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B.1 Signal Conditioning Boards

B.1.1 Eagle Analog Input (EAI) Signal Conditioning Board

B.1.1.1 Functional Description

[ ] c

The EAI board is classified as 1E protection-grade equipment, but since it receives inputs from protection-grade transmitters and supplies outputs to the protection-grade loop processor subsystem, it is not a class 1E isolation barrier.

B.1.1.2 Performance Specifications

B.1.1.2.1 Analog Input Characteristics --

[

]b,c

B.1.1.2.2 Loop Supply Characteristics --

[ ] b,c

B.1.1.2.3 Power Supply Requirements --

[ ] b,c

B.1.2 Eagle RTD Input (ERI) Signal Conditioning Board

B.1.2.1 Functional Description

[ ] c

The ERI boards are classified as 1E protection-grade equipment, but since they receive inputs from protection-grade RTDs and supply outputs to the protection-grade loop processor subsystem, they are not class 1E isolation barriers.

B.1.2.2 Performance Specifications

B.1.2.2.1 Analog Input Characteristics --

[ ]

b,c

B.1.2.2.2 RTD Reference Characteristics --

[ ] b,c

B.1.2.2.3 Power Supply Requirements --

[ ] b,c

B.1.3 Eagle Partial Trip (EPT) Signal Conditioning Board

B.1.3.1 Functional Description

[ ] c

[The four EPT channels are fail-safe in that the failure of the loop processor subsystem causes the channels to trip after a brief time-out period.]$_c$ In most applications, the EPT receives input signals from the class 1E LPS and sends output signals to the class 1E voting logic systems (SSPS or relay logic). In these applications it is not a class 1E isolation barrier. However the EPT has been classified as a class 1E isolation barrier for possible future applications.

B.1.3.2 Performance Specifications

B.1.3.2.1 Digital Output Characteristics --

[ ] b,c

B.1.3.2.2 Power Supply Requirements --

[ ] b,c

B.1.4 Eagle Contact Output (ECO) Signal Conditioning Board

B.1.4.1 Functional Description

[ ] c

2. Provides class 1E isolation between the protection cabinet and the control systems that receive the contact signals

[ ] c

B.1.4.2 Performance Specifications

B.1.4.2.1 Contact Output Characteristics --

[ ] b,c

B.1.4.2.2 Power Supply Requirements --

[ ] b,c

B.1.5 Eagle Analog Output (EAO) Signal Conditioning Board

B.1.5.1 Functional Description

[ ] c

2. Provides class 1E isolation for current loop signals sent to field receivers such as control board indicators and process control loops

[ ] c

B.1.5.2 Performance Specifications

B.1.5.2.1 Analog Output Characteristics --

[redacted] b,c

B.1.5.2.2 Power Supply Requirements --

[redacted] b,c

B.2 Microprocessor Boards

B.2.1 Digital Filter Processor (DFP) Board

B.2.1.1 Functional Description

[ ] b,c

[ ] c

B.2.1.2 Performance Specifications

B.2.1.2.1 Power Supply Requirements --

[ ] b,c

B.2.2 Analog to Digital Converter (ADC) Board

B.2.2.I Functional Description

[ ] c

[ ] b,c

B.2.2.2 Performance Specifications

B.2.2.2.1 Compatibility --

[ ] b,c

B.2.2.2.2 Power Supply Requirement --

[ ] b,c

B.2.3 Loop Calculation Processor (LCP) Board

B.2.3.1 Functional Description

[ ]

