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NRW-FPGA-Based I&C System Qualification Project

Equipment Qualification Test Plan

Title: Nuclear Instrumentation & Control Systems Department
Equipment Qualification Test Plan for
Safety-Related Oscillation Power Range Monitor (OPRM)

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APPENDIXES

TABLES

FIGURES

1. Purpose

This Equipment Qualification Test Plan (EQ Test Plan) prescribes the test requirements, conditions, and methodologies for equipment qualification of the Oscillation Power Range Monitor (OPRM) for NRW-FPGA-Based I&C System Qualification Project.

The purposes of EQ test are:

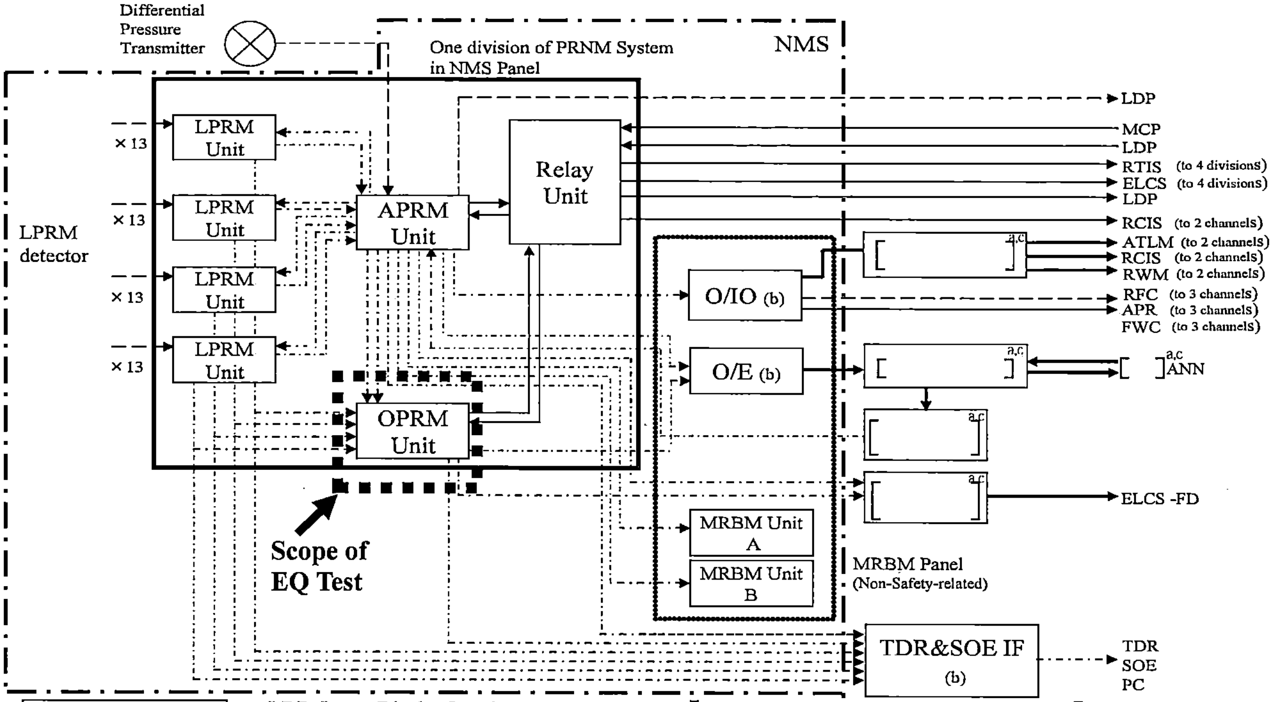
- To reduce the potential of common mode failures due to environmental effects, and
- To demonstrate the soundness of safety-related functions and the post-accident monitoring function under the required environmental conditions.

2. Scope

The Power Range Neutron Monitor (PRNM) subsystem has four equivalent divisions. One division of the PRNM subsystem consists of four Local Power Range Monitor (LPRM) units, one Average Power Range Monitor (APRM) unit, one OPRM unit, and one Relay unit. The LPRM units, APRM unit, OPRM unit, and Relay unit are included in the Neutron Monitor System (NMS) Panel per division and installed in the Main Control Room (MCR) back panel area.

Therefore, the scope of the EQ Test Plan is to develop an equipment qualification plan for one OPRM unit that is a part of functional subsystem of the PRNM per one division in accordance with Section 5.1.1 Type testing of the IEEE Std. 323-2003 (Reference (6)), as enclosed by the bold and dotted line in Figure 2-1 which is a copy of Figure 4-1 of the Equipment Design Specification (EDS) (Reference (12)).

According to the Advanced Boiling Water Reactor Design Control Document (ABWR DCD) (Reference (10)), the PRNM subsystem is classified as Category I for seismic category, Class 1E for electrical equipment, and Safety Class 3 (SC-3). The PRNM subsystem also has the post-accident monitoring function (PAM) and is classified as Category I Type B, as described in the ABWR DCD. However, since PRNM instruments mounted on the NMS panel in the MCR are mild environment equipment and do not adversely affect safety-related functions under the design basis accident (DBA) condition, the DBA/post-DBA test which demonstrates the PAM functions under the DBA condition is out of scope of this qualification activity.



———	Discrete
– – – –	Analog
-·-·-·-	Optical
———	Ethernet

Note:
(a): Safety-related CI
(b): Non-Safety-related CI

LDP: Large Display Panel
MCP: Main Control Panel
RTIS: Reactor Trip and Isolation System
RCIS: Rod Control & Information System
ATLM: Automated Thermal Limit Monitor
RWM: Rod Worth Minimizer
RFC: Recirculation Flow Control System
APR: Automatic Power Regulator
FWC: Feedwater Control System
ANN: Annunciator

[ ]a,c
ELCS: Engineered Safety Features (ESF) Logic and Control System
TDR: Transient Data Recorder
SOE: Sequence of Event
GW: Gateway
IF: Interface
CI: Communication Interface
O/IO: Optical to Analog/Discrete Output Converter
O/E: Optical to Ethernet Converter
PC: Personal Computer

Figure 2-1 Scope of the EQ test

3. References

(1) 10 CFR21 Title 10, CFR, Part 21: Reporting of Defects and Non-compliances

(2) 10CFR50 Appendix B Title 10, CFR, Part50, Appendix B: Quality Assurance Criteria for Nuclear Power Plants and, Fuel Reprocessing Plants

(3) Regulatory Guide 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants, March 2007"

(4) IEEE Std 7-4.3.2-2003, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations"

(5) IEEE Std. 323-1983, "Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(6) IEEE Std. 323-2003, "Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(7) IEEE Std. 344 -1987, "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(8) IEEE Std 498-1990, "Standard Requirements for the Calibration and Control of Measuring Equipment Used in Nuclear Facilities (ANSI)"

(9) IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations"

(10) ABWR Design Control Document (DCD)

(11) EPRI TR-107330 "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants, December 1996."

(12) FC51-3002-1000 Rev.1, "Equipment Design Specification for Power Range Neutron Monitor" (EDS)

(13) FC51-3201-1000 Latest Revision, "Electrical Cable Wiring Diagram (ECWD) for OPRM Test System".

(14) FC51-3702-1000 Rev.2, "OPRM Unit Detailed Design Specification for Power Range Neutron Monitor" (Unit DDS)

(15) [deleted]

(16) FC51-7021-1000 Rev.0, "Master Test Plan"

(17) NQ-2003, "Procedure for Control of Software Tools"

(18) NQ-2019, "Preparation Procedure for Test Specification"

(19) NQ-2024, "Procedure for Document Control"

(20) NQ-2035, "Procedure for Design Change Control"

(21) NQ-3003, "General Requirements for packaging, shipping, receiving , storage and handling"

(22) NQ-3011, "Qualification Procedure of Test Personnel and QC Inspector"

(23) NQ-3015, "Test Control Procedure"

(24) NQ-3017, "Measuring and Test Equipment Control Standard"

(25) NQ-3019, "Procedure for Control of Nonconformance and Corrective Action"

4. Definitions and Abbreviations

4.1 Definitions

(1) Class 1E

The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment. (Reference (9))

(2) Cutoff Frequency

The frequency in the response spectrum where the zero period acceleration asymptote begins. This is the frequency beyond which the single-degree-of-freedom oscillators exhibit no amplification of motion, and indicate the upper limit of the frequency content of the waveform being analyzed. (Reference (7))

(3) Damping

An energy dissipation mechanism that reduces the amplification and broadens the vibratory response in the region of response. Damping is usually expressed as a percentage of critical damping. Critical damping is defined as the least amount of viscous damping that causes a single-degree-of-freedom- system to return to its original position without oscillation after initial disturbance. (Reference (7))

(4) Design Basis Accident (DBA)

Those plant conditions resulting from various postulated equipment and piping failures during which safety-related equipment shall operate without impairment of the safety- related function in a harsh environment. A design basis accident is a subset of a design basis event. (Reference (5))

(5) Design Life

The time period during which satisfactory performance can be expected for a specific set of service conditions. (Reference (6))

(6) Environmental Qualification

The generation and maintenance of evidence to ensure that equipment will operate on demand to meet system performance requirements during normal and abnormal service conditions and postulated design basis events. (Reference (6))

(7) Harsh Environment

An environment resulting from a design basis event, i.e., loss-of-coolant accident (LOCA), high-energy line break (HELB), and main steam line break (MSLB). (Reference (6))

(8) Margin

The difference between service conditions and conditions to which the equipment is qualified. (Reference (6))

(9) Mild Environment

An environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences. (Reference (6))

(10) Operating Basis Earthquake (OBE)

An earthquake that could reasonably be expected to occur at the plant site during the operating life of the plant considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the vibratory ground motion for which those features of the nuclear power plant, necessary for continued operation without undue risk to the health and safety of the public, are designed to remain functional. (Reference (7))

(11) Qualified life

The period of time, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions. (Reference (6))

(12) Required Response Spectrum (RRS)
The response spectrum issued by the user or his agent as part of his specifications for seismic qualification or artificially created to cover future applications. The RRS constitutes a requirement to be met. (Reference (7))

(13) Resonant Frequency

A frequency at which a response peak occurs in a system subjected to forced vibration. This frequency is accompanied by a phase shift of response relative to the excitation. (Reference (7))

(14) Response Spectrum

A plot of the maximum response, as a function of oscillator frequency, of an array of single-degree-of-freedom damped oscillators subjected to the same base excitation. (Reference (7))

(15) Safe Shutdown Earthquake (SSE)
An earthquake that is based on an evaluation of the maximum earthquake potential considering the regional and local geology, seismology and specific characteristic of local subsurface materials. It is that earthquake that produces the maximum vibratory ground motion for which certain structures, systems and components are designed to remain functional. These structures, systems, and components are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shutdown condition; and (3) the capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposure comparable to the 10 CFR Part 100 guidelines. (Reference (7))

(16) Safety Function

One of the processes or conditions (e.g., emergency negative insertion, post-accident heat removal, emergency core cooling, and post-accident radioactivity removal and containment isolation) essential to maintain plant parameters within acceptable limits established for a design basis event. (Reference (9))

(17) Significant aging mechanism
An aging mechanism that, under normal and abnormal service conditions, causes degradation of equipment that progressively and appreciably renders the equipment vulnerable to failure to perform its safety function(s) during the design basis event conditions. (Reference (6))

(18) Test Specimen

The set of Programmable Logic Controller (PLC) modules, hardware and software configuration, and Test System Application Program used as the basis for generic Qualification Testing.

[This definition is extracted from Section 2.1 of EPRI TR-107730 (Reference (11)). For the purpose of this project, this definition is interpreted as "FPGA-based OPRM unit, which is the set of unit chassis and modules including FPGA chip that embeds FPGA logic to perform its intended safety functions, used as the basis for generic Qualification Testing."]

(19) Test Equipment

A. Panel of other device for connecting to the inputs and outputs. This device shall contain methods for stimulating inputs and monitoring outputs as required to support acceptance and operability testing.
B. Test and measuring equipment with accuracy needed to support the acceptance criteria.
C. Any special tools and devices needed to support testing. (Reference (11))

(20) Test Response Spectrum (TRS)
The response spectrum that is developed from the actual time history of motion of shake table. (Reference (7))

(21) Type Test

Type Test means a test on one or more sample components of the same type and manufacturer to qualify other components of that same type and manufacturer. A type test is not necessarily a test of the as-built structures, systems, or components. (Reference (10))

4.2 Abbreviations

AC	Alternating Current
APRM	Average Power Range Monitor
C	Celsius
CI	Communication Interface
DBA	Design Basis Accident
DC	Direct Current
DCD	Design Control Document
DQR	Dynamic Qualification Report
ECWD	Electrical Cable Wiring Diagram
EDS	Equipment Design Specification
ELCS	Engineered safety features Logic and Control System
EPRI	Electric Power Research Institute
EQ	Equipment Qualification
EQR	Environmental Qualification Report
ESF	Engineered Safety Features
F	Fahrenheit
FD	Flat Display
FPGA	Field Programmable Gate Array
GRA	Growth Rate-Based Detection Algorithm
HELB	High-Energy Line Break
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers, Inc.
I/O	Input/output
I&C	Instrumentation & Control
kHz	Kilo Hertz
LDP	Large Display Panel
LOCA	Loss of Coolant Accident
LPRM	Local Power Range Monitor
M&TE	Measuring and Test Equipment
MSLB	Main Steam Line Break
NMS	Neutron Monitoring System
NICS-QC	Quality Control Sect. for Nuclear Instrumentation & Control Systems
NICSD	Nuclear Instrumentation & Control Systems Department
NIST	National Institute of Standard and Technology
NNR	Non-Conformance Notice Report
NRC	Nuclear Regulatory Commission
NRW-FPGA	Non-Rewritable FPGA
OBE	Operating Basis Earthquake
OPRM	Oscillation Power Range Monitor
PAM	Post-Accident Monitoring
PBDA	Period Based Detection Algorithm
PFC	Power Factor Correction

[ ]a,c

PLC	Programmable Logic Controller
PRNM	Power Range Neutron Monitor
QA	Quality Assurance
QC	Quality Control
RG	Regulatory Guide
RPS	Reactor Protection System
RRS	Required Response Spectra
SC	Safety Class
SER	Safety Evaluation Report
SNNR	Fuchu Site Nonconformance Notice Report
SOE	Sequence of Event
SSE	Safe Shutdown Earthquake
TDR	Transient Data Recorder
TID	Total Integrated Dose
TRS	Test Response Spectra
TRRS	Test Required Response Spectra

[ ]a,c

5. Test System

5.1 Description of OPRM unit

The OPRM unit monitors neutron flux oscillation. The OPRM unit receives 52 LPRM Levels from 4 LPRM units and forms 44 OPRM Cell configurations to monitor the neutron flux behavior of all regions of the core. For each Cell, the peak to average value of the OPRM signal is determined to evaluate the amplitude of oscillation and to be used in the setpoint algorithm. The OPRM trip protection algorithm consists of trip logic depending on signal oscillation amplitude, a signal oscillation period, and signal oscillation growth rate. If one of the Cells fulfills any one of three trip conditions, the OPRM unit generates a trip signal.

The OPRM unit also receives APRM Level and Core Flow Level from the APRM unit and the trip algorithms are automatically bypassed if APRM Level is less than 30% (initial setpoint) or Core Flow Level is greater than 60% (initial setpoint).

The OPRM provides optical transmission output signals to the [ ]a,c Sequence of Event (SOE) and Transient Data Recorder (TDR) via Non-Safety-Related Communication Interface (CI) and Engineered Safety Features (ESF) Logic & Control System Flat Display (ELCS FD) via Safety-Related CI.

5.2 Test System

The test system consists of test specimen, and test equipment which support the EQ testing. The test system configuration is as shown in Figure 5-1.

The test specimen comprises one OPRM unit with two Power Factor Correction modules (PFCs). The test specimen is mounted on a test specimen rack or test chamber based on actual installation. The detailed configuration of the test specimen is described in Section 5.3.1 and the features of the test specimen are described in Section 5.3.2.

[ ]a,c

The [ ]a,c simulates one APRM unit. A redundant optical transmission input signal from the APRM unit is simulated by [ ]a,c Since optical transmission input signals from the APRM unit are only used for OPRM Region determination in the OPRM unit and need not undergo a transient change, those signals are output as constant data. The OPRM unit always monitors optical transmission input signals from the APRM unit, and the soundness of the constant data is ensured through a performance test before and after the EQ test. Thus the simulated output of the APRM unit is not monitored at the [ ]a,c during the EQ test. The [ ]a,c is used to simulate four LPRM units. One port of the [ ]a,c simulates optical transmission signals of one LPRM unit containing 13 LPRM Levels, which undergoes a transient change, and provides those signals to the OPRM unit. The [ ]a,c sends same data as the [ ]a,c for loopback monitoring.

The [ ]a,c monitors the optical transmission output signals from the OPRM unit. Since the optical transmission signals output from the OPRM unit to ELCS and [ ]a,c are equivalent, one typical port of those four ports on the TRN module (TRN1) in the OPRM unit is monitored with one port of the [ ]a,c Since the optical signals output from the OPRM unit to SOE and TDR are equivalent, one typical port of those four ports on the TRN module (TRN2) in the OPRM unit is monitored with one port of the [ ]a,c The [ ]a,c monitors the optical transmission output signals from the [ ]a,c The signals recorded in the [ ]a,c are not normally evaluated. However, if there is a problem in the qualification test result, these signals will be used to check the soundness of the optical signal transmit simulator operation.

The relay unit is simulated by the aux-relay plate which uses a general mechanical relay. A DO signal as trip signal issued from the OPRM unit is monitored with the data recorder via the aux-relay plate. A DI signal as a bypass signal is provided to the OPRM unit via the aux-relay plate.

