ENCLOSURE 4

Westinghouse Electric Corporation, WCAP-11896,
"Noise, Fault, Surge, and Radio Frequency Interface
Test Report for Eagle 21 Process Protection Upgrade System,"
dated July 1988 (nonproprietary)

WESTINGHOUSE CLASS 3

QA Record
WCAP-11896

B26 '88 0930 350

APRROVED
This approval does not relieve the Contractor from any part of his responsibility for the correctness of design, details and dimensions.
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TENNESSEE VALLEY AUTHORITY
and'd by ltr # WBN-10043
Watts Bar Project Engineer

PROJECT: WBN DATE SEP 30 1988
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NOISE, FAULT, SURGE, AND RADIO FREQUENCY INTERFERENCE TEST REPORT

FOR

Westinghouse Eagle-21™ Process Protection Upgrade System

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July 1988

WESTINGHOUSE POWER SYSTEMS
Pittsburgh, Pennsylvania 15230

ABSTRACT

The following test report documents the Eagle 21™ protection system adverse electrical noise test program. The primary objective of this test program was to demonstrate that the Eagle 21™ system remained operational before, during, and after the applied noise conditions. Other objectives were to demonstrate the physical independence of class non-1E and class-1E circuitry within the Eagle 21™ system.

The Eagle 21™ system met all performance requirements specified by the acceptance criteria. The adverse noise conditions applied to the Eagle 21™ system are designed to exceed worst-case noise environment conditions.

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SECTION 1
INTRODUCTION

This report documents the "adverse noise" test results of the Eagle 21™ Process Protection System.

The Eagle 21™ is a microprocessor-based functional replacement for the analog process protection equipment originally installed in a nuclear power generating plant.

The testing of the Eagle 21™ equipment was performed to demonstrate system operability before, during, and after the "adverse noise" conditions were applied. These adverse noise conditions are separated into four catagories:

- o Noise Interference
- o Fault Isolation
- o Surge Withstand Capability (SWC)
- o Radio Frequency Interference (RFI)

A description of the tests, acceptance criteria, and test results of the Eagle 21™ in these adverse noise environments are contained in this report.

The Radio Frequency Interference tests were performed in an anechoic chamber [ ]$_c$, with the balance of the tests performed at the Westinghouse Instrumentation Technology Training Center (ITTC) located in Monroeville, Pennsylvania. These tests were performed during a three-month period from December 1987 through February 1988.

SECTION 2
EAGLE 21™ SYSTEM DESCRIPTION

2.1 INTRODUCTION

The Westinghouse Eagle 21™ Process Protection Upgrade System is a qualified, microprocessor-based functional replacement for the analog process protection equipment originally installed in a nuclear power generating plant. the modular design of the Eagle 21™ hardware permits installation in existing process protection system cabinets after the analog electronics and internal cabinet wiring are removed. There is minimum disruption of external wiring because cabinet field terminal blocks and field cables are mostly undisturbed. All system inputs and outputs are preserved, and all existing field interfaces are maintained. Figure 2-1 depicts one Eagle 21™ cabinet.

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2.1.1 Replacement of Existing Process Instrumentation

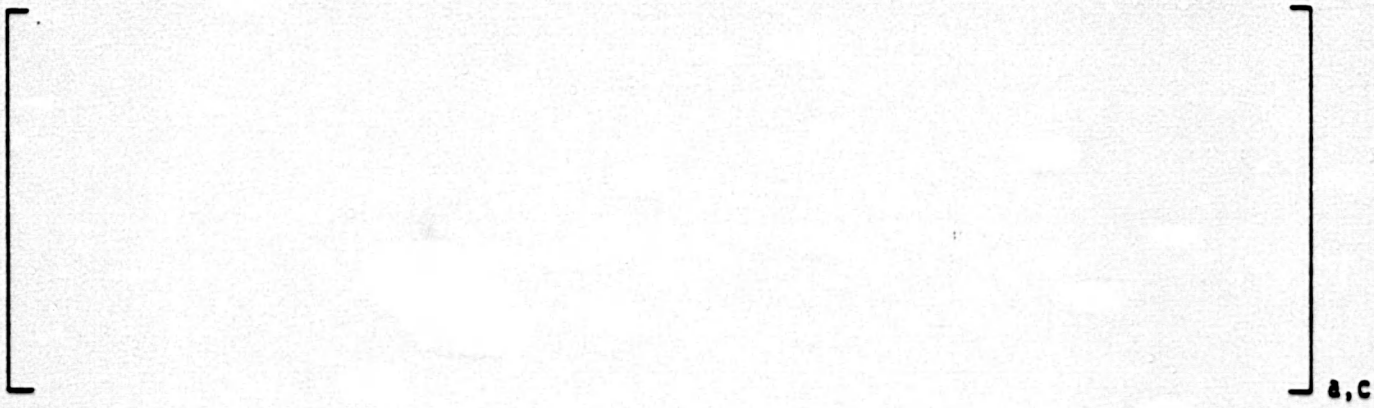

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Figure 2-1 Eagle 21™ Process Protection Upgrade System Cabinet