C

B.2.3.2 Performance Specifications

B.2.3.2.1 Power Supply Requirements --

[ ] b,c

B.2.4 Loop Processor Subsystem Digital Input/Output (LPSDIO) Board

B.2.4.1 Functional Description

[ ] c

[ ] c

B.2.4.2 Performance Specifications

B.2.4.2.1 Power Supply Requirements --

[ ] b,c

B.2.5 Digital-to-Analog Converter (DAC) Board

B.2.5.1 Functional Description

[ ] c

[ ]c

B.2.5.2 Performance Specifications

B.2.5.2.1 Electrical Specifications --

[ ]b,c

[ ]b,c

B.2.5.2.2 Power Supply Requirements

[ ]b,c

B.2.6 Loop Processor Subsystem Data Link Handler (DLH) Board

B.2.6.1 Functional Description

[ ]c

[ ]c

B.2.6.2 Performance Specification

B.2.6.2.1 Power Supply Requirement (as shipped) --

[ ]b,c

B.2.7 Tester Subsystem Data Link Handler (DLH) Board

B.2.7.1 Functional Description

[ ]c

[ ] c

B.2.7.2 Performance Specification

B.2.7.2.1 Power Supply Requirement (as shipped) --

[ ] b,c

B.2.8 Test Sequence Processor (TSP) Board

B.2.8.1 Functional Description

[ ] c

[ ]c

B.2.8.2 Performance Specifications

B.2.8.2.1 Power Supply Requirements --

[ ]b,c

B.2.9 High Precision Digital-to-Analog Converter (HPDAC) Board

B.2.9.1 Functional Description

[ ]c

B.2.9.2 Performance Specifications

B.2.9.2.1 Electrical Specifications --

[ ]b,c

[ ] b,c

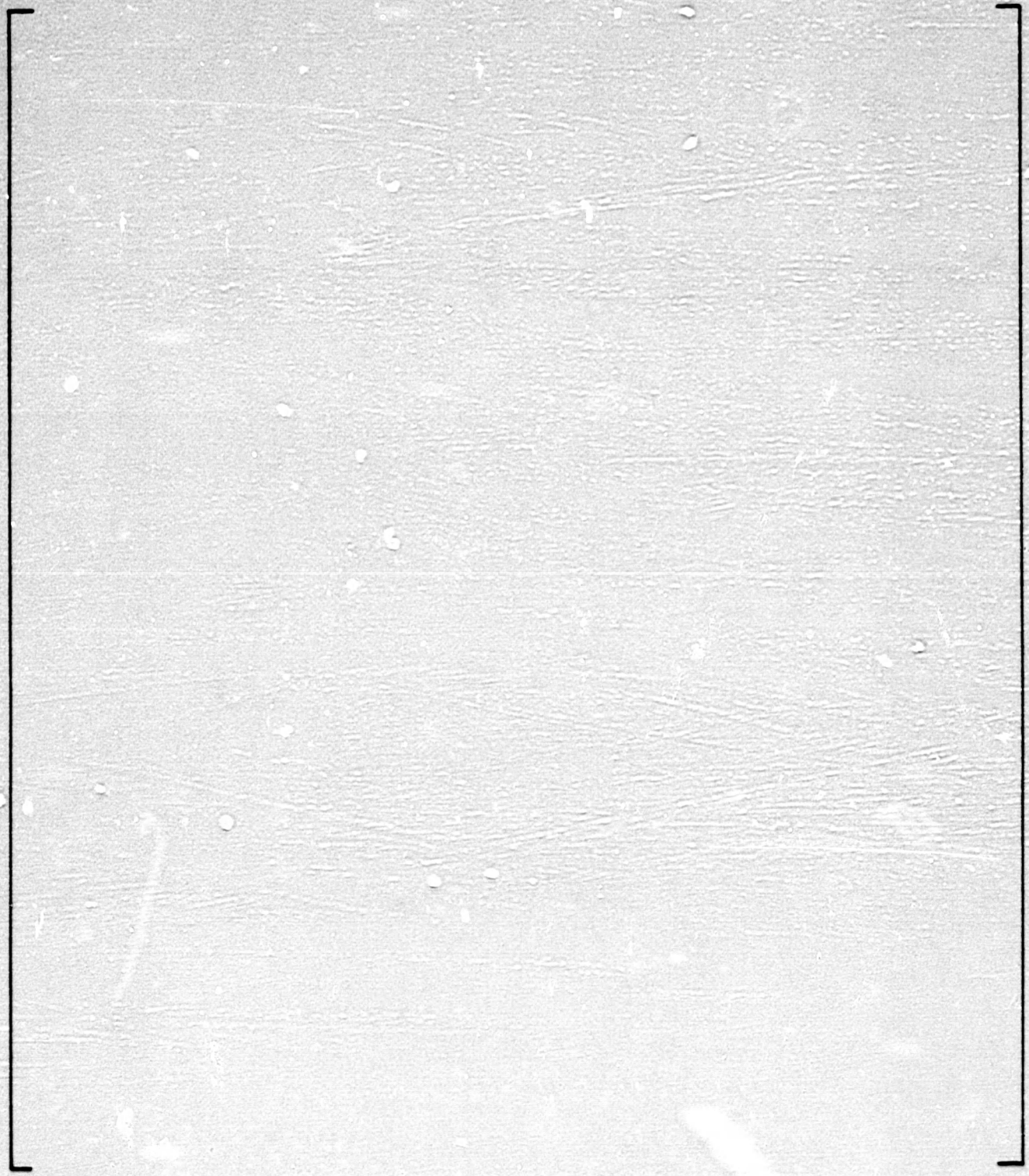
B.2.9.2.2 Power Supply Requirements

[ ] b,c

B.2.10 Test Subsystem Digital Input/Output (TSDIO) Board

B.2.10.1 Functional Description

[ ] c



c

B.2.10.2 Performance Specifications

B.2.10.2.1 Power Supply Requirements --

[ ] b,c

APPENDIX C
TEST PROCEDURES

NOISE TEST PROCEDURE

FOR

EAGLE-21 PROTECTION

SYSTEM

1.0 INTRODUCTION

This procedure details the electrical interference "noise" tests to be applied to the Eagle-21 protection system.

These tests will consist of applying the following noise sources to the antenna/non-class 1E wiring and measuring the effects on system input/output processing.

- o Random Noise
- o Crosstalk Noise
- o Mil N19900 Noise
- o High Voltage Transient Noise
- o Static Noise

The test configuration is documented in Attachment B.

2.0 PREPARATION FOR TEST

2.1 Connect the field cabling to sensor simulation, load simulation, and contact output loads per Attachments B, C and table 1-1.

2.2 Obtain system baseline data:

2.2.1 System baseline data will be taken to verify system operation. Input voltage and current and resistance values corresponding to 0 - 100% of scale in 25% increments and record. Obtain MMI printout of analog input information and record analog input/output readings via data logger printout.