The OPRM unit is powered from two redundant Class 1E AC power supplies. Both of those AC power supplies provide nominal 120 VAC, 60 Hz power. Therefore, those two power supplies which satisfy the above-mentioned specifications are used as the test equipment in the EQ test. Fuses, varistors, and noise filters equivalent to actual products are inserted to the power lines in the test specimen rack. These fuses, varistors, and noise filters are dealt as test equipment not as test specimen.

The test equipment is detailed in Section 5.4.

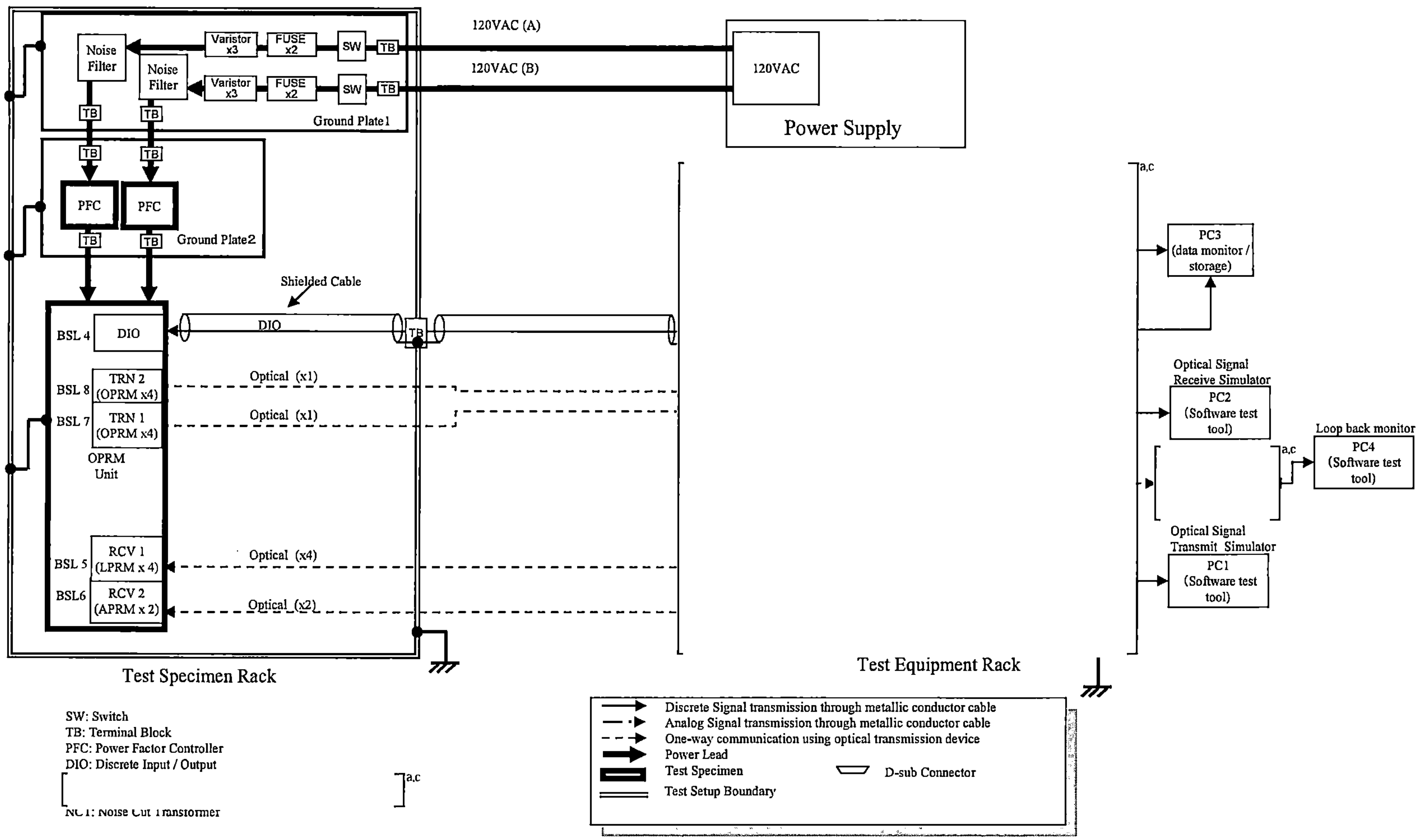


Figure 5-1 Test System

5.3 Test Specimens

5.3.1 Identification, Description, and Quantity of Test Specimens

Identification, description, and quantity of the test specimen is shown below in Table 5-1.

Table 5-1 Test Specimens List

No.	Description		Model Number	Serial Number	Manufacturer	Qty	Figure
1	OPRM Unit	Processor	HNU1200B00000	10920017	Toshiba	1	Figure A- 3
	OPRM Chassis	Chassis	[		][a,c]	1	
	CELL Module	Processor	HNS0400B00000	1206818335	Toshiba	1	
	AGRD Module	Processor	HNS0420B00000	1206818331	Toshiba	1	
	PBD Module	Processor	HNS0430B00000	1206818312	Toshiba	1	
	DAT/ST Module	Processor	HNS0410B00000	1206818322	Toshiba	1	
	LVPS Module	Power supply	HNS0500B00000	1282858 1282859	Toshiba	2	
	DIO Module	Interlock	HNS0520B00000	1202803706	Toshiba	1	
	TRN Module	Optical Transmitter	HNS0531B00000	1206818325 1206818326	Toshiba	2	
	RCV Module	Optical Receiver	HNS0541B00000	1206818316 1206818317	Toshiba	2	
	PFC	Power Factor Correction	[		][a,c]	2	Figure A- 4

5.3.2 Features of Test Specimens

- OPRM Unit

Dimensions: 482.6 (W) x 440.8 (D) x 177.0 (H) [mm] (19.00 (W) ×17.35 (D) ×6.97 (H) [inch])

Mass: 17 kg or less

The OPRM unit consists of a unit chassis and 11 modules comprising eight different functions: two RCV, one CELL, one AGRD, one PBD, one DAT/ST, two TRN, one DIO, and two LVPS modules.

- PFC

Dimensions: 170.0 (W) x 127.0 (D) x 35.0 (H) [mm] (6.69(W) ×5.00 (D) ×1.38(H) [inch])

Mass: 0.56 kg or less

The PFC receives AC voltage from an external AC power supply. The AC voltage is converted into DC voltage (about 220 VDC) by the PFC. The PFC supplies DC voltage to the LVPS modules.

5.3.3 Qualified and Design Life Goals

The design life of the OPRM unit and PFCs are specified as[ ][a,c] years. The design life of the OPRM unit is guaranteed by conducting appropriate maintenance and replacement, as described in Section 5.4 of the EDS (Reference (12)). Since the OPRM unit and PFCs are equipment located in a mild environment which has no significant aging mechanisms, a qualified life is not required as described in Section 4.1 of IEEE Std. 323-2003 (Reference (6)).

5.3.4 Spare Parts

Spare parts are not prepared in this EQ test. Should a part used in the test specimens fail during the EQ test, the EQ test is interrupted. In this case, after the test specimen is modified or replaced, the EQ test is performed again from the beginning.

5.3.5 Maintenance Parts

Maintenance parts are not prepared in this EQ test.

5.4 Test Equipment

The test equipment used to support the EQ test is listed in Table 5-2.

The test equipment involved in this qualification test plan is supplied for test purposes only. The test equipment is not qualified along with the test specimens. The ECWD (Reference (13)) describes the test equipment setup configuration. Operation of the test equipment shall be defined in each test procedure. The configuration of application program used in the test equipment shall be controlled in accordance with "Procedure for Control of Software Tools" (NQ-2003 (Reference (17)).

The test equipment categorized as "Measuring and Test Equipment (M&TE)" in the list shall be traceable to US National Institute of Standard and Technology (NIST), NIST through a Mutual Recognition Arrangement (MRA), or US nationally recognized standards in accordance with NQ-3017 (Reference (24)). If no nationally recognized standards exist, the basis for calibration shall be documented. All test equipment shall be controlled per IEEE Std 498 (Reference (8)). These records shall demonstrate that the type, range, accuracy, resolution, and tolerance of the instrumentation are suitable for application. The test vendor's M&TEs, or general M&TEs such as voltmeter are not listed in Table 5-2. The test vendor's M&TEs shall meet the requirements specified in vendor QA program. The vendor QA program should be verified through the vendor evaluation by Toshiba.

Table 5-2 Test Equipment List

Name	Quantity	Type of Equipment	Column
Test Specimen Rack	1	Test Support Equipment	24" wide x 27" deep x 63" tall
Test Equipment Rack	1	Test Support Equipment	24" wide x 28" deep x 63" tall
Noise Filter	2	Test Support Equipment	[ ]a,c
DIO Cable	1	Test Support Equipment	Shielded Cable (equivalent for actual product)
DIO Cable (For Seismic) (For Temperature & Humidity)	1	Test Support Equipment	Shielded Cable (equivalent for actual product)
Fiber-optic Cable	12	Test Support Equipment	[ ]a,c (equivalent for actual product)
DC Power Supply	1	Test Support Equipment	
Scope corder	1	M&TE	
Data Logger	1	Test Support Equipment	For Analysis
PC (For Scope corder & Data Logger)	1	Test Support Equipment	
Aux-Relay Plate	1	Test Support Equipment	
Optical Signal Transmit Simulator	1	Test Support Equipment	Software Tool Registration Application Form Number: FDTR-12-0003-KM
[ ]a,c	3	Test Support Equipment	[ ]a,c
	1	Test Support Equipment	
PC	1	Test Support Equipment	
Optical Signal Receive Simulator	1	Test Support Equipment	Software Tool Registration Application Form Number: FDTR-12-0003-KM
[ ]a,c	1	Test Support Equipment	[ ]a,c
	1	Test Support Equipment	
PC	1	Test Support Equipment	
Noise Cut Trans	1	Test Support Equipment	
Multimeter	1	M&TE	For measuring voltage, frequency, and register
Thermo-Hydrometer	2	M&TE	
PC (For Thermo-Hydrometer)	2	Test Support Equipment	
Accelerometer	3	M&TE	
Loop back monitor	1	Test Support Equipment	Software Tool Registration Application Form Number: FDTR-12-0003-KM
[ ]a,c	1	Test Support Equipment	[ ]a,c
	1	Test Support Equipment	
PC	1	Test Support Equipment	

6. Safety-related Functions to be demonstrated

The safety-related functions to be demonstrated by the EQ testing are described below:

(1) Generate Normalized Oscillation Signal

The OPRM unit generates the Normalized Oscillation Signals using LPRM Levels for each OPRM Cell. The Normalized Oscillation Signals shall be checked by the optical transmission output signals from the TRN modules.

(2) Generate the following trip signals and provide to the Reactor Protection System (RPS)

The OPRM unit generates the following trip signals as discrete output signals.

(2-1) Growth Rate-Based Trip (GRA Trip)

The OPRM unit generates the GRA Trip signal when the amplitude growth rate of Normalized Oscillation Signal exceeds specified values. The GRA Trip shall be checked by monitoring a discrete output signal from the DIO module. Contact of discrete output interface opens if the GRA Trip signal is generated.

(2-2) Amplitude-Based Maximum Trip (ABA Trip)

The OPRM unit generates the ABA Trip signal when the relative signal amplitude of Normalized Oscillation Signal exceeds specified values. The ABA Trip shall be checked by monitoring a discrete output signal from the DIO module. Contact of discrete output interface opens if the ABA Trip signal is generated.

(2-3) Period-Based Trip (PBDA Trip)

The OPRM unit generates the PBDA Trip signal when the number of successive oscillation cycles within that frequency range and the oscillation amplitude of Normalized Oscillation Signal exceed specified values. The PBDA Trip shall be checked by a monitoring discrete output signal from the DIO module. Contact of discrete output interface opens if the PBDA Trip signal is generated.

(2-4) OPRM Inoperative

The OPRM unit generates the OPRM Inoperative signal when the instrument anomalies or error on the processes, or loss of all the power supplies occur, as described in "(6) Failure Detection and Diagnostic functions", which may cause significant negative impact on signal processing or trip determination. The OPRM Inoperative signal shall be checked by monitoring discrete output signals from the DIO module. Contact of discrete output interface opens if the OPRM Inoperative signal is generated.

(2-5) OPRM Trip

The OPRM unit generates the OPRM Trip signal if any of the following conditions is satisfied:

(a) The ABA Trip is detected in any of 44 OPRM Cells.
(b) The GRA Trip is detected in any of 44 OPRM Cells.
(c) The PBDA Trip is detected in any of 44 OPRM Cells.

The OPRM Trip signal shall be checked by monitoring discrete output signals from the DIO module. Contact of discrete output interface opens if the OPRM Trip signal is generated.

(3) Provide data signals, bypass state, trip state, annunciator, and operation state.

The OPRM unit provides one-way optical transmission output signal as safety-related signal to the Engineered safety features Logic and Control System (ELCS) - Flat Display (FD) from one TRN module (hereinafter

referred to as "ELCS/[ ]a,c data"). While, the OPRM unit also provides one-way optical transmission output signals as non-safety-related signals to Transient Data Recorder (TDR) and Sequence of Event (SOE) from the other TRN module (hereinafter referred to as "PC data").

Normally, the "ELCS/[ ]a,c data" as safety-related signal is only evaluated and the "PC data" is not evaluated. However, the "PC data" is generated based on the same information and equivalent processes as the "ELCS/[ ]a,c data" in the DAT/ST module, although the "PC data" is not safety-related signal. The "PC data" also contains more information for demonstrating the soundness of the OPRM units in addition to "ELCS/[ ]a,c data." Therefore, "PC data" should be monitored and recorded for failure analysis in case of failure under the environmental stress.

(4) Receive the bypass signal
The OPRM unit receives the APRM Bypass signal as discrete input signal at the DIO module from the Large Display Panel (LDP). According to Section 5.2.2.4.2.2 of the EDS, the OPRM Trip and OPRM Inoperative are bypassed by the APRM Bypass Signal in the Relay Unit. In the OPRM unit, only when the APRM Bypass turns to disable from enable, the function of the OPRM unit is initialized. The APRM Bypass signal shall be checked by monitoring discrete input signals from the aux-relay plate to guarantee the soundness of the APRM Bypass signal. When APRM Bypass signal is provided to the OPRM unit, input voltage of the discrete input is 24VDC. Otherwise input voltage of the discrete input is 0VDC.

(5) Generate the OPRM Automatic Bypass signal
The OPRM Automatic Bypass signal is not classified as a safety-related function as described in Section 4.1.1.3 of the EDS. According to Section 5.2.2.3.7 of the EDS, however, the OPRM trip functions are automatically bypassed if the APRM reading or the same channel is 30% below the rated power or the core follow reading is 60% above the rated flow. Because the function of the OPRM trip is bypassed automatically under the condition stated above, the OPRM Automatic Bypass signal is regarded as a safety-related function in the EQ test.

The OPRM Automatic Bypass signal shall be checked by a monitoring discrete output signal from the DIO module.

(6) Failure Detection and Diagnostic functions
The OPRM has the following function of failure detection and diagnostic functions:

(a) [ ]a,c
(b)
(c)
(d)
(e)
(f)
(g) Number of Active OPRM Cell is lower than the setpoint
(h) Any one of the modules is disconnected
(i) [ ]a,c
(j) APRM Inoperative occurs (APRM Inoperative flag is included in APRM Unit Data 1 and 2)

In the EQ testing, the functions (a), (b), (e), (h) and (i) of the OPRM Inoperative cannot be simulated unless the OPRM unit is decomposed. Since those functions are designed to be "fail-safe", it is ensured that the OPRM Inoperative signal is generated whenever there is an error in any of those functions. Even if the OPRM Inoperative signal cannot be generated by spurious FPGA behavior, the error is also to be detected from abnormal optical transmission output data. Therefore, as long as the OPRM Inoperative signal and optical transmission output data are constantly monitored, the soundness of the OPRM unit is ensured without simulating the functions (a), (b), (e), (h) and (i).

The functional specifications of the OPRM unit are detailed in Section 5.1 of the EDS (Reference (12)).

7. Qualification Test Program

This section describes the Equipment Qualification test program based on IEEE Std 323 (Reference (6)), IEEE Std. 344 (Reference (7)), and EPRI TR-107330 (Reference).

7.1 Performance Proof Test Program

The performance proof test is performed prior to the qualification testing to provide a baseline of the qualification testing. The performance proof test is also performed upon completion of the shipment and the qualification testing to demonstrate the soundness of the safety-related functions.

7.1.1 Set-up & Check-out Test

(1) Visual Inspection

To verify damage and deterioration of the test specimens, visual inspection shall be performed before/during (as appropriate) /after the test.

(2) Mounting

The test specimens shall be mounted to the test specimen rack so that the test specimens coincide with the axis of actual installation. The test specimens shall be mounted in a manner and a position that simulates its expected installation. The test system grounding and power line filter shall be identical to the actual installation. Material incompatibilities at interfaces shall be considered and evaluated.

(3) Connections

All the wiring connections between pins shall be checked point by point in accordance with the ECWD (Reference (13)). All the errors or omissions shall be corrected before performing further testing. Incorrect wirings shall be completely removed from the test system. Once the wiring connections check is complete, the check needs not to be repeated in proceeding to further testing. It shall be checked and ensured, however, that the power supply lines do not cause short circuit and cables connection is appropriate.

(4) Typical Simulated Input Signal Confirmation

It shall be confirmed that proper connection and operation of the entire test system have been established including monitoring instruments, power supplies, signal simulators, and communication links.

