Attachment 9

Non-proprietary version of GA-ESI test report 04508905-QR, "Qualification Test Report for RM-1000 Processor Module and Current-To-Frequency Converter," Revision A

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
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[redacted]

NUCLEAR SAFETY RELATED
SEISMIC CATEGORY I

GENERAL ATOMICS
ELECTRONIC SYSTEMS

4949 GREENCRAIG LANE
SAN DIEGO, CA 92123-1675

		DATE	
DRAWN	A.E. BUTT	1/29/01	
CHECKED	________	________	QUALIFICATION TEST REPORT FOR RM-1000 PROCESSOR MODULE AND CURRENT-TO-FREQUENCY CONVERTER
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CHANGE RECORD

Issue	Date	Description of Change
Rev. -	January 2001	Original Issue
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CONTENTS

APPENDICES

FIGURES

TABLES

1. OBJECTIVE

The objective of this report is to document the environmental and seismic qualification for the Sorrento Electronics RM-1000 Processor Module and Current-to-Frequency Converter.

The qualification tests were established to demonstrate that the RM-1000 Processor Module, with its associated NIM Bin assembly, and Current-to-Frequency Converter are capable of operating at the extremes of their environmental range and are capable of withstanding seismic events at most nuclear plant sites. The tests were conducted as a functional qualification of the RM-1000 Processor Module with simulated interfaces to typical process and area monitor systems.

The tests included:

- Component age conditioning
- Age conditioning margin
- Environmental extremes testing
- Functional testing
- Generic seismic testing

The test articles were:

- RM-1000 (SE P/N 04501000-001) mounted in a NIM Bin and connected to a remote pulse generator to simulate an area detector.
- RM-1000 (SE P/N 04501000-001) mounted in a NIM Bin and connected to a remote pulse generator to simulate a process detector.
- NIM Bin assembly (SE P/N 04500801-001 and –002)
- Current-to-Frequency (I/F) Converter Module (SE P/N 04506150-001) mounted in a separate enclosure connected to a remote RM-1000 and a current source to simulate an ion chamber detector.

The qualification program was prepared in accordance with and intended to satisfy the requirements of:

- IEEE Std. 323-1983 and 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

- IEEE Std. 344-1987 and 344-1975, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.
- IEEE Std. 381-1977, IEEE Standard Criteria for Type Tests of Class 1E Modules used in Nuclear Power Generating Stations.
- SE Document E-115-699, Rev. 3 (June 1986), Class 1E Equipment Qualification and Aging Plan.

This report presents the test results in the following sections:

Section 1. OBJECTIVE. This section defines the reason for the report, an outline of the tests performed, a list of test articles, the standards to which the test articles were qualified, and a description of each section of the report.

Section 2. EQUIPMENT DESCRIPTION. This section is a detailed description of the test articles. It examines both hardware and software configurations.

Section 3. TEST PROGRAM. This section describes the qualification program and sequence of tests performed. It includes a brief description of the functional requirements, component selection for aging, and seismic spectra determination.

Section 4. TEST SUMMARY. This section summarizes the results of testing and provides a cross reference to the test data contained in the appendices of this report.

Section 5. TEST FACILITIES. This section contains a brief description of the test facilities used to conduct the tests.

Section 6. MODIFICATIONS. This section demonstrates the qualification basis for modification to the RM-1000, with its associated NIM Bin assembly, and I/F converter that have qualification significance. The section is arranged by Engineering Change Order (ECO) number.

Section 7. CONCLUSIONS AND RECOMMENDATIONS. This section provides a conclusion, regarding the qualification of the RM-1000, with its associated NIM Bin Assembly, and I/F Converter. It includes a description of deviations and anomalies and reference to their resolution, as well as a listing of limited life components.

APPENDICES. These appendices included as part of this report; are the Age Conditioning Evaluation, the Required Response Spectra, the seismic test fixture, the Technical Evaluation of DC-DC Converter Replacement, and theTechnical Evaluation of Replacement Power Supply.

2. EQUIPMENT DESCRIPTION

The RM-1000 Radiation Monitoring Processor Module [redacted] radiation detectors. The RM-1000 provides [redacted] The modules are packaged as industry standard Nuclear Instrumentation Modules (NIM), in a double width NIM size. Figure 2-1 is the front view of the RM-1000. This section describes the basic RM-1000 module, its physical arrangement, functionality, and the test article configurations. Figures are located at the end of the section.

The description of the basic RM-1000 module (Section 2.1) includes the physical location of the module subassemblies, their interconnection and functionality. The Current-to-Frequency Converter is used with the RM-1000 Processor Module for ion chamber detectors. A description of the I/F Converter is provided in Section 2.2. The basic RM-1000 can be used as either an area radiation monitor or a process radiation monitor. The RM-1000 module mounts in a standard NIM Bin assembly that is further described in Section 2.3. Section 2.4 describes the configurations for the test articles, their functionality and the interface to the area and process detectors to simulate connection in an actual monitor installation.

2.1 The Basic RM-1000 Radiation Monitoring Processor Module

This section describes the physical and functional arrangement of the basic RM-1000 Radiation Monitoring Processor module configuration. Figures 2-2 through 2-5 identify the major subassemblies of the RM-1000.

2.1.1 Physical Description

The module's processing is based on the use of an [redacted] except for the more extensive use of on-chip peripherals. Memory includes [redacted] of battery-backed RAM to provide programming and data storage. Counters are used to store pulse outputs and a digital algorithm is applied to produce the measured countrate or dose rate output values. [redacted] are provided, which allow the implementation of two energy windows. Digital-to-analog converters are used to provide analog outputs to remote meters. Data entry is via a 16-button keypad. Front panel display is provided by a [redacted] which is programmed to provide a [redacted] Also displayed are various operator interface menus and data entry functions. An [redacted] is used for communications to [redacted] pair wire. [redacted]s also provided to allow software uploading. The front plate of the module is hinged to allow ready access to test points.

Figure 2-1 is an external front view of the RM-1000. The components shown on the front panel includes the gas plasma display screen, channel status LED indicators, and the operator interface keypad. The display screen presented shows the normal operation display of the bargraph and digital value for the current radiation level, with the two alarm setpoints flagged, Trip 1 and Trip 2. [redacted]

Figure 2-2 is an exploded view of the RM-1000. The RM-1000 is modular in design. A motherboard contains a backplane with connector sockets in which the CPU, Counter, and Output boards are inserted. A high voltage power supply module is attached internally to the rear panel of the module and connects to the motherboard through a cable harness. A Keypad/Display board is mounted to the front panel and connects to the CPU board by means of a ribbon cable.

2.1.2 Functional Description

The RM-1000 is able to perform [redacted] nature of its circuitry. These two basic operating modes are selectable using a [redacted] switch, prior to installation. For area monitor [redacted] the application type 1 mode is selected, and for process detectors, the application type 2 mode is selected.

The RM-1000 is a pin-compatible replacement for SE's RP-1, RP-2, and RP-30 analog processor modules (and their variations, e.g., RP-1A, RP-2A, RP-30A, etc.). The RP-1 readout module accepts signals from Geiger-Mueller (GM) tube detectors, the RP-2 module accepts signals from ion chambers, and the RP-30 accepts signals from scintillation detectors. The RP-30 contains additional discriminator circuitry to provide single channel radiation analysis. [redacted]

2.2 The Current-to-Frequency Converter

The Current-to-Frequency (I/F) Converter is a separate module that converts the current signal from ion chamber detectors into pulses that can be counted by the RM-1000 processor module. The module contains [redacted] with capability similar to that found in the RM-2000 and RM-80 microprocessors. It is capable of accurately [redacted] and converting these currents into pulses that can be counted by the RM-1000 in the application type 2 processor mode.

The I/F converter has a signal input connector from the detector and a signal output connector to the RM-1000 processor module. It includes a test circuit that provides a known input current to check the operation of the electronics to provide a specific output.

2.3 NIM Bin Assembly

A standard NIM Bin assembly (SE P/N 04500801-001 through –006) is used to mount from one to six RM-1000 modules. The NIM Bin assembly mounts to a standard 19-inch rack or cabinet using four number 10 screws. The NIM Bin assembly includes an interface connector to field wiring as well as a low voltage power supply for each RM-1000 module.

2.4 Test Article Configuration

Two RM-1000 and I/F converter test articles were constructed and configured for qualification testing. One RM-1000 was configured as an area monitor module; the other as a process monitor module. The RM-1000 test articles were installed in a standard NIM Bin assembly. The I/F converter was a stand-alone device mounted, as it would be in service. The I/F converter used a remote RM-1000 configured as an ion chamber area monitor module. The physical arrangements for the RM-1000 and I/F converter assemblies are shown in Figure 2-3. The wiring arrangement for the area RM-1000 system is shown in Figure 2-4. The wiring arrangement for the process RM-1000 system is shown in Figure 2-5. The wiring arrangement for the I/F converter is shown in Figure 2-6.

Wiring was connected in the same manner as found in a control room cabinet installation. Wiring was connected to plug type connectors that mated with the connectors on the back of the RM-1000s or to the connectors on the I/F converter.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

3. TEST PROGRAM

Figure 3-1 shows the qualification test sequence and identifies the procedures and appendices where the test information may be found. This section describes:

1. The test sequence
2. The functional requirements
3. The rationale for the selection of components to be age conditioned.
4. The rationale for selection of the required response spectra.

The results of these tests are described in Section 4. Figures and tables are located at the end of this section.

3.1 TEST SEQUENCE

The test sequence is as follows:

1. Component age conditioning
2. Test article assembly
3. Relay driver age conditioning
4. Pre-environmental functional test
5. Age conditioning margin test
6. Extremes test
7. Post environmental functional test
8. Seismic test set up
9. Pre-seismic functional test
10. Seismic test
11. Post seismic functional test
12. Visual inspection

3.2 FUNCTIONAL REQUIREMENTS

The intention of qualification testing is to demonstrate that the RM-1000 Processor Module (RM-1000), with its associated NIM Bin Assembly, and the I/F converter are capable of performing their safety functions before, during and after the environmental extremes and a seismic event. The following sections describe the functional requirements for the RM-1000 and the I/F converter and present the acceptance criteria to be used to judge the RM-1000's and the I/F converter's acceptability. Generally, the RM-1000 and I/F converter must perform a variety of functions before and after the environmental extremes and a seismic event. During the environmental extremes and the seismic event, the RM-1000 and the I/F converter must maintain their status and not introduce errors or false alarms.

The allocation table of the System Requirements Specification, SE Document 04507000, Appendix B, Revision B, provides a listing of Critical Characteristics, RG-1.97 Functions and Safety Functions. The table further identifies where the requirements are met by Hardware, Software, and/or Operating Procedures.

IEEE-323 qualification requires that safety functions that apply to hardware be qualified in accordance with the standard's requirements. In some cases the software must be functional in order to qualify the hardware. The dividing line is difficult to establish, therefore, as a conservative measure the software must be fully functional. For our purposes, the RG-1.97 functions will also be qualified.

The safety and RG-1.97 functions being qualified by this testing program are described in Table 3-1. They must be met before and after the environmental extremes and seismic events. Other Safety and RG 1.97 functions listed in SE document 04507000, Revision B, Appendix B, are described in Table 3-2. Their qualification is described in Section 3.2.3.

Table 3-1 RM-1000 Functional Requirements

FUNCTION	SAFETY FUNCTION	RG-1.97 FUNCTION	REQUIREMENT
Analog Output		X	[redacted]
Analog Voltage		X	
Analog Current		X	
Trip 1 Alarm	X	X	

FUNCTION	SAFETY FUNCTION	RG-1.97 FUNCTION	REQUIREMENT
			radiation value is equal to or greater than the Trip 1 setpoint, the Trip 1 relay deenergizes and the front panel yellow Alert LED shall come on until the alarm is manually cleared.
Trip 2 Alarm	X	X	RM-1000 Trip 2 Alarm status shall indicate the channel radiation level has exceeded the alarm setpoint. When the radiation value is equal to or greater than the Trip 2 setpoint, the Trip 2 relay deenergizes and the front panel red High LED shall come on until the alarm is manually cleared.
Loss of Operate Alarm		X	The RM-1000 shall generate a visual loss of operate (fail) status alarm indication when a failure occurs. The fail relay shall deenergize when the alarm occurs and shall remain deenergized until the alarm clears.
Alarm State During Power Failure	X	X	The alarm relays shall deenergize when the RM-1000 is powered off.
Front Panel (General Description)		X	The front panel shall provide the RM-1000 user interface. The user interface shall acquire information from the system [redacted]
System Display And Current Activity Display		X	[redacted]
100X Over-Range		X	All RM-1000 radiation detection channels shall produce a full-scale reading when subjected to radiation fields, as a minimum, 100 times higher than full scale. The channel shall be protected against over-range such that the operation and calibration are unaffected subsequent to an over-range condition. The RM-1000 shall display data that is consistent

FUNCTION	SAFETY FUNCTION	RG-1.97 FUNCTION	REQUIREMENT
			with an over-range condition.
Loss of Counts		X	The channel shall be considered to have a detector failure if no pulses have been detected within a period of time that is a user adjustable parameter. The Operate LED shall be extinguished upon this condition.
Alarm Processing Checks	X		RM-1000 checks for Trip 1 and Trip 2 alarm shall always be performed, except when a checksource test is in progress when alarm status shall remain unchanged.
Power Fail Recovery	X	X	The RM-1000 shall have a capability to preserve user adjustable parameters and calibration data during periods in which there is a loss of input power and to recover the data when power is restored.
RM-1000 Accuracy	X		[redacted]

The requirements listed in Table 3-1 were the basis for the Functional Tests performed on the RM-1000 and I/F Converter. It should be noted that the qualification of the I/F Converter is based upon the proper input to the RM-1000.