2.2.2 Set signal inputs per table 1-1. Adjust analog input signals, using the MMI to obtain the expected engineering unit values specified in table 1-1. Using figure B-6 as a reference, adjust the variable RTD channel per the following procedure:

- o Open the manual switch input to the variable RTD board.

- Adjust the high adjust potentiometer so that channel TE-441A3 reads 618.261+/-.375 Deg f on the MMI.

- Verify that the TAVG MMI reading equals 589.740 + .2 Deg f. Verify the following actual bistable output status:

  TS/441C = Not Tripped
  TS/441G = Not Tripped
  TS/441D = Not Tripped
  TS/441H = Not Tripped
  TS/442D = Tripped
  TS/442G = Tripped

  Obtain a printout of the Delta T/TAVG system analog inputs, analog test points and comparator information MMI screens.

- Close the manual switch input to the variable RTD board.

- Adjust the low adjust potentiometer so that channel TE-441A3 reads 615.501+/-.375 Deg f on the MMI.

- Verify that the Delta T MMI reading equals 104.237-.3PU. Verify the following actual bistable output status:

  TS/1441C = Tripped
  TS/1441G = Tripped
  TS/1441D = Tripped
  TS/1441H = Tripped
  TS/1442D = Not Tripped
  TS/1442G = Not Tripped

  Obtain a printout of the Delta T/TAVG system analog inputs, analog test points and comparator information MMI screens.

- o Open the manual switch input to the variable RTD board and record the results. Obtain MMI printout of analog input information and record analog input/output readings via data logger printout.

2.2.3 Set the function generator output to the variable RTD board (see figure B-3) in the positive square wave pulse mode with a 0-5 volt amplitude at .05HZ and a duty cycle of approximately 10%.

2.2.4 Close the recorder start switch and verify that the trip output signals switch upon receipt of the function generator switch signal (positive square wave pulse).

3.0 NOISE TEST PROCEDURE SEQUENCE

The noise test sequence described below will be followed for each noise test type specified in Sections 4.0 through 8.0.

3.1 Pretest

Obtain a data logger printout of "normal" analog input/output and digital output values.

3.2 Disconnect data logger and verify "antenna" connections and configuration for each injection point per Attachment A.

3.3 Connect the noise source and verify the readiness of the data acquisition system. Enter identifying records in tape recorder log and noise test data sheet (figure 1-6). Follow the test specific instructions given in Sections 4 through 8.

