

# Post-Maintenance Testing Guide, Revision 1



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# **Post-Maintenance Testing: A Reference Guide, Revision 1**

(Formerly NP-7213)

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# CITATIONS

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# REPORT SUMMARY

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This Nuclear Maintenance Applications Center (NMAC) guide addresses the concern of member utilities regarding the adequacy and consistency of post-maintenance testing programs. The guide provides information on structuring, developing, organizing, and controlling a post-maintenance testing program in a power plant. It stresses the importance of advance planning for post-maintenance testing.

## **Background**

In an NMAC survey, concern about post-maintenance testing ranked high among maintenance issues facing the nuclear industry. The Institute of Nuclear Power Operations (INPO) Good Practice Document No. 87-028, "Post-Maintenance Testing," provides programmatic guidance on this subject; but no industry document is available as an implementation guide for testing specific equipment. This NMAC reference guide is designed to recommend an approach to maintenance functions and to identify post-maintenance testing activities needed on specific equipment. It includes the most common equipment and components found in a nuclear power plant.

Additionally, this revision includes recommendations on post-maintenance testing of digital equipment that is now appearing in nuclear power plants. Most digital components are self-diagnosing and provide users with a means of determining functionality without conducting traditional testing. Sometimes, this testing can even be accomplished without actually conducting a traditional performance test. Additionally, many digital components/systems have provisions for providing users with alarms and indications of failures or degraded performance. Because of this, plant personnel are faced with new challenges along with different components and features that can be used to determine functionality and that are quite different from traditional methods. This revision will attempt to explain these new capabilities as well as provide guidance to plant personnel on post-maintenance testing.

## **Objectives**

- To provide detailed technical assistance in specifying and implementing post-maintenance testing
- To provide additional reference material for use in implementing post-maintenance testing functions at a typical nuclear power plant

## **Approach**

Researchers evaluated existing post-maintenance testing programs at several utilities to develop and formulate a methodology. The philosophy of this guide is to define post-maintenance testing in terms of a progressive series of testing steps.

## **Results**

For each component covered in the guide, a matrix provides various combinations of tests for each type of work activity performed. In addition, the guide offers a set of test definitions to assist in the efficient and consistent execution of post-maintenance testing. While avoiding repetitive testing, the guide covers every inspection, check, or verification that occurs during or after the maintenance activity. The selected tests must always be appropriate for the component and the type of work performed. Accordingly, to use the guide at an operating facility, adjustments and conversions to site-specific documents will be required.

## **EPRI Perspective**

NMAC developed this guide to meet the concern of member utilities about post-maintenance testing and to fill a void in comprehensive documentation on post-maintenance testing. It is expected that, by using this guide, member utilities will enhance their programs by using consistent test selection and implementation of post-maintenance testing. Post-maintenance testing covers a vast territory; this guide is intended as a first step in addressing industry concerns on this important topic.

## **Keywords**

Equipment testing

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# CONTENTS

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<b>1 INTRODUCTION .....</b>	<b>1-1</b>
1.1 Background.....	1-1
1.2 Scope of the Report.....	1-2
1.3 Need for Revision .....	1-2
1.4 Acronyms.....	1-2
<b>2 TECHNICAL APPROACH.....</b>	<b>2-1</b>
<b>3 UNDERLYING PHILOSOPHY.....</b>	<b>3-1</b>
3.1 Maintenance Testing .....	3-1
3.2 Run/Operational Testing.....	3-2
3.3 Functional Testing .....	3-2
3.4 Special Testing .....	3-3
<b>4 COORDINATING WITH REGULATORY/LICENSING COMMITMENTS.....</b>	<b>4-1</b>
<b>5 INSTRUCTIONS .....</b>	<b>5-1</b>
<b>6 CONSIDERATIONS FOR SITE-SPECIFIC IMPLEMENTATION.....</b>	<b>6-1</b>
6.1 Hierarchy of PMT Procedures.....	6-1
6.2 Development of Site-Specific Criteria .....	6-1
6.3 Integration with Existing Plant Testing Activities.....	6-2
6.4 Correlation of PMT to Plant Equipment .....	6-2
<b>7 CONCLUSIONS .....</b>	<b>7-1</b>
<b>8 REFERENCES .....</b>	<b>8-1</b>
<b>A COMPONENT TEST MATRICES .....</b>	<b>A-1</b>
Electrical Equipment - Component Test Matrices .....	A-1

EBC – Component Test Matrix Battery/Battery Charger .....	A-2
EC – Component Test Matrix Electrical Contactor .....	A-3
ECB – Component Test Matrix Circuit Breaker .....	A-4
ECP – Component Test Matrix Cathodic Protection .....	A-5
EDG – Component Test Matrix Diesel Generator .....	A-6
EDG – Component Test Matrix Diesel Generator .....	A-6
EFB – Component Test Matrix Fuse/Fuse Block .....	A-7
EGN – Component Test Matrix Generator, Main .....	A-8
EH – Component Test Matrix Electric Heater.....	A-9
EHT – Component Test Matrix Heat Tracing Circuit/Equipment .....	A-10
EIN – Component Test Matrix Inverter .....	A-11
EM – Component Test Matrix Electric Motor.....	A-12
EMG – Component Test Matrix Motor-Generator .....	A-13
EPN – Component Test Matrix Penetration .....	A-14
EPS – Component Test Matrix Electrical Power Supply .....	A-15
ER – Component Test Matrix Relay/Meter.....	A-16
ERC – Component Test Matrix Recombiner .....	A-17
ESG – Component Test Matrix Switchgear.....	A-18
ESW – Component Test Matrix Electrical Switch.....	A-19
ETR – Component Test Matrix Transformer .....	A-20
EWC – Component Test Matrix Wire/Cable.....	A-21
Instrumentation and Controls - Component Test Matrices.....	A-22
IA – Component Test Matrix Annunciator.....	A-23
IB – Component Test Matrix Bistable/Relay.....	A-24
ICI – Component Test Matrix Computer I/O Devices .....	A-25
ICN – Component Test Matrix Converter .....	A-26
ICS – Component Test Matrix Control Switch .....	A-27
ID – Component Test Matrix Digital Component and Assembly .....	A-28
IFD – Component Test Matrix Fire Detection.....	A-29
IGG – Component Test Matrix Gauge.....	A-30
IIN – Component Test Matrix Indicators .....	A-31
INI – Component Test Matrix Nuclear Instrumentation .....	A-32
IPC – Component Test Matrix Process Controller.....	A-33
IR – Component Test Matrix Recorder.....	A-34

IRM – Component Test Matrix Radiation Monitor .....	A-35
IRT – Component Test Matrix RTD/Thermocouple .....	A-36
IT – Component Test Matrix Transmitter .....	A-37
Mechanical Equipment - Component Test Matrices.....	A-38
MAH – Component Test Matrix Air Handling Unit/Fan/Blower .....	A-39
MC – Component Test Matrix Coupling .....	A-41
MCD – Component Test Matrix Condenser .....	A-42
MCH – Component Test Matrix Crane/Hoist .....	A-43
MCP – Component Test Matrix Compressor.....	A-44
MD – Component Test Matrix Dryer .....	A-45
MDD – Component Test Matrix Damper/Ducting .....	A-46
MDE – Component Test Matrix Diesel Engine .....	A-47
MFP – Component Test Matrix Fire Protection Devices .....	A-49
MFS – Component Test Matrix Filter/Strainer/Demineralizer .....	A-50
MGT – Component Test Matrix Gearbox/Transmission .....	A-51
MGV – Component Test Matrix Governor, Hydraulic .....	A-52
MHD – Component Test Matrix Hydraulic Drive.....	A-53
MHX – Component Test Matrix Heat Exchanger .....	A-54
MP – Component Test Matrix Pump .....	A-55
MPP – Component Test Matrix Piping/Tubing/Welded Components.....	A-56
MPS – Component Test Matrix Pipe Support/Hanger .....	A-57
MRC – Component Test Matrix Refrigeration Unit/Chiller.....	A-58
MRF – Component Test Matrix Radiation Filter .....	A-59
MS – Component Test Matrix Snubber .....	A-60
MT – Component Test Matrix Turbine.....	A-61
MTV – Component Test Matrix Tank/Vessel/Accumulator.....	A-62
MV – Component Test Matrix Valve, Manually Operated .....	A-63
MVA – Component Test Matrix Valve, Air-/Pneumatic-Operated.....	A-64
MVC – Component Test Matrix Valve, Check .....	A-65
MVM – Component Test Matrix Valve, Motor-Operated .....	A-66
MVR – Component Test Matrix Valve, Relief and Safety .....	A-67
MVS – Component Test Matrix Valve, Solenoid .....	A-68
<b>B ELECTRICAL TESTING GUIDE AND TEST DEFINITIONS.....</b>	<b>B-1</b>
EG Electrical Equipment – General Testing.....	B-3

EG-1 – General Electrical Maintenance/Installation Check .....	B-3
A. Inspection Check.....	B-3
B. Electrical Check .....	B-3
C. Equipment Qualification Check.....	B-4
EG-2 – General Electrical Run/Operational Test.....	B-4
EG-3 – General Electrical Functional Test .....	B-5
EBC Battery/Battery Charger Component Testing .....	B-7
EBC-1 – Maintenance/Installation Check .....	B-7
EBC-2 – Termination Integrity Check.....	B-8
EBC-3 – Operational Check - Power Off .....	B-8
EBC-4 – Functional Test .....	B-9
EC Electrical Contactor Component Testing .....	B-10
EC-1 – Maintenance/Installation Check.....	B-10
EC-2 – Termination Integrity Check .....	B-11
EC-3 – Insulation Resistance Check .....	B-11
EC-4 – Functional Test.....	B-12
ECB Circuit Breaker Testing.....	B-13
ECB-1 – Maintenance/Installation Check .....	B-13
ECB-2 – Termination Integrity Check.....	B-14
ECB-3 – Insulation Resistance Check.....	B-14
ECB-4 – Functional Test .....	B-14
ECP Cathodic Protection Component Testing .....	B-16
ECP-1 – Maintenance/Installation Check .....	B-16
ECP-2 – Functional Test .....	B-16
EDG Diesel Generator Component Testing.....	B-17
EDG-1 – Maintenance/Installation Check.....	B-17
EDG-2 – Termination Integrity Check.....	B-18
EDG-3 – Operational Check - Power Off.....	B-18
EDG-4 – Functional Test.....	B-19
EFB Fuse Block Component Testing .....	B-20
EFB-1 – Maintenance/Installation Check.....	B-20
EFB-2 – Termination Integrity Check .....	B-20
EFB-3 – Functional Test.....	B-21
EGN Main Generator Component Testing.....	B-22

EGN-1 – Maintenance/Installation Check.....	B-22
EGN-2 – Termination Integrity Check.....	B-22
EGN-3 – Operational Check - Power Off.....	B-23
EGN-4 – Functional Test.....	B-23
EGN-5 – Vibration Testing.....	B-24
EGN-6 – Air Test .....	B-24
EH Electric Heater Component Testing.....	B-25
EH-1 – Maintenance/Installation Check.....	B-25
EH-2 – Termination and Integrity Check .....	B-25
EH-3 – Functional Test.....	B-25
EHT Heat Tracing Circuits and Equipment Component Testing .....	B-27
EHT-1 – Maintenance/Installation Check/Inspection .....	B-27
EHT-2 – Termination Integrity Check .....	B-27
EHT-3 – Thermal Insulation Check .....	B-27
EHT-4 – Functional Test.....	B-28
EIN Inverter Component Testing.....	B-29
EIN-1 – Maintenance/Installation Check.....	B-29
EIN-2 – Termination Integrity Check .....	B-29
EIN-3 – Operation Check- Power Off .....	B-30
EIN-4 – Functional Test.....	B-30
EM Electric Motor Component Testing.....	B-32
EM-1 – Maintenance/Installation Check .....	B-32
EM-2 – Rotation Test.....	B-32
EM-3 – Run/Operation Test.....	B-33
EM-4 – Functional Test .....	B-33
EMG Motor Generator Component Testing .....	B-35
EMG-1 – Maintenance/Installation Check .....	B-35
EMG-2 – Run/Operation Test.....	B-36
EMG-3 – Functional Test.....	B-36
EPN Penetration Component Testing .....	B-37
EPN-1 – Maintenance/Installation Check .....	B-37
EPN-2 – Termination Integrity Check.....	B-37
EPN-3 – Insulation Resistance Check.....	B-38
EPN-4 – Functional Test .....	B-38

EPN-5 – Instrument/Channel Calibration .....	B-38
EPS Power Supply Component Testing.....	B-39
EPS-1 – Maintenance/Installation Check .....	B-39
EPS-2 – Termination Integrity Check .....	B-39
EPS-3 – Operational Check - Power Off .....	B-40
EPS-4 – Functional Test.....	B-40
EPS-5 – Temperature Check .....	B-41
ER Relay/Meter Component Testing .....	B-42
ER-1 – Maintenance/Installation Check .....	B-42
ER-2 – Termination Integrity Check .....	B-42
ER-3 – Relay Operational Check - Power Off .....	B-43
ER-4 – Functional Test.....	B-43
ERC Recombiner Component Testing .....	B-44
ERC-1 – Maintenance/Installation Check .....	B-44
ERC-2 – Functional Test .....	B-44
ERC-3 – Calibration.....	B-45
ESG Switchgear Component Testing .....	B-46
ESG-1 – Maintenance/Installation Check .....	B-46
ESG-2 – Termination Integrity Check.....	B-47
ESG-3 – Insulation Resistance Check .....	B-47
ESG-4 – Functional Test .....	B-48
ESG-5 – Infrared Scan/Thermography Check.....	B-48
ESW Electrical Switch Component Testing.....	B-49
ESW-1 – Maintenance/Installation Check .....	B-49
ESW-2 – Termination Integrity Check .....	B-49
ESW-3 – Operational Check- Power Off .....	B-49
ESW-4 – Functional Test.....	B-50
ETR Transformer Component Testing .....	B-51
ETR-1 – Maintenance/Installation Check .....	B-51
ETR-2 – Termination Integrity Check .....	B-51
ETR-3 – Operational Check - Power Off .....	B-52
ETR-4 – Functional Test.....	B-53
ETR-5 – Oil Analysis .....	B-53
EWC Wire/Cable Component Testing .....	B-54

EWC-1 – Maintenance/Installation Check .....	B-54
EWC-2 – Termination Integrity Check .....	B-54
EWC-3 – Insulation Resistance Check.....	B-55

**C INSTRUMENTATION AND CONTROLS TESTING GUIDE AND TEST DEFINITIONS ..... C-1**

IG Instrumentation and Controls General Testing .....	C-2
IG-1 – General Instrumentation and Controls Maintenance/Installation Check.....	C-2
A. Inspection Check.....	C-2
B. Instrument Line/Tubing Check/Leak Test .....	C-2
C. Equipment Qualification Check.....	C-3
IG-2 – General I&C Run/Operational Test.....	C-3
IG-3 – General Instrumentation and Controls Functional Test .....	C-4
IG-4 – General I&C Special Test - Component Calibration .....	C-5
IA Annunciator Component Testing .....	C-6
IA-1 – Maintenance/Installation Check .....	C-6
IA-2 – Termination Integrity Check .....	C-6
IA-3 – Functional Test .....	C-6
IB Bistable/Relay Component Testing.....	C-7
IB-1 – Maintenance/Installation Check .....	C-7
IB-2 – Tubing Check.....	C-7
IB-3 – Termination Integrity Check .....	C-7
IB-4 – Functional Test .....	C-8
ICI Computer Input/Output Component Testing .....	C-9
ICI-1 – Maintenance/Installation Check .....	C-9
ICI-2 – Termination Integrity Check.....	C-9
ICI-3 – Functional Test .....	C-9
ICN Converter Component Testing .....	C-11
ICN-1 – Maintenance/Installation Check .....	C-11
ICN-2 – Leak Test .....	C-11
ICN-3 – Termination Integrity Check .....	C-11
ICN-4 – Functional Test.....	C-12
ICS Control Switch Component Testing.....	C-13
ICS-1 – Maintenance/Installation Check.....	C-13
ICS-2 – Leak Test.....	C-13
ICS-3 – Termination Integrity Check .....	C-14

ICS-4 – Operational Check – Power Off.....	C-14
ICS-5 – Functional Test.....	C-14
ICS-6 – Calibration .....	C-14
ID Digital Devices and Systems .....	C-15
Background .....	C-15
General Guidance for Post-Maintenance Testing for Digital Devices and Systems.....	C-19
ID-1 – Maintenance/Installation Check .....	C-19
ID-2 – Termination Integrity Check.....	C-20
ID-3 – Functional Test .....	C-20
IFD Fire Detection Component Testing .....	C-23
IFD-1 – Maintenance/Installation Check.....	C-23
IFD-2 – Termination Integrity Check.....	C-23
IFD-3 – Functional Test .....	C-24
IGG Gauge Component Testing .....	C-25
IGG-1 – Maintenance/Installation Check .....	C-25
IGG-2 – Leak Test.....	C-25
IGG-3 – Calibration.....	C-25
IIN Indicator Component Testing.....	C-26
IIN-1 – Maintenance/Installation Check .....	C-26
IIN-2 – Termination Integrity Check.....	C-26
IIN-3 – Functional Test .....	C-26
IIN-4 – Calibration.....	C-26
INI Nuclear Instrumentation Component Testing .....	C-27
INI-1 – Maintenance/Installation Check.....	C-27
INI-2 – Channel Calibration .....	C-27
INI-3 – Detector Calibration .....	C-27
INI-4 – Functional Test .....	C-28
IPC Process Controller Component Testing .....	C-29
IPC-1 – Maintenance/Installation Check .....	C-29
IPC-2 – Operational Check.....	C-29
IPC-3 – Device Calibration .....	C-30
IPC-4 – Channel Calibration.....	C-30
IPC-5 – Channel Functional Test .....	C-30
IR Recorder Component Testing.....	C-32

IR-1 – Maintenance/Installation Check .....	C-32
IR-2 – Termination Integrity Check.....	C-32
IR-3 – Functional Test .....	C-32
IR-4 – Calibration.....	C-32
IRM     Radiation Monitor Component Testing.....	C-33
IRM-1 – Maintenance/Installation Check.....	C-33
IRM-2 – Leak Test.....	C-33
IRM-3 – Termination Integrity Check.....	C-33
IRM-4 – Functional Test .....	C-34
IRM-5 – Calibration.....	C-34
IRT     RTD/Thermocouple Component Testing .....	C-35
IRT-1 – Maintenance/Installation Check.....	C-35
IRT-2 – Leak Test.....	C-35
IRT-3 – RTD or Thermocouple Termination Integrity Check .....	C-35
IRT-4 – Functional Test .....	C-36
IRT-5 – Calibration .....	C-36
IT     Transmitter Component Testing .....	C-37
IT-1 – Maintenance/Installation Check .....	C-37
IT-2 – Leak Test .....	C-37
IT-3 – Termination Integrity Check .....	C-37
IT-4 – Functional Test.....	C-38
IT-5 – Calibration .....	C-38
<b>D MECHANICAL TESTING GUIDE AND TEST DEFINITIONS.....</b>	<b>D-1</b>
MG     Mechanical Equipment General Testing .....	D-3
MG-1 – General Mechanical Maintenance/Installation Check.....	D-3
A.    Inspection Check.....	D-3
MG-2 – General Mechanical Run/Operational Test .....	D-4
MG-3 – General Mechanical Functional Test.....	D-5
MG-4 – General Mechanical Special Test.....	D-7
A.    Vibration Testing .....	D-7
MAH    Air Handling Unit/Fan/Blower Component Testing.....	D-8
MAH-1 – Maintenance/Installation Check .....	D-8
MAH-2 – Functional Test.....	D-8
MAH-3 – Special Test - Vibration Test .....	D-9

MC	Coupling Component Testing.....	D-10
	MC-1 – Maintenance/Installation Check.....	D-10
	MC-2 – Functional Test.....	D-10
MCD	Condenser Component Testing .....	D-11
	MCD-1 – Maintenance/Installation Check .....	D-11
	MCD-2 – Leak Test .....	D-11
	A. Tube Leak Test .....	D-11
	B. Condenser Leak Test.....	D-12
	MCD-3 – Functional Test.....	D-12
MCH	Crane and Hoist Component Testing.....	D-13
	MCH-1 – Maintenance/Installation Check .....	D-13
	MCH-2 – Operational Check - Unloaded.....	D-13
	MCH-3 – Functional Test.....	D-14
MCP	Compressor Component Testing .....	D-15
	MCP-1 – Maintenance/Installation Check .....	D-15
	MCP-2 – Operational Check- Unloaded.....	D-15
	MCP-3 – Functional Test.....	D-16
MD	Dryer Component Testing .....	D-17
	MD-1 – Maintenance/Installation Check .....	D-17
	MD-2 – Leak Test.....	D-17
	MD-3 – Functional Test .....	D-17
	MD-4 – Dew Point Test .....	D-18
	MD-5 – Particulate Test.....	D-18
MDD	Damper and Ducting Component Testing.....	D-19
	MDD-1 – Maintenance/Installation Checks .....	D-19
	MDD-2 – Functional Test.....	D-19
MDE	Diesel Engine Component Testing.....	D-20
	MDE-1 – Maintenance/Installation Checks.....	D-20
	MDE-2 – Functional Test.....	D-20
	MDE-3 – Fuel Test .....	D-22
MFP	Fire Protection Device Component Testing .....	D-23
	MFP-1 – Maintenance/Installation Checks .....	D-23
	MFP-2 – Leak Test.....	D-24
	MFP-3 – Termination Integrity Check.....	D-24

MFP-4 – Valve Cycle/Exercise Test .....	D-24
MFP-5 – Operational Check .....	D-24
MFP-6 – Functional Test .....	D-25
MFS Filter, Strainer, and Demineralizer Component Testing .....	D-26
MFS-1 – Maintenance/Installation Check .....	D-26
MFS-2 – Functional Test .....	D-26
MGT Gearbox/Transmission Component Testing.....	D-27
MGT-1 – Maintenance/Installation Check.....	D-27
MGT-2 – Functional Test.....	D-27
MGV Governor, Hydraulic Component Testing.....	D-28
MGV-1 – Maintenance/Installation Checks.....	D-28
MGV-2 – Functional Test.....	D-28
MHD Hydraulic Drive Component Testing .....	D-29
MHD-1 – Maintenance/Installation Checks.....	D-29
MHD-2 – Hydraulic Drive Functional Test .....	D-29
MHD-3 – Hydraulic Drive Vibration Test.....	D-29
MHX Heat Exchanger Component Testing .....	D-30
MHX-1 – Maintenance/Installation Check .....	D-30
MHX-2 – Leak Test.....	D-30
A. Tube Leak Test for the Maintenance or Repair of Tubes.....	D-30
B. Hydrostatic Leak Test .....	D-31
C. General Leak Test.....	D-31
MHX-3 – Functional Test.....	D-31
MHX-4 – Special Requirements or Tests - Hydrostatic In-Service Test.....	D-31
MP Pump Component Testing .....	D-32
MP-1 – Maintenance/Installation Checks .....	D-32
MP-2 – Operational Check Unloaded.....	D-33
MP-3 – Pump Functional Test.....	D-33
MPP Piping/Tubing/Welded Component Testing.....	D-34
MPP-1 – Maintenance/Installation Checks .....	D-34
MPP-2 – Hydrostatic Test.....	D-34
MPS Pipe Support/Hanger Component Testing .....	D-35
MPS-1 – Maintenance Checks/Installation Visual Inspections .....	D-35
MPS-2 – Hanger Setting Verification.....	D-35

MRC	Refrigeration Unit/Chiller Component Testing.....	D-36
	MRC-1 – Maintenance/Installation Checks .....	D-36
	MRC-2 – Refrigeration System Operational Check.....	D-36
	MRC-3 – Refrigeration System Functional Test.....	D-37
	MRC-4 – Refrigeration System Leak Test.....	D-38
	A. Tube Leak Test for the Maintenance or Repair of Tubes.....	D-38
	B. Hydrostatic Leak Test .....	D-38
	C. In-Service Leak Test .....	D-38
MRF	Radiation Filter Component Testing.....	D-39
	MRF-1 – Maintenance/Installation Checks .....	D-39
	MRF-2 – Radiation Filter Functional Test.....	D-39
MS	Snubber Component Testing .....	D-40
	MS-1 – Maintenance/Installation Checks .....	D-40
	MS-2 – Setting Check.....	D-40
	MS-3 – Stroke Test.....	D-41
MT	Turbine Component Testing .....	D-42
	MT-1 – Maintenance/Installation Checks .....	D-42
	MT-2 – Leak Test .....	D-43
	MT-3 – Operational Check .....	D-43
	MT-4 – Functional Test.....	D-45
MTV	Tank, Vessel, and Accumulator Component Testing .....	D-46
	MTV-1 – Maintenance/Installation Check.....	D-46
	MTV-2 – Pressure Test .....	D-46
	MTV-3 – Parameter Check.....	D-46
MV	Valve, Manually Operated Component Testing .....	D-47
	MV-1 – Maintenance/Installation Check .....	D-47
	MV-2 – Valve Cycle/Exercise Test .....	D-47
	MV-3 – Flow and Pressure Test .....	D-47
	MV-4 – Leak Test .....	D-47
	MV-5 – Manual Valve Position Indication Checks .....	D-48
	MV-6 – Manual Valve Seat Leakage Test.....	D-48
MVA	Valve, Air-/Pneumatic-Operated Component Testing .....	D-49
	MVA-1 – Maintenance/Installation Check.....	D-49
	MVA-2 – Valve Cycle/Exercise Test.....	D-49

MVA-3 – Air Operated Valve Stroke Time Test.....	D-49
MVA-4 – Position Verification Check.....	D-50
MVA-5 – Leak Test.....	D-50
MVA-6 – Air-Operated Valve Automatic Operation Test .....	D-50
MVC Valve, Check Component Testing.....	D-51
MVC-1 – Maintenance/Installation Check.....	D-51
MVC-2 – Leak Test.....	D-51
MVC-3 – Valve Cycle and Position Indication Check.....	D-51
MVC-4 – Reverse Flow Test .....	D-52
MVC-5 – Flow and Pressure Test .....	D-52
MVC-6 – Seat Leakage Test .....	D-52
MVM Valve, Motor-Operated Component Testing .....	D-53
MVM-1 – Maintenance/Installation Check .....	D-53
MVM-2 – Valve Cycle/Exercise Test .....	D-53
MVM-3 – Valve Stroke Time Test.....	D-54
MVM-4 – Valve Position Indication and Torque Switch Check.....	D-54
MVM-5 – Valve Current Test .....	D-54
MVM-6 – Automatic Operation Test .....	D-54
MVM-7 – Special Test - Valve Diagnostics .....	D-54
MVR Valve, Relief and Safety Component Testing .....	D-55
MVR-1 – Maintenance/Installation Check.....	D-55
MVR-2 – Set Point Check.....	D-55
MVR-3 – Valve Packing Leak Test.....	D-56
MVR-4 – Position Indication Check .....	D-56
MVR-5 – Seat Leakage Test .....	D-56
MVS Valve, Solenoid Component Testing.....	D-57
MVS-1 – Maintenance/Installation Check.....	D-57
MVS-2 – Valve Cycle/Exercise Test.....	D-57
MVS-3 – Position Indication Check .....	D-57
MVS-4 – Seat Leakage Test .....	D-57
MVS-5 – Automatic Operation Test.....	D-57
<b>E TRANSLATED TABLE OF CONTENTS .....</b>	<b>E-1</b>
Français (French).....	E-2

日本語 (Japanese).....	E-17
Español (Spanish).....	E-37

## **LIST OF TABLES**

---

Table C-1 Applications for Digital Components and Assemblies in Nuclear Power Plants.....	C-15
Table C-2 Attributes of Digital Devices Often Verified by Post-Maintenance Testing.....	C-18



# 1

## INTRODUCTION

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### 1.1 Background

This reference guide was originally developed to provide technical reference material to support post-maintenance testing (PMT) functions at operating nuclear power plants. Specifically, guidance is provided to support the basic PMT functions of specification and implementation activities. The need for additional guidance was identified as an area of concern by plant management and maintenance personnel, based on previous industry surveys. The Nuclear Maintenance Applications Center (NMAC) has sponsored the technical guide development as a basic reference document for assistance toward the consistent and adequate implementation of these functions. The emphasis is on the technical aspect of component testing following typical maintenance activities.

Programmatic guidance has already been established by the Institute of Nuclear Power Operations (INPO) in two guidelines. INPO has issued guidance in Good Practice No. 87-028 (MA-305), “Post-Maintenance Testing.” Also, INPO Good Practice No. 85-038, “Guidelines for the Conduct of Maintenance at Nuclear Power Stations,” discusses this subject in Chapter 8, entitled “Post-Maintenance Testing.” This NMAC guide is not meant to change or contradict information in these documents. Rather, it provides additional technical reference material to augment the efforts that are programmatically outlined by the INPO guidelines.

Specifically, this guide deals mostly with the technical aspects of:

- Specifying post-maintenance testing
- Defining post-maintenance tests
- Providing a framework for comprehensive PMT program improvement

The guide development included data-gathering site visits to eight operating plants of different nuclear steam supply system (NSSS) types and ages. These site visits reviewed the existing PMT programs and procedures. Individuals involved in all program aspects were visited and interviewed. Site-specific practices, implementation systems, work orders, and test documentation were also reviewed and evaluated. The effort provided a good understanding of the functions involved in executing the PMT program and a hands-on perspective to develop additional technical reference material for such a program.

The conclusions from the site visits are the recommendations and technical references that make up this PMT guide.

## **1.2 Scope of the Report**

This guide has a general discussion regarding the PMT technical aspects and specific PMT recommendations for common nuclear power plant components. The component selection included in the guide is based on an evaluation of the most common nuclear power plant components in the country. Additionally, consideration was given to the amount and depth of maintenance work that may be routinely performed on such components.

Also included in this guide are some generic and component-specific test definitions. These are divided into electrical, instrumentation and controls, and mechanical sections. Most work planning is functionally assigned to such discipline groups at the plant sites. These test definitions are included as a comprehensive reference for PMT attributes that may be applicable for the maintained component. Also, component-specific test matrices were developed and are included in this guide. These test matrices recommend a level of PMT for most common corrective and preventive maintenance activities. The remainder of this guide discusses a methodology and recommended technical approach that should improve PMT specification and implementation.

## **1.3 Need for Revision**

During 2004, NMAC was requested to revisit the guidance contained in the report and determine any areas where amendment or revision was necessary. One of the major findings from this comprehensive review was the need to add post-maintenance testing guidance for digital components and assemblies used in nuclear power plants.

Revision 1 of this report incorporates the most current post-maintenance testing guidance for digital equipment and updates the guidance, as necessary, for the types of components included in the original report.

## **1.4 Acronyms**

AC – alternating current

AOV – air-operated valve

ASME – American Society of Mechanical Engineers

BOP – balance of plant

CFR – Code of Federal Regulations

CPM – cycles per minute

CRT – cathode ray tube

CT – current transformer

D/P – differential pressure

DB – dry bulb

DC – direct current

DG – diesel generator

DOP – dioctyl phthalate

E/P – voltage to pressure

HVAC – heating, ventilating, and air conditioning

I&C – instrumentation and controls

I/O – input/output

I/P – current to pressure

INPO – Institute of Nuclear Power Operations

IST – in-service testing

M&TE – measurement & test equipment

MCCB – molded case circuit breaker

MG – motor generator

MOV – motor-operated valve

NDE – nondestructive examination

NDT – nondestructive testing

NI – nuclear instrumentation

NMAC – Nuclear Maintenance Applications Center

NRC – Nuclear Regulatory Commission

NSSS – nuclear steam supply system

*Introduction*

NUMARC – Nuclear Utility Management and Resource Council

P&ID – piping and instrumentation drawing

PMT – post-maintenance test

PT – potential transformer

PTC – performance test code

RCS – reactor coolant system

RPM – revolutions per minute

RTD – resistance temperature detector

# 2

## TECHNICAL APPROACH

---

For the development of the original report, a review of existing practices in specifying and implementing PMT was conducted. Many variables affect the site-specific PMT programs. These variables were evaluated to identify additional guidance that would make PMT more effective. These variables include:

- Site functional organization
- Personnel test experience specifying PMT
- Detail and content of maintenance procedures
- Available technical references
- Computer use in maintenance work order planning
- Historical work order records
- Status of preventive monitoring/predictive monitoring programs
- Technical specification surveillance program integration
- Scope of performance monitoring and reliability monitoring programs
- Commercial grade parts dedication program status
- Status and integration of predictive monitoring program
- Content of equipment and system testing procedures

Many plants have performed, or have underway, significant efforts to upgrade preventive maintenance programs and maintenance procedures. Also, several plants have established formal stand-alone post-maintenance testing programs and technical appendices, including some test matrices.

This guide provides test matrices for basic nuclear power plants components. The test matrices included in Appendix A summarize the PMT level that a component may require for different maintenance activities. A common definition set for specific component tests was also established. These test definitions are essential to establishing consistency in the scope and criteria of the PMT activities. Definitions developed for electrical, instrumentation and controls, and mechanical components are included as Appendices B, C, and D, respectively. The definitions correspond to the testing activities found in the component test matrices and are assigned a reference test code for easy tracking.

*Technical Approach*

For components covered in this guide, the possible PMT can be reviewed and selected by the PMT specifier. These actions should take place during the maintenance planning stages. However, this is intended as a basic reference guide, and the specifier should use sound engineering judgment. The PMT specifier should decide if a certain test or the attributes within that test are appropriate for the work performed.

# 3

## UNDERLYING PHILOSOPHY

---

The underlying philosophy of an effective post-maintenance test program is that the level of testing should be appropriate for the work being performed. The PMT goal is to provide assurance that a component and its associated subsystem has been sufficiently checked out and tested after maintenance. Thus, the tested component provides a high degree of confidence that it is capable of performing its design/safety function(s). Certain inspections and checks that satisfy some PMT requirements follow the activities conducted during maintenance phase. These inspections, verifications, or checks are usually an integral part of the maintenance procedures. After the maintenance is completed, the additional verifications and tests performed ensure that the component or system is ready for operations. The PMT activities should be designed to ensure that the functionality of the component is verified through a series of progressive testing steps, avoiding duplicate testing. A common definition of post-maintenance testing is:

“Any appropriate combination of inspections, checks, and testing performed following maintenance to verify that a particular piece of equipment or system performs its intended function based on its design criteria and verification that the original deficiency has been corrected.”

Generically, the level and detail of post-maintenance testing activities should be a phased approach. This testing should be appropriate for the following:

- The level of work performed
- The complexity of the component and its importance to nuclear safety or plant reliability

The typical post-maintenance tests can be categorized into one of four testing levels defined as:

1. Maintenance testing
2. Run or component operational testing
3. Component and/or subsystem functional testing
4. Special testing

### 3.1 Maintenance Testing

This type of testing demonstrates that the original abnormal condition was corrected and that no new deficiency was introduced as a result of the maintenance performed. Maintenance testing includes installation testing, which is a group of activities to demonstrate that the installation (or unit replacement), workmanship, and materials are satisfactory. These maintenance testing activities can include:

### *Underlying Philosophy*

- Assembly hydrostatic testing
- Wiring checks
- Megger checks
- Torque verifications
- Others

Many of these checks and verifications are performed during maintenance because they could not be accomplished after maintenance (for example, a clearance check on an internal component).

**Note:** Some of these activities may be intrinsic to the work activity and are actually performed as a maintenance step. Certain instances may require verification that these were performed. These verifications or performance of these maintenance checks/tests are considered as prerequisites to run further tests or functional tests for the component that has been maintained.

## **3.2 Run/Operational Testing**

Run/operational testing demonstrates the normal operation of the component on which maintenance was performed. This test and series of operational checks would normally involve returning the equipment to service or otherwise operating it at normal operating pressures, temperatures, and normal service conditions. These tests/checks may involve simple data gathering or observations to gauge proper operation, but they may not require the extensive data gathering of a full functional test. A run test would include operation of the equipment and simple data logging, similar to operational logs for that type of equipment. The acceptance criteria would usually be qualitative in nature, except normal operation department log bands or tolerance limits.

**Note:** The term *operational test/check* is not to be confused with a test that satisfies Technical Specification requirements, which is frequently referred to as an “operability” test.

## **3.3 Functional Testing**

A functional test or verification directly demonstrates that the component, equipment, or subsystem affected by the maintenance activity is completely capable of performing its design functions. A functional test may be satisfied by performing the applicable Technical Specification surveillance test(s) or by performing the required test per ASME Section XI Inservice Tests, including pressure tests, pump tests, and valve tests. Performance of a functional test may satisfy pre-operability requirements. For balance-of-plant (BOP) equipment, functional testing would include detailed equipment and subsystem performance tests. For most functional tests, there would be extensive data logging, usually with prescribed data sheets to be completed and included in the documentation package for the work and test. The acceptance criteria would typically be quantitative in nature with specific measuring points, tolerances, and possible subsequent calculations.

### **3.4 Special Testing**

Either special testing does not fit into the categories described above, or it is testing that warrants specific identification. In some cases, a higher level of testing may be prudent, beyond the three levels previously identified. For example, for large multiple maintenance tasks affecting a large portion of a system or the entire plant, a series of plant integrated tests may be specially configured following the maintenance phase of the work. As another specific example, impact assessments of large amount of work activities on safeguard systems may deem it appropriate to conduct an integrated safeguard actuation test, even if this is not specifically required from the review of individual work packages.

Other special tests may include testing to support the station predictive monitoring program efforts. Usually, these condition monitoring efforts must be re-baselined after maintenance if that work affects the parameters that are being used to gauge equipment condition. These activities typically include vibration monitoring and infrared (thermography) monitoring/scanning.

Other special tests may be specified or developed on a case-by-case basis for specific components, systems, or special maintenance activities.



# 4

## COORDINATING WITH REGULATORY/LICENSING COMMITMENTS

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In the process of specifying PMT and while reviewing the planned work activities, the reviewer should know and understand the station's commitments to certain regulation-driven programs. These programs can define the minimum level of testing activities that are required following maintenance. These programs include the following:

- Technical Specification operability requirements and station surveillance testing requirements.
- ASME Section XI Repair and Replacement program requirements, including in-process NDE checks, component hydrostatic tests, and post-work system/component pressure tests.
- Environmental qualification program requirements, including required preventive maintenance, spare part replacement requirements, and possible PMT.
- Motor-operated valve testing per NRC Generic Letter 89-10. This includes special testing of motor-operated valves, following certain maintenance activities or adjustments, to ensure valve operation during design basis transients.
- ASME Section XI pressure testing requirements.
- ASME Section XI in-service testing for pumps.
- ASME Section XI in-service testing for valves.
- Containment component leak rate testing per 10CFR50 Appendix J. Valves are usually included in the valve in-service testing program, but other components may require additional local leak rate tests.
- Snubber/hanger program requirements.
- Maintenance Rule.

The person who specifies PMT should determine if the subject component falls within one of the station programs or within the procedures for regulation-driven programs listed above. If it does, then the specifier should know and understand the program requirements on the maintenance work and the PMT. This person must be able to determine if the planned work requires special testing to be performed in order to satisfy the station regulation commitments to the above programs. Fortunately, these programs are well documented in station procedures. Technical support is available from the plant technical staff responsible for each program development and upkeep. Also, detailed test procedures exist to perform and document the evaluation as well as the testing conducted after such maintenance work.

*Coordinating with Regulatory/Licensing Commitments*

Because these regulatory programs dictate specific testing requirements, some of the material in this guide may be superseded by the component requirements included in these programs. For that reason, the most significant enhancement to PMT from this guide may be to equipment not in the scope of such regulatory programs but in the balance-of-plant areas.

# 5

## INSTRUCTIONS

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This guide is for use by personnel for specifying and assuring the adequacy of PMT following corrective or preventive maintenance activities. The primary users of the guide are expected to be work document planners, maintenance personnel, outage planning personnel, and shift operations personnel.

This generic post-maintenance testing guide, or preferably a site-specific post-maintenance program document, should be used during the work order planning phase to compare the planned work activities to the possible generic or component-specific tests defined in the appendices.

The work document should be reviewed, and the components affected by the maintenance activity should be identified. These components should then be compared to the component test matrices in Appendix A to see if there is any correlation to the component and work activities shown in the matrices. If a component match is found, the planned work should be compared to the work activities shown in the matrix. Once the work activity is identified in the matrix, the required testing is defined by the 'X' entry under the listed test activities. Each of the test activities has an assigned test code, which corresponds to the codes in the discipline testing guides, and a test definition that is listed in Appendix B, C, or D. The specifier should then use sound engineering judgment, based on the work scope, to select from each of the test activities the applicable test/check that should be used as the required PMT for that component's maintenance.

In addition, at the beginning of each of the discipline test guides and test definitions in the Appendices, there is a section that includes general definitions for maintenance checks, run/operational checks, and functional tests. These test definitions are intended as a generic supplement to the more specific test requirements that appear in each component test definitions. The specifier should refer to these general definition sections when reference is made in the specific component test code definition or when the specific component testing definitions do not address the planned work scope. Also, for components not found in the PMT guide, these general sections can be an additional source of information from which PMT can be specified.

If the specifier is not able to determine the proper scope of testing to be performed, and if this guide does not address the specific component type, a cognizant plant engineer should be consulted.

It is intended that the matrix and definitions serve only as guides because different manufacturers and equipment models may make some tests inappropriate. Also, within a test definition, the actual attributes to be verified, checked, or tested may be selected at the specifier's judgment.

*Instructions*

Again, the attributes included are generic and may be dependent on specific equipment as well as the exact scope of work performed.

The testing addressed in this guide may not be applicable for every situation and is offered only for consideration. Additional testing should be identified based on plant-specific experience, lessons learned from previous work orders, and input from engineering and technical support personnel.

# 6

## CONSIDERATIONS FOR SITE-SPECIFIC IMPLEMENTATION

---

This PMT guide has been developed with the goal of providing additional technical reference material for site-specific PMT programs and implementing procedures. However, much of the information in the attachments is generic and was not written in a manner to be directly applied at a specific nuclear plant site. To use this material at an individual site, some adjustments may be necessary. The following key activities should be considered:

- The technical information in this guide should be compared to the existing site programs and procedures for PMT.
- Based on this comparison, an evaluation should be made by site personnel regarding what actions, if any, should be taken to make the post-maintenance test program more effective.