The function tests required are divided into the three types of modules being qualified.

3.2.1 RM-1000 Functional Verifications

- Current activity and system display
- Analog output current
- Analog output voltage

- Trip 1 (Alert) and Trip 2 (High) Alarms and indications
- Loss of Operate Alarm
- Loss of Counts Indications
- Alarm state during power fail and power recovery
- 100X Over-range and over-range indications

3.2.2 I/F Converter Functional Verification

- Current activity and system display
- Analog output current
- Analog output voltage
- Loss of Operate Alarm
- Loss of Counts Indication
- Alarm state during power fail and power recovery
- 100X Over-range and over-range indications
- Accuracy over the activity range

During the environmental extremes test, the RM-1000 and I/F converter are required to meet the following acceptance criteria:

1. There shall be no visible damage to the test articles that could affect their operation.
2. The analog and displayed output of the RM-1000 shall be within [redacted] environmental testing.
3. When the current source and pulse generator signal input is above a pre-established setpoint, the RM-1000 front panel indicator displays an alarm status (before and after environmental testing) and the RM-1000 alarm relays deenergize.
4. The RM-1000 front panel switches and indicators shall operate properly before and after environmental testing.
5. The RM-1000 self-test shall function properly before and after environmental testing.
6. The RM-1000 and the I/F converter shall pass post-functional test.

7. The I/F converter module accuracy shall have log conformity [redacted]

During the seismic test, the RM-1000 and the I/F converter are required to meet the following acceptance criteria:

1. No equipment shall generate a missile, which could affect adjacent safety equipment.
2. There can be no visible damage to the equipment, which could affect its operation.
3. Indicated output activities of radiation detector input signals shall not vary more than [redacted] of initial reading during or following the seismic tests as viewed on the front panel of the RM-1000s. [redacted]
4. The analog activity output shall be within [redacted] of the equivalent analog full-scale output during and after the seismic tests.
5. When detector signal input is above a preestablished setpoint, the RM-1000 front panel indicator displays an alarm status and alarm output relays deenergize. (This function is not required until after the seismic event has occurred).
6. Front panel switches and indicators to operate properly after seismic event.
7. Self-test to function properly after the seismic event.

3.2.3 Other Safety and RG 1.97 Functional Requirements

Table 3-2 Other Functional Requirements

FUNCTION	SAFETY FUNCTION	RG-1.97 FUNCTION	REQUIREMENT
Conducted Emissions	X		A type test for conducted emissions shall be performed on the RM-1000 per MIL-STD-461D (CE-102) to demonstrate acceptable conducted emissions.
Conducted EMI Immunity	X		A type test for conducted EMI field immunity shall be performed on the RM-1000 per MIL-STD-461D (CS-101) and ENV 50141 to demonstrate acceptable immunity to injected, conducted electromagnetic fields.
Electrical Fast Transients Immunity	X		A type test for electrical fast transients shall be performed on the RM-1000 per EN 61000-4-4 to demonstrate acceptable immunity to electrical fast transients and bursts on the power input, signal and data leads.
Radiated RF EMI Field Immunity	X		A type test for RF fields such as those produced by hand held walkie-talkie units shall be performed on the RM-1000 per ENV 50140 to demonstrate acceptable walkie-talkie RF field immunity.
Radiated RF Emissions	X		A type test to demonstrate that the RM-1000 does not produce unacceptable radiated magnetic and electric fields shall be performed on the RM-1000 per ENV 55011, Class A and EN 55022, Class B.
Electrostatic Discharge Immunity	X		A type test to demonstrate acceptable RM-1000 immunity to electrostatic discharges shall be performed per EN 6100-4-2.

FUNCTION	SAFETY FUNCTION	RG-1.97 FUNCTION	REQUIREMENT
Surge Withstand Capability	X		A type test to demonstrate RM-1000 surge withstand capability shall be performed per EN 61000-4-5.
Magnetic Field Immunity	X		A type test for magnetic fields shall be performed on the RM-1000 per EN 61000-4-8 to demonstrate acceptable immunity to magnetic fields at the power frequency.
Supply Voltage Dips and Variations Immunity	X		A type test for supply voltage dips and variations shall be performed on the RM-1000 per EN 61000-4-11 to demonstrate acceptable immunity to voltage dips and variations on the power input.
Checksum Verification	X		The RM-1000 shall calculate checksums for program and configuration data memories respectively. If neither of the above conditions have been detected, the checksums shall be verified. Either a program checksum verification failure or configuration data checksum failure shall result in an operate failure. To clear the configuration data checksum failure, a configuration data value must be altered causing a new configuration data checksum to be calculated. A program checksum verification failure shall not be cleared without re-loading the program. During normal operation, the RM-1000 shall verify the checksums periodically and shall report checksum failures as defined above.
Checksum Failure	X		Checksum failure shall be indicated if there are no counts input to the channel in a specified period of time. The Operate LED shall be extinguished upon this condition.

3.2.3.1 Conducted Emissions

Conducted emissions are noise emissions, generated within the RM-1000, conducted on the power lines that could affect other equipment. Generally, other equipment is tested for immunity against a specified level of emissions from any source that may be conducted on the power lines. The RM-1000 must, therefore, have the capability to limit the level of noise transmitted outside the module to within a specified level. This is accomplished by low noise generation circuit design and the use of EMI/RFI filters on the power lines.

The RM-1000 has successfully passed MIL-STD-461D (CE-102) tests at normal laboratory conditions. Neither the environmental extremes nor the seismic events affect the ability of the RM-1000 to limit these emissions for the following reasons.

Environmentally, the filter system used within the RM-1000 [redacted] and is sealed within the [redacted] The conducted emissions are, therefore, unaffected by the environmental service conditions.

Seismically, the conducted emissions filter, as described above, is a wafer securely held within the connector with no moving parts. It has functioned successfully during seismic testing with no evidence of malfunction. The ability of the filter to limit conducted emissions is, therefore, unaffected by the seismic event.

Since the RM-1000 conducted emissions are unaffected by both environmental and seismic service conditions, conducted emissions during these service conditions are considered acceptable without further testing.

3.2.3.2 Conducted EMI Immunity

Conducted EMI Immunity is the ability of the RM-1000 to function properly when electromagnetic interference is present on the incoming power lines. The sources of the EMI may vary widely and are not relevant to the ability of the RM-1000's immunity when a specified level is present on the power line.

The RM-1000 has successfully passed MIL-STD-461D (CS-101) to demonstrate that it has acceptable immunity to conducted electromagnetic interference. For the same reasons given for conducted emissions (Section 3.2.3.1) the RM-1000 is immune to the specified level of conducted EMI at the environmental extremes and during seismic events.

3.2.3.3 Electrical Fast Transient Immunity

Electrical Fast Transients are high frequency electromagnetic interference present on power lines and other signal interface lines into the RM-1000. Sources of the fast transients are generally discharges in the power system that can cause a pulse of high frequency EMI to be present on the power lines or through coupling, on signal lines. The RM-1000 is required to be immune to specified frequencies and levels of this type of EMI.

The RM-1000 successfully passed type tests to demonstrate that the module is immune to fast transients per EN 61000-4-4 under laboratory conditions. The results of theses tests are unaffected by the extremes environment or the seismic event for the following reasons.

The methods used for limiting fast transient EMI from entering the RM-1000 circuitry is essentially the same as with conducted EMI described in Section 3.2.3.1 and 3.2.3.2.

The use of a connector interface filter and ferrite beads reduces the conducted EMI to a level that will not affect the performance of the RM-1000 during environmental extremes and seismic events. The reasons are the same as those given for Conducted Emissions, Section 3.2.3.1.

3.2.3.4 Radiated RF EMI Field Immunity

Radiated RF EMI Fields are radio frequency fields present in the air around the RM-1000. The sources of the RF field can be hand held communication devices and other similar sources. The RM-1000 must be immune to specified levels of RF EMI fields and still able to perform its safety functions properly.

Shielding reduces levels of RF EMI fields. The shielding used for the RM-1000 consists of the outer metal cases, as well as, internal shielding around sensitive openings at the rear of the RM-1000 module. These shields are passive structures with no moving parts, that have temperature ratings above the extremes environments and are impervious to moisture.

The RM-1000 has successfully passed Radiated RF EMI Field Immunity tests in accordance with ENV 50140. The shielding has been exposed to extremes environment and seismic event without problems. The ability of the RM-1000 shielding to reduce the RF level to that which the RM-1000 can tolerate, without anomalous performance, is unaffected by the environmental extremes or the seismic events. Therefore, the RM-1000 is considered acceptable without further testing.

3.2.3.5 Radiated RF Emissions

Radiated RF Emissions are radio frequency fields present around the outside of the RM-1000 module. The source of the RF field is the RM-1000 itself. The RF field in the vicinity of the RM-1000 must be within specified levels so that it does not affect other equipment that may be near the module.

As with Radiated RF EMI Field Immunity the RF field emissions are controlled by shielding (See Section 3.2.3.4 for a discussion of the shielding used in the RM-1000).

The RM-1000 has successfully passed tests in accordance with ENV 55011, Class A and EN 55022, Class B. For the same reasons given in Section 3.2.3.4 the Radiation RF Emissions are unaffected by extreme environments and seismic events.

3.2.3.6 *Electrostatic Discharge Immunity*

Electrostatic Discharge occurs when an object or person with an electrostatic charge comes in close proximity with the RM-1000 and there is a discharge of that charge to the RM-1000. The RM-1000 must be able to withstand discharges of a specified level without performance being affected.

Electrostatic discharge is dissipated by carrying the charge away from sensitive circuits through the equipment grounding system. The discharge is carried by the outer conductive surfaces connected to grounding wire to the plant's equipment ground system. This equipment grounding system is separated from the instrument grounding system so instrument signals will not be affected by the discharge.

The RM-1000 has successfully passed Electrostatic Discharge Immunity tests in accordance with EN 6100-4-2. The immunity of the RM-1000 to electrostatic discharge is not affected by environmental extremes or seismic events since the ground system pathways are unaffected by these conditions.

3.2.3.7 *Surge Withstand Capability*

Surges can occur on power lines due to disruptive conditions (such as short circuits) elsewhere in the power system. The RM-1000 must be capable of performing its safety functions if a voltage surge of a specified level and wave shape occurs.

The RM-1000 sensitive circuitry is protected from surges by [redacted] devices. The devices used within the RM-1000 are [redacted] above that specified as acceptable.

The RM-1000 has successfully passed Surge Withstand Capability tests in accordance with EN 61000-4-5. The environmental extremes and seismic events do not affect the ability of the [redacted] devices from performing their function. The devices are solid state encapsulated with no moving parts. They have temperature ratings above the environmental extremes and are unaffected by humidity due to the encapsulation. The [redacted] have been successfully tested for functionality in both environmental extremes and seismic events as described in this document. The [redacted] do not have any age related failure mechanisms, therefore, the surge withstand capability of the RM-1000 is unaffected by environmental extremes and seismic events.

3.2.3.8 *Magnetic Field Immunity*

Magnetic fields are fields in the area of the RM-1000 at power frequencies. As with Radiated RF EMI Fields in Section 3.2.3.4, the RM-1000 must be immune to specified levels of magnetic fields.

Magnetic fields are diminished by shielding as described in Section 3.2.3.4.

RM-1000 has successfully passed magnetic field immunity tests in accordance with EN 61000-4-8. For the same reasons given in Section 3.2.3.4 the immunity of the RM-1000 to magnetic fields is unaffected by the environmental extremes and seismic events.

3.2.3.9 Supply Voltage Dips and Variations Immunity

Supply voltage dips and variations are rapid changes in supply voltage for short durations as a result of load changes in the plant power system. The RM-1000 must be immune to changes of a specified level, duration and rate of change.