3.4 Disconnect the data logger, close the recorder start switch, start the tape recorder and record 2 minutes of pretest data. Simultaneously energize the noise sources and close the event marker switch. Record 2 minutes of data with the noise source applied. Observe the strip chart recorder and record and analog output signal deviations

and/or trip output status failures. A trip output status failure is defined as a failure of a trip output signal to switch upon receipt of the switch signal from the test station. Remove the noise source and open the event marker switch. Record 2 minutes of post test data and open the recorder start switch and stop the tape recorder.

3.5 Obtain a data logger printout and confirm system recovery by comparing to pretest data. Record any discrepancies.

3.6 With the system confirmed to be in the pretest condition, proceed to the next test.

4.0 RANDOM NOISE TEST

4.1 Connect the [ ]$_{b,c}$ random noise generator to the ENI 240L power amplifier as shown in figure 1-1. Connect the center conductor of the power amplifier to one conductor of the antenna. Terminate the cabinet end of the antenna to an unused internal block connection.

4.2 Follow the instructions given for antenna coupled tests given in Table A-2a. Follow the test sequence described in Section 3 for each channel designated in Table A-2a.

5.0 CROSSTALK NOISE TEST

5.1 Connect the 125 volt DC chattering relay to the antenna assembly as shown in figure A-2a. Short the cabinet end of the antenna across an unused terminal block connection. Terminate and load the non-1E test cable as specified in Table A-2a.

5.2 Follow the test sequence described in Section 3 for each channel designated in Table A-2a.

5.3 Repeat 5.1 and 5.2 above using a 118V AC chattering relay. (figure 1-2b)

5.4 Disconnect the cabinet end of the antenna and terminate across the first set of terminals shown in Table A-2b. Disconnect the isolator wiring and short the wires specified in Table A-2b.

5.5 Follow the test sequence described in Section 3 for each channel designated in table A-2b.

5.6 Repeat 5.4 and 5.5 above using a 125 volt DC chattering relay. (figure 1-2b)

6.0 MIL N19900 NOISE TEST

6.1 Connect "noise source 1" to the antenna assembly as shown in figure 1-3. Short the cabinet end of the antenna across an unused terminal block connection. Terminate and load the non-1E test cable as specified in Table A-2a.

6.2 Follow the test sequence described in Section 3 for each channel designated in Table A-2a.

6.3 Repeat 6.1 and 6.2 above using "noise source 2." (see figure 1-3)

7.0 SURGE TRANSIENT GENERATOR

7.1 Connect the [ ]$_{b,c}$ surge generator and [ ]$_{b,c}$ isolation network as shown in figure 1-4. Terminate the cabinet end of the antenna across 150 ohms. Terminate and load the non-1E test cable as specified in Table A-2a.

7.2 Follow the test sequence described in Section 3 for each channel designated in Table A-2a.

8.0 STATIC NOISE TEST

8.1 Connect the 580 VAC static noise source to the antenna assembly as shown in figure 1-5. Terminate the cabinet end of the antenna across two separate (open circuit) unused terminal block connections. Terminate and load the non-1E test cable as specified in Table A-2a.

8.2 Follow the test sequence described in Section 3 for each channel designated in Table A-2a.

8.3 Disconnect the cabinet end of the antenna and terminate across the first set of terminals shown in table A-2b. Disconnect the isolator wiring at the termination frame and open circuit the wires as specified in table A-2b.

8.4 Follow the test sequence described in Section 3 for each channel designated in table A-2b.

(See figure 5-3 of WCAP test report)

Figure 1-1 Random Noise Test Connections

(See figure 5-4a of WCAP test report)

Figure 1-2a Crosstalk Noise - Chattering dc Relay Test Connections

(See figure 5-4b of WCAP test report)

Figure 1-2b Crosstalk Noise - Chattering ac Relay Test Connections

(See figure 5-5 of WCAP test report)

Figure 1-3 Military Specification Noise Sources

(See figure 5-6 of WCAP test report)

Figure 1-4 High Voltage Transient Noise Test Connections

(See figure 5-7 of WCAP test report)

Figure 1-5 Transformer Connection for the 580 Vac Static Noise Source

9.0 ACCEPTANCE CRITERIA

9.1 Description

The acceptance criteria for the Eagle 21 (1E Safety Related System) is that the system shall maintain protective actions before, during and after the injection of credible noise into or adjacent to the class non-1E wiring.