### 6.1 Hierarchy of PMT Procedures

One action would be the possible development of a hierarchy of PMT procedures. Many of the attributes of the maintenance/installation checks may reside in the discipline maintenance procedures. Some of the attributes of the run/operation tests may reside in the operations department equipment procedures. Similarly, for some components, the functional testing may be addressed for some components in the Technical Specification surveillance test procedures. The results of a site-specific evaluation should establish both the site-specific philosophy underlying the PMT program and the efforts, if any, that should be undertaken to upgrade the program.

### 6.2 Development of Site-Specific Criteria

The test definitions in Appendices B, C, and D are not intended to be used directly in the work/test documents. Site-specific testing precautions, safety considerations, initial conditions, and test prerequisites are beyond the scope of this guide. Similarly, site-specific data record sheets, including clear acceptance criteria must be developed and included in the final documentation package, where appropriate. The final implementation of the material in this guide should take the form of written instructions/procedures, approved under station-specific processes.

### **6.3 Integration with Existing Plant Testing Activities**

Some of these “tests” are identical to preventive maintenance tasks, surveillance tests, and other repetitive tasks defined in site-specific procedures and implementation systems (maintenance computer application programs). These activities should be compared and integrated. Certainly, one goal of an effective PMT program is to avoid excessive testing of plant equipment and systems.

### **6.4 Correlation of PMT to Plant Equipment**

A final effort to make the site-specific program effective and controllable includes the correlation of the equipment to the test procedure or repetitive task numbers. To help the planner/specifier of PMT, a database should be established that includes the following relational fields:

- Component type
- Equipment tag numbers
- PMT testing type (maintenance test, functional test, etc.)
- Test procedure number or task number

This database could be manual or computerized, but it is essential to be able to make the final correlation between the work and the total pre-defined testing activities that will return the component to “operable” status following maintenance.

# 7

## CONCLUSIONS

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This PMT guide provides technical direction for both the specification and implementation of post-maintenance activities following maintenance on nuclear plant components. This guide presents recommended testing, specified within the test matrices, for most common component types used at operating power plants. Where appropriate, testing activities have been defined. The underlying philosophy and the detailed material provide a framework for a consistent implementation of an effective post-maintenance test program.

Site-specific actions may be required to convert some of this generic data to site-specific components and documents. The *PMT Reference Guide* should be reviewed, evaluated, and compared to the existing site PMT philosophy. The suggested test definitions and component test attributes should also be reconciled with existing site documents. Site actions may include the development or upgrade of site-specific test definitions or test procedures. These documents would include the detailed test data sheets for testing records, including clear acceptance criteria.

The component test matrices and test definitions are offered as a guide only. The final decision for the scope of post-maintenance testing should be made by site personnel responsible for implementing the post-maintenance testing program.



# 8

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# A

## COMPONENT TEST MATRICES

### INDEX TO COMPONENT TEST MATRICES

#### Electrical Equipment - Component Test Matrices

Equipment Code	Type of Equipment	Page
EBC	Battery/Battery Charger	A-2
EC	Contactors, Electrical	A-3
ECB	Circuit Breaker	A-4
ECP	Cathodic Protection	A-5
EDG	Diesel Generator	A-6
EFB	Fuse Block	A-7
EGN	Generator, Main	A-8
EH	Electric Heater	A-9
EHT	Heat Tracing Circuit/Equipment	A-10
EIN	Inverter	A-11
EM	Motor, Electric	A-12
EMG	Motor-Generator	A-13
EPN	Penetration	A-14
EPS	Electrical Power Supply	A-15
ER	Relay/Meter	A-16
ERC	Recombiner	A-17
ESG	Switchgear	A-18
ESW	Switch, Electrical	A-19
ETR	Transformer	A-20
EWC	Wire/Cable	A-21

**EBC – Component Test Matrix  
Battery/Battery Charger**

**Components:  
Station Batteries  
Battery Chargers**

		Test Activities →	Maintenance/ Installation Check EBC-1	Termination Integrity Check EBC-2	Operational Check - Power Off EBC-3	Functional Test EBC-4		
		Test Code →						
<b>Work Activities</b>	<b>Clean/Inspect: Battery Racks/Cells/Ventilation Filter</b>		X					
	<b>Add Water/Electrolyte</b>		X					
	<b>Replace or Disconnect Cells</b>		X	X	X Note 1	X Note 1		
	<b>Maintain or Adjust Battery Charger</b>		X	X	X	X Note 2		
	<b>Repair or Replace Battery Charger</b>		X	X	X	X Note 2		

**Note 1:** To perform this test, the battery charger and related system should be operable.

**Note 2:** The charger should be connected to the battery to perform this test.

**Cross-References:** None

**EC – Component Test Matrix  
Electrical Contactor**

**Components:  
Contactors**

		Test Activities →	Maintenance/ Installation Check EC-1	Termination Integrity Check EC-2	Insulation Resistance Check EC-3	Functional Test EC-4		
		Test Code →						
<b>Work Activities</b>	<b>Repair or Adjust</b>		X	X	X	X		
	<b>Replace Component</b>		X	X	X	X		
	<b>Inspect or Clean</b>		X					

**Notes:** None

**Cross-References:** None

**ECB – Component Test Matrix  
Circuit Breaker**

**Components:**

**Molded Case Circuit Breakers**

**480-Volt Circuit Breakers**

**Electrical Panels, Motor Control Centers, Contactors**

Test Activities →		Maintenance/ Installation Check ECB-1	Termination Integrity Check ECB-2	Insulation Resistance Check ECB-3	Functional Test ECB-4		
Test Code →							
<b>Work Activities</b>	<b>Adjust Breaker Timing</b>	X	X		X Note 1		
	<b>Repair Breaker Components</b>	X	X	X	X Note 1		
	<b>Replace Breaker</b>	X	X	X	X Note 1		
	<b>Clean/Inspect/Lubricate</b>	X					
	<b>Work on Lights or Indicators</b>	X					
	<b>Control Circuit Maintenance</b>	X	X	X	X Note 1		

**Note 1:** Electrical surveillance test procedures may be required to be performed for certain breakers that feed safety components, such as reactor safeguard components, containment penetrations, and so on.

**Cross-References:** Switchgear (ESG), Contactor (EC)

**ECP – Component Test Matrix  
Cathodic Protection**

**Components:  
Cathodic Protection Components**

		Test Activities →	Maintenance/ Installation Check ECP-1	Functional Test ECP-2				
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace Anode</b>		X	X				
	<b>Replace Electrode</b>		X	X				
	<b>Repair or Replace Rectifier</b>		X	X				
	<b>Clean Rectifier</b>		X	X				

**Notes:** None

**Cross-References:** None

**EDG – Component Test Matrix  
Diesel Generator**

**Components:  
Diesel Generator, Electrical**

		Test Activities →	Maintenance/ Installation Check EDG-1	Termination Integrity Check EDG-2	Operational Check - Power Off EDG-3	Functional Test EDG-4		
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace Exciter or Voltage Regulator</b>	X	X Note 1	X	X Note 2			
	<b>Repair Generator</b>	X	X Note 1	X	X Note 2, 3			
	<b>Repair or Replace Protective Interlocks</b>	X	X Note 1	X	X Note 2			
	<b>Replace Bearings, Slip-Rings, or Brushes</b>	X		X	X Note 2, 3			
	<b>Control Circuit Maintenance</b>	X	X Note 1	X	X Note 2			

**Note 1:** Check only the features affected by maintenance activity.

**Note 2:** Surveillance test procedures should be used if available.

**Note 3:** Perform the vibration testing as required by the station predictive monitoring program.

**Cross-References:** Diesel Engine (MDE)

**EFB – Component Test Matrix  
Fuse/Fuse Block**

Components:  
Electrical Fuses  
Electrical Fuse Blocks

		Test Activities →	Maintenance/ Installation Check EFB-1	Termination Integrity Check EFB-2	Functional Test EFB-3			
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace Fuse Block</b>		X	X	X			
	<b>Replace Fuse</b>		X	X	X			
	<b>Replace Fuse Clips</b>		X	X	X			
	<b>Dress Contacts, Blades, or Jaws</b>		X	X	X			
	<b>Clean Fuse Block</b>		X					

Notes: None

Cross-References: None

**EGN – Component Test Matrix  
Generator, Main**

**Components:  
Main Generator**

		Test Activities →	Maintenance/ Installation Check EGN-1	Termination Integrity Check EGN-2	Operational Check - Power Off EGN-3	Functional Test EGN-4	Vibration Test EGN-5	Air Test EGN-6
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace Bearings, Slip Rings, or Brushes</b>		X		X	X Note 1	X	
	<b>Repair or Replace H<sub>2</sub> Seal Ring</b>		X				X	X
	<b>Repair or Replace Generator Gas System/Comp.</b>		X					X
	<b>Repair Hydrogen Leak</b>		X					
	<b>Repair/Replace or Clean/Inspect Windings</b>		X	X	X	X Note 1	X	X
	<b>Repair or Replace Seal Oil System Components</b>		X					
	<b>General Inspection</b>		X Note 1	X Note 1	X Note 1	X Note 1	X	X Note 1
	<b>Check Insulation Resistance Rotor or Stator</b>		X	X	X	X Note 1	X	

**Note 1:** During major overhauls, special test or manufacturer test procedures may be required to be performed in addition to this test.

**Cross-References:** None

***EH – Component Test Matrix  
Electric Heater***

**Components:  
Electric Heaters**

		Test Activities →	Maintenance/ Installation Check EH-1	Termination Integrity Check EH-2	Functional Test EH-3			
		Test Code →						
<b>Work Activities</b>	Repair or Replace Coil or Heater Element		X	X	X			
	Repair or Replace Thermostat		X	X	X			
			X					

**Notes:** None

**Cross-References:** None

**EHT – Component Test Matrix  
Heat Tracing Circuit/Equipment**

**Components:**  
Heat Tracing Circuits  
Heat Tracing Wiring, Controls, Cards, and Thermostats

		Test Activities →	Maintenance/ Installation Check EHT-1	Termination Integrity Check EHT-2	Thermal Insulation Check EHT-3	Functional Test EHT-4		
		Test Code →						
<b>Work Activities</b>	<b>Repair or Calibrate</b>		X	X		X		
	<b>Replace Component</b>		X	X	X			
	<b>Remove/Reinstall Insulation</b>		X		X			

**General Note:** Verify that boric acid lines are drained prior to maintenance. Ensure that the line is not crystalized after the piping is refilled.

**Cross-References:** None

**EIN – Component Test Matrix  
Inverter**

**Components:  
Static Inverters**

		<b>Test Activities →</b>	<b>Maintenance/ Installation Check EIN-1</b>	<b>Termination Test EIN-2</b>	<b>Operation Check Power Off EIN-3</b>	<b>Functional Test EIN-4</b>		
		<b>Test Code →</b>						
<b>Work Activities</b>	<b>Clean and Inspect, Replace Air Filters</b>	X						
	<b>Repair/Adjust Voltage, Control Circuit Devices</b>	X	X	X	X			
	<b>Replace Control Circuit Devices</b>	X	X	X	X			

**Notes:** None

**Cross-References:** Wire/Cable (EWC)

**EM – Component Test Matrix  
Electric Motor**

**Components:**  
Electric AC Motors  
Electric DC Motors

		Test Activities →	Maintenance/ Installation Check EM-1	Rotation Check EM-2	Run/ Operational Test EM-3	Functional Test EM-4		
		Test Code →						
<b>Work Activities</b>	<b>Basic Inspection, Cleaning, and Lubrication</b>		X		X	X Note 1		
	<b>Replace Bearings</b>		X	X	X	X Note 1		
	<b>Repair Motor in Place</b>		X	X	X	X Note 1		
	<b>Replace or Repair Motor</b>		X	X	X	X Note 1		

**Note 1:** If the component is identified in the ASME Inservice Test (IST) program, conduct the testing as required by the station program and test procedures.

**Cross-References:** None

**EMG – Component Test Matrix  
Motor-Generator**

Components:  
CRDM Motor-Generator Sets

		Test Activities →	Maintenance/ Installation Check EMG-1	Run/ Operation Test EMG-2	Functional Test EMG-3			
		Test Code →						
<b>Work Activities</b>	<b>Clean Windings</b>		X	X	X			
	<b>Lubricate</b>		X	X				
	<b>Replace Bearings</b>		X	X				
	<b>Repair or Replace Coupling or Flywheel</b>		X	X				
	<b>Repair or Replace Generator, Motor, or Exciter</b>		X	X	X			
	<b>Replace Slip Rings, Brushes, or Commutators</b>		X	X	X			
	<b>Repair or Replace Speed Pick-Up Devices or Speed Controllers</b>		X	X	X			

Notes: None

Cross-References: Motor (EM), Generator (EGN), Cooler (Heat Exchanger – MHX)

**EPN – Component Test Matrix  
Penetration**

**Components:  
Electrical Penetrations**

		Test Activities →	Maintenance/ Installation Check EPN-1	Termination Integrity Check EPN-2	Insulation Resistance Check EPN-3	Functional Test EPN-4	Calibration EPN-5	Local Leak Rate Test
		Test Code →						
<b>Work Activities</b>	<b>Repair or Rework Gasket or Seal</b>		X	X	X	X		X Note 1
	<b>Replace Module</b>		X	X	X	X	X	X Note 1
	<b>De-Terminate/Re-Terminate</b>		X	X	X	X		

**Note 1:** Perform local leak rate testing per the station program requirements and test procedures.

**Cross-References:** None

**EPS – Component Test Matrix  
Electrical Power Supply**

**Components:**  
AC Regulated Power Supplies  
DC Regulated Power Supplies

		Test Activities →	Maintenance/ Installation Check EPS-1	Termination Integrity Check EPS-2	Operational Check - Power Off EPS-3	Functional Test EPS-4	Temperature Check EPS-5	
		Test Code →						
<b>Work Activities</b>	<b>Clean</b>		X				X	
	<b>Repair or Replace</b>		X	X	X	X	X	
	<b>Power Supply Adjustment</b>		X			X	X	

**Notes:** None

**Cross-References:** None

Component Test Matrices

**ER – Component Test Matrix  
Relay/Meter**

**Components:  
Time Delay Relays  
Meters**

		Test Activities →	Maintenance/ Installation Check ER-1	Termination Integrity Check ER-2	Operational Check - Power Off ER-3	Functional Test ER-4		
		Test Code →						
<b>Work Activities</b>	<b>Clean and Inspect</b>		X					
	<b>Adjust or Calibrate</b>		X		X	X		
	<b>Repair or Replace</b>		X	X	X	X		

**Notes:** None

**Cross-References:** None

**ERC – Component Test Matrix  
Recombiner**

Components:  
Hydrogen Recombiners

		Test Activities →	Maintenance/ Installation Check ERC-1	Functional Test ERC-2	Calibration ERC-3			
		Test Code →						
<b>Work Activities</b>	<b>Remove or Replace Fuses</b>		X	X				
	<b>Remove or Replace Transformer</b>		X	X				
	<b>Repair or Rework Wiring</b>		X	X	X			
	<b>Remove or Replace Heater</b>		X	X	X			
	<b>Remove or Replace Controller</b>		X	X	X			
	<b>Adjust Breaker Trip</b>		X	X	X			

Notes: None

Cross-References: Circuit Breakers (ECB), Electric Heaters (EH)

**ESG – Component Test Matrix  
Switchgear**

**Components:  
Load Centers  
High-Voltage Bus Ducts**

		Test Activities →	Maintenance/ Installation Check ESG-1	Termination Integrity Check ESG-2	Insulation Resistance Check ESG-3	Functional Test ESG-4	Infrared Scan/ Thermography Check ESG-5	Special Requireme nt Test
		Test Code →						
<b>Work Activities</b>	<b>Repair/Adjust Breaker Components</b>		X	X	X	X	X	X Note 1
	<b>Replace Breaker</b>		X	X	X	X	X	X Note 1
	<b>Protective Relaying/Instrumentation/ Control Circuit Maintenance</b>		X	X	X	X		X Note 1
	<b>Clean and Inspect or Lubricate</b>		X				X	
	<b>Work on Lights or Indicators</b>		X	X				

**Note 1:** Electrical surveillance procedures may be required to be performed for certain breakers that feed safety components, such as reactor safeguard components, containment penetrations, and others.

**Cross-References:** None

**ESW – Component Test Matrix  
Electrical Switch**

Components:  
Hand Switches  
Pushbutton Switches  
Selector Switches

		Test Activities →	Maintenance/ Installation Check ESW-1	Termination Integrity Check ESW-2	Operational Check - Power Off ESW-3	Functional Test ESW-4		
		Test Code →						
<b>Work Activities</b>	Clean or Inspect in Place		X			X		
	Clean or Repair – Remove and Reinstall		X	X	X	X		
	Replace		X	X	X	X		

Notes: None

Cross-References: None

**ETR – Component Test Matrix  
Transformer**

Components:  
Wet Transformers  
Dry Transformers

		Test Activities →	Maintenance/ Installation Check ETR-1	Termination Integrity Check ETR-2	Operational Check - Power Off ETR-3	Functional Test ETR-4	Oil Analysis ETR-5	
		Test Code →						
<b>Work Activities</b>	<b>Repair Dry Transformer</b>		X	X	X	X		
	<b>Repair Wet Transformer</b>		X	X	X	X	X	
	<b>Repair Auxiliaries</b>		X	X	X	X		
	<b>Replace Transformer</b>		X Note 1	X Note 1	X Note 1	X Note 1	X Note 1	
	<b>Replace Oil</b>		X				X	
	<b>Clean or Inspect Bus Connections, Core, Windings, Insulation, and Oil</b>		X	X	X	X	X	

**Note 1:** Large transformers may require a special test procedure(s) to be written for their replacement.

**Cross-References:** None

**EWC – Component Test Matrix  
Wire/Cable**

Components:

Low-Voltage Wire or Cable

High-Voltage Wire or Cable

		Test Activities →	Maintenance/ Installation Check EWC-1	Termination Integrity Check EWC-2	Insulation Resistance Check EWC-3			
		Test Code →						
<b>Work Activities</b>	<b>Lifted Lead/Repair De-Terminate/Re-Terminate</b>		X	X				
	<b>Replace High-Voltage Cable</b>		X	X	X			
	<b>Replace Low-Voltage Cable</b>		X	X	X			
	<b>Repair Stress Cones</b>		X	X	X			
	<b>Splice</b>		X		X			

Notes: None

Cross-References: None

**Instrumentation and Controls - Component Test Matrices**

Equipment Code	Type of Equipment	Page
IA	Annunciator	A-23
IB	Bistable/Relay	A-24
ICI	Computer I/O	A-25
ICN	Converter	A-26
ICS	Control Switch	A-27
ID	Digital Component and Assembly	A-28
IFD	Fire Detection	A-29
IGG	Gauge	A-30
IIN	Indicator	A-31
INI	Nuclear Instrumentation	A-32
IPC	Process Controller	A-33
IR	Recorder	A-34
IRM	Radiation Monitor	A-35
IRT	RTD/Thermocouple	A-36
IT	Transmitter	A-37

**IA – Component Test Matrix  
Annunciator**

**Components:**  
Main Annunciator Panels  
Local Alarm Panels

		Test Activities →	Maintenance/ Installation Check IA-1	Termination Integrity Check IA-2	Functional Test IA-3			
		Test Code →						
<b>Work Activities</b>	Replace Light Bulbs		X		X			
	Replace Lenses		X		X			
	Repair or Replace Circuit Board		X	X	X			
	Clean or Inspect		X		X			

**Notes:** None

**Cross-References:** None

Component Test Matrices

**IB – Component Test Matrix  
Bistable/Relay**

**Components:  
Bistables/Relays**

		Test Activities →	Maintenance/ Installation Check IB-1	Tubing Check IB-2	Termination Integrity Check IB-3	Functional Test IB-4		
		Test Code →						
<b>Work Activities</b>	Clean		X			X		
	Repair or Replace Bistable/Relay		X	X	X	X		

**General Note:** Specific plant procedures may be available to conduct these tests and/or to calibrate.

**Cross-References:** None

**ICI – Component Test Matrix  
Computer I/O Devices**

Components:  
Computer I/Os and Hardware

		Test Activities →	Maintenance/ Installation Check ICI-1	Termination Integrity Check ICI-2	Functional Test ICI-3	Calibration		
		Test Code →						
<b>Work Activities</b>	Clean or Inspect, Replace Filter		X					
	Repair or Replace Input/Output Device or Card		X	X	X	X Note 1		
	Rewire Device		X	X	X			
	Lift and Re-Land Terminations		X	X				
	Modify Software				X			

**Note 1:** Channel calibrations and checks are performed per the station procedures.

**Cross-References:** None

Component Test Matrices

**ICN – Component Test Matrix  
Converter**

Components:  
E/P Converters  
I/P Converters

		Test Activities →	Maintenance/ Installation Check ICN-1	Leak Test  ICN-2	Termination Integrity Check ICN-3	Functional Test  ICN-4	Calibration	
		Test Code →						
<b>Work Activities</b>	Clean and Inspect		X	X	X	X		
	Repair or Replace		X	X	X	X	X Note 1	

**Note 1:** Channel checks and calibrations are performed in accordance with the station procedures.

**Cross-References:** Air-Operated Valves (MVA)

**ICS – Component Test Matrix  
Control Switch**

**Components:**

**Control Switches, Flow Switches, Pressure Switches, Limit Switches, Temperature Switches, Level Switches**

		<b>Test Activities →</b>	<b>Maintenance/ Installation Check ICS-1</b>	<b>Leak Test  ICS-2</b>	<b>Termination Integrity Check ICS-3</b>	<b>Operational Check - Power Off ICS-4</b>	<b>Functional Test  ICS-5</b>	<b>Calibration  ICS-6</b>
		<b>Test Code →</b>						
<b>Work Activities</b>	<b>Clean and Inspect</b>		X			X	X	
	<b>Adjust Settings</b>		X	X Note 1	X Note 1	X Note 1	X	X Note 2
	<b>Repair or Replace Component</b>		X	X	X	X	X	X Note 2

**Note 1:** Perform the test when the instrument is physically removed from the original location.

**Note 2:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** None

**ID – Component Test Matrix  
Digital Component and Assembly**

**Components:  
Digital Components and Assemblies**

		Test Activities →	Maintenance/ Installation Check ID-1	Termination Integrity Check ID-2	Functional Test ID-3	Calibration (See General Note)		
		Test Code →						
<b>Work Activities</b>	<b>Replace Analog System with Digital Component or Assembly</b>		X	X	X			
	<b>Repair or Replace Digital Component or Assembly</b>		X	X	X			
	<b>Rewire Digital Device</b>		X	X	X			
	<b>Modify Software</b>		X	X	X			

**General Note:** Most digital platform analog input modules require no calibration. However, until the industry gains more experience with the technology, the calibration accuracy must be confirmed periodically. This can be done in conjunction with instrument calibration.

**Cross-References:** None

**IFD – Component Test Matrix  
Fire Detection**

**Components:**  
 Ionization Detectors  
 Heat Detectors, Heat Sensors  
 Fire Detection Panel Devices

		Test Activities →	Maintenance/ Installation Check IFD-1	Termination Integrity Check IFD-2	Functional Test IFD-3			
		Test Code →						
<b>Work Activities</b>	Clean or Inspect		X					
	Adjust, Repair, or Replace Detectors/Sensing Wire		X	X	X Note 1			
	Adjust, Repair, or Replace Internal Panel Cards		X	X	X Note 1			

**Note 1:** Perform the testing as required by the station fire protection program and per the station test procedures. Contact the fire protection coordinator for any other administrative requirements.

**Cross-References:** Fire Protection Devices (MFP)

Component Test Matrices

**IGG – Component Test Matrix  
Gauge**

**Components:  
Local Gauges  
Gauge Savers**

		Test Activities →	Maintenance/ Installation Check IGG-1	Leak Test  IGG-2	Calibration  IGG-3			
		Test Code →						
<b>Work Activities</b>	<b>Clean or Inspect</b>		X	X				
	<b>Repair or Replace Gauge</b>		X	X	X Note 1			
	<b>Repair or Replace Gauge Saver</b>		X	X				

**Note 1:** Calibration is to be performed per the station procedures.

**Cross-References:** None

**IIN – Component Test Matrix Indicators**

Components:  
Board Indicators

		Test Activities →	Maintenance/ Installation Check IIN-1	Termination Integrity Check IIN-2	Functional Test IIN-3	Calibration IIN-4		
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace</b>		X	X	X Note 1	X Note 2		
	<b>Clean or Inspect</b>		X					
	<b>Indicator/Loop Adjustments</b>		X	X	X	X Note 2		

**Note 1:** A loop test is performed if the indicator is for remote indication or for a signal to protective circuitry or if it is a computer input.

**Note 2:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** None

**INI – Component Test Matrix  
Nuclear Instrumentation**

**Components:**

**Ex-Core Nuclear Instrumentation Components**

**In-Core Nuclear Instrumentation Components**

		Test Activities →	Maintenance/ Installation Check INI-1	Channel Calibration INI-2	Detector Calibration INI-3	Functional Test INI-4		
		Test Code →						
<b>Work Activities</b>	<b>Repair or Replace Cable</b>		X	X	X			
	<b>Repair or Replace Detectors</b>		X	X	X	X		
	<b>Repair or Replace Signal Conditioning Components or Channel Power Supply</b>		X Note 1	X		X		

**Note 1:** Power supplies should be bench-checked for AC ripple voltage prior to installation.

**Cross-References:** None

**IPC – Component Test Matrix  
Process Controller**

Test Activities →		Maintenance/ Installation Check IPC-1	Operation Check IPC-2	Device Calibration IPC-3	Channel Calibration IPC-4	Channel Functional Test IPC-5	
Test Code →							
<b>Work Activities</b>	<b>Remove or Replace Controller</b>	X	X	X	X	X	
	<b>Remove or Replace Pneumatics</b>	X	X	X	X	X	
	<b>Repair Electronics</b>	X	X	X	X	X	
	<b>Clean and Inspect Controller</b>	X	X		X	X	
	<b>Repair or Replace Relays</b>	X	X			X	
	<b>Perform Adjustments to Settings</b>	X		X	X	X	

**General Note:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** Control Switches (ICS), Transmitters (IT), Bistables (IB)

Component Test Matrices

**IR – Component Test Matrix Recorder**

**Components:  
Strip Chart Recorders**

		Test Activities →	Maintenance/ Installation Check IR-1	Termination Integrity Check IR-2	Functional Test IR-3	Calibration IR-4		
		Test Code →						
<b>Work Activities</b>	Clean or Inspect, Lubricate		X		X			
	Repair or Replace Pens or Drive Components		X		X			
	Repair or Replace Electronic Component		X	X	X	X Note 1		

**Note 1:** The calibration is performed per the station procedures.

**Cross-References:** None

**IRM – Component Test Matrix  
Radiation Monitor**

**Components:  
Process Radiation Monitor  
Area Radiation Monitor**

		Test Activities →	Maintenance/ Installation Check IRM-1	Leak Test  IRM-2	Termination Integrity Check IRM-3	Functional Test  IRM-4	Calibration  IRM-5	
		Test Code →						
<b>Work Activities</b>	<b>Clean, Survey, or Inspect and Lubricate</b>		X			X		
	<b>Repair or Replace Electronic Component</b>		X		X	X	X Note 1	
	<b>Repair or Replace Mechanical Component or Detector</b>		X	X	X	X	X Note 1	

**Note 1:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** None

**IRT – Component Test Matrix  
RTD/Thermocouple**

**Components:**  
Resistance Temperature Detectors (RTDs)  
Thermocouples  
Thermowells

		Test Activities →	Maintenance/ Installation Check IRT-1	Leak Test  IRT-2	Termination Integrity Check IRT-3	Functional Test  IRT-4	Calibration  IRT-5	
		Test Code →						
<b>Work Activities</b>	<b>Clean or Inspect</b>		X	X				
	<b>Repair or Replace RTD or Thermocouple</b>		X		X	X	X Note 1	
	<b>Repair or Replace Thermowell</b>		X	X		X		

**Note 1:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** Transmitter (IT)

**IT – Component Test Matrix  
Transmitter**

**Components:**  
 Pressure Transmitters  
 Level Transmitters  
 Flow Transmitters  
 Temperature Transmitters

		Test Activities →	Maintenance/ Installation Check IT-1	Leak Test IT-2	Termination Integrity Check IT-3	Functional Test IT-4	Calibration IT-5	
		Test Code →						
<b>Work Activities</b>	Clean or Inspect		X			X		
	Repair or Replace Transmitter		X	X	X	X	X Note 1	
	Repair or Replace Power Supply		X		X	X	X Note 1	
	Repair or Replace Pneumatics		X	X		X	X Note 1	

**Note 1:** Instrument calibrations, channel (loop) checks, channel calibrations, and device calibrations are performed in accordance with the station procedures.

**Cross-References:** Power Supply (EPS)

## **Mechanical Equipment - Component Test Matrices**

<b>Equipment Code</b>	<b>Type of Equipment</b>	<b>Page</b>
MAH	Air Handling Unit/Fan/Blower	A-39
MC	Coupling	A-41
MCD	Condenser	A-42
MCH	Crane/Hoist	A-43
MCP	Compressor	A-44
MD	Dryer	A-45
MDD	Damper/Ducting	A-46
MDE	Diesel Engine	A-47
MFP	Fire Protection Devices	A-49
MFS	Filter/Strainer/Demineralizer	A-50
MGT	Gearbox/Transmission	A-51
MGV	Governor, Hydraulic	A-52
MHD	Hydraulic Drive	A-53
MHX	Heat Exchanger	A-54
MP	Pump	A-55
MPP	Piping/Tubing/Welded Components	A-56
MPS	Pipe Support/Hanger	A-57
MRC	Refrigeration Unit/Chiller	A-58
MRF	Radiation Filter	A-59
MS	Snubber	A-60
MT	Turbine	A-61
MTV	Tank/Vessel/Accumulator	A-62
MV	Valve, Manually Operated	A-63
MVA	Valve, Air-/Pneumatic-Operated	A-64
MVC	Valve, Check	A-65
MVM	Valve, Motor-Operated	A-66
MVR	Valve, Relief/Safety	A-67
MVS	Valve, Solenoid	A-68

**MAH – Component Test Matrix  
Air Handling Unit/Fan/Blower  
(Page 1 of 2)**

**Components:  
Squirrel-Cage Fans  
Air-Handling Units  
Vane Axial Fans**

		Test Activities →	Maintenance/ Installation Check MAH-1	Functional Test MAH-2	Special Test MAH-3			
		Test Code →						
<b>Work Activities</b>	<b>Adjust or Replace Drive Belts</b>	X	X	X Note 1				
	<b>Repair or Replace Bearings or Coupling</b>	X	X	X Note 1				
	<b>Repair or Replace Motor</b>	X	X	X Note 1				
	<b>Clean and Inspect Air Handler or Fan</b>	X	X					
	<b>Repair or Replace Fan, Blades, or Rotating Component</b>	X	X	X Note 1				
	<b>Alignment</b>	X	X	X Note 1				
	<b>Adjust Blade Pitch and Adjust Balance</b>	X	X	X Note 1				

**Note 1:** Special tests should include vibration monitoring for the components in the predictive monitoring program.

**Cross-References:** Motor (EM), Control Switch (ICS)

**MAH – Component Test Matrix  
Air Handling Unit/Fan/Blower  
(Page 2 of 2)**

**Components:  
Squirrel-Cage Fans  
Air Handling Blowers  
Vane Axial Fans**

		Test Activities →	Maintenance/ Installation Check MAH-1	Functional Test MAH-2	Special Test MAH-3			
		Test Code →						
<b>Work Activities</b>	<b>Replace Access Door or Manway Gaskets</b>		X	X				
	<b>Lubricate Air Handler or Fan</b>		X	X				
	<b>Clean or Replace Filters or Screens</b>		X	X				
	<b>Replace Water Pump</b>		X	X	X Note 1			
	<b>Repair, Rework, or Replace Fan Controls</b>		X	X				
	<b>Calibrate Pressure Switches or Controls</b>		X	X				

**Note 1:** Special tests should include vibration monitoring for the components in the predictive monitoring program.

**Cross-References:** Motor (EM), Control Switch (ICS)

**MC – Component Test Matrix  
Coupling**

**Components:  
Couplings**

		Test Activities →	Maintenance/ Installation Check MC-1	Functional Test MC-2				
		Test Code →						
<b>Work Activities</b>	<b>Clean and Lubricate</b>		X					
	<b>Alignment</b>		X	X				
	<b>Remove/Repair/Replace</b>		X	X				

**Notes:** None

**Cross-References:** None

**MCD – Component Test Matrix  
Condenser**

**Components:  
Main Condenser**

		Test Activities →	Maintenance/ Installation Check MCD-1	Leak Test MCD-2	Functional Test MCD-3	Cathodic Protection Check	Instrument Check	
		Test Code →						
<b>Work Activities</b>	<b>Clean and Inspect Waterside of Condenser</b>		X	X	X	X Note 1	X Note 2	
	<b>Clean and Inspect Steam Side of Condenser</b>		X	X			X Note 2	
	<b>Tube or Tube Sheet Repair</b>		X	X	X	X Note 1	X Note 2	
	<b>Inspect or Repair Baffles</b>		X	X	X			
	<b>Plug Condenser Tube(s)</b>		X	X	X			
	<b>Inspect and Repair Coatings</b>		X					

**Note 1:** Refer to the cathodic protection test matrix (ECP).

**Note 2:** Refer to the general instrument checks (EG1) and applicable I&C component test matrix.

**Cross-References:** Cathodic Protection (ECP), Instrumentation

**MCH – Component Test Matrix  
Crane/Hoist**

Components:  
Cranes and Gantry Cranes  
Hoists  
Trolleys

		Test Activities →	Maintenance/ Installation Check MCH-1	Operation Check (Unloaded) MCH-2	Functional Test MCH-3			
		Test Code →						
<b>Work Activities</b>	Clean, Inspect, and Lubricate		X	X				
	Repair or Replace Cable		X	X	X			
	Repair Trolley, Bridge, or Hoist		X	X	X			
	Replace Brakes, Internals		X	X	X			
	Replace Motor		X Note 1	X	X			

**Note 1:** Perform the test per the appropriate component test matrix.

**Cross-References:** Motor (EM)

**MCP – Component Test Matrix  
Compressor**

**Components:  
Air/Gas Compressors**

		Test Activities →	Maintenance/ Installation Check MCP-1	Operation Check (Unloaded) MCP-2	Functional Test (Note 1) MCP-3			
		Test Code →						
<b>Work Activities</b>	<b>Rework Compressor Internals (Note 2)</b>		X	X	X			
	<b>Rework Intercoolers or Aftercoolers (Note 2)</b>		X	X	X			
	<b>Bearing Work</b>		X	X	X			
	<b>Repack Compressor</b>		X	X				
	<b>Rework Prime Mover</b>		X	X				

**Note 1:** The functional test will include a capacity test on positive displacement.

**Note 2:** External relief valves should be tested in accordance with the separate test matrix.

**Cross-References:** Relief and Safety Valves (MVR)

**MD – Component Test Matrix  
Dryer**

Components:  
Air System Dryer

		Test Activities →	Maintenance/ Installation Check MD-1	Leak Test MD-2	Functional Test MD-3	Dew Point Test MD-4	Particulate Test MD-5	
		Test Code →						
<b>Work Activities</b>	Replace Solenoid Coil		X		X			
	Change Desiccant		X	X	X	X	X	
	Clean or Replace Filters		X	X	X		X	
	Clean or Lubricate Transfer Valve Internals		X		X			
	Repair or Replace Control Box or Timer		X		X			
	Repair or Replace Heater		X	X	X			

Notes: None

Cross-References: None

**MDD – Component Test Matrix  
Damper/Ducting**

**Components:  
HVAC Dampers  
HVAC Ducting**

		Test Activities →	Maintenance/ Installation Check MDD-1	Functional Test MDD-2				
		Test Code →						
<b>Work Activities</b>	<b>Remove, Replace, or Repair Components</b>		X	X				
	<b>Repair or Rework Damper Seats</b>		X	X				
	<b>Repair or Rework Damper Linkage</b>		X	X				
	<b>Change Filters</b>		X Note 1	X Note 1				
	<b>Repair or Rework Damper Operators</b>		X Note 1	X Note 1				

**Note 1:** Refer to the applicable test matrices for these components.

**Cross-References:** None

**MDE – Component Test Matrix  
Diesel Engine  
(Page 1 of 2)**

**Components:  
Diesel Engine**

		Test Activities →	Maintenance/ Installation Check MDE-1	Functional Test  MDE-2 (Note 1)	Fuel Test  MDE-3			
		Test Code →						
<b>Work Activities</b>	<b>Change Belts or Adjust Tension</b>		X	X				
	<b>Remove/Repair/Rework/ Reinstall Lube Oil Pump or Lube Oil Heater</b>		X	X				
	<b>Change Lube Oil and Filter</b>		X	X				
	<b>Replace Coolant or Hoses</b>		X	X				
	<b>Replace Gaskets</b>		X	X				
	<b>Replace Main Bearings</b>		X	X				

**Note 1:** Refer to page 2 of 2 of this component test matrix.

**Cross-References:** Tank (MTV), Pump (MP), Valves, Motors (EM), Fans (MAH), Diesel Generator (EDG), Heat Exchanger (MHX)

**MDE – Component Test Matrix  
Diesel Engine  
(Page 2 of 2)**

**Components:  
Diesel Engine**

		Test Activities →	Maintenance/ Installation Check MDE-1	Functional Test  MDE-2 (Note 1)	Fuel Test  MDE-3			
		Test Code →						
<b>Work Activities</b>	<b>Clean or Adjust Injectors</b>	X Note 1	X	X Note 2				
	<b>Clear or Repair Fuel System Component</b>	X	X	X Note 2				
	<b>Repair Turbocharger</b>	X	X					
	<b>Repair or Adjust Air Start System/Component</b>	X	X					
	<b>Repair or Replace Air Start Air Compressor</b>	X	X					
	<b>Repair or Replace Cooling Water System Component</b>	X	X					

**Note 1:** Use the surveillance test procedure as applicable.

**Note 2:** The fuel test for particulate, aging, and biological contamination is per the station surveillance program.

**Cross-References:** Tank (MTV), Pump (MP), Valves, Motors (EM), Fans (MAH), Diesel Generator (EDG), Heat Exchanger (MHX)

**MFP – Component Test Matrix  
Fire Protection Devices**

Components: Fire Hydrant, Fire Panel Fire Alarm, Monitor Switches, Fire Doors, Deluge Valves, Halon/CO<sub>2</sub> System Components (Note 2)

Test Activities →		Maintenance/ Installation Check MFP-1	Leak Test  MFP-2	Termination Integrity Check MFP-3	Valve Cycle/ Exercise Test  MFP-4	Operational Check  MFP-5	Functional Test  MFP-6
Test Code →							
<b>Work Activities</b>	Clean, Inspect, or Lubricate	X					
	Repair or Replace Fire Hose Station	X	X		X		X Note 1
	Repair or Replace Deluge Valves, Hydrant, or System Clapper Isolation Valve	X	X		X	X	X Note 1
	Adjust or Replace: Spray/Sprinklers/Halon or CO <sub>2</sub> Nozzles or Press. Regul.	X	X			X	X Note 1
	Repair or Replace Air or Water Pressure Switch	X	X	X		X	X Note 1
	Repair, Replace, or Adjust Monitor Switch Emergency Light, or Fire Door Switch	X Note 2		X		X	
	Repair or Replace Fire Alarm Panel Component or Control Circuit Cards	X Note 2		X		X	X Note 1

**Note 1:** Perform the test as required by the station fire protection program and per the station test procedures. Contact the fire protection coordinator for any other administrative requirements.

**Note 2:** Pumps, valves, instrumentation, tanks, etc., used to support the fire protection system should be tested per the applicable component test matrix.

**Cross-References:** Fire Detection (IFD)

**MFS – Component Test Matrix  
Filter/Strainer/Demineralizer**

**Components:**  
Filters  
Strainers  
Demineralizer

		Test Activities →	Maintenance/ Installation Check MFS-1	Functional Test MFS-2				
		Test Code →						
<b>Work Activities</b>	Clean or Inspect		X	X				
	Repair Housing – Demineralizer Vessel		X	X				
	Replace Cartridge Element Housing or Resin		X	X				

**Notes:** None

**Cross-References:** None

**MGT – Component Test Matrix  
Gearbox/Transmission**

**Components:**  
Gearboxes  
Transmissions  
Reduction Gears

		Test Activities →	Maintenance/ Installation Check MGT-1	Functional Test MGT-2				
		Test Code →						
<b>Work Activities</b>	<b>Remove and Replace</b>		X	X				
	<b>Repair, Rework, or Replace Internal Parts</b>		X	X				
	<b>Align Shaft</b>		X	X				
	<b>Change Oil and Filter</b>		X	X				
	<b>Replace Seals</b>		X	X				

**Notes:** None

**Cross-References:** Coupling, Motor

**MGV – Component Test Matrix  
Governor, Hydraulic**

**Components:  
Hydraulic Governor**

		Test Activities →	Maintenance/ Installation Check MGV-1	Functional Test MGV-2				
		Test Code →						
<b>Work Activities</b>	<b>Clean and Lubricate</b>		X	X				
	<b>Adjust Linkage</b>		X	X				
	<b>Adjust or Replace Packing</b>		X	X				
	<b>Replace Wire (Note 1)</b>		X	X				
	<b>Disassemble, Inspect, Replace, or Repair Governor</b>		X	X				
	<b>Repair or Replace Actuator</b>		X	X				
	<b>Replace or Replenish Hydraulic Fluid (Oil)</b>		X	X				

**Note 1:** Check the appropriate matrix to identify additional test(s).

**Cross-References:** Electrical Wire/Cable (EWC)

**MHD – Component Test Matrix  
Hydraulic Drive**

Components:  
Hydraulic Drives

		Test Activities →	Maintenance/ Installation Check MHD-1	Functional Test MHD-2	Vibration Test MHD-3			
		Test Code →						
<b>Work Activities</b>	<b>Change Hydraulic Fluid</b>		X	X				
	<b>Overhaul Hydraulic Drive</b>		X Note 1	X	X			
	<b>Repair or Replace Non-Rotating Component</b>		X	X				
	<b>Repair or Replace Rotating Component</b>		X Note 1	X	X			

**Note 1:** Check the coupling matrix (MC) for possible additional testing.

**Cross-References:** Coupling (MC)

**MHX – Component Test Matrix  
Heat Exchanger**

Components:  
Mechanical Heat Exchanger  
Feedwater Heater  
Steam Generator

		Test Activities →	Maintenance/ Installation Check MHX-1	Leak Test MHX-2	Functional Test MHX-3	Special Requirements or Tests MHX-4		
		Test Code →						
<b>Work Activities</b>	<b>Disassemble, Clean and Inspect, and Reassemble</b>	X	X	X	X	Note 1		
	<b>Remove and Install or Repair Access Cover</b>	X	X	X	X	Note 1		
	<b>Rework Tube Bundle</b>	X	X	X	X	Note 1		
	<b>Inspect Repair Baffles</b>	X	X	X	X	Note 1		
	<b>Plug Tubes</b>	X	X	X	X	Note 1		
	<b>Remove, Repair, or Replace Insulation</b>	X						
	<b>Inspect and Repair Coatings</b>	X						
	<b>Replace Cathodic Protection Component</b>	X Note 2						

**Note 1:** If the work affects pressure-retaining components, ASME Section XI requirements may apply.

**Note 2:** Check the other matrices for additional test requirements.

**Cross-References:** Cathodic Protection (ECP)

**MP – Component Test Matrix  
Pump**

**Components:**  
Centrifugal Pumps  
Positive Displacement Pumps

		Test Activities →	Maintenance/ Installation Check MP-1	Operation Check Unloaded MP-2	Functional Test MP-3	Special Test		
		Test Code →						
<b>Work Activities</b>	<b>Repack Pump</b>		X	X		X Note 1		
	<b>Replace Seal</b>		X	X	X	X Note 1		
	<b>Replace Bearing</b>		X	X	X	X Note 1		
	<b>Lubricate</b>		X					
	<b>Repair or Replace Internal Parts</b>		X	X	X	X Note 1		
	<b>Replace Pump</b>		X	X	X	X Note 1		
	<b>Motor/Prime Mover Maintenance</b>		X Note 2	X Note 2	X Note 2	X Note 1		

**Note 1:** Pumps identified in the ASME Inservice Testing program should be tested in accordance with the program commitments and per the station procedures.