Supply voltage dips and variations are handled by the RM-1000 through the power supply. The power supply has been sized to accommodate a derating at the upper extreme of the environmental requirements. The RM-1000 has successfully passed supply voltage dips and variations immunity tests in accordance with EN 61000-4-11 in accordance with Table 3-2. The power supply has no moving parts and has successfully passed seismic testing as described in this document. Further, the RM-1000, with the power supply, has been age condition [redacted] while maintaining relative [redacted] The voltage [redacted] for each [redacted] The RM-1000 functioned properly during these cycles. The results of the supply voltage dips and variations are considered unaffected by environmental extremes and seismic events.

3.2.3.10 Checksum Verification and Checksum Failure

Checksum verification and checksum failure are strictly software functions and are independent of the environmental extremes and seismic events.

3.3 SELECTION OF COMPONENTS TO BE AGE CONDITIONED

An evaluation of components and parts within the RM-1000, its associated NIM Bin Assembly, and I/F converter assembly was made to identify those that required age conditioning prior to environmental and seismic testing. The results of that evaluation are provided in this section.

A review of SE document E-115-699 and EPRI Report NP-3326 was made to identify the types of components that required age conditioning. Each component type listed in E-115-699 is discussed in Appendix A. Failure mechanisms that have significance for either environmental conditions or seismic events were separated from those that do not have significance. EPRI Report NP-3326 was consulted for generic types of components that do not have failure mechanisms with seismic significance.

A multilevel bill of materials was prepared for the RM-1000, and its associated NIM Bin Assembly, and evaluated for the parts and components identified.

Radiation aging was not required, since the RM-1000 modules, its associated NIM Bin Assembly, and I/F converter would be located in nuclear power plant areas with mild environments and radiation dosages less than $1x10^3$ RADS (total integrated dose).

From this review, the following components were identified to be age conditioned.

1. [redacted]
2.
3.
4.
5.
6.
7.

Table 3-3 lists the components that were age conditioned for the RM-1000 test articles. Section 4 describes the age conditioning requirements and results.

3.4 DETERMINING REQUIRED RESPONSE SPECTRA

The Required Response Spectra (RRS) for the RM-1000, its associated NIM Bin Assembly, and I/F converter seismic test was selected to envelop the requirements of plant locations where SE had available floor response spectra. The RM-1000 and I/F converter should be capable of functioning properly mounted on existing installed equipment.

Appendix B contains the results of a review of previous test reports, as well as the requirements for replacement and new installations. [redacted]

The generic seismic qualification requirements for the RM-1000 Module for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) shown in GA-ESI document 04508905-QR, Figures 3-2 and 3-3 [redacted]. The Required Response Spectra (RRS) are provided in Seismic Qualification Test Results, GA-ESI Test Report 04508903-1TR is used for this RRS. The SSE RRS used for seismic tests are shown in Appendix B, Figure B-1.

[redacted]

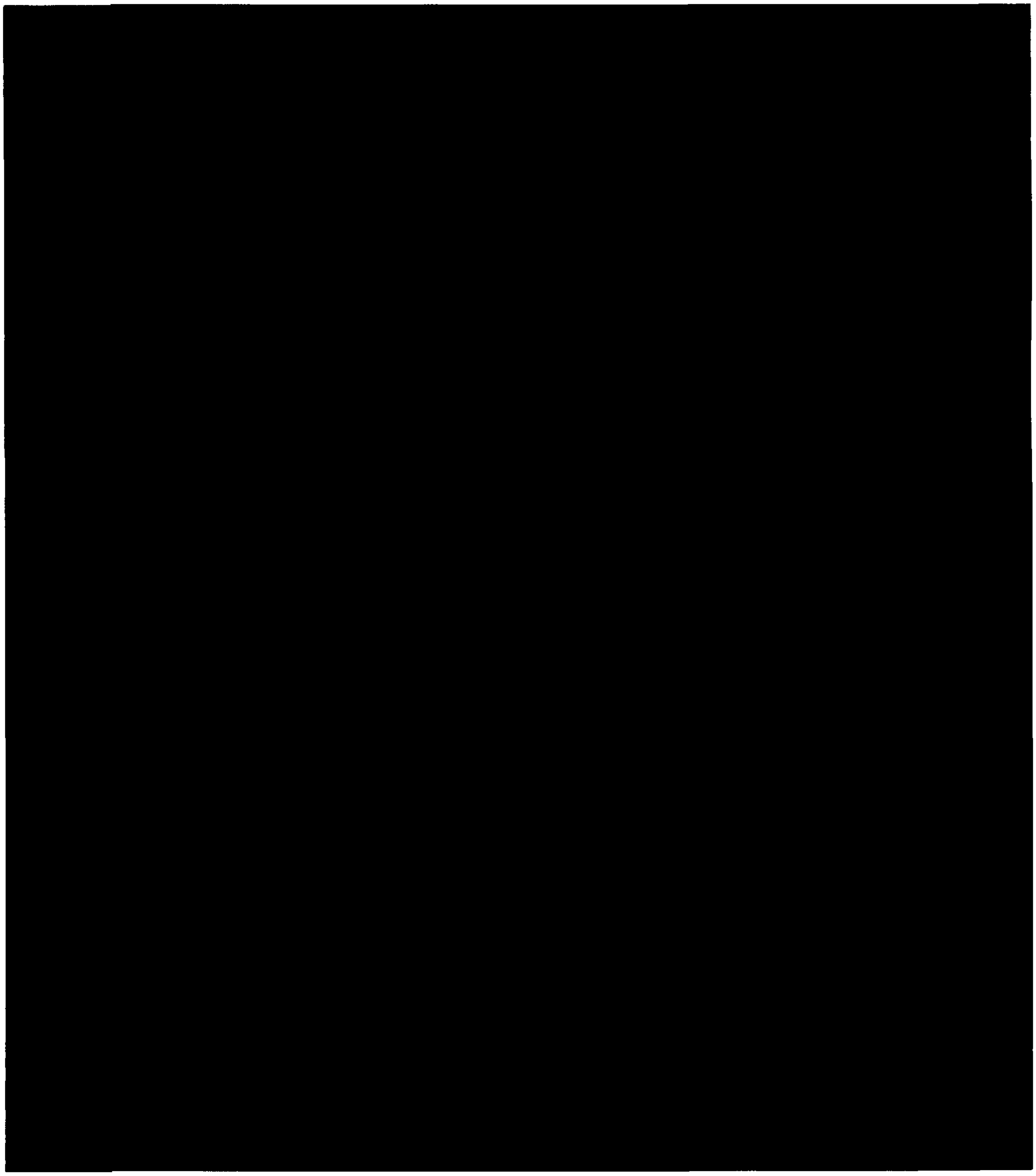


Figure 3-2 Horizontal Generic SSE Required Response Spectrum

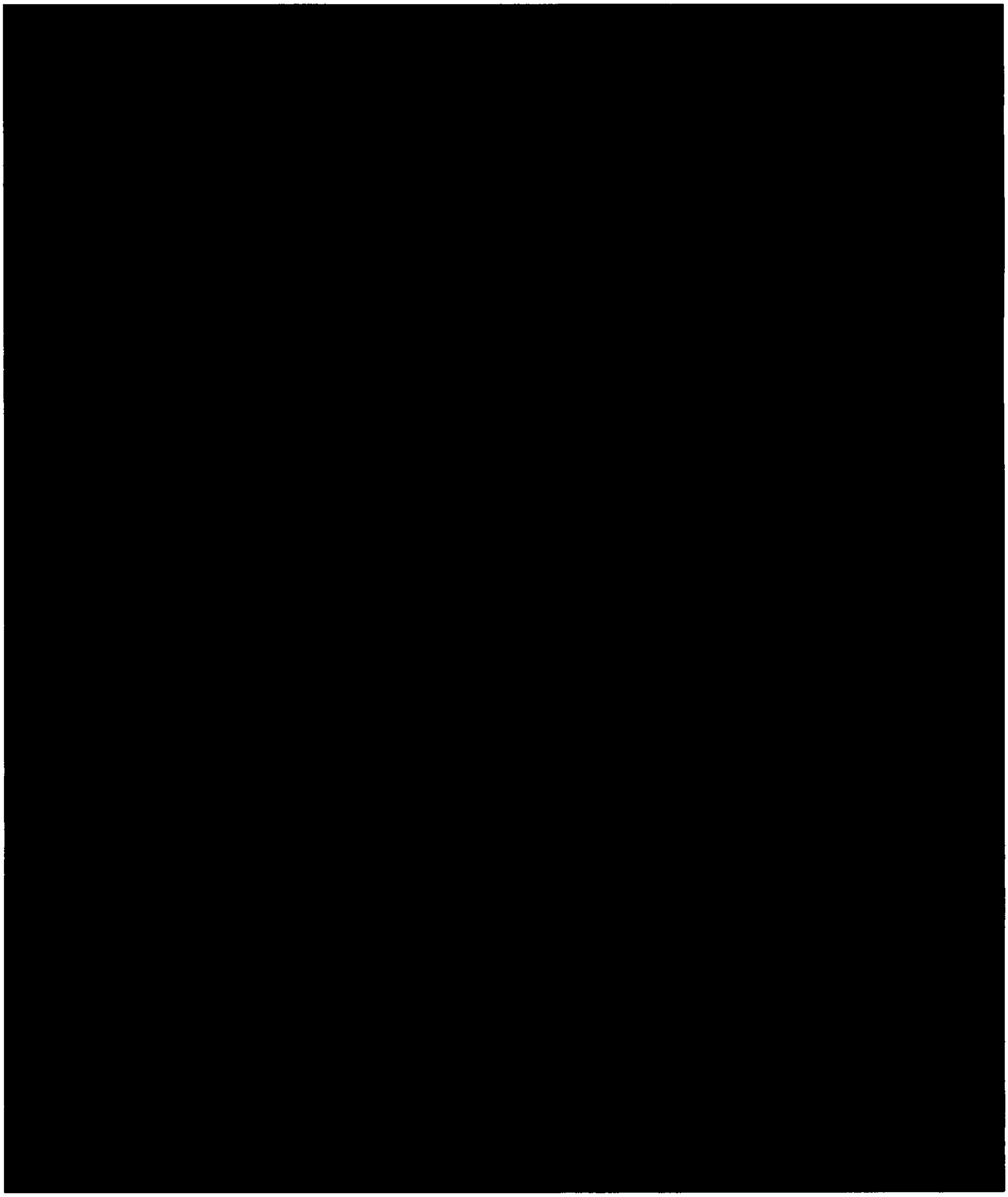


Figure 3-3 Vertical Generic SSE Required Response Spectrum

[redacted]

[redacted]

[redacted]

[redacted]

4. TEST SUMMARY

This section summarizes the tests performed, significant results, anomalies or deviations observed and the results of reviews of anomalies or deviations. The section is organized in the sequence in which the tests were performed. Refer to the flow chart shown in Figure 3-1. Figures and tables for this section are located with the written material.

4.1 COMPONENT AGING

This section describes the age conditioning performed on those components identified in Table 3-3. It includes keypad, gas plasma displays, aluminum electrolytic capacitors, power supplies, ribbon cable assemblies, relays, and relay drivers. The detail results of the age conditioning are provided in SE document 04508901-1TR "Age Conditioning Test Results RM-1000 Module".

4.1.1 Sixteen Key Matrix Keypad (SE P/N 50015691-534)

The only manual switches that are actuated a significant number of cycles, are the keypad switches. These were mechanically age conditioned by depressing each switch for the number of cycles expected in service. [redacted] The number of cycles was based on [redacted] SE document 04508901-1TR describes the test procedure followed. Table 4-1 lists the total cycles to which the keypads were aged. The keypad switches were energized with 5 volts dc during the aging. The keypad switches functioned properly during the age conditioning.

Table 4-1 Keypad Switches

Age Part S/N	Total Cycles
KB001	[redacted]
KB002	[redacted]
KB003	[redacted]

4.1.2 [redacted]isplays (SE P/N GD00640160-01)

The [redacted]isplay has an aging failure mechanism of loss of pixels. In order to place the displays in an end of life condition, two sets of displays used for the test articles were age conditioned at separate times and temperatures. The first set of displays was aged conditioned [redacted]he second set of displays was age conditioned at [redacted] These temperatures and times are equivalent to [redacted]nd are based on the age conditioning of [redacted] the worse case limited life components in radiation monitoring equipment). Table 4-2 lists the [redacted] Displays that were age conditioned, the temperature at which the displays were age conditioned and the total hours at that temperature.