TABLE 1-1
SIMULATED INPUT SIGNAL

	Channel Name	Channel Tag #	Terminal Block	Terminal Connection Hi	Lo	Sh	I/O Board Location	I/O Board Connection Hi	Lo	Sh	Simulator Signal	Expected Signal in E.U.
1.	Neutron Flux Lower Ion	NT-441A	13-C	4	5	6	13T-4	9	13		3.00	10.00 ± .005
2.	Neutron Flux Upper Ion	NT-441B	13-C	1	2	3	13T-4	2	6		4.04 volt	20.00 ± .005
3.	Pressurizer Pressure	PT/430Q	13-H	-	-	-	13T-6	11	12	14	36.75 MA	2235 ± 1.00
4.	Cold Leg Temperature	TE-441B	13-B	1,2	4,3	5	13T-6	6,3	7,4	1	423.000 ohms	582.70 ± .375
5.	Cold Leg Temperature	TE-446B	13-B	7,8	10,9	11	13T-6	8,11	9,12	14	423.000 ohms	582.70 ± .375
6.	Hot Leg Temperature	TE-441A1	13-A	1,2	4,3	5	13T-5	6,3	7,4	1	447.382 ohms	618.041 ± .375
7.	Hot Leg Temperature	TE-441A2	13-A	7,8	10,9	11	13T-5	8,11	9,12	14	447.382 ohms	618.041 ± .375
8.	Hot Leg Temperature	TE-441A3	13-C	8,9	11,10	12	13T-5	20,17	21,18	15	xx ohms	± XX
9.	Steam Generator Level Loop 2	LT-302'	13-E	1	2	3	13T-2	8	11	14	20 MA	25 ± .125%
10.	Steam Generator Level Loop 3	LT-303	13-E	4	5	6	13T-2	20	17	15	40 MA	75 ± .125%
11.	RCS Wide Range Pressure	PT-400	13-H	1	2	3	13T-8	20	18	15	12 MA	1500 ± 3.75
12.	Pressurizer Vapor Temp	TE-434	13-D	1,2	4,3	5	13T-4	20,17	21,18	15	400 OHMS	650.200 ± 1.05
13.	Residual Heat Removal Pump Discharge Temp	TE-812	13-D	8,9	11,10	12	13T-4	22,25	23,26	28	300 OHMS	200.400 ± 1.05

NOTE: - XX - Variable RTD input, set nominally at 447.175 ohms (615.902 Deg f) for the low resistance reading and 448.284 ohms (618.201 Deg f) for the high resistance reading. See step 2.3.2 for details.

EAGLE-21 NOISE TEST REPORT

TEST TYPE/PROCEDURE NUMBER(REV)_____

DATE_____

NOISE INJECTION CHANNEL NUMBER/TAG NO._____

DATA LOGGER PRINTOUT: _____
(PRETEST/POST-TEST)

BISTABLE PERFORMANCE (PASS/FAIL): _____

REMARKS/OBSERVATIONS:

ANALOG OUTPUT	PRETEST		NOISE APPLIED		
NAME/TAG NO.	DC VALUE	P-P NOISE	DC VALUE	P-P NOISE	%DEV
PZR VAP/T454A					
NR TEMP/T441L					
NR TEMP/T441K					
WR PRE/P408B					

TAPE SET:

TAPE FOOTAGE:
(PRETEST/TEST/POST-TEST)

REMARKS/OBSERVATIONS:

PERFORMED BY/DATE:

Figure 1-6. Noise Test Data Sheet

ATTACHMENT A
NOISE INJECTION "ANTENNA" CONNECTIONS

NOTE: The antenna for noise injection is to be a 40 foot length of unshielded, non-twisted two conductor cable bundled to the non-class 1E test cable. The class non-1E test cable shall consist of a non-shielded twisted pair cable. The antenna and class non-1E cabling is separated from the class-1E cabling outside the protection cabinet. The antenna, class-1E and class non-1E cabling are all bundled together inside the protection cabinet. See figures B-1 and B-2 for antenna placement.