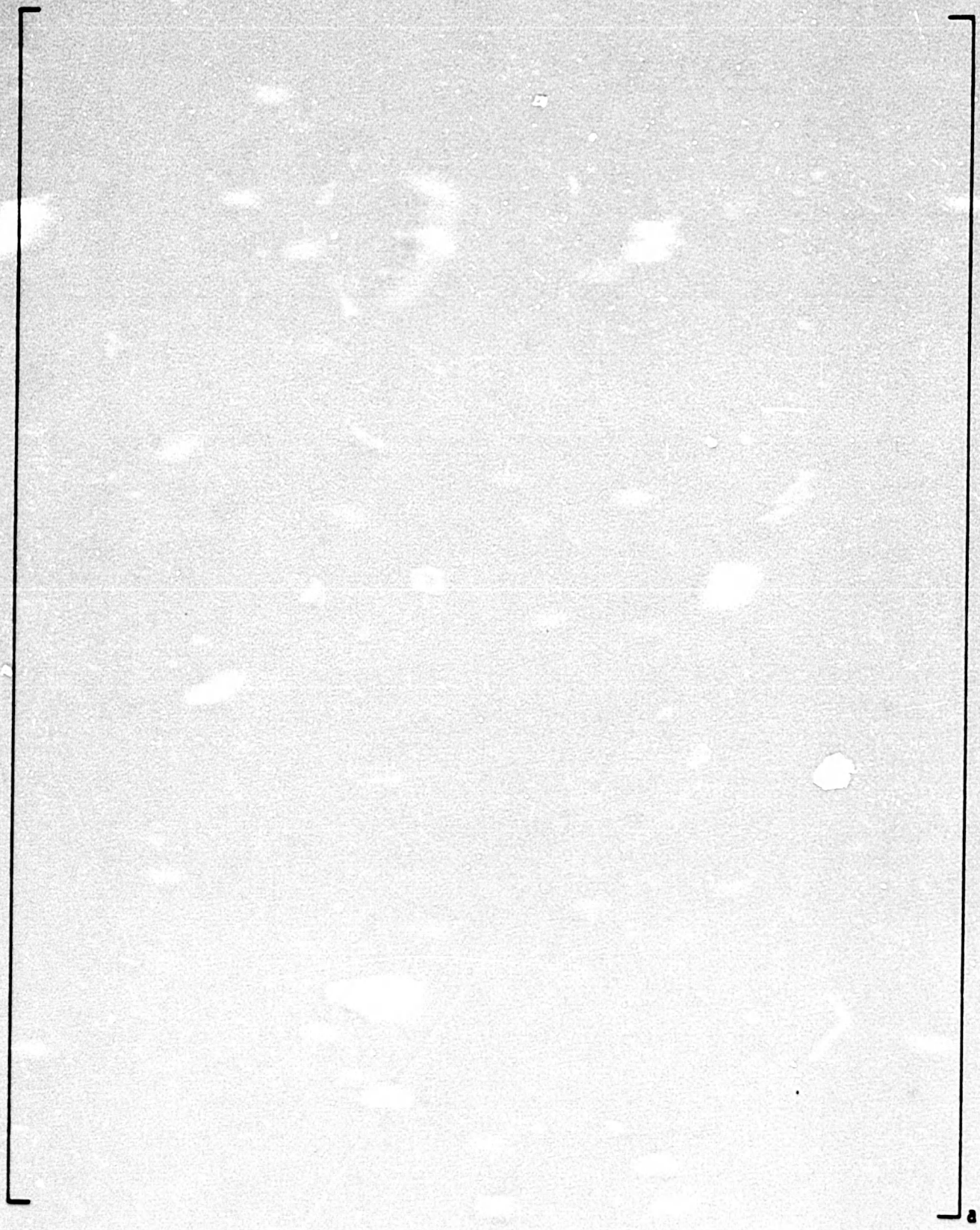

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Figure 2-2 Eagle 21™ Cabinet Installation