Table 4-2 [redacted]

Age Part S/N	Temperature °C	Total Hours
D02	[redacted]	[redacted]
D03	[redacted]	[redacted]
D04	[redacted]	[redacted]
D05	[redacted]	[redacted]
D07	[redacted]	[redacted]
D08	[redacted]	[redacted]

Before, periodically during, and after the [redacted] Displays were age conditioned, the displays were given visual tests to ensure that there were no missing pixels, there was not any flicker, there were not any shifted pixels and that the displays were capable of displaying the activity screen, the function screen, horizontal and vertical lines, and patterns of dots. Table 4-3 shows the results of these tests.

Table 4-3 [redacted]isplay Test Results

Test Description	D02	D03	D04	D05	D07	D08
• Normal Activity Screen	P	P	P	P	P	P
• Select Function Screen	P	P	P	P	P	P
• 10 Thick Horizontal Lines	P	P	P	P	P	P
• 10 Thick Horizontal Lines (Shifted)	P	P	P	P	P	P
• 5 ½ Thick Vertical Lines	P	P	P	P	P	P
• 5 Thick Vertical Lines (Shifted)	P	P	P	P	P	P
• 3 Thick Vertical Line and 4 Thin Horizontal Lines	P	P	P	P	P	P
• 20 Dotted Lines	P	P	P	P	P	P
• 4 Dotted Lines	P	P	P	P	P	P
• 1 Dotted Line	P	P	P	P	P	P
• No Missing Pixels	P	P	P	P	P	P
• No Flicker	P	P	P	P	P	P
• No Shifted Pixels	P	P	P	P	P	P

Notes: P = Passed F = Failed N/A = Not Applicable A note is indicated by a number.

4.1.3 Power Supply (SE P/N 04502005-001)

The power supply, mounted on the rear of the NIM Bin Assembly, contains [redacted] as well as un-encapsulated coils, transformers, and wire. These parts were removed from the two test power supplies for age conditioning to a [redacted]

The [redacted] were age conditioned for [redacted] The transformers and coils were age conditioned at [redacted] The wire was age conditioned at [redacted] Table 4-4 identifies the power supply in which each part is located and shows the results of age conditioning of each part.

Table 4-4 Low Voltage Power Supplies

Component	Age Part S/N	Location	Temperature °C	Time hr	Results
Capacitor	C006	LVPS01	[redacted]	[redacted]	Passed
	C007	LVPS01			Passed
	C008	LVPS01			Passed
	C009	LVPS01			Passed
	C010	LVPS02			Passed
	C011	LVPS02			Passed
	C012	LVPS02			Passed
	C013	LVPS02			Passed
Transformers	L001	LVPS01			Passed
	L004	LVPS02			Passed
Coils	L002	LVPS01			Passed
	L003	LVPS01			Passed
	L004	LVPS02			Passed
	L005	LVPS02			Passed
Wire	W001	LVPS01			Passed
	W002	LVPS02			Passed

These parts were assembled into the appropriate test low voltage power supply for subsequent qualification testing.

4.1.4 [redacted] (SE P/N 50015688-001)

The Output PWA (SE P/N 04503010-001) contains two [redacted] These [redacted] were age conditioned at [redacted] The age conditioning included energizing the [redacted] with rated voltage. [redacted] and after the age conditioning the [redacted] was measured, the equivalent series [redacted] calculated, and the leakage current measured. The results of the testing are provided in Table 4-5. Details of the test are provided in SE document 04508901-1TR Section 4.1.

Table 4-5 [redacted]

Age Part S/N	Temperature °C	Time hr	Results
C001	[redacted]	[redacted]	Passed
C002			Passed
C003			Passed
C004			Passed

After age conditioning the [redacted] were assembled on the Output PWAs used for the qualification test article.

4.1.5 Relays (SE P/Ns DS1E-S-DC24V and DS2E-S-DC24V)

Relays used on the output PWA and the counter PWA were given a thermal age conditioning and a mechanical age conditioning for an equivalent life of [redacted] The thermal age conditioning consisted of a burn-in at [redacted] Before and after the age conditioning the relay normally closed contact resistance was measured, the relays were energized, and the normally open contact resistance was measured. The results of the thermal age conditioning are shown in Table 4-6. Additional test details are found in SE document 04508901-1TR Section 4.2.

Table 4-6 Relay Thermal Age Conditioning

Age Part S/N	Temperature °C	Time hr.	Results
K001	[redacted]	[redacted]	Passed
K002			Passed
K003			Passed
K004			Passed
K005			Passed
K006			Passed
K007			Passed
K008			Passed
K009			Passed
K010			Passed
K011			Passed
K012			Passed
K013			Passed
K014			Passed
K015			Passed
K016			Passed
K017			Passed

The above relays were than mechanically age conditioned along with the associated relay drivers on the output PWA and the counter board PWA. The relays were switched on and off for [redacted] Each relay contact was loaded with [redacted] second off throughout the test. Contact resistance was measured in the same manner as the thermal aging. The results of the mechanical age conditioning are provided in Table 4-7. Additional test details are given in SE document 04508901-1TR Section 4.3.

Table 4-7 Relay Mechanical Age Conditioning

Age Part S/N	Number of Cycles	Results
K001	[redacted]	Passed
K002		Passed
K003		Passed
K004		Passed
K005		Passed
K006		Passed
K007		Passed
K008		Passed
K009		Passed
K010		Passed
K011		Passed
K012		Passed
K013		Passed
K014		Passed
K015		Passed
K016		Passed
K017		Passed

The relays and relay drivers functioned properly after age conditioning was completed.

4.1.6 Display/Keypad Cable Assembly (SE P/N 8810B-701-0)

The Display/Keypad cable assemblies contain PVC insulated ribbon wire that has a [redacted]

[redacted]

[redacted]

To simulate the [redacted] the ribbon cable assemblies required age conditioning at [redacted] The ribbon cables were aged as assemblies to prevent damage to the insulation during termination to the connectors after aging. They were placed in a [redacted] The cable assemblies passed a visual inspection [redacted]

Table 4-8 lists the results for each part age conditioned. The detail age conditioning results are provided in SE document 04508901-1TR Section 4.7.

Table 4-8 Display/Keypad Cable Assembly

Age Part S/N	Temperature °C	Time hr	Results
KC001	[redacted]	[redacted]	Passed
KC002	[redacted]	[redacted]	Passed
KC003	[redacted]	[redacted]	Passed

4.1.7 Test Article Assembly

When the age conditioning of the components with significant age related failure mechanisms was completed the aged components were assembled into five RM-1000 assemblies. A list of aged parts for each RM-1000 test article is provided in Table 4-9. The NIM Bin Assembly included two low voltage power supplies, aged components numbers LVPS01 and LVPS02.

Table 4-9 Test Article/Aged Parts Identification

Assembly/Part	SE Part Number	Aging S/N by Test Article S/N				
		001	002	003	004	005
CPU PWA	04503000-001	019	011	012	009	013
Counter PWA	04503020-001	004	019	001	002	003
Relay K201	DS1E-S-DC24V	K005	K001	N/A	N/A	N/A
Output PWA	04503010-001	021	014	016	024	007
Relay K301	DS1E-S-DC24V	K003	K002	N/A	N/A	N/A
K302	DS2E-S-DC24V	K015	K014	N/A	N/A	N/A
K303	DS2E-S-DC24V	K016	K017	K013	N/A	N/A
K304	DS1E-S-DC24V	K009	K006	K004	N/A	N/A
K305	DS1E-S-DC24V	K010	K012	K008	N/A	N/A
K306	DS1E-S-DC24V	K011	K007	N/A	N/A	N/A
Capacitor C310	50015688-001	C002	C001	C004	N/A	N/A
C310	50015688-001	C003	C005	N/A	N/A	N/A
Front Panel						
Cable	8810B-701-0	KC001	KC002	KC003	KC004	KC005
Display	GD00640160-01	D02	D03	D04	D05	D07
Keypad	50015691-534	Note 1	Note 1	Note 1	N/A	N/A

Note: [redacted]

4.2 Environmental Tests

This section describes the environmental tests performed on the area and process RM-1000, their associated NIM Bin Assembly, and the I/F converter test articles. It includes the wiring connections, calibration, test setup, pre-environmental functional tests, power up and test conditions, the age margin conditioning, the environmental extremes tests, and the post environmental functional tests. The results for these tests are provided in SE document 04508902-1TR and are summarized in the following sections.

4.2.1 Test Setup and Wiring Connections

The area and process RM-1000 processors and the I/F converter were arranged as shown in Figure 2-3 for the environmental tests. The NIM Bin Assembly containing the RM-1000 test articles and the I/F converter were installed in an environmental chamber while the rest of the components shown in Figure 2-3 was in the room ambient environment.

The interconnections between the components for each test article are shown in Figure 2-4 for the Area RM-1000 Processor, Figure 2-5 for the Process RM-1000 Processors, and Figure 2-6 for the I/F Converter.

4.2.2 Calibration

Prior to performing the functional and environmental tests, the test articles RM-1000 processors were calibrated. Table 4-10 lists the calibrations performed for each test article RM-1000 processor.

Table 4-10 Test Article RM-1000 Calibration Performed

Calibration	Area RM-1000	Process RM-1000	I/F Converter RM-1000
Power Supply Voltage Check	Yes	Yes	Yes
Baseline Restorer Adjustment	Yes	Yes	Yes
Analog Output Calibration	Yes	Yes	Yes
Discriminator and Counter Test	N/A	Yes	No

4.2.3 Pre-Environmental Functional Test

After the area RM-1000 processor, the process RM-1000 processor, and I/F converter were set up and calibrated, a pre-environmental functional test was performed in accordance with SE document 04508902. The results of the functional tests are shown in SE document 04508902-1TR, pre-environmental functional tests. These results are summarized in Table 4-11.

Table 4-11 Pre-Environmental Functional Tests

Description	Area RM-1000	Process RM-1000	I/F Converter
Current Activity System Display	Passed	Passed	Passed
Analog Output Current	Passed	Passed	Passed
Analog Output Voltage	Passed	Passed	N/A
Trip 1 Alarms & Indications	Passed	Passed	Passed
Trip 2 Alarms & Indications	Passed	Passed	Passed
Loss of Operate Alarm	Passed	Passed	Passed
Loss of Counts Indication	Passed	Passed	Passed
Alarm State During Power Fail	Passed	Passed	Passed
100X Overrange	Passed	Passed	Passed
Overrange Indication	Passed	Passed	N/A
Discriminator and Counter Test	N/A	Passed	N/A
Accuracy over the Activity Range	N/A	N/A	Passed

The area RM-1000 processor, the process RM-1000 processor, and the I/F converter passed the pre-environmental functional tests.

4.2.4 Power Up and Test Condition

Since the test articles were inside an environmental chamber at both low and high temperatures it was not possible to use the front panel to perform functional testing. To ensure that the test articles were functioning properly during the environmental testing the RM-1000 test articles were placed in alert alarm with an activity that could be monitored at a recorder. The I/F converter activity current was also recorded throughout the testing. The power up and test conditions are summarized in Table 4-12.

Table 4-12 Power Up and Test Conditions

Description	Area RM-1000	Process RM-1000	I/F Converter
State of RM-1000 Alarms			
Failure	Normal	Normal	Normal
Trip 1 (Alert)	Alarm	Alarm	Normal
Trip 2 (High)	Normal	Normal	Normal
Functions Recorded			
Failure	Record	Record	N/A
Trip 1	Record	Record	N/A
Trip 2	Record	Record	N/A
RM-1 Output	Record	Record	N/A
RM-3 Output	Record	Record	Record

4.2.5 Age Conditioning Margin

The age conditioning margin test is specified in SE document E-115-699. The test is "...designed to add additional stress levels in the form of temperature, humidity and energy source cycling." The test compensates for applying [redacted] to complex assemblies at the component level. In this regard, it is used to compensate for [redacted] The age conditioning margin was a [redacted] following the cycles shown in Figure 4-1. It consisted of [redacted] while maintaining the relative humidity between [redacted] The RM-1000 processors, the NIM Bin Assembly, and I/F converter had power applied with the display in a current activity screen mode.

Prior to the start of the age conditioning margin, the test articles were set up in a POWER UP AND TEST CONDITION.

The voltage applied was set at [redacted] The test articles were subjected to the age conditioning margin in accordance with SE document 04508902-1TR, Section 4.6, with no adverse effects. SE document 04508902-1TR provides the verification of the voltages applied. Appendix C of this document provides the documentation for the temperature and humidity cycles.

At the end of the age conditioning margin and after cooling to ambient, the status of the front panel display and the analog output were verified to be within the RM-1000 acceptance criteria.

[redacted]

4.2.6 Environmental Extremes Tests

An extremes test was performed to demonstrate the capability of the RM-1000 processor, the NIM Bin Assembly, and the I/F converter at the lower and upper limit of normal temperature range. Prior to the environmental extremes test the test articles were given a baseline functional test in accordance with SE document 04508902 Section 4.7.1. The results of these tests are provided in SE document 04508902-1TR and summarized in Table 4-13. The test articles met the acceptance criteria.