**Note 2:** Refer to the prime mover component matrix (for example, motor) for additional component tests.

**Cross-References:** Motor (EM), Diesel Engine (MDE)

**MPP – Component Test Matrix  
Piping/Tubing/Welded Components**

**Components:**  
Piping  
Tubing  
Welded Components

		Test Activities →	Maintenance/ Installation Check MPP-1	Hydrostatic Test MPP-2	Special			
		Test Code →						
<b>Work Activities</b>	<b>Remove or Replace</b>	X	X	X Note 1				
	<b>Weld Repair</b>	X	X	X Note 1				
	<b>Inspection/Clean</b>	X						

**Note 1:** The pipe code class determines the applicable ASME Section XI or B31.1 program to be used to re-establish pressure boundary integrity. Perform all pressure tests and at-pressure inspections as required by the station program and procedures.

**Cross-References:** Snubbers, Pipe Supports/Hangers

**MPS – Component Test Matrix  
Pipe Support/Hanger**

Components:  
Pipe Supports  
Spring Cans  
Pipe Hangers

		Test Activities →	Maintenance/ Installation Check	Hanger Setting Verification				
		Test Code →	MPS-1	MPS-2				
<b>Work Activities</b>	<b>Repair Piping or Pipe Attachment</b>	X						
	<b>Inspect and Adjust Hanger</b>	X	X Note 1					
	<b>Repair or Replace Support and Hanger</b>	X	X Note 1					

**Note 1:** Thermal expansion checks for high-temperature systems are as required.

**Cross-References:** None

**MRC – Component Test Matrix  
Refrigeration Unit/Chiller**

**Components:  
Refrigeration Units  
Chiller and Coolers**

		Test Activities →	Maintenance/ Installation Check MRC-1	Operational Check MRC-2	Functional Test MRC-3	Leak Test MRC-4		
		Test Code →						
<b>Work Activities</b>	<b>Open and Inspect Heat Exchangers/Coils</b>		X	X	X	X		
	<b>Repair or Replace Pump or Compressor</b>		X	X	X Note 1	X		
	<b>Recharge Refrigerant</b>		X	X	X	X		
	<b>Repair or Replace Control Devices/Control Valves</b>		X	X	X	X		
	<b>Change Oil in Compressor</b>		X	X		X		

**General Note:** Refer to the individual component test matrices for pumps, valves, fans, and other components.

**Note 1:** The testing should include vibration monitoring.

**Cross-References:** Pump (MP), Fan (MAH), Air-Operated Valve (MVA)

**MRF – Component Test Matrix  
Radiation Filter**

**Components:  
Radiation Filters**

		Test Activities →	Maintenance/ Installation Check MRF-1	Functional Test MRF-2				
		Test Code →						
<b>Work Activities</b>	<b>Remove or Replace Filter</b>	X	X					
	<b>Replace Cartridge</b>	X	X					
	<b>Install New Top Flange on Filter</b>	X	X					

**Notes:** None

**Cross-References:** None

**MS – Component Test Matrix  
Snubber**

**Components:  
Snubbers**

		Test Activities →	Maintenance/ Installation Check MS-1	Setting Check MS-2	Stroke Test MS-3			
		Test Code →						
<b>Work Activities</b>	<b>Remove for Testing</b>	X	X	X				
	<b>Repair or Replace</b>	X	X	X				
	<b>Add Fluid (Hydraulic)</b>	X		X				
	<b>Replace Control Valve (Hydraulic)</b>	X	X	X				

**Notes:** None

**Cross-References:** None

**MT – Component Test Matrix  
Turbine**

Components:  
Main Turbine  
Terry Turbine  
Feedwater Pump Turbine

		Test Activities →	Maintenance/ Installation Check MT-1	Leak Test MT-2	Operational Check MT-3	Functional Test MT-4		
		Test Code →						
<b>Work Activities</b>	Open and Inspect Bearings, Rotor, Blading, and Nozzles; Work Bearings		X	X	X	X		
	Inspect, Repair, or Clean Lube Oil System Sump, Strainers		X		X			
	Repair Control System, Overspeed Devices, or Overspeed Trip Mechanism		X		X	X		
	Turbine Alignment		X		X	X		
	Repair or Rework Throttle Valves, Admission Valves, or Intercept Valves		X	X	X	X		
	Repair or Replace Casing/Relief Valve		X	X				
	Repair Gland Seal Regulator		X	X	X			

**General Note:** Refer to other mechanical and I&C component test matrices for individual component details including valves, pumps, tanks, controllers, governors, and other components.

**Cross-References:** None

**MTV – Component Test Matrix  
Tank/Vessel/Accumulator**

**Components:**  
Tanks, Accumulators  
Pressure Vessels, Open Vessels  
Filter Housings, Dryer Housings

		Test Activities →	Maintenance/ Installation Check MTV-1	Pressure Test MTV-2	Parameter Check MTV-3			
		Test Code →						
<b>Work Activities</b>	Clean or Inspect External Appurtenances	X						
	Clean or Inspect Internal Components	X		X				
	Repair Pressure Boundary, Structural Members, Walls, Baffles, Penetrations	X	X	X				
	Repair to Internal Coatings or Components Inside Tank/Vessel	X	X	X				
	Repair or Replace Gaskets, Flanges, or Leaks	X	X					
	Replace Vessel	X	X	X				

**Notes:** None

**Cross-References:** None

**MV – Component Test Matrix  
Valve, Manually Operated**

Components:

Manually Operated: Globe Valves, Gate Valves, Butterfly Valves, Needle Valves, and Remote Manual Operators

Test Activities →		Maintenance/ Installation Check MV-1	Valve Cycle/ Exercise Test MV-2	Flow and Pressure Test MV-3	Leak Test MV-4	Position Indication Check MV-5	Seat Leakage Test MV-6
Test Code →							
<b>Work Activities</b>	<b>Packing Adjustment or Replacement</b>	X	X Note 2		X		
	<b>Valve Replacement</b>	X	X Note 2	X	X	X	X
	<b>Disassembly and Repair of Valve</b>	X	X Note 2		X	X	X Note 1
	<b>Bonnet Gasket Repair</b>	X	X Note 2				
	<b>Remote Manual Operator Repair</b>	X	X Note 2			X	
	<b>Clean, Inspect, and Lubricate</b>	X	X Note 2				

**General Note:** Certain containment isolation valves may require local leak rate testing for certain maintenance actions.

**Note 1:** This test should be accomplished following repairs to correct excessive seat leakage or repairs that may affect seat leakage.

**Note 2:** If the valve is in service, contact the control room to perform valve cycling.

**Cross-References:** None

**MVA – Component Test Matrix  
Valve, Air-/Pneumatic-Operated**

**Components:  
Air-Operated Valves**

		Test Activities →	Maintenance/ Installation Check MVA-1	Valve Cycle/ Exercise Test MVA-2	Stroke Time Test MVA-3	Position Indication Check MVA-4	Leak Test MVA-5	Automatic Operation Test MVA-6
		Test Code →						
<b>Work Activities</b>	<b>Packing Replacement or Packing Adjustments</b>		X Note 1	X	X Note 2		X	
	<b>Valve Replacement</b>		X Note 1	X	X Note 2		X	X
	<b>Internal Valve Repairs</b>		X Note 1	X	X Note 2		X	
	<b>Limit Switch Repair or Replacement</b>		X	X	X Note 2	X		X
	<b>Air Actuator Repair or Replacement</b>		X	X	X Note 2	X		X
	<b>Solenoid Repair or Replacement</b>		X	X	X Note 2			
	<b>Adjust Stroke</b>		X	X	X Note 2	X		

**General Note:** Certain valves may require local leak rate testing. Refer to the station program and procedures.

**Note 1:** Perform maintenance checks per the manual valve test guide and matrix (MV).

**Note 2:** Perform stroke time measurements for valves required by the inservice test (ASME IST) program.

**Cross-References:** Manual Valve (MV), Converter (ICN)

**MVC – Component Test Matrix  
Valve, Check**

**Components:  
Check Valves**

		Test Activities →	Maintenance/ Installation Check	Leak Test	Valve Cycle and Position Indication Check MVC-3	Reverse Flow Test	Flow and Pressure Test	Seat Leakage Test
		Test Code →	MVC-1	MVC-2	MVC-3	MVC-4	MVC-5	MVC-6
<b>Work Activities</b>	<b>Valve Replacements</b>	X	X	X Note 1	X	X	X	X Note 2
	<b>Valve Internals Repairs</b>	X	X	X Note 1	X	X	X	X Note 2
	<b>Clean/Inspection or Lubrication</b>	X	X	X Note 1				

**General Note:** Local leak rate testing may be required for work on the containment isolation valves. Refer to the station program and procedures.

**Note 1:** Perform this check if an indicator is installed.

**Note 2:** This test may be performed in the shop or by the valve vendor (for a new valve).

**Cross-References:** None

**MVM – Component Test Matrix  
Valve, Motor-Operated**

**Components:  
Motor-Operated Valves**

		Test Activities →	Maintenance/ Installation Check MVM-1	Valve Cycle/ Exercise Test MVM-2	Stroke Time Test MVM-3	Position Ind./Torque Switch Check MVM-4	Current Test MVM-5	Automatic Operation Test MVM-6
		Test Code →						
<b>Work Activities</b>	<b>Packing Replacement or Packing Adjustments</b>	X Note 1	X	X			X	
	<b>Internal Valve Repairs</b>	X Note 1		X Note 2			X Note 2	
	<b>Motor Repair or Replacement</b>	X	X	X	X	X	X	X
	<b>Limit Switch Repair or Replacement</b>	X		X Note 2	X			
	<b>Torque Switch Repair or Replacement</b>	X	X	X	X	X	X	
	<b>Stroke Adjustments</b>		X		X			
	<b>Valve Replacement</b>	X Note 1	X	X Note 2	X	X	X Note 2	X

**General Note:** Certain valves may require local leak rate testing. Refer to the station program and procedures. Certain valves may require valve diagnostic testing per licensing commitments. Refer to the station program and test procedures.

**Note 1:** Perform maintenance checks per the manual valve test guide and matrix (MV).

**Note 2:** Verify the stroke time/current tests as required by the ASME inservice test program requirements and technical specifications. Refer to the appropriate program and procedures.

**Cross-References:** Manual Valve (MV)

**MVR – Component Test Matrix  
Valve, Relief and Safety**

Components:  
Relief Valves  
Safety Valves

		Test Activities →	Maintenance/ Installation Check MVR-1	Set Point Check MVR-2	Valve Packing Leak Test MVR-3	Position Indication Check MVR-4	Seat Leakage Test MVR-5	
		Test Code →						
<b>Work Activities</b>	<b>Disassembly of Valve (Note 3)</b>		X	X Note 1, 2	X	X	X	
	<b>Spring Replacement</b>		X	X Note 1, 2	X			
	<b>Replace Valve (Note 3)</b>		X	X Note 1, 2	X	X	X	

**General Note:** Certain valves may require local leak rate testing for containment isolation.

**Note 1:** Conduct periodic relief settings checks as dictated by the ASME Code and the station relief valve program.

**Note 2:** Bench-test set pressure prior to installation.

**Note 3:** Check the licensing documents for special test requirements.

**Cross-References:** None

Component Test Matrices

**MVS – Component Test Matrix  
Valve, Solenoid**

**Components:  
Solenoid Valves**

		Test Activities →	Maintenance/ Installation Check MVS-1	Valve Cycle/ Exercise Test MVS-2	Position Indication Check MVS-3	Seat Leakage Test MVS-4	Automatic Operation Test MVS-5	Special Tests
		Test Code →						
<b>Work Activities</b>	<b>Solenoid Valve Replacement</b>	X Note 1	X	X	X	X	X	X Note 2
	<b>Internal Repairs (Kit)</b>	X Note 1	X	X	X	X		X Note 2
	<b>Coil Repair or Replace</b>	X	X	X			X	X Note 2

**Note 1:** Perform the maintenance checks per the manual valve test matrix (MV).

**Note 2:** Certain valves may require special testing, such as local leak rate testing and other ASME inservice testing. Refer to the station program and procedures.

**Cross-References:** Manual Valves (MV)

# B

## ELECTRICAL TESTING GUIDE AND TEST DEFINITIONS

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### INDEX TO ELECTRICAL EQUIPMENT TESTING GUIDE AND TEST DEFINITIONS

#### Electrical Equipment – General Testing

Equipment Code	Guidance	Page
EG-1	General Electrical Maintenance/Installation Checks	B-3
EG-2	General Electrical Run/Operational Tests	B-4
EG-3	General Electrical Functional Tests	B-5

#### Electrical Equipment – Component Testing

Equipment Code	Guidance	Page
EBC	Battery/Battery Charger	B-7
EC	Electrical Contactor	B-10
ECB	Circuit Breaker	B-13
ECP	Cathodic Protection	B-16
EDG	Diesel Generator	B-17
EFB	Fuse Block	B-20
EGN	Generator, Main	B-22
EH	Electric Heater	B-25
EHT	Heat Tracing Circuits/Equipment	B-27
EIN	Inverter	B-29
EM	Motor, Electric	B-32
EMG	Motor Generator	B-35
EPN	Penetration	B-37
EPS	Power Supply	B-39
ER	Relay/Meter	B-42
ERC	Recombiner	B-44

*Electrical Testing Guide and Test Definitions*

<b>Equipment Code</b>	<b>Guidance</b>	<b>Page</b>
ESG	Switchgear	B-46
ESW	Switch, Electrical	B-49
ETR	Transformer	B-51
EWC	Wire/Cable	B-54

## EG Electrical Equipment – General Testing

### ***EG-1 – General Electrical Maintenance/Installation Check***

The following are general tests that should be performed where appropriate.

#### A. Inspection Check

1. Visually inspect to determine that the component is securely fastened to a support structure, and verify seismic qualification acceptability; for example, bolts must be at the specified torque to ensure that the component does not receive excessive "g" loading and does not jeopardize the seismic qualification.
2. Verify that all fasteners are in place and that connections to terminal blocks are tight.
3. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
4. Verify that there is no corrosion on the component terminals, and check for component cleanliness.
5. Verify that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.

#### B. Electrical Check

1. Point-to-point wiring verifications (continuity checks).
2. Verify that values of opens, shorts, and grounds are acceptable. For components that require casing or cabinet ground, verify that continuity exists between the component and station ground, using a low-voltage continuity test (resistance should not exceed 0.5 ohms).
3. Termination Checks:
  - Check the terminals connecting the component to cables against the plant electrical wiring or elementary drawings to verify that the connections match those documents.
  - Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the component.
  - Verify that the terminal lugs are torqued, when required, to the values specified in the manufacturer's bulletins or other documents. Verify that all washers and other fasteners are in place on the terminal lug per the applicable drawings.
4. Meggering/dielectric/hi pot testing of cables, connections, or splices to test the dielectric breakdown strength of electrical insulation and oils.
5. Verify that all control and protective circuits have been checked to ensure operability. For any work that was completed on the devices (such as relays), the appropriate test matrix should be referenced to determine if additional PMT is required.
6. Verify that a circuit reenergizes upon replacement of a breaker or other rework.

### C. Equipment Qualification Check

1. Review the plant equipment qualification procedures and the manufacturer's installation instructions, bulletins, and equipment qualification lists to ensure that the correct parts have been used for replacement.
2. Verify that the existing parts in use are not worn excessively. If any worn parts are found that could affect the equipment qualification, ensure that the correct disposition of those parts is performed; for example, the part does not complete its qualified life and fails early, necessitating a new analysis of qualified life for the part.
3. Verify that inspection of splices, seals, or torquing of disturbed components is performed to ensure that environmental qualification is maintained.
4. Verify that any lubricants, gaskets, or other expendables used during maintenance are of the type specified in the equipment qualification program.

### **EG-2 – General Electrical Run/Operational Test**

This testing demonstrates the normal operation of the component for which maintenance has been completed. The following tests or checks are general and are provided for consideration where specific test guides have not been provided.

1. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
2. Verify that the support or auxiliary systems related to the component are functioning properly:
  - Fire detection systems, if applicable
  - Lubrication systems
  - Space heaters
  - Cooling heat exchanger and cooling water flow
3. Verify that all control and protective circuits have been checked to ensure operability. For any work on the components (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
4. Verify proper operation visually. This is a qualitative assessment based on experience. For example, a motor should start on demand and drive process equipment acceptably while operating at rated speed.
  - Operate the equipment several times over the extent of its operating range.
  - Verify the operation of controllers for intended interlocked components.
5. For rotating equipment:
  - Verify that the physical rotation of the component is free from binding, noise, and drag effects.

- Verify that the proper rotation and process flow direction are correct.
  - Vibration testing may be included with a run test; if vibration testing is not performed, verify that there are no abnormal noises.
  - Verify that the lube system is functioning properly and that the bearing temperature does not exceed the manufacturer’s specifications.
  - Inspect for leaks and proper lube level while the equipment is running. Verify that excess lubricant is cleaned.
  - For other lubricants, operate the equipment, relieve the excess lubricants, inspect, and clean the excess, as required.
6. Performance tests/parameter checks may be conducted to verify adequate performance and to obtain baseline operational data, as determined by testing personnel.

For components not identified in the guide, the PMT specifier must select the applicable test requirements to verify the normal operation of the component. For example, the selected test attributes for a **relay** are:

- Verify that continuity exists between any grounds used on the relay and the station ground, using a low-voltage continuity test.
- Verify that the resistance of the connection of the relay terminals to the cable(s) is not high and that the connections are within a reasonable value of each other.
- Verify that the correct phases/polarity have been connected to the relay.

### **EG-3 – General Electrical Functional Test**

This test or verification ensures that the component, equipment, or subsystem that was affected by the maintenance activity is capable of performing its design functions. The following tests or checks are general and are provided for consideration where specific test guides have not been provided.

1. Verify that the support or auxiliary systems related to the component are functioning properly. Check the following for operability:
  - Fire detection systems, if applicable
  - Lubrication systems
  - Space heaters
  - Cooling heat exchanger and cooling water flow
  - Ventilation system
2. Verify that all control and protective circuits have been checked to ensure operability. For any work on the components (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
3. Verify that the alarm, plant computer input, control, and indication circuits associated with the equipment operation have been checked for operability.

*Electrical Testing Guide and Test Definitions*

4. Verify that all jumpers have been removed. Also, verify that all fuses have been installed.
5. Verify that the correct voltage is present on all energized parts.
6. Energize each circuit that was repaired or reworked, and verify the correct voltage output and load acceptance for that circuit. Record the voltage and test equipment data.
7. Energize the component unloaded, if possible, and verify proper operation per vendor or plant requirements.
8. Verify with the equipment operating that no excessive vibration exists, no pipe connection leaks occur, seal leakage is within acceptable limits, bearing cooling is being provided, and the equipment is performing acceptably.
9. Load the component to minimum, and adjust the output voltage to the vendor's minimum and maximum per specification. Verify that the component operates within the vendor or plant specification limits. Record the results.
10. Verify that the component operates freely with no overheating or other abnormalities occurring during the tests conducted with the load connected. Cycle the component several times, if possible.
11. Verify that the component temperature stabilizes and conforms to vendor or plant requirements.
12. Conduct performance tests/parameter checks to verify adequate performance and to obtain baseline operational data, as determined by testing personnel or plant procedures.

For components not identified in the guide, the PMT specifier must select the applicable test requirements to verify the component design function. For example, the selected test attributes for a **relay** are:

- Verify that all indication, alarm, and control circuits have been checked to ensure operability.
- Verify that all jumpers have been removed and that any fuses have been replaced.
- Energize the relay, and cycle a minimum of three times by actuating at least one switch or relay contact of the coil circuit.
- The relay energizes and deenergizes to pick up or drop out, and all contact functions on the applicable plant documentation operate as expected.
- The time delay, if applicable, that is set in the relay has been checked to ensure that the value is in accordance with the required setpoint.
- Contact wipe, pickup, dropout, and resistance are adjusted in accordance with the vendor or plant documentation.
- No contact binding exists, and if the relay is a time-delay type, the required time setting has been calibrated for the relay.

## **EBC Battery/Battery Charger Component Testing**

### ***EBC-1 – Maintenance/Installation Check***

The following maintenance checks apply to batteries and battery charger components. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, and equipment qualification
2. Verify that the batteries and/or chargers are the correct size specified and that the components are labeled according to plant drawings. Record the updated data.
3. Verify that structural supports and cell spacers for the battery have been reinstalled and that the orientation and overall installation conform to the design documents.
4. Verify that internal sediment does not touch the battery plates, that the plates in the cells are not discolored, that no plate growth has occurred, and that the plates are properly aligned and spaced. Verify that there is no visible distortion.
5. Verify that no internal cracking or other evidence of degradation, such as cell leakage, has occurred.
6. Verify that the electrolyte level is at the correct marking on the battery and above the plates and that the vents are clear.
7. Verify that the charger has been reinstalled in the correct location per the appropriate station documents.
8. Verify that the charger is reinstalled securely with all required brackets attached.
9. Visually inspect to determine that all locally mounted instrumentation is in current calibration and has normal indication as specified on drawings.
10. Verify that all fasteners are in place and that connections to terminal blocks are tight.
11. Verify that the identification of the cable conductors and termination points is correct according to the plant documentation.
12. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
13. Verify that all indicating lights associated with the device are operating acceptably and that the correct color coding has been used when replacing the lamps.
14. Verify that there is no corrosion on terminals, and check for cleanliness of the components.
15. Verify that the ventilation openings are not obstructed and that all dust is removed.

### **EBC-2 – Termination Integrity Check**

1. Check the terminals connecting the battery charger to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the battery charger.
3. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug.
4. Verify that the battery charger has been connected to the proper polarity by physically observing the connections and checking them with a meter.
5. Verify that no grounds (unless required for operation) exist on the battery charger.

### **EBC-3 – Operational Check - Power Off**

Ensure that the battery components and all control circuit interfaces perform correctly with control power. Test parameter results should be reviewed against the applicable manufacturer's documents and the design documents. If available, use the plant procedures with acceptance criteria to verify acceptable performance. Identified problems should be corrected and evaluated for additional repairs and retest requirements. Applicable data should be included in the plant trending programs.

1. Verify that the battery has been properly charged, especially if the battery has been in storage for an extended time.
2. Verify that the battery is disconnected from its battery charger and from all loads for this check. Ensure that the battery ventilation system is operational.
3. Verify that individual cell specific gravity, electrolyte level, and temperature readings are taken. Ensure that the specific gravity is corrected for temperature.
4. Verify that individual cell voltage readings are taken, and also record the battery terminal voltage.
5. Verify that continuity exists between the battery charger mounting and station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the battery charger and the ground grid does not exceed 0.5 ohms.
6. Perform intercell resistance checks on the battery, if required by plant procedures.
7. Verify that the resistance of the connection of the battery charger terminals to the cable(s) is not high and that the connections are within a reasonable value of each other.
8. Verify that the correct polarities have been connected to the battery charger by conducting a polarity test.
9. If any work has been performed on the feeder breakers, instruments, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.

10. Verify that the support or auxiliary systems related to the battery charger are functioning properly. Check the operating fire detection systems, if applicable.
11. Verify that all control and protective circuits have been checked to ensure operability. For any work on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
12. Verify that each of the current transformers (CTs) and potential transformers (PTs) has had the following checks performed:
  - CTs should be given ratio checks, polarity checks, saturation tests, and winding resistance to ground checks, according to the vendor or plant documentation.
  - Verify that each of the CTs and PTs is mounted correctly and with the correct polarity.
  - Verify that insulation tests have been performed on each PT.

### ***EBC-4 – Functional Test***

Verify the operability of the battery and battery charger by ensuring the capability to charge, that the battery parameters (specific gravity, cell voltage), after charging, are within the acceptance criteria, and that the battery capacity/service discharge and performance discharge are within tolerances specified by the plant procedures or design requirements.

1. Verify through testing (consists of charging the battery and connecting it to the load) that:
  - The battery charger will charge the batteries in the appropriate mode.
  - The individual cell specific gravity is correct.
  - The individual cell voltage is correct.
  - The battery terminal voltage is correct.
  - The required time for charging is correct.
2. Perform a battery capacity/service discharge test according to the plant procedures.
3. Perform a battery discharge test according to the plant procedures.
4. Verify that the alarm, control, and indication circuits associated with the battery charger operation have been checked for operability.
5. Notify operations that power is to be applied to the battery or charger, and verify that the alarm, indication, and control circuits are energized.
6. Perform the following tests by operating the battery charger with the batteries connected:
  - Verify that the dc voltage in float charge mode is correct.
  - Verify that the charger output current is correct.
  - Verify that the dc voltage in equalizing charge mode is correct.
  - Verify that the charging times for worst-case battery conditions meet design criteria.

## **EC Electrical Contactor Component Testing**

### ***EC-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to contactors. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Check the connection to terminal blocks and bus bars for tightness.
3. Verify that the contactor and its components have been reassembled correctly, that all fasteners are in place, and that they are torqued, when required, to the values specified.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that there is no corrosion on terminals or excess dust on conductive parts, and check for cleanliness of the components.
6. Verify that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
7. Verify that the nameplate data on the contactor and its arrangement agree with plant documents.
8. Verify that any fuse or circuit protection associated with the contactor is according to the plant documentation requirements and that the rating or capacity is correct.
9. Verify that any lamps associated with the contactor have been reassembled correctly (with lights in the correct order) and that they are capable of functioning properly.
10. Inspect to verify that no excess heating of parts, charred insulation/odor, corrosion, or dust exists.
11. Verify that contact surfaces on main and auxiliary contactor devices do not contain excessive pitting, roughness, or copper oxide.
12. Examine moving parts to ensure that evidence of binding does not exist.
13. Verify that the contactor spring tension and contact area are acceptable.
14. Verify that auxiliary contacts open and close as required by the plant documentation.

**EC-2 – Termination Integrity Check**

1. Check the terminals connecting the contactor to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the contactor.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or the plant documents. Verify that all washers and other fasteners are in place on the terminal lug per the plant drawings.
4. Verify that the contactor has been connected to the proper phases by physically observing the connections.

**EC-3 – Insulation Resistance Check**

1. Verify that continuity exists between the ground used on and between the contactor and station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the contactor and the ground grid does not exceed 0.5 ohms.
2. Verify that the contactor terminal resistance to the cable and connections to bus bars are less than 0.5 ohms.
3. Verify that the correct phases have been connected to the contactor.
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Conduct a megger check to verify correct insulation resistance. Determine if the contactor has acceptable insulation resistance.
6. Verify by checking with a meter that the contact resistance is within vendor or plant specifications.
7. Close the contactor by operating it manually. Measure with an ohmmeter the resistance between the line and load terminals of each pole. Verify that the resistance meets vendor or plant requirements. Record the following test data:

**Insulation Resistance Test**

- Line-to-load resistance (all phases)
- Phase-to-phase resistance (all phases)
- Phase-to-frame resistance (all phases)

*Electrical Testing Guide and Test Definitions*

**Pole Resistance Test**

- Actual resistance forward (all phases)
  - Actual resistance reverse (all phases).
8. Verify that the auxiliary contact resistance is less than 0.5 ohms.
  9. Verify that the contactor operates freely with no overheating, burning, or other abnormalities occurring during the tests conducted with the load disconnected.

***EC-4 – Functional Test***

1. Verify that the alarm, control, and indication circuits associated with the contactor operation have been checked for operability.
2. Notify operations that power is to be applied to the contactor, and verify that the alarm, indication, and control circuits are energized.
3. Verify that the contactor operates freely with no overheating or other abnormalities occurring during the tests conducted with the load connected. Cycle the contactor several times.

## ECB Circuit Breaker Testing

### ***ECB-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to circuit breakers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Check the connection to terminal blocks and bus bars for tightness.
3. Verify that the circuit breaker and its components have been reassembled correctly, that all fasteners are in place, and that the proper torque of fasteners is used, where applicable.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that there is no corrosion on terminals or excess dust on conductive parts, and check for cleanliness of the components.
6. Verify that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
7. Verify that all insulators are not damaged and that insulation barriers are in place.
8. Verify that the nameplate data on the circuit breaker and its arrangement agree with plant documents.
9. Verify that any lamps associated with the circuit breaker have been reassembled correctly (with lights in the correct order) and that they are capable of functioning properly.
10. Verify that no excess heating of parts, charred insulation/odor, corrosion, or dust exists.
11. Verify that contact surfaces do not contain excessive pitting roughness, or copper oxide and that they have acceptable gap/alignment.
12. Verify that the contactor spring tension and contact area are acceptable.
13. Verify that flexible leads do not have frayed or broken strands. Ensure that leads are flexible and not brittle.
14. Clean the magnet faces; check the shading coils; inspect for misalignment.
15. Visually inspect the wear patterns of the main power stabs. If excessive wear or pitting is found, replace the stabs. Inspect all control stabs using a tension-testing tool (a standard flat-blade screwdriver ground to the dimensions of male stabs). Adjust as necessary.
16. Verify the fuses for proper rating, where applicable, and ensure that the fuse clip pressure is sufficient for proper contact.

17. Verify that the overload heater size is correct.
18. With the breaker isolated from the power source, close and reset the breaker manually to ensure that latching surfaces are free of any binding.

### ***ECB-2 – Termination Integrity Check***

1. Check the terminals connecting the circuit breaker to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the circuit breaker.
3. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug.
4. Verify that the circuit breaker has been connected to the proper phasing by physically observing the connections and checking with a meter.
5. Verify that no grounds (unless required for operation) exist on the circuit breaker.

### ***ECB-3 – Insulation Resistance Check***

1. Verify that continuity exists between the ground used on and between the circuit breaker cubicles and the station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the circuit breaker and the ground grid does not exceed 0.5 ohms.
2. Verify that the correct phases have been connected to the circuit breaker.
3. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
4. Conduct a megger check to verify correct insulation resistance. Determine if the circuit breaker has acceptable insulation resistance.
5. Verify by checking with a meter that the contact resistance is within vendor or plant specifications.

### ***ECB-4 – Functional Test***

1. Prepare the breaker for overload trip tests, and energize the breaker to verify that trip currents and trip times conform to the manufacturer's specifications. Record the data.

**Note:** Periodic thermal and magnetic trip testing of balance-of-plant molded-case circuit breakers (MCCB) should be carefully evaluated. Refer to NUMARC 90-14. It summarizes industry experience with MCCBs.

2. Verify that the alarm, control, protection, and indication circuits associated with circuit breaker operation have been checked for operability.

3. Verify that all protective relay settings have been checked, as necessary. A check of the relay test records is sufficient.
4. Notify operations that power is to be applied to the circuit breaker, and verify that the alarm, indication, and control circuits are energized. Verify successful breaker operation with the load connected.

## **ECP Cathodic Protection Component Testing**

### ***ECP-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to cathodic protection. The criteria for the inspection are as stated in the verification.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: termination, continuity, insulation resistance, equipment grounding, and equipment qualification
2. Verify that no electrode/anode deterioration has occurred.
3. Verify that the rectifier, anode, and electrode are installed in the proper location.
4. Verify continuity for each lifted lead.

### ***ECP-2 – Functional Test***

1. Verify the operability of the cathodic protection by ensuring that the associated parameters (ac input voltage, dc output voltage/amps, etc.) are within the acceptance criteria after the system is reconnected following maintenance completion. Appropriate engineering or vendor manual information should be used to determine acceptability.
2. Verify acceptable values for:
  - ac input voltage
  - dc output voltage/amps
  - Electrode potential between the structure and the reference
3. Adjust the rectifier output so that the anode current is acceptable.

## EDG Diesel Generator Component Testing

### ***EDG-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the generator portion of the diesel generator is complete and that the generator is ready for operational testing. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Verify that the applicable general maintenance installation checks per MG-1 and EG-1 are completed.
2. Verify that gaskets, O-rings, and other expendables have been replaced as required by the vendor or plant documentation.
3. Visually inspect to determine that the generator is securely fastened to a support structure, and verify seismic qualification acceptability; for example, bolts must be at the specified torque to ensure that the generator does not receive excessive "g" loading and does not jeopardize seismic qualification.
4. Verify that all fasteners are in place and that connections to terminal blocks are tight.
5. Verify that there are no broken or missing parts.
6. Check that the wire routing is secure and that it does not bind when covers are closed or moved. Verify that all wiring has been connected according to the vendor or plant documentation; ensure correct phase connections.
7. Verify that all indicating lights associated with the generator are operating acceptably.
8. Verify that there is no corrosion on terminals or the generator, and check for cleanliness of the component.
9. Verify that structural supports for conduit and the generator have been reinstalled and that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.
10. Ensure that slip-rings or brushes were replaced per the manufacturer's strict instructions.
11. Verify that all auxiliary attachments are properly installed.
12. Verify that all drives and couplings are properly aligned.
13. Verify that the generator is reassembled and reconnected according to the plant documentation.

### **EDG-2 – Termination Integrity Check**

1. Verify continuity for each lifted lead.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the generator.
3. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Also, verify that all washers and other fasteners are in place on the terminal lug.

### **EDG-3 – Operational Check - Power Off**

1. Verify that continuity exists between the generator casing and station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the generator and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the generator terminals to the cable(s) is less than 0.5 ohms.
3. Conduct a phase rotation test to verify that the correct phases have been connected to the generator.
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Verify that the support or auxiliary systems related to the generator are functioning properly. Check the following for operability:
  - Fire detection systems, if applicable
  - Lubrication systems
  - Space heaters
  - Cooling heat exchanger and cooling water flow
6. Verify that all control and protective circuits have been checked to ensure operability. For any work on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
7. Check the physical rotation of the generator by manually rotating the shaft in the direction that the diesel generator is expected to run. Verify that it is free from binding, noise, and drag effects.
8. If bearings are disassembled, verify that generator air gap is according to the manufacturer's documentation.

### **EDG-4 – Functional Test**

This testing will demonstrate successful operation of the diesel generator following the maintenance activity.

1. Verify that the control circuit operational check has been performed and that the results are acceptable.
2. Verify that the support or auxiliary systems related to the equipment, such as ventilation, space heaters, cooling heat exchanger, and lubrication, are functioning properly.
3. Verify that the generator breaker is open before energizing the diesel generator.
4. Verify with the diesel generator operating that no excessive vibration exists, no pipe connection leaks occur, seal leakage is within acceptable limits, bearing cooling is being provided, and the diesel engine is performing acceptably.
5. Verify that the diesel generator starts and comes up to speed within the allotted time and operates for at least 10 minutes. Verify the following:
  - Bearing temperature increase does not exceed plant tolerances.
  - Winding temperature does not exceed plant limits.
  - Running direction is correct.
  - Running current does not exceed full load on the nameplate or plant limits.
  - Bus supply and generator terminal voltages are within the nameplate values.
  - Voltage imbalance does not exceed the value specified.
  - Acceptance criteria for vibration readings have been specified. Take readings from at least five points, including the top and outboard ends. Convert the reading to mils displacement. Record the test locations, velocity, and displacement of each point.
  - Vibration switches have been set during the period in which the diesel generator is running.
6. Perform the sequencer load test, if applicable.
7. Verify the diesel generator auto-start functions, and verify synchronization and load speed control and governor control. Return the diesel generator to standby mode.

## **EFB Fuse Block Component Testing**

### ***EFB-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the fuse block is complete and that the fuse block is ready for operational testing. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Verify that the applicable general maintenance installation checks per EG-1 are completed.
2. Verify that the fuse block is reinstalled in the correct location according to the plant documentation.
3. Verify that the fuse block is reinstalled securely and torqued as required.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that all indicating lights associated with the fuse block are operating acceptably.
6. Verify that there is no corrosion on the terminals or the fuse block, and check for cleanliness of the component.
7. Verify that each lifted wire is replaced per the applicable wiring diagram.
8. Verify the correct size, make, and manufacturer for any replacement fuse or fuse block and that it is identical to the original or is an engineering-approved substitute.

### ***EFB-2 – Termination Integrity Check***

1. Check the terminals connecting the fuse block against the plant single line and elementary wiring diagrams to verify that the connections are according to those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting the fuse block.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug.
4. Verify that continuity exists between the grounds used on and between the fuse block station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the fuse block and the ground grid does not exceed 0.5 ohms.
5. Verify that the resistance of the connection of the fuse block terminals to the cable and connections to any bus bar is approximately zero and that the connections are within a reasonable value of each other.
6. Verify that the correct phases have been connected to the fuse block.
7. Conduct megger and polarization index checks to verify acceptable insulation characteristics. Record the data.

### ***EFB-3 – Functional Test***

This testing will demonstrate successful operation of the fuse block following the maintenance activity.

1. Visually inspect the block to verify that nothing will short out.
2. Notify operations that power is to be applied to the fuse block. Conduct testing that energizes the fuse block.
3. Verify that the correct voltage is present on all energized parts.
4. Energize each circuit that was repaired or reworked, and verify the correct voltage output and load acceptance for that circuit. Record the voltage and test equipment data.
5. Verify that all interfaces, such as alarms, plant computer input, and other status output, occur as required.

## **EGN Main Generator Component Testing**

### ***EGN-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to the main generator. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1 and MG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Verify that the main generator and its components have been reassembled correctly, that all fasteners are in place, and that the proper torque of fasteners is used where applicable.
3. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
4. Verify that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
5. Verify that any lamps associated with the main generator have been reassembled correctly (with lights in the correct order) and that they are capable of functioning properly.
6. Ensure that slip-rings or brushes were replaced per the manufacturer's strict instructions.
7. Verify that all appropriate vendor checks have been completed.

### ***EGN-2 – Termination Integrity Check***

1. Check the terminals connecting the main generator to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify each lifted lead by performing a continuity check on each lead.
3. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the main generator.
4. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug per the plant documentation.
5. Verify that the main generator has been connected to the proper phasing by physically observing the connections and checking them with a meter.

**EGN-3 – Operational Check - Power Off**

1. Verify that the support systems associated with the main generator are operational and functioning properly:
  - Isolated phase bus
  - Lube oil systems
  - Heaters
  - Cooling systems
  - Ventilation systems
  - Fire protection systems
2. Conduct a megger check to verify acceptable insulation resistance and record data.
3. Verify that the resistance of the connections from the generator to the isolated phase bus is approximately zero.
4. Check the generator ground and the station ground grid, using a low-voltage continuity test. Verify that the resistance of the connection between the main generator ground and the ground grid does not exceed 0.5 ohms.
5. Verify correct phases connected to the Main Generator.
6. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
7. Verify that all control and protective circuits have been checked to ensure operability. For any work that was completed on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
8. Verify that the physical rotation of the generator is free from binding, noise, and drag effects.

**EGN-4 – Functional Test**

1. Verify that the control circuit check has been performed and that the results are acceptable.
2. Verify that the support systems associated with the main generator are operable and functioning. Verify operation of:
  - Isolated phase bus
  - Lube oil systems
  - Heaters
  - Cooling systems
  - Ventilation systems
  - Fire protection systems

*Electrical Testing Guide and Test Definitions*

3. Verify that a test with specified criteria is completed that includes the following parameter checks:
  - The bearing temperature increase does not exceed the vendor or plant specifications.
  - The winding temperature does not exceed the vendor or plant specifications.
  - The running direction is correct.
  - The generator terminal voltage is within acceptable nameplate or plant requirements.
  - The voltage imbalance does not exceed the plant-specified value.
4. Verify acceptable vibration per EG5, as necessary or as determined by testing personnel.

***EGN-5 – Vibration Testing***

**Note:** Refer also to MG4, General Mechanical Special Test, Vibration Testing, for general requirements.

1. Verify that vibration levels meet acceptable limits by taking a full set of vibration readings on the generator rotor (vertical and horizontal, if possible). The readings should include amplitude and phase angle.
2. Check the vibration of the bearing bracket (vertical and horizontal). Verify acceptable results according to plant requirements.
3. Record generator load, megaVARS, bearing oil drain temperatures, seal oil temperature, and hydrogen gas temperature.

***EGN-6 – Air Test***

1. With air in the generator, raise the pressure to the normal operating pressure of hydrogen (start and end the test at the same time of day over a 24-hour period):
  - Record the pressure drop over a suitable time period.
  - Calculate the equivalent leakage rate of hydrogen.
  - Compare to the specified limits.
  - Record the generator ambient temperature and the barometric pressure before and after the test.