7.1.2 Operability Test

The operability test shall be planned to confirm satisfactory operation of the OPRM unit in the EQ testing. The operability test shall include the following test items:

(1) Accuracy

Accuracy of safety-related functions is not required as described in Section 5.1.5.3 of the EDS (Reference (12)).

(2) Response time

The response time of safety-related functions is not required, as described in Section 5.1.4 of the EDS.

(3) Discrete input operability

The discrete inputs shall be tested for their ability to detect changes of safety-related functions defined in Section 6 (4). These tests shall be performed on at least one channel of each type of discrete inputs.

(4) Discrete output operability

The discrete outputs for safety-related functions defined in Section 6 (2) shall be tested for their ability. The test shall be performed on at least one channel of each type of discrete outputs in the qualification envelope.

(5) Communication operability

The optical transmission output signals against the optical transmission input signals for safety-related functions defined in Section 6 (3) shall be tested for their ability. The test shall be performed on at least one channel of each type of optical transmission outputs in the qualification envelope.

(6) Failure Detection and Self-Diagnosis

The functions to detect and diagnose failures shall be checked by the OPRM Inoperative signal and optical transmission input signals described in Section 6 (6).

(7) Loss of Power Test

The AC power shall be shut off for at least 30 seconds and reapplied.

(8) Power Interruption Test

The AC power source shall be interrupted for 40 ms.

(9) Power Quality Tolerance Test

The power quality tolerance test shall be performed to check the soundness of the function in the input voltage range described in Section 5.5.8 of the EDS.

7.1.3 Prudency Test

The prudency test shall include the following items:

(1) Burst of Events Test

This test consists of simultaneous actions as follows:

- Toggling all the discrete input signals
- Toggling all the input signal which change the operational mode of the OPRM unit

(2) Failure of Optical Transmission Signal Test

This test consists of simultaneous actions as follows:

- Failure of all the fiber-optic cables for LPRM signals shall be simulated.
- Failure of one side of the redundant APRM signal shall be simulated.
- Parity error in the optical transmission input signals shall be simulated.

(3) Fault Simulation Test

Failure shall be simulated by power loss on one side of the redundant LVPS module.

7.2 Equipment Qualification Test Program

7.2.1 Test Items

The EQ test is conducted to demonstrate compliance with IEEE Std. 323-2003 (Reference (6)), and to demonstrate the suitability of equipment when they are subjected to the stress conditions. The EQ test shall simulate the service conditions with margins, and shall take into account the normal/abnormal plant operations. Test items selected for this equipment qualification test are identified in Table 7-1 as compared to the requirements of Section 6.3.1 of EPRI TR-107330 (Reference (11)) and IEEE Std. 323-2003. The basis of selection is described in the following section.

Table 7-1 Test Items

Test Item	Mild Environment		
	EPRI TR-107330 Rev.1	IEEE Std 323 2003	OPRM Qualification Project
Environmental Qualification			
Thermal aging		X	
Radiation aging	X	X	
Wear Aging			X
Nonseismic Vibration Aging		X	
Temperature & Humidity test	X	X	X
Dynamic Qualification (Seismic Test)	X	X	X

X: Applicable

7.2.2 Environmental Qualification

7.2.2.1 Environmental Conditions

Summary of environmental conditions are shown in Table 7-2 which is a copy of Table 5-22 of the EDS (Reference (12)).

Table 7-2 Normal and Abnormal Environmental Conditions

	Normal Environmental Conditions	Abnormal Environmental Conditions
Temperature Range	Min 16°C(60°F), Max 40°C(104°F)	Min 4°C(40°F), Max 50°C(120°F)
Humidity Range	Min 40%, Max 95%*	Min 10%, Max 95%*
Radiation Exposure	10^3RADS	10^3RADS

*: non condensing

7.2.2.2 Aging

"C. REGULATORY POSITION (1)" of RG 1.209 (Reference (3)) states that:

- Selective use of the service conditions mentioned in Section 6.1.5.1 of IEEE Std. 323-2003 should be based on the actual environmental conditions.
- The NRC does not consider that the age conditioning described in Section 6.2.1.2 of IEEE Std. 323-2003 is

applicable because of the absence of significant aging mechanisms on microprocessor-based modules.

The OPRM unit with PFCs is located in a mild environment in the MCR. Test items listed in Table 7-1 are selected appropriately based on the above aging condition as described in the following sections.

7.2.2.2.1 Thermal Aging

The OPRM unit is located in a mild environment of the MCR where the temperature and humidity is controlled. There are no parts which have significant effect on safety-related functions in the OPRM unit due to temperature and relative humidity in the OPRM unit. The operator is able to find the signs of degradation of parts which occurred under the unexpected conditions, since the condition of the OPRM unit is always monitored even if there is degradation unexpected on the parts used in the OPRM unit. While, the soundness of the safety-related functions in the OPRM unit under abnormal conditions will be demonstrated in the temperature and humidity test in accordance with the EPRI TR-107330 (Reference (11)). Therefore, the thermal aging test is not required.

7.2.2.2.2 Radiation Aging

The OPRM unit is designed to operate in the specification for radiation exposure of up to 10^3 rads, as shown in Table 7-2.

According to Paragraph 6 of "B. DISCUSSION" of RG 1.209 (Reference (3)) states:

> Ionizing dose radiation hardness levels for MOS IC families range from about 10 gray (Gy) or 1 kilorad (krad) for commercial off-the-shelf (COTS) circuits to about 10^5 Gy (10^4 krad) for radiation-hardened circuits.

According to Section 3.2 "Radiation Protection" of the Tier 1 of the ABWR DCD (Reference (10)), the MCR of Control Building is classified into the Zone A where the maximum expected radiation dose rate does not exceed the 6 x 10^{-6} Sv/h. Furthermore, design dose rate in the MCR under the accident condition does not exceed 150 x 10^{-6} Sv/h (averaged over 30 days). The expected total integrated dose (TID) during the design life is less than 1 Sv. Where the radiation weighting factor is set to 1, the TID becomes 1 Gy. Therefore, the maximum expected ionizing dose radiation levels of the OPRM unit is a sufficiently low compared with ionizing dose radiation hardness levels for MOS IC families as described in RG 1.209. In addition, the TID of MCR in the typical ABWR plant designed by Toshiba is also 1.3 Gy or less during the design life, 15 years. Therefore, since the OPRM unit has no significant effect on safety-related functions in the OPRM unit due to radiation, the radiation aging test is not required.

7.2.2.2.3 Wear Aging

The wear aging test shall be required to simulate the expected mechanical and electrical wear of the test specimens. As a result of the design, since attachment of connectors and switching of a key-switch may cause wear degradation, the wear aging testing for them shall be performed. The wear aging test also is performed prior to the temperature and humidity test, in order to apply severe condition such as interface oxidation due to wear aging. The wear aging test for any screw used in the test specimen is not required since it is managed with a controlled torque.

7.2.2.2.4 Nonseismic Vibration Aging

Nonseismic vibration aging is not required, since the OPRM unit located in the MCR is not subjected to any nonseismic vibration loads, such as a safety relief valve, under the normal and abnormal conditions.

7.2.2.3 Temperature & Humidity Test

The temperature and humidity test shall be required to demonstrate the soundness of the safety-related functions for the test specimens under the normal and abnormal conditions, as shown in Table 7-2. During the temperature and humidity test, the power quality tolerance test shall be performed in the input voltage range and frequency range given in Section 5.5.8 of the EDS (Reference (12)).

7.2.3 Dynamic Qualification (Seismic Test)

The OPRM is considered as a safety system with Category 1 Seismic classification. The test specimen shall meet this performance requirement for the seismic loading shown in Figure 5-8 of the EDS (Reference (12))*. All seismic testing shall conform to IEEE Std. 344-1987 (Reference (7)). The seismic test shall be performed in the following order:

(1) Pre-test Resonance Search
(2) Five triaxial OBE
(3) One triaxial SSE
(4) A complete operability test
* The damping value of 5% is per section 7.6.1.3 of IEEE Std. 344-1987.

7.2.3.1 Resonance Search

The test specimens shall be subjected to a resonant frequency search to determine its dynamic characteristics which establish the equipment rigidity toward the applicable dynamic loads. The resonance frequency search test shall be performed in the form of low-level continuous sinusoidal sweep. The resonance frequency search test is performed with the acceleration level of 0.2 g, which is intended to excite all modes between 1 Hz to 100 Hz at the sweep rate of 1 octave per minute or less.

7.2.3.2 Random Multifrequency Test

The test specimen shall be subjected to 30-second duration triaxial multifrequency random motion, which shall be amplitude-controlled in one-sixth octave bandwidths spaced one-sixth octave apart over the frequency range of 1 to 100Hz.

7.2.3.3 Dynamic Analysis Requirement

In addition to reporting the Test Response Spectrum (TRS) from the control and response accelerometers at the 5% damping, the spectrum shall be reported for 0.5, 1, 2, and 3% damping.

8. General Acceptance Criteria

In this Section, general acceptance criteria are described. Detail acceptance criteria in each test are specified in the APPENDIX 1 to 4.

8.1 General Acceptance Criteria

The followings indicate the general acceptance criteria.

(1) The test specimens shall maintain their structural integrity not to adversely affect safety-related functions during and after the qualification testing.

(2) Performance of safety-related functions shall be achieved in accordance with Section 8.2.

(3) There shall be no loss of output signal for safety-related functions (for example, open or short circuit).

(4) There shall be no spurious or unwanted output for safety-related functions (for example, relay contact bounce exceeding the specified limits).

(5) There shall be no loss of required performance characteristics for safety-related functions (for example, inability to change state).

8.2 Performance Acceptance Criteria for Safety-related Functions

The followings indicate the performance acceptance criteria for the test specimens.

(a) Accuracy. Accuracy of the input/output signals is not required, as described in Section 5.1.5.3 of the EDS.

(b) Response Time. Response time of the trip signal is not required, as described in Section 5.1.4 of the EDS.

(c) Discrete Input Operability. The filtering and trip functions of the OPRM unit shall be initialized in accordance with the initialization requirements given in Section 5.2.1 of the OPRM Unit Detailed Design Specification (OPRM Unit DDS) (Reference (14)), when the APRM Bypass turns to disable from enable.

(d) Discrete Output Operability. All the trip signals described in Section 6 (2) shall be changed according to the trip generation within the requirements given in Section 5.2.2.3.5 of the EDS.

(e) Communication Operability. The optical transmission output data described in Section 6 (3) shall be transmitted as expected against the optical transmission input signals.

(f) Failure Detection and Self-Diagnosis. The OPRM Inoperative signal shall be generated at the conditions described in Section 6 (6).

(g) Loss of Power Test. When the OPRM unit is powered off, all the trip signals described in Section 6 (2) shall be generated as fail-safe. After the OPRM unit is powered on, normal operation shall be resumed. The normal operation shall be determined in the Setup & Check-out Test Specification based on the design information of the EDS and the OPRM Unit DDS.

(h) Power Interruption Test. If the AC power source is interrupted, all the trip signals described in Section 6 (2) shall be unaffected to the interruption.

9. Test Plan

9.1 Test Policy

This section describes test policy to perform the EQ test.

9.1.1 Control Requirements under Normal Operating Conditions

The test specimens shall be maintained at the following temperature, humidity and pressure, when there is no special requirement.

- Temperature : 77 +/- 18 F (25 +/- 10 C)
- Relative Humidity : 90% Max. (Expected value: 70%), non-condensing
- Pressure : Atmospheric pressure

9.1.2 Margin

Each test parameter shall be applied with margins given in Table 9-1, based on Section 6.3.1.6 of IEEE Std. 323-2003 (Reference (6)). Measured test parameters shall envelope test requirements with margins. Margins could be positive or negative depending on the critical points that the test requires.

Table 9-1 Margin

Parameter	Test Margin	Comments
Peak Temperature	+ 8 C	
Relative humidity	None	
Pressure	None	Nominally atmospheric.
Equipment operating time	+10% of the period of time	+10% of the period of time the equipment is required to operate following the start of the design basis event
Voltage & Frequency	Voltage: +/-10% Frequency: +/-5%	Not to exceed equipment design limits.
Dynamic/Vibration	+10%	+10% added to the acceleration requirements at the mounting point of the equipment

9.1.3 Soundness of the OPRM function

The OPRM unit generates trip signals with the following steps (See also Figure 9-1, which a copy of the figure 5-1 of the OPRM Unit DDS (Reference (14))). (1) After one of the RCV module in the OPRM unit receives the optical transmission signals including the LPRM levels from each LPRM unit, the RCV module converts the received optical signals to digital data, and provides the digital data to the CELL module. (2) The CELL module selects three or four LPRM levels corresponding to each Cell from the received digital signals, and (3) performs sequential calculation to obtain a Normalized Oscillation Signal for Cell 1 thorough 44 respectively. (4) The obtained Normalized Oscillation Signal is provided to the AGRD module and the PBD module via the same serial bus. (5) In each module, a trip signal is sequentially generated from the Normalized Oscillation Signal for each Cell.

Since a trip signal generated in each Cell is sequentially processed through the same route with the same algorithm as stated above, a trip signal in an arbitrary Cell for one of the trips described in section 6 (2) is monitored under the environmental stress as a minimum. Trip signals as discrete output and communication as optical transmission data are monitored during the testing. Trip signal operability in a target Cell and the soundness of communication shall be checked during the test, and the details of all signals including data of the untargeted Cells shall be analyzed in

consideration of all time-dependent environmental parameters after the test.

While, since the failure mode of the OPRM unit under the environmental stress is irreversible, performance degradation of the OPRM unit is evaluated in the performance proof test after exposing environmental stress. In the performance proof test, all kinds of trip operability in all Cells should be checked and be analyzed.

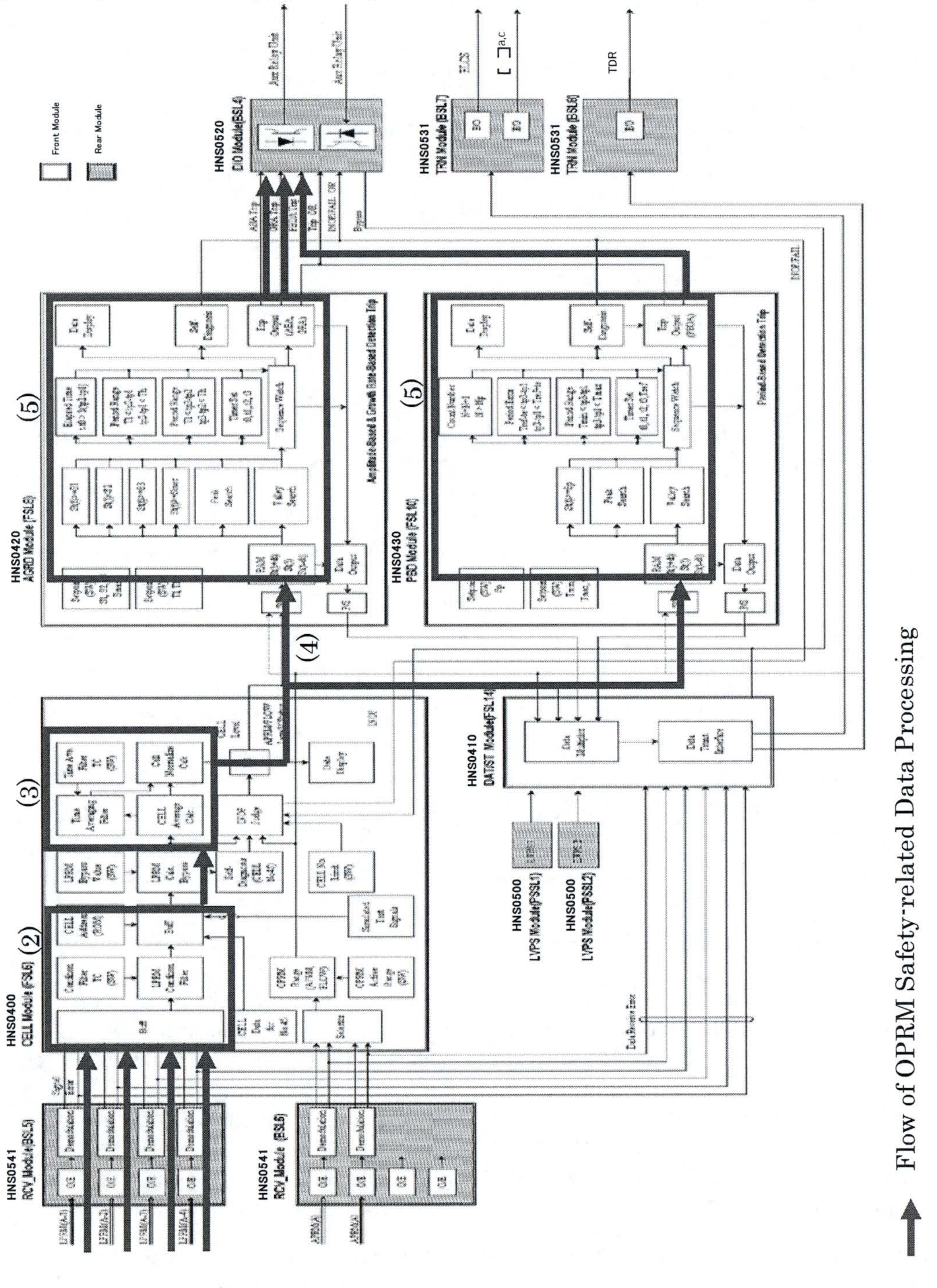


Figure 9-1 OPRM Unit Block Diagram

9.1.4 Test Pattern

This section is described about the test pattern which is set to the OPRM unit in order to demonstrate the soundness of the test specimen under the environmental stress.