2.1.2 Plant Applications

The Eagle 21™ Process Protection Upgrade System is utilized in nuclear power generating stations to monitor Nuclear Steam Supply System (NSSS) parameters and to display indications of these parameters to the operating personnel. These indications meet the post-accident monitoring (PAM) requirements of Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident." Figure 2-3 depicts the typical interconnections between the process protection equipment and other plant systems. [ ]a

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Figure 2-3 Typical I&C System Configuration

The NSSS parameters monitored by the Eagle 21™ Process Protection Upgrade System consist of temperatures, pressures, liquid levels, and flows. Resistance temperature detectors (RTDs) are used for temperature measurements. Electronic transmitters having either a 4- to 20-mA or 10- to 50-mA range are used to monitor pressure, level, and flow parameters. The system can also accept analog voltage or current inputs from other nuclear process systems such as the Nuclear Instrumentation System (NIS).

All inputs are converted to digital signals by the microprocessor-based Eagle 21™ electronics. After the desired signal conditioning is accomplished (including dynamic compensation of time-dependent signals, summation, and scaling), the system produces the following types of outputs:

- Analog outputs -- 10- to 50-mA or 4- to 20-mA (or 1- to 5-vdc) signals supplied to control board indicators or the process control systems

- Contact outputs -- On/off signals used to actuate control board annunciators

- Channel trip outputs -- On/off signals used to control 120-vac input relays of the Solid State Protection System (SSPS), or a relay-based protection system, for reactor trip and safeguards actuation signals

2.1.3 Design Features

Major design features of the Eagle 21™ Process Protection Upgrade System are described in the following paragraphs.

2.1.3.1 Single Failure Criterion

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2.1.3.2 Instrument Power Source

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2.1.3.3 Channel Integrity

The Eagle 21™ Process Protection Upgrade System has been designed to perform its protective functions under extreme operating conditions relating to its environment, its energy supply, any malfunctions, and any accidents.

2.1.3.4 Channel Independence

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2.1.3.5 Control and Protection System Interaction

The Eagle 21™ Process Protection Upgrade System functions with complete independence from the plant's control systems. (Control systems include remote indicators, computer data points, and annunciators as well as circuits that automatically control plant parameters.) Protective functions are electrically isolated from any fault or malfunction that occurs in the control systems.

2.2 FUNCTIONAL DESCRIPTION

The following paragraphs provide a brief functional description of the Eagle 21™ Process Protection Upgrade System, based on the simplified functional block diagram shown in figure 2-4.