This attachment contains the following tables:

- Table A-1a - Noise Injection Field Connections (Antenna Coupled)
- Table A-1b - Noise Injection Field Connections (Direct Coupled)

TABLE A-1a

NOISE INJECTION FIELD CONNECTION (Antenna Coupled)

Channel #	I/O Description	Channel Tag #	CONNECT NON-1E TEST CABLE TO: Terminal Block	Terminal Connection Hi	Lo	Sh	Isolator Type	I/O Board Location/ Channel #	CONNECT LOAD TO NON-1E TEST CABLE
1.	Bistable Partial Trip	ITS/442G	13-M	1	2		Class non 1E/1E Isolation Barrier	13T-10/1	40 Watt Light Bulb
2.	Analog Output	IPY/408A	13-N	4	5	6	Class non 1E/1E Isolation Barrier	13T-16/2	600 OHMS
3.	Contact Output (No)	ITY/441A	13-M	7	8		Class non 1E/1E Isolation Barrier	13T-12/2	Open Circuit
4.	Contact Output (NC)	ITY/441A	13-M*	7	8		Class non 1E/1E Isolation Barrier	13T-12/2	Open Circuit
5.	Contact Output (No)	TY/441A	13-M	7	8		Class non 1E/1E Isolation Barrier	13T-12/2	Short Circuit
6.	Contact Output (Nc)	TY/441A	13-M*	7	8		Class non 1E/1E Isolation Barrier	13T-12/2	Short Circuit

*Move wire terminated on 13T-12-6 to 13T-12-7 to test NC configuration.

TABLE A-1b

NOISE INJECTION FIELD CONNECTION (Direct Coupled)

Channel #	I/O Description	Channel Tag #	Terminal Block	Connect Antenna to Hi	Lo	Isolator Type	I/O Board Location/ Channel #	DISCONNECT WIRES AT TERMINATION FRAME
1.	Bistable Partial Trip	ITS/442G	13-M	1	2	Class non 1E/1E Isolation Barrier	13T-10/1	2, 3
2.	Analog Output	IPY/408A	13-N	4	5	Class non 1E/1E Isolation Barrier	13T-16/2	5, 7
3.	Contact Output	ITY/441A	13-M	7	8	Class non 1E/1E Isolation Barrier	13T-12/2	5, 6

ATTACHMENT B
FIELD CONNECTIONS AND SIMULATION

This attachment contains the following figures:

- o Figure B-1 Noise Test Setup (Antenna Coupled)
- o Figure B-2 Noise Test Setup (Direct Coupled)
- o Figure B-3 Strip Chart Recorder/Function Generator Connections
- o Figure B-4 4-50 mA Transmitter
- o Figure B-5 Wide Range Resistance Temperature Detector
- o Figure B-6 Narrow Range Resistance Temperature Detector
- o Figure B-7 10-50 mA Current Loop Output Monitoring
- o Figure B-8 Contact Output Monitoring Connection
- o Figure B-9 Partial Trip Output Monitoring

Cabinet Configuration Information:

The cabinet under test, Qualification Unit 2, is an exact replica of Watts Bar Nuclear Power Station Protection Rack 13. The following drawings document the cabinet configuration. Copies of these drawings will be included as part of the final test report.

Drawing Description	Drawing Number/Rev.
Terminal Block Wiring Diagram, Protection Set 4	1-47043 PW-13, rev. 3E
Process Control Block Diagram, Delta T/T_{AVG} System	108D408 sh. 10, rev. 11
Process Control Block Diagram, W.R. S.G. Level	108D408 sh. 34, rev. 8
Process Control Block Diagram, Pressurizer Liquid/Vapor Temp.	108D408 sh. 38, rev. 4

Process Control Block Diagram, RHR Pump Discharge Temp	108D408 sh. 39, rev. 5
Process Control Block Diagram, RCS Wide Range Pressure	108D408 sh. 43, rev. 1
Eagle-21 Schematic Diagrams, Rack 13 Protection Set 4	1856E69 sh. 2, rev. 2

(See figure 5-1 of WCAP test report)

Figure B-1 Noise Test Setup (Antenna Coupled)

(See figure 5-2 of WCAP test report)

Figure B-2 Noise Test Setup (Direct Coupled)