## **EH Electric Heater Component Testing**

### ***EH-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to electric heaters. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Verify that the heater has been reinstalled in the correct location per appropriate plant drawings.
3. Verify that the heater is reinstalled securely with all required brackets attached.
4. Verify that all fasteners are in place and that connections to the terminal blocks are tight.
5. Verify that the identification of the cable conductors and termination points is correct according to the plant documentation.
6. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
7. Verify that there is no corrosion on terminals, and check for cleanliness.

### ***EH-2 – Termination and Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and torqued, where required.
3. Verify that all cable markers are in place and that they match the appropriate wiring diagrams.
4. Verify that heaters are individually wired for the proper heating rate (volt/amps).
5. Verify that the heating element is dry (except the immersion type) and free from dirt and foreign material.
6. Megger the element, and verify that the insulation resistance is within acceptable limits. Record the results.

### ***EH-3 – Functional Test***

1. Notify operations that power is to be applied to the heater.
2. Energize the heater, and verify the following:

*Electrical Testing Guide and Test Definitions*

- The heater current is adequate but not excessive. Refer to the manufacturer's specifications.
  - The thermostat is functioning to regulate temperature within plant requirements.
  - The heater circuit does not trip or overheat.
  - Allow the required time, and verify that the heater is maintaining the required temperature.
  - Any low temperature alarms clear or lights extinguish.
3. Verify that the heater trips at the required amperage when the flow or heating medium is reduced for heaters with over-current protection, except where fuses are installed.
  4. Verify that the heater interlocks with fans or blowers operate in accordance with the plant documentation.

## **EHT Heat Tracing Circuits and Equipment Component Testing**

### ***EHT-1 – Maintenance/Installation Check/Inspection***

The following maintenance checks are both general and specific to the major components in the electrical heat tracing circuits, power supplies, and controls. The criteria for the inspection are as stated in the check/inspections.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Verify the proper location of temperature sensors.
3. Verify the correct re-installation of insulation.

### ***EHT-2 – Termination Integrity Check***

1. Check the terminals connecting the power supply to the heat circuits against the wiring diagrams and or the elementary wire list.
2. Verify that the correct terminal types have been used, and verify the markings on the interconnection cables.
3. Verify that all of the terminal lugs are properly torqued.
4. Verify that no grounds exist.
5. Verify the correct polarity of any connections.

### ***EHT-3 – Thermal Insulation Check***

1. Verify the proper type and thickness of the insulation material.
2. Verify that any insulation ends or splices are properly taped.
3. Verify the proper location of the wiring and temperature controls.
4. Verify that insulation coverage is according to plant drawings.

***EHT-4 – Functional Test***

1. Energize the heat trace circuit, adjust the temperature, and perform a circuit wattage test to ensure the capacity per the design.
2. Verify that over-/under-temperature control set points and alarm set points are per the vendor technical manual requirements.
3. Perform the circuit control card functional check per the vendor manual.
4. Perform the central control unit calibration per the vendor manual.

## **EIN Inverter Component Testing**

### ***EIN-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to inverters. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Visually inspect to determine that all locally mounted instrumentation has been tested and is within calibration and that all devices identified on the plant drawings are located as specified on those drawings.
3. Check that all fasteners are in place and that connections to the terminal blocks are tight.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that all indicating lights associated with the device are operating acceptably and that the correct color coding has been used when replacing the lamps.
6. Verify that there is no corrosion on the terminals, and check for cleanliness of the components.
7. Verify that the ventilation openings are not obstructed.
8. Verify that the nameplate data are correct.

### ***EIN-2 – Termination Integrity Check***

1. Check the terminals connecting the inverter to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the inverter.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lugs per the plant drawings.
4. Verify that the inverter has been connected to the proper phases (ac side) and polarity (dc side) by physically observing the connections and checking with a meter.
5. Verify that no grounds (unless required for operation) exist on the inverter.

### ***EIN-3 – Operation Check- Power Off***

1. Verify that continuity exists between the inverter mounting and the station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the inverter and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the inverter terminals to the cable(s) is not high and that the connections are within a reasonable value of each other.
3. Conduct a phase check (ac side) and a polarity test (dc side) to verify that the correct terminals have been connected to the inverter.
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Verify that the support or auxiliary systems related to the inverter are functioning properly.
6. Verify that all control and protective circuits have been checked to ensure operability. For any work on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
7. Verify that each of the current transformers (CTs) and potential transformers (PTs) has had the following checks performed, and record the information on the appropriate data sheet:
  - CTs should be given ratio checks, polarity check saturation tests, and winding resistance to ground checks per the vendor or plant instructions.
  - Each of the CTs and PTs is mounted correctly and with the correct polarities.
  - The insulation tests have been performed on each PT.

### ***EIN-4 – Functional Test***

Ensure that the inverter and all control circuit interfaces perform acceptably. Test parameter results should be reviewed against the applicable vendor and design documents, and if available, plant procedures with acceptance criteria should be used to verify acceptable performance. Identified problems should be corrected and evaluated for additional repairs and retest requirements.

1. Verify that the alarm, control, and indication circuits associated with the inverter operation have been checked for operability.
2. Notify operations that power is to be applied to the inverter. Verify that the alarm, indication, and control circuits are energized.
3. Energize the inverter, and verify that the following parameters meet vendor or plant requirements:
  - Output current and dc voltage are correct.
  - Phase rotation is correct.
  - DC voltage on the primary source of power is correct.

- Inverter output current under load is correct.
- DC voltage on the alternate source feed is correct.
- Proper output voltage exists with input at the minimum design limit.

## **EM Electric Motor Component Testing**

### ***EM-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the motor is complete and that the motor is ready for operational testing. The acceptance criteria are stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify the applicable general maintenance installation checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Visually inspect to determine that the motor is securely fastened to a support structure, and verify seismic qualification acceptability; for example, bolts must be at the specified torque to ensure that the motor does not receive excessive "g" loading and does not jeopardize the seismic qualification.
3. Verify that the motor and its associated components have been reassembled correctly, that all fasteners are in place, and that connections to terminal blocks, windings, and bus bars are tight.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved. Verify that all wiring has been connected according to the vendor or plant documentation; ensure correct phase connections.
5. Verify that all indicating lights associated with the motor are operating acceptably.
6. Verify that there is no corrosion on terminals or the motor, and check for cleanliness of the component.
7. Verify that structural supports for conduit and the motor have been reinstalled and that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.
8. Verify that any fuse or circuit protection associated with the motor is according to the plant documentation requirements and that ratings or capacities are correct.

### ***EM-2 – Rotation Test***

Verify that the motor is free of binding and that rotation is correct after the maintenance work is complete.

1. Verify that the motor is uncoupled before manually rotating it, if possible.
2. Verify that any reverse rotation device is uncoupled before the rotation.
3. Check the physical rotation of the motor by manually rotating the shaft in the direction that the motor is expected to drive the equipment. Verify that it is free from binding, noise, and drag effects.

4. Conduct a phase rotation test to verify that the correct phases have been connected to ac motors. For dc motors, verify that the polarity connections are correct.
5. When the motor is coupled to the driven component, verify the correct process flow direction (for example, air flow).

### ***EM-3 – Run/Operation Test***

This testing demonstrates the normal operation of the motor. The acceptance criteria are noted in the verification steps.

1. Verify proper operation visually. This is a qualitative assessment based on personnel experience. The Motor should start on demand, reach rated speed, and drive process equipment acceptably while operating at rated speed.
2. For work involving oil, operate the equipment, inspect for leaks and proper oil levels.
3. For other lubricants, operate the equipment, relieve the excess lubricants, inspect, and clean the excess, as required.
4. Verify that bearing temperature is acceptable.
5. Verify proper rotation and that the process flow direction is correct
6. Vibration testing may be included with a run test; if the testing is not performed, verify that there are no abnormal noises.
7. Performance tests/parameter checks may be conducted to verify adequate performance and to obtain baseline operational data, as determined by testing personnel.

### ***EM-4 – Functional Test***

Demonstrate that the motor is capable of performing its intended function. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Bump and energize the motor, and then operate it until the bearing temperature stabilizes.
2. Verify that the bearing temperature increase does not exceed the manufacturer's tolerances or the design documentation.
3. Verify that the winding temperature does not exceed the manufacturer's tolerances.
4. Verify that the running direction and process flow (for example, air flow) are correct.
5. Verify that the motor speed is within tolerance.
6. Verify that start and run currents do not exceed the full load on the nameplate or other appropriate values, as determined by the engineering documentation.
7. Verify that the bus voltage and the voltage imbalance are within specifications.

*Electrical Testing Guide and Test Definitions*

8. Sample the oil if the lube capacity is greater than 10 gallons (38 liters). Verify that the contamination levels and oil viscosity are within specifications.
9. Perform vibration tests per the station predictive monitoring program. Refer to MG4 General Mechanical Special Test, Vibration Testing, for general requirements.

## EMG Motor Generator Component Testing

### ***EMG-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the motor generator is complete and that it is ready for operational testing. The acceptance criteria are stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify the applicable general maintenance installation checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Visually inspect to determine that the motor generator is securely fastened to a support structure, and verify seismic qualification acceptability; for example, bolts must be at the specified torque to ensure that the motor generator does not receive excessive "g" loading and does not jeopardize the seismic qualification.
3. Verify that the motor generator and its associated components have been reassembled correctly, that all fasteners are in place, and that connections to terminal blocks, windings, and bus bars are tight.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved. Verify that all wiring has been connected according to the vendor or plant documentation; ensure the correct phase connections.
5. Verify that all indicating lights associated with the motor generator are operating acceptably.
6. Verify that there is no corrosion on terminals or the motor generator, and check for cleanliness of the component.
7. Verify that structural supports for conduit and the motor generator have been reinstalled and that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.
8. Verify that any fuse or circuit protection associated with the motor generator is according to the plant documentation requirements and that ratings or capacities are correct.
9. Ensure that slip-rings or brushes were replaced per the manufacturer's strict instructions.
10. For maintenance on the motor, perform motor rotation checks per EM2.

### **EMG-2 – Run/Operation Test**

This testing demonstrates the normal operation of the motor generator set. The acceptance criteria are noted in the verification steps.

1. Verify proper operation visually; this is a qualitative check based on the observer's experience with the system. The motor generator set should start on demand, reach rated speed, supply the proper load and voltage while operating at rated speed.
2. Verify that the lube system is functioning properly and that the bearing temperature does not exceed the manufacturer's specifications.
3. Inspect for leaks and proper lube level while equipment is running. Verify that excess lubricant is cleaned.
4. For other lubricants, operate the equipment, relieve the excess lubricants, inspect, and clean the excess, as required.
5. Vibration testing may be included with a run test; if this testing is not performed, verify that there are no abnormal noises.
6. Performance tests/parameter checks may be conducted to verify adequate performance and to obtain baseline operational data, as determined necessary by testing personnel or plant procedures.

### **EMG-3 – Functional Test**

Demonstrate that the motor generator is capable of performing its intended function. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Verify that HVAC and other support systems are operable, as applicable.
2. Energize the motor to demonstrate that the set starts on demand and reaches the rated speed; then operate it until the bearing temperature stabilizes.
3. Verify that the starting and running current is acceptable, and record the data.
4. Verify that the auto-synchronization circuit is functional.
5. Inspect for leaks and proper lube level while the equipment is running. Verify that excess lubricant is cleaned.
6. For other lubricants, operate the equipment, relieve the excess lubricants, inspect, and clean the excess, as required.
7. Verify that the motor generator set will accept load and regulate within the required specifications. Adjust the controls as necessary per the applicable procedures or the vendor documentation.
8. Ensure that the motor generator set does not exceed the manufacturer's maximum allowable vibration. Conduct the test per the appropriate surveillance procedure.

## EPN Penetration Component Testing

### ***EPN-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to containment electrical penetrations. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Check the connection to the terminal blocks and bus bats for tightness.
3. Verify that the penetration and its components have been reassembled correctly, that all fasteners are in place, and that the proper torque of fasteners is used where applicable.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that there is no corrosion on terminals or excess dust on conductive parts, and check for cleanliness of the components.
6. Verify that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
7. Verify the nameplate data on the penetration.
8. Verify that any fuse or circuit protection associated with the penetration is according to the plant documentation requirements and that the rating or capacity is correct.
9. Verify that the multi-pin connector pins are not bent or broken.
10. Verify that the pressurization system for the penetration is operable.

### ***EPN-2 – Termination Integrity Check***

1. Check the terminals connecting the penetration to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the penetration.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug per the plant drawings.
4. Verify that the penetration has been connected to the proper phases or polarity by physically observing the connections and checking with a meter.
5. Verify that no grounds (unless required for operation) exist on the penetration.

### ***EPN-3 – Insulation Resistance Check***

1. Verify that continuity exists between the ground used on and between the penetration and station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the penetration and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the penetration terminals to the cable and the connections to the bus bars is not high. Check that the connections are within a reasonable value of each other.
3. Verify that the correct phases have been connected to the penetration
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Conduct a megger check to verify the correct insulation resistance. Determine if the penetration has acceptable insulation resistance.

### ***EPN-4 – Functional Test***

1. Perform a circuit functional test. Consult the penetration wiring and single line drawings for the type of equipment that is connected to the electrical penetration to determine the PMT required. Determine the acceptance criteria for these tests by consulting the appropriate matrices and test guides.

### ***EPN-5 – Instrument/Channel Calibration***

1. Determine the instruments that should be loop checked, and consult the appropriate matrices and test guides for the recommended PMT. Verify that the loop/channel is in an acceptable state for the loop check to be performed.

## EPS Power Supply Component Testing

### ***EPS-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to regulated power supplies. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, insulation resistance, equipment grounding, and equipment qualification
2. Verify that the supply has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the supply is reinstalled securely with all required brackets attached.
4. Visually inspect to determine that all locally mounted instrumentation is in current calibration and has normal indication and that all devices identified on the plant drawings are located as specified on those drawings.
5. Verify that all fasteners are in place and that the connections to terminal blocks are tight.
6. Verify that the identification of the cable conductors and termination points is correct according to the plant documentation.
7. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
8. Verify that all indicating lights associated with the device are operating acceptably and that the correct color coding has been used when replacing the lamps.
9. Verify that there is no corrosion on terminals, and check for cleanliness of the component.
10. Verify that the ventilation openings are not obstructed and that all dust is removed.

### ***EPS-2 – Termination Integrity Check***

1. Check the terminals connecting the supply to cables against the plant single line and/or elementary wire list to verify that the connections match those documents and are secure.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the supply.
3. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug.

*Electrical Testing Guide and Test Definitions*

4. Verify that the supply has been connected to the proper polarity by physically observing the connections and checking with a meter.
5. Verify that no grounds (unless required for operation) exist on the power supply.

**EPS-3 – Operational Check - Power Off**

1. Verify that continuity exists between the supply mounting and the station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the supply and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the supply terminals to the cable(s) is not high and that the connections are within a reasonable value of each other.
3. Verify that the correct polarities have been connected to the supply by conducting a polarity test.
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Verify that the support or auxiliary systems related to the supply are functioning properly. Check the fire detection system operation, if applicable.
6. Verify that all control and protective circuits have been checked to ensure operability. For any work on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.

**EPS-4 – Functional Test**

1. Verify that the alarm, control, and indication circuits associated with the supply operation have been checked for operability.
2. Notify operations that power is to be applied to the supply, and verify that the alarm, indication, and control circuits are energized.
3. Verify that the cooling fan (if applicable) is operating.
4. Energize the supply unloaded, and verify the correct output voltage per the vendor or plant requirements. Record the results.
5. Load the supply to minimum, and adjust the output voltage to the vendor's minimum and maximum per specification. Verify that the output voltage is within the vendor/plant specification limits. Record the results.
6. Load the supply to 100%, and again adjust the input voltage to the minimum required for operation. Verify that the output voltage is within the vendor or plant requirements.
7. Allow the supply to remain loaded with a median input voltage for a time period as recommended by the vendor manual. Verify that the output voltage is within the vendor or plant limits. Record the results.
8. Verify the supply temperature according to EPS5.

***EPS-5 – Temperature Check***

1. Verify that the cooling fan (if applicable) is operating satisfactorily.
2. Operate the supply under normal operational loaded conditions, and verify that the outlet air and case temperature are within the vendor or plant limits.

## **ER Relay/Meter Component Testing**

### ***ER-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the relay/meter is complete and that the relay is ready for operational testing. The acceptance criteria are stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify the applicable general maintenance installation checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Visually inspect connections to terminal blocks for tightness.
3. Verify that the relay and its associated components have been reassembled correctly, that all fasteners are in place, and that connections to terminal blocks, windings, and bus bars are tight.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved. Verify that all wiring has been connected according to the vendor or plant documentation; ensure correct phase connections.
5. Verify that all indicating lights associated with the relay are operating acceptably.
6. Verify that there is no corrosion on terminals or the relay, and check for cleanliness of the component.
7. Verify that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.
8. Verify that any fuse or circuit protection associated with the relay is according to the plant documentation requirements and that ratings or capacities are correct.
9. Verify that the nameplate data on the relay match the plant documents.

### ***ER-2 – Termination Integrity Check***

1. Check the terminals connecting the relay/meter to cables against the plant single line and elementary wiring diagrams to verify that the connections are according to those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting the relay.
3. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Also, verify that all washers and other fasteners are in place on the terminal lug.

4. Verify that the relay has been connected to the proper phasing by physically observing the connections and checking with a meter.
5. Verify that no grounds (unless required for operation) exist on the relay.

### **ER-3 – Relay Operational Check - Power Off**

1. Verify that continuity exists between any grounds used on the relay/meter and the station ground, using a low-voltage continuity test.
2. Verify that the resistance of the connection of the relay terminals to the cable(s) is not high and that the connections are within a reasonable value of each other.
3. Verify that the correct phases/polarity have been connected to the relay.

### **ER-4 – Functional Test**

This testing will demonstrate successful operation of the relay/meter following the maintenance activity.

1. Verify that all indication, alarm, and control circuits have been checked to ensure operability.
2. Notify operations that power is to be applied to the relay. Conduct testing that consists of the following:
  - Verify that all jumpers have been removed and that any fuses have been replaced.
  - Energize the relay, and cycle a minimum of three times by actuating at least one switch or relay contact of the coil circuit.
  - The relay energizes and deenergizes to pick up or drop out, and all contact functions on the applicable plant documentation operate as expected.
  - The time delay, if applicable, set in the relay has been checked to ensure that the value is according to the required setpoint.
3. Conduct testing that consists of energizing the relay at rated voltage, and verify the following:
  - Contact wipe, pickup, dropout, and resistance are adjusted according to the vendor or plant documentation.
  - No contact binding exists, and if the relay is a time-delay type, the required time setting has been calibrated for the relay.

## **ERC Recombiner Component Testing**

### ***ERC-1 – Maintenance/Installation Check***

1. Verify that the applicable general maintenance installation checks per MG-1, EG-1, and IPC-1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place, is not visibly loose or broken, and is torqued where required.
  - Verify that the associated equipment and valves are reinstalled and aligned according to plant requirements.
  - Verify that all electrical connections are complete and correct according to plant requirements and that there is no evidence of loose wiring or foreign deposits of material and debris.
  - Verify that all tubing is connected, that it is not damaged, and that the couplings are tight
2. Verify that the recombiner is physically reassembled and reconnected properly according to the vendor or plant documentation.

### ***ERC-2 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the recombiner meet design and operational requirements.

1. Perform a system operational check to ensure that the minimum reaction chamber gas is maintained above the minimum requirement stipulated in the Technical Specifications or other appropriate plant requirement.
2. Verify the integrity of the heater electrical circuits by performing a continuity and resistance to ground test. The resistance to ground should not be less than required to meet Technical Specifications or other plant specifications.
3. Verify that the equipment vibration measurements under normal operating conditions do not exceed plant or vendor specifications. Perform vibration testing according to MG4 Mechanical Special Testing - Vibration Testing.
4. Verify that operational parameters meet plant requirements:
  - Pressure
  - Temperature
  - Flow
  - Bearing temperature
  - Motor running amperage

***ERC-3 – Calibration***

1. Perform a channel calibration according to plant procedures.

Refer to the Instrumentation and Controls section for general and component-specific PMT guidance.

## **ESG Switchgear Component Testing**

### ***ESG-1 – Maintenance/Installation Check***

The following maintenance checks apply to all classes/voltages of electrical switchgear. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: continuity, equipment grounding, and equipment qualification
2. Check the connection of the control wiring to the terminal blocks for tightness. Check the bus bars and termination connections for tightness.
3. Verify that the switchgear and its components have been reassembled correctly, that all fasteners are in place, and that the proper torque of fasteners is used, where applicable.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that there is no corrosion on terminals or excess dust on conductive parts, and check for cleanliness of the components.
6. Verify that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
7. Verify that the nameplate data on the switchgear and its arrangement agree with plant documents.
8. Verify that any fuse or circuit protection associated with the switchgear is according to the plant documentation requirements and that the rating or capacity is correct.
9. Verify that any lamps associated with the switchgear have been reassembled correctly and that they are capable of functioning properly.
10. Visually inspect the power cables for excessive bending radius, as determined by the plant requirements.
11. Visually inspect insulators for any damage.
12. For switchgear using insulating gas, verify that the gas pressure meets requirements.
13. Verify that the arc chute has not been damaged, that the operating mechanism is performing correctly, and that the mechanism has the proper lubrication.

**ESG-2 – Termination Integrity Check**

1. Check the terminals connecting the switchgear to cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the switchgear.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug per plant drawings.
4. Verify that the switchgear has been connected to the proper phases by physically observing the connections and testing with a meter.
5. Verify that no grounds (unless required for operation) exist on the switchgear.

**ESG-3 – Insulation Resistance Check**

1. Verify that continuity exists between the ground used on and between the switchgear and the station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the switchgear and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the switchgear terminals to the cable and the connections to bus bars is less than 0.5 ohms. Check that the connections are within a reasonable value of each other.
3. Verify that the correct phases have been connected to the switchgear.
4. If any work has been performed on the feeder breakers, bus tie breakers, or control panels, verify that the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
5. Verify that each of the current transformers (CTs) and potential transformers (PTs) has had the following checks performed, and record the information on the appropriate data sheet:
  - CTs should be given ratio checks, polarity check saturation tests, and winding resistance to ground checks per vendor or plant instructions.
  - Verify that each of the CTs and PTs is mounted correctly and with the correct polarities.
  - Verify that the insulation tests have been performed on each PT.
6. Conduct a megger or Doble check to verify the correct insulation resistance.
7. Close the switchgear by operating it manually. Verify the following, and record the information on the appropriate data sheet:
  - Electrical connections are made.
  - Auxiliary switches, interlocks, and contacts are properly operated.
8. Verify that the contact resistance is within the vendor's specifications, and record the information on the appropriate data sheet

**ESG-4 – Functional Test**

1. Verify that the alarm, control, protection and indication circuits associated with the switchgear operation have been checked for operability.
2. Notify operations that power is to be applied to the switchgear, and verify that the alarm, indication, and control circuits are energized.
3. Energize the switchgear by closing the supply breaker and verifying that no abnormal noises exist.
  - Measure and record the voltages of the switchgear on the appropriate data sheets.
  - Trip set point and time are acceptable per specifications.
  - Verify that the phase sequence is correct.
4. Verify that the switchgear operates freely with no overheating or other abnormalities occurring during the tests conducted with the load connected.

**ESG-5 – Infrared Scan/Thermography Check**

1. Contact the plant predictive monitoring groups to determine if the switchgear being maintained is within the scope for infrared monitoring.
2. Conduct thermography scans at appropriate points to monitor heat generated by loose connections, excessive contact resistance, insulation breakdowns, inadvertent grounding of wiring or components, and excessive loads on the switchgear.
3. Compare the data against similar load conditions. Evaluate any adverse trends.

## **ESW Electrical Switch Component Testing**

### ***ESW-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the switch is complete and the switch is ready for operational testing. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Verify that applicable general maintenance installation checks per EG-1 are completed.
2. Visually inspect for tightness of the switch block and escutcheon.
3. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
4. Verify that all indicating lights associated with the switch are operating acceptably and that the correct color coding has been used when replacing the lamps.
5. Verify that there is no corrosion on terminals or the switch, and check for cleanliness of the component.
6. Verify that any fuse or circuit protection associated with the switch is according to the plant documentation requirements and that ratings or capacities are correct.

### ***ESW-2 – Termination Integrity Check***

1. Check the terminals connecting the switch to the terminal block against the plant single line and elementary wiring diagrams to verify that the connections are according to those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting the switch.
3. Verify that the terminal lugs are torqued, when required, to the values specified in the vendor or plant documents. Also, verify that all washers and other fasteners are in place on the terminal lug.

### ***ESW-3 – Operational Check- Power Off***

1. Verify, using a low-voltage continuity test, that wires are terminated to the correct point compared with the plant documents.
2. Verify that the normal switch position is according to the plant documentation, using a continuity check. Place the switch in various possible configurations, and verify that the correct contact actuates.
3. If the switch is a keylock, verify that the correct key actuates the switch and that the switch operates.
4. Verify that the correct nameplate is on the control board or switch location and that it is not damaged.

### ***ESW-4 – Functional Test***

This testing will demonstrate successful operation of the switch following the maintenance activity.

1. Notify operations that power is to be applied to the switch. Conduct testing that operates the switch and the associated circuitry in all possible modes. Check to determine that the associated components function according to the plant requirements.
2. Verify that all interfaces, such as alarms, plant computer input, and other status output, occur as required.
3. Verify that all indication is correct, that no burned-out lights occur, and that indication has not been reversed.

## **ETR Transformer Component Testing**

### ***ETR-1 – Maintenance/Installation Check***

Demonstrate that maintenance on the transformer is complete and that the transformer is ready for operational testing. The acceptance criteria are stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify that the applicable general maintenance installation checks per EG-1 are completed.
2. Visually inspect to determine that the transformer and its associated components are securely fastened to a support structure, and verify seismic qualification acceptability; for example, bolts must be at the specified torque to ensure that the transformer does not receive excessive “g” loading and does not jeopardize the seismic qualification.
3. Verify that the transformer and its associated components have been reassembled correctly, that all fasteners are in place, and that connections to terminal blocks, windings, and bus bars are tight.
4. Verify that the wet transformer has no oil leaks.
5. Check that the wire routing is secure and that it does not bind when covers are closed or moved. Verify that all wiring has been connected according to the vendor or plant documentation; ensure correct phase connections.
6. Verify that all indicating lights associated with the transformer are operating acceptably.
7. Verify that there is no corrosion on terminals or the transformer, and check for cleanliness of the component and for excess oil.
8. Verify that structural supports for conduit and the transformer have been reinstalled and that the surrounding area is free of maintenance equipment such as chain falls, tools, and debris.
9. Verify that any fuse or circuit protection associated with the transformer is according to the plant documentation requirements and that ratings or capacities are correct.
10. Verify that all insulators are not damaged and that insulation barriers are in place.
11. Verify that all porcelain high-voltage bushings and other high-voltage insulators are not cracked or damaged. Inspect to ensure that each of the current transformers and potential transformers is on the correct bus and is not damaged.
12. For wet transformers, verify that the oil level is within the operating range and that the oil gauge is functioning properly.

### ***ETR-2 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Check the terminals connecting the transformer switchgear to cables against the plant single line and elementary wiring diagrams to verify that the connections are according to those documents.

*Electrical Testing Guide and Test Definitions*

3. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting the transformer.
4. Verify that the terminal lugs and bus connections are torqued, when required, to the values specified in the vendor or plant documents. Also, verify that all washers and other fasteners are in place on the terminal lug.
5. Verify that the transformer has been connected to the proper phasing by physically observing the connections and checking with a meter.
6. Verify that no grounds (unless required for operation) exist on the transformer.
7. Verify that any high-voltage type cable has been properly prepared according to the vendor or plant documentation.

***ETR-3 – Operational Check - Power Off***

1. Verify that continuity exists between the transformer casing and the station ground, using a low-voltage continuity test. In addition, verify that the resistance of any connection between the transformer and the ground grid does not exceed 0.5 ohms.
2. Verify that the resistance of the connection of the transformer terminals to the cable(s) and the connection to the bus bar is not high and that the connections are within a reasonable value of each other.
3. Verify that a Doble test has been conducted on the lightning arresters and other high-voltage bushings.
4. Conduct a megger test, a hi-pot test, and a polarization index to verify correct insulation resistance characteristics. record the information on the appropriate data sheet.
5. Verify that the feeder breaker, control circuit, and secondary and primary cables have all been tested within their prescribed preventive maintenance cycle. For work that has been performed on the feeder breakers, bus tie breakers, or control panels, the appropriate matrices and test guides have been used for these components to determine if any further testing is required.
6. Verify that all indication, alarm, and protective circuits have been checked to ensure operability. For any work on the devices (such as relays), the appropriate test matrix and guide should be referenced to determine if additional PMT is required.
7. Verify that auxiliary support systems, such as pumps, oil coolers, fans, and fire protection systems, are operable.
8. Verify that the tap positions are correct to provide the voltage transformation required. Verify that the tap changer has been tested so that the winding ratio corresponds with the vendor or plant engineering documentation.
9. Verify that an oil analysis was performed according to plant procedures and that the dielectric strength, neutralization number, and color are within specified limits.

10. Verify that a leak check was performed on the transformer by pressurizing it to at least 5 psi (35 kilopascals) and that no appreciable leakage was detected.
11. Verify that a dew point check was conducted on the nitrogen blanket in the transformer and that the results were acceptable.

#### ***ETR-4 – Functional Test***

This testing will demonstrate successful operation of the transformer following the maintenance activity.

1. Verify that the control circuit operational check has been performed and that the results are acceptable.
2. Verify that all indication, alarm, and protective circuits have been checked to ensure operability. A review of test records is acceptable for the protective relay settings.
3. Verify that the transformer breaker is open before energizing the transformer.
4. Notify operations that power is to be applied to the transformer. Conduct testing consisting of the following:
  - Energize the transformer by closing the supply breaker. Load breakers should be open. Check the transformer for abnormal noises, excessive vibration, arcing, gas emission, or other evidence of problems.
  - Measure and record the bus voltage of the transformer. Verify that acceptance criteria are specified from the plant documentation for the high and low side.
  - Verify that the proper phase sequence exists. Verify that acceptance criteria have been specified.
  - Verify that there are no abnormal operating characteristics (for example, temperature and oil level changes) for a 24-hour period before loading the secondary of the transformer.
  - Check the breaker test records to verify that trip times are adequate.
  - Check other tie or alternative feed breakers, using the same test sequence as necessary.

#### ***ETR-5 – Oil Analysis***

1. After filling the transformer, obtain a representative oil sample using the station procedures. Send the sample to the laboratory for normal analysis.
2. Repeat the sample after the oil has been in service for at least one week. Review the laboratory results, and monitor them for contamination and particulate. Evaluate any adverse findings.

## **EWC Wire/Cable Component Testing**

### ***EWC-1 – Maintenance/Installation Check***

The following maintenance checks apply to electrical wire and cable. The criteria for the inspection are as stated in the verification. Identified problems should be reevaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1:
  - Inspection checks
  - Electrical checks including: equipment grounding and equipment qualification
2. Verify that the cable bend radius is acceptable according to plant requirements.
3. Verify that the wire is the correct type for the installation, using plant or engineering documents for a list of cable types and requirements.
4. Check that the wire routing is secure and that it does not bind when covers are closed or moved.
5. Verify that there is no corrosion on terminals or excess dust on conductive parts, and check for cleanliness of the components.
6. Verify that the structural supports for conduits are reinstalled and that the surrounding area is free of maintenance equipment such as scaffolding, tools, and debris.
7. Verify that the identification of the wire is correct, compared to the maintenance/work order, and that the identification tag has not been removed during maintenance.
8. Verify that the cable or wire is securely fastened, according to the installation drawings or other plant documents.
9. Verify that any fire detection devices in the cable trays removed during maintenance have been replaced.

### ***EWC-2 – Termination Integrity Check***

1. Check the terminals connecting the wire or cables against the plant single line and/or elementary wire list to verify that the connections match those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting to the wire.
3. Verify that the routing of the cable is according to the plant wire and cable/raceway drawings or list. Verify that separation requirements are met and that the cable is installed in the correct train of the applicable system.
4. Verify that any connections have the proper torque applied and that all terminals are secure.
5. Verify that any cable preparation has been conducted according to the vendor or plant requirements.

***EWC-3 – Insulation Resistance Check***

1. Using a low-voltage continuity test, check that wires are terminated to the correct point compared to the plant documentation.
2. Verify that grounds do not exist on the wires or cable by using phase-to-phase or pair checks. Where grounds are required, verify that the correct reference ground (for example, the instrument bus or station ground) is connected.

Megger and hi-pot check the cables. Determine the acceptance criteria from the engineering or plant documentation, and verify that the results are acceptable.



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## INSTRUMENTATION AND CONTROLS TESTING GUIDE AND TEST DEFINITIONS

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### INDEX TO INSTRUMENTATION AND CONTROLS TESTING GUIDE AND TEST DEFINITIONS

#### Instrumentation and Controls – General Testing

<b>Equipment Code</b>	<b>Guidance</b>	<b>Page</b>
IG-1	I & C Maintenance/Installation Checks	C-2
IG-2	I & C Run/Operational Tests	C-3
IG-3	I & C Functional Tests	C-4
IG-4	I & C Special Tests	C-5

#### Instrument and Controls – Component Testing

<b>Equipment Code</b>	<b>Guidance</b>	<b>Page</b>
IA	Annunciator	C-6
IB	Bistable/Relay	C-7
ICI	Computer I/O	C-9
ICN	Converter	C-11
ICS	Control Switch	C-13
ID	Digital Devices and Systems	C-15
IFD	Fire Detection	C-23
IGG	Gauge	C-25
IIN	Indicator	C-26
INI	Nuclear Instrumentation	C-27
IPC	Process Controller	C-29
IR	Recorder	C-31
IRM	Radiation Monitor	C-32
IRT	RTD/Thermocouple	C-34
IT	Transmitter	C-36

## **IG Instrumentation and Controls General Testing**

### ***IG-1 – General Instrumentation and Controls Maintenance/Installation Check***

The following are general tests that should be performed where appropriate.

#### **A. Inspection Check**

1. Verify that the component has been reinstalled in the correct location per the appropriate plant drawings and that the related components are correctly attached.
2. Verify that the component is reinstalled securely with all the required brackets and linkages. All supports are in conformance with the plant engineering and vendor instructions.
3. Verify that all probes are fully inserted into the process being monitored.
4. Verify that all fasteners, covers, terminal blocks, connectors, couplings, and feedback mechanisms are in place and that connections to terminal blocks are tight.
5. Verify that the reinstalled component has the correct nameplate data. Ensure that the component serial number corresponds to as designed documentation.
6. Verify that the mechanical components have all of the required linkages securely connected.
7. Verify that the correct type of tubing joint compound is used.
8. Verify that the reinstalled component has the correct scale graduations.
9. Verify that any disturbed human factors color banding has been reinstalled.
10. Verify that all indicating lamps and lamp caps are properly installed. Replace all burned-out lamps and broken caps.
11. Before energizing the instrument loops, verify that the power, control, and signal circuits containing fuses are checked for proper fuse type and rating. Fuse holders should be checked for dirt, corrosion, looseness, and missing parts.
12. Verify proper equipment grounding and that a separate plant instrument ground bus is used, if required.
13. Verify that the power supply is compatible with all circuit/channel components.
14. Verify sensing, signal, and sample line cleanliness; clean to remove dirt and debris by blowing with air or flushing with a fluid that is compatible with the system, as required.

#### **B. Instrument Line/Tubing Check/Leak Test**

1. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
2. Verify that all disturbed connections are tight, and bring the line to operating pressure:

- Exercise care to protect instruments during leak checks.
  - Identify loop isolation boundaries and isolate, as needed.
  - Verify that equalizers are open on D/P instruments.
  - Record the attained test pressure when required.
3. Verify that all fluid pressure boundaries, including diaphragms or bellows, are not leaking fluid and can hold pressure.
  4. Verify at operating pressure that the air pressure boundaries are tight and are not leaking by using an approved leak detection fluid.
  5. Verify that any ASME pressure boundary components are tested according to the ASME plant program requirements.

### **C. Equipment Qualification Check**

1. Review the plant equipment qualification procedures and the manufacturer's installation instructions, bulletins, and equipment qualification lists to ensure that the proper parts are used for replacement.
2. Verify that existing parts in use are not worn excessively. If any worn parts are found that could affect the equipment qualification, ensure that the proper disposition of those parts is performed, for example, the part does not complete its qualified life and fails early, necessitating a new analysis of qualified life for the part.
3. Verify that the inspection of disturbed splices, seals, or torqued components is performed to ensure that environmental qualification requirements are maintained.
4. Verify that any lubricants, gaskets, or other expendable materials used during maintenance are of the type specified in the equipment qualification program.

### ***IG-2 – General I&C Run/Operational Test***

Perform an operational check by energizing the loop and checking the indicated output value against a known output obtained from redundant channels or operational knowledge. Verify that the indicated value is within tolerance. This operational check is typically conducted with the channel out of service.

1. Verify that all indicators operate per design in a timely manner.
2. Verify that all control stations function.
3. Verify that all blocks, permissives, interlocks, and protective devices function in a timely manner.
4. Verify that inputs to computer monitoring pads operate.
5. Verify that all instrument switches and relays function in a timely manner.

**IG-3 – General Instrumentation and Controls Functional Test**

This test or verification ensures that the component, equipment, or subsystem that was affected by the maintenance activity is completely capable of performing its design functions. The following tests or checks are general and are provided for consideration where specific test guides have not been provided. Perform the channel functional test (loop check), when possible, if it is found that the operational check does not completely verify channel operation.

1. Verify that the supply voltage is correct and that no grounds exist on the system.
2. Verify that the fuses have been replaced in the supply circuit and that the power to the device has been restored, consistent with plant tagging procedures.
3. Verify that the appropriate maintenance inspections, electrical checks, and calibrations have been satisfactorily completed.
4. Verify that the correct nameplate data, including serial number, is on the component and that it matches the controls on locations such as the control board.
5. For equipment specified in the Technical Specifications, the applicable surveillance test should be performed.
6. For other equipment, especially quality-related equipment, a documented test that verifies operability should be performed.
7. Energize the loop and allow the loop to stabilize. Check the output value against a known output obtained from operating knowledge. Verify that the reading is reasonable. If the component is one that has a tolerance determined by channel checks or surveillance tests, verify that the channel is within that tolerance:
  - Check the voltage to the circuit, and verify that the system does not trip or overheat.
  - Verify proper operation of the loop components.
  - Start any required pumps, and adjust the flows to the correct value.
  - Momentarily toggle, jumper, or lift (as appropriate) the respective field input, and verify that the output changes state relative to the actual condition (for example, windows flash, horns sound). Restore the input condition by removing the jumper or lifted leads, as appropriate, to verify that the output again changes state.
  - Verify that the electronics are in the correct state for the operational condition.
  - Conduct system diagnostic tests as provided by the manufacturer or plant procedures.
  - Verify that the air pressure and loop voltage are within limits.
  - Verify that the electronic pneumatic device is driving the end device properly.
8. Using the plant drawings, procedures, and other manuals as necessary, operate the component and the associated circuitry in all possible modes. Check to determine that the associated components function according to the plant documentation requirements.
9. Verify that all interfaces, such as alarms, plant computer input, and other status output, occur as required.

10. Verify that all indication is correct, that there are no burned-out lights, and that indication has not been reversed.
11. Verify that the computer I/O devices operate correctly by loading and running the appropriate diagnostics. If the diagnostics fail, contact the appropriate personnel for resolution.
12. Verify that I/O equipment, such as link systems, disk drives, Versitech, or CRT, operates correctly by using the applicable tester.
13. Perform a channel/loop check or surveillance if it is found that the functional test does not adequately demonstrate operability or as dictated by the plant requirements.

#### ***IG-4 – General I&C Special Test - Component Calibration***

When an instrument is repaired or replaced, it must be calibrated. If the instrument is removed or disturbed where its accuracy or set points are suspected, the instrument should be considered for calibration. Component calibration is fundamental to PMT. The success of subsequent testing during operational and functional tests is dependent on the component calibration effectiveness.

Detailed component calibration guides are beyond the scope of this guide. However, the station maintenance programs cover component calibration very effectively through detailed instructions and procedures. This section's objective is mainly to stress the importance of calibration and its function in the PMT process. Plant procedures or other approved documents should be used to perform component calibration.

The following general items should also be considered when conducting component calibration:

1. Calibration may impact the operation of plant equipment in addition to the instrument being calibrated.
2. The calibration/test performed by manufacturers may be accepted with the proper documentation.
3. The manufacturer's instructions and tests should be followed to prevent instrument damage.
4. Only gas or fluid compatible with the manufacturer's specifications should be used as calibration media.
5. Switches should be checked for both set point and reset point.
6. Analog instruments should receive at least a five-point calibration that checks for zero, span, linearity, hysteresis, and covering the required span of the instrument.
7. Bi-directional recorded data should be used to support hysteresis checks, where required.
8. Data should be recorded to a sufficiently accurate value to compare or calculate the desired value.
9. Instruments must be calibrated to required accuracies/tolerances or better. The manufacturer's specified accuracies/tolerances should be superior to the plant requirements to ensure reliable use over time.

## **IA Annunciator Component Testing**

### ***IA-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to annunciators. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1 and IG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
  - Applicable instrument checks
2. Verify that the annunciator has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the annunciator is reinstalled securely with all circuit boards positively engaged.
4. Verify that all fasteners are in place and that connections to terminal blocks are tight.

### ***IA-2 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and torqued where required.
3. Verify that all cable markers are in place and that they match the appropriate wiring diagrams.

### ***IA-3 – Functional Test***

1. Notify operations that power is to be applied to the annunciator circuit.
2. Apply power and check voltage to the annunciator circuit, and verify that the system does not trip or overheat.
3. Momentarily toggle, jumper, or lift (as appropriate) the field input, and verify that the output changes state relative to the actual condition (for example, windows flash, horns sound).
4. Restore or change the input condition by toggle, jumper, or lift lead (as appropriate) to verify that the output again changes state.

## **IB Bistable/Relay Component Testing**

### ***IB-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to bistables/relays. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1 and IG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the bistable/relay has been reinstalled in the correct location per appropriate plant drawings and that the high and low tubing is correctly attached, if applicable.
3. Verify that the bistable/relay is reinstalled securely with all required brackets and linkages.
4. Verify that components/cards are properly programmed.
5. Verify that fuses have the proper rating and are installed.