2.2.1 Block Diagram

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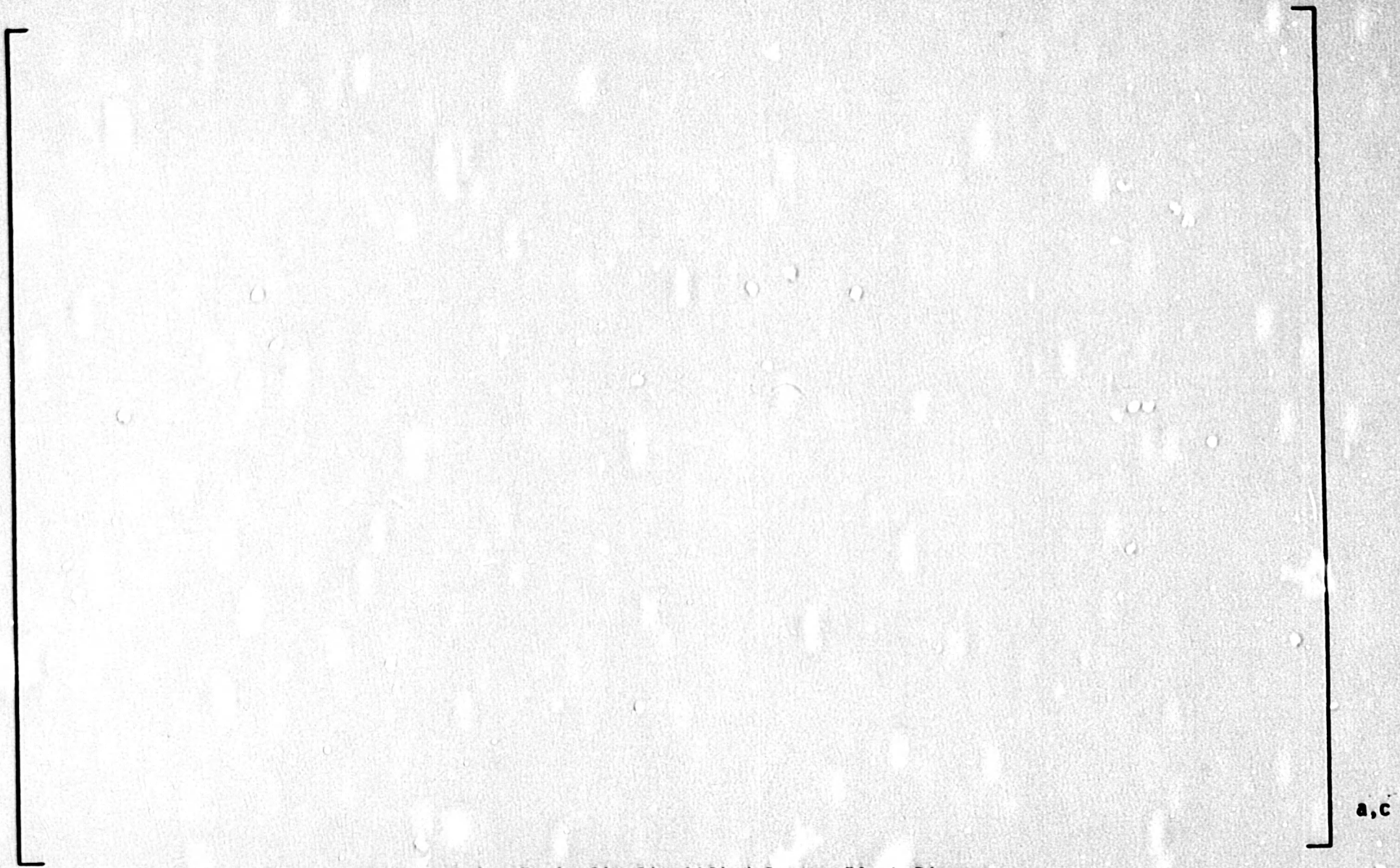
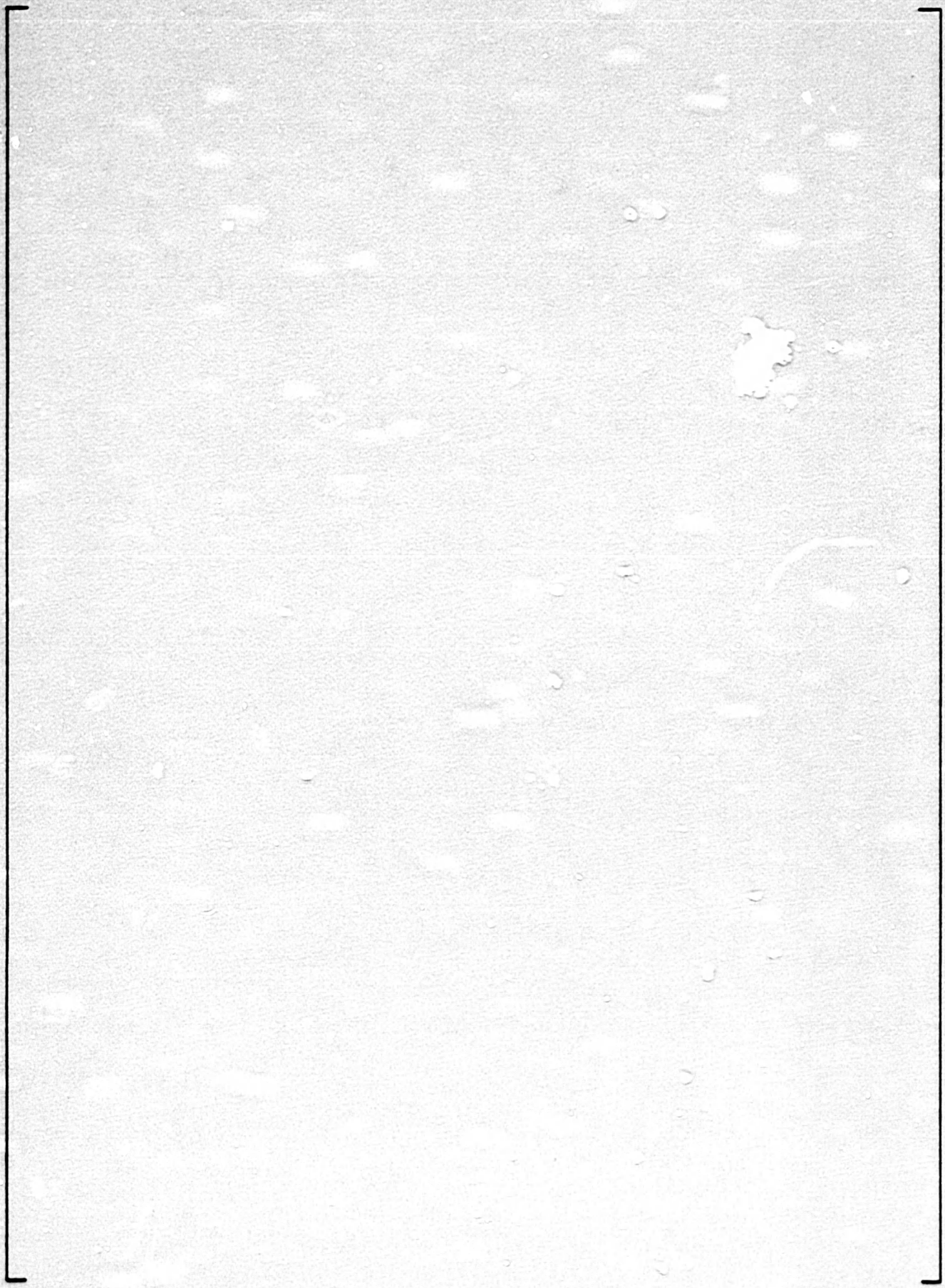


Figure 2-4. Eagle 21™ Simplified System Block Diagram



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2.3 CABINET DESCRIPTION

The Eagle 21™ Process Protection Upgrade System is housed in existing process instrumentation cabinets to which structural bracing and mounting rails have been installed. Cabinet front and rear views are shown in figures 2-6 and 2-7. [ ]c

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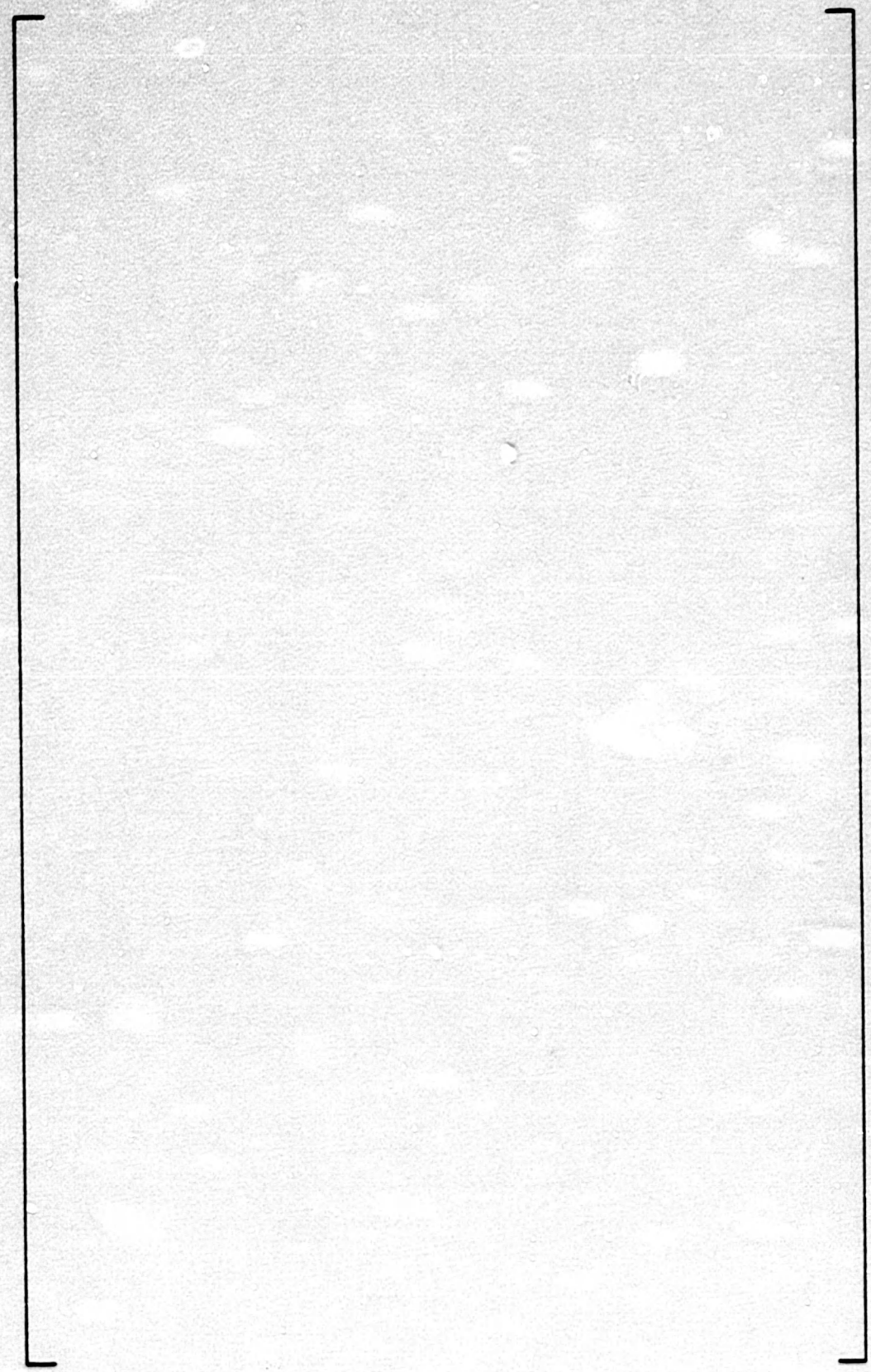