Table 4-13 Baseline Functional Test

Test	Area RM-1000	Process RM-1000	I/F Converter
Loss of Operate/Loss of Counts	Passed	Passed	Passed
Alarm State During Power Fail	Passed	Passed	Passed
100X overrange	Passed	Passed	Passed
Accuracy	N/A	N/A	Passed

The test articles were placed in their POWER UP AND TEST CONDITION.

The temperature within the environmental chamber was [redacted] RH. This condition was held for [redacted] to ensure that all components stabilized to the ambient conditions. At the end of the test period, while [redacted]RH a functional test was performed in accordance with SE document 04508902, Section 4.7.2. The results of the functional tests are provided in SE document 04508902-1TR and summarized in Table 4-14. Appendix C provides the documentation for the temperature and humidity conditions.

[redacted]

Following the low temperature extremes test, the environmental chamber [redacted] and the relative humidity [redacted] This condition was [redacted] to ensure that all components stabilized to the ambient conditions. [redacted] The extremes test was continued by increasing the temperature to [redacted] The humidity [redacted] This deviation is recorded in NMR 15806 item 0006. See Appendix F for resolution of this discrepancy. While [redacted] a functional test was performed in accordance with SE document 04508902, Section 4.7.3. The results of the functional test are shown in SE document 04508902-1TR and summarized in Table 4-15. Appendix C provides documentation for the temperature and humidity conditions.

Table 4-15 High Temperature Functional Test

Test	Area RM-1000	Process RM-1000	I/F Converter
Loss of Operate/Loss of Counts	Passed	Passed	Passed
Alarm State During Power Fail	Passed	Passed	Passed
100X overrange	Passed	Passed	Passed
Accuracy	N/A	N/A	Passed

The area RM-1000 processor, process RM-1000 processor, the NIM Bin Assembly, and I/F converter passed the High Temperature Extremes Test.

4.2.7 Post Environmental Functional Tests

The environmental chamber was returned to ambient conditions and post environmental functional tests were performed in accordance with SE document 04508902, Section 4.8. The results of the functional tests are provided in SE document 04508902-1TR, post environmental functional tests and are summarized in Table 4-16.

Table 4-16 Post- Environmental Functional Tests

Description	Area RM-1000	Process RM-1000	I/F Converter
Current Activity System Display	Passed	Passed	Passed
Analog Output Current	Passed	Passed	Passed
Analog Output Voltage	Passed	Passed	Passed
Trip 1 Alarms & Indications	Passed	Passed	Passed
Trip 2 Alarms & Indications	Passed	Passed	Passed
Loss of Operate Alarm	Passed	Passed	Passed
Loss of Counts Indication	Passed	Passed	Passed
Alarm State During Power Fail	Passed	Passed	Passed
100X overrange	Passed	Passed	Passed
Overrange Indication	Passed	Passed	N/A
Discriminator and Counter Test	N/A	Passed	N/A
Accuracy over the Activity Range	N/A	N/A	Passed

The area RM-1000 processor, the process RM-1000 processor, the NIM Bin Assembly, and the I/F converter passed the Post-Environmental Functional Tests.

4.3 SEISMIC TESTS

This section describes the seismic tests performed on the area and process RM-1000 processor, their associated NIM Bin Assembly, and the I/F converter test articles. Two sets of seismic tests were run. [redacted] seismic test [redacted] RM-1000 processor and two I/F converters. The test sets included the pre-seismic test setup, the pre-seismic functional tests (not done for second test set), the seismic tests, the post seismic functional tests, and the final visual inspection. The results for these tests are provided in SE document 04508903-1TR and are summarized in the following sections.

The generic seismic qualification requirements for the RM-1000 Module for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) shown in GA-ESI document 04508905-QR, Figures 3-2 and 3-3 were not attainable for the shake table on which the seismic tests were performed. The Required Response Spectra (RRS) are provided in Seismic Qualification Test Results, GA-ESI Test Report 04508903-1TR is used for this RRS. The SSE RRS used for seismic tests are shown in Appendix B, Figure B-1.

4.3.1 First Seismic Test Setup and Wiring Connections

The area and process RM-1000 processors, the NIM Bin Assembly, and the I/F converter were arranged as shown in Figure 2-3 for the seismic tests. The NIM Bin Assembly containing the RM-1000 test articles and the I/F converter were installed in a seismic fixture (SE P/N 04619028) that in turn was installed on the seismic shake table, while the rest of the components shown in Figure 2-3 were setup off the table. The mounting fixture used for the seismic test was rigid angle metal structure, configured to simulate an installation in a standard 19 inch enclosure shown in Appendix C.

Two RM-1000 processors were mounted in a standard NIM Bin, which was mounted in the seismic test fixture using four 3/16-inch long 10-32 screws. The screws were snug wrench tightened not torqued. The I/F converter was mounted to the seismic fixture in a manner similar to the manner it would be installed in an equipment rack.

In addition to the above test articles, [redacted] were installed around the display ribbon cable within the RM-1000 processors, and a cable interface module with its associated mounting hardware was installed on the seismic fixture.

The [redacted] assembly (two halves held together with tape) to [redacted] the flat ribbon cable, 0.25 x 1.125 x 2.50 inches long, manufactured by [redacted] The tape was polyimide film (Kapton), 1.0 wide x 0.012 inches thick, (manufacturer 3M part number 1205(1).

The ribbon cable interface module with mounting hardware was SE P/N 50015724-001. The relay track was SE P/N 03560550-001 and the rail end stop was SE P/N 50015735-001

The interconnections between the components for each test article are shown in Figure 4-2 for the Area RM-1000 Processor, Figure 4-3 for the Process RM-1000 Processors, and Figure 2-6 for the I/F Converter.

The cables were tied to the table and the fixture with tie wraps to prevent relative motion during the test. Cable bundles were brought from the shake table in a catenary that allowed freedom of movement to the full extension of the table, without stressing the terminations or the RM-1000 processor and I/F converter assemblies. Figure 4-4 shows the test articles and fixture mounted to the shake table.

[redacted]

[redacted]

[redacted]

Accelerometers were attached to the test articles in accordance with SE Procedure 04508903, Section 4.3.1 in the locations described in Table 4-17.

Table 4-17 Accelerometer Locations

Accelerometer Location	Accelerometer Number		
	X	Y	Z
Table Input	1	2	1
Seismic Fixture Top Front	3	6	3
Back of NIM Bin Center	4	7	4
I/F Converter Mounting Surface	5	8	5

X - Direction is RM-1000 and I/F Converter side to side.

Y - Direction is RM-1000 and I/F Converter vertical.

Z - Direction is RM-1000 and I/F Converter front to back.

4.3.2 First Seismic Test Calibration

Prior to performing the functional and seismic tests, the test articles RM-1000 processors were calibrated. Table 4-18 lists the calibrations performed for each test article RM-1000 processor.

Table 4-18 Test Article RM-1000 Calibration Performed

Calibration	Area RM-1000	Process RM-1000	I/F Converter RM-1000
Power Supply Voltage Check	Yes	Yes	Yes
Baseline Restorer Adjustment	Yes	Yes	Yes
Analog Output Calibration	Yes	Yes	Yes
Discriminator and Counter Test	N/A	Yes	No

4.3.3 First Seismic Test Pre-Seismic Functional Test

After the area RM-1000 processor, the process RM-1000 processor, and I/F converter were set up and calibrated, a pre-seismic functional test was performed in accordance with SE document 04508904. The results of the functional tests are shown in SE document 04508903-1TR, pre-seismic functional tests. These results are summarized in Table 4-19.

Table 4-19 Pre-Seismic Functional Tests

Description	Area RM-1000	Process RM-1000	I/F Converter
Current Activity System Display	Passed	Passed	Passed
Analog Output Current	Passed	Passed	Passed
Analog Output Voltage	Passed	Passed	N/A
Trip 1 Alarms & Indications	Passed	Passed	N/A
Trip 2 Alarms & Indications	Passed	Passed	N/A
Loss of Operate Alarm	Passed	Passed	Passed
Loss of Counts Indication	Passed	Passed	Passed
Alarm State During Power Fail	Passed	Passed	Passed
100X Overrange	Passed	Passed	Passed
Overrange Indication	Passed	Passed	N/A
Discriminator and Counter Test	N/A	Passed	N/A
Accuracy over the Activity Range	N/A	N/A	Passed

The area RM-1000 processor, the process RM-1000 processor, and the I/F converter passed the pre-seismic functional tests.

4.3.4 First Seismic Test Resonance Searches

Before the seismic test, resonance searches were performed in the horizontal (x-axis) and vertical (y-axis) in accordance with SE document 04508903, Section 4.3.1. The resonance searches were performed at [redacted] No resonances were found in either the horizontal or vertical axis.

4.3.5 First Seismic Test Power Up and Test Condition

With the test articles mounted on the seismic shake table, it was not possible to use the front panel to perform functional testing. To ensure that the test articles were functioning properly during the seismic testing the RM-1000 test articles were placed in Alert alarm with an activity that could be monitored at a recorder. The I/F converter activity current was also recorded throughout the testing. Alarm relays (both energized and contacts deenergized) were monitored for chatter. The power up and test conditions are summarized in Table 4-20.

Table 4-20 First Seismic Test Power Up and Test Conditions

Description	Area RM-1000	Process RM-1000	I/F Converter
State of RM-1000 Alarms			
Failure	Normal	Normal	Normal
Trip 1 (Alert)	Alarm	Alarm	Normal
Trip 2 (High)	Normal	Normal	Normal
Functions Recorded or Monitored			
Failure	Chatter Monitor	Chatter Monitor	N/A
Trip 1	Chatter Monitor	Chatter Monitor	N/A
Trip 2	Chatter Monitor	Chatter Monitor	N/A
RM-1 Output	Record	Record	N/A
RM-3 Output	Record	Record	Record

4.3.6 First Seismic Tests (X-Y Axis)

During the set up for the first [redacted] process RM-1000 processor and the I/F converter. (NMR 15813 item 001 and 15813 item 002 describes the problem with the area RM-1000. [redacted]

The two test articles were subjected to the Required Response Spectra (RRS) for eight OBEs and two Safe Shutdown Earthquake (SSE) tests. [redacted] The tests were performed in accordance with SE document 04508903 Section 4.5.1. The results of the tests are provided in SE document 04508903-1TR and summarized in Table 4-21. The TRS versus the RRS for the last SSE are shown in Figures 4-5 and 4-6.

[redacted]

[redacted]

[redacted]

4.3.7 First Seismic Tests (Z-Y Axis)

The test articles were rotated 90° on the seismic shake table and given a resonance search test in the horizontal (Z-axis) in accordance with SE document 0458903, Section 4.5.1.18. The resonance search was [redacted] No resonances were found.

The test articles (process RM-1000 and I/F converter) were placed in a POWER UP AND TEST CONDITION as described in section 4.3.4. The two test articles were subjected to the RRS for six OBEs and one SSE. [redacted] The SSE enveloped the SSE RRS. The tests were performed in accordance with SE document 04508903, Section 4.5.1. The results of the tests are provided in SE document 04508903-1TR and summarized in Table 4-22. The TRS versus the RRS for the SSE are shown in Figures 4-7 and 4-8.

[redacted]

[redacted]

[redacted]

4.3.8 First Seismic Test Post-Seismic

After the process RM-1000 processor and I/F converter were seismically tested, a post-seismic functional test was performed in accordance with SE document 04508904. The results of the functional tests are shown in SE document 04508903-1TR, post-seismic functional tests. These results are summarized in Table 4-23.

[redacted]

4.3.9 Second Seismic Test Setup and Wiring

A second seismic test was performed to test the area RM-1000 processor and retest the I/F converter. Two I/F converters were used as test articles. The area RM-1000 processor test article was reconfigured from the process RM-1000 processor used in the first seismic test. One of the I/F converters was the I/F converter used in the first seismic test.

The area RM-1000 processor and the I/F converters were arranged as shown in Figure 2-3 for the seismic test. The NIM Bin assembly containing the RM-1000 test articles and the I/F converters were installed in a seismic fixture (SE P/N 04619028) that in turn was installed on the seismic shake table, while the rest of the components shown in Figure 2-3 were setup off the shake table. The seismic test setup was similar to that described in Section 4.3.1 of this document.

Accelerometers were attached to the test articles in accordance with SE procedure 04508903, Section 4.3.1 in the locations described in Table 4-24.

The area RM-1000 processor and the I/F converter RM-1000 processors were connected as shown in Figures 4-9 and 4-10.