### ***IB-2 – Tubing Check***

1. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
2. Verify that all disturbed connections are tight. Bring the bistable/relay to operating pressure and record.
3. Verify that all fluid pressure boundaries, including diaphragms or bellows, are not leaking fluid and can hold pressure.
4. Verify that the air pressure boundaries are not leaking by using an approved leak detection fluid.

### ***IB-3 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable/wire markers are in place and that they match the wiring diagrams.
4. Check that contact resistance is less than or equal to 0.5 ohms. Check the contacts to ensure that no oxidation is present.

***IB-4 – Functional Test***

1. Notify operations that power is to be applied to the bistable/relay circuit.
2. Energize the loop, and verify that the bistable/relay is in the correct state for the operational condition. Verify that the applied voltage is correct.
3. Perform a channel/loop check if the previous check was unacceptable.
4. Verify that the relay energizes and deenergizes to pick up or drop out and that all contact interlocks operate as designed.
5. Verify that no contact binding exists and, if the relay is a time-delay type, that the required time setting was calibrated for the relay.

## **ICI Computer Input/Output Component Testing**

### ***ICI-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to computer input/output devices. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that any circuit components replaced have been placed properly on the circuit board, that the card has been securely fastened in its slot, and that the correct type of component has been used for replacement, according to the vendor or plant technical data.
3. Verify that filters are clean in the area where maintenance has been completed, that solder joints are acceptable, and that no corrosion exists on any connectors or terminals.
4. Verify that the correct markings exist that identify the component and circuit board. Ensure that the identification tags have not been disturbed and that the nameplate data are correct.

### ***ICI-2 – Termination Integrity Check***

1. Check the terminals connecting the component or system to the computer I/O device (CRT, power supply, or I/O cabinet) with the vendor or plant wire list, and verify that the correct connections have been made.
2. Verify that the correct terminal types have been used and that adequate marking is in place on the wires.
3. Verify that any screw or friction connections are secure and that any cable ties removed have been replaced.

### ***ICI-3 – Functional Test***

1. Verify that the supply voltage is correct and that no grounds exist on the system that are not required.
2. Verify that fuses have been replaced in the supply circuit and that power to the device has been restored, consistent with plant tagging procedures.
3. If the computer I/O is a process termination cabinet, compare the point that has been maintained with another existing channel that is reading the same process variable. If the channel does not exist, verify that the process is correct by alternate means. Verify that the reading is reasonable. If the component is one that has a tolerance determined by channel checks or surveillance tests, verify that the channel is within that tolerance.

*Instrumentation and Controls Testing Guide and Test Definitions*

4. Verify that any other device performs its intended function as an I/O device. Ensure that it can display its normal parameters in the correct configuration.
5. Verify that I/O equipment, such as link systems, disk drives, Versitech, or CRT, operate correctly by using the applicable tester.
6. Verify that security I/O, if applicable, operates correctly by using the appropriate test records.
7. Verify that the computer I/O devices operate correctly by loading and running the appropriate diagnostics. If the diagnostics fail, contact the appropriate personnel for resolution.

## **ICN Converter Component Testing**

### ***ICN-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to E/P or I/P devices. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the E/P or I/P has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the E/P or I/P is reinstalled securely with all required brackets attached.
4. Verify that the reinstalled E/P or I/P has the correct nameplate data.

### ***ICN-2 – Leak Test***

1. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
2. Verify that all disturbed connections are tight. Bring the system to operating pressure and record.
3. Verify that all fluid pressure boundaries, including diaphragms or bellows, are not leaking fluid and can hold pressure.
4. Verify that the air pressure boundaries are not leaking by using an approved leak detection fluid.

### ***ICN-3 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable/wire markers are in place and that they match the wiring diagrams.

***ICN-4 – Functional Test***

1. Notify operations that power is to be applied to the E/P or I/P circuit.
2. Energize the loop, and verify that the air pressure and loop voltage are within limits.
3. Input the appropriate current or voltage, and verify that the output response in pressure is acceptable according to plant requirements.
4. Perform a channel/loop check, when operating conditions permit, to verify that the E/P or I/P is driving the end device properly.

## **ICS Control Switch Component Testing**

### ***ICS-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to control switches. The acceptance criteria are stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify that the applicable general maintenance installation checks per EG-1 and IG-1 are completed.
2. Verify that the control switch is reinstalled in the correct location according to the plant documentation.
3. Verify that all fasteners are in place and that connections to terminal blocks are tight.
4. Check wire routing to ensure that it is secure and that it does not bind when covers are closed or removed.
5. Verify that all indicating lights associated with the switch are operating acceptably.
6. Verify that no corrosion is present on terminals or the switch, and check for cleanliness of the component.
7. Verify that each lifted wire is replaced per the applicable wiring diagram.
8. Verify that environmental qualification has been maintained as a result of the maintenance activities.

### ***ICS-2 – Leak Test***

1. Verify that all tubing/capillary has no kinks, dimples, or sags, and that it is securely supported.
2. Verify that all ASME pressure boundaries are tight, according to the ASME program requirements.
3. Verify at operating pressure that all air pressure boundaries are tight and not weeping by using an approved leak-detecting fluid.
4. Verify that all capillary tubing and diaphragm assemblies are not weeping.
5. Verify that all fluid pressure boundaries are not leaking and can hold pressure.

### ***ICS-3 – Termination Integrity Check***

1. Check the terminals connecting the control switch to the terminal block against the plant single line and elementary wiring diagrams to verify that the connections are according to those documents.
2. Verify that the correct terminal types have been used in any replacement work and that markers are in place on the cables connecting the switch
3. Verify that the terminal lugs are torqued to their proper values according to the vendor or plant documents. Verify that all washers and other fasteners are in place on the terminal lug.

### ***ICS-4 – Operational Check – Power Off***

1. Using a low-voltage continuity test, check that wires are terminated to the correct point according to the plant documentation.
2. Using a continuity check, verify that the normal switch position is according to the plant documentation. Place the control switch in various possible configurations, and verify that the correct contact actuates.

### ***ICS-5 – Functional Test***

This testing will demonstrate successful operation of the control switch following the maintenance activity.

1. Notify operations that power is to be applied to the control switch circuit. Conduct testing that energizes the control switch, and verify the correct response to a simulated signal.
2. Using the plant drawings, procedures, and other manuals as necessary, operate the switch and associated circuitry in all possible modes. Check to determine that the associated components function according to the plant document requirements.
3. Verify that the switch is properly valved and vented. Check the indication, if applicable, against redundant indications.
4. Verify that all interfaces, such as alarms, plant computer input, and other status output, occur as required.
5. Verify that all indication is correct, that there are no burned out lights, and that indication has not been reversed.

### ***ICS-6 – Calibration***

1. Perform a device calibration according to the plant procedures. This can be a bench or in-place calibration.
2. Perform the station instrumentation and controls (I&C) channel surveillance procedures, including channel calibration and channel functional tests, as required. Verify the actuation and reset point for alarms, control settings, actuation, and indication.

## **ID Digital Devices and Systems**

### ***Background***

Digital devices and systems may be installed in nuclear power plant systems primarily to address equipment obsolescence and to improve system functionality. Improved functionality can be achieved with digital instead of analog technology because digital electronics are essentially free of drift; consequently, they maintain their calibration better. They also offer improved system performance in terms of accuracy and computational capabilities. Finally, digital devices and systems have superior data handling and storage capacities; as a result, operating conditions can be more fully measured and displayed.

For the purposes of this report and to ensure consistency with other EPRI reports, key terms are defined as follows:

Digital devices – Single pieces of equipment containing both hardware and software, such as digital meters, (Refer to EPRI report TR-108831)

Digital systems – More than one piece of equipment with some custom-developed software, such as distributed control systems. (Refer to EPRI report TR-108831)

Table C-1 provides a list of common applications for digital upgrades in nuclear power plants. The table is quite comprehensive and covers most instrumentation and control systems in a typical plant. More simply stated, digital technology can be used to replace any analog instrumentation and control component or system. The user of this report should recognize that many new hardware components are now being built with embedded microprocessors that provide extra functionality and protection.

The listing is categorized into two primary groups: control systems and protective systems.

**Table C-1  
Applications for Digital Components and Assemblies in Nuclear Power Plants**

<b>Control Systems</b>	<b>Protective Systems</b>
Steam and Power Conversion Controls <ul style="list-style-type: none"> <li>• Diesel Generator Load Sequencer</li> <li>• Feedwater Heaters Controls</li> <li>• Steam Dump Controls</li> <li>• Turbine Controls</li> <li>• Turbine By-Pass Valves</li> <li>• Pressure Regulation</li> </ul>	Plant Trip Systems <ul style="list-style-type: none"> <li>Emergency Safeguard Features Actuation Systems</li> <li>Anticipated Transient Without SCRAM</li> <li>Engineered Safety Features                             <ul style="list-style-type: none"> <li>• Emergency Core Cooling</li> <li>• Safety Injection</li> <li>• Residual Heat Removal</li> </ul> </li> </ul>

**Table C-1(continued)**  
**Applications for Digital Components and Assemblies in Nuclear Power Plants**

<ul style="list-style-type: none"> <li>• Turbine Stop Valve Closure</li> <li>• Feedwater Controls</li> <li>• Feedwater Pump Speed Controls</li> <li>• Main Feed Regulator Valves</li> <li>• Main Generator</li> <li>• Load Rejection Steam Dump Control</li> <li>• Steam Header Pressure Control</li> <li>• Circulation Water Control</li> <li>• Steam Generator Blowdown</li> </ul> <p>Inventory Control (Primary and Secondary Sides)</p> <ul style="list-style-type: none"> <li>• Feedwater Heater Level Control</li> <li>• Steam Generator Level Control</li> <li>• Condensate Control</li> <li>• Reactor Pressure Control</li> <li>• Reactor Water Clean-Up</li> <li>• Control Rod Drive</li> <li>• Emergency Service Water Controls</li> <li>• Reactor Make-Up</li> <li>• Pressurizer Level and Pressure Controls</li> <li>• Condensate and Feedwater Chemical Injection</li> <li>• Reactor Coolant System Pressure Control</li> <li>• Letdown Line Isolation Control</li> <li>• Emergency Feedwater Control</li> <li>• Steam and Power Conversion</li> </ul> <p>Reactivity Controls</p> <ul style="list-style-type: none"> <li>• Rod Worth Minimizer</li> <li>• Rod Partition Indication</li> <li>• Rod Block Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Containment Isolation</li> <li>• Hydrogen Gas Control</li> <li>• Emergency Feedwater System</li> <li>• Essential Feedwater System</li> <li>• Component Cooling Water</li> <li>• Containment Spray Actuation</li> <li>• Recirculation Actuation</li> <li>• Air Purification and Clean-Up</li> <li>• Core Flooding</li> <li>• Reactor Coolant Make-Up and Purification</li> <li>• Decay Heat Removal</li> <li>• Main Steam Line Isolation</li> <li>• Leak Detection</li> <li>• Area Radiation Monitoring</li> <li>• Safety Relief Valve and Actuation</li> </ul>
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**Table C-1(continued)**  
**Applications for Digital Components and Assemblies in Nuclear Power Plants**

<ul style="list-style-type: none"> <li>• Recirculation Flow</li> <li>• Standby Liquid Control</li> <li>• Neutron Monitoring</li> <li>• Rod Control</li> <li>• Boron Recycling</li> <li>• Full-Length Rod Control</li> <li>• Partial-Length Rod Control</li> <li>• Automatic Turbine Runback</li> </ul> <p>Auxiliary Systems Controls</p> <ul style="list-style-type: none"> <li>• Fuel Handling and Storage</li> <li>• Compressed Air</li> <li>• Equipment and Flow Drainage</li> <li>• Auxiliary Steam</li> <li>• Nitrogen and Hydrogen</li> <li>• 120-Volt ac Vital Power</li> <li>• 120-Volt Regulator Power</li> <li>• Emergency Power</li> <li>• 250/125 Volt dc Power</li> <li>• Spent Fuel Cooling</li> <li>• 120/208 Volt ac Power</li> </ul> <p>Waste Processing Controls</p> <ul style="list-style-type: none"> <li>• Waste Disposal</li> <li>• Gaseous, Liquid, and Solid Waste Handling</li> <li>• Process/Effluent Radiation Monitoring</li> </ul>	
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Due to their complexity and unique design features, digital components and devices undergo a significant amount of verification activities, which begin during the manufacture and assembly of the digital device. Typically, verification of the overall functionality of the device, confirmation of special features, and software verification make up the scope of these activities. Software verification often must begin long before hardware assembly and manufacture, and it is typically not left until the device is installed in the plant system. For more information and guidance regarding the extent and type of verification/testing typically performed during assembly and manufacture, see EPRi reports TR-108831 and EPRi TR-103291.

The user of this guidance should recognize that there are some unique challenges associated with the use of digital technology in nuclear power plants. For example, digital systems can be much more complex than their analog predecessors and have a greater potential for unintended behaviors and subtle failure modes. Digital instrumentation is also generally more susceptible to electromagnetic interference (EMI) than its analog counterparts. This susceptibility necessitates special installation considerations and qualification for electromagnetic compatibility.

Table C-2 lists typical attributes of digital devices that can be verified by post-maintenance testing.

**Table C-2  
Attributes of Digital Devices Often Verified by Post-Maintenance Testing**

<b>Required Functionality</b>
<ul style="list-style-type: none"> <li>• Input processing. This is typically automatically checked through self-testing. For safety systems, input accuracy is checked if the maintenance affects analog input signal conditioning modules.</li> </ul>
<ul style="list-style-type: none"> <li>• Output signal requirements. CPU to output module communication is typically tested automatically, but output module to plant component (pump, valve) communication must often be tested manually.</li> </ul>
<ul style="list-style-type: none"> <li>• Human-machine interface (HMI) functionality. This may not constitute actual functional testing. HMI functionality is verified by turning the device on and confirming that it is being refreshed (typically by the dynamics of a designated icon or by the seconds update on a clock display.)</li> </ul>
<ul style="list-style-type: none"> <li>• Test and diagnostic functions (on-line and off-line). After maintenance, there is typically a report from the boot-up diagnostics or at least some front panel indications that show the diagnostics have run correctly.</li> </ul>
<b>Performance Requirements Related to the Required Functionality</b>
<ul style="list-style-type: none"> <li>• Response time/accuracy. Note that in the vast majority of cases, response time verification is checked only for safety systems and only at surveillance intervals, not after maintenance.</li> </ul>
<ul style="list-style-type: none"> <li>• Data throughput rate. Note that this attribute is exhaustively tested in the factory. As such, only a cursory check at surveillance intervals for safety systems is typically required.</li> </ul>
<ul style="list-style-type: none"> <li>• Interfaces including power, signal, and data communication. Note that power and data communication checks are typically automated. Inputs and outputs require manual checks.</li> </ul>

The user of this report should recognize that often digital devices and systems will undergo testing to verify behavior under specific abnormal or faulted conditions. These tests/verifications should not be considered part of post-maintenance testing. These tests/verifications are in fact performed at the factory and constitute design verification (that is, equipment qualification) of the digital devices and/or system.

## **General Guidance for Post-Maintenance Testing for Digital Devices and Systems**

In general, there should be no periodic maintenance of digital systems that requires post-maintenance testing. The periodic maintenance is, in fact, the testing. Analog inputs are checked for input accuracy, outputs are generated to test the interface to plant components. In well-designed digital systems, these tests can be conducted without removing wires, adding jumpers, or creating any bypass or inoperable conditions. Therefore, there are no additional post-maintenance tests *per se*. However, if any of these things that cause out-of-service conditions occur, then post-maintenance tests must be run to ensure that correct on-line configuration and operability have been restored.

The remaining maintenance of digital systems is in response to random unplanned failures, where equipment must be replaced. Either failures are automatically detected and alarmed, or the failures are detected through the manual periodic testing discussed above. The real issue is what testing must be done on the system after the equipment has been replaced to ensure that full operability has been restored. There is no definitive guidance on this, but a common philosophy is simply to rerun whatever test originally found the problem. Since most failures are found through self-tests, this usually entails plugging in the new module and letting the system recheck it. Additional tests beyond this are rare.

The following guidance is provided with the underlying assumption that the final post-maintenance tests should be in accordance with the manufacturer's recommendations and should be consistent with the design capabilities of the particular digital device.

### **ID-1 – Maintenance/Installation Check**

The following maintenance checks are both general and specific to digital components and assemblies. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks. Note that, after maintenance, there are many inspections of front panel indications and indications on HMI devices to ensure that the system is operating correctly.
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification. Note that insulation and grounding are checked during initial installation but only for the parts of the system affected by installation (that is, factory-assembled items are typically not rechecked).
2. Verify that any circuit components replaced have been placed properly on the circuit board, that the card has been securely fastened in its slot; and that the correct type of component has been used for replacement according to the vendor or plant technical data. Note that for digital systems there is very little replacement of component parts on circuit boards. Instead, complete boards are replaced. This is because high component density in newer digital systems makes board repair outside the factory nearly impossible.

3. Verify that air filters are clean in the area where maintenance has been completed, that solder joints are acceptable, and that no corrosion exists on any connectors or terminals. The need for cleanliness is not unique to digital systems. In a well-designed system, all digital components are typically plug replaceable. There is typically no need to unscrew terminations or solder connections.
4. Verify that the correct markings exist that identify the component and circuit board. Ensure that the identification tags have not been disturbed and that the nameplate data are correct. In a well-designed digital system, if the wrong circuit board is plugged into a slot, the CPU will not energize it, and error messages/lights will be generated. If a board can be damaged by insertion into the wrong slot, then it will commonly have mechanical keying to prevent improper insertion.

### ***ID-2 – Termination Integrity Check***

1. Check the terminals connecting the component or system to the digital device or system with the vendor or plant wire list, and verify that the correct connections have been made. Note that the vast majority of replacements should be with plugs. Terminations should not be disturbed after the initial installation.

### ***ID-3 – Functional Test***

In most cases, the digital device or system has been designed with self-diagnostic features that allow it to automatically perform various verification activities that ensure performance in accordance with design requirements. These self-diagnostic features vary from device to device, and as such, the PMT guidance described below should be tailored to meet the device-specific capabilities and the application-specific requirements.

Functional testing of digital components and assemblies typically can be categorized into the following types of tasks:

- Confirmation tasks – Establishing that the maintenance has been correctly completed
- Restoration tasks – Putting equipment or systems back in service or configuring them for normal operation
- Monitoring tasks – Establishing that the maintenance was successful

#### **Confirmation Tasks**

- Verify that all module front-panel indications show that the module is operational. This is typically an indication that the CPU has confirmed that the correct module type is positioned in the rack, that communication between the module and the CPU is successful, and that no internal errors or I/O errors are being reported.
- Confirm the operability of built-in redundancies, if inherent to the component/system design, by carefully following the manufacturer's procedures.

### **Restoration Tasks**

- Verify the operability of control and time stamping functions. Note that this may not be necessary in most cases because if the CPU is operating and the program memory has not changed, there is no need to test any functionality when power is restored.
- Verify the operability of failed equipment bypasses. Note that there is typically no need for this unless bypasses are in the hardware. However, in most digital systems, they are integral to the software.

### **Monitoring Tasks**

- Perform self-diagnostic checks.
- Verify the completion of a complete self-test during the initial boot sequence of a digital platform, which typically includes:
  - Execution of CPU instructions
  - Initial display of modular LEDs
  - Test of operating system and application memory
  - Check of all memory locations
  - Verification of communication interfaces and channels
  - Verification of capacity (whether the processor has sufficient capacity to perform its functions within the times specified)
- Verify that the following diagnostics are executed on a continuous run-time basis after the initial boot-up:
  - Test of operating system and application memory
  - Identification of read-only RAM domains
  - Verification of real-time clock and that the interrupt is being generated correctly
  - RAM check
  - Verification of data communications to detect physical layer failures and failures of the communication link to another communication processor module
- Verify the operability of watchdog timers that provide broad detection of system application errors if they have been built in to the product.
- Verify the communications with CPUs used to drive video display units (VDU) to indicate that the display system is being properly updated.
- Verify the operability of error detection schemes for critical control or protection applications that should detect failures that do not result in out-of-range conditions.
- Verify the operability of equipment failure indicators.
- Verify the operability of equipment failure alarms.
- Verify the operability of the system to monitor age-related failures (batteries and electrolytic capacitors).

All of the monitoring tests described above are typical of most digital systems, but the extent to which the system provides positive indication that these tests are being run varies significantly from product to product. For many products, there is no positive indication, and as such, post-maintenance verification may be beneficial.

- Perform application level testing. There are two types of automatic application level testing: passive and active. Passive testing is the process of monitoring the operations of the application and annunciating any anomalies. Active testing is the process of injecting test signals and observing the corresponding response by the application. Both are often designed as a part of the system so that all testing can be conducted without the need for temporary modifications. Passive and active application testing typically includes the following:
  - Passive testing – Corresponding data from redundant control processors are periodically compared, which compares input values (process measurements) and output values (trip and pre-trip) between redundant channels or between redundant processors within a channel.
  - Active testing – This is typically used to check calibration accuracies, to check correct logic/algorithm execution, and to verify system response times.
  - Internal function testing – Continuous active testing is used to allow extension of manual surveillance intervals. It should normally be used only for internal functions that do not affect the system's output interfaces. Based on the need to initiate bypasses prior to testing, internal function tests should be manually initiated and not conducted on a continuous automatic basis. Automatic interlocks should ensure that the system is in the proper bypassed mode before allowing the tests to be initiated. Bypass alarms and indications should be provided to operations personnel.
  - Testing output devices and controlled components – The internal tests described above provide coverage up to the final actuation output devices. Some platforms provide internal test schemes that confirm some functionality of the output device, such as coil continuity. However, a complete test of the output device (for example, output contacts) should be executed in conjunction with a test of the plant component that is actually controlled. For output interface tests, it is critical that appropriate indication and interlocks are provided to avoid spurious plant disturbances. Therefore, these tests should be manually initiated.
- Response time testing. Verifying response time may provide better detection of failure complexities with software-based systems. Note that there is not a consensus regarding the need for response time testing in digital systems. As such, testing should be at the discretion of each licensee.

## **IFD Fire Detection Component Testing**

### ***IFD-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to fire detection components. The acceptance criteria are as stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting.

1. Verify that the applicable general maintenance installation checks per EG-1 and IG-1 are completed. Particular attention should be paid to the following:
  - Verify that the reinstalled component has the correct nameplate data.
  - Verify that the power, control, and signal circuits containing fuses are checked for proper fuse type and rating. The fuse holder should be checked for dirt, corrosion, looseness, and missing parts.
2. Verify that the relay- or zone-indicating unit is clean with no indication of moisture.
3. Verify that no discoloration of relay- or zone-indicating unit exists that may indicate overheating.
4. Verify that the relay- or zone-indicating unit is firmly connected into a socket if it is a plug-in type.

### ***IFD-2 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that the correct terminal types have been used in any replacement work, that markers are in place, and that they match the plant wiring diagrams.
3. Verify that each termination is tight and torqued, where required.

### ***IFD-3 – Functional Test***

This testing will demonstrate successful operation of the fire detection components following the maintenance activity. Use the applicable station surveillance procedures to verify component function.

1. Perform a supervisory circuit check and channel check after maintenance on any component replaced on that channel.
2. Perform an operability test on the relay- or zone-indicating unit. Using a detector test kit, apply an activating source to the detector, and verify that the detector functions properly. Verify the actuation of alarms locally and in the master supervisory panel. Clear the alarm at the master panel.
3. Verify that when smoke, light, or temperature device is detected, the appropriate automatic function occurs, that is, dampers close, fans trip, etc.
4. After maintenance on the control panel power circuit, perform channel checks and supervisory circuit checks on all detector channels that reside in that panel.

## **IGG Gauge Component Testing**

### ***IGG-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to gauges. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable inspection checks of IG-1.
2. Verify that the gauge has been reinstalled in the correct location per the appropriate plant drawings and that the high and low tubing is correctly attached.
3. Verify that the gauge is reinstalled securely with all required brackets and linkages.
4. Verify that mechanical gauges have all of the required linkages securely connected.
5. Verify that only authorized sealing compound is used on pipe or tubing joints.
6. Verify that the reinstalled gauge has the correct scale graduations and nameplate data.
7. Verify that any disturbed human factor color banding has been reinstalled.

### ***IGG-2 – Leak Test***

1. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
2. Verify that all ASME pressure boundaries are tight according to the ASME program requirements.
3. Verify at operating pressure that all air pressure boundaries are tight and not weeping by using an approved leak-detecting fluid.
4. Verify that all capillary tubing and diaphragm assemblies are not weeping.
5. Verify that all fluid pressure boundaries are not leaking and can hold pressure.
6. Verify that the valve lineup has been properly restored.
7. Verify that gauge reading is consistent with other indication checks.

### ***IGG-3 – Calibration***

1. Perform a device calibration according to plant procedures. This can be a bench or in-place calibration.

## **IIN Indicator Component Testing**

### ***IIN-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to indicators. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the indicator has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the indicator is reinstalled securely with all required brackets and linkages.
4. Verify that the reinstalled indicator has the correct scale graduations and nameplate data.
5. Verify that any disturbed human factor color banding has been reinstalled.

### ***IIN-2 – Termination Integrity Check***

1. Verify continuity for each lifted lead variation.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable and wire markers are in place and that they match the wiring diagram.

### ***IIN-3 – Functional Test***

1. Energize the loop, and check the indicated value against a known input obtained from redundant channels or operational knowledge. Verify that the indicated value is within tolerance.
2. Perform a channel/loop check, when possible, if the functional check does not satisfactorily demonstrate operability or as the plant requirements dictate.

### ***IIN-4 – Calibration***

1. Perform a device calibration according to the plant procedures. This can be a bench or in-place calibration.

## **INI Nuclear Instrumentation Component Testing**

### ***INI-1 – Maintenance/Installation Check***

The following maintenance checks apply to in-core/ex-core nuclear instrumentation components and are both general and specific. The criteria are as stated in the verification step. Identified problems should be evaluated for additional repairs and retest requirements

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks.
  - Electrical checks including: termination, continuity, insulation resistance, and equipment grounding.
  - Ensure that equipment qualifications have been maintained as a result of the maintenance activity.
2. Verify that the detector, power supply, and/or circuit card has been installed in the correct location per the station drawings.
3. Verify the reinstallation of environmental seals or covers.
4. Verify continuity for each lifted lead.
5. Verify that each termination is tight and properly torqued.
6. Verify the accuracy and proper location of wire markers.

### ***INI-2 – Channel Calibration***

1. Perform the appropriate maintenance checks of power supply, meter, instrument drawer, and indicator per the appropriate component test matrix.
2. Perform channel calibration per the existing station procedures for the affected NI channel, including channel checks, channel calibration, channel functional checks, and periodic comparisons to calorimetric calculations.
3. Verify that all auto-actuation/interlock set points and resets function properly.
4. If applicable, perform an in-core detector channel calibration (normalization) per the plant procedures.

### ***INI-3 – Detector Calibration***

1. Perform detector calibrations per the vendor technical manual or plant procedures, establish the initial setting, and ensure channel operability.
2. Depending on the work performed, initiate a caution tag for at-power checks for overlap and cross-calibrations. If there are any questions, contact the station reactor engineering staff.

***INI-4 – Functional Test***

1. Verify the actuation settings from the channel calibrations.
2. During reactor startup, verify proper operation by comparison with the redundant channel at each indication point.
3. If applicable, perform in-core/ex-core calibrations per the station procedures.
4. If applicable, perform high power primary to secondary calorimetrics to verify the reactor power against the turbine power, and reconcile per the station procedures.
5. If applicable, perform a trip actuation device test.
6. If applicable, perform an in-core detector drive test.

## **IPC Process Controller Component Testing**

### ***IPC-1 – Maintenance/Installation Check***

The following maintenance checks apply to process controller components to verify their proper reinstallation and restoration following maintenance.

The criteria are as stated in the verification step. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG-1 and IG-1:
  - Inspection checks.
  - Electrical checks including: termination, continuity, insulation resistance, and equipment grounding.
  - Ensure that environmental qualification has been maintained as a result of the maintenance activity.
2. Verify that the controller has been installed in the correct location.
3. Verify that the controller is reinstalled securely with all the required brackets attached.
4. Verify that the controller has the correct nameplate data.

### ***IPC-2 – Operational Check***

Perform an operational check by energizing the loop and checking the indicated output value against a known output obtained from redundant channels or operational knowledge. Verify that the indicated value is within tolerance. This operational check is typically conducted with the channel out of service. If it is found that the operational check does not completely verify channel operation, perform a channel functional test (loop check) when possible.

1. Verify that all indicators operate per design in a timely manner.
2. Verify that all control stations function in a timely manner.
3. Verify that all blocks, permissives, interlocks, and protective devices function in a timely manner.
4. Verify that inputs to computer monitoring pads operate.
5. Verify that all instrument switches and relays function in a timely manner.

### ***IPC-3 – Device Calibration***

Device calibration is the adjustment, standardization, or setting of instrumentation and controls to established values. Simulated process signals are input to the device and the response measured by M&TE.

1. The signal input (% of span) is documented on a data sheet.
2. The desired output is documented.
3. The as-found value, increasing or decreasing, is recorded to a sufficiently accurate value and compared to the desired value.
4. Adjustments are made as necessary until the instrument response is within the acceptance criteria range.
5. The as-left output value is documented on the data sheet.
6. Failure of the device to meet acceptance criteria following adjustment should be documented, and appropriate actions taken to repair/replace and evaluate the condition.

### ***IPC-4 – Channel Calibration***

Channel calibration is an adjustment of the channel (or loop) so that it responds with the required range, accuracy, and timeliness to known values of input. This test encompasses the entire channel including the sensors, alarm, interlock, and/or trip functions and can be performed by any series of sequential, overlapping, or total channel steps so that the entire channel is calibrated.

1. Consult the plant set point document/scaling manual.
2. The general steps for device calibration should be followed for the channel or series of sequential or overlapping calibrations.

### ***IPC-5 – Channel Functional Test***

A channel functional test (channel/loop check) is the qualitative assessment of channel (or loop) behavior during operation by observation. This determination should include, when possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter.

1. Verify that appropriate maintenance inspections, electrical checks, and calibrations have been satisfactorily completed.
2. For equipment specified in the Technical Specifications, the applicable surveillance test should be performed.
3. For other equipment, especially quality-related equipment, a documented test that verifies operability should be performed.

4. Energize the loop, and allow it to stabilize. Check the controller output value against a known output obtained from operating knowledge. Verify that the value is within tolerance, and operationally check the loop, when plant conditions permit, to verify that the controller is operating correctly throughout its range.
5. Verify the proper operation of loop components (see the list in IPC2 Operational Check).

## **IR Recorder Component Testing**

### ***IR-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to recorders. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional re-pairs and retest requirements.

1. Verify the applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the recorder has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the recorder is reinstalled securely with all required brackets and linkages.
4. Verify that the reinstalled recorder has the correct nameplate data.
5. Verify that any disturbed human factor color banding has been reinstalled.

### ***IR-2 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable and wire markers are in place and that they match the wiring diagram.

### ***IR-3 – Functional Test***

1. Energize the loop, and check the indicated value against a known input obtained from redundant channels or operational knowledge. Verify that the indicated value is within tolerance.
2. If the functional check does not satisfactorily demonstrate operability (or as the plant requirements dictate), perform a channel/loop check when possible.
3. Verify that a correct trace is indicated/recorded versus input.
4. Verify that multipoint print heads are synchronized to the proper input.
5. Verify that recorder printout quality is adequate to be reproduced or photographed.
6. Verify proper chart speed and take up.

### ***IR-4 – Calibration***

1. Perform a device calibration according to plant procedures. This can be a bench or in-place calibration.

## **IRM Radiation Monitor Component Testing**

### ***IRM-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to radiation monitors. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the radiation monitor has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the radiation monitor is reinstalled securely with all required brackets and linkages.
4. Verify that the reinstalled radiation monitor has the correct nameplate data.
5. Verify that any radiation symbols that were removed during maintenance have been replaced.
6. Verify that any radiation shielding removed for maintenance has been reinstalled.

### ***IRM-2 – Leak Test***

1. Verify that any ASME pressure boundaries components are tested according to the ASME plant program requirements.
2. Verify that all flange connections have the appropriate gasket material.
3. Verify that any inlet strainers or filters are clean.
4. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
5. Bring the monitor to operating pressure, and verify that all air fluid boundaries are not leaking any fluid.
6. Verify that all air pressure boundaries are tight and are not weeping by using an approved leak-detecting fluid.

### ***IRM-3 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable and wire markers are in place and that they match the wiring diagram.

***IRM-4 – Functional Test***

1. Energize the monitor, and verify that all indicators are illuminated.
2. Start any required pumps, and adjust the flows to the correct value.
3. Allow the unit to stabilize, and verify that the indicated value is within limits, as prescribed by the vendor or plant documentation.
4. If it is found that the functional test does not adequately demonstrate operability, perform a channel/loop check or surveillance.
5. Verify the computer inputs.
6. Verify the source status.
7. Verify the automatic functions including: alarms, indications, and automatic actuations.

***IRM-5 – Calibration***

1. Perform a device calibration according to plant procedures. This can be a bench or in-place calibration.
2. Perform channel calibration, as required, according to the plant surveillance procedures.

## **IRT RTD/Thermocouple Component Testing**

### ***IRT-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to RTDs or thermocouples. The acceptance criteria are stated in the verification steps. Unacceptable performance should be evaluated for additional repairs and retesting.

1. Verify the applicable general maintenance installation checks of EG-1 and IG-1:
  - Inspection checks.
  - Electrical checks including: termination, continuity, insulation resistance, and equipment grounding.
  - Ensure that equipment qualifications have been maintained as a result of the maintenance activity.
2. Verify that the RTD or thermocouple is reinstalled in the correct location and process tap according to the plant documentation.
3. Verify that all fasteners are in place and that connections to terminal blocks are tight.
4. Check wire routing to ensure that it is secure and that it does not bind when covers are closed or removed.
5. Verify that no corrosion is present on terminals or the RTD or thermocouple, and check for cleanliness of the component.
6. Verify that each lifted wire is replaced per the applicable wiring diagram.
7. Verify that the RTD or thermocouple and thermowell have the correct nameplate data.

### ***IRT-2 – Leak Test***

1. Verify that any ASME pressure boundaries components are tested according to the ASME plant program requirements.
2. Verify at operating pressure that all air pressure boundaries are tight and not weeping by using an approved leak-detecting fluid.
3. Verify that all fluid pressure boundaries are not leaking and can hold pressure.

### ***IRT-3 – RTD or Thermocouple Termination Integrity Check***

1. Continuity check each lifted lead.
2. Verify that each thermocouple wire is properly color coded and terminated per the design documents.
3. Verify that each termination is tight and that all wiring is neatly dressed.

### ***IRT-4 – Functional Test***

This testing will demonstrate successful operation of the RTD or thermocouple following the maintenance activity.

1. Notify operations that power is to be applied to the RTD or thermocouple circuit.
2. Energize the loop, and check the indicated value against a known input obtained from redundant channels or operational knowledge. Verify that the indication check is within tolerance. Refer to the Transmitter Component Test Matrix, IT, for additional tests.
3. Verify RTD resistance at a known temperature using a precision bridge instrument. Compare to the actual process temperature, and record.
4. If it is found that the functional test does not satisfactorily demonstrate operability, perform a channel/loop check when possible.

### ***IRT-5 – Calibration***

1. Perform a device calibration according to the plant procedures. This can be a bench or in-place calibration.
2. Perform a channel calibration of all channel components, except sensor, according to the plant procedures.

## **IT Transmitter Component Testing**

### ***IT-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to transmitters. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify applicable maintenance checks of IG-1 and EG-1:
  - Inspection checks
  - Electrical checks including: insulation resistance, equipment grounding, and equipment qualification
2. Verify that the transmitter has been reinstalled in the correct location per the appropriate plant drawings.
3. Verify that the transmitter is reinstalled securely with all required brackets and linkages.
4. Verify that the reinstalled transmitter has the correct nameplate data.

### ***IT-2 – Leak Test***

1. Verify that any ASME pressure boundary components are tested according to the ASME plant program requirements.
2. Verify that all tubing/capillary has no kinks, dimples, or sags and that it is securely supported.
3. Verify that all disturbed connections are tight. Bring the transmitter to operating pressure, and record.
4. Verify that all fluid pressure boundaries, including diaphragms, are not leaking fluid and can hold pressure.
5. Verify that the air pressure boundaries are not leaking by using an approved leak-detection fluid.

### ***IT-3 – Termination Integrity Check***

1. Verify continuity for each lifted lead.
2. Verify that each termination is tight and that all wiring is neatly dressed.
3. Verify that cable and wire markers are in place and that they match the wiring diagram.

***IT-4 – Functional Test***

1. Energize the loop, and check the indicated value against a known input obtained from redundant channels or operational knowledge. Verify that the indicated value is within tolerance and responds in a timely manner.
2. If the step above is not satisfactory, perform a channel/loop check when possible.
3. Verify that the transmitter output functions are correctly actuated, including alarms, computer inputs, remote indications, interlocks, and actuation devices. Compare signal indication, if applicable, against redundant indications.

***IT-5 – Calibration***

Perform a device calibration according to the plant procedures. This can be a bench or in-place calibration.

# D

## MECHANICAL TESTING GUIDE AND TEST DEFINITIONS

### INDEX TO MECHANICAL TESTING GUIDE AND TEST DEFINITIONS

#### Mechanical Equipment – General Testing

Equipment Code	Guidance	Page
MG-1	General Mechanical Maintenance/Installation Check	D-3
MG-2	General Mechanical Run/Operational Tests	D-4
MG-3	General Mechanical Functional Tests	D-5
MG-4	Mechanical Special Tests	D-7

#### Mechanical Equipment – Component Testing

Equipment Code	Guidance	Page
MAH	Air Handling Unit/Fan/Blower	D-8
MC	Coupling	D-10
MCD	Condenser	D-11
MCH	Crane/Hoist	D-13
MCP	Compressor	D-15
MD	Dryer	D-17
MDD	Damper/Ducting	D-19
MDE	Diesel Engine	D-20
MFP	Fire Protection Device	D-23
MFS	Filter/Strainer/Demineralizer	D-26
MGT	Gear Box/Transmission	D-27
MGV	Governor, Hydraulic	D-28
MHD	Hydraulic Drive	D-29
MHX	Heat Exchanger	D-30
MP	Pump	D-32

*Mechanical Testing Guide and Test Definitions*

<b>Equipment Code</b>	<b>Guidance</b>	<b>Page</b>
MPP	Piping/Tubing/Welded Component	D-34
MPS	Pipe Support/Hanger	D-35
MRC	Refrigeration Unit/Chiller	D-36
MRF	Radiation Filter	D-39
MS	Snubber	D-40
MT	Turbine	D-42
MTV	Tank/Vessel/Accumulator	D-46
MV	Valve, Manually Operated	D-47
MVA	Valve, Air-/Pneumatic-Operated	D-49
MVC	Valve, Check	D-51
MVM	Valve, Motor-Operated	D-53
MVR	Valve, Relief/Safety	D-55
MVS	Valve, Solenoid	D-57

## MG Mechanical Equipment General Testing

### MG-1 – General Mechanical Maintenance/Installation Check

The following are general tests that should be performed where appropriate.

#### A. Inspection Check

1. Debris removed from the vicinity of piping, motor, pump base, drains, tanks, vessels, and the general vicinity of the equipment.
2. All auxiliary piping is connected including bearings, jacket and gland cooling, priming lines, vents, and drains.
3. All joints are properly made up:
  - Flange joints are complete with gaskets and bolts, which are tightened.
  - Welded joints are completely welded.
  - Disconnect joints are made up according to engineering and/or the manufacturer's information.
  - Unused openings, which do not serve as process connections, are closed according to engineering and/or the manufacturer's requirements.
4. Coupling guards are installed where required.
5. Keys are tight and locked.
6. All components are properly identified.
7. All piping, tanks, and vessels are heat traced/insulated/coated according to approved engineering documents.
8. Verify that all hangers and restraints are in position and that spring hangers and snubbers are operable. Spring hangers are showing load and are not bottomed out or pinned. All lock pins have been removed from hangers after hydrostatic test, and all temporary rigging has been removed. Also, verify that the hydraulic fluid in hydraulic snubbers is at the proper level and that it does not leak.
9. Verify that tank and vessel internals are installed and that any protective linings are applied and are undamaged. Vessel interiors are free of all loose scale and debris.
10. Verify that a Code operating certificate for pressure vessels is obtained where applicable.
11. Verify that all handhold and manway covers are made up, complete with gaskets and bolts that are tightened.
12. Permanent and temporary strainers are clean and in place. Gauges are installed to measure D/P across strainers, if necessary.
13. Verify that the system has been flushed and hydrostatically tested, as required by the installation documentation or other approved engineering specifications.

*Mechanical Testing Guide and Test Definitions*

14. Use flow diagrams/P&IDs to verify the correct mechanical configuration of piping runs, equipment, and components, as applicable. For recording test results, use a marked-up (highlighted) flow diagram/P&ID.
15. Verify that sufficient thread engagement is visible on bolted fasteners.

**MG-2 – General Mechanical Run/Operational Test**

This testing demonstrates the normal operation of the component after maintenance has been completed. The following tests or checks are general and are made available for consideration where specific test guides have not been provided.

1. Verify proper operation or alignment of all auxiliary or necessary attendant functions for the component:
  - Cooling heat exchanger
  - Fans
  - Instrumentation
  - Fire protection devices
  - Power source alignment
  - Valve alignment
  - Process fluid
2. Start the component, and allow it to operate. Verify that abnormal noises, improper bearing lubrication, or excessive vibration are not present, as determined by experience.
3. Verify that the component and, if applicable, the motor temperature are in the correct range, as determined by the plant documentation or experience.
4. Verify free movement of the component and correct rotation of the motor and component, if applicable.
5. Verify proper rotating speed, when applicable.
6. With the system operating verify:
  - Oil - Level, pressure, and temperature
  - Pressure - Suction, discharge, interstage, and differential
  - Temperature of primary and secondary fluids - Inlet and outlet
  - Primary and secondary fluid flow and level
7. Verify that there are no lubricant or process leaks.

8. Verify that the component operates correctly in all modes (manual, automatic, standby, and failsafe).
9. Verify normal cycling of the component or system, if applicable.
10. Verify normal component or system response by varying the controls and observing smooth reaction of the component and proper transition of the process.

### **MG-3 – General Mechanical Functional Test**

This test or verification ensures that the component, equipment, or subsystem that was affected by the maintenance activity is completely capable of performing its design functions. The following tests or checks are general and are made available for consideration where specific test guides have not been provided.

1. Verify the proper operation or alignment of all auxiliary or necessary attendant functions for the component:
  - Cooling heat exchanger for bearing cooling, room cooling, etc.
  - Fans
  - Instrumentation
  - Fire protection devices
  - Power source alignment
  - Valve alignment
  - Process fluid
2. Verify proper rotation and correct process-flow direction by jogging the driver.
3. Operate the equipment under normal conditions. Verify through observation that the component and couplings or attachments operate smoothly without excessive vibration or noise.
4. Verify that the equipment vibration under normal operating conditions does not exceed the vendor or plant specifications. See MG4 General Mechanical Special Tests - Vibration Testing for general testing.
5. Verify that the component does not stick due to tight packing or parts that are defective or worn.
6. Verify proper rotating speed where applicable.
7. If adjustments were made that could alter the motor loading, verify the motor's capacity to handle the load requirements.
8. Verify that the motor does not overheat; check that the motor current meets the requirements.
9. Verify that there are no lubricant or unacceptable process leaks. Check all connections and cover seals for leaks.
10. Verify that outlet pressure and flow rate meet requirements.

*Mechanical Testing Guide and Test Definitions*

11. Verify, if applicable, that the cooling water operates and regulates properly on component startup and shutdown.
12. Verify, as applicable, that the following parameters are according to vendor and plant engineering documentation, and record:
  - Component discharge pressure and temperature
  - Component oil pressure and temperature
  - Component bearing temperature
  - Motor current at rated component capacity
  - Interstage pressure
  - Lube oil level
  - Lube oil temperature
  - Lube oil pressure
  - Coolant level
  - Coolant temperature
  - Fuel oil temperature
  - Fuel oil level
  - Fuel oil pressure
  - Critical component temperatures such as bearing, cylinder, windings, etc.
  - Flow rates of the primary and secondary fluids, as applicable
  - Inlet and discharge temperatures of both the primary and secondary fluids
  - Pressure at the inlet and discharge of both the primary and secondary fluids
13. Verify that the component functions correctly in all modes (auto, manual, and standby).
14. Verify that the component failure modes are according to requirements.
15. Verify that the component cycles normally and that any timers operate properly according to the manufacturer and plant requirements.
16. Verify operation of the heaters, if applicable.
17. Verify that the pressure differential across the component is within operating limits.
18. Verify that the system flow and balance meet requirements.
19. For dual-function equipment, shift to the alternate to verify shift mechanism operability and proper process control on the alternate.

20. Verify that the component and associated devices respond to change in speed/load setpoint, if applicable:
  - Verify that there are no step increases or decreases in speed or load during a ramp up/down.
  - Verify that the system control is stable and that the speed or load corresponds to the set point.
21. Determine the pressure drop and heat transfer characteristics of the component, and compare them to the design requirements.
22. Verify that component performance characteristics or curves are within the requirements stipulated by the engineering requirements.

#### ***MG-4 – General Mechanical Special Test***

The following tests are generic and can be used where appropriate to meet testing requirements in the absence of other specific testing.

##### **A. Vibration Testing**

Appropriate vibration data sheets should be completed for the equipment being tested. All vibration readings should be taken under normal operating conditions in three directions at each location. Also, record rpm measurements and any equipment parameters (number of fan blades, impeller vanes, bearing balls/rollers, and gear teeth).

1. For vibration frequencies between 600–60,000 cpm, record filtered-out vibration velocity readings on the bearing housing. Acceptable levels are 0.25 inches/second (6  $\mu\text{m}$ /second) or less unless otherwise specified in the manufacturer manuals or other plant documentation.
2. For vibration readings below 600 cpm, use accelerometer transducers, and record the acceleration readings in addition to the velocity readings. Acceptable levels must be less than 0.25 inches/second (6  $\mu\text{m}$ /second) and below the “failure zone,” as defined in the plant documentation.
3. For vibration greater than 60,000 cpm, record both acceleration and vibration readings. Acceptable levels must be less than 5 g’s unless otherwise specified by the manufacturer or plant documentation.
4. For anti-friction bearing application in high-speed rotation more than 3400 cpm, record the spike energy readings. Acceptable levels must be less than 0.5 g’s unless otherwise specified by the manufacturer or plant documentation.

## **MAH Air Handling Unit/Fan/Blower Component Testing**

### ***MAH-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to air handling units, fans, or blowers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of MG1 and EG1.
2. Verify that the motors, blades/fan wheel, fan housing, and surroundings are clean and free of debris.
3. Verify that the fan is securely mounted and that all bolts, fasteners, and electrical connections are tight.
4. Verify that no corrosion on electrical terminals or motor components is present.
5. Verify that the fan blade angles (pitch of the blades) are uniform.
6. Ensure that all wiring is secure.
7. Verify that the installation is according to the vendor or plant requirements.
8. Verify that the bearings are properly aligned and are lubricated with an approved lubricant.
9. Verify free rotation and clearances of the fan blades.
10. Verify that the belt tension is correct, if applicable.
11. Verify that safety devices are installed properly.
12. For work that may have affected fan balancing, verify that the fan/wheel is balanced within the plant requirements.
13. For maintenance on the motor, perform motor maintenance checks per EM1.

### ***MAH-2 – Functional Test***

This test will demonstrate successful fan, motor, and air flow operation.

1. Verify proper rotation and correct air flow direction by jogging the driver.
2. Verify that no unusual vibration or noise exists when the fan is operated.
3. Verify that there are no lubricant leaks.
4. Verify the proper rotating speed, when applicable.
5. Verify that outlet pressure and flow rate meet requirements.

6. If fan speed or pitch adjustments were made, verify the motor's capacity to handle the load requirements.
7. Verify that the motor does not overheat. Check that the motor current meets requirements.
8. Verify proper filter operation, as applicable.

***MAH-3 – Special Test - Vibration Test***

This testing will ensure that the fan is properly balanced and that the vibration does not exceed the plant requirements.

1. Perform a vibration test according to Mechanical Special Test MG4. Verify that vibration measurements under normal operating conditions do not exceed the plant requirements.

## **MC Coupling Component Testing**

### ***MC-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to couplings. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional re-pairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify by visual inspection that the coupling has sufficient lubrication, adequate clearance, and no evident sign of excessive wear.
3. Verify that, when applicable, coupling covers are in place.
4. Check for leaks, and confirm that lubricant plugs, gaskets, and seals are clean and in place.
5. Check the static supply of lubricant inside the coupling.
6. Check the condition of the seals, and verify that there are no leaks.
7. Verify that no abrasive materials or lubrication contaminants are present.
8. Verify that the coupling is properly mounted on the driving and driven shafts.
9. Verify that the keys fit properly in both shafts and hub.
10. Verify the proper tension, if chain driven.
11. Verify the alignment for proper axial spacing, angular misalignment, and parallel misalignment.
12. Verify the alignment and proper function by rotating the shafts by hand.

### ***MC-2 – Functional Test***

This test demonstrates that the coupling is capable of performing its intended function. The acceptance criteria are stated in the verification steps.

1. Operate the equipment under normal conditions. Verify through observation that the coupling operates smoothly without excessive vibration.
2. Verify that the vibration of the equipment is according to the manufacturer's or the plant engineering documentation. Refer to General Mechanical Special Test, MG4 to perform the vibrations check, if appropriate.

## **MCD Condenser Component Testing**

### ***MCD-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to the main condenser. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify that the condenser interior and tubes are free of all loose scale and debris. The system has been flushed and filters cleaned of sludge and debris.
3. Verify that all tubes are clear or plugged.
4. Verify that all vessel internals are installed and secure and that all internal scaffolding has been removed.
5. Verify that welds are complete and that any welding elements or deposits have been removed.
6. Verify that access covers are properly installed with gaskets and that all bolts are properly torqued.
7. Verify that all connecting equipment is attached and that vents are closed.
8. Verify that protective coatings inside waterboxes or tube sheets are intact.
9. Verify that support or auxiliary equipment or systems, such as leak detection system, condenser cleaning system, or cathodic protection system, etc., have been inspected and are functioning properly. Additional component matrices should be reviewed to ensure that other interactive components are evaluated for testing requirements.

### ***MCD-2 – Leak Test***

Any structure or component which must, as part of its design requirements, be leak tight must be leak tested by whatever appropriate means to ensure that its ability to fulfill its intended design function has been achieved by the maintenance activity.

#### **A. Tube Leak Test**

1. Pressurize the individual tubes, and monitor the pressure decay to determine if tubes are leaking.
2. Test the condensate conductivity for indication of a tube leak.

## **B. Condenser Leak Test**

Ensure that there are no leaks in the condenser shell:

1. Verify that no tube sheet leaks.
2. Verify that access covers do not leak.
3. Verify that the condenser shell has no vacuum leak, and record the vacuum level during the test period.

### ***MCD-3 – Functional Test***

This is an equipment operation and thermal performance test to confirm that the operational and thermal characteristics of the condenser have been restored by the maintenance activity and to provide baseline data for performance monitoring. Refer to the station thermal performance program procedures or the appropriate ASME Performance Test Code (PTC).

1. Measure the tube side cooling water flow rate.
2. Measure the inlet and outlet discharge temperatures of both the cooling water and the steam and condensate.
3. Measure the pressure at the inlet and discharge of both the cooling water and the condenser steam inlet and vacuum.
4. Calculate the heat transfer and pressure drop characteristics of the condenser, and compare this to the design and baseline data.

## **MCH Crane and Hoist Component Testing**

### ***MCH-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to cranes and hoists. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and not visibly loose or broken.
  - Verify that the equipment and valves are per the plant requirements.
  - Verify that all fluid connections and tubing are connected tight without damage and that the couplings are tight.
  - Verify that the equipment is physically reassembled and reconnected properly according to the vendor or plant documentation.
  - Verify that there are no loose electrical connections, bolts, or nuts.
2. Verify that hooks have no deformation, cracks, or unacceptable wear.
3. Verify that hoisting cables have no broken wire, abrasion, kinks, or improper spooling on the drum.
4. Verify that hydraulic systems have no deterioration or leaks. For maintenance on the hydraulic system, review the MHD1 guidelines.
5. Verify that the hoisting hook is secure from possible impacting equipment and that the crane or hoist travel path is free from obstructions and maintenance equipment.
6. Inspect the condition of the electrical busswork over its entire length.
7. Verify the installation of mechanical stops, if applicable.

### ***MCH-2 – Operational Check - Unloaded***

This is an equipment operational test to confirm that the characteristics of the crane/hoist meet the design and operational requirements for prestart and unloaded operation.

1. Operate the crane/hoist several times over the extent of its travel.
2. Verify the operation of controllers for intended movement for each of the crane/hoist directions and motions.
3. Verify the operation of all brakes.
4. Verify the operation of travel limit stops.
5. Verify the hook operation over its entire range.

**MCH-3 – Functional Test**

1. Subject the crane to a load test according to the vendor or plant documentation to confirm the load rating (static and dynamic lift tests may be required).
2. Verify load-related interlocks.
3. Verify that travel speed of the hook/trolley moves as per the design.

## **MCP Compressor Component Testing**

### ***MCP-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to compressors. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify that the compressor inlet piping is clear and that clean filters/strainers have been installed.
3. Verify that the compressor is adequately lubricated and has sufficient lubricant levels. Ensure that the lube sumps have been cleaned.
4. Verify that the air compressor, air receiver, and air distribution system are free of obstacles.
5. Verify that the drive belts are properly aligned and have the correct tension.
6. Verify that there are no leaks.
7. Verify that the compressor is free of binding
  - Uncouple the compressor, if appropriate.
  - Verify by manual rotation, if possible, that interference or binding of working parts is not present.
8. Inspect the breathing air compressor oil and after-cooling systems according to the manufacturer's or plant documentation.

### ***MCP-2 – Operational Check- Unloaded***

Verify that the compressor and associated components operate properly in an unloaded condition. The acceptance criteria are as stated in the verification steps.

1. Start the compressor and allow it to operate unloaded. Verify that abnormal noises, improper bearing lubrication, or excessive vibration are not present as determined by experience or the manufacturer's documentation.
2. Verify that the motor, current and temperature, and the compressor temperature are in the correct range as determined by the manufacturer's or plant documentation, or experience.
3. Verify that the air temperature, discharge pressure, cooling flow, oil level, and bearing temperature are within the required manufacturer's or plant specifications.

### **MCP-3 – Functional Test**

This test demonstrates that the compressor is capable of performing its intended function. The acceptance criteria are stated in the verification steps. Appropriate data should be recorded for plant trending analysis.

1. Verify that the cooling water regulates properly on compressor startup and shutdown.
2. Verify that the following parameters are according to the vendor and plant engineering documentation.
  - Compressor discharge pressure and temperature
  - Compressor oil pressure and temperature
  - Compressor bearing temperature
  - Motor current at rated air compressor capacity
  - Interstage pressure
  - Vibration measurements
3. Verify that the compressor functions correctly in all modes (auto, manual, and standby).
4. Verify that the compressor cycles normally.

## **MD Dryer Component Testing**

### ***MD-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to dryers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed.
2. Verify that there are no visible signs of improper equipment assembly.
3. Verify that gauges are intact and that calibration is current.
4. Verify that all connecting equipment is attached and that the linkages are in place and operate freely.

### ***MD-2 – Leak Test***

Any structure or component that must, as part of its design requirements, be leak tight, must be leak tested by whatever appropriate means to ensure that the ability to fulfill its intended design function has been achieved by the maintenance activity.

1. Visually examine the pressure-retaining component while the system is under a predetermined pressure. Typically, this inspection is performed at component normal operating temperature and pressure.
2. Verify that at mechanical joints or connections leakage is acceptable or nonexistent, by using an approved leak-detection solution.

### ***MD-3 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the dryer meet design and operational requirements.

1. Verify that the timer operates properly and that the dryer cycles according to the vendor and plant requirements.
2. Verify the operation of the heater, and record the amperage.
3. Verify that the pressure differential across the dryer is within operating limits.
4. Verify the successful regeneration of the desiccant.
5. Verify that the correct purge flow rate through the tower is being regenerated.

***MD-4 – Dew Point Test***

1. Verify that exit process air is adequately dry.
2. Record the dew point temperature.

***MD-5 – Particulate Test***

1. Sample by blowdown various sections of piping into test media.
2. Monitor for rust particles, desiccant fines, or other solid contaminants. The maximum contaminant size should be 3 microns (3  $\mu\text{m}$ ).

## **MDD Damper and Ducting Component Testing**

### ***MDD-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to dampers and ducting. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed.
2. Verify that there are no visible signs of improper equipment assembly.
3. Verify that the intake and discharge screens in local areas are clear.
4. Verify that the dampers and linkages are in place and that threaded connections are properly locked.
5. Verify that all instrument test and access holes are covered.
6. Verify that the damper seal material is in good condition.
7. Before placing the ventilation system in operation, verify that the damper movement over full travel is smooth.
8. Verify tight closure of the dampers against the casing, frame, or cone, as applicable.
9. Verify that the damper position indicators, where appropriate, are properly adjusted.
10. Verify that the damper linkage is properly lubricated, according to the vendor or plant requirements.
11. Verify that the insulation is in good serviceable condition and that it is not torn or missing.
12. Verify that ducts are insulated or coated, according to the plant documentation.
13. Verify the proper installation of the “fuse link” (a fire-protective device) for fire curtains, if applicable.

### ***MDD-2 – Functional Test***

This testing will demonstrate the successful operation of the ducting and damper following the maintenance activity.

1. Verify with the ventilation system in operation that the damper operates as required.
2. Verify that the damper failure modes are according to requirements.
3. Verify that system air flow balance meets the requirements, and adjust as necessary.
4. Verify that the damper leakage meets the plant requirements.
5. Verify that damper with auto-open/close or interlock functions performs its automatic actions by the insertion of appropriate test signals or by the operation of interlocked components.

## **MDE Diesel Engine Component Testing**

### ***MDE-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to diesel engines. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed.
2. Verify that there are no visible signs of improper equipment assembly and that all bolts have been torqued according to the requirements.
3. Verify that there are no broken or missing parts.
4. Verify that all auxiliary attachments including hoses, tubes, and clamps are properly installed.
5. Verify that there are no visible signs of leakage of fuel, lube oil, or coolant.
6. Verify that belts are properly aligned and that they have the correct tension.
7. Verify that the quantity of fuel in the storage tank is correct.
8. Verify that the level of coolant in cooling system is correct and that there are no signs of coolant in the lube oil.
9. Verify that all indicating lights associated with the diesel are operating properly.
10. After major overhauls, follow the manufacturer's specified inspections and instructions for prestart and operational test requirements.

### ***MDE-2 – Functional Test***

This testing will demonstrate the successful operation of the diesel engine following the maintenance activity.

1. Verify that the support or auxiliary systems have been inspected or tested and are functioning properly, such as:
  - Air starting system - Air tank, tank outlet check and manual valves, pressure regulating valve, starting air solenoid valve, drive air control valve, cranking air motor, etc.
  - Fuel oil system - Diesel and electric fuel oil pumps, strainer, fuel metering valve, injectors, etc.
  - Lube oil system - Filter/strainer clearing; main, piston, and scavenging oil pumps; oil replacement; lube oil cooler; temperature controls; etc.

- Cooling water system - Pump, radiator, expansion tank, electric water heater, turbocharger aftercooler, temperature control valve, etc.
- Ventilation system - Louvers, exhaust fans, cooling coils, filters, temperature controls, etc.

A review of related component matrices should be conducted for additional interactive testing, if required.

2. Start the diesel and load it from the remote and local control stations, and verify that the following parameters meet the design and plant requirements, as applicable:
  - Lube oil level
  - Lube oil temperature (record)
  - Lube oil pressure (record)
  - Coolant level
  - Coolant temperature (record)
  - Fuel oil level
  - Fuel oil temperature (record)
  - Fuel oil pressure (record)
  - Cylinder temperatures (record)
  - Cylinder firing compression
  - Exhaust temperature
  - Turbocharger operation
  - Alarms and warning system
  - Indicating lights and monitoring instrumentation
  - Governor operation
  - Starts within the required time at rated speed
  - Overspeed trip
3. Verify that the engine RPM is correct and record it.
4. Verify that no unusual noise or vibration exists. Perform vibration tests, as required or as desired by test personnel.

***MDE-3 – Fuel Test***

1. All fresh or new fuel should meet the acceptance criteria per the plant surveillance procedures before placing it in the main storage tanks.
2. Bottom samples should be tested for visual appearance, water, particulate, and microbiological contamination.
3. Fuel in the fuel lines should be tested for degradation, being subject to high heat, in addition to those parameters in Item 2, above.
4. Fuel in the filters/housing should be periodically drained to avoid buildup of contaminants.

## MFP Fire Protection Device Component Testing

### ***MFP-1 – Maintenance/Installation Checks***

The following maintenance checks apply to fire hoses, fire extinguishers, spray or halon nozzles, hydrants, piping, fire doors, and deluge valves to verify proper restoration following maintenance or replacement. The criteria for the inspections are as stated in the verifications. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of EG1, IG1, and MG1. Particular attention should be paid to the following:
  - Verify that all fasteners are in place and that connections to terminal blocks are tight.
  - Verify that there is no corrosion on terminals or the component, and check for cleanliness of the component.
  - Verify the sensing signal and other lines cleanliness. Clean to remove dirt, sediment, and debris by blowing with air or flushing with fluid that is compatible with the process.
  - Verify that all wiring and instrumentation are connected properly per the plant documentation.
  - Verify that piping has been reconnected and that all welds are satisfactory.
  - Verify that flanged joints are complete with gaskets installed and that all bolts and threaded fittings are tight and properly torqued.
  - Verify that all supports, including hangers, struts, and clamps, are in position and that all supporting hardware is properly assembled and tightened.
2. Verify that equipment and instrumentation are physically reassembled, securely mounted, and re-connected properly, according to the manufacturer or plant requirements.
3. Verify that equipment is adequately lubricated and that all lubricant reservoirs are full.
4. Verify that there is no excessive corrosion present that can prevent operation of the component.
5. Verify that fire protection doors are not damaged and that they have proper fit. Verify that doors are operable and are not blocked open.
6. Verify that replaced fire hoses or nozzles are in good condition.
7. Verify that halon nozzles or sprinkler heads are clean, free of paint, and unobstructed.
8. Verify that the halon control head/valve is properly installed with no leakage. Also, verify proper halon cylinder volume, if applicable.

*Mechanical Testing Guide and Test Definitions*

9. Verify that the rotating equipment and driver are properly coupled.
10. Verify that fire hoses have been hydrostatically tested within the proper interval of time per the plant requirements.
11. Verify that fire extinguishers have the proper amount of extinguishing agent, as measured by weight, pressure, or volume.

**MFP-2 – Leak Test**

1. Verify that all tubing/capillary has no kinks, dimples, or sags, and that it is securely supported.
2. Verify that all disturbed connections are tight. Bring the line to operational pressure and record.
  - Exercise care to protect instruments during leak tests.
  - Identify isolation valves, and isolate as needed.
  - Verify that all fluid pressure boundaries are not leaking and can hold the required pressure.

**MFP-3 – Termination Integrity Check**

1. Verify continuity for each lifted lead.
2. Verify that the correct terminal types have been used in any replacement work, that markers are in place, and that they match the plant wiring diagrams.
3. Verify that each termination is tight and properly torqued to requirements.

**MFP-4 – Valve Cycle/Exercise Test**

1. Verify that valve packing is properly installed, that it does not interfere with operation of the stem, and that it is not blocked against the valve body.
2. Verify that the valve stem and handwheel have adequate clearance for valve travel, if applicable.
3. Operate the valve through one cycle of full travel, and verify that no binding occurs.

**MFP-5 – Operational Check**

This testing will demonstrate the successful operation of the fire protection components following the maintenance activity. Testing may consist of a simulated signal to or actual actuation of a component to verify its operability, including alarms and/or trip functions.

1. Notify operations and fire protection personnel that the fire equipment is to be operated/tested.
2. Verify that fire protection door switches provide the correct response when the door is opened or closed. Verify that the door closes automatically after opening.

3. Vary the pressure on a pressure switch, and verify the change of state of switch contacts. Return the instrumentation to service, and verify the proper plant indication.
4. Verify that the fire hydrant operated correctly by monitoring the downstream pressure or flow and indication are proper.
5. Verify the interlock functions of the sprinkler system by performing a clapper/inlet isolation valve cycle/exercise check. Verify that the water pressure and supervisory air pressure are within the plant requirements.
6. Verify the proper volume and pressure for the halon cylinder.

### ***MFP-6 – Functional Test***

This test demonstrates that the fire protection component/system is capable of performing its intended function. Use the station surveillance procedure to perform and document this test. Parameters that need to be verified include:

- Supervisory air pressure
- Water pressure
- Component/system water flow tests
- System control circuit functional test
- Automatic functions (start, stop, interlocks)
- Monitoring/status lights and alarms
- Parameters of key components such as pumps, motors, and diesel engine

## **MFS Filter, Strainer, and Demineralizer Component Testing**

### ***MFS-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to filters, strainers, and demineralizers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify that there are no visible signs of improper equipment assembly. Ensure the proper seating of the filter/strainer housing.
3. Verify that the system contains no bypassing that would compromise the function of the filter/strainer.
4. Verify the proper type and number of replacement filters, and ensure the proper closure of inspection openings.
5. Verify that the filter/strainer is clean and undamaged.
6. Verify that the filter/strainer is secure and that bolts, nuts, and connections are tight.
7. Verify that there are no leaks.
8. Verify that differential pressure gauges are intact and connected, and that valves are open.

### ***MFS-2 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the filter/strainer meet the design and operational requirements.

1. Verify that all doors, hatches, and openings are closed. Start the system, and ensure sufficient flow and pressure per the applicable plant documents.
2. Check all connections, and cover the seals for leaks.
3. Verify that the pressure differential across the filter/strainer during operation is according to the vendor and plant requirements.
4. For dual-element strainers, shift the strainer to verify shift mechanism operability and proper differential pressure on the other basket.
5. Verify that there is no leakage.

## **MGT Gearbox/Transmission Component Testing**

### ***MGT-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to gearboxes and transmissions. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify that there is no excessive wear or deterioration on the working surface of the gear teeth and no unacceptable gear tooth breakage.
3. Verify that no foreign objects are circulating through the gear mesh.
4. Verify that the gearbox is physically reassembled, mounted, and reconnected properly, according to vendor or plant documentation.
5. Verify the proper reinstallation of shaft coupling, and perform the applicable checks according to MC “Coupling Component Testing.”

### ***MGT-2 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the gearbox meet the design and operational requirements.

1. Operate the gear drive, and check the performance to ensure proper and smooth operation based on experience.
2. Verify that the gearbox performs the correct reduction.
3. Verify that there are no unusual noises.

## **MGV Governor, Hydraulic Component Testing**

### ***MGV-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to hydraulic governors. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MGI, EGI, and IG1 are completed. Particular attention should be paid to the following:
  - Verify that the linkages are properly connected and that there is no evidence of binding.
  - Verify that the hydraulic fluid level is per the specifications.
  - Verify that there is no evidence of hydraulic fluid leaks.
  - Verify that the gauges operate and that the gauge glasses are intact
  - Verify that the equipment and valves are per the plant requirements.
  - Verify that all electrical connections are complete and correct per the plant requirements.
  - Verify that all bolting is installed and torqued to the specified values.
  - Verify that all tubing is connected, not damaged, and that the couplings are tight.
2. Verify that the governor is physically reassembled and reconnected properly, according to the vendor or plant documentation.

### ***MGV-2 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the governor meet the design and operational requirements.

1. Operate the governor, and verify that the governor valve does not stick due to tight packing or defective/worn parts.
2. Verify that there is no steam leakage through the governor valve due to improper adjustment.
3. Stroke the governor valve by varying the control oil pressure manually and recording the governor valve travel. Verify that the specifications are met.
4. Vary the governor oil pressure manually, and record the control oil pressure. Plot the results.
5. Verify that there are no step increases or decreases in speed or load during a ramp up/down.
6. Verify that the governor load control is stable and that the speed/load corresponds to the design requirements. Check the governor's entire operating range from quick start to full load.
7. Verify that the governor limiter stops are operable.

## **MHD Hydraulic Drive Component Testing**

### ***MHD-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to hydraulic drives. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and not visibly loose or broken.
  - Verify that the hydraulic drive is securely anchored and that bolts and nuts are torqued to the specified values or tight as required.
  - Verify that the equipment and valves are aligned per the plant requirements.
  - Verify that all fluid connections and tubing are connected tight without damage. Verify that the couplings are tight and that there are no leaks.
2. Verify that the equipment is physically reassembled and reconnected properly, according to vendor or plant documentation.
3. Verify the cleanliness of the hydraulic fluid and ensure that the level of contamination in the hydraulic fluid is lower than the manufacturer's or plant specifications.
4. Verify that the alignment between the sections of the hydraulic drive is according to vendor and plant documentation.
5. Uncouple the hydraulic drive, when possible, before manually rotating it. Rotate, if possible and verify that there is no interference or binding of working parts.
6. Verify that couplings are properly reassembled, if applicable, according to MC "Coupling Component Testing."

### ***MHD-2 – Hydraulic Drive Functional Test***

This is an equipment operational test to confirm that the characteristics of the hydraulic drive meet the design and operational requirements for prestart and unloaded operation.

1. Start the unit, and operate it unloaded. Verify that there are no abnormal noises or excessive vibration, based on operational experience. Ensure that temperatures are in the correct range.
2. Verify that the hydraulic drive provides power to the driven component.
3. Verify that the hydraulic drive responds to a change in speed or load set point, if applicable.

### ***MHD-3 – Hydraulic Drive Vibration Test***

Perform the vibration tests according to MG4, Mechanical Special Tests.

## **MHX Heat Exchanger Component Testing**

### ***MHX-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to heat exchangers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general inspection checks per MG1 are completed.
2. Verify that the vessel interior and tubes are free of all loose scale and debris and that the system has been flushed and cleaned of sludge and debris.
3. Verify that tubes are clear or plugged.
4. Verify that all vessel internals are installed and secure.
5. Verify that welds are complete and that any welding elements or deposits have been removed.
6. Verify that access covers are properly installed with gaskets and that all bolts are properly torqued.
7. Verify that all connecting equipment is attached and that vents are closed.
8. Inspect internal coating and verify that it is in adequate condition per the manufacturer's specifications.
9. Verify the condition of the cathodic protection devices. Refer to the ECP matrix for additional testing, if appropriate.
10. Verify the status of relief valves, and prepare the valves for hydrostatic testing, if required. Refer to the MVR matrix for additional testing, if appropriate.
11. Verify that the thermal insulation has been replaced per the plant requirements.

### ***MHX-2 – Leak Test***

Any structure or component that must, as part of its design requirements, be leak tight must be leak tested by whatever means are appropriate to ensure that its ability to fulfill its intended design function has been achieved by the maintenance activity. For ASME Code-required tests, refer to section MHX4.

#### **A. Tube Leak Test for the Maintenance or Repair of Tubes**

1. Pressurize the shell side of the tubes to the applicable pressure with fluid or gas that can be detected at the tube sheets.
2. Examine the tube ends in the tube sheet to detect the fluid or gas used at the shell side of the tubes.

3. Examine the plugged tubes to detect any leaking plugs.
4. As an alternative to the above, pressurize the individual tubes and monitor the pressure decay to determine the leaking tubes.

#### B. Hydrostatic Leak Test

1. Before starting to pressurize the components, verify that the heat exchanger is isolated.
2. Pressurize the heat exchanger to its applicable test pressure, and inspect it for leaks. Provide overpressure protection for the remainder of the system, and hydrostatically test for leakage at the required pressure for the length of time stipulated by the plant documentation.

#### C General Leak Test

1. The pressure-retaining component should be visually examined while the system is under a predetermined pressure. Typically, this inspection is performed at the component's normal operating temperature and pressure.
2. Verify that at mechanical joints or connections, leakage is acceptable or nonexistent.

#### ***MHX-3 – Functional Test***

This is an equipment operational test to confirm that the characteristics of the heat exchanger have not been degraded by the maintenance activity and to provide baseline data for performance monitoring.

1. Measure the flow rates of the primary and secondary fluids.
2. Measure the inlet and discharge temperatures of both the primary and secondary fluids.
3. Measure the pressure at the inlet and discharge of both the primary and secondary fluids.
4. Calculate the heat transfer and pressure drop characteristics of the heat exchanger, and compare them to the design requirements.

#### ***MHX-4 – Special Requirements or Tests - Hydrostatic In-Service Test***

ASME Section XI is involved when the pressure boundary of a Safety Class 1 2 3 component or pipe is broken or when the minimum pipe wall thickness is violated. Also, following repairs by welding on a pressure-retaining boundary of components, a pressure test may be required. Refer to station program requirements for the specific testing required, and perform utilizing the station test procedures.

## MP Pump Component Testing

### MP-1 – Maintenance/Installation Checks

The following maintenance checks are both general and specific to pumps. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that the piping has been reconnected and that all welds are complete.
  - Verify that flanged joints are complete with gaskets installed and that all bolts and threaded fittings are tight and torqued to requirements.
  - Verify that all auxiliary piping, wiring, and instrumentation are connected properly.
  - Verify that all insulation has been installed according to the plant requirements.
  - Verify that unused openings are closed according to the plant requirements.
  - Verify that all supports, including hangers, seismic restraints, struts, and clamps, are in position and that all supporting hardware is properly assembled and tight.
  - Verify that shielding is re-installed.
2. Verify that the pump motor/turbine is physically reassembled, securely mounted, and reconnected properly according to the vendor or plant requirements:
  - Safety guards, shields, and locking devices are properly installed.
  - Packing leaks are within the vendor specification.
  - Mechanical seal leakage meets the vendor or plant requirements.
3. Verify that the pump is adequately lubricated and that all lubricant reservoirs are full.
4. Verify that the pump and motor/turbine are properly coupled. Review the MC Coupling Component Testing and EM Electric Motor or MT Turbine matrices for additional testing.
5. Check the pump reverse rotation due to degraded check valves after the system is refilled.
6. Ensure proper valve line up to provide the pump with an adequate fluid supply to avoid pump cavitation.

### ***MP-2 – Operational Check Unloaded***

This test will demonstrate the successful operation of the pump for prestartup and minimum flow operation.

1. Verify that the pump and its driver are capable of rotating freely and rotates in the proper direction.
2. Verify that the shaft packing is not binding on the shaft and that it has been loosened enough to become wet.
3. Verify the operation of interlocks, as required, prior to starting the pump.
4. Notify operations that the pump is to be started. Start the pump, and allow it to operate at minimum flow. Verify the following:
  - Seal leaks are within vendor specification.
  - There are no abnormal noises.
  - Bearing lubrication is adequate.
  - Vibration is not abnormal.
5. Verify that the seal leakage is within the equipment specifications.
6. Verify that the bearing cooling is being provided during operation.
7. Verify that the pump is providing flow and discharge pressure.

### ***MP-3 – Pump Functional Test***

1. Verify that the pump rotation, speed, direction, and flow are according to the vendor or plant requirements.
2. Verify that the pump suction and discharge temperature and pressure are according to the vendor or plant requirements, and record on the appropriate data sheets.
3. Verify that the pump motor current at rated capacity meets the vendor specifications.
4. Verify that the pump performance curves are within the requirements stipulated by the engineering requirements. Check the performance parameters at three different points on the pump curve.
5. Verify that the pump bearing temperature does not exceed the vendor or plant requirements.
6. Tighten the packing gland and verify that seal leakage is within the vendor or plant requirements.
7. Verify that the equipment vibration under normal operating conditions does not exceed the vendor or plant specifications. See MG4 Mechanical Special Testing – Vibration Testing for the general requirements.

## **MPP Piping/Tubing/Welded Component Testing**

### ***MPP-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to piping, tubing, and welded components. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that the piping has been reconnected and that all welds are complete.
  - Verify that the welding of the component is acceptable by conducting surface NDT or other nondestructive testing, as appropriate.
  - Verify that flanged joints are complete with gaskets installed and that all bolts and threaded fittings are tight and torqued to requirements.
  - Verify that all auxiliary piping and instrumentation are connected.
  - Verify that all insulation has been installed according to the plant requirements (after any necessary hydrostatic tests are performed).
  - Verify that unused openings are closed according to the plant requirements. Verify that all supports, including hangers, seismic restraints, struts, and clamps, are in position and that all supporting hardware is properly assembled and tight. Verify that temporary shoring is removed.
2. Verify that the pipe is properly coated and that flow direction arrows and identification labels have been provided per the plant requirements.
3. Verify that pipe cleanliness was maintained or perform flushing to meet the cleanliness program requirements for the affected system.
4. Verify that heat tracing is restored and functional and that insulation is restored, if applicable.
5. Verify that the fluid's chemistry is compatible with the piping/tubing system.

### ***MPP-2 – Hydrostatic Test***

After maintenance on a piping/tubing system that involves the opening of the system and/or welding on the system, an integrity check must be performed according to the system class code or to ASME Code requirements.

1. Verify that the piping section to be tested is isolated by closing the necessary valves.
2. Pressurize the piping to its applicable test pressure, and inspect for leaks. Provide overpressure protection for the remainder of the system, and hydrostatically test for leakage at the required pressure for the length of time stipulated by the plant requirements.

## **MPS Pipe Support/Hanger Component Testing**

### ***MPS-1 – Maintenance Checks/Installation Visual Inspections***

The following maintenance checks verify the proper reinstallation and restoration of pipe supports and hangers following maintenance. The criteria for inspections or checks are as stated in the verification steps. Identified problems should be evaluated for additional repairs and retesting requirements.

1. Verify the applicable maintenance checks per MG1, including inspection checks.
2. Verify that all hangers and restraints are located according to the plant documentation.
3. Verify that all bolts and nuts are tight and torqued, where required, and that attachments are secure.
4. Verify that the hangers are loaded and not bottomed out.
5. Verify that all lock pins have been removed.
6. Verify that the hangers have sufficient clearance to allow movement to accommodate displacements without interference.
7. Verify that all temporary rigging has been removed.
8. Verify that the hanger is adequately identified, and record the nameplate data.
9. Verify that welding is complete and acceptable by conducting surface NDT or other nondestructive testing, as appropriate.

### ***MPS-2 – Hanger Setting Verification***

1. Verify that the actual hanger setting agrees with the hanger drawings/as-built set (cold or hot setting) for that tag number on the hanger. Record on the appropriate data sheet.
2. Verify the proper clearance of the pipe and the hanger from other area components.
3. Verify for proper pipe movement and growth for thermal expansion (applicable to high-temperature lines).
4. Verify the pipe to hanger attachment orientation at normal operating conditions.

## **MRC Refrigeration Unit/Chiller Component Testing**

### ***MRC-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to refrigeration systems. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks of MG1 and EG1.
2. Verify that all equipment is properly mounted and that it is aligned according to the plant requirements.
3. Verify that all components are clean with no sign of corrosion and that the surroundings are clean and free of debris.
4. Verify that the equipment is securely mounted and that all bolts, fasteners, and electrical connections are tight.
5. Verify that there is no corrosion on electrical terminals or motor components and that all wiring is secure.
6. Verify that the system is leak tight to avoid loss of oil and refrigerant and prevent entrance of water, air, and other noncondensable fluids.
7. Verify that the installation is according to the vendor or plant requirements.
8. Verify proper alignment and that all safety and protective guards are installed.
9. Verify the condition of the cooler/condenser tubes and that the tube sheets are in good condition.
10. Verify that all drive belts are properly aligned and that the tension is correct, if applicable.
11. Verify that there is adequate lubrication to eliminate premature failure of the bearings.
12. Verify that there is no physical damage, bent blades, misalignment, worn belts, or loose control wiring.
13. For maintenance on the motors, perform motor rotation checks per EM2.

### ***MRC-2 – Refrigeration System Operational Check***

This test will demonstrate successful refrigeration system and motor operation.

1. Verify that the system piping is filled and vented.
2. With the refrigeration system operating, verify the following:
  - Oil level
  - Pressure
  - Temperature

3. Verify that the refrigerant level and pressure are correct.
4. Verify the free and correct rotation of the motor and compressor.
5. Verify that no unusual vibration or noise exists when the refrigeration system is operated.
6. Verify that there are no lubricant or refrigerant leaks.
7. Verify proper rotating speed, when applicable.
8. Verify that the motor does not overheat. Check that the motor current meets requirements.
9. Verify that equipment and piping insulation is installed or restored.

### **MRC-3 – Refrigeration System Functional Test**

1. Verify that the checks for MRC2 were performed.
2. Operate the system, and verify that the following parameters meet the vendor or plant requirements. Record for trend analysis:

#### **Compressors**

- Pressures, suction and discharge
- Oil pressure and temperature
- Voltage
- Amperage

#### **Water-Cooled Condenser**

- Water temperature, in and out
- Water pressure, in and out
- Water flow rates

#### **Air-Cooled Condenser**

- Fan flow
- Fan motor amperage
- Fan speed, RPM
- Entrance air, dry bulb (DB) temperature (Average)
- Exit air DB temperature (Average)

#### **Evaporator**

- Refrigerant entrance and exit temperatures
- Coil air entrance and exit temperatures
- Coil air flow

*Mechanical Testing Guide and Test Definitions*

3. Calculate the system heat load and equipment performance characteristics, and compare them to the vendor or plant specifications.
4. Verify that the environmental condition of the room is acceptable according to the plant requirements.
5. Verify that the equipment vibration under normal operating conditions does not exceed the plant or vendor specifications. Refer to MG4 Mechanical Special Testing - Vibration Testing.

**MRC-4 – Refrigeration System Leak Test**

Any structure or component that must, as part of its design requirements, be leak tight must be leak tested by whatever appropriate means to ensure that its ability to fulfill its intended design function has been achieved by the maintenance activity.

**A. Tube Leak Test for the Maintenance or Repair of Tubes**

1. Pressurize the shell side of the tubes to the applicable pressure with fluid or gas that can be detected at the tube sheets.
2. Examine the tube ends in the tube sheet to detect the fluid or gas used at the shell side of the tubes.
3. Examine the plugged tubes to detect any leaking plugs.

As an alternative to the above, pressurize the individual tubes, and monitor the pressure decay to determine the leaking tubes.

**B. Hydrostatic Leak Test**

1. Before starting to pressurize equipment, verify that the tube coil is isolated.
2. Pressurize the tube coil to its applicable test pressure, and inspect for leaks. Provide overpressure protection for the remainder of the system, and hydrostatically test for leakage at the required pressure for the length of time stipulated by the plant documentation.

**C. In-Service Leak Test**

1. The pressure-retaining component should be visually examined while the system is under a predetermined pressure. Typically, this inspection is performed at the component's normal operating temperature and pressure.
2. Verify that at mechanical joints or connections leakage is acceptable or nonexistent.

## **MRF Radiation Filter Component Testing**

### ***MRF-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to radiation filters. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed.
2. Verify that there are no visible signs of improper equipment assembly. Ensure proper seating of the filter and gaskets.
3. Verify structural integrity of the mounting frames. Ensure that there are no leaks in the mounting frames or between the mounting frame and housing.
4. Verify that the system contains no bypassing that would compromise the function of the filter.
5. Verify the proper type and number of the replacement filter. Ensure proper closure of inspection openings.
6. Verify that the filter element is clean and undamaged.
7. Verify that the filter is secure and that connections are tight.

### ***MRF-2 – Radiation Filter Functional Test***

This is an equipment operational test to confirm that the characteristics of the filter meet the design and operational requirements.

1. Establish the air flow through the filter.
2. Verify that the differential pressure across the filter is according to the plant documentation.
3. Inject DOP aerosol upstream of the filter.
4. Measure and record the DOP concentration upstream and downstream of the filter.
5. Verify that the penetration of DOP particles and the pressure drop across the filter is within the plant specifications.

## **MS Snubber Component Testing**

### ***MS-1 – Maintenance/Installation Checks***

The following maintenance checks are both general and specific to snubbers. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken.
  - Verify that all bolting is installed and torqued to the specified values.
  - Verify that the equipment is physically reassembled and reconnected properly, according to vendor or plant documentation.
2. Verify that the snubber has no visible indications of damage, that the shaft is not scored, that the snubber is free from foreign material, and that the attachments to the foundation and supporting structure are secure.
3. Verify that all pins, washers, and cotter pins are installed.
4. Verify that the snubber is not in contact with piping, clamps, and obstacles that will impede its operation.
5. Verify that the reservoir on a hydraulic snubber is upright to allow fluid access into the snubber.
6. Verify that the hydraulic fluid level at the snubber reservoir is adequate. Check the condition of the fluid.
7. Verify that there is no leakage for hydraulic snubbers.
8. Verify that the original snubber or an equivalent replacement is installed in the proper location.
9. Verify that the size and rating are correct, according to the plant documentation.
10. Verify that the snubber is adequately identified and that the nameplate data are correct.
11. Verify that snubber is loaded and not bottomed out.

### ***MS-2 – Setting Check***

1. Verify that the stroke setting agrees with the cold and the hot settings, based on the snubber baseline information.

**MS-3 – Stroke Test**

1. Verify that the mechanical snubber extends and retracts smoothly over its stroke without binding.
2. Use caution to avoid bottoming out the snubber.

## **MT Turbine Component Testing**

### ***MT-1 – Maintenance/Installation Checks***

The following maintenance checks are applicable to the turbine following maintenance or inspections. The criteria for the inspections are as stated in the verifications. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify the applicable maintenance checks per MG1, EGO, and IG1. Particular attention should be paid to the following:
  - Verify that all fasteners are in place and that connections to terminal blocks are tight.
  - Verify that there is no corrosion on the component or the terminals.
  - Verify the cleanliness of the component.
  - Verify the cleanliness of sensing, signal and other instrument lines.
  - Verify that all wiring and instrumentation are connected properly, per the plant documentation.
  - Verify that piping has been reconnected and that all welds are adequate.
  - Verify that flanged joints are complete with gaskets installed and that all bolts and threaded fittings are tight and properly torqued.
  - Verify that all supports, including hangers, struts, and clamps, are in position and that all supporting hardware is properly assembled and tight.
  - Verify that all handholds and manway covers are made up complete with gaskets and bolts that are properly tightened.
2. Verify that the equipment and instrumentation are physically reassembled, securely mounted, and reconnected properly, according to the manufacturer or plant requirements.
3. Verify that the equipment is adequately lubricated and that all lubricant reservoirs are full.
4. Verify that the rotating equipment and driven component are properly coupled.
5. Verify that coupling guards are in place and secure.
6. Verify that the trip throttle limit switches are installed.
7. Verify that the trip throttle valve is coupled to its operator and that the operator cover is on.
8. Verify that the trip solenoid is in place.
9. Verify that the trip throttle valve packing gland is installed.
10. Verify that all support and auxiliary systems are available, tested, and functional to support turbine testing, such as:
  - Lube oil system
  - Cooling water system

- Electrohydraulic control system
- Steam and condensing systems
- Vacuum system
- Feedwater and condensate systems
- Power supply systems
- Turbine protective features and interlocks
- Indicating lights and alarms
- Turning gear equipment and lift pumps
- Steam seal system
- Electric generator and cooling systems
- Instrument air

Refer to the appropriate component matrices for additional testing, if required.

### ***MT-2 – Leak Test***

1. Verify that all tubing/capillary has no kinks, dimples, or sags, and that it is securely supported.
2. Verify that all disturbed connections are tight. Bring the line to operating pressure.
  - Exercise care to protect instruments during leak tests.
  - Identify the isolation boundaries, and isolate as needed.
  - Verify that all fluid pressure boundaries are not leaking and can hold pressure.
  - Check the turbine casing, manway covers, and mechanical joints for leaks.

### ***MT-3 – Operational Check***

This testing will demonstrate successful operation of the turbine following its maintenance activity.

1. Notify operations that the turbine equipment is to be operated or tested.
2. Verify that all auxiliary systems and components are ready to support the turbine checks:
  - Lube oil system.
  - Electrohydraulic control system.
  - Cooling water system.
  - Turbine protective features and interlocks.

*Mechanical Testing Guide and Test Definitions*

- Steam is available, and the lines are warmed up.
  - Verify the proper lineup of valves, circuit breakers, local and remote switches, trips, and resets have been performed.
3. Start the turning gear equipment per the operating procedures, and observe for at least 15 minutes for:
    - Adequacy of lube oil flow to all bearings
    - Indications of lube oil leaks
    - Indications of rubbing or binding
    - Proper operation of lube oil heaters
    - Oil filter differential pressure that is below the design specification
  4. Cycle the trip/throttle valve fully closed and fully open, using the normal operator and motor operator, while observing:
    - Mechanical joints for leakage
    - Packing gland leakage
    - Valve operation for indication of binding
    - Proper operation of remote indicators
  5. Trip throttle valve is open, and verify remote indication and annunciation.
  6. Other prestart checks that should be conducted utilizing the plant operating procedures, where applicable, are:
    - Oil system alarms, auxiliary oil pump, and emergency oil pump operation and readiness
    - Overspeed trip mechanism test
    - Lube oil temperature is at least at the minimum required by the plant documents.
    - Observe the maximum differential temperatures between the upper and lower casing.
    - Observe the maximum differential temperature between the highest casing temperature and the condensate temperature.
    - Steam seal flow is established.
  7. Verify that the overspeed linkage on the turbine is reset.
  8. Place the turbine in operation according to the applicable operating procedures.
  9. Observe the running equipment for any abnormal noise, odor, vibration, oil leaks, or other indication of improper operation:
    - Lube oil temperature out of the cooler is maintained as required by the plant documents.
    - Rotor vibration is at least below the maximum allowable level.
    - Record readings of the thrust wear indicators.
    - The steam seal outlet temperature and pressure are maintained per the plant document requirements.

- Speed control is not erratic.
- Bearing oil pressure and bearing temperatures are maintained as required by the plant documents.

10. Conduct a turbine overspeed trip test according to the plant procedures, as applicable.

***MT-4 – Functional Test***

This test demonstrates that the turbine component/system is capable of performing its design function. Use the station surveillance procedures or operating procedures to perform and document this test. Parameters that need to be verified include:

- Steam pressure and flow.
- System control circuit functioning.
- Automatic functions (start, stop, interlocks).
- Monitoring/status lights and alarms.
- Parameters of pumps, motor, and fans.
- Bearing temperatures.
- Speed and vibration amplitude.
- Heat balance/thermal efficiency. This may include a thermal performance test per ASME Performance Test Codes or simplified heat/rate calculations.

## **MTV Tank, Vessel, and Accumulator Component Testing**

### ***MTV-1 – Maintenance/Installation Check***

The following maintenance checks apply following maintenance on tanks, pressure vessels, and accumulators. The criteria are as stated in the verification. Identified problems should be evaluated for additional repairs and retesting.

1. Perform the applicable visual inspection of MG1.
2. Verify that there are no visual indications of deterioration, damage, cracks, or leaks.
3. Verify that attachments to the foundation or supporting structures are securely tightened.
4. Verify that the vessel interiors are free of loose scale and debris. Verify that protective linings are applied and are undamaged.
5. Verify that the vessel internals are intact and will move or operate properly and that they have been properly secured before closing the tank or vessel.
6. For a closed vessel, verify that all access covers are installed, that gaskets are in place, and that bolts are properly tightened.
7. Verify that any auxiliary piping, including vents, and drains, are properly connected and that unused openings are properly sealed.
8. Verify that all welds are complete and satisfactory.

### ***MTV-2 – Pressure Test***

Verify the integrity of the pressure boundary of the tank or vessel, and visually inspect for leaks under test conditions.

1. Isolate the tank by closing the necessary valves.
2. Pressurize the tank or vessel to the applicable test pressure, and inspect for leaks. Provide overpressure protection for the remainder of the system as required by the station pressure test program. Test pressures and hold times are specified by that program.

### ***MTV-3 – Parameter Check***

Verify the proper operation of the tank under service conditions. This includes the verification of instrument, heaters, and tank controls.

1. Perform any instrument checks per the appropriate test matrix.
2. Verify the proper operation of level, pressure, and temperature indicators. Independently verify the proper level by redundant indication of volumes.
3. Sample the tank contents, and verify the purity of the fluid per the station documents.

## **MV Valve, Manually Operated Component Testing**

### ***MV-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to manual valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken and that it is torqued to the specified values.
  - Verify that the valve has no physical deterioration.
  - Verify that the nameplate data are correct.
2. Verify that the valve is physically reassembled, securely mounted, and reconnected properly, according to the vendor or plant requirements. Ensure that the internal parts are capable of operating smoothly without binding. Ensure that the seats are clear of foreign matter and in good condition.
3. Verify the proper orientation of the valve.
4. Verify that the valve is properly lubricated.

### ***MV-2 – Valve Cycle/Exercise Test***

1. Verify that the valve stem and handwheel have adequate clearance for travel, if applicable.
2. Verify that the valve packing is properly installed, that it does not interfere with the operation of the stem, and that it is not blocked against the valve body.
3. Operate the valve through one complete cycle of full travel, and verify that there is no binding.

### ***MV-3 – Flow and Pressure Test***

1. Obtain a positive flow or pressure indication by cycling the valve or allowing changes in the flow or pressure across the valve. Flow is permitted in the proper direction.

### ***MV-4 – Leak Test***

1. At the component's normal operating temperature and pressure, verify that leakage at the packing gland, mechanical joints, or connection is acceptable or nonexistent.

***MV-5 – Manual Valve Position Indication Checks***

1. Verify the proper operation of the local and remote position indications.

***MV-6 – Manual Valve Seat Leakage Test***

1. Verify that valve seat leakage is acceptable or nonexistent. For valves in the ASME Inservice Test program, and RCS pressure boundary valves, refer to the station program requirement, and test them using the station surveillance procedures.

## **MVA Valve, Air-/Pneumatic-Operated Component Testing**

### ***MVA-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to air-/pneumatic-operated valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken. Verify that bolting is torqued to the specified values.
  - Verify that the valve and motor have no physical deterioration.
  - Verify that the nameplate data are correct.
  - Verify that electrical checks are complete.
2. Verify that the valve is physically reassembled, securely mounted, and reconnected properly according to the vendor or plant requirements. Ensure that the internal parts are capable of operating smoothly without binding and that the seats are clear of foreign matter and in good condition.
3. Verify the proper orientation of the valve.
4. Verify that the valve is properly lubricated.

### ***MVA-2 – Valve Cycle/Exercise Test***

1. Verify that the valve stem and handwheel have adequate clearance for travel, if applicable.
2. Verify that the valve packing is properly installed, that it does not interfere with operation of the stem, and that it is not blocked against the valve body.
3. Operate the valve through one complete cycle. Verify full stroke, no binding, proper valve seating, and proper operation of the remote position indication.

### ***MVA-3 – Air Operated Valve Stroke Time Test***

1. Verify that the valve strokes (open or close) from the fully closed position to the fully opened position in the time specified by plant documents, including procedures, technical specification, and the ASME In-Service Test program. Operate the valve using all the modes of actuation and in both open and close directions.

#### ***MVA-4 – Position Verification Check***

1. For maintenance performed on control/limit switches:
  - Exercise the valve, and verify the proper seating of the valve by ensuring that no discernible leakage exists.
  - If the AOV has specific leakage requirements or is a containment isolation valve, then the AOV should undergo a seat leakage test.
  - Verify that the control/limit switch prevents damage to the valve seat.
2. Verify proper operation of the local and remote position indications.

#### ***MVA-5 – Leak Test***

1. At the component's normal operating temperature and pressure, verify that leakage at the packing gland, mechanical joints, or connection is acceptable or nonexistent.

#### ***MVA-6 – Air-Operated Valve Automatic Operation Test***

1. If the AOV performs an automatic opening or closing function in response to specific signals or as a fail-safe operation, these functions should be tested by inserting the appropriate simulated test signals. Verify the proper AOV response.
2. For maintenance on the AOV control circuitry:
  - Ensure that the AOV operates on demand by exercising the valve from all control locations.
  - For throttle/control AOVs, verify that valve is operable in both manual and auto modes (if possible), and perform a loop check verification.
3. If the AOV provides an interlock or auto-close/open function in the control circuit of another component, the other component should be demonstrated operable by performing an automatic function test of all the open/close functions/interlocks, according to the appropriate simulated test signals.

## **MVC Valve, Check Component Testing**

### ***MVC-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to check valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken. Verify that bolting is torqued to the specified values.
  - Verify that the valve has no physical deterioration.
  - Verify that the nameplate data are correct.
2. Verify that the valve is physically reassembled, securely mounted and reconnected properly, according to the vendor or plant requirements. Ensure that the internal parts are capable of operating smoothly without binding and that the seats are clear of foreign matter and in good condition.
3. Verify proper orientation of the valve.

### ***MVC-2 – Leak Test***

1. At the component's normal operating temperature and pressure, verify that leakage at the packing gland, mechanical joints, or connection is acceptable or nonexistent.

### ***MVC-3 – Valve Cycle and Position Indication Check***

1. For normally open check valves, the exercise test should verify that the disk travels to the seat with reversal of the flow. Confirmation of the flow should be by visual observation, by position indication, or by observation of the appropriate system dynamic indications.
2. For normally closed check valves, the exercise test should ensure that the disk moves away from the seat with flow being initiated through the valve. Confirmation of the opening should be by visual observation, position indication, or by free-flow observation through the valve, as indicated by the system dynamic indications.
3. For valves that cannot be adequately tested, a disassembly and visual inspection are appropriate during the maintenance process.
4. For check valves with position indication, verify proper operation of the local and remote position indications.
5. Verify that there are no unusual sounds during the opening/closing of the valve.

*Mechanical Testing Guide and Test Definitions*

***MVC-4 – Reverse Flow Test***

1. Verify that the valve seats against the backflow. For non-return valves, use the manual override lever on the air-piston assembly.

***MVC-5 – Flow and Pressure Test***

1. Obtain a positive flow or pressure indication by cycling the valve or allowing changes in the flow or pressure across the valve. Flow is permitted in the proper direction.
2. Verify that there are no unusual sounds such as clatter, banging, or whining during the minimum flow checks.

***MVC-6 – Seat Leakage Test***

1. Verify that valve seat leakage is acceptable or nonexistent. For valves in the ASME In-Service Test program or for RCS pressure boundary valves, refer to the station program requirements and test them, using the station surveillance procedures.

## MVM Valve, Motor-Operated Component Testing

### ***MVM-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to motor-operated valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken. Verify that bolting is torqued to the specified values.
  - Verify that the valve and motor have no physical deterioration.
  - Verify that the nameplate data are correct.
  - Verify that electrical checks are complete.
2. Verify that the valve does not leak through its packing or connections.
3. Verify that the valve is physically reassembled, securely mounted, and reconnected properly, according to the vendor or plant requirements. Ensure that the internal parts are capable of operating smoothly without binding and that the seats are clear of foreign matter and in good condition.
4. Verify proper orientation of the valve.
5. Verify that the valve is properly lubricated.
6. Determine if the valve operator requires a diagnostic signature analysis testing to be performed according to plant requirements.

### ***MVM-2 – Valve Cycle/Exercise Test***

1. Verify that the valve stem and handwheel have adequate clearance for travel, if applicable.
2. Verify that the valve packing is properly installed, that it does not interfere with operation of the stem, and that it is not blocked against the valve body.
3. Operate the valve through one complete cycle. Verify full stroke, no binding, proper valve seating, and proper operation of the remote position indication.

### ***MVM-3 – Valve Stroke Time Test***

1. Verify that the valve strokes (open or close) from the fully closed (opened) position to the fully opened (closed) position in the time specified by plant documents (procedures, Technical Specifications). Ensure valve operability under the most severe operating conditions it may encounter. If conditions cannot be established, appropriate diagnostic testing should be performed. Verify that the required thrust is developed or that the torque switches actuate at the desired set point.

### ***MVM-4 – Valve Position Indication and Torque Switch Check***

1. For maintenance performed on the MOV torque switch:
  - Verify that the torque switch or operator thrust is set per the plant or manufacturer specifications.
  - Exercise the valve, and verify the proper seating of the valve by ensuring that no discernible leakage exists.
  - If the MOV has specific leakage requirements or is a containment isolation valve, the MOV should undergo a seat leakage test.
2. Verify proper operation of the local and remote positions indication.

### ***MVM-5 – Valve Current Test***

1. Verify that the MOV starting and running current (opening and closing) are within the operational limits.

### ***MVM-6 – Automatic Operation Test***

1. If the MOV performs an automatic opening or closing function in response to specific signals or as a fail-safe operation, these functions should be tested by inserting the appropriate simulated test signals. Verify proper MOV response.
2. For maintenance on MOV control circuitry, ensure that the MOV operates on demand by exercising the valve from all control locations.
3. If the MOV provides an interlock or auto-close/open function in the control circuit of another component, the other component should be demonstrated operable by performing an automatic function test of all the open/close functions/interlocks according to appropriate simulated test signals.

### ***MVM-7 – Special Test - Valve Diagnostics***

1. The valve diagnostic signature analysis test establishes new baseline data for the valve. This test may satisfy some of the requirements of the previous tests. Refer to the station program requirements and perform diagnostic analysis, using the plant procedures.

## MVR Valve, Relief and Safety Component Testing

### ***MVR-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to relief and safety valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken. Verify that the bolting is torqued to the specified values.
  - Verify that the safety valve has no physical deterioration.
  - Verify that the nameplate data are correct.
  - Verify that the discharge piping is securely attached.
  - Verify that appropriate shielding is in place to prevent the discharge from damaging the equipment.
2. Verify that the valve is not gagged to prevent operation; ensure that gagging is not required in the existing mode of operation before removing the gag.
3. Verify that any new relief valve has been bench tested or that other required relief set point adjustments/checks have been made.
4. Verify position indication, if applicable.
5. Verify the acceptable condition of the internal surfaces of the valve, if required for the valve type and function.
6. Verify that the blowdown rings/settings are replaced per the manufacturer's documentation, if applicable.

### ***MVR-2 – Set Point Check***

1. Verify the lift set point of a relief/safety valve under controlled conditions such as a bench test stand, if possible:
  - Use a dead weight tester or other suitable method.
  - Use the proper medium for the test.
  - Record the initial, as-found set point data.
  - Adjust the valve, and repeat the test until the average of three successful tests show acceptable results that match the set point criteria.
  - For new valves, certified manufacturer's test records are an acceptable substitute method.

*Mechanical Testing Guide and Test Definitions*

**MVR-3 – Valve Packing Leak Test**

1. At component normal operating temperature and pressure, verify that leakage at the packing gland, mechanical joints, or connection is acceptable or nonexistent.

**MVR-4 – Position Indication Check**

1. Verify proper operation of the local and remote position indications, if applicable.

**MVR-5 – Seat Leakage Test**

1. Verify that the downstream pipe or process temperature instruments do not detect a significant temperature change as evidence of valve seat leakage. Acoustic instruments may also be used to detect leakage. Valve chattering is not acceptable, and the valve may need to be reset or replaced.

## **MVS Valve, Solenoid Component Testing**

### ***MVS-1 – Maintenance/Installation Check***

The following maintenance checks are both general and specific to solenoid valves. The criteria for the inspection are as stated in the verification. Identified problems should be evaluated for additional repairs and retest requirements.

1. Verify that the applicable general maintenance installation checks per MG1 and EG1 are completed. Particular attention should be paid to the following:
  - Verify that all bolting is in place and is not visibly loose or broken. Verify that bolting is torqued to specified values.
  - Verify that the valve and motor have no physical deterioration.
  - Verify that the nameplate data are correct.
  - Verify electrical checks are complete.
2. Verify that the valve is physically reassembled, securely mounted, and reconnected properly, according to the vendor or plant requirements. Ensure that the internal parts are capable of operating smoothly without binding and that the seats are clear of foreign matter and in good condition.
3. Verify proper orientation of the valve.
4. Verify that environmental qualifications are maintained as a result of the maintenance activity.

### ***MVS-2 – Valve Cycle/Exercise Test***

1. Operate the valve. Verify proper valve seating and proper operation.

### ***MVS-3 – Position Indication Check***

1. Verify the proper display of the local and remote position indicators.

### ***MVS-4 – Seat Leakage Test***

1. Verify that valve seat leakage is acceptable or nonexistent. For valves in the ASME In-Service Test program and for RCS pressure boundary valves, refer to the station program requirements, and test the valve using the station surveillance procedures.

### ***MVS-5 – Automatic Operation Test***

1. If the solenoid valve performs an automatic opening or closing function in response to specific signals or as a fail-safe operation, these functions should be tested by inserting the appropriate simulated test signals. Verify proper solenoid valve response.

*Mechanical Testing Guide and Test Definitions*

2. For maintenance on control circuitry, ensure that the solenoid valve operates on demand by exercising the valve from all control locations.
3. If the solenoid valve provides an interlock or auto-close/open function in the control circuit of another component, the other component should be demonstrated operable by performing an automatic functional test of all the open/close functions/interlocks according to the appropriate simulated test signals.

# **E**

## **TRANSLATED TABLE OF CONTENTS**

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## **RESUME**

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### **Objectifs**

- Fournir l'assistance technique détaillée en indiquant et en mettant en application le contrôle de post - maintenance
- Fournir la documentation de référence supplémentaire pour mettre en application les fonctions de contrôle de post - maintenance d'une centrale nucléaire typique

# TABLE DES MATIERES

<b>1 INTRODUCTION .....</b>	<b>1-1</b>
1.1 Context .....	1-1
1.2 Etendue du rapport .....	1-2
1.3 Besoin de mise à jour .....	1-2
1.4 Acronymes .....	1-2
<b>2 APPROCHE TECHNIQUE .....</b>	<b>2-1</b>
<b>3 PHILOSOPHIE FONDAMENTALE .....</b>	<b>3-1</b>
3.1 Contrôle de maintenance .....	3-1
3.2 Fonctionnement/contrôle de fonctionnement .....	3-2
3.3 Contrôle fonctionnel .....	3-2
3.4 Contrôle spécial .....	3-3
<b>4 COORDINATION AVEC LES ENGAGEMENTS REGLEMENTAIRES .....</b>	<b>4-1</b>
<b>5 INSTRUCTIONS .....</b>	<b>5-1</b>
<b>6 CONSIDERATIONS POUR L'APPLICATION PARTICULIERE DE SITE .....</b>	<b>6-1</b>
6.1 Hiérarchie des procédures .....	6-1
6.2 Développement des critères de Site-Particuliers .....	6-1
6.3 Intégration avec les activités existante de tests de la centrale .....	6-2
6.4 Corrélation des actions de maintenance préventive avec le matériel de la centrale.....	6-2
<b>7 CONCLUSIONS .....</b>	<b>7-1</b>
<b>8 REFERENCES .....</b>	<b>8-1</b>

<b>A MATRICES DE TESTS DE COMPOSANT .....</b>	<b>A-1</b>
Appareillage électrique - matrices de test de composant.....	A-1
Matrices de test de composant /chargeur de batterie .....	A-2
Matrices de test de composant/ Contacteur électrique .....	A-3
Matrices de test de composant/ Disjoncteur .....	A-4
Matrices de test de composant/ Protection cathodique .....	A-5
Matrices de test de composant/ Générateur diesel .....	A-6
Matrices de test de composant/ Générateur diesel .....	A-6
Matrices de test de composant/ bloc fusible .....	A-7
Matrices de test de composant/ Générateur Principal.....	A-8
Matrices de test de composant/ Réchauffeur .....	A-9
Matrices de test de composant/ Circuit de traçage .....	A-10
Matrices de test de composant/ Inverseur .....	A-11
Matrices de test de composant/ Moteur électrique.....	A-12
Matrices de test de composant/ Génératrice.....	A-13
Matrices de test de composant/ Pénétration .....	A-14
Matrices de test de composant/ Alimentation électrique .....	A-15
Matrices de test de composant/ Relais de mesure.....	A-16
Matrices de test de composant/ recombineur.....	A-17
Matrices de test de composant/ protection de coupure.....	A-18
Matrices de test de composant/ Contact électrique.....	A-19
Matrices de test de composant/ Transformateur .....	A-20
Matrices de test de composant/ Cables .....	A-21
Instrumentation et contrôles - Matrices de test de composant.....	A-22
Matrices de test de composant/ Annonceur .....	A-23
Matrices de test de composant/ Relais bistables .....	A-24
Matrices de test de composant/ Unités d'E/S .....	A-25
Matrices de test de composant/ Convertisseur .....	A-26
Matrices de test de composant/ Commutateur de commande .....	A-27
Matrices de test de composant/ Composants digitaux .....	A-28
Matrices de test de composant/ Détection d'incendie .....	A-29
Matrices de test de composant/ Jauge.....	A-30
Matrices de test de composant/ Indicateurs .....	A-31
Matrices de test de composant/ Instrumentation nucléaire .....	A-32

Matrices de test de composant/ Contrôleur de processus .....	A-33
Matrices de test de composant/ Enregistreur .....	A-34
Matrices de test de composant/ Moniteur de rayonnement .....	A-35
Matrices de test de composant/ thermocouple .....	A-36
Matrices de test de composant/ Transmetteur de tests.....	A-37
Matériel mécanique - Matrices de test de composant .....	A-38
Matrices de test de composant/ Circuit d'air, ventilateur, soufflante .....	A-39
Matrices de test de composant/ Accouplement.....	A-41
Matrices de test de composant/ Condenseur .....	A-42
Matrices de test de composant/ Grue/élévateur.....	A-43
Matrices de test de composant/ Compresseur .....	A-44
Matrices de test de composant/ Dessiccateur .....	A-45
Matrices de test de composant/ Amortisseur de canalisation .....	A-46
Matrices de test de composant/ Moteur diesel .....	A-47
Matrices de test de composant/ Dispositifs de protection contre les incendies .....	A-49
Matrices de test de composant/ Filtre/tamis/déminéraliseur .....	A-50
Matrices de test de composant/ Boîte de vitesse .....	A-51
Matrices de test de composant/ Régulateur hydraulique .....	A-52
Matrices de test de composant/ Entraînement hydraulique et magnétohydrodynamique .....	A-53
Matrices de test de composant/ Échangeur de chaleur .....	A-54
Matrices de test de composant/ Pompe .....	A-55
Matrices de test de composant/ Tuyauterie /composants soudés .....	A-56
Matrices de test de composant/ Support/bride de fixation .....	A-57
Matrices de test de composant/ Élément de réfrigération .....	A-58
Matrices de test de composant/ Filtre de radiation.....	A-59
Matrices de test de composant/ Séparateur.....	A-60
Matrices de test de composant/ Turbine .....	A-61
Matrices de test de composant/ réservoir/accumulateur .....	A-62
Matrices de test de composant/ Robinet manuel .....	A-63
Matrices de test de composant/ Robinet Pneumatique .....	A-64
Matrices de test de composant/ Clapet .....	A-65
Matrices de test de composant/ Robinet à moteur électrique .....	A-66
Matrices de test de composant/ Soupape .....	A-67
Matrices de test de composant/ Robinet à actionner par électrovanne.....	A-68

<b>GUIDE DE TEST DES APPAREILS ELECTRIQUES .....</b>	<b>B-1</b>
Equipement général - Tests .....	B-3
Maintenance/test électriques généraux de Installation .....	B-3
A. Test d'inspection .....	B-3
B. Test électrique .....	B-3
C. Test de qualification de matériel .....	B-4
Test de fonctionnement .....	B-4
Test fonctionnel électrique général.....	B-5
Contrôle de de batterie /chargeur de batterie .....	B-7
Entretien /test de L'installation .....	B-7
Test d'intégrité .....	B-8
Test de fonctionnement .....	B-8
Test fonctionnel .....	B-9
Contacteur Electrique.....	B-10
Entretien test de Installation .....	B-10
Test d'intégrité des connexions .....	B-11
Test de résistance d'isolant .....	B-11
Test fonctionnel .....	B-12
Contrôle de disjoncteur .....	B-13
Entretien /test de Installation .....	B-13
Test d'intégrité des connexions .....	B-14
Test de résistance d'isolant .....	B-14
Test fonctionnel .....	B-14
Protection cathodique.....	B-16
Entretien /test de Installation .....	B-16
Test de résistance d'isolant .....	B-16
Générateur diesel.....	B-17
Entretien /test de Installation .....	B-17
Test d'intégrité des connexions .....	B-18
Test de fonctionnement hors puissance .....	B-18
Test fonctionnel .....	B-19
Contrôle du bloc fusibles.....	B-20
Entretien /test de Installation .....	B-20
Test d'intégrité des connexions .....	B-20
Test fonctionnel .....	B-21

Génératrice .....	B-22
Entretien /test de Installation .....	B-22
Test d'intégrité des connexions .....	B-22
Test de fonctionnement hors puissance .....	B-23
Test fonctionnel .....	B-23
Contrôle de vibration .....	B-24
Test en air.....	B-24
Contrôle du circuit de chauffage.....	B-25
Entretien /test de Installation .....	B-25
Test d'intégrité des connexions .....	B-25
Test fonctionnel .....	B-25
Circuits de traçage .....	B-27
Entretien /test/Inspection de Installation .....	B-27
Test d'intégrité des connexions .....	B-27
Test d'isolant thermique.....	B-27
Test fonctionnel .....	B-28
Inverseur .....	B-29
Entretien /test de Installation .....	B-29
Test d'intégrité des connexions .....	B-29
Test de fonctionnement hors Tension .....	B-30
Test fonctionnel .....	B-30
Moteur électrique .....	B-32
Entretien /test d'installation .....	B-32
Test de rotation.....	B-32
Test de marche.....	B-33
Test fonctionnel .....	B-33
Groupe convertisseur.....	B-35
Entretien /test de Installation .....	B-35
Test de marche.....	B-36
Test fonctionnel .....	B-36
Pénétration.....	B-37
Entretien /test de Installation .....	B-37
Test d'intégrité des connexions .....	B-37
Test de résistance d'isolant .....	B-38
Test fonctionnel .....	B-38

*Translated Table of Contents*

Étalonnage d'instrumentation .....	B-38
Contrôle des composant d'alimentations .....	B-39
Entretien /test de l'installation .....	B-39
Test d'intégrité des connexions .....	B-39
Test de fonctionnement hors puissance .....	B-40
Test fonctionnel .....	B-40
Test de la température .....	B-41
Relais de mesure .....	B-42
Entretien /test d'installation .....	B-42
Test d'intégrité des connexions .....	B-42
Test de fonctionnement hors puissance .....	B-43
Test fonctionnel .....	B-43
Recombineur .....	B-44
Entretien /test de Installation .....	B-44
Test fonctionnel .....	B-44
Étalonnage .....	B-45
Protection électriques.....	B-46
Entretien /test de Installation .....	B-46
Test d'intégrité des connexions .....	B-47
Test de résistance d'isolant .....	B-47
Test fonctionnel .....	B-48
Test infrarouges thermographie .....	B-48
Contacteurs électriques .....	B-49
Entretien /test d'installation .....	B-49
Test d'intégrité des connexions .....	B-49
Test de fonctionnement hors tension .....	B-49
Test fonctionnel .....	B-50
Contrôle de transformateur .....	B-51
Entretien /test de Installation .....	B-51
Test d'intégrité des connexions .....	B-51
Test de fonctionnement hors tension .....	B-52
Test fonctionnel .....	B-53
Analyse d'huile .....	B-53
Câbles .....	B-54
Entretien /test de Installation .....	B-54

Test d'intégrité des connexions .....	B-54
Test de résistance d'isolant .....	B-55
<b>INSTRUMENTATION ET CONTROLE GUIDE DE TEST .....</b>	<b>C-1</b>
Instrumentation méthode générale de tests .....	C2
Instrumentation entretien /test généraux de Installation .....	C2
A. Test d'inspection .....	C2
B. Ligne d'instrument/test de tuyauterie/essai d'étanchéité .....	C2
C. Test de qualification de matériel .....	C-3
Test de fonctionnement d'I&C .....	C-3
Instrumentation générale et test fonctionnel de contrôles .....	C-4
Test spécial général - étalonnage .....	C-5
Contrôle des composants d'alarmes .....	C-6
Entretien /test de Installation .....	C-6
Test d'intégrité des connexions .....	C-6
Test fonctionnel .....	C-6
Contrôle de relais bistable.....	C-7
Entretien /test de Installation .....	C-7
Test de tuyauterie.....	C-7
Test d'intégrité des connexions .....	C-7
Test fonctionnel .....	C-8
Contrôle des composants E/S d'ordinateur .....	C-9
Entretien /test de Installation .....	C-9
Test d'intégrité des connexions .....	C-9
Test fonctionnel .....	C-9
Contrôle des composant du convertisseur .....	C-11
Entretien /test de Installation .....	C-11
Essai d'étanchéité.....	C-11
Test d'intégrité des connexions .....	C-11
Test fonctionnel .....	C-12
Contrôle des composant du commutateur de commande .....	C-13
Entretien /test de Installation .....	C-13
Essai d'étanchéité.....	C-13
Test d'intégrité des connexions .....	C-14
Test de fonctionnement hors tension .....	C-14

*Translated Table of Contents*

Test fonctionnel .....	C-14
Étalonnage .....	C-14
Dispositifs et systèmes d'identification Digital .....	C-15
Contexte .....	C-15
Conseils généraux pour le Post-Entretien des dispositifs principaux des systèmes digitaux .....	C-19
Entretien test de Installation .....	C-19
Test d'intégrité des connexions .....	C-20
Test fonctionnel .....	C-20
Contrôle de composant de détection d'incendie .....	C-23
Entretien /test d'installation .....	C-23
Test d'intégrité des connexions .....	C-23
Test fonctionnel .....	C-24
Contrôle de jauge .....	C-25
Entretien /test de Installation .....	C-25
Essai d'étanchéité .....	C-25
Étalonnage .....	C-25
Contrôle de composant d'indicateur .....	C-26
Entretien /test de Installation .....	C-26
Test d'intégrité des connexions .....	C-26
Test fonctionnel .....	C-26
Étalonnage .....	C-26
Contrôle des composant d'instrumentation nucléaire .....	C-27
Entretien /test d'installation .....	C-27
Étalonnage de la voie .....	C-27
Étalonnage de détecteur .....	C-27
Test fonctionnel .....	C-28
Contrôle de processus .....	C-29
Entretien /test d'installation .....	C-29
Test de fonctionnement .....	C-29
Étalonnage du dispositif .....	C-30
Étalonnage de la voie .....	C-30
Test fonctionnel de la voie .....	C-30
Contrôle des composant de l'enregistreur .....	C-32
Entretien /test de Installation .....	C-32

Test d'intégrité des connexions .....	C-32
Test fonctionnel .....	C-32
Étalonnage .....	C-32
Contrôle de composant du moniteur de rayonnement .....	C-33
Entretien /test d'installation .....	C-33
Essai d'étanchéité.....	C-33
Test d'intégrité des connexions .....	C-33
Test fonctionnel .....	C-34
Étalonnage .....	C-34
Contrôle composant de thermocouple .....	C-35
Entretien /test de Installation .....	C-35
Essai d'étanchéité.....	C-35
Test d'intégrité des connexions .....	C-35
Test fonctionnel .....	C-36
Étalonnage .....	C-36
Contrôle de composant d'émetteur .....	C-37
Entretien /test d'installation .....	C-37
Essai d'étanchéité .....	C-37
Test d'intégrité des connexions .....	C-37
Test fonctionnel .....	C-38
Étalonnage .....	C-38
<b>CONTROLES MECANQUES - GUIDE DE TEST .....</b>	<b>D-1</b>
Contrôle général du matériel mécanique .....	D-3
Entretien /test mécaniques généraux de Installation .....	D-3
A. Test d'inspection .....	D-3
Test de fonctionnement .....	D-4
Test fonctionnel mécanique.....	D-5
Test spécial mécanique .....	D-7
A. Contrôle de vibration .....	D-7
Circuit d'air/composant de ventilateur/Soufflante .....	D-8
Entretien /test d'installation .....	D-8
Test fonctionnel .....	D-8
Test spécial - test de vibration .....	D-9
Contrôle des composants d'accouplement .....	D-10

*Translated Table of Contents*

Entretien /test d'installation .....	D-10
Test fonctionnel .....	D-10
Contrôle du Condenseur .....	D-11
Entretien / test d'installation .....	D-11
Essai d'étanchéité.....	D-11
A. Essai d'étanchéité des faisceaux .....	D-11
B. Essai d'étanchéité du condensateur .....	D-12
Test fonctionnel .....	D-12
Contrôle des composants de grues et d'élévateurs .....	D-13
Entretien /test d'installation .....	D-13
Test de fonctionnement - déchargé .....	D-13
Test fonctionnel .....	D-14
Contrôle des composant des compresseurs.....	D-15
Entretien /test d'installation .....	D-15
Test de fonctionnement à vide .....	D-15
Test fonctionnel .....	D-16
Contrôle de composant du sécheur .....	D-17
Entretien /test de Installation .....	D-17
Essai d'étanchéité.....	D-17
Test fonctionnel .....	D-17
Test de point de condensation .....	D-18
Test particulière.....	D-18
Contrôle de composant d'amortisseur de canalisations.....	D-19
Entretien/installation .....	D-19
Test fonctionnel .....	D-19
Contrôle des composants de moteurs diesel .....	D-20
Entretien/Installation .....	D-20
Test fonctionnel .....	D-20
Test carburant .....	D-22
Contrôle des composants des dispositifs de protection contre les incendies .....	D-23
Entretien/Installation .....	D-23
Essai d'étanchéité.....	D-24
Test d'intégrité des connexions .....	D-24
Cycle de robinet /test de fonctionnement .....	D-24
Test de fonctionnement .....	D-24

Test fonctionnel .....	D-25
Filtre, tamis, et contrôle des composants du déminéraliseur .....	D-26
Entretien /test de Installation .....	D-26
Test fonctionnel .....	D-26
Contrôle de boîte de vitesse /composant de boîte de vitesses .....	D-27
Entretien /test de Installation .....	D-27
Test fonctionnel .....	D-27
Régulateur, contrôle d'élément hydraulique .....	D-28
L'entretien/Installation.....	D-28
Test fonctionnel .....	D-28
Contrôle hydraulique des composant d'entraînement magnétohydrodynamiques .....	D-29
L'entretien/Installation.....	D-29
Test fonctionnel d'entraînement hydraulique.....	D-29
Test hydraulique de vibration d'entraînement .....	D-29
Contrôle de composant d'échangeur de chaleur .....	D-30
Entretien /test d'installation .....	D-30
Essai d'étanchéité .....	D-30
A. Essai d'étanchéité de tubes, entretien ou dépannage des tubes .....	D-30
B. Essai d'étanchéité hydrostatique .....	D-31
Essai d'étanchéité général.....	D-31
Test fonctionnel .....	D-31
Conditions et tests spéciaux - test en service hydrostatique .....	D-31
Contrôle de composant de pompes .....	D-32
L'entretien/Installation .....	D-32
Test de fonctionnement hors charge .....	D-33
Test fonctionnel de pompe .....	D-33
Tuyauterie rigide /tuyauterie soudée.....	D-34
Entretien/Installation .....	D-34
Test hydrostatique .....	D-34
Support de tuyauterie/contrôle des composants de brides de fixation .....	D-35
Tests d'entretien /inspections visuelles de Installation .....	D-35
Bride de fixation réglage et vérification .....	D-35
Contrôle d'élément de réfrigération /composant de réfrigérateur .....	D-36
L'entretien/installation .....	D-36
Test de fonctionnement de systèmes de réfrigération.....	D-36

*Translated Table of Contents*

Test fonctionnel des système de réfrigération.....	D-37
Essai d'étanchéité des système de réfrigération .....	D-38
A. Essai d'étanchéité des tube et l'entretien ou dépannage des tubes .....	D-38
B. Essai d'étanchéité hydrostatique .....	D-38
C. Essai d'étanchéité en service .....	D-38
Contrôle des composant de filtre de radiation.....	D-39
L'entretien/Installation.....	D-39
Test fonctionnel de filtre de radiation .....	D-39
Contrôle de composant séparateur .....	D-40
L'entretien/Installation.....	D-40
Test de réglage .....	D-40
Test de course .....	D-41
Contrôle de composant de turbine .....	D-42
Entretien/installation .....	D-42
Essai d'étanchéité.....	D-43
Test de fonctionnement .....	D-43
Test fonctionnel .....	D-45
Réservoir et contrôle de composant d'accumulateur .....	D-46
Entretien /test d'installation .....	D-46
Test de pression .....	D-46
Test de paramètre .....	D-46
Robinet manuels .....	D-47
Entretien /test de Installation .....	D-47
Course de robinet /test .....	D-47
Débit et test en pression .....	D-47
Essai d'étanchéité .....	D-47
Tests manuels d'indicateurs de position .....	D-48
Essai d'étanchéité.....	D-48
Robinet Pneumatique.....	D-49
Entretien /test de Installation .....	D-49
Course du robinet /test .....	D-49
Temps de course .....	D-49
Test de vérification de position .....	D-50
Essai d'étanchéité.....	D-50
Test automatique de fonctionnement des robinets a actionneur pneumatique .....	D-50

Clapet anti retour.....	D-51
Entretien /test de Installation .....	D-51
Essai d'étanchéité.....	D-51
Course et indicateur de fermeture .....	D-51
Test de débit inverse .....	D-52
Débit et test en pression .....	D-52
Essai d'étanchéité.....	D-52
Robinet Electrique Tests des composants .....	D-53
Entretien test d'installation .....	D-53
Course/test d'exercice .....	D-53
Test de temps de course .....	D-54
Test des contacts et limiteur de couple .....	D-54
Test de courant moteur .....	D-54
Test automatique de fonctionnement .....	D-54
Test spécial .....	D-54
Soupapes et contrôle des composants de sécurité .....	D-55
Entretien /test de Installation .....	D-55
Test de point de tarage .....	D-55
Essai d'étanchéité des garnitures .....	D-56
Test de l'indicateur de position .....	D-56
Essai d'étanchéité .....	D-56
Electrovannes .....	D-57
Entretien /test de Installation .....	D-57
Course /test d'exercice .....	D-57
Test de l'indicateur de position .....	D-57
Essai d'étanchéité .....	D-57
Test automatique de fonctionnement .....	D-57

## **LISTE DE TABLEAUX**

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Applications des composants digitaux dans les centrales nucléaires .....	C-15
Fonctions des systèmes digitaux fréquemment vérifiés lors de tests de post maintenance .....	C-18

## レポートの概要

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### 目的

- 保全後試験を、内容を定義し、実施することについて、技術的サポートをすること。  
。
- 典型的な原子力発電所において、保全後試験を実施するうえで、役立つ追加資料を、提供すること。

# 目次

<b>1はじめに</b> .....	<b>1-1</b>
1.1背景.....	1-1
1.2この報告書の範囲.....	1-2
1.3修正の必要性.....	1-2
1.4 頭辞語.....	1-2
<b>2技術アプローチ</b> .....	<b>2-1</b>
<b>3背景となる考え方</b> .....	<b>3-1</b>
3.1 保全確認テスト.....	3-1
3.2運転確認テスト.....	3-2
3.3機能テスト.....	3-2
3.4特別なテスト.....	3-3
<b>4規制または認可上行った複数の約束の相互調整</b> .....	<b>4-1</b>
<b>5使用手順</b> .....	<b>5-1</b>
<b>6個別サイトで実施するうえでの考察</b> .....	<b>6-1</b>
6.1 保全後テスト手順の階層的関係.....	6-1
6.2サイト個別判断基準の作成.....	6-1
6.3プラントに既に存在するテストとの統合.....	6-2
6.4プラント設備への保全後テストの関係.....	6-2

<b>7結論</b> .....	<b>7-1</b>
<b>8参照</b> .....	<b>8-1</b>
<b>構成部テストマトリックス</b> .....	<b>A-1</b>
電気機器-テストマトリックス .....	A-1
EBC-テストマトリックス 電池/充電器 .....	A-2
EC-テストマトリックス 電気接触器 .....	A-3
ECB-テストマトリックス 遮断機 .....	A-4
ECP-テストマトリックス 陰極防食 .....	A-5
EDG-テストマトリックス ディーゼル発電機 .....	A-6
EFB-テストマトリックス ヒューズ/ヒューズのブロック .....	A-7
EGN-テストマトリックス 主発電機 .....	A-8
EH-テストマトリックス 電気ヒーター .....	A-9
EHT-テストマトリックス 電熱保温回路/装置 .....	A-10
EIN-テストマトリックス インバーター .....	A-11
EM-テストマトリックス 電動機 .....	A-12
EMG-テストマトリックス モータ-発電機 .....	A-13
EPN-テストマトリックス 貫通部 .....	A-14
EPS-テストマトリックス 電源 .....	A-15
ER-テストマトリックス リレー/メーター .....	A-16
ERC-テストマトリックス 再結合器 .....	A-17
ESG-テストマトリックス 開閉装置 .....	A-18
ESW-テストマトリックス 電気スイッチ .....	A-19
ETR-テストマトリックス 変圧器 .....	A-20
EWC-テストマトリックス 電線/ケーブル .....	A-21
計装および制御機器 - テストマトリックス .....	A-22

Translated Table of Contents

IA-テストマトリックス	アナンシエーター	A-23
IB-テストマトリックス	双安定リレー	A-24
ICI-テストマトリックス	コンピュータ I/Oデバイス	A-25
ICN-テストマトリックス	コンバーター	A-26
ICS-テストマトリックス	制御スイッチ	A-27
ID-テストマトリックス	デジタル機器およびアセンブリ	A-28
IFD-テストマトリックス	火災探知	A-29
IGG-テストマトリックス	ゲージ	A-30
IIN-テストマトリックス	インディケータ	A-31
INI-テストマトリックス	核計装	A-32
IPC-テストマトリックス	プロセスコントローラ	A-33
IR-テストマトリックス	レコーダー	A-34
IRM-テストマトリックス	放射線モニタ	A-35
IRT-テストマトリックス	抵抗温度計/熱電対	A-36
IT-テストマトリックス	トランスミッタ	A-37
機械装置-テストマトリックス		A-38
MAH-テストマトリックス	エアハンドリングユニット/ファン/ブロア	A-39
MC-テストマトリックス	カップリング	A-41
MCD-テストマトリックス	コンデンサー	A-42
MCH-テストマトリックス	クレーン/起重機	A-43
MCP-テストマトリックス	圧縮機	A-44
MD-テストマトリックス	ドライヤー	A-45
MDD-テストマトリックス	ダンパー/ダクト	A-46
MDE-テストマトリックス	ディーゼル機関	A-47
MFP-テストマトリックス	防火装置	A-49

MFS-テストマトリックス	フィルター/ストレーナー/デミ .....	A-50
MGT-テストマトリックス	ギヤボックス/トランスミッション .....	A-51
MGV-テストマトリックス	ガバナ/油圧 .....	A-52
MHD-テストマトリックス	油圧駆動機構 .....	A-53
MHX-テストマトリックス	熱交換器 .....	A-54
MP-テストマトリックス	ポンプ .....	A-55
MPP-テストマトリックス	配管/チューブ/溶接部品 .....	A-56
MPS-テストマトリックス	管サポート/ハンガー .....	A-57
MRC-テストマトリックス	冷却ユニット/チラー .....	A-58
MRF-テストマトリックス	放射線フィルター .....	A-59
MS-テストマトリックス	スナッパ .....	A-60
MT-テストマトリックス	タービン .....	A-61
MTV-テストマトリックス	タンク/容器/アキュムレーター .....	A-62
MV-テストマトリックス	弁、手動 .....	A-63
MVA-テストマトリックス	弁、空気/気体作動 .....	A-64
MVC-テストマトリックス	弁、チェック .....	A-65
MVM-テストマトリックス	弁、電動 .....	A-66
MVR-テストマトリックス	弁、逃がし安全弁 .....	A-67
MVS-テストマトリックス	弁、ソレノイド .....	A-68
<b>B電気テストガイドおよびテストの内容</b> .....		<b>B-1</b>
EG 電気機器 - 一般テスト .....		B-3
EG-1 - 一般的電気保全/据付チェック .....		B-3
A. 外観検査 .....		B-3
B. 電気チェック .....		B-3
C. 品質管理上の観点からのチェック .....		B-4

## Translated Table of Contents

EG-2 –一般的電気運転確認テスト .....	B-4
EG-3 –一般的電気機能テスト .....	B-5
EBC電池/充電器のテスト.....	B-7
EBC-1 –一般的電気保全/据付チェック .....	B-7
EBC-2 –ターミナル健全性チェック.....	B-8
EBC-3 –運転確認試験-電源off .....	B-8
EBC-4 –機能テスト .....	B-9
EC 電気接触器のテスト .....	B-10
EC-1 –保全/据付チェック.....	B-10
EC-2 –ターミナル健全性チェック .....	B-11
EC-3 –絶縁抵抗チェック.....	B-11
EC-4 –機能テスト .....	B-12
ECB 遮断機のテスト .....	B-13
ECB-1 –保全/据付チェック .....	B-13
ECB-2 –ターミナル健全性チェック.....	B-14
ECB-3 –絶縁抵抗チェック .....	B-14
ECB-4 –機能テスト .....	B-14
ECP 陰極防食のテスト.....	B-16
ECP-1 –保全/据付チェック .....	B-16
ECP-2 –機能テスト .....	B-16
EDG ディーゼル発電機のテスト.....	B-17
EDG-1 –保全/据付チェック .....	B-17
EDG-2 –ターミナル健全性チェック .....	B-18
EDG-3 –運転チェック-電源Off.....	B-18
EDG-4 –機能テスト.....	B-19

EFB ヒューズ部分のテスト .....	B-20
EFB-1 –保安/据付チェック .....	B-20
EFB-2 –ターミナル健全性チェック .....	B-20
EFB-3 –機能テスト .....	B-21
EGN  主要な発電機のテスト .....	B-22
EGN-1 –保安/据付チェック .....	B-22
EGN-2 –ターミナル健全性チェック .....	B-22
EGN-3 –運転チェック-電源Off.....	B-23
EGN-4 –機能テスト.....	B-23
EGN-5 –振動テスト.....	B-24
EGN-6 –空気圧テスト .....	B-24
EH  電気ヒーターのテスト.....	B-25
EH-1 –保安/据付チェック.....	B-25
EH-2 –ターミナル健全性チェック .....	B-25
EH-3 –機能テスト .....	B-25
EHT  電熱保温回路および装置のテスト.....	B-27
EHT-1 –保安/据付チェック .....	B-27
EHT-2 –ターミナル健全性チェック .....	B-27
EHT-3 –熱遮蔽のチェック .....	B-27
EHT-4 –機能テスト .....	B-28
EINインバーターのテスト .....	B-29
EIN-1 –保安/据付チェック.....	B-29
EIN-2 –ターミナルチェック .....	B-29
EIN-3 –運転チェック-電源Off.....	B-30
EIN-4 –機能テスト .....	B-30

## Translated Table of Contents

EM 電動機のテスト .....	B-32
EM-1 –保全/据付チェック .....	B-32
EM-2 –回転テスト .....	B-32
EM-3 –運転テスト .....	B-33
EM-4 –機能テスト .....	B-33
EMG 電動発電機のテスト .....	B-35
EMG-1 –保全/据付チェック .....	B-35
EMG-2 –運転テスト .....	B-36
EMG-3 –機能テスト .....	B-36
EPN 貫通部のテスト .....	B-37
EPN-1 –保全/据付チェック .....	B-37
EPN-2 –ターミナル健全性チェック .....	B-37
EPN-3 –絶縁抵抗チェック .....	B-38
EPN-4 –機能テスト .....	B-38
EPN-5 –計装/チャンネルキャリブレーション .....	B-38
EPS 電源のテスト .....	B-39
EPS-1 –保全/据付チェック .....	B-39
EPS-2 –ターミナル健全性チェック .....	B-39
EPS-3 –運転チェック-電源Off .....	B-40
EPS-4 –機能テスト .....	B-40
EPS-5 –温度チェック .....	B-41
ER リレー/メーターのテスト .....	B-42
ER-1 –保全/据付チェック .....	B-42
ER-2 –ターミナルの健全性チェック .....	B-42
ER-3 –リレー運転チェック-電源Off .....	B-43

ER-4 –機能テスト .....	B-43
ERC 再結合器のテスト .....	B-44
ERC-1 –保全/据付チェック .....	B-44
ERC-2 –機能テスト .....	B-44
ERC-3 –キャリブレーション .....	B-45
ESG 開閉装置のテスト .....	B-46
ESG-1 –保全/据付チェック .....	B-46
ESG-2 –ターミナル健全性チェック .....	B-47
ESG-3 –絶縁抵抗チェック .....	B-47
ESG-4 –機能テスト .....	B-48
ESG-5 –赤外線スキャン/サーモグラフィーチェック .....	B-48
ESW 電気スイッチのテスト .....	B-49
ESW-1 –保全/据付チェック .....	B-49
ESW-2 –ターミナル健全性チェック .....	B-49
ESW-3 –運転性チェック-電源Off .....	B-49
ESW-4 –機能テスト .....	B-50
ETR 変圧器のテスト .....	B-51
ETR-1 –保全/据付チェック .....	B-51
ETR-2 –ターミナル健全性チェック .....	B-51
ETR-3 –運転性チェック-電源-Off .....	B-52
ETR-4 –機能テスト .....	B-53
ETR-5 –油分析 .....	B-53
EWC電線/ケーブルのテスト .....	B-54
EWC-1 –保全/据付チェック .....	B-54
EWC-2 –ターミナルキャリブレーションチェック .....	B-54

Translated Table of Contents

EWC-3 –絶縁抵抗チェック .....	B-55
<b>C計装および制御系のテストガイドとテスト内容.....</b>	<b>C-1</b>
IG 計装及び制御系(I&C)の一般テスト .....	C-2
IG-1 –一般的計装および制御系の保全/据付チェック .....	C-2
A.点検チェック .....	C-2
B.計装ライン/管のチェック/リークテスト .....	C-2
C.品質管理上のチェック .....	C-3
IG-2 –一般的I&C運転性試験 .....	C-3
IG-3 –一般的計装制御系の機能テスト .....	C-4
IG-4 –一般的I&C特殊テスト-機器キャリブレーション .....	C-5
IA アナシエーターのテスト .....	C-6
IA-1 –保全/据付チェック .....	C-6
IA-2 –ターミナル健全性チェック .....	C-6
IA-3 –機能テスト .....	C-6
IB 双安定リレーのテスト .....	C-7
IB-1 –保全/据付チェック .....	C-7
IB-2 –チュービングチェック .....	C-7
IB-3 –ターミナル健全性チェック .....	C-7
IB-4 –機能テスト .....	C-8
ICI コンピュータ入出力のテスト .....	C-9
ICI-1 –保守/据付チェック .....	C-9
ICI-2 –ターミナル健全性チェック .....	C-9
ICI-3 –機能テスト .....	C-9
ICNのコンバーターのテスト .....	C-11
ICN-1 –保全/据付チェック .....	C-11

ICN-2 –リークテスト .....	C-11
ICN-3 –ターミナル健全性チェック .....	C-11
ICN-4 –機能テスト .....	C-12
ICS 制御スイッチのテスト .....	C-13
ICS-1 –保全/据付のチェック .....	C-13
ICS-2 –リークテスト .....	C-13
ICS-3 –ターミナル健全性チェック .....	C-14
ICS-4 –運転性チェック–電源Off .....	C-14
ICS-5 –機能テスト .....	C-14
ICS-6 –キャリブレーション .....	C-14
IDデジタル装置およびシステム .....	C-15
背景 .....	C-15
デジタル装置及びシステムのための保全後試験の一般的ガイド .....	C-19
ID-1 –保全/据付チェック .....	C-19
ID-2 –ターミナル健全性チェック .....	C-20
ID-3 –機能テスト .....	C-20
IFD 火災検知装置 .....	C-23
IFD-1 –保全/据付チェック .....	C-23
IFD-2 –ターミナル健全性チェック .....	C-23
IFD-3 –機能テスト .....	C-24
IGG ゲージのテスト .....	C-25
IGG-1 –保全/据付チェック .....	C-25
IGG-2 –リークテスト .....	C-25
IGG-3 –キャリブレーション .....	C-25

## Translated Table of Contents

IIN 表示器のテスト .....	C-26
IIN-1 –保全/据付チェック .....	C-26
IIN-2 –ターミナル健全性チェック .....	C-26
IIN-3 –機能テスト .....	C-26
IIN-4 –キャリブレーション .....	C-26
INI 核器械使用のテスト .....	C-27
INI-1 –保全/据付チェック .....	C-27
INI-2 –チャンネルキャリブレーション .....	C-27
INI-3 –探知器のキャリブレーション .....	C-27
INI-4 –機能テスト .....	C-28
IPC プロセスコントローラのテスト .....	C-29
IPC-1 –保全/据付チェック .....	C-29
IPC-2 –運転性チェック .....	C-29
IPC-3 –装置のキャリブレーション .....	C-30
IPC-4 –チャンネルキャリブレーション .....	C-30
IPC-5 –チャンネル機能テスト .....	C-30
IR レコーダーのテスト .....	C-32
IR-1 –保全/据付のチェック .....	C-32
IR-2 –ターミナルの健全性チェック .....	C-32
IR-3 –機能テスト .....	C-32
IR-4 –キャリブレーション .....	C-32
IRM 放射線モニタのテスト .....	C-33
IRM-1 –保全/据付チェック .....	C-33
IRM-2 –リーク試験リークテスト .....	C-33
IRM-3 –ターミナルの健全性チェック .....	C-33

IRM-4 –機能テスト .....	C-34
IRM-5 –キャリブレーション .....	C-34
IRT RTD/熱電対のテスト .....	C-35
IRT-1 –保全/据付のチェック .....	C-35
IRT-2 –リークテスト .....	C-35
IRT-3 –RTDか熱電対ターミナルの健全性チェック .....	C-35
IRT-4 –機能テスト .....	C-36
IRT-5 –キャリブレーション .....	C-36
ITトランスミッタのテスト .....	C-37
IT-1 –保全/据付チェック .....	C-37
IT-2 –リークテスト .....	C-37
IT-3 –ターミナルの健全性チェック .....	C-37
IT-4 –機能テスト .....	C-38
IT-5 –キャリブレーション .....	C-38
<b>D機械テストガイドおよびテスト内容 .....</b>	<b>D-1</b>
MG機械装置の一般的テスト .....	D-3
MG-1 –一般的機械の保全/据付チェック .....	D-3
A. 検査チェック .....	D-3
MG-2 –一般的機械に対する運転テスト .....	D-4
MG-3 –一般的機械に対する機能テスト .....	D-5
MG-4 –一般的機械に対する特別なテスト .....	D-7
A. 振動テスト .....	D-7
MAH エアハンドリングユニット/ファン/ブロアのテスト .....	D-8
MAH-1 –保全/据付チェック .....	D-8
MAH-2 –機能テスト .....	D-8

## Translated Table of Contents

MAH-3 –特別なテスト-振動試験 .....	D-9
MC カップリングのテスト .....	D-10
MC-1 –保全/据付チェック .....	D-10
MC-2 –機能テスト .....	D-10
MCDのコンデンサーのテスト .....	D-11
MCD-1 –保全/据付チェック .....	D-11
MCD-2 –リークテスト .....	D-11
A. 管のリークテスト .....	D-11
B. コンデンサーのリークテスト .....	D-12
MCD-3 –機能テスト .....	D-12
MCHのクレーンおよび起重機のテスト .....	D-13
MCH-1 –保全/据付チェック .....	D-13
MCH-2 –運転性チェック-荷下ろし .....	D-13
MCH-3 –機能テスト .....	D-14
MCP圧縮機のテスト .....	D-15
MCP-1 –保全/据付チェック .....	D-15
MCP-2 –運転性チェック-荷下ろし .....	D-15
MCP-3 –機能テスト .....	D-16
MD ドライヤーのテスト .....	D-17
MD-1 –保全/据付チェック .....	D-17
MD-2 –リークテスト .....	D-17
MD-3 –機能テスト .....	D-17
MD-4 –露点テスト .....	D-18
MD-5 –微粒子テスト .....	D-18
MDD ダンパーおよびダクトのテスト .....	D-19

MDD-1 –保全/据付チェック .....	D-19
MDD-2 –機能テスト .....	D-19
MDE ディーゼル機関のテスト .....	D-20
MDE-1 –保全/据付チェック .....	D-20
MDE-2 –機能テスト .....	D-20
MDE-3 –燃料テスト .....	D-22
MFP 防火装置のテスト .....	D-23
MFP-1 –保全/据付チェック .....	D-23
MFP-2 –リークテスト .....	D-24
MFP-3 –ターミナルの健全性チェック .....	D-24
MFP-4 –弁のサイクル/作動テスト .....	D-24
MFP-5 –運転性チェック .....	D-24
MFP-6 –機能テスト .....	D-25
MFSフィルター、ストレーナー、およびデミのテスト .....	D-26
MFS-1 –保全/据付チェック .....	D-26
MFS-2 –機能テスト .....	D-26
MGT ギヤボックス/伝達装置のテスト .....	D-27
MGT-1 –保全/据付チェック .....	D-27
MGT-2 –機能テスト .....	D-27
MGV 調節器、油圧装置のテスト .....	D-28
MGV-1 –保全/据付チェック .....	D-28
MGV-2 –機能テスト .....	D-28
MHD油圧駆動機構のテスト .....	D-29
MHD-1 –保全/据付チェック .....	D-29
MHD-2 –油圧駆動機構の機能テスト .....	D-29

## Translated Table of Contents

MHD-3 –油圧駆動機構の振動試験.....	D-29
MHX 熱交換器のテスト.....	D-30
MHX-1 –保全/据付チェック .....	D-30
MHX-2 –リークテスト.....	D-30
A. 管の保全または修理のためのリークテスト.....	D-30
B. 耐圧リークテスト.....	D-31
C. 一般的リークテスト.....	D-31
MHX-3 –機能テスト .....	D-31
MHX-4 –テストに関わる特別な条件-耐圧インサービステスト.....	D-31
MP ポンプのテスト.....	D-32
MP-1 –保全/据付チェック .....	D-32
MP-2 –運転性チェック-無負荷 .....	D-33
MP-3 –ポンプ機能テスト.....	D-33
MPP 配管/チューブ/溶接部品のテスト.....	D-34
MPP-1 –保全/据付チェック.....	D-34
MPP-2 –耐圧テスト.....	D-34
MPS 管、サポート/ハンガーのテスト.....	D-35
MPS-1 –保全/据付の目視検査.....	D-35
MPS-2 –ハンガー設定の確認.....	D-35
MRC 冷却ユニット/チラーのテスト.....	D-36
MRC-1 –保全/据付チェック .....	D-36
MRC-2 –冷房装置の運転性チェック .....	D-36
MRC-3 –冷房装置の機能テスト.....	D-37
MRC-4 –冷房装置のリークテスト.....	D-38
A. 管の保全または修理のためのリークテスト.....	D-38

B.耐圧リークテスト .....	D-38
C.インサースリークテスト .....	D-38
MRF 放射性フィルターテスト .....	D-39
MRF-1 –保全/据付チェック .....	D-39
MRF-2 –放射性フィルター機能テスト .....	D-39
MS スナッパのテスト .....	D-40
MS-1 –保全/据付チェック .....	D-40
MS-2 –設定のチェック .....	D-40
MS-3 –ストロークテスト .....	D-41
MT タービンのテスト .....	D-42
MT-1 –保全/据付チェック .....	D-42
MT-2 –リークテスト .....	D-43
MT-3 –運転性チェック .....	D-43
MT-4 –機能テスト .....	D-45
MTVタンク、容器、およびアキュムレータのテスト .....	D-46
MTV-1 –保全/据付チェック .....	D-46
MTV-2 –圧力試験 .....	D-46
MTV-3 –パラメータチェック .....	D-46
MV 手動弁のテスト .....	D-47
MV-1 –保全/据付のチェック .....	D-47
MV-2 –弁のサイクル/作動テスト .....	D-47
MV-3 –流れおよび圧力試験 .....	D-47
MV-4 –リークテスト .....	D-47
MV-5 –手動弁の位置指示確認チェック .....	D-48
MV-6 –手動弁シートのリークテスト .....	D-48

Translated Table of Contents

MVA 空気/空気作動弁のテスト .....	D-49
MVA-1 –保全/据付チェック .....	D-49
MVA-2 –弁のサイクル/作動テスト .....	D-49
MVA-3 –空気作動弁のストローク時間テスト .....	D-49
MVA-4 –位置指示確認のチェック .....	D-50
MVA-5 –リークテスト .....	D-50
MVA-6 –空気作動弁の運転性テスト .....	D-50
MVC チェック弁のテスト .....	D-51
MVC-1 –保全/据付チェック .....	D-51
MVC-2 –リークテスト .....	D-51
MVC-3 –弁のサイクルおよび位置指示チェック .....	D-51
MVC-4 –リバースフローテスト .....	D-52
MVC-5 –流れおよび圧力試験 .....	D-52
MVC-6 –シートリークテスト .....	D-52
MVM 電動弁のテスト .....	D-53
MVM-1 –保全/据付チェック .....	D-53
MVM-2 –弁のサイクル/作動テスト .....	D-53
MVM-3 –弁のストローク時間テスト .....	D-54
MVM-4 –弁の位置の指示、トルクスイッチチェック .....	D-54
MVM-5 –弁の電流テスト .....	D-54
MVM-6 –自動作動テスト .....	D-54
MVM-7 –特別なテスト-弁の診断 .....	D-54
MVR 逃がし安全弁のテスト .....	D-55
MVR-1 –保全/据付チェック .....	D-55
MVR-2 –セット・ポイントチェック .....	D-55

MVR-3 –弁のパッキングリークテスト .....	D-56
MVR-4 –位置指示チェック .....	D-56
MVR-5 –シートリークテスト .....	D-56
MVS ソレノイド弁のテスト .....	D-57
MVS-1 –保全/据付チェック .....	D-57
MVS-2 –弁のサイクル/作動テスト .....	D-57
MVS-3 –位置指示チェック .....	D-57
MVS-4 –シートリークテスト .....	D-57
MVS-5 –自動操作テスト .....	D-57

## テーブルのリスト

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テーブルC-1原子力発電所のデジタル部品とアセンブリの適用.....	C-15
テーブルC-2保全後テストでしばしば確認されるデジタル装置の属性.....	C-18

## **RESUMEN DEL REPORTE**

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### **Objetivos**

- Para ofrecer dirección en mantenimiento y aplicaciones relacionadas en mantenimiento de reguladores de voltaje de Basler SBSR en servicio nuclear de EDG.
- Para ofrecer dirección en mantenimiento, incluyendo una descripción de los sistemas específicos de regulador de voltaje; un repaso de historia de fallas, sintonizando, localizando averías, tareas rutinarias de mantenimiento preventivo; y discusiones de las tareas de mantenimiento especial.

# CONTENIDO

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<b>1 INTRODUCCIÓN .....</b>	<b>1-1</b>
1.1 Antecedentes .....	1-1
1.2 Alcance del Reporte .....	1-2
1.3 Necesidad para Revisión .....	1-2
1.4 Siglas .....	1-2
<b>2 ACERCAMIENTO TÉCNICO .....</b>	<b>2-1</b>
<b>3 ENFOCÁNDOSE EN FILSOFIA .....</b>	<b>3-1</b>
3.1 Pruebas de Mantenimiento .....	3-1
3.2 Pruebas Corrida/Operacional .....	3-2
3.3 Pruebas Funcional .....	3-2
3.4 Prueba Especial .....	3-3
<b>4 COORDINANDO CON COMPROMISOS LICENCIADOS/REGULATORIOS .....</b>	<b>4-1</b>
<b>5 INSTRUCCIONES .....</b>	<b>5-1</b>
<b>6 CONSIDERACIONES PARA IMPLEMENTACION DE SITIO-ESPECIFICO .....</b>	<b>6-1</b>
6.1 Jerarquía de procedimientos de PMT .....	6-1
6.2 Desarrollo de los Criterios de Sitio-Específicos .....	6-1
6.3 Integración con Existentes Actividades de Pruebas de Planta .....	6-2
6.4 Correlación de PMT para Equipos de Planta .....	6-2
<b>7 CONCLUSION .....</b>	<b>7-1</b>
<b>8 REFERENCIAS .....</b>	<b>8-1</b>
<b>A MATRICES DE EVALUACIÓN DE COMPONENTES.....</b>	<b>A-1</b>
Equipos Eléctrico – Matriz de Evaluación de Componentes .....	A-1

EBC – Matriz de Evaluación de Componentes de Batería/Cargador de Batería .....	A-2
EC – Matriz de Evaluación de Componentes de Contactor Eléctrico .....	A-3
ECB – Matriz de Evaluación de Componentes de Disyuntor .....	A-4
ECP – Matriz de Evaluación de Componentes de Protección Catódica .....	A-5
EDG – Matriz de Evaluación de Componentes de Generador Diesel .....	A-6
EFB – Matriz de Evaluación de Componentes de Fusible/Bloque de Fusibles.....	A-7
EGN – Matriz de Evaluación de Componentes de Generador .....	A-8
EH – Matriz de Evaluación de Componentes de Calefactor Eléctrico.....	A-9
EHT – Matriz de Evaluación de Componentes de Circuito de Aplicación de Calor/Equipo.....	A-10
EIN – Matriz de Evaluación de Componentes de Inversor .....	A-11
EM – Matriz de Evaluación de Componentes de Motor eléctrico.....	A-12
EMG – Matriz de Evaluación de Componentes de Generador .....	A-13
EPN– Matriz de Evaluación de Componentes de Penetración .....	A-14
EPS – Matriz de Evaluación de Componentes de Fuente de Energía Eléctrica .....	A-15
ER – Matriz de Evaluación de Componentes de Reles/Metros.....	A-16
ERC – Matriz de Evaluación de Componentes de Recombinador .....	A-17
ESG – Matriz de Evaluación de Componentes de Conmutador .....	A-18
ESW – Matriz de Evaluación de Componentes de Interruptor Eléctrico .....	A-19
ETR – Matriz de Evaluación de Componentes de Transformador .....	A-20
EWC – Matriz de Evaluación de Componentes de Cable .....	A-21
Instrumentación y Controles - Matriz de Evaluación de Componentes de.....	A-22
IA – Matriz de Evaluación de Componentes de Anunciador .....	A-23
IB – Matriz de Evaluación de Componentes de Releo/Biestable .....	A-24
ICI – Matriz de Evaluación de Componentes de Dispositivos de Computadora de Entrada-Salida.....	A-25
ICN – Matriz de Evaluación de Componentes de Convertidor .....	A-26
ICS – Matriz de Evaluación de Componentes de Interruptor de Control.....	A-27
ID – Matriz de Evaluación de Componentes de Componentes Digitales y Asamblea.....	A-28
IFD – Matriz de Evaluación de Componentes de Detección de Fuego.....	A-29
IGG – Matriz de Evaluación de Componentes de Galga.....	A-30
IIN – Matriz de Evaluación de Componentes de Indicador .....	A-31
INI – Matriz de Evaluación de Componentes de Instrumentación Nuclear .....	A-32
IPC – Matriz de Evaluación de Componentes de Controlador de Procesos .....	A-33
IR – Matriz de Evaluación de Componentes de Registrador.....	A-34
	E-39

*Translated Table of Contents*

IRM – Matriz de Evaluación de Componentes de Monitor de Radiación .....	A-35
IRT – Matriz de Evaluación de Componentes de RTD/Termopar .....	A-36
IT – Matriz de Evaluación de Componentes de Transmisor .....	A-37
Equipo Mecánico - Matrices de Evaluación de Componentes .....	A-38
MAH – Matriz de Evaluación de Componentes de Unidad que Maneja el Aire/Ventilador .....	A-39
MC – Matriz de Evaluación de Componentes de Acoplamiento .....	A-41
MCD – Matriz de Evaluación de Componentes de Condensador .....	A-42
MCH – Matriz de Evaluación de Componentes de Grúa/Montacargas .....	A-43
MCP – Matriz de Evaluación de Componentes de Compresor .....	A-44
MD – Matriz de Evaluación de Componentes de Secador .....	A-45
MDD – Matriz de Evaluación de Componentes de Amortiguador/Conductor .....	A-46
MDE – Matriz de Evaluación de Componentes de Motor Diesel.....	A-47
MFP – Matriz de Evaluación de Componentes de Dispositivos de Protección Contra Incendios .....	A-49
MFS – Matriz de Evaluación de Componentes de Filtro/Tamiz/Desmineralizador.....	A-50
MGT – Matriz de Evaluación de Componentes de Caja de Engranajes/Transmisión.....	A-51
MGV – Matriz de Evaluación de Componentes de Regulador,Hidráulico .....	A-52
MHD – Matriz de Evaluación de Componentes de Mando Hidráulico.....	A-53
MHX – Matriz de Evaluación de Componentes de Cambiador de Calor.....	A-54
MP – Matriz de Evaluación de Componentes de Bomba Hidráulica .....	A-55
MPP – Matriz de Evaluación de Componentes de Piperías/Tubería/Componentes Soldados.....	A-56
MPS – Matriz de Evaluación de Componentes de Soporte de Tubería/Soporte Colgante .....	A-57
MRC – Matriz de Evaluación de Componentes de Unidad de Refrigeración/Refrigerador .....	A-58
MRF – Matriz de Evaluación de Componentes de Filtro de Radiación .....	A-59
MS – Matriz de Evaluación de Componentes de Amortiguador .....	A-60
MT – Matriz de Evaluación de Componentes de Turbina .....	A-61
MTV – Matriz de Evaluación de Componentes de Tanque/Vasija/Acumulador .....	A-62
MV – Matriz de Evaluación de Componentes de Válvula, Manual .....	A-63
MVA – Matriz de Evaluación de Componentes de Válvula, Aire-/Neumática-Operada.....	A-64
MVC – Matriz de Evaluación de Componentes de Válvula, Comprobación.....	A-65
MVM – Matriz de Evaluación de Componentes de Válvula, Motorizada .....	A-66

MVR – Matriz de Evaluación de Componentes de Válvula, de Alivio y Seguridad ..... A-67

MVS – Matriz de Evaluación de Componentes de Válvula, Solenoide ..... A-68

**B GUIAS DE PRUEBAS ELÉCTRICA Y DEFINICIONES DE PRUEBAS ..... B-1**

EG Equipos Eléctrico – Pruebas General ..... B-3

EG-1– Mantenimiento Eléctrico General/Verificación de Instalación ..... B-3

    A. Verificación de Inspección ..... B-3

    B. Verificación Eléctrica ..... B-3

    C. Verificación de Cualificación de Equipos ..... B-4

EG- 2 – Corrida Eléctrica General/Prueba Operacional ..... B-4

EG-3 – Prueba Funcional Eléctrica General ..... B-5

EBC Batería/Prueba de Componente del Cargador de Batería ..... B-7

EBC-1 – Mantenimiento/Prueba de Instalación..... B-7

EBC-2 – Prueba de Integridad de Terminación..... B-8

EBC-3 – Prueba de Operaciones - Apagado ..... B-8

EBC-4 – Prueba Funcional..... B-9

EC Prueba de Componente Contactor Eléctrico ..... B-10

EC-1 – Mantenimiento/Prueba de Instalación ..... B-10

EC-2 – Prueba de Integridad de Terminación ..... B-11

EC-3 – Prueba de Resistencia de Aislamiento..... B-11

EC-4 – Prueba Funcional ..... B-12

ECB Prueba del Disyuntor..... B-13

ECB-1 – Mantenimiento/Prueba de Instalación..... B-13

ECB-2 – Prueba de Integridad de Terminación..... B-14

ECB-3 – Prueba de Resistencia de Aislamiento ..... B-14

ECB-4 – Prueba Funcional..... B-14

ECP Prueba de Componente de Protección Catódica ..... B-16

ECP-1 – Mantenimiento/Prueba de Instalación..... B-16

ECP-2 – Prueba Funcional..... B-16

EDG Diesel Generator Component Testing..... B-17

EDG-1 – Mantenimiento/Prueba de Instalación ..... B-17

EDG-2 – Prueba de Integridad de Terminación ..... B-18

EDG-3 – Prueba Operacional - Apagado ..... B-18

*Translated Table of Contents*

EDG-4 – Prueba Funcional .....	B-19
EFB Prueba de Componente de Bloque de Fusible .....	B-20
EFB-1 – Mantenimiento/Prueba de Instalación .....	B-20
EFB-2 – Prueba de Integridad de Terminación .....	B-20
EFB-3 – Prueba Funcional .....	B-21
EGN Prueba de Componente de Generador de Aire .....	B-22
EGN-1 – Mantenimiento/Prueba de Instalación .....	B-22
EGN-2 – Prueba de Integridad de Terminación .....	B-22
EGN-3 – Prueba Operacional - Apagado .....	B-23
EGN-4 – Prueba Funcional .....	B-23
EGN-5 – Prueba de Vibración .....	B-24
EGN-6 – Prueba de Aire.....	B-24
EH Prueba de Componente de Calentador Eléctrico .....	B-25
EH-1 – Mantenimiento/Prueba de Instalación .....	B-25
EH-2 – Prueba de Integridad y Terminación .....	B-25
EH-3 – Prueba Funcional .....	B-25
EHT Prueba de Componente del Equipo y Circuito de Rastreo de Calor .....	B-27
EHT-1 – Mantenimiento/Prueba de Instalación/Inspección .....	B-27
EHT-2 – Prueba de Integridad de Terminación .....	B-27
EHT-3 – Prueba de Insulacion Térmica .....	B-27
EHT-4 – Prueba Funcional .....	B-28
EIN Prueba de Componente Inversor .....	B-29
EIN-1 – Mantenimiento/Prueba de Instalación .....	B-29
EIN-2 – Prueba de Integridad de Terminación .....	B-29
EIN-3 – Prueba Operacional - Apagado .....	B-30
EIN-4 – Prueba Funcional .....	B-30
EM Prueba de Componente del Motor Eléctrico .....	B-32
EM-1 – Mantenimiento/Prueba de Instalación.....	B-32
EM-2 – Prueba de Rotación .....	B-32
EM-3 – Corriendo/Prueba Operacional .....	B-33
EM-4 – Prueba Funcional.....	B-33
EMG Prueba de Componente del Generador a Motor .....	B-35
EMG-1 – Mantenimiento/Prueba de Instalación .....	B-35
EMG-2 – Corriendo/Prueba Operacional .....	B-36
EMG-3 – Prueba Funcional .....	B-36

EPN	Prueba de Componente de Penetración.....	B-37
	EPN-1 – Mantenimiento/Prueba de Instalación.....	B-37
	EPN-2 – Prueba de Integridad de Terminación.....	B-37
	EPN-3 – Prueba de Resistencia de Aislamiento .....	B-38
	EPN-4 – Prueba Funcional.....	B-38
	EPN-5 – Instrumento/Calibración del Canal.....	B-38
EPS	Prueba de Componente del Suministro Eléctrico .....	B-39
	EPS-1 – Mantenimiento/Prueba de Instalación.....	B-39
	EPS-2 – Prueba de Integridad de Terminación.....	B-39
	EPS-3 – Prueba Operacional - Apagado.....	B-40
	EPS-4 – Prueba Funcional .....	B-40
	EPS-5 – Prueba de Temperatura .....	B-41
ER	Prueba de Componente de Reles/Metros.....	B-42
	ER-1 – Mantenimiento/Prueba de Instalación .....	B-42
	ER-2 – Prueba de Integridad de Terminación .....	B-42
	ER-3 –Prueba Operacional de Reles- Apagado.....	B-43
	ER-4 – Prueba Funcional .....	B-43
ERC	Prueba de Componente del Recombinador .....	B-44
	ERC-1 – Mantenimiento/Prueba de Instalación .....	B-44
	ERC-2 – Prueba Funcional.....	B-44
	ERC-3 – Calibración.....	B-45
ESG	Prueba de Componente del Conmutador .....	B-46
	ESG-1 – Mantenimiento/Prueba de Instalación .....	B-46
	ESG-2 – Prueba de Integridad de Terminación .....	B-47
	ESG-3 – Prueba de Resistencia de Aislamiento .....	B-47
	ESG-4 – Prueba Funcional.....	B-48
	ESG-5 – Búsqueda de Infrarojo/Prueba de Termografo .....	B-48
ESW	Prueba de Componente del Interruptor Eléctrico.....	B-49
	ESW-1 – Mantenimiento/Prueba de Instalación.....	B-49
	ESW-2 – Prueba de Integridad de Terminación.....	B-49
	ESW-3 – Prueba Operacional - Apagado.....	B-49
	ESW-4 – Prueba Funcional .....	B-50
ETR	Prueba de Componente del Transformador.....	B-51
	ETR-1 – Mantenimiento/Prueba de Instalación.....	B-51
	ETR-2 – Prueba de Integridad de Terminación.....	B-51

*Translated Table of Contents*

ETR-3 – Prueba Operacional - Apagado.....	B-52
ETR-4 – Prueba Funcional .....	B-53
ETR-5 – Análisis de Aceite.....	B-53
EWC Prueba de Componente de Cable.....	B-54
EWC-1 – Mantenimiento/Prueba de Instalación.....	B-54
EWC-2 – Prueba de Integridad de Terminación.....	B-54
EWC-3 – Prueba de Resistencia de Aislamiento .....	B-55

<b>C INSTRUMENTACIÓN Y PRUEBAS DE CONTROLES Y DEFINICIONES DE PRUEBAS .....</b>	<b>C-1</b>
IG Instrumentación y Pruebas General de Controles.....	C-2
IG-1 – Instrumentación General y Mantenimiento de Controles/Prueba de Instalación .....	C-2
A. Prueba de Inspección .....	C-2
B. Línea de Instrumento/Prueba de Tubería/Prueba de Fuga.....	C-2
C. Prueba de Calificación de Equipo .....	C-3
IG-2 – Corriendo I&C General/Prueba Operacional .....	C-3
IG-3 – Prueba Funcional de Instrumentación y Controles General .....	C-4
IG-4 – Prueba Especial I&C General – Calibración de Componente .....	C-5
IA Prueba de Componente del Anunciador.....	C-6
IA-1 – Mantenimiento/Prueba de Instalación.....	C-6
IA-2 – Prueba de Integridad de Terminación.....	C-6
IA-3 – Prueba Funcional.....	C-6
IB Pruebas de Componente de Biestable/Reles .....	C-7
IB-1 – Mantenimiento/Prueba de Instalación.....	C-7
IB-2 – Prueba de Tubería .....	C-7
IB-3 – Prueba de Integridad de Terminación.....	C-7
IB-4 – Prueba Funcional.....	C-8
ICI Prueba de Componente de Entrada/Salida de la Computadora .....	C-9
ICI-1 – Mantenimiento/Prueba de Instalación .....	C-9
ICI-2 – Prueba de Integridad de Terminación .....	C-9
ICI-3 – Prueba Funcional.....	C-9
ICN Prueba de Componente del Convertidor.....	C-11
ICN-1 – Mantenimiento/Prueba de Instalación.....	C-11
ICN-2 – Prueba de Fuga .....	C-11
ICN-3 – Prueba de Integridad de Terminación.....	C-11

ICN-4 – Prueba Funcional .....	C-12
ICS Prueba de Componente del Interruptor de Control .....	C-13
ICS-1 – Mantenimiento/Prueba de Instalación .....	C-13
ICS-2 – Prueba de Fuga.....	C-13
ICS-3 – Prueba de Integridad de Terminación .....	C-14
ICS-4 – Prueba Operacional - Apagado.....	C-14
ICS-5 – Prueba Funcional .....	C-14
ICS-6 – Calibración .....	C-14
ID Sistemas y Dispositivo Digital .....	C-15
Antecedentes.....	C-15
Guia General para Prueba Tras Mantenimiento para Sistemas y Dispositivos Digatels.....	C-19
ID-1 – Mantenimiento/Prueba de Instalación .....	C-19
ID-2 – Prueba de Integridad de Terminación .....	C-20
ID-3 – Prueba Funcional.....	C-20
IFD Prueba de Componente de Detección de Fuego.....	C-23
IFD-1 – Mantenimiento/Prueba de Instalación .....	C-23
IFD-2 – Prueba de Integridad de Terminación .....	C-23
IFD-3 – Prueba Funcional .....	C-24
IGG Prueba de Componente de la Galga.....	C-25
IGG-1 – Mantenimiento/Prueba de Instalación .....	C-25
IGG-2 – Prueba de Fuga.....	C-25
IGG-3 – Calibration.....	C-25
IIN Prueba de Componente del Indicador .....	C-26
IIN-1 – Mantenimiento/Prueba de Instalación .....	C-26
IIN-2 – Prueba de Integridad de Terminación .....	C-26
IIN-3 – Prueba Funcional.....	C-26
IIN-4 – Calibración.....	C-26
INI Prueba de Componentes de la Instrumentación Nