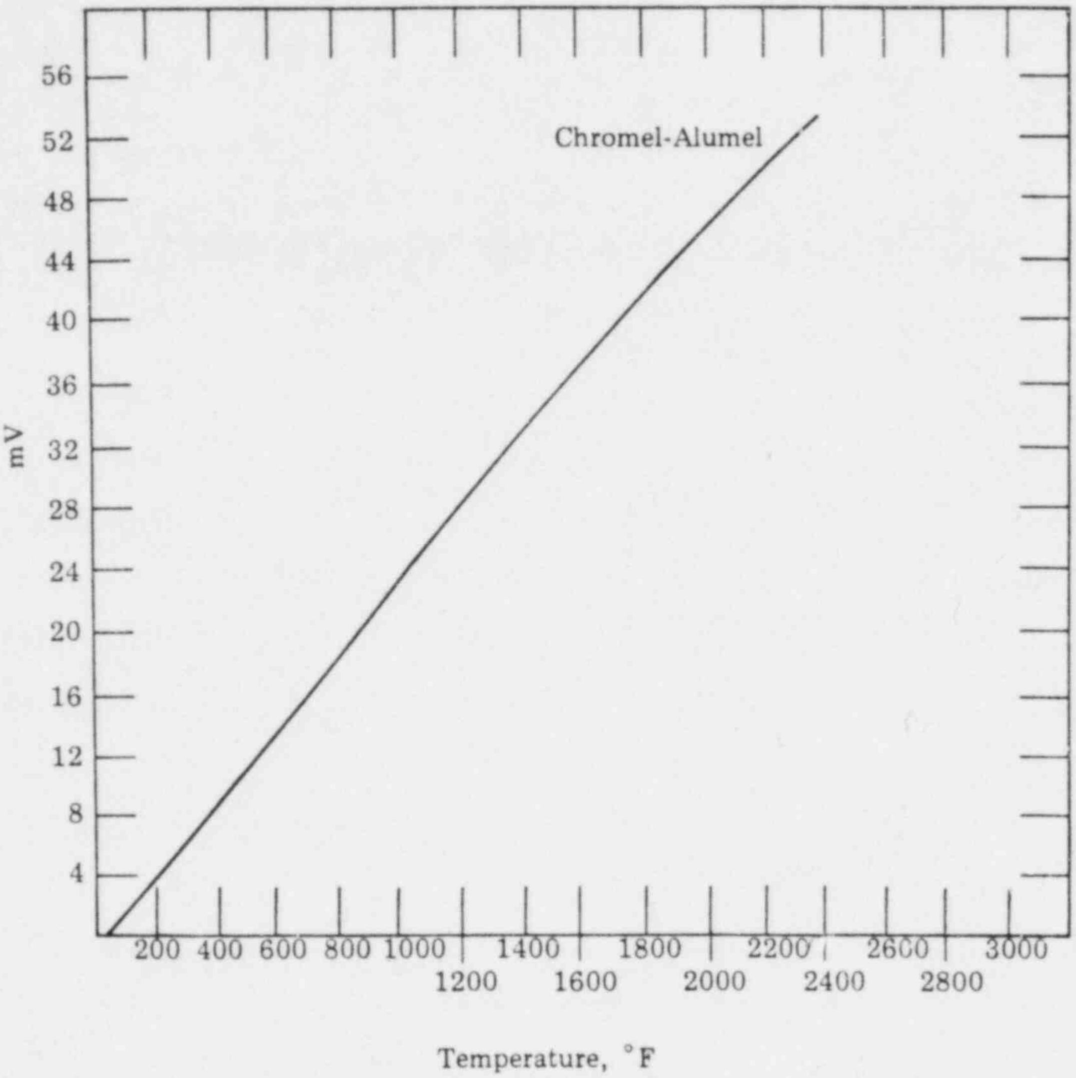