[redacted]

[redacted]

Table 4-24 Second Seismic Test - Accelerometer Locations

Accelerometer Location	Accelerometer Number		
	X	Y	Z
Table Input	1	2	1
Seismic Fixture Top Front	3	6	3
Back of NIM Bin Center	4	7	4
I/F Converter Mounting Surface	5	8	5

X - Direction is RM-1000 and I/F Converter side to side.

Y - Direction is RM-1000 and I/F Converter vertical.

Z - Direction is RM-1000 and I/F Converter front to back.

4.3.10 Second Seismic Test Calibration

Prior to performing the functional and seismic tests the test article RM-1000 processors were calibrated. Table 4-25 lists the calibrations performed for each test article RM-1000 processor.

Table 4-25 Second Seismic Test - Test Article RM-1000 Calibration Performed

Calibration	Area RM-1000	I/F Converter #1 RM-1000	I/F Converter #2 RM-1000
Power Supply Voltage Check	Yes	Yes	Yes
Baseline Restorer Adjustment	Yes	Yes	Yes
Analog Output Calibration	Yes	Yes	Yes
Discriminator and Counter Test	N/A	No	No

4.3.11 Second Seismic Test Pre-Seismic Functional Test

[redacted]

4.3.12 Second Seismic Test Power Up and Test Condition

Before the seismic test, resonance searches were performed in the horizontal (X-axis) and vertical Y-axis) in accordance with SE document 04508903, Section 4.3.1. The resonance searches were performed at [redacted] No resonances were found in either the horizontal or vertical axis.

4.3.13 Second Seismic Test Power Up and Test Condition

With the test articles mounted on the seismic shake table, it was not possible to use the front panel to perform functional testing. To ensure that the test articles were functioning properly during the seismic testing, the RM-1000 test articles were placed in alert alarm with an activity that could be monitored at a recorder. The I/F converter activity current was also recorded throughout the testing. Alarm relays (both energized and contacts deenergized) were monitored for chatter. The power up and test conditions are summarized in Table 4-26.

Table 4-26 Second Seismic Test Power Up and Test Conditions

Description	Area RM-1000	I/F Converters
State of RM-1000 Alarms		
Failure	Normal	Normal
Trip 1 (Alert)	Alarm	Normal
Trip 2 (High)	Normal	Normal
Functions Recorded or Monitored		
Failure	Chatter Monitor	N/A
Trip 1	Chatter Monitor	N/A
Trip 2	Chatter Monitor	N/A
RM-2 Output	Record	Record
RM-3 Output	Record	Record

4.3.14 Second Seismic Test (X-Y Axis)

The area RM-1000 processor and two I/F converters were subjected to the RRS for five OBE and two SSE tests. All seismic test TRSs enveloped the RRS. The tests were performed in accordance with SE document 04508903, Section 4.5.1. The results of the tests are provided in SE document 04508903-1TR and summarized in Table 4-27. The TRS versus the RRS for the last SSE are shown in Figures 4-11 and 4-12.

Table 4-27 Second Seismic Test X-Y Axis Seismic Test Results

Data Item	OBE					SSE
	1	2	3	4	5	
Area RM-1000						
Operational Status	P	P	P	P	P	P
Failure Relay Chatter	P	P	P	P	P	P
Trip 1 Relay Chatter	P	P	P	P	P	P
Trip 2 Relay Chatter	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P
I/F Converter #1						
Operational Status	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P
I/F Converter #2						
Operational Status	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P

[redacted]

[redacted]

4.3.15 Second Seismic Test (Z-Y Axis)

The test articles were rotated 90° on the seismic shake table and given a resonance search test in the horizontal (Z-axis) in accordance with SE document 04508903, Section 4.5.1. The resonance search was [redacted] No resonances were found.

The test articles (area RM-1000 and two I/F converters) were placed in a POWER UP AND TEST CONDITION as described in Section 4.3.12. The test articles were subjected to the RRS for two SSEs and five OBEs (in that order). The tests were performed in accordance with SE document 04508903, Section 4.5.1. The results of the tests are provided in SE document 04508903-1TR and summarized in Table 4-28. The TRS versus the RRS for the SSE are shown in Figures 4-13 and 4-14.

Table 4-28 Second Seismic Test Z-Y Axis Seismic Test Results

Data Item	SSE	OBE				
		1	2	3	4	5
Area RM-1000						
Operational Status	P	P	P	P	P	P
Failure Relay Chatter	P	P	P	P	P	P
Trip 1 Relay Chatter	P	P	P	P	P	P
Trip 2 Relay Chatter	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P
I/F Converter #1						
Operational Status	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P
I/F Converter #2						
Operational Status	P	P	P	P	P	P
RM-2 Output	P	P	P	P	P	P
RM-3 Output	P	P	P	P	P	P

Note: 1. P = Passed F = Failed

[redacted]

[redacted]

4.3.16 Second Seismic Test Post-Seismic Functional Test

After the area RM-1000 processor and two I/F converters were seismically tested a post-seismic functional test was performed in accordance with SE document 04508904. The results of the functional tests are shown in SE document 04508903-1TR, post-seismic functional tests. These results are summarized in Table 4-29.

[redacted]

5. TEST EQUIPMENT AND FACILITIES

All equipment provided during the tests had [redacted] of the measured parameter requirement and, [redacted] Manufacturer, model number, serial number, and calibration due date for all pertinent equipment used, were recorded on Test Equipment Record sheets that are included with each test procedure. These items include digital voltmeters, voltage input signal sources, low- and high-voltage power supplies, pulse generators, accelerometers, seismic excitation equipment, temperature controllers, environmental chambers, etc.

The seismic tests were conducted at Wyle Laboratories in Norco, California.

Age conditioning margin and environmental extremes tests were conducted at Teledyne-Ryan in San Diego, California.

All other testing was conducted at Sorrento Electronics in San Diego, California.

6. MODIFICATIONS

The RM-1000 and its associated NIM Bin Assembly have been enhanced by several modifications, since the qualification tests were performed. This section describes the qualification significant modifications and provides a qualification basis for each. The qualification basis reflects the configuration of the RM-1000 Radiation Monitoring Processor Module on December 21, 2000.

The qualification significant modifications that were made by Engineering Change Orders (ECOs) are:

6.1 ECO 17531

ECO 17531 changed mounting hardware head configuration and star washers to split locking washers. The ECO states that Qualification Documents are affected and refers to QSR 04638901. This change is not significant to the NIM Bin Assembly and, therefore, does not affect the NIM Bin Assembly's qualification.

6.2 ECO 17656A

This ECO improved the performance of the RM-1000 when subjected to Electro Magnetic and Radio Frequency Interference. Among the changes made by this ECO the following have significance.

- The addition of a section of coaxial cable.
- The addition of an EMI filter for P401 connector.
- The addition of an EMI shield between the motherboard and the High Voltage Power Supply/Module Connector.

The coaxial cable, SE P/N 50000828-001, is a standard RG 174 A/U 50 ohm coaxial cable. This coaxial cable is a passive device with a temperature rating of 75°C well above the normal and abnormal temperatures of the RM-1000. This cable, therefore, does not have significant thermal related failure mechanisms and is considered environmentally qualified. The cable is approximately 7.6 inches long and connects the High Voltage Power supply connector P2 and the motherboard connector P401. The cable is one of a number of wires bundled together and considered seismically rigid. The added mass of the cable is insignificant to the seismic performance of the cable bundle. The cable is considered qualified seismically. The change to a coaxial cable does enhance the functional performance of the RM-1000 when subjected to either EMI or RFI. This functionality is fully verified as part of the Acceptance Tests for the RM-1000.

The EMI filter, SE P/N 045402035-001, is a thin wafer filter that is placed between the two halves of a mated connector. The filter is low mass without moving parts held securely in place by the connector halves. The wafer is thin enough so that it does not affect the attachment of the connector to the module or the mating of the connector halves. The wafer does not have any age related failure mechanisms and has been selected to perform properly within the range of environmental extremes. The EMI filter is considered qualified seismically and environmentally.

The EMI shield, SE P/N 04502040-001, is a [redacted] component formed to enclose the compartment behind the motherboard to shield the motherboard and the components within the compartment from external RFI/EMI. The shield is passive and only has seismic significance. The shield is held in place by virtue of its structure and can not cause damage during a seismic event. The shield is considered qualified.

6.3 ECO 17677

ECO 17677 replaces the power supply on the Output PWA with one of a higher current rating. Appendix D provides a technical evaluation of the replacement power supply, SE P/N 04503050-001. As can be seen in Appendix D, the replacement power supply and its standoffs are considered similar to the original converter functionally and environmentally. The standoff for the replacement power supply has a [redacted] considered structurally sound [redacted] The replacement power supply is considered qualified.

6.4 ECO 17702

ECO 17702 changes the NIM Bin Assembly's (SE P/N 04500801-001 through –006) power supply from SE P/N 04502005-001 to SE P/N 04502050-001. The ECO also changes the rear NIM Bin plate to accommodate the new power supply.

The replacement power supply's qualification basis is provided in Appendix E, Technical Evaluation Replacement Power Supply 04502050. The new power supply is provided by the same manufacturer and model series, but is somewhat larger and heavier, having a higher current output. The Technical Evaluation compares the new power supply with the original and demonstrates that the supplies are similar. The Technical Evaluation further demonstrates, through analysis, that the stresses on the mounting hardware for the new power supply are well within the material's allowable stresses for [redacted] ZPA. The new power supply, as with the original power supply, [redacted]

6.5 ECO 17708

ECO 17708 moved the [redacted] for the display/keyboard cable assembly from one end of the cable assembly to a location approximately halfway between the connectors. This improves the internal clearance in accordance with the seismic test article. Additionally, a neoprene tape was added to improve the clamping between the ferrite bead and the ribbon cable.

This change has only seismic significance since the function has not changed and there are no environmentally significant aging failure mechanisms. (The neoprene tape has a temperature rating of 90°C). The change improves clearances and does not add mass to the cable harness. The harness is short and the distance the [redacted] is moved is approximately 1.75 inches. This is not considered significant and is considered qualified.

6.6 ECO 17903

ECO 17903 added an insulator panel between the back of the [redacted] and the circuit boards (CPU board, counter board and output board). The insulator panel is a thin low mass rigid organic insulator material. It does not have any age related failure mechanisms and is a passive device. The insulator is held in place with the four mounting screws that hold the [redacted] to the front plate. The performance of the RM-1000 is verified by Acceptance Testing to demonstrate that the insulator does not impare the function of the RM-1000. The insulator is considered qualified.

6.7 ECO 17920

Among other changes, ECO 17920 revises SE document 04507000 (RM-1000 System Requirements Specification). The changes to SE document 04507000 reflect a revision in the safety and RG 1.97 functions and, therefore, have impact on the RM-1000's qualification.

The changes to SE document 04507000 are:

- Revision of the RM-1000 accuracy requirements to include the acceptance criteria of the qualification program.
- Deletion of Human Factors Considerations as RG 1.97 function.

These changes have been reflected in Section 3.2 of this document. The changes maintain consistency between the Equipment Qualification Program and the System Requirements Specification.

7. CONCLUSIONS AND RECOMMENDATIONS

The RM-1000 processor module, with its associated NIM Bin Assembly, and the I/F converter are considered environmentally and seismically qualified [redacted] This section also contains a list of limited life components and their qualified life. The I/F converter does not contain any limited life components; therefore, [redacted]

7.1 Environmental Qualification

The RM-1000 processor module and the I/F converter are considered environmentally qualified. The [redacted] See Appendix F for [redacted]

7.1.1 NMR 15806 Item 0005 Low Temperature Extremes [redacted]

[redacted]

7.1.2 NMR 15806 Item 0006 High Temperature [redacted]

At the [redacted] the process RM-1000 processor module [redacted] signal.

7.2 Seismic Qualification

The RM-1000 processor module and the I/F converter are considered seismically qualified. [redacted] See Appendix F for [redacted]

7.2.1 NMRs 15813 Item 0001 and 15813 Item 0002

The area RM-1000 processor [redacted] The zener diode D317 was [redacted] and the RM-1000 [redacted]

7.2.2 NMR 15814 Item 0001

The process RM-1000 processor [redacted]

7.2.3 NMR 15814 Item 0003

The I/F converter S/N 98001 powered up [redacted] The high voltage [redacted]

7.2.4 NMR 15814 Item 0004

The I/F converter's RM-1000 processor took [redacted]

7.2.5 No Pre-Seismic Functional Test

The second seismic test was performed without the performance of a pre-seismic baseline functional test due to time constraints. Even though procedures were not followed, this is considered acceptable, because the performance of the outputs were being recorded and the functional test was performed after the seismic tests.