9.1.4.1 Input Prerequisite

As described in Section 5.2.2.3.3 of the EDS (Reference (12)), the OPRM unit calculates the Normalized Oscillation Signal at the following steps.

First, each LPRM level that makes up a Cell is passed through a second order Butterworth lowpass filter to remove high frequency noise. The resulting signal is shifted in phase relative to the original signal, and is called Filtered Flux. Second, an Averaged Filter Flux for each Cell is calculated by averaging three or four Filtered Fluxes. Third, each Averaged Filter Flux is passed through a second order Butterworth lowpass filter to normalize each Cell. The resulting signal is also shifted in phase relative to the Averaged Filter Flux, and called the Time Averaged Flux. The Normalized Oscillation Signal is generated by dividing the Averaged Filter Flux by the Time Averaged Filter Flux. By taking these steps, the OPRM unit generates trip signals using the Normalized Oscillation Signal.

Thus, the LPRM level is determined by simulating the Normalized Oscillation Signal that leads to generation of trip signals. Since the second order Butterworth lowpass filter in the OPRM unit has applied the analog prototyping method, the validity of the filter design is to be demonstrated by comparing the actual Normalized Oscillation Signal generated by the OPRM unit with the simulated Normalized Oscillation Signal obtained by the theoretical formula.

An OPRM unit per division monitors the oscillation states of 44 Cells shared with 52 LPRM levels in the reactor core, and generates the ABA trip, GRA trip, and PBDA trip, as described in Section 6 (2-1) through (2-3). Each of those trip signals is generated by combination of one or more trip conditions satisfied in those 44 Cells. Therefore, the LPRM levels is to be provided to the OPRM unit so as to establish the condition that each trip signal is generated only in a target Cell. To validate the internal calculation process under the environmental stress, LPRM levels as additional inputs are to be provided to the OPRM unit so as to establish the condition that the PBDA trip overlapped with noise (10 Hz or more) is generated only in a target Cell. As a result, those LPRM levels are filtered to generate a PBDA trip at the same timing with the original PBDA trip, which is not overlapped with the noise.

9.1.4.2 Input Condition

A LPRM level will be set by the following equation.

[a,c]

If all the LPRM levels in a Cell synchronize, the Normalized Oscillation Signal (St) simulated by the

theoretical formula may be simplified with a filtered single LPRM level except noise as follows.

Normalized Oscillation Signal (St):

$$St = \left[\qquad \right]^{a,c}$$

[ ]a,c

The Normalized Oscillation Signals filtered simulated by the theoretical formula are shown in Figure 9-2, and the information of target Cells is shown in Figure 9-3.

Cell 9: PBDA Trip
LPRM levels 5, 16, 28, and 41 will be provided so as to establish the condition that the PBDA trip is generated only in Cell 9.

Cell 12: GRA Trip
LPRM levels 4, 17, 31, and 42 will be provided so as to establish the condition that the GRA trip is generated only in Cell 12.

Cell 30: ABA Trip
LPRM levels 8, 21, 36, and 49 will be provided so as to establish the condition that the ABA trip is generated only in Cell 30.

Cell 33: PBDA Trip
LPRM levels 9, 11, 48, and 50 will be provided so as to establish the condition that the PBDA trip overlapped with noise is generated only in Cell 33.

To demonstrate the soundness of the OPRM TRIP signal which is generated by a combination of the PBDA, ABA, GRA trip signals with "OR" logic, the four above-mentioned test patterns are configured for trip generation at each different point of time.

The LPRM levels not involved in the test patterns above will be provided as a constant signal, 50% power. Since those LPRM levels which make up Cell 7, 14, 21, 28, 41, 42, 43, and 44 do not oscillate, the Normalized Oscillation Signal of those Cells always become "1".

The APRM Level is provided with 50% power and the Core Flow Level is provided with 25% speed so that OPRM Automatic Bypass does not operate.

The cycle of the test pattern is recommended to be less than 30 seconds as per the requirement of seismic test

duration, since excessive excitation causes cumulative fatigue damage that may lead to unexpected failures.

The OPRM Inoperative signal is a failure signal as described in Section 6 (2-4). Since a failure due to the environmental stress is irreversible, the OPRM Inoperative signal is monitored during the testing and its operability is demonstrated in the operability test after exposure to environmental stress.

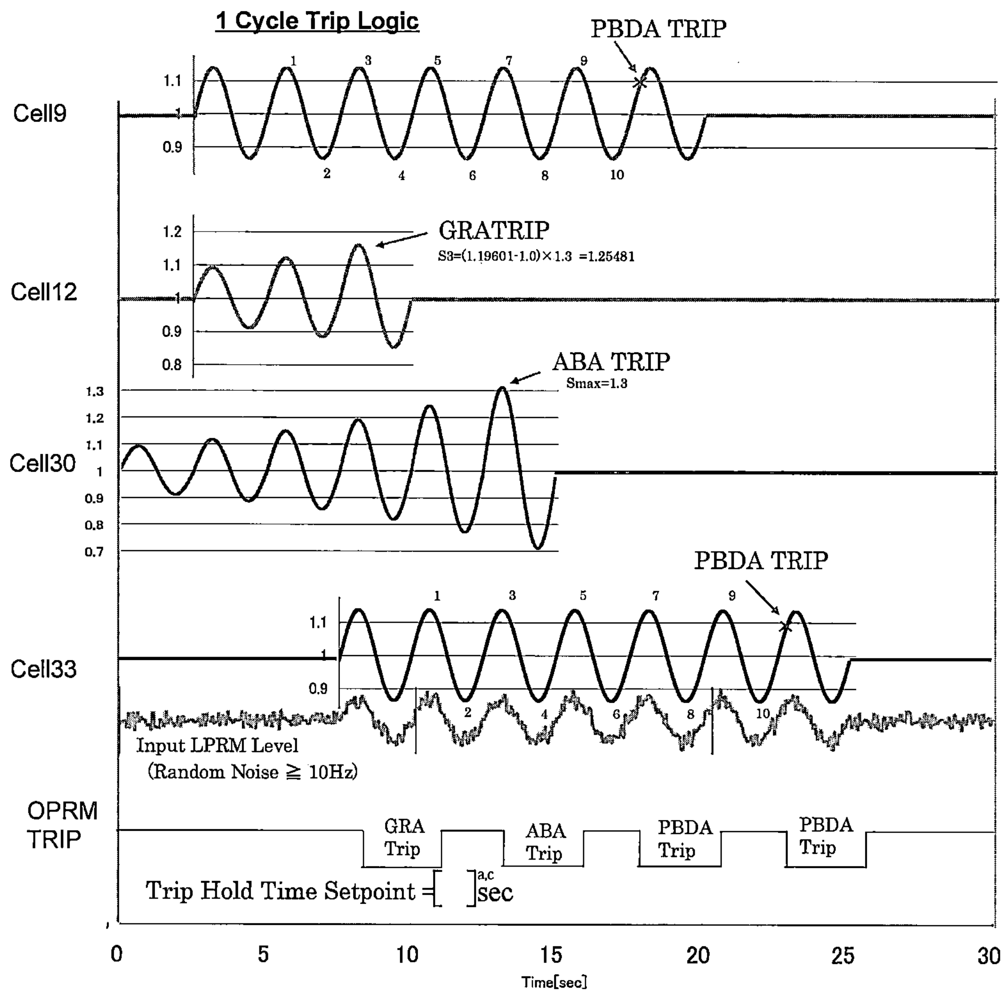


Figure 9-2 Test Pattern

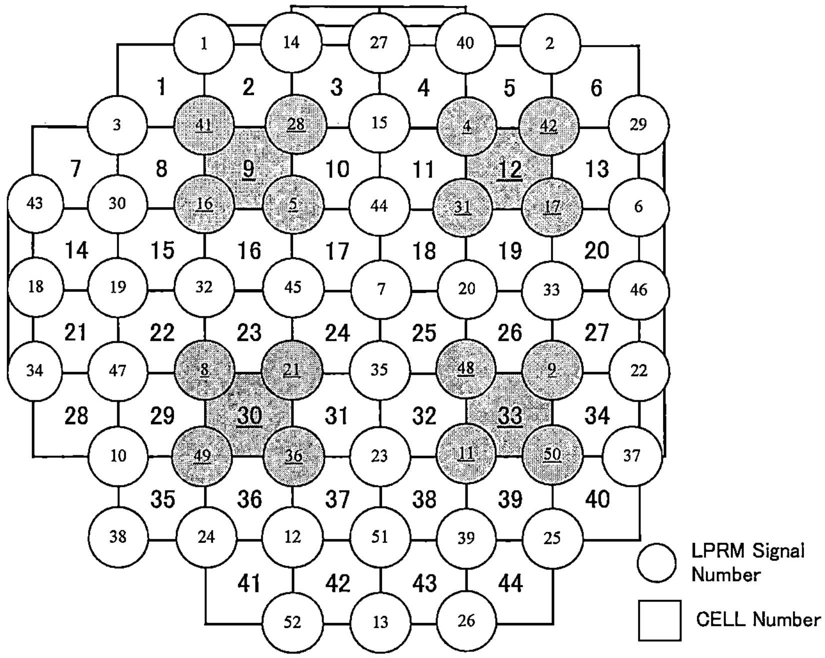


Figure 9-3 Allocation of Input LPRM signal and Cell Number

9.1.4.3 Acceptance Criteria of Test Pattern

After the test pattern shown in Figure 9-2 is input in 30-second cycles, the following four durations starting at the time of each trip occurrence are checked with discrete outputs and optical transmission output data, as shown in Figure 9-4.

1. T_{ga}: Time duration from the time when the GRA trip occurs to the time when the ABA trip occurs.
2. T_{ap}: Time duration from the time when the ABA trip occurs to the time when the first PBDA trip occurs.
3. T_{PP}: Time duration from the time when the first PBDA trip occurs to the time when the second PBDA trip occurs.
4. T_{cyc}: Time duration from the time when the GRA trip occurs at the first cycle to the time when the GRA trip occurs at the second cycle.

Since digital processing is implemented throughout the test system including the OPRM unit, test results independent of environmental conditions are to be obtained. Thus the trip output in interval to the test pattern input in a constant cycle in the optical transmission output data has an interval accuracy within [ ]a,c msec. Since the DIO signals in this test system are monitored via relays which are same as actual products, the interval accuracy is within [ ]a,c ms in consideration of delay of the relay contact's operation. A trip occurrence point different from the right occurrence point and/or a calculated Normalized Oscillation Signal inconsistent with expected values due to malfunction of the OPRM unit will cause unsatisfaction of this operation accuracy. For the random multifrequency test in the seismic test, a cycle in the test pattern shall be evaluated during a 30-second duration before, during, and after the vibration respectively. When the test patterns for the temperature and humidity test are checked, data of at least [ ]a,c cycles in a [ ]a,c-minute duration once every [ ]a,c-hour shall be evaluated. When the test pattern for the setup & checkout test is checked, data of at least [ ]a,c cycles in a [ ]a,c-minute duration shall be evaluated.

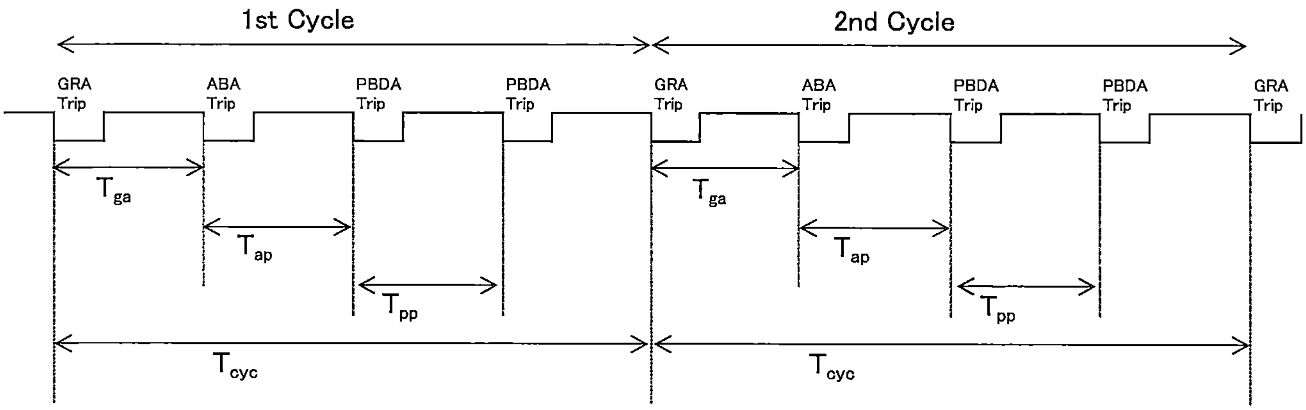


Figure 9-4 Trip Interval Time in Test Pattern

9.1.5 Operability Test Policy

The first performance proof test is the baseline test for the EQ test, as "Baseline functional test" described in the IEEE Std. 323-2003 (Reference (6)). The performance proof test is performed at the hold point of the EQ test. In the operability test, all the performances of safety-related functions are checked to satisfy the acceptance criteria described in Section 8, as described in Table 9-2.

Table 9-2 Operability Test Items

	Performance Acceptance Criteria		Safety-related Functions to be demonstrated										Signal to check
			6(1)	6(2-1)	6(2-2)	6(2-3)	6(2-4)	6(2-5)	6(3)	6(4)	6(5)	6(6)	
Contents (Section 7.1.2)	EQ Test Plan	EDS	Nomalization Oscillation Signal	GRA Trip	ABA Trip	PBDA Trip	OPRM Inoperative	OPRM Trip	Optical transmission signal	APRM Bypass (DI)	OPRM Automatic Bypass	Failure Detection &Diagnostic	
(1) Accuracy	8.2 A	5.1.5.3	Not Required										
(2) Response Time	8.2 B	5.1.4	Not Required										
(3) Discrete Input Operability	8.2 C	–	X	X	X	X	X	X	X	X	X		DO
(4) Discrete Output Operability	8.2 D	–	X	X	X	X	X	X	X		X		DO
(5) Communication Operability	8.2 E	5.1.6	X	X	X	X	X	X	X		X	X	OPT
(6) Failure Detection and Self-Diagnosis	8.2 F	5.1.8					X	X	X			X	DO
(7) Loss of Power Test	8.2 G	–	X	X	X	X	X	X	X			X	DO
(8) Power Interruption Test	8.2 H	5.5.8	X	X	X	X	X	X	X			X	DO
(9) Power Quality Tolerance Test	8.2 H	5.5.8											PFC Output

OPT: Optical Transmission Output, DO: Discrete Output

9.1.6 Wear Aging Test Policy

The wear aging for the OPRM unit is considered as follows:

(1) Connectors used for the OPRM unit shall be attached and detached to simulate the end of life of connectors due to wear aging. The number of times the connectors are attached and detached till turnover is estimated to be [ ]a,c. Upon periodic surveillance, it is estimated to be [ ]a,c times; the number of times is to be [ ]a,c (=[ ]a,c x [ ]a,c) in total at the end of their design life ([ ]a,c years). Thus the number of overall testing is to be [ ]a,c times in

consideration of 10% margin.

(2) A key switch for switching modes on the front surface of the OPRM unit shall be turned and backed to simulate the end of life of connectors due to wear aging. The number of times the key switch is turned and backed till turnover is estimated to be [ ][a,c] times. Upon periodic surveillance, it is estimated to be 30 times; the number of times is to be [ ][a,c] (=[ ][a,c]) in total at the end of their design life [ ][a,c] years). Thus the number of overall testing is to be [ ][a,c] times in consideration of 10% margin.

9.1.7 Temperature and Humidity Test Policy

The OPRM unit is designed to operate in the temperature range of 4 to 50 degrees C with up to 95% relative humidity shown in Section Table 7-2, which a copy of Table 5-22 of the EDS.

To provide the margin shown in Table 9-1, the temperature and a humidity test is performed in the two cycles with 60 degrees C as shown in Figure 9-5. In this test, as shown in Figure 9-5, the operability test except the test item listed in Section 7.1.2 (6) is performed at the end of high/low temperature, the prudency test except Section Prudency Test (3) is performed at the end of high temperature, and the power quality tolerance test is performed at the end of high temperature. The measurement values of temperature and relative humidity enveloping this profile are acceptable. The input voltage and frequency are varied in accordance with the requirements in Section 4 of IEEE Standard 603-1991(Reference (9)), including margin shown in Table 9-1. The test specimens shall be provided with the typical test pattern described in Section 9.1.4 and monitored continuously during the temperature and humidity test. The monitoring points include all safety-related functions described in Section 6.