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Figure 2-5 Man-Machine Interface (MMI) Cart

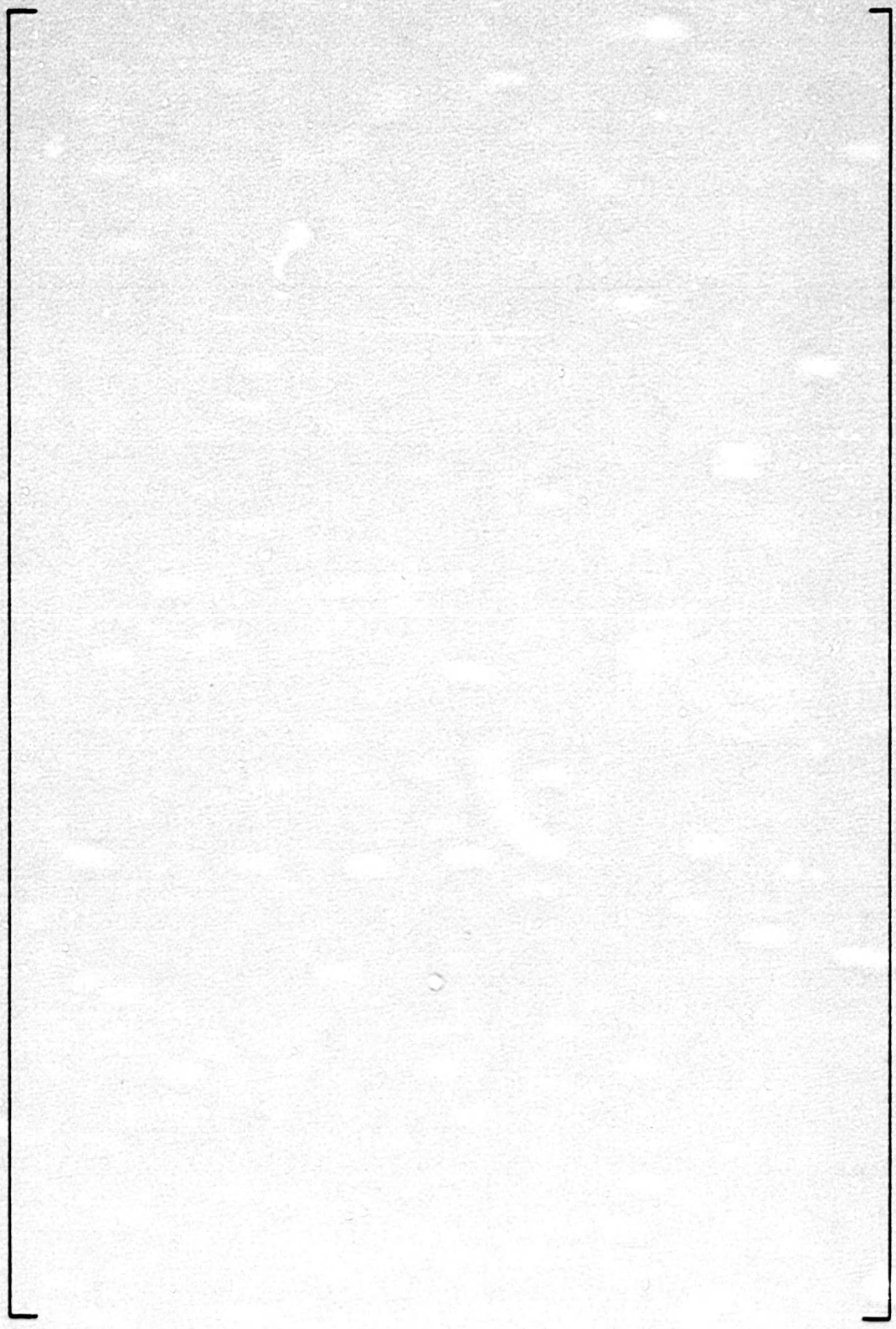

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Figure 2-6 Cabinet Front View

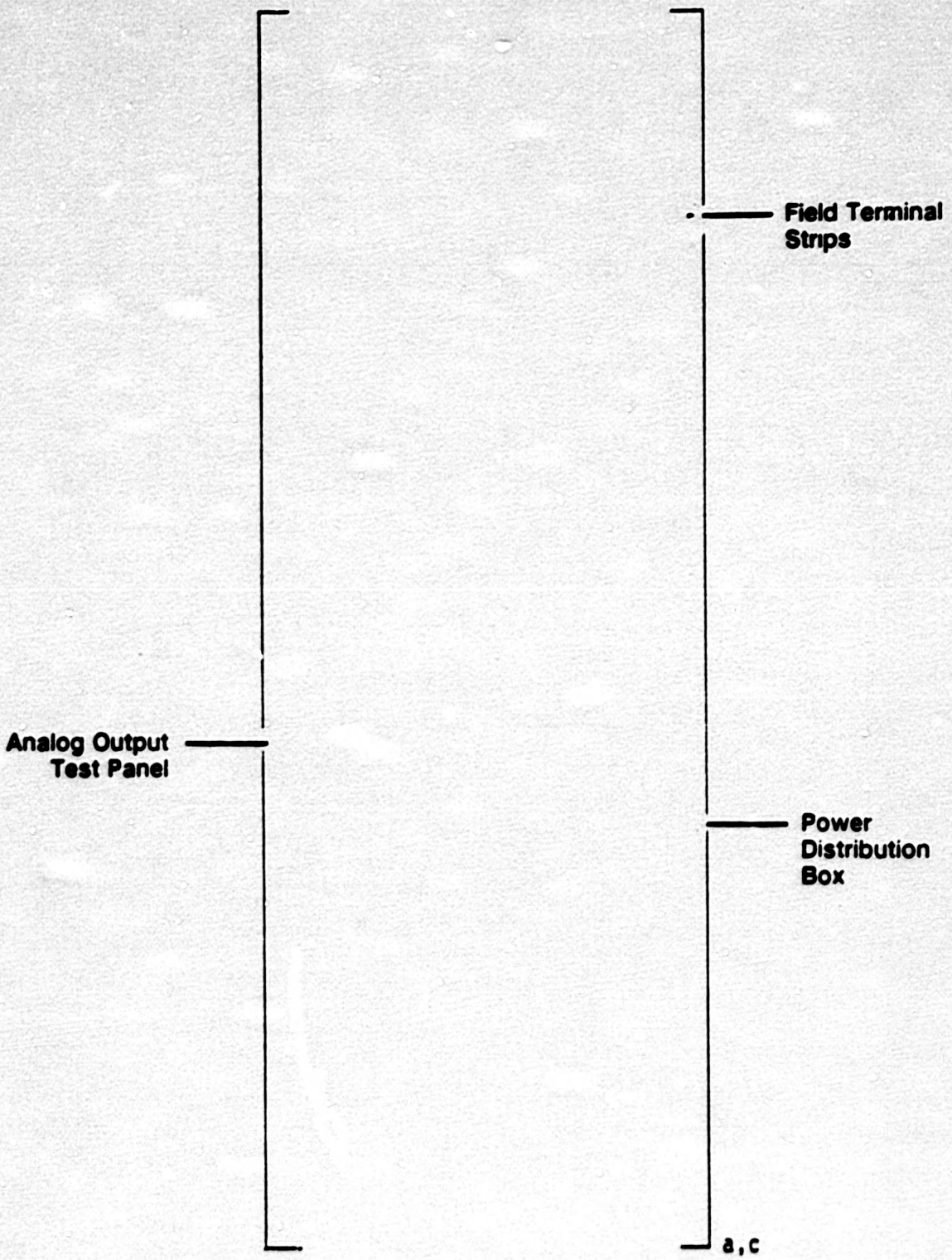

Figure 2-7 Cabinet Rear View

SECTION 3

EAGLE 21™ SYSTEM CONFIGURATION

3.1 DESCRIPTION

The Eagle 21™ system tested (Qualification Unit 2) is an exact replica of Watts Bar Nuclear Power Station protection rack 13. This rack contains the following instrument loops (subsystems):