7.2.6 Reverse Order of the OBE and SSE

In order to save time (shake table availability was limited) the Z-Y axis tests of the second seismic test were performed in reverse order. This is considered acceptable, since the test articles had previously been through five OBEs and one SSE as part of the first seismic test.

7.3 MODIFICATIONS

The qualification of modifications is described in Section 6. All modifications made as of December 21, 2000 are considered qualified.

7.4 NIM BIN ASSEMBLIES

NIM Bin Assemblies (SE P/N 04500801-001 through –006) are considered qualified both environmentally and seismically. This test program included only the –001 and –002 configurations. Even so, the NIM Bin for the –003 through –006 only differs from the –001 and –002 in the number of RM-1000 modules and Low Voltage power supplies installed. Environmentally there is not a difference in the component types, therefore, any number of the same type are qualified. Seismically the NIM Bin with the test articles is not full and weighs less than a full NIM Bin Assembly. In a number of previous tests the NIM Bin Assemblies have been tested with full assemblies with Test Response Spectra equal to or higher than the Required Response Spectra in this test program. The NIM Bin Assemblies met acceptance criteria and are considered seismically acceptable.

For NIM Bin Assemblies similar to this design and with multiple RM-2300 units mounted and enveloping the same seismic levels tested (Appendix B, Figure B1), see GA-ESI Doc. No. 04619036-QSR.

Table 7-1 RM-1000 Limited Life Components

Component	SE Part Number	Life Years @ 30°C, 86°F
RM-1000 Processor Module	04501000-001	[redacted]
Output PWA	04503010-001	
[redacted]	50015688-001	
Front Plate Assembly	04501060-001	
Keypad/Display PWA	04503040-001	
Keypad, 16 key matrix	87YY3616A-534	
[redacted]	GD00640160-01	
Display/Keypad Cable Assy	04502018-001	
Low Voltage Switching Power Supply	04502050-001	
[redacted]		
Transformer		
Coil LF1		
Wire		

8. REFERENCE DOCUMENTS

SE DRAWINGS

04500801	**RM-1000 NIM BIN ASSEMBLY**
04501000	RM-1000 RADIATION PROCESSOR MODULE
04506150	CURRENT-TO-FREQUENCY CONVERTER MODULE
04507000	RM-1000 SYSTEM REQUIREMENTS SPECIFICATION
04619028	SEISMIC TEST FIXTURE FOR RM-2300

SE TEST REPORTS

E-115-699	CLASS 1E EQUIPMENT QUALIFICATION AND AGING PLAN
04508901-1TR	AGE CONDITIONING TEST RESULTS
04508902-1TR	ENVIRONMENTAL QUALIFICATION TEST RESULTS
04508903-1TR	SEISMIC QUALIFICATION TEST RESULTS
04508904	FUNCTIONAL TEST PROCEDURE FOR RM-1000 AND I/F CONVERTER

INDEPENDENT LABORATORY REPORTS, EPRI, AND SUPPLIER REPORTS

EPRI NP-3326	CORRELATION BETWEEN AGING AND SEISMIC QUALIFICATION FOR NUCLEAR PLANT ELECTRICAL COMPONENTS

APPENDIX A
AGE CONDITIONING EVALUATION

This appendix contains a database of component types described in SE document E-115-699. The database was used to identify parts in the multi-level bill of materials that are referenced in E-115-699. The database further identifies the parts that require age conditioning.

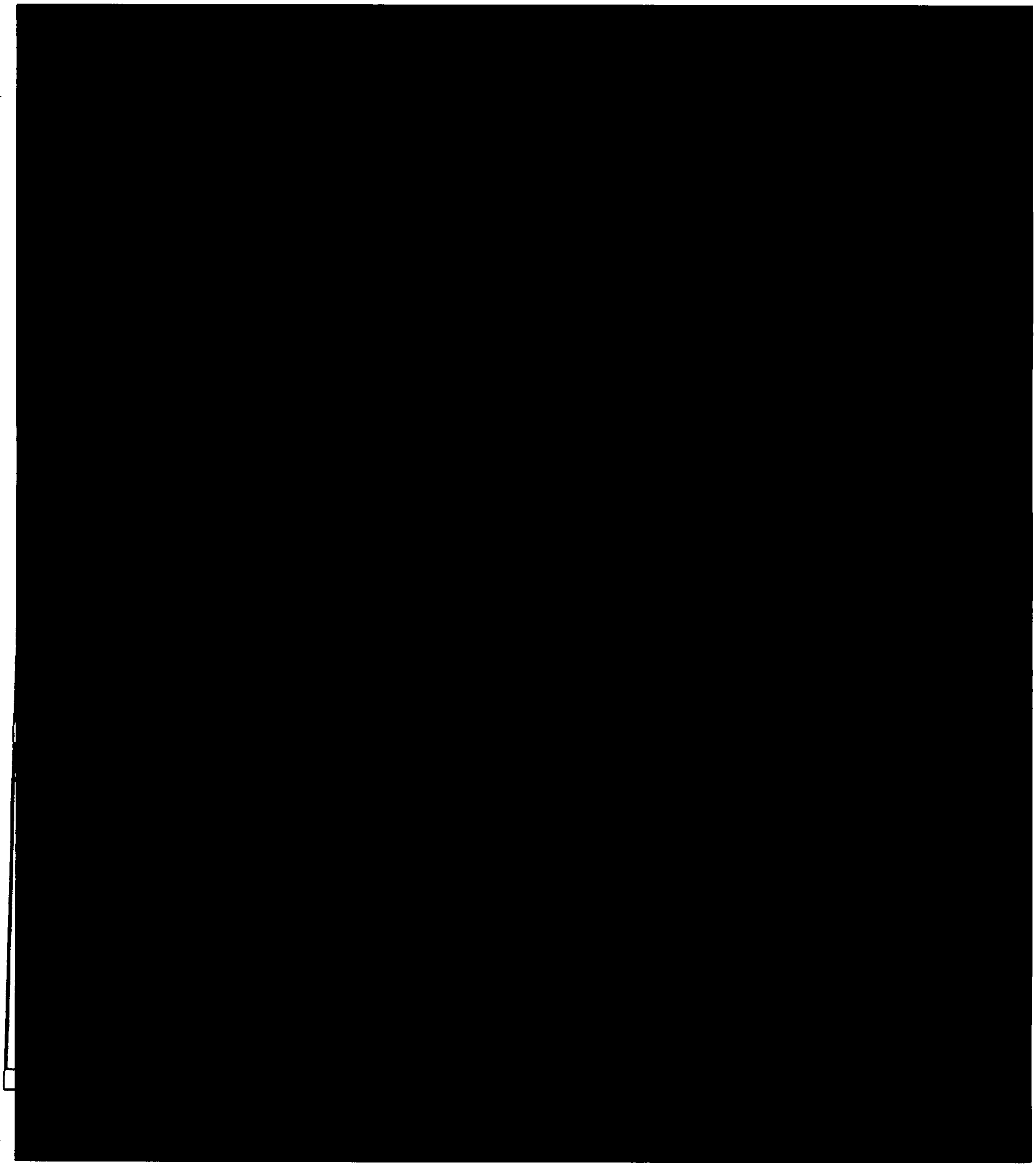
Each database record consists of the following fields of information:

AGE_ITEM:	A numeric code for the component that can be used in the multi-level Bill of Materials to codify the part.
Component Description:	The generic name for the component as described in SE document E-115-699.
Failure Mechanism:	The age related failure mechanism described in SE document E-115-699.
Remarks:	General age conditioning requirements from SE document E-115-699, SE aging practice, and EPRI Report NP-3326.
Requires Aging:	Whether the component should be age conditioned or not.
Reason:	Supporting information from SE document E-115-699, EPRI Report NP-3326, and SE experience.

[redacted]

[redacted]

[redacted]



[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

APPENDIX B
RM-1000 AND I/F CONVERTER
REQUIRED RESPONSE SPECTRA

The generic seismic qualification requirements for the RM-1000 Module for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) shown in GA-ESI document 04508905-QR, Figures 3-2 and 3-3 [redacted] which the seismic tests were performed. The Required Response Spectra (RRS) are provided in Seismic Qualification Test Results, GA-ESI Test Report 04508903-1TR are used for this qualification. The SSE RRS used for seismic tests are shown in Figure B-1.

[redacted]

DETERMINATION OF REQUIRED RESPONSE SPECTRA

The first step in determining the Required Response Spectra (RRS) is to review the previous test reports for control cabinets and to determine the maximum amplification for the cabinet structure. The reports with useful data are SNUPPS, Waterford, St. Lucie, Maanshan, and River Bend.

A plot of the amplification for each axis is included below. As can be seen the maximum flexibility is in the x axis. Except for Waterford the z axis and y axis do not have great amplifications. The Waterford cabinet will not be used for the determining the RRS. With that in mind we can generalize as following:

- HORIZONTAL: [redacted]
- VERTICAL: [redacted]

[redacted]

Using these amplifications, a review of approximately 19 nuclear plant Required Floor Response Spectra was made. The plants reviewed were:

1. Millstone
2. SNUPPS plants
3. SONGS
4. La Salle
5. Byron-Braidwood
6. Maanshan
7. Kori
8. Kuosheng
9. Sizewell
10. Watts Bar
11. Salem
12. Beznau
13. Peach Bottom
14. Comanche Peak
15. Yonggwang
16. Hope Creek
17. River Bend
18. Waterford
19. St. Lucie

Amplifying the RRS for these plants resulted in a composite RRS that was greater than the capability of the test facility table. The curves were then readjusted by removing several plants. The plants removed were Waterford, Maanshan, Kori, Kuosheng, and Sizewell. When the composite RRS was calculated without these plants the resulting RRS was within the capability of the laboratory shake table. The following figures are the resulting composite RRS curves.

[redacted]

[redacted]

APPENDIX C

SEISMIC TEST FIXTURE FOR RM2300

SE DRAWING 04619028

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

[redacted]

SHEET	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
REV																												
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
REV																												

SORRENTO ELECTRONICS

DRAWN A.BUTT aab	DATE 6/24/94	
CHECKED	6/24/94	SEISMIC TEST FIXTURE FOR RM-2300
ENGR	6/24/94	
ENGR REV	6/24/94	
PROJ ENGR Robert J Kennedy	6/27/94	
MFG ENGR —	—	
QUAL MGR D	6/27/94	
ENGR MGR —	—	

SIZE	FSCM NO	DRAWING NO	REV
A	58307	04619028	—

RELEASE 6/29/94	SHEET 1 OF 3
DRAWING LEVEL 3	

DWG NO. 04619028 REV —

NOTES: UNLESS OTHERWISE SPECIFIED

△1. DIMENSIONS AND HOLE SIZES TO BE PROVIDED BY TEST LAB TO FIT SHAKE TABLE

LIST OF MATERIALS

ITEM NO.	QTY	DRAWING NO.	DESCRIPTION	MATERIAL/SPEC
1	AR		BASE PLATE 3/8 THK	CARB STL ASTM-A-36
2	AR		ANGLE 2 X 2 X 1/4 THK	CARB STL ASTM-A-36
3	1	03606047-001	SUPPORT - NIM BIN	
4	2	50000366-001	SCR, PHL, PAN HD, 10-32 X 1/2	
5	2	50000318-001	WSHR, LK, SPLIT, #10	
6	2	50005573-001	WSHR, FL, #10, CAD STL	
7	1	50012091-001	STRAP, 3/4 X 31.25	

[redacted]

APPENDIX D

TECHNICAL EVALUATION

REPLACEMENT PRINTED WIRING ASSEMBLY

04503050 WITH DC-DC CONVERTER

Purpose

The purpose of this technical evaluation is to examine the addition of printed wiring assembly (PWA) 04503050, Power Supply Adapter (PSA), with its DC-DC converter as a replacement for DC-DC converter DR24D15/100G (the original converter). Both DC-DC converters take [redacted] The original converter was mounted directly to PWA 04503010, Output, used in the RM-1000 Module. The original converter was qualified for [redacted] as documented in the main body of this report.

During the development of the RM-1000 [redacted] provided by the original converter [redacted] The replacement [redacted] PSA PWA with its DC-DC converter is mounted to Output PWA with standoffs and replaces the original converter. It is an alternate item as it is not a like-for-like replacement.

Safety Function

The general safety functions assigned to these DC-DC converters are:

Provide Signal	Applies to components which generate signal or transmit a process signal used for control or indication purposes
Maintain Circuit Integrity	Maintain electrical state such that design current flow is accomplished and excess current flow, caused by shorting, does not occur
Maintain Structural Integrity	Active and passive components required to maintain structural form. Component does not collapse, disassemble, or disintegrate.

The functional mode for these DC-DC converters is passive.