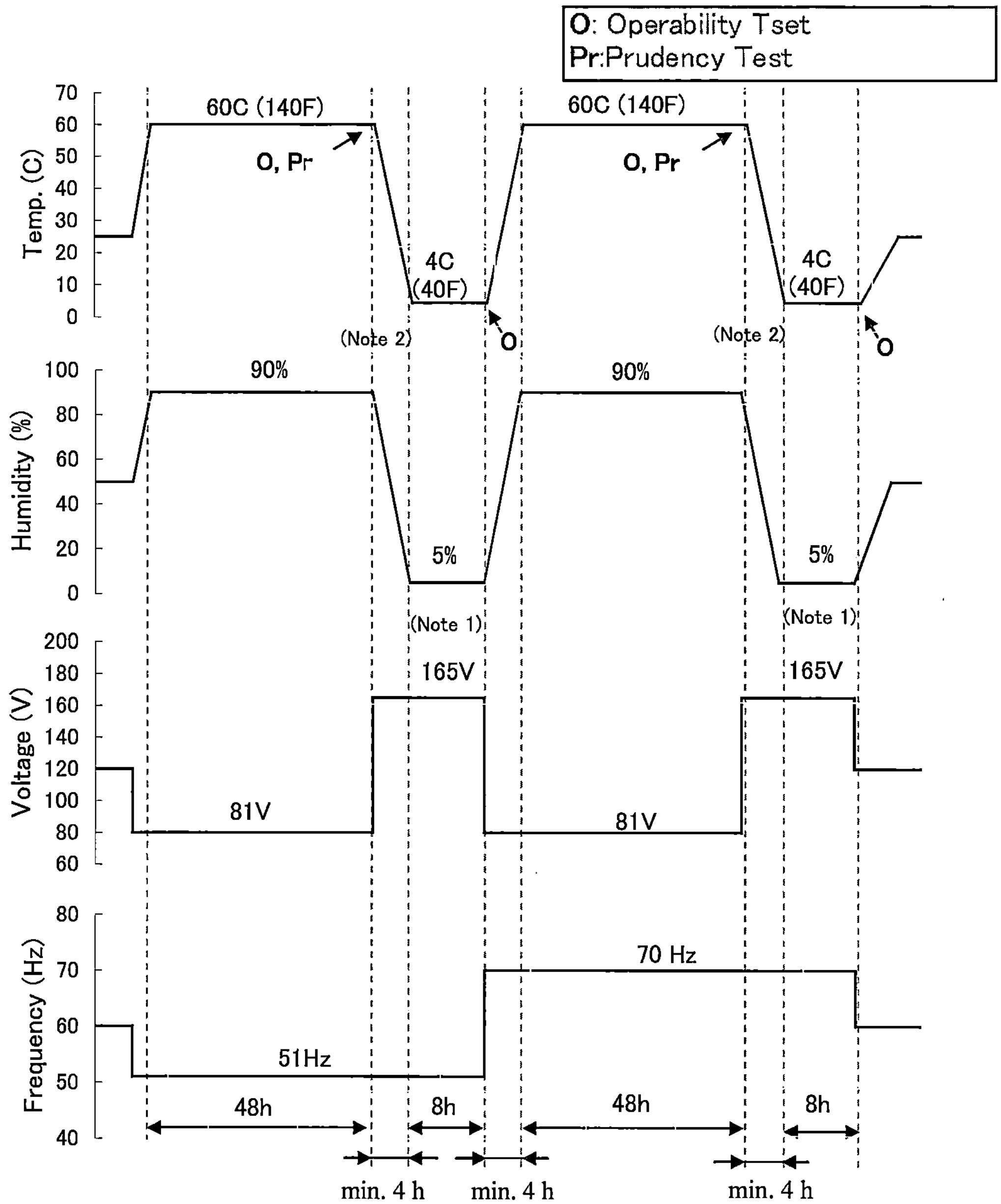


Figure 9-5 Temperature and Humidity Test Profile

Note 1:
For the low temperature exposure test, if the specified low relative humidity cannot be achieved for the specified temperature, the following steps shall be taken:

- First, run the test for the specified time at the low temperature and at the lowest relative humidity that can be achieved at the specified temperature (including initial ramp down over 4 hours, followed by a hold period of at least 8 hours);
- Second, run the test at the lowest temperature that the low specified relative humidity can be achieved (the hold period is at least 8 hours).

Note 2:
For this transition, first reduce the relative humidity, and then reduce the temperature. This is required to maintain a non-condensing atmosphere.

9.1.8 Seismic Test Policy

The seismic test will be performed in the following order accordingly.

(1) Resonance search

(2) Five triaxial operating basis earthquakes (OBEs) for aging

(3) One triaxial safe shutdown earthquake (SSE) following the OBEs

(4) Post-test visual inspection

Test Required Response Spectra (TRRS) at 5% critical damping is shown in Figure 9-6. Ten-present margin was added to the Required Response Spectra (RRS), which is specified in Table 9-1, to obtain TRRS. An OBE shown in Figure 9-6 uses 70% of the SSE over the range of 1 to 100 Hz, NOT one half of the SSE amplitude over the frequency range of 1 to 33 Hz.

During the vibration, all the safety-related functions are checked by providing the typical test pattern described in Section 9.1.4. The operability test and prudency test are not performed during the seismic test. Because when the test specimen has damage, abnormalities of the test specimen will be found by monitoring the optical transmission output signal.

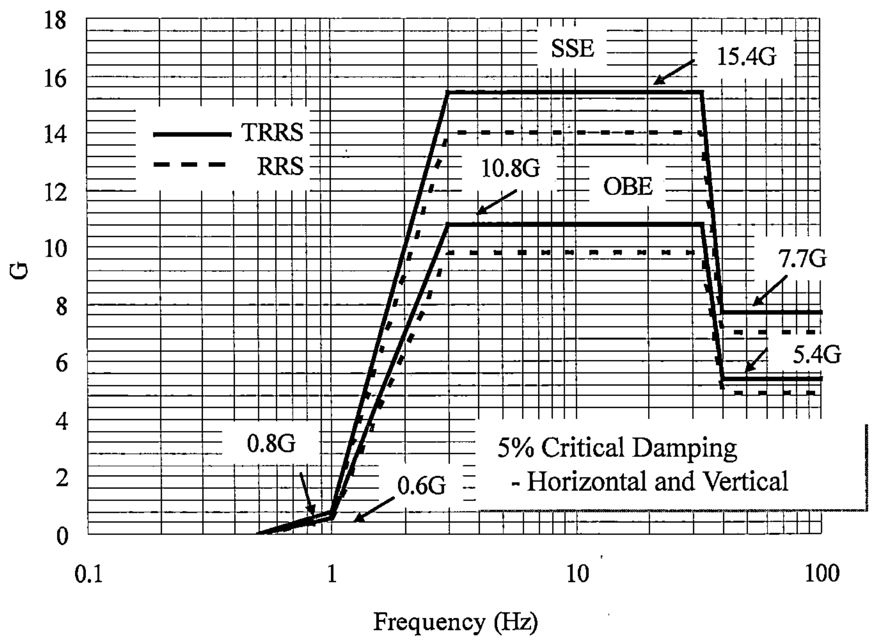


Figure 9-6 Test Required Response Spectra

9.2 Test Plans and Sequence

The EQ test for the OPRM unit is planned to be performed by Toshiba Fuchu Complex (Toshiba Fuchu) and [ ][a,c] The EQ test shall be performed in the sequence as shown in Table 9-3 and Figure 9-7. Each test plan is described in APPENDIX 1 to APPENDIX 4.

Table 9-3 Test Sequence for OPRM Instruments

Seq. No.	Test	Site	Test Plan	Comments
1	Performance Proof Test	[ ][a,c]	APPENDIX 1	This test is performed as baseline test in the pre-qualification test activity.
2	Wear Aging Test		APPENDIX 2	These tests are performed in the environmental qualification activity.
3	Operability Test		APPENDIX 1	
4	Temperature and Humidity Test		APPENDIX 3	
5	Performance Proof Test		APPENDIX 1	
6	Performance Proof Test		APPENDIX 1	This test is performed to check the soundness of the test specimen after the transportation.
7	Seismic Test		APPENDIX 4	This test is performed in the dynamic qualification activity.
8	Performance Proof Test		APPENDIX 1	This test is performed upon completion of the qualification test activity.

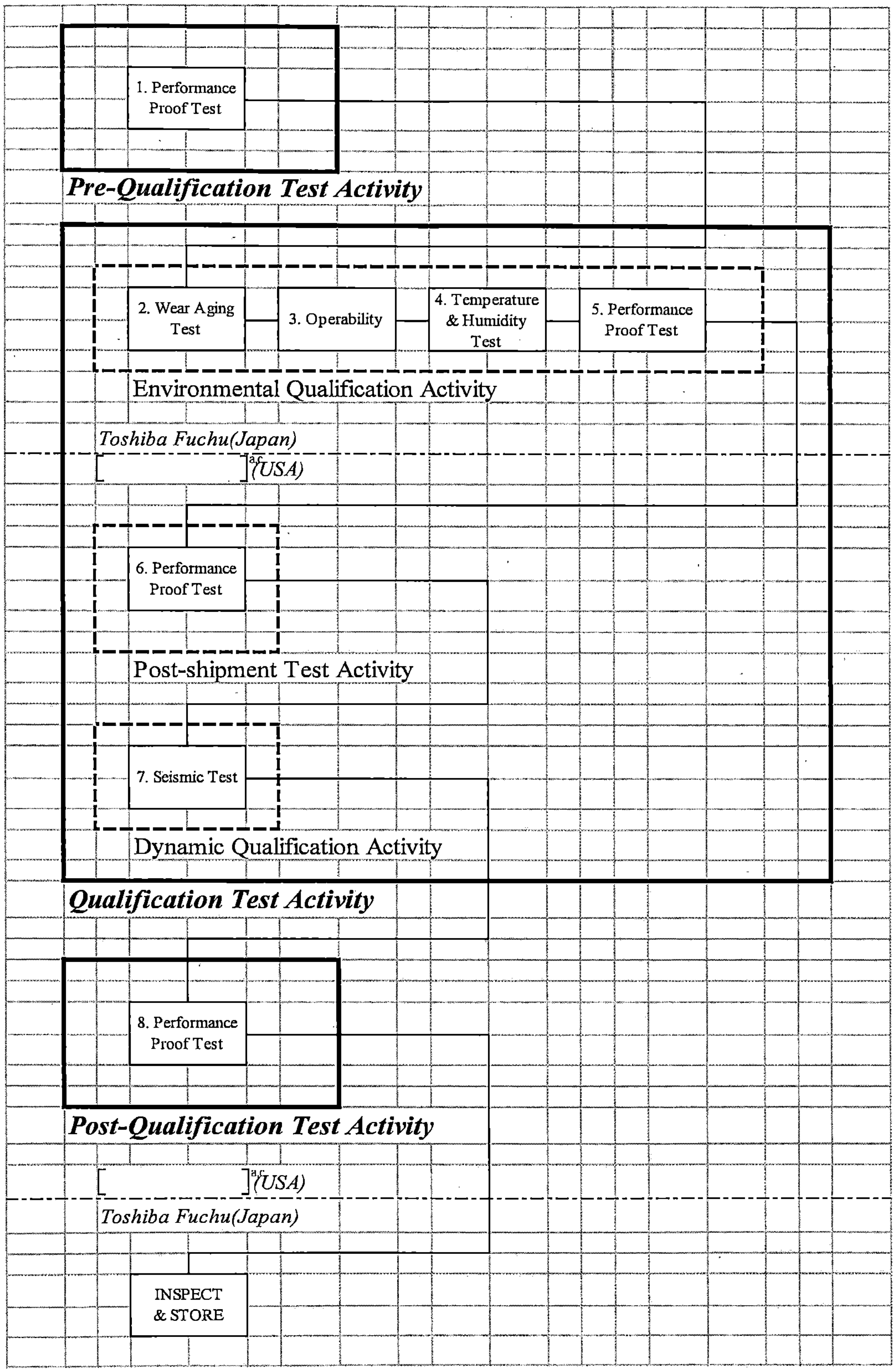


Figure 9-7 EQ Test Plan Flow Diagram

10. Test Program Implementation

10.1 Methodology

All the tests shall be performed in accordance with written test procedures and the test results shall be recorded. Qualification test processes should be clearly identified along with procedural steps in the test procedure. The procedural steps should identify the interface between Toshiba Test Personnel activities and the test vendor's tester activities. Test procedures and test records created by Toshiba will be prepared, reviewed and approved in accordance with the Test Control Procedure (NQ-3015 (Reference (23))). The test vendor shall prepare test procedures to specify their activities in providing qualification testing support including limitations of acceptability for the qualification parameters and any exceptions. Prior to performing any qualification efforts, the procedure shall be accepted by the Toshiba.

For certain tests, hold points may be required to evaluate the validity and acceptability of test results at intermediate points during the test. These hold points shall be required when it is necessary to suspend tests when unexpected conditions have occurred. Hold points shall be defined in applicable test procedures.

10.2 Test Quality Assurance

Qualification activities shall be performed under a quality assurance/quality control program consistent with 10CFR50, Appendix B (Reference (2)) and 10 CFR Part 21 (Reference (1)). Therefore, these tests are performed by Toshiba itself under the NICSD's quality assurance program in accordance with 10CFR50 Appendix B requirements. The test vendor shall perform qualification activities according to the requirements of the test vendor's 10 CFR 50 Appendix B quality assurance program.

Toshiba Test Personnel in regard of qualification test activities shall be qualified in accordance with NQ-3011 (Reference (22)). All related documents shall be controlled in accordance with Document Control Procedure (NQ-2024 (Reference (19))).

10.3 Responsibilities

The EQ engineers have the responsibility to implement qualification test programs. The EQ engineers are also responsible to identify all test equipment performance characteristics to be used in the test, including a block diagram of the instrumentation system, and the laboratory test procedure prior to commencing any testing.

The equipment design engineers are responsible to confirm the contents of the documents regarding the EQ test activity.

For qualification test activities in Toshiba Fuchu Complex, the NICS-QC is responsible for implementing the qualification test. For qualification test activities in the test vendor's facility, the responsibilities of NICS-QC and test vendor are described in the following subsections. Those responsibilities are mapped in Table 10-1.

Table 10-1 Responsibilities in the test vendor's facility

Section	Items		Responsibilities	
			NICS-QC	Test vendor
10.3.1.1	Preparation	Power source	-	responsible
10.3.1.2		Signal cables and equipment for data recording for the test specimens	responsible	-
10.3.1.3		Test facility and test instruments	-	responsible
10.3.2.1	Installation	Placement	-	responsible
10.3.2.2 (1)		Connection of the cables for qualification tests monitoring and data recording	-	responsible
10.3.2.2 (2)		Connection of the cables for the test specimens except for the connection to test vendors' test equipment.	responsible	-
10.3.3.1	Operation	The test system	responsible	-
10.3.3.2		Test facility	-	responsible
10.3.3.3		Test instrumentation for test facility	-	responsible
10.3.4.1	Monitoring /Recording	Atmospheric condition	-	responsible
10.3.4.2		Data recording of the test specimens	responsible	-
10.3.4.3		Test instrumentation for qualification test	-	responsible
10.3.5 (14.2, 14.3)	Documentation	Test procedure and test record	responsible	responsible

10.3.1 Preparation

10.3.1.1 Preparation of Power Source

Test vendors are responsible for preparation of power sources for all the tests. The variable voltage power supply used for all the tests is prepared by Toshiba. Requirements for the power sources used in the test activities are as follows:

(1) 120VAC/60Hz/20A for the test specimens and test equipment

(2) 100VAC/60Hz/30A via Isolation Transformer (for test support equipment).

(3) Alternative Power Supply which is AC-tunable (80 V to 165 V), frequency-tunable (50 Hz to 70 Hz), and capable of performing 40 ms interrupt test (for performance test) or the power source (170 V to 250V - Single Phase, 60Hz) for power supply unit.

10.3.1.2 Preparation of Signal Cables and Equipment for Data Recording for Test Specimens

Toshiba is responsible for preparation of signal cables and data recording equipment for the test specimens.

10.3.1.3 Preparation of Test Facility and Test Instrumentation

Test vendors are responsible for preparation of test facilities such as test chamber and test instrumentation including sensors for the qualification test. Test vendors shall provide information of the test facilities and test instrumentation such as sensors. Test vendors shall perform pretest calibration of the sensors and associated instrumentation and data acquisition system, if necessary.

10.3.2 Installation

10.3.2.1 Placement

Test vendors are responsible for transferring all the equipment to test laboratory and installing them in appropriate positions at each test. Placement requirements for each test are described in each test plan and procedure.

10.3.2.2 Connection

(1) Test vendors are responsible for connection of monitoring cables and data recording equipment, such as thermometers, hygrometers, and accelerometers for the qualification test.

(2) Toshiba is responsible for connection of the test specimens' cables except (1).

10.3.3 Operation

10.3.3.1 Operation of Test System

Toshiba is responsible for operation of the test system, such as parameter input changing or switch positioning.

10.3.3.2 Operation of Test Facility

Test vendors are responsible for operation of the test facility such as chamber and shake table controlling.

10.3.3.3 Operation of Test Instrumentation

Test vendors are responsible for operation of the test instrumentation such as sensors.

10.3.4 Monitoring and Recording

The test records obtained in the same test by Toshiba and its test vendor's tester shall be mutually available at both companies, and the document numbers can be mutually referred to in their records.

10.3.4.1 Monitoring under Atmospheric Condition

Test vendors are responsible for monitoring atmospheric conditions such as temperature or relative humidity, as described in the test procedure.

10.3.4.2 Data Recording of Test Specimens

Toshiba is responsible for output data recording of the test specimens obtained using the test equipment in each test.

10.3.4.3 Data Recording of Test Instrumentation for Qualification Tests

Test vendors are responsible for data recording of the test instrumentation for the qualification test. The data to be recorded in each test contains in the test level, raw data, and test start/stop time

10.3.5 Documentation

The responsibilities to create the documents in the EQ test are described in Section 14.

11. Maintenance/Modifications during Test

Planned maintenance or occurrence of a random failure during the course of the qualification does not invalidate the qualification test. Practical considerations may require re-calibration between test sequences and during aging of the test specimens. This is acceptable provided that it is consistent with the planned maintenance of the equipment in actual installation. Maintenance conducted during test will be performed by Toshiba's Test Personnel or test vendors' qualified tester.

System configuration shall be verified prior to each test as part of test activity at specific points defined in test procedures as necessary. Configuration verification, maintenance and/or configuration change activities shall be performed only by personnel qualified to Level II Test Personnel in accordance with NQ-3011 (Reference (22)). Details of these verification, maintenance and/or configuration change activities shall be documented by Toshiba in the applicable test reports. These controls shall be in place throughout the qualification test program to maintain the test validity.