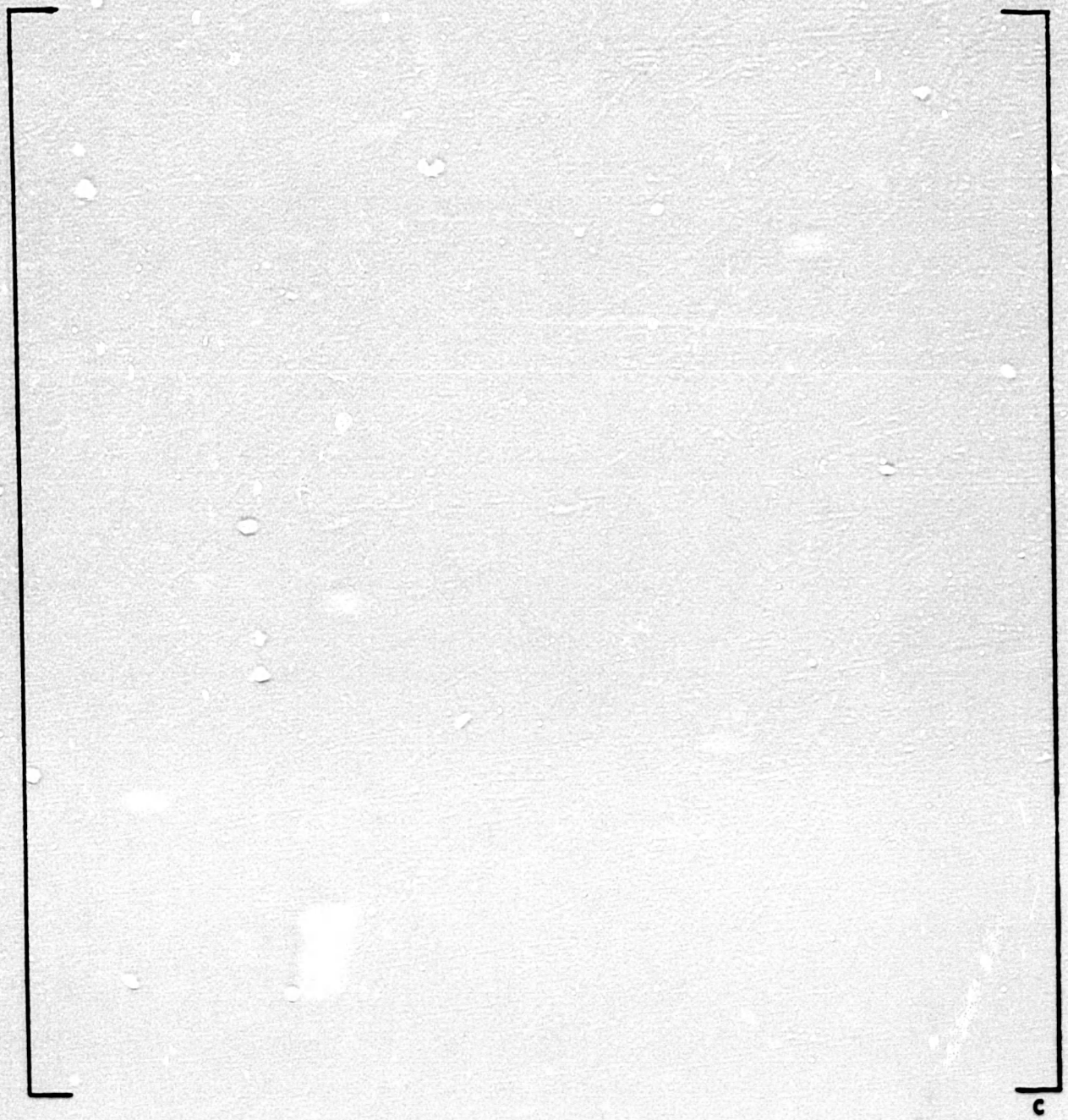


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Figure B-3 Strip Chart Recorder/Function Generator Connections

(See Figure 6-4 of WCAP test report)

Figure B-4 4-50 mA Transmitter

(See figure 6-5 of WCAP test report)

Figure B-5 Wide Range Resistance Temperature Detector (RTD)

(See figure 6-6 of WCAP test report)

Figure B-6 Narrow Range Resistance Temperature Detector

(See figure 6-7 of WCAP test report)

Figure B-7 10-50 mA Current Loop Output Monitoring

(See figure 6-9 of WCAP test report)

Figure B-8 Contact Output Monitoring

(See figure 6-8 of WCAP test report)

Figure B-9 Partial Trip Output Monitoring