Design Characteristics

Critical design characteristics are identifiable and measurable attributes of an item which can be verified. These characteristics are to provide reasonable assurance that the item replaced is as good as the original item. Critical design characteristics address the item's safety functions and the item's interaction with other items

The replacement converter uses integrated circuits, diodes, transistors, resistors, inductors and transformer. There are no digital circuits and no aluminum electrolytic capacitors. The replacement converter is encapsulated. So it is not feasible to evaluate at the subcomponent level.

The replacement converter can be evaluated on the basis of performance characteristics shown in Table 1.

Characteristic		
Manufacturer	[redacted]	[redacted]
Part Number	[redacted]	[redacted]
Output Voltage	[redacted]	[redacted]
Output Voltage Accurcay	[redacted]	[redacted]
Output Current	[redacted]	[redacted]
Operating Temperature (max) without derating	[redacted]	[redacted]
Load Regulation	[redacted]	[redacted]
Input Voltage Range	[redacted]	[redacted]
Efficiency	[redacted]	[redacted]
Over Voltage Protection	[redacted]	[redacted]
Weight	[redacted]	[redacted]
Case Material	[redacted]	[redacted]

Table 1 DC-DC Converter Characteristics

It can be seen that the key functional characteristics of output voltage, output voltage accuracy, load regulation, and input voltage range of the replacement converter are as good as or better than the original converter characteristics. The key environmental characteristic of maximum operating temperature without derating is identical.

The replacement converter is manufactured under an ISO 9001 program.

The PSA PWA is mounted on 10 standoffs. Each standoff is 0.050 inch in diameter and 0.42 inch long. The material is tin coated brass. The standoffs are swaged into the PSA PWA and are soldered into the Output PWA.

The analysis is simplified to that of a single standoff with all of the PSA PWA mass located at the far end of the standoff:

Natural Frequency

The standoff and PSA PWA are modeled conservatively as a [redacted] with PSA PWA mass at the end with the standoff modeled as a uniform load. The natural frequency is calculated from [redacted]

[redacted]

where

[redacted]

[redacted]

The DC-DC converter weighs [redacted] and the PSA PWB [redacted]
Thus [redacted].

The diameter of the standoff is [redacted]

This yields a natural frequency of [redacted]

The purpose of this evaluation is to demonstrate that the [redacted] Since this has been demonstrated, the standoffs and PSA PWA can be treated as a rigid body. This allows the zero period accelerations (ZPA's) from the seismic response spectra to be inputs to the stress analysis of the standoff.

Stresses

The stress at the point where the standoffs are soldered to the circuit board is given by

where [redacted]

The test SSE ZPA's in all directions were [redacted] The historical approach has been to take the [redacted] for the acceleration. The moment of inertia of a [redacted]

Then the maximum stress is calculated to be [redacted] proportional limit for brass.

If the peak acceleration was used and [redacted]
This would result in a [redacted]

Then the maximum stress is calculated to be [redacted] proportional limit for brass.

Since stresses are well below allowable levels, the mounting maintains seismic qualification.

APPENDIX E

TECHNICAL EVALUATION

REPLACEMENT POWER SUPPLY 04502050

If the peak acceleration was used and [redacted] in all directions. This would result in a [redacted]

Then the maximum stress is [redacted] for carbon steel.

Since stresses are below allowable levels, the mounting maintains seismic qualification.

Purpose

The purpose of this technical evaluation is to examine power supply 04502050-001 as a replacement for power supply 04502005-001. Both power supplies provide +24 VDC power for RM-1000 Modules. Power supply 04502005-001 (the original item) was qualified for mild environment applications by test, as documented in the main body of this report.

During the development of applications for the RM-1000 product, it was determined that the [redacted] for some of the RM-1000 applications. Power supply 04502050-001, with its 1.8 amp rating, was specified as the replacement supply to accommodate the wider range of RM-1000 applications. It is an alternate item as it is not a like-for-like replacement.

Safety Function

The general safety functions assigned to these power supplies are:

Provide Signal	Applies to components which generate signal or transmit a process signal used for control or indication purposes
Maintain Circuit Integrity	Maintain electrical state such that design current flow is accomplished and excess current flow, caused by shorting, does not occur
Maintain Structural Integrity	Active and passive components required to maintain structural form. Component does not collapse, disassemble, or disintegrate.

The functional mode for these power supplies is passive.

Design Characteristics

Critical design characteristics are identifiable and measurable attributes of an item that can be verified. These characteristics are to provide reasonable assurance that the item replaced is as good as the original item. Critical design characteristics address the item's safety functions and the item's interaction with other items

It is accepted practice per EPRI guidelines that an alternate item that is an asssembly of components can be evaluated on the basis of performance characteristics, if it is of the same manufacturer and model series as the qualified original item. This is the case as discussed below, for the power supplies being evaluated. For any other case, it would be necessary to review the characteristics of the individual components making up the assembly.

Both, the qualified, original power supply and the new, alternate supply are available under two different part numbers from two manufacturers (Meanwell and Astrodyne). In each case, the supplies are identical in materials, construction and performance.

Characteristic	[redacted]
Manufacturer	
Part Number	
Output Voltage	
Output Voltage Accuracy	
Output Current	
Operating Temperature (max) without derating	
Load Regulation	
Input Voltage Range	
Input Frequency Range	
Efficiency	
Over Voltage Protection	
Weight	
Dimensions (inches)	

Table 1 24 VDC Power Supply Characteristics

It can be seen that the key functional characteristics of output voltage, output voltage accuracy, load regulation, input voltage range and input frequency range of the alternate supply are as good as or better than the original supply characteristics. The key environmental characteristic of maximum operating temperature without derating is identical.

Regarding seismic qualification, it is next necessary to evaluate the larger weight and dimensions of the replacement power supply. The outer cases are identical in material (perforated steel) and thickness. The printed wiring boards are of the same material and thickness.

The original supply was mounted with two 4-40 screws. The alternate supply is mounted with three 4-40 screws. The seismically induced stress on the alternate supply screws is conservatively estimated by analyzing the two mounting screws. The vertical seismic loading of 3 g's (ZPA) plus the weight of the alternate supply (equivalent to 1 g) is conservatively assumed to be at the far end of the supply, or 5.08 inches away from the mounting screws. This is to say that the center of gravity location, which is not known, can be enveloped by placing it at its extreme possible location. The vertical separation of the screws is 3 inches. Then the moment balance around the lower screw is yields the seismic force on the upper screw:

[redacted]

The horizontal separation of the two lower (horizontally separated) screws is 0.71 in^2. Balancing the moments [redacted] horizontal loads for these screws yields a tensile stress [redacted] This stress is well below the allowable stresses for typical carbon steels. The yield strength for typical [redacted]. The tensile stress limit is [redacted] (80 % of the yield strength) and the [redacted] (50 % of the yield strength). The shear stress for the alternate power supply screws are lower than the tensile stresses, as there is no moment amplification.

Since stresses are well below allowable levels, the mounted alternate supply maintains seismic qualification.

[redacted]

APPENDIX F
CLOSED NONCONFORMING MATERIAL REPORTS

NMR 15806, ITEMS 0001, 0002 AND 0004 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

These NMR items involved separate occurrences of the same observed discrepancy. The periodic checks of the test articles found the RM-1000 for the I/F Converte[redacted] After each discovery, the RM-1000 Module was returned t[redacted] From the recordings of Converter output, the abnormality causing the Loss of Signal could be seen during the programmed [redacted] During the [redacted] the output [redacted] the RM-1000, then later, the [redacted]

RESOLUTION:

Engineering evaluation determined that the test conditions were not correct during the test chamber [redacted] The nature of the [redacted] inside the Converter. [redacted] in the chamber during the controlled temperature changes. The qualification [redacted]

A separate test of the Converter test article at SE was performed, simulating both [redacted] during a like change in temperature. When known [redacted] occurred, the Converter [redacted] With non-[redacted] the response was normal.
The test article was then re-tested at the environmental test facility, [redacted] the temperature ramp cycles, and then the [redacted] after reaching the new temperature. This re-test showed normal operation of the Converter, and confirmed that the [redacted] not the I/F Converter. The Converter subsequently successfully passed its post-environmental functional test. The [redacted] and successful re-test provide the basis of closing NMR-15806, Items 0001, 0002 and 0004.

NMR 15806, ITEM 0005 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

During the functional test with the RM-1000 for the I/F Converter portion of the test, [redacted] The Loss of Signal [redacted] RM-1000. A data base item in the RM-1000 is set to a [redacted] where a count rate [redacted] the RM-1000 to create the [redacted]

RESOLUTION:

Engineering evaluation of the I/F circuit operation determined that the Converter output at its low-end of range provides enough output count rate signal that must be accounted for in the RM-1000 module itself. The remaining output signal from the Converter with no input is low enough for the RM-1000 to process its Loss Of Signal [redacted] RM-1000data base [redacted] accordingly.

The above operational design limit is required to be included in technical instructions for the user for the data base. The Scaling Background data base item No. 009 controls the Loss of Signal failure status. Therefore, [redacted] is listed [redacted] in the RM-1000 Data Base Description Document 04507100, for ion chamber applications. No change is required for the I/F Converter. Re-test of the equipment [redacted] in the RM-1000 was successful, providing the basis for closing NMR-15806 Item 0006.

NMR 15806, ITEM 0006 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

The periodic check of the test found the RM-1000 for the process monitor indicating [redacted]

RESOLUTION:

Examination of RM-1000 and continued testing of it [redacted] the unit continued proper operation through the remainder of the test. [redacted] this NMR item is thereby closed.

NMR 15806, ITEM 0007 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

During the functional test with the RM-1000 for the area monitor, [redacted] This condition repeated the next day, and for both occurrences, a repeated power-fail test operated successfully.

RESOLUTION:

Examination of RM-1000 internal boards and relays [redacted] The [redacted] in the test chamber, [redacted] as discussed for NMR 15806 Items 0001, 0002, and 0004. Therefore, [redacted] and the NMR item is closed.

NMR 15813, ITEMS 0001 AND 0002 RESOLUTION

This information is in addition and supplementary for these NMR items that are closed.

DISCREPANCY/ FAILURE SUMMARY:

Before initiation of seismic testing, the shake table [redacted] Item 0001 of the NMR described that the internal PWAs of both the area and process RM-1000s [redacted]. After the process RM-1000boards were re-installed, it was operational. The area RM-1000 [redacted] D31 7 [redacted] Item 0002 was written for the area RM-1000 after the seismic test [redacted]

RESOLUTION:

Due to the [redacted] The Output Board on the area RM-1000 [redacted]

NMR 15814, ITEM 0001 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

When the SN 002 Process Module was tested at SE after the seismic test, the module [redacted] rocedure 04508904 step 4.1.2.29A. The other discriminator tests were passed. The test was [redacted]

RESOLUTION:

This unit operated satisfactorily [redacted]. The conclusion was that this was a random failure. Subsequently, an engineering evaluation failed to identify any cause other than a random failure.

NMR 15814, ITEM 0002 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

During functional test after seismic test, the display test for the area RM-1000 [redacted]

RESOLUTION:

Engineering evaluation was made for both the area and process RM-1000s. The conclusion was that the display anomaly was a [redacted] The process RM-1000 operated satisfactorily in the post-test functional test. In addition, the area RM-1000 operated satisfactorily following the second seismic test series, which took place for retesting the I/F converter. The area monitor RM-1000 [redacted] compared to the process unit (Ref. NMR 15813, Items 0001 and 0002).

NMR 15814, ITEM 0003 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

During functional test after the second seismic test series, the S/N 003 RM-1000 powered up with the High Voltage off, instead of on, requiring a manual turn-on in the Calibrate mode.

RESOLUTION:

This unit operated satisfactorily after the first seismic test, as the other RM-1000 for both tests. [redacted]

NMR 15814, ITEM 0004 RESOLUTION

DISCREPANCY/ FAILURE SUMMARY:

During the functional test of the RM-1000 for the [redacted] failure message did not appear at the RM-1000. A data base item in the RM-1000 is set to a low count rate value, where a count rate lower than the setpoint causes the RM-1000 to create the Loss of Signal alarm failure message.

RESOLUTION:

Engineering evaluation of the I/F circuit operation determined that the Converter output at its low-end of range provides enough output count rate signal that must be accounted for in the RM-1000 module itself. The remaining output signal from the Converter with no input is low enough for the RM-1000 to process its Loss Of Signal failure, provided the RM-1000 [redacted]

The above operational design limit is required to be included in technical instructions for the user for the data base. The Scaling Background data base item No. 009 controls the Loss of Signal failure status. Therefore, this limit [redacted] is listed [redacted] in the RM-1000 Data Base Description Document 04507100, for ion chamber applications. No change is required for the I/F Converter. Re-test of the equipment using the new trip limit in the RM-1000 was successful, providing the basis for closing NMR-15806 Item 0006.