Toshiba Test Personnel and its test vendors' qualified tester who find any nonconformance, such as system malfunctions or unanticipated failures in the equipment, shall notify the Manager of NICS-QC. The Manager of NICS-QC will issue the Fuchu Site Nonconformance Notice Report (SNNR-I) for a Group or Section which caused the nonconformance, in accordance with "Procedure for Control of Nonconformance and Corrective Action" (NQ-3019 (Reference (25))). When the test is interrupted due to occurrence of nonconformance, the Manager of NICS-QC notifies Test Personnel or QC inspector of the test resumption, after completion of disposition.

Modifications and upgrades made to the equipment or to the test units during or after the test may render the test results inconclusive. Modifications may be made only if full justification is documented on the basis that such modifications have no bearing on the validity of the test. Modifications to test specimen are considered as design changes and will be processed in accordance with "Procedure for Design Change Control" (NQ-2035 (Reference (20))).

Should components in the test specimens fail during the EQ test and require replacement, replacements shall be made using spare components that have been exposed to aging conditions as described in Section 7.2.2.2 . In addition, replacement of a part/module shall be performed in accordance with the manual presented prior to the test.

12. Test Deviations/Failures

Deviation from the required performance of the safety system is accounted for after each test sequence step.

Deviations in the qualification tests shall be treated as nonconformance, and shall be documented on Fuchu Site Nonconformance Notice Reports (SNNR) in accordance with "Procedure for Control of Nonconformance and Corrective Action" (NQ-3019 (Reference (25))). Toshiba shall document any test deviations in the test report.

13. Other Considerations

13.1 General Requirements for Packaging, Shipping, Receiving, Storing and Handling

The qualification test activities consist of tests at Toshiba and its test vendors. After testing at Toshiba Fuchu Complex, the test specimens and some test equipment are shipped to test vendors. Packaging and shipping shall be performed in accordance with "General Requirements for packaging, shipping, receiving, storage and handling" (NQ-3003 (Reference (21))). At test vendor site, Toshiba shall perform a performance proof test as post-shipment test as described in Section 9.2.

Test vendors shall ship the test specimen and test equipment among the test facilities in accordance with the test vendors' 10CFR50 Appendix B compliant quality assurance program if necessary. Toshiba will audit test vendors' shipping procedures as part of the procurement activities for testing services furnished by the test vendors.

After the qualification test, the test specimens and test equipment are shipped to Fuchu Complex Packaging, shipping, storing and handling shall also be performed in accordance with NQ-3003.

14. Documentation

The documentation structure and responsibilities in the EQ test activities are shown in Figure 14-1. The details of the requirements and responsibilities for documents created by Toshiba are described in the following subsection.

The test vendor shall submit the laboratory test procedures in accordance with the test vendors' 10 CFR 50 Appendix B Quality Assurance Program and the test procedures shall be reviewed by the Toshiba EQ engineers prior to the qualification test. The test vendor shall also submit the test records and the raw data. The test records shall be reviewed by the Toshiba EQ engineers at the completion of the qualification test.

14.1 Test Specification

Regarding the Performance test, EQ engineers should create the following test specifications in accordance with "Preparation Procedure for Test Specification" (NQ-2019 (Reference (18))).

- Setup & Checkout Test Specification
- Operability Test Specification
- Prudency Test Specification

Test specifications of Environmental Qualification Test and Dynamic Qualification Test are described in Appendix 2 to Appendix 4.

14.2 Test Procedure

The NICS-QC is responsible for preparing test procedures in accordance with "Test Control Procedure" NQ-3015 (Reference(23)). In addition, test procedures shall include the following items as a minimum:

(a) Test specimen part number, serial number, drawing and revision, model number

(b) Test equipment information, including accuracy specifications and calibration records

(c) Test laboratory requirements, such as shake table

(d) Mounting details, including required torque specifications as applicable

(e) Location of sensors as applicable

(f) Torque specifications on electrical connections as applicable

(g) Listing of electrical connections being qualified

(h) Restraining criteria on electrical interfacing cables as applicable

(i) Monitoring signals (temperature, vibration, voltage, current, etc) which result in automatic starting or stopping of equipment or which are required by control room operators

(j) Minimum and maximum operating voltage of electrical and electro-mechanical equipment

(k) Operational settings (minimum, maximum, or range of settings) for related parameters

(l) Functional testing before, after test runs, after test completion as applicable

(m) Service condition and test sequence

(n) Performance requirements and acceptance criteria for test specimen

(o) Test data sheets and test logs

(p) Any preconditioning requirements

(q) Treatment of deviations and anomalies

14.3 Test Record

The NICS-QC shall create test records. The test records shall include the following items as a minimum:

(a) Test Record including test summary, test objective, date of test, type of observation, results and acceptability, action taken in connection with any deviations noted, SNNRs, and person evaluating test results

(b) Documentation of the test setup, including identification of equipment arrangement (including power supply configurations) and mounting details and photographs

(c) Acceptance criteria for test specimen

(d) Description of the test specimen

(e) Description of test laboratories

(f) Reference to test procedures

(g) Discussion of significant aging mechanism(s) if necessary

(h) Preconditioning and test specimens

(i) Description of test monitoring instrumentation (type, manufacturer, model, range, accuracy specifications and calibration records) and location used

(j) Test data sheets and test logs including laboratory temperature and humidity data

(k) Applicable regulatory and industry requirements

(l) References

14.4 Environmental Qualification Report

An environmental qualification report shall be prepared which documents all the aspects of the qualification program. The EQ engineer shall document environmental qualification report. The equipment qualification documentation shall completely capture the following main qualification items:

a) Identification and description of the equipment being qualified.

b) Identification of the equipment performance specifications which establishes the necessary parameters and margins against which the qualification was demonstrated.

c) The interface or boundary conditions of the equipment.

d) Applicable regulatory and industry requirements

e) Details of the qualification methods employed.

f) Details of test units and number of the test specimens

g) Description of the qualification test and test sequence

h) Details of all the analyses used as part of the qualification process. The assumptions and models utilized shall be described along with the results of the analyses and conclusions.

i) The methods used to address aging in the qualification

j) Specific radiation requirements and actual radiation dose employed for qualification.

k) Functional operations of the test units under environmental and seismic conditions.

l) Acceptance and failure criteria of the equipment

m) Modifications made to test units during the qualification process and criteria for modifications.

n) Evaluation of test anomalies and test deviations

o) Qualification based preventive maintenance and surveillance.

p) Comparison of results to requirements

q) Summary and conclusions, including limitations and qualified life.

r) Statement that the equipment is qualified.

s) References

t) Approval signature and date.

14.5 Dynamic Qualification Report

The EQ engineer shall document dynamic qualification report. The dynamic qualification report contains the following items.

1) Title Page

The following information shall be shown on the Title Page:

a. Client

b. Contractor and equipment name

c. Job number

d. Revision number

e. Date

2) General

This section shall include a description of the equipment, its safety function and the qualification program used to verify this function. In addition, the following information must be given:

a. Project

b. Original equipment manufacturer's name

c. Seller's name

d. Engineer's name

e. Specification and purchase order numbers

f. Equipment name and model number

g. Organization(s) performing qualification programs

h. Description of test vendor

i. Justification for using single axis or single frequency test for all the items that are tested in this manner

j. Calculation of equipment damping coefficient if there is resonance in 1 Hz to 100 Hz range or over the range of the test response spectra

k. Summary of the results

l. Procedures to be used by the operators to perform the safety-related functions manually

m. Any failures that can prevent the satisfactory accomplishment of one or more safety-related functions

n. Approval signatures and dates

3) Data and Assumptions

a. Test Section:

a.1 Type of test machine

a.2 Loads considered and attempts made to idealize them during the test

a.3 Methods used to simulate the supporting structure

a.4 Position and orientation of setting equipment

a.5 Steps taken to monitor the function of equipment during the test and accelerometer locations and orientations (photographs are required).

a.6 Means of generating test response spectra (if applicable)

b. Analytical Section:

b.1 Loads considered

b.2 Damping values used in the analysis

b.3 Codes and Standards applied as bases for the analysis

b.4 Assumptions and engineering judgments made for idealizing boundary conditions, converting the load criteria to actual loads used for calculations and converting the design criteria to actual stress, deformation and stability limits. Justification shall be provided for all the assumptions and engineering judgments used.

b.5 A list of computer programs used in the analysis and the documentation which establish the validity of any computer programs used, if not included in the public domain.

4) Qualification Procedure

a. Test

State type of test, wave form, frequency intervals and range, acceleration levels, axes of excitation, phase between inputs monitoring set-up and any other data to completely describe the input motion and show how it is applied.

b. Analytical

State the method used in the analysis, analytical equations and their derivation from basic principles including appropriate references.

5) Results

a. Test

Test shall include the measurements obtained from the test and their interpretations.

Findings and observations from monitoring the function of the equipment and/or inspection shall be presented. The generated test response spectra curves superimposed on the required response spectra curve shall be described in this section, when applicable. All the results shall be presented in either numerical or graphical form. All the test

anomalies and failures shall be discussed in the report and their resolution.

b. Analytical

Show actual design calculations and sketches for the mathematical models, including numbering used for the node points and elements. If possible, show loads, resultant forces, moments, stresses and deformations on the mathematical model of the equipment.

6) Foundation Loads

The foundation loads resulting from all the applicable loads shall be calculated from Section 14.5 5). Results are presented here.

7) Conclusions

Give a brief summary of the results obtained from the qualification program. A concise statement of the conclusion reached, which shall satisfy the qualification requirements, shall be stated in this section.

8) Drawings

Submit design drawings of the equipment and all the supporting documents. All the necessary dimensions shall be described on these drawings.

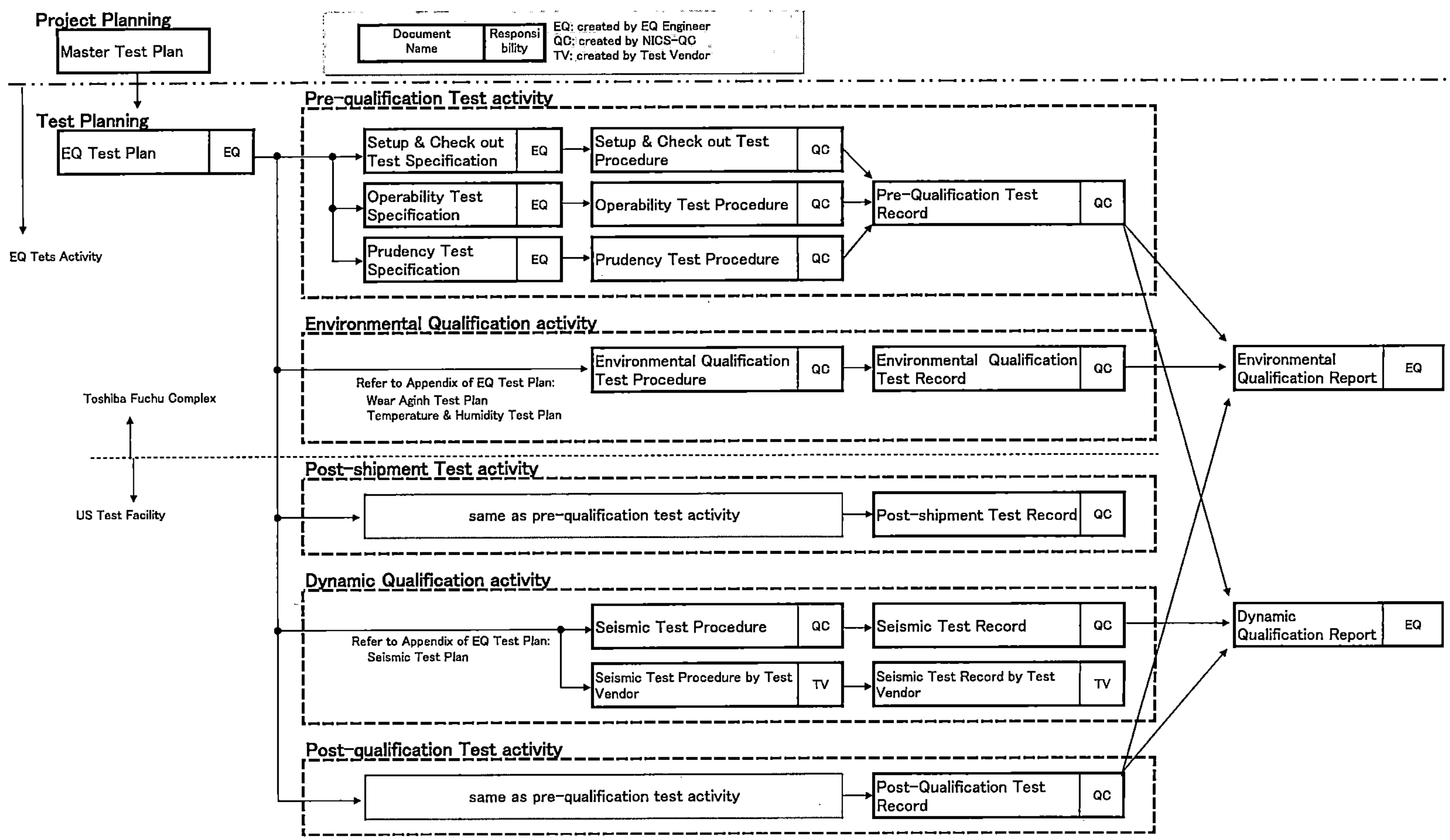


Figure 14-1 Documentation Structure & Responsibility in the EQ test activity

APPENDIX 1. Performance Proof Test Plan

APPENDIX 1-1. General

The performance proof test is performed to determine the operational validation of the test system, and to demonstrate the soundness of the safety-related functions. The performance proof test consists of the set-up & check-out test, operability test, and prudency test.

APPENDIX 1-2. References

(1) FC51-3002-1000 Rev.1, "Equipment Design Specification for Power Range Neutron Monitor"

(2) IEEE Std. 323-2003, "Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(3) EPRI TR-107330," Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants"

APPENDIX 1-3. Test Configuration

Test configuration is shown in Figure 5-1.

APPENDIX 1-4. Test Specimens

The test specimen is an OPRM unit with two PFCs.

APPENDIX 1-5. Test Equipment

The test equipment provided by Toshiba is listed in Table 5-2. General requirements of the test equipment are described in the section 5.4. If no nationally recognized standards exist, the basis for calibration shall be documented. The records shall demonstrate that the sensitivity, accuracy, and repeatability of the instrumentation are suitable for application.

APPENDIX 1-6. Test Conditions

APPENDIX 1-6-1. Service Conditions

The required conditions of temperature, and relative humidity under which the test specimens operate normally are shown in Section 9.1.1.

APPENDIX 1-6-2. Test Sequence

This qualification test is performed in the following sequence.

(1) Set-up & Check-out Test

(2) Operability Test

(3) Prudency Test

APPENDIX 1-6-3. Set-up & Check-out Test

The purpose of this test is to verify proper assembly, integration and operation of the assembled test system. This test confirms proper connection and operation of the test system including monitoring instruments, power supplies, signal simulators, and communication links. The test items to be implemented are as follows.

(1) Visual Inspection

a. Inspection of a blemish and damage of each part

(2) Calibration Record

a. Record serial numbers and calibration information of all the M&TE

(3) Test System Setup and Wiring Check

a. Check the mounting, grounding, and wiring of the test system according to the ECWD (Reference (13))

(4) Power Supply and Power ON

a. Check the voltages of power supply from distribution panel
b. Provide 120VAC-60Hz power to the test specimen

(5) LVPS Voltage Check and Standard Parameter Setting

a. Check the voltages of LVPS modules
b. Set and check the standard parameter setting of the test specimen. The standard parameters are specified in the Table 5-21 of the EDS and Table 5-3, Table 5-11 and 5-18 of the Unit DDS except the following two parameters
- Peak and Valley Detection Width Setpoint of the AGRD module is set to [ ] [a,c]
- Peak and Valley Detection Width Setpoint of the PBD module is set to [ ] [a,c]

(6) Normal Status Check

a. Check the normal status of the OPRM unit. The normal status means all LPRM levels are constant, and APRM and FLOW levels satisfies OPRM region condition. Details of the normal status shall be determined in the Setup & Check-out Test Specification based on the design information of the EDS and the OPRM Unit DDS.

(7) Typical Simulated Signal

a. Check the typical simulated signal as described in Section 9.1.4 In addition, error data of the optical transmission output signal such as protocol error or parity error shall not be detected.

Detailed test specifications are described in the set-up & check-out test specification.

APPENDIX 1-6-4. Operability Test

The purpose of this test is to verify the soundness of the test specimens' functions and performance. The test items to be implemented are as follows.

(1) Discrete Input Operability

(1-1) OPRM Function Change by APRM Bypass Signals

(2) Discrete Output Operability

(2-1) ABA Trip Function

(2-2) GRA Trip Function

(2-3) PBDA Trip Function

(2-4) OPRM Trip Function

(2-5) OPRM Inoperative Function

(2-6) OPRM Automatic Bypass

(3) Communication Operability

(3-1) Function of optical transmission outputs for “ELCS/[ ]a,c data”

(4) Failure Detection and Self-Diagnosis Test

(4-1) [ ]a,c input error

(4-2) “STANDBY” mode or “CAL” mode is selected

(4-3) Number of Active OPRM Cell is lower than the setpoint

(4-4) APRM Inoperative occurs (APRM Inoperative flag is included in APRM Unit Data 1 and 2)

(5) Power Quality Tolerance Test

The power quality tolerance test shall confirm whether the test specimen operates correctly within the following AC power supply voltage and frequency ranges.