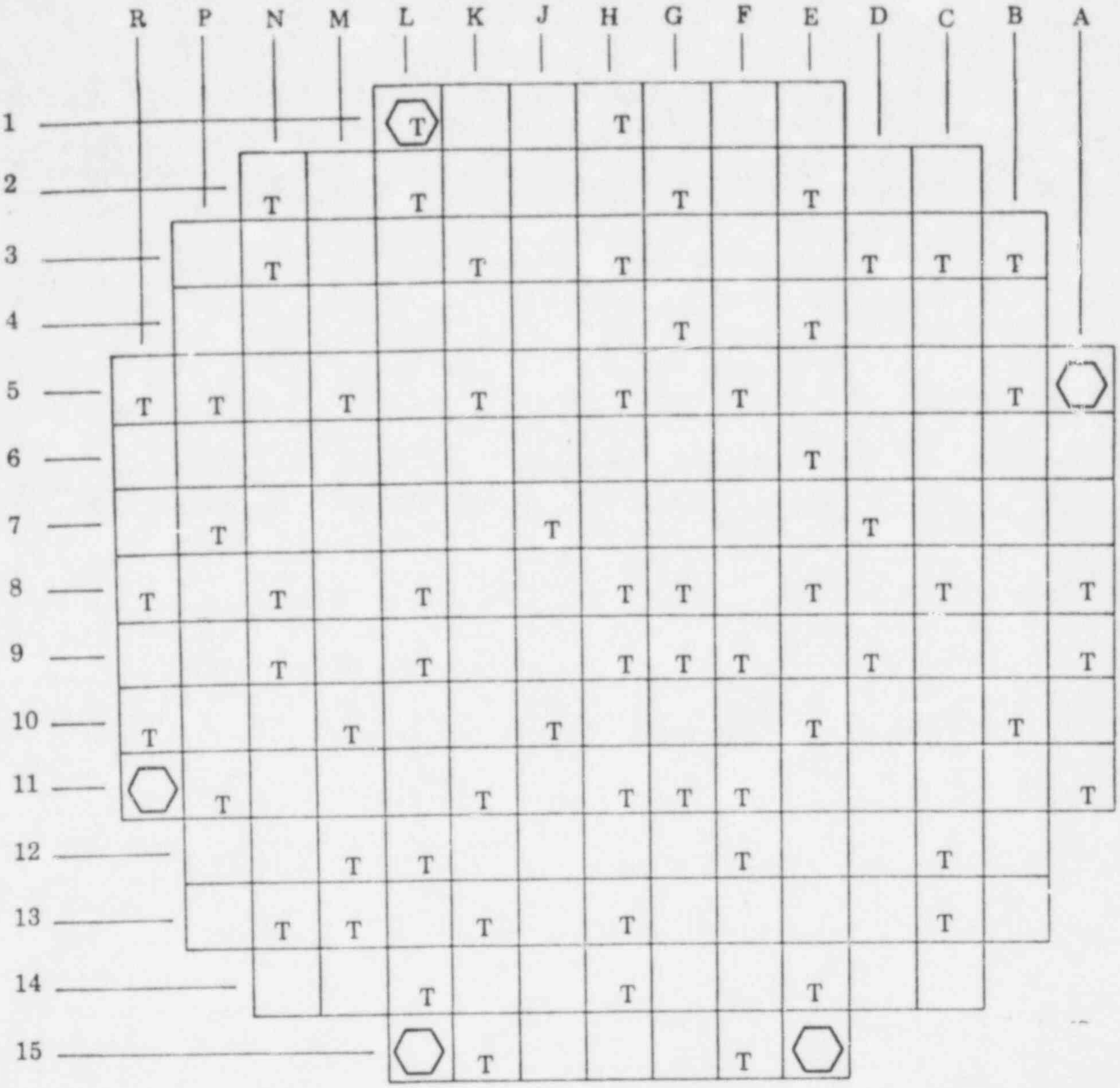