- o Delta T/Tavg, Protection
- o Steam Generator Wide Range Level, Post Accident Monitoring (PAM) (2 Channels)
- o Pressurizer Vapor Temperature, (PAM)
- o Residual Heat Removal Pump Discharge Temperature, (PAM)
- o Reactor Coolant System Wide Range Pressure, (PAM)

3.2 CONFIGURATION/DESIGN LEVEL DRAWINGS

The following drawings/revision levels are attached to document the system configuration tested:

Drawing Description	Drawing Number/Revision
Terminal Block Wiring Diagram, Protection Set 4	1-47043, PW-13, Revision 3E
Process Control Block Diagram, Delta T/T_{avg} System	108D408, sheet 10, Revision 11
Process Control Block Diagram, WR SG Level	108D408, sheet 34, Revision 8
Process Control Block Diagram, Pressurizer Liquid/Vapor Temperature	108D408, sheet 38, Revision 4

Drawing Description	Drawing Number/Revision
Process Control Block Diagram, RHR Pump Discharge Temperature	108D408, sheet 39, Revision 5
Process Control Block Diagram, RCS Wide Range Pressure	108D408, sheet 43, Revision 1
Eagle 21™ Schematic Diagrams, Rack 13 Protection Set 4	1856E69, sheet 2, Revision 2

The following drawings/revision levels are referenced to document the system hardware tested:

Drawing Description	Drawing Number/Revision
Cabinet General Assembly	1870E97G01, Revision 3
Analog Input Board, 10-50, 4-20 mA (EAI-G01)	5367C57, Revision 4
WR RTD Input Board (ERI-G01)	5368C29, Revision 2
NR RTD Input Board (ERI-G02)	5368C29, Revision 2
Partial Trip Output Board (EPT-G01)	2D33786, Revision 2
Digital Contact Output Board (ECO-G01)	5367C61, Revision 3
Analog Output Board 10-50 mA (EAO-G02)	5367C60, Revision 3
Power Distribution Box (G01)	1871E34, Revision 3
Termination Module Assembly 0-10 Volt (G01)	2D33779, Revision 1

Drawing Description	Drawing Number/Revision
Termination Module Assembly 4-20 mA (G01)	2D27362, Revision 1
Termination Module Assembly 10-50 mA (G06)	2D27362, Revision 1
Baseline Design Document	956093, Revision 0
*Digital Contact Output Board (ECO-G01)	5367C61, Revision 4
*Partial Trip Output Board (EPT-G01)	2D33786, Revision 3

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*Boards modified to successfully complete fault testing. Modifications made and required retests are described in sections 8.2, 8.3 and Appendix A.

I/O and microprocessor boards were configured per design specification 956073, Revision D.

System software used has been retained on permanent file.

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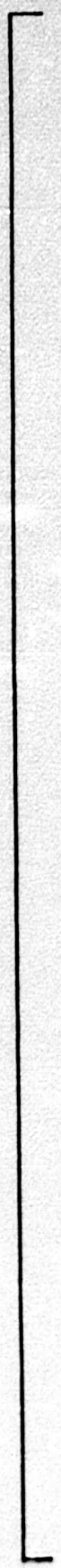

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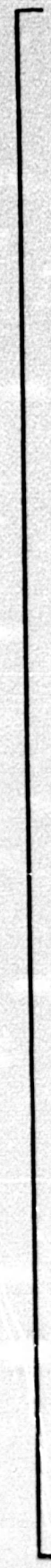

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SECTION 4

ISOLATION DEVICES PHILOSOPHY

4.1 DESCRIPTION

The Eagle 21™ System uses the output signal conditioning boards as an isolation barrier between field level signals and the microprocessor subsystem. The Eagle 21™ uses the following types of isolation devices for interfacing Class 1E signals with non-1E equipment.

Isolator Board Type	Isolation Device
Analog Output Board (current loop), EAO Digital Contact Output Board, ECO Partial Trip Output Board, EPT	[ ] c

In addition, high voltage transient protection is provided for each cabinet input/output, including the ac power feed, by transient suppression circuitry. Fault currents are limited by preferred failure mode components.