- Voltage range: 90-150 VAC plus 10% margin as required by Table 9-1.
  Based on the requirement stated above, the required test voltage range is 81-165 VAC.

- Frequency range: 57-63 Hz plus 10% margin as required by Table 9-1.
  Based on the requirement stated above, the required test frequency range is 51-70 Hz.

The output voltages of PFCs shall only be measured under the following input power supply condition, since output voltages of PFCs are controlled by feedback regulation.

(1) Input Voltage: 81 V, Input Frequency 51 Hz
(2) Input Voltage: 81 V, Input Frequency 70 Hz
(3) Input Voltage: 165 V, Input Frequency 51 Hz
(4) Input Voltage: 165 V, Input Frequency 70 Hz

(6) Loss of Power Test

a. AC power sources are shut off at least 30 seconds and reapplied

(7) Power Interruption Test

a. AC power sources are interrupted for 40 milliseconds

Detailed test specifications are described in the operability test specification.

APPENDIX 1-6-5. Prudency Test

The purpose of this test is to verify the soundness of the test specimens' functions and performance to simulate potential in-service stresses. The test items to be implemented are as follows.

(1) Burst of Event Test

(1-1) Bypass Signals Toggling (Discrete Input Signals Toggling)

a. APRM Bypass ON/OFF Cycle, 1 second +/- 10% interval for 1 minute

(1-2) Input Signal Toggling

a. Driving all the LPRM level inputs from 0 to 125% at 1 Hz interval for at one minute simultaneously.
b. Driving all the APRM level and Core Flow level inputs from 0 to 125% at 1 Hz interval for at one minute simultaneously.

(2) Failure of Optical Transmission Signal Test

a. All LPRM signals loss
b. One side of the redundant APRM signals loss
c. Parity error in the optical transmission input signals

(3) Fault Simulation Test

a. Power loss on one side of the redundant LVPS module

Detailed test specifications are described in the prudency test specification.

APPENDIX 1-7. Acceptance Criteria

APPENDIX 1-7-1. Acceptance Criteria in Set-up & Check-out Test

(1) Visual Inspection

a. The test specimens shall maintain their structural integrity not to adversely affect safety-related functions.

(2) Calibration Record

a. No criterion

(3) Test System Setup and Wiring Check

a. The test system shall be correctly configured according to the ECWD (Reference (13))

(4) Power Supply and Power ON

a. Both of those AC power supplies provide nominal 120VAC, 60Hz power. Their AC power fluctuation range shall be + 10% to - 15% (voltage) and +/- 2.0 Hz (frequency).
b. No criterion

(5) LVPS Voltage Check and Standard Parameter Setting

a. Accuracy of each voltage of the LVPS shall be +/-5% or less.
b. The parameters set in the OPRM unit shall be conformable in the initial setpoint specified in APPENDIX 1-6-3 (5) b.

(6) Normal Status Check

a. The normal status of discrete outputs and optical outputs shall be checked.

(7) Typical Simulated Signal

a. Data of at least 2 cycles in a 2-minute duration shall be evaluated. The acceptance criteria of the check are that the time interval of trip signals monitored by providing a typical test pattern, which generates a trip periodically, shall be as follows:

- Trip interval time of the optical transmission output signal shall be less than [ ][a,c] ms of the expected value
- Trip interval time of the discrete output signal shall be less than [ ][a,c] ms of the expected value

Detailed acceptance criteria are specified in the set-up & check-out test specification.

APPENDIX 1-7-2. Acceptance Criteria in Operability Test

The test specimens shall satisfy performance acceptance criteria specified in Section 8.2. For the power quality tolerance test, output voltages of PFCs shall be within 220VDC +/- 4.5% (+/- 10V). Detailed acceptance criteria are specified in the operability test specification.

APPENDIX 1-7-3. Acceptance Criteria in Prudency Test

(1) Burst of Event Test

(1-1) Bypass Signals Toggling (Discrete Input Signals Toggling)

a. All the trip signals described in Section 6 (2) are not generated during APRM Bypass signal toggling.

(1-2) Signal Toggling

a. The discrete and optical outputs (OPRM Inoperative) are generated 60 times within 60 seconds.
The trip signal described in Section 6 (2-5) is not generated during the signal toggling.

b. The discrete and optical outputs (OPRM Automatic Bypass) are generated 120 times within 60 seconds.
The trip signals described in Section 6 (2-4) and (2-5) are not generated during the signal toggling.

(2) Failure of Optical Transmission Signal Test

a. The discrete outputs as the OPRM Inoperative shall occur when all LPRM signals are lost.

b. Failure of one of the redundant APRM signal shall not cause the I/O signal to change state except "OPRM Minor Failure".

c. The "OPRM Minor Failure" shall be detected. All the trip signals and OPRM Inoperative signal shall not be detected.

(3) Fault Simulation Test

a. Failure of one of the redundant power supplies shall not cause the I/O signal to change state except

"OPRM Minor Failure".

Detailed acceptance criteria are specified in the prudency test specification.

APPENDIX 1-8. Documentation

(1) Setup and Checkout Test Specification

(2) Operability Test Specification

(3) Prudency Test Specification

(4) Setup and Checkout Test Procedure

(5) Operability Test Procedure

(6) Prudency Test Procedure

(7) Performance Test Record

(8) Calibration Record

APPENDIX 2. Wear Aging Test Plan

APPENDIX 2-1. General

The purpose of the wear aging test is to demonstrate the suitability of the test specimens for qualification as safety-related devices under the condition equivalent to the end of the test specimens' life.

APPENDIX 2-2. Reference

(1) FC51-3002-1000 Rev.1, "Equipment Design Specification for Power Range Neutron Monitor"

(2) IEEE Std. 323-2003, "Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

APPENDIX 2-3. Test Specimens

The test specimen is the OPRM unit. Refer to Table A- 1 for application point.

APPENDIX 2-4. Test Equipment

The test equipment provided by Toshiba is listed in Table 5-2. General requirements of the test equipment are described in the section 5.4. If no nationally recognized standards exist, the basis for calibration shall be documented. The records shall demonstrate that the sensitivity, accuracy, and repeatability of the instrumentation are suitable for application.

APPENDIX 2-5. Mounting

The test specimens shall be mounted to the test specimen rack in the same way as that for the performance proof test.

APPENDIX 2-6. Connections

All the cables shall be connected to the test systems according to the ECWD (Reference (13)).

APPENDIX 2-7. Monitoring

There is no requirement. The test specimen is not energized during the wear aging test.

APPENDIX 2-8. Test Condition

APPENDIX 2-8-1. Service Conditions

The required conditions of temperature and relative humidity under which the test specimens operate normally are shown in Section 9.1.1.

APPENDIX 2-8-2. Test Sequence

The wear aging test does not require any specific test sequence.

An operability test is to be performed after the wear aging test in accordance with APPENDIX 1-6-4, and the operability test may serve as the operability test performed prior to the temperature and humidity test as well.

APPENDIX 2-8-3. Wear Aging Test

The test specimen is not energized during the wear aging test. The application of the test specimens and the test conditions are shown in Table A- 1.

Table A- 1 Wear Aging Test Targets, Methodology, and Test Cycle

Target	Module	Methodology (1 cycle)	Test Cycles	Reference Section
OPRM Unit				
Power input connector	LVPS 1 (Slot ID PSSL 1)	Attached /Detached	[ ]a,c	9.1.6 (1)
DIO connector	DIO	Attached /Detached		9.1.6 (1)
Optical transmission Input connector (from a representative signal including LPRM levels)	RCV 1 IN1 (Slot ID BSL5)	Attached /Detached		9.1.6 (1)
Optical transmission output connector (for ELCS/[ ]a,c data)	TRN 1 OUT1 (Slot ID BSL7)	Attached /Detached		9.1.6 (1)
Key Switch	CELL	Turn to "STANDBY" / Turn to "CAL" / Turn back to "OP"		9.1.6 (2)
Key Switch	AGRA	Turn to "STANDBY" / Turn to "CAL" / Turn back to "OP"		9.1.6 (2)
Key Switch	PBD	Turn to "STANDBY" / Turn to "CAL" / Turn back to "OP"		9.1.6 (2)

Key switch has three positions: operation mode position (OP), standby mode position (STANDBY), and Calibration mode position (CAL).

APPENDIX 2-9. Acceptance Criteria

For the operability test performed at the completion of the wear aging test, the test specimens shall satisfy performance acceptance criteria specified in Section 8.2.

APPENDIX 2-10. Documentation

(1) Environmental Qualification Test Procedure

(2) Environmental Qualification Test Record

(3) Environmental Qualification Report

APPENDIX 3. Temperature and Humidity Test Plan

APPENDIX 3-1. General

The purpose of the temperature and humidity test is to demonstrate the suitability of the test specimens for qualification as safety-related devices under the environmental conditions specified in Figure 9-5 .

APPENDIX 3-2. Reference

(1) FC51-3002-1000 Rev.1, "Equipment Design Specification for Power Range Neutron Monitor"

(2) IEEE Std. 323-2003, "Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(3) EPRI TR-107330 "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants, December 1996."

APPENDIX 3-3. Test Configuration

Seismic Test Configuration is shown in Figure A- 1.

APPENDIX 3-4. Test Specimens

The test specimen is an OPRM unit with two PFCs.

APPENDIX 3-5. Test equipment

The test equipment provided by Toshiba is listed in Table 5-2. General requirements of the test equipment are described in the section 5.4. If no nationally recognized standards exist, the basis for calibration shall be documented. The records shall demonstrate that the sensitivity, accuracy, and repeatability of the instrumentation are suitable for application.

APPENDIX 3-6. Mounting

All the test specimen is mounted on a simple structure that does not enclose the test specimens into the environmental test chamber. When the test specimen is affected by noise from the chamber, the test specimens' chassis should not be grounded to the chamber GND directly.

APPENDIX 3-7. Connections

The test specimens shall be connected with test equipment according to the ECWD (Reference (13)) and the environmental test procedure.

APPENDIX 3-8. Monitoring

APPENDIX 3-8-1. Environmental Parameters

The temperature and humidity should be monitored at the bottom of the test specimen in principal. However, if a monitoring point is affected by external factors such as cooling fan or condensate drain, thermo-hydrometers shall be attached to the points other than the bottom of the test specimen. At least two thermo-hydrometers shall be attached; one is the primary sensor and the other is the backup sensor.

APPENDIX 3-8-2. Electrical Parameters

The minimum monitoring points during the temperature and humidity test are as follows.

(1) Discrete Output Signal (7 points)

- OPRM Trip (“A” pin of connector on the DIO module)
- PBDA Trip (“B” pin of connector on the DIO module)
- ABA Trip (“R” pin of connector on the DIO module)
- GRA Trip (“S” pin of connector on the DIO module)
- OPRM Inoperative (“M” pin of connector on the DIO module)
- OPRM Automatic Bypass (“P” pin of connector on the DIO module)
- OPRM Minor Failure (“N” pin of connector on the DIO module)

(2) Discrete Input Signal (1 point)

- APRM Bypass (“JJ” pin of connector on the DIO module)

(3) Optical Transmission Input Signal (4 points)

- Simulated LPRM unit-1 (OUT 1 on the [ ]a,c
- Simulated LPRM unit-2 (OUT 2 on the
- Simulated LPRM unit-3 (OUT 3 on the
- Simulated LPRM unit-4 (OUT 4 on the

(4) Optical Transmission Output Signal (2 points)

- ELCS/[ ]a,c data (OUT 1 on the TRN1)
- PC data (OUT 1 on the TRN2)

When a measured value deviates from acceptance criteria, the time and the measured value which deviated shall be indicated and recorded.

APPENDIX 3-9. Test Conditions

APPENDIX 3-9-1. Service Conditions

The temperature and humidity environmental profile is shown in Figure 9-5. The temperature and humidity within the thermal test chamber shall be maintained to envelop the required temperature and humidity as follows:

High temperature range: +60.0 to +65.0 C, High humidity range: +90 to +95 %RH

Low temperature range: +0.0 to +4.0 C, Low humidity range: +0.0 to +5 %RH

Temperature and humidity range in transition region: Not specified

APPENDIX 3-9-2. Test Operating Conditions and Sequence

Prior to the temperature and humidity test, the set-up & check-out test and operability test will be performed as described in APPENDIX 1-6-3 and APPENDIX 1-6-4 respectively, and the operability test may serve as the operability test performed after the wear aging test as well.

The test specimens shall be provided with typical test pattern described in Section 9.1.3 and monitored continuously during the temperature and humidity test.

The temperature and humidity environmental tests are performed in the following sequence:

(1) 1st High Temperature and High Humidity (at least 48 hours)

(2) Operability Test, except ""STANDBY" mode or "CAL" mode is selected" in APPENDIX 1-6-4 (4-2).

(3) Prudency Test, except "Fault Simulation Test" in APPENDIX 1-6-5 (3).

(4) 1st Low Temperature and Low Humidity
(Including initial ramp down over 4 hours, followed by a hold period of at least 8 hours)

(5) Operability Test, except ""STANDBY" mode or "CAL" mode is selected" and "Power Quality Tolerance Test" in APPENDIX 1-6-4 (4-2) and (5) respectively.

(6) 2nd High Temperature and High Humidity (at least 48 hours)

(7) Operability Test, except ""STANDBY" mode or "CAL" mode is selected" in APPENDIX 1-6-4 (4-2).

(8) Prudency Test, except "Fault Simulation Test" in APPENDIX 1-6-5 (3).

(9) 2nd Low Temperature and Low Humidity
(Including initial ramp down over 4 hours, followed by a hold period of at least 8 hours)

(10) Operability Test, except ""STANDBY" mode or "CAL" mode is selected" and "Power Quality Tolerance Test" in APPENDIX 1-6-4 (4-2) and (5) respectively.

(11) Ambient Environment
(Ramp up over 4 hours, followed by a hold period until environmental conditions stabilizes).

(12) Operability Test, except ""STANDBY" mode or "CAL" mode is selected" and "Power Quality Tolerance Test" in APPENDIX 1-6-4 (4-2) and (5) respectively.

APPENDIX 3-10. Acceptance Criteria

Measurement of temperature and relative humidity shall envelop the required test profile shown in Figure 9-5.

During the test, the discrete signals shall be generated normally by monitoring and checking the data recorder via relay panel, and error data of the optical transmission output signals such as protocol error or parity error shall be not detected by [ ]a,c modules. After the test, acquired data once every ten-hour of at least 2 cycles in a 2-minute duration shall be checked. The acceptance criteria are that the time interval of trip signals monitored by providing a typical test pattern, which generates a trip periodically, shall be as follows:

- Trip interval time of the optical transmission output signal shall be less than [ ]a,c ms of the expected value

- Trip interval time of the discrete output signal shall be less than [ ][a,c] ms of the expected value

For the operability test performed during or after the temperature and humidity test, the test specimens shall satisfy performance acceptance criteria specified in Section 8.2. For the prudency test performed during the test, the test specimens shall satisfy acceptance criteria specified in APPENDIX 1-7-3.

APPENDIX 3-11. Documentation

(1) Environment Qualification Test Procedure

(2) Environment Qualification Test Record

(3) Environment Qualification Report

(4) Calibration Record

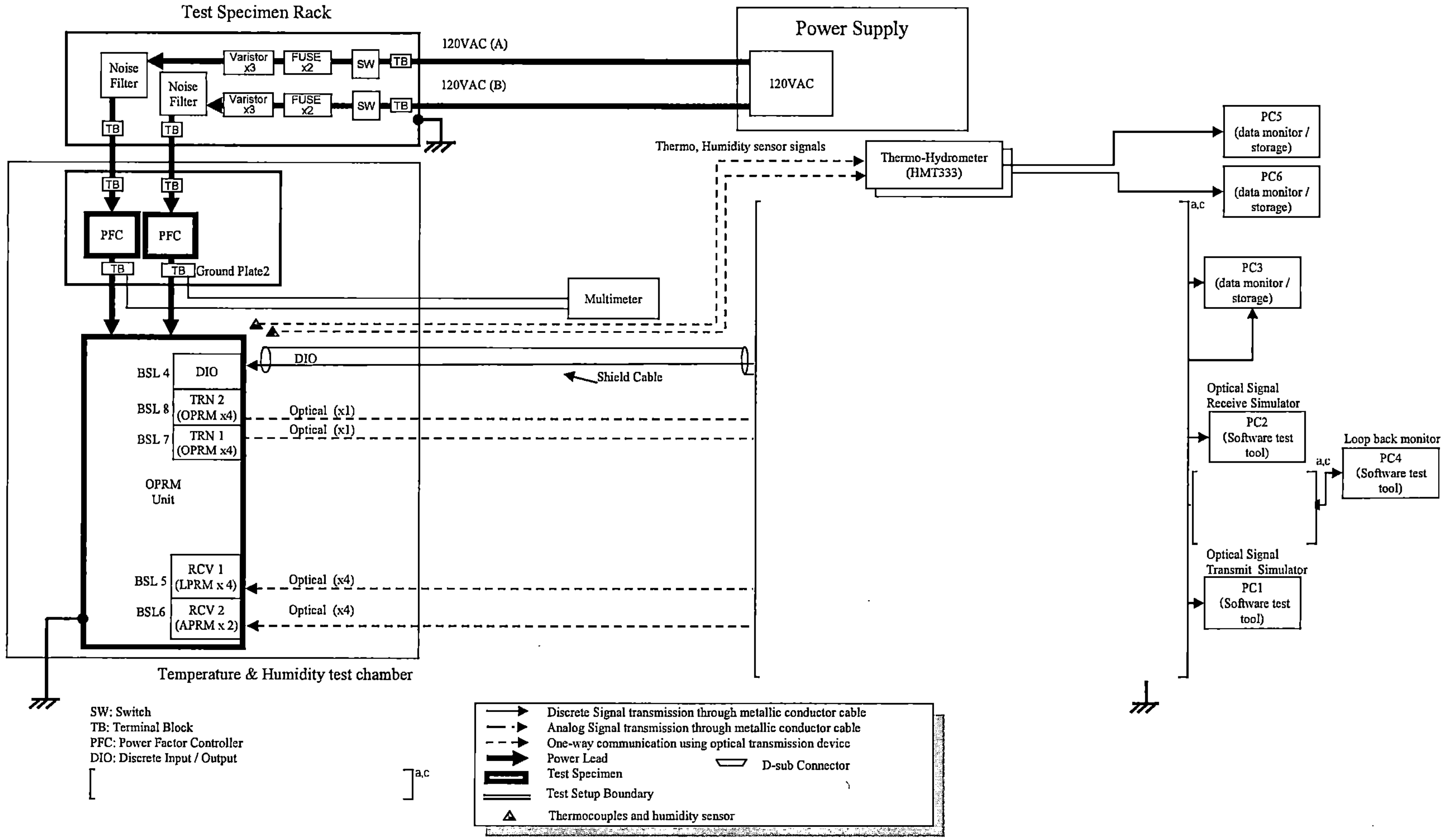


Figure A- 1 Temperature & Humidity Test Configuration

APPENDIX 4. Seismic Test Plan

APPENDIX 4-1. General

The seismic test is performed to assure that the test specimens provide sufficient performance and have seismic capacity under the seismic condition described in Section 5.5.2 of the EDS.