Figure 7b-II-A2
Electromotive Force (emf) vs. Temperature
for the Chromel-Alumel Thermocouple



T — Thermocouple

⬡ — Upper Head Penetration for Thermocouples (5)

Figure 7b-II-A3

Distribution of Thermocouples for the Incore Thermocouple System

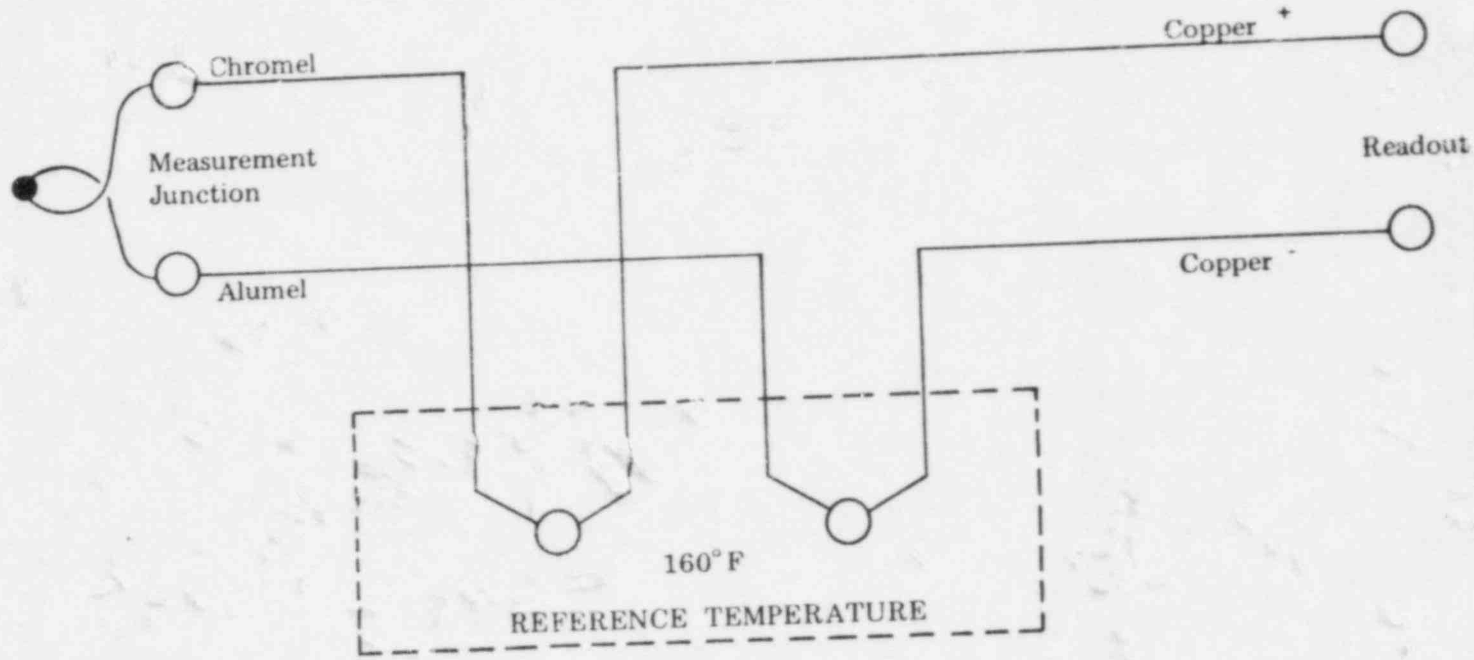


Figure 7b-II-A4
Thermocouple Reference Junction Box

B. SYSTEM ALARMS

There are no thermocouple alarms. The Incore Thermocoule System is employed only for temperature surveillance of the reactor core.

C. CONTROL FUNCTIONS AND INTERLOCKS

The Incore Thermocouple System is used only for reactor coolant fuel assembly outlet temperature surveillance and does not have any control functions or interlocks associated with it.

D. INPUTS TO THE REACTOR PROTECTION SYSTEM AND ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

The Incore Thermocouple System does not have any inputs to the Reactor Protection System or Engineereed Safety Features Actuation System.

III. INTERCONNECTIONS WITH OTHER SYSTEMS

A. PHYSICAL CONNECTIONS WITH OTHER SYSTEMS

The Incore Thermocouple System has physical connections with the following plant systems:

1. Reactor Coolant System
2. Plant Computer

1. Reactor Coolant System

The Incore Thermocouple System penetrates into the Reactor Coolant System through the reactor vessel head instrument ports in order to monitor core coolant outlet temperatures.

2. Plant Computer

The Plant Computer monitors the output signal of each of the 65 incore thermocoules in order to analyze the reactor core performance to help determine hot channel limitations.

B. SYSTEMS REQUIRED FOR THE SUPPORT OF THE INCORE THERMOCOUPLE SYSTEM

The AC Electrical Power System is required to provide power for the reference junction boxes and the thermocouple indicator panel.

IV. OPERATIONAL LIMITATIONS

THE FOLLOWING IS A SUMMARY OF SYSTEM TECHNICAL SPECIFICATIONS. FOR PURPOSES OF PLANT OPERATION, ENSURE THAT THE MOST RECENT TECHNICAL SPECIFICATION LIMITS ARE MET.

A. LIMITATIONS

The Incore Thermocouple System has no Technical Specifications. However, it is advisable to have the system operable because it provides an independent means of determining core exit temperature during normal and post-accident conditions.

B. VERIFICATION

The core thermocouples have no verification requirements.

C. BASES

The Thermocouple System is not an integral part of the Reactor Protection System. This system is, rather, a surveillance system which may be required in the event of an abnormal occurrence such as a power tilt or a control rod misalgnment. Since such occurrences cannot be predicted before they occur, it is prudent to have this surveillance system in an operable state.

D. TECHNICAL SPECIFICATION REFERENCES

None.

V. BASIC SYSTEM OPERATION

THIS SECTION OUTLINES THE MAJOR STEPS PERFORMED DURING SYSTEM OPERATION AND IS NOT INTENDED TO SUBSTITUTE FOR PLANT OPERATING PROCEDURES.

A. NORMAL OPERATION

This system is supplied with two methods of thermocouple temperature readout. Normally the thermocouples are read using the Plant Computer. They may also be read locally on the 0-2500°F temperature indicator. The operator simply selects the individual thermocouple that is intended to be measured. Only one thermocouple can be measured at any one time.

The individual toggle switches for selection of the individual thermocouples are on the front panel. The operator simply reads the thermocouple output as a temperature directly. The instrument is calibrated in terms of temperature.

B. INFREQUENT OPERATIONS

This section does not apply to the Incore Thermocouple System.

C. ABNORMAL OPERATIONS

This section does not apply to the Incore Thermocouple System.

VI. REFERENCES

DOCUMENT DESCRIPTION	DOCUMENT NUMBER	REVISION
Westinghouse Manual for Incore Nuclear Instrumentation	Volume 1	0
Zion Station FSAR Vol. III	Sect. 7.6	25