APPENDIX 4-2. Reference

(1) FC51-3002-1000 Rev.1, "Equipment Design Specification for Power Range Neutron Monitor"

(2) IEEE Std. 344 -1987, "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations"

(3) EPRI TR-107330 "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants, December 1996."

APPENDIX 4-3. Test Configuration

Seismic Test Configuration is shown in Figure A- 2.

APPENDIX 4-4. Test Specimens

The test specimen is an OPRM unit with two PFCs, as shown in Figure A- 3 and Figure A- 4. All the test specimens listed in Table 5-1 will be operated simultaneously in the seismic test. However, each test specimen can be tested separately for convenience of test.

APPENDIX 4-5. Test equipment

The test equipment provided by Toshiba is listed in Table 5-2. General requirements of the test equipment are described in the section 5.4. If no nationally recognized standards exist, the basis for calibration shall be documented. The records shall demonstrate that the sensitivity, accuracy, and repeatability of the instrumentation are suitable for application.

APPENDIX 4-6. Test Laboratory

The test vendor shall provide a summary identifying all test suppliers' instrumentation performance characteristics to be used in the test, including a block diagram of the instrumentation system, and the laboratory test procedure prior to commencing any testing. The information in the summary shall include force capabilities, maximum payload, maximum acceleration and as a function of payloads, maximum velocity capabilities with respect to frequencies, maximum displacement capabilities, table dimensions, data acquisition system, sensitivity, electrical monitoring capabilities, overhead crane capacity and other relevant information.

APPENDIX 4-7. Mounting

The test specimen is mounted s to the triaxial table with its principal axes collinear with the principal axes of the test table. All the test specimens will be mounted on a metal rack with mounting bolts equivalent to actual properties. The OPRM unit is fixed in the metal rack with four M5 screws in the front side and eight M4 screws in the back side. The torque to tighten the screws is 2.6 to 3.4 N・m on the front side, and 1.3 to 1.7 N・m on the back side. The PFCs are fixed in the metal rack with four M4 screws. The torque to tighten the screws is 1.3 to 1.7 N・m. All the mounting bolts shall be tightened with a controlled torque by test vendor, and the torque values shall be recorded. The metal rack shall be stiff enough so that there is no resonance below 100 Hz. The metal rack will be mounted on the triaxial table rigidly by bolting. When the test specimen is affected by noise from the vibration table, the test specimens' chassis should not be grounded to the table GND directly.

APPENDIX 4-8. Connections

The test specimens will be connected in a manner that simulates their actual installation state according to the ECWD (Reference (13)) and the seismic test procedure.

Note: Cable support same actual installation shall be simulated.

APPENDIX 4-9. Monitoring

APPENDIX 4-9-1. Accelerometers

The minimum monitoring points for vibration are as follows:

(1) Shake table (Control accelerometer).

The attachment point of control accelerometer shall follow the test facility seismic test procedure.

(2) The mounting point of the test specimens (Response accelerometer)

a. One of the lower mounting points of the OPRM unit (See marked "a" in Figure A- 3)

b. One of the mounting points of the PFCs (See marked "b" in Figure A- 4)

(3) The center of the upper panel (Additional Response accelerometer)

c. Center of the top panel of the OPRM unit (See marked "c" in Figure A- 3)

Note: (3) is used for the seismic analysis.

APPENDIX 4-9-2. Electrical Monitoring

The minimum monitoring points during the seismic test are as follows.

(1) Discrete Output Signal (7 points)

- OPRM Trip ("A" pin of connector on the DIO module)
- PBDA Trip ("B" pin of connector on the DIO module)
- ABA Trip ("R" pin of connector on the DIO module)
- GRA Trip ("S" pin of connector on the DIO module)
- OPRM Inoperative ("M" pin of connector on the DIO module)

- OPRM Automatic Bypass ("P" pin of connector on the DIO module)
- OPRM Minor Failure ("N" pin of connector on the DIO module)

(2) Discrete Input Signal (1 point)

- APRM Bypass ("JJ" pin of connector on the DIO module)

(3) Optical Transmission Input Signal (4 points)

- Simulated LPRM unit-1 (OUT 1 on the [ ][a,c]
- Simulated LPRM unit-2 (OUT 2 on the [ ]
- Simulated LPRM unit-3 (OUT 3 on the [ ]
- Simulated LPRM unit-4 (OUT 4 on the [ ]

(4) Optical Transmission Output Signal (2 points)

- ELCS/[ ][a,c] data (OUT 1 on the TRN1)
- PC data (OUT 1 on the TRN2)

APPENDIX 4-10. Test Conditions

APPENDIX 4-10-1. Service Conditions

The required conditions of temperature and relative humidity under which the test specimens operate normally are shown in Section 9.1.1.

APPENDIX 4-10-2. Test Sequence

Prior to the seismic test, a set-up & check-out test will be performed in accordance with APPENDIX 1-6-3.

The seismic test shall be performed in the following sequence.

(1) Resonance search

(2) Five triaxial operating basis earthquakes (OBEs) for aging

(3) Post-test visual inspection

(4) One triaxial safe shutdown earthquake (SSE) following the OBEs

(5) Post-test visual inspection

(6) Operability Test

APPENDIX 4-10-3. Resonance Search

The purpose of this test is to determine whether the test specimens have a resonance point in each orthogonal direction (IEEE Std. 344-1987, Section 7.1.4.1).

The resonance search shall be performed under the following conditions:

- Sin Sweep Survey,
- For each direction (X, Y or Z),
- Input Level: 0.2G,
- Frequency Range: 1Hz to 100Hz, and
- Sweep rate: 1 octave per minute or less.

Test vendor's tester operates the shake table and measure the acceleration of each axis with each accelerometer. The response data shall be recorded. Test vendor's tester shall create and submit the resonance search report in accordance with test vendors' test procedure. The test specimen is not energized during the resonance search test.

APPENDIX 4-10-4. Random Multifrequency Test

The test specimens shall be provided with typical test pattern described in Section 9.1.3 and monitored continuously during the OBE and SSE tests.

The duration of each OBE and SSE shall be 30 seconds as a minimum. One SSE shall use the SSE level with the Test Required Response Spectrum (TRRS) obtained as shown in Figure 9-6. Five OBEs also shall use the 70% of SSE level with the TRRS. However, there is an exception that the maximum acceleration of the OBE TRRS shall be the highest achievable (but not to exceed 10.8 g) with the test specimen mounted onto the seismic table, and the maximum acceleration of the SSE TRRS shall be the highest achievable (but not to exceed 15.4 g). The Test Response Spectrum (TRS) shall be obtained to envelop the TRRS for each axial.

APPENDIX 4-10-5. Post-test Visual Inspection

The post-test visual inspection is performed to validate the external appearance and structure. This test is same as the visual inspection test described in APPENDIX 1-6-3. In the post-test visual inspection after five OBEs, it shall be checked that all the electrical connectors are fastened tightly.

APPENDIX 4-10-6. Operability Test

The operability test is performed to demonstrate the soundness of all safety-related function prior to removal of the test specimen. The test items to be performed in the operability test are APPENDIX 1-6-4 (1-1), (2-5), and (2-6).

APPENDIX 4-11. Acceptance Criteria

TRS measured at each attaching point shall envelop the TRRS shown in Figure 9-6. The test vendor shall evaluate all seismic test runs to confirm that the TRS envelops the TRRS shown in Figure 9-6 per the requirements of IEEE Std. 344-1987, Section 7.6.3.1.

For the post visual inspection testing, the test specimens shall be structurally intact to perform the safety-related functions.

During the seismic test, a cycle in the test pattern shall be evaluated during a 30-second duration before, during, and after the vibration respectively. The time interval of trip signals monitored by providing a typical test pattern, which generates a trip periodically, shall be as follows:

- Trip interval time of the optical transmission output signal shall be less than [ ][a,c] ms of the expected value.

- Trip interval time of the discrete output signal shall be less than [ ][a,c] ms of the expected value.

In addition, error data of the optical transmission output signal such as protocol error or parity error shall not be detected.

For the operability test performed at the completion of the seismic test, the test specimens shall satisfy performance acceptance criteria specified in Section 8.2.

APPENDIX 4-12. Documentation

(1) Seismic Test Procedure

(2) Seismic Test Record

(3) Dynamic Qualification Report (DQR)

(4) Seismic Test Procedure by Test Vendor

(5) Seismic Test Record by Test Vendor

(6) Calibration Record

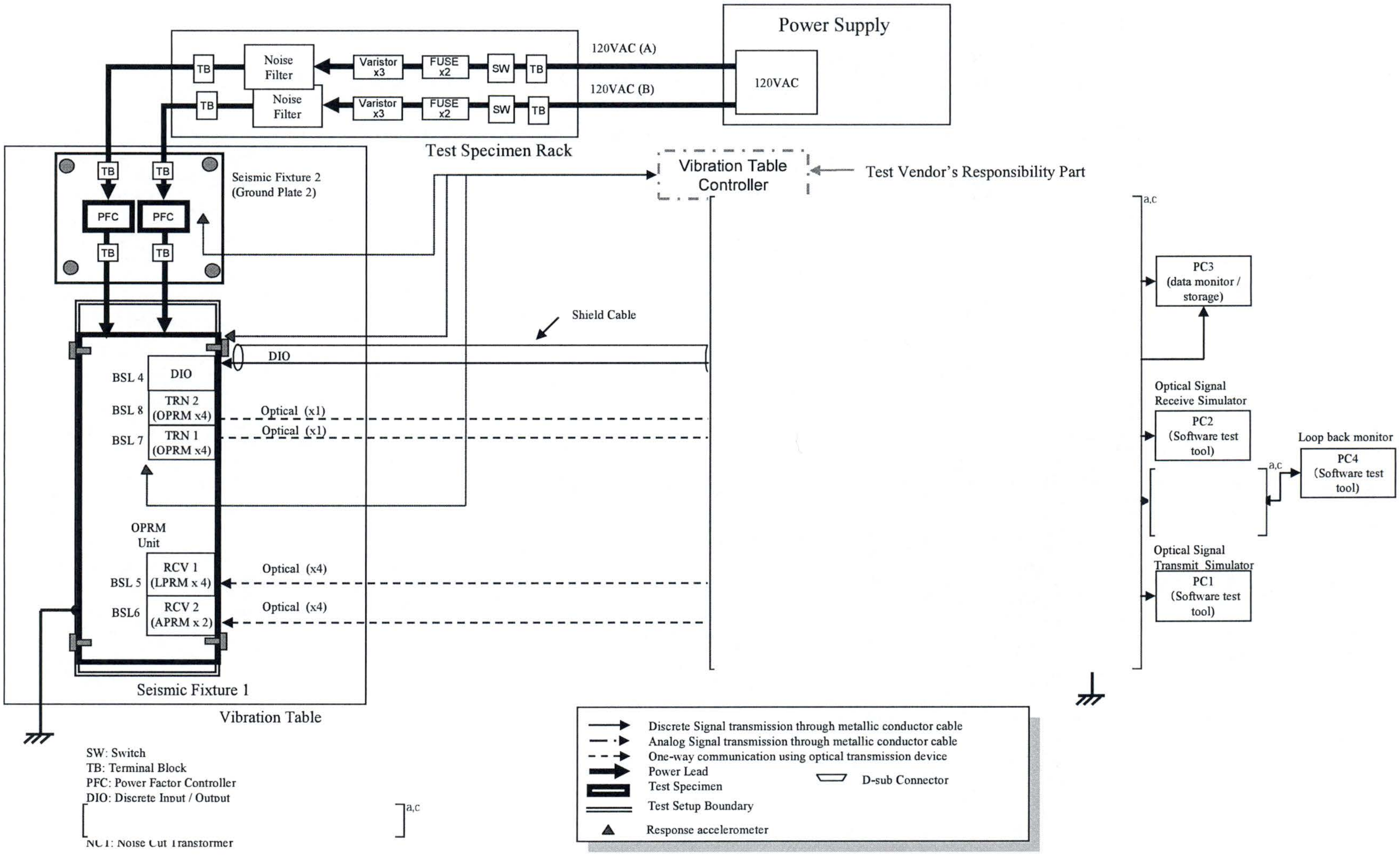


Figure A- 2 Seismic Test Configuration

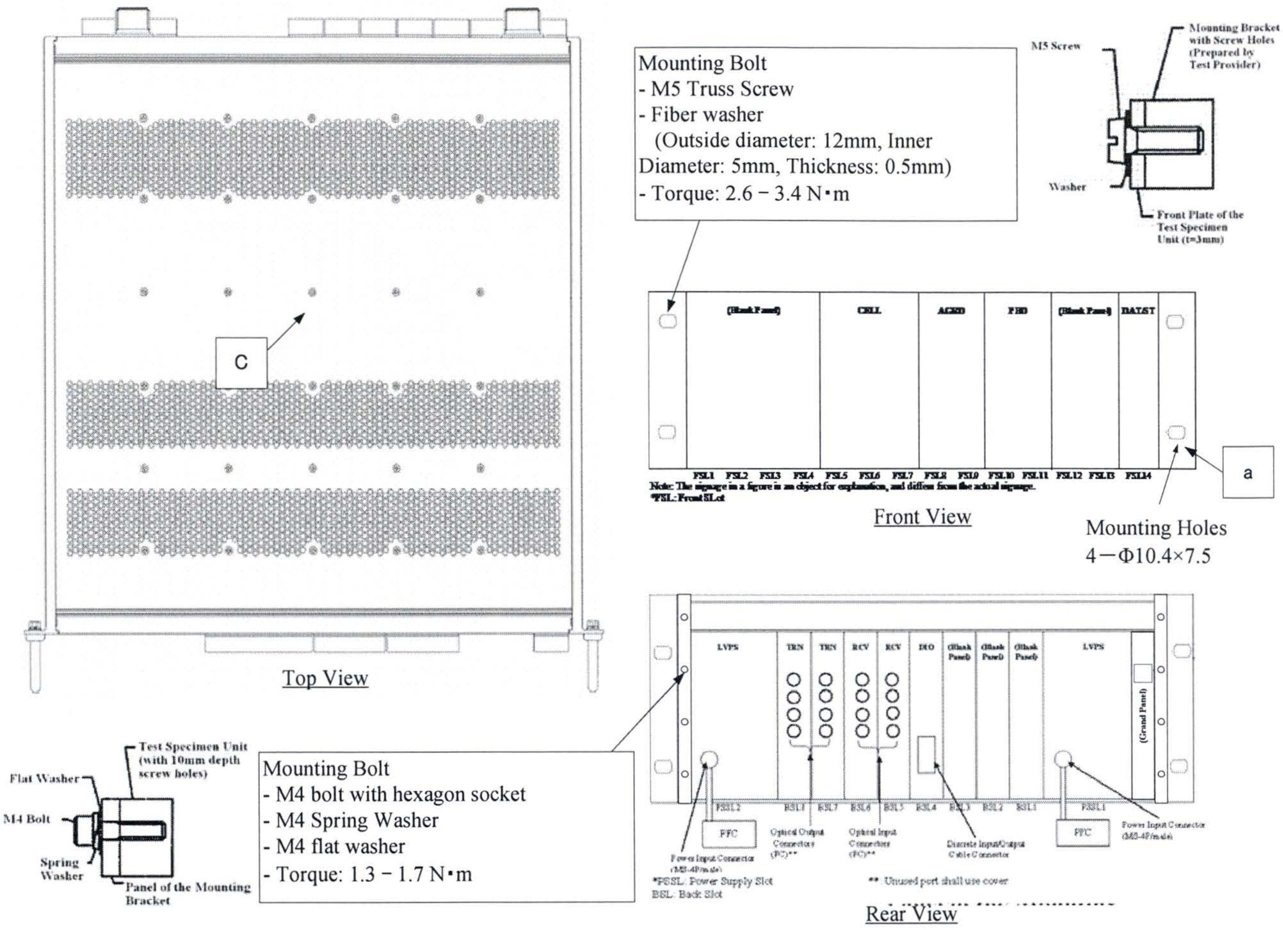


Figure A- 3 OPRM Unit

a,c

Figure A- 4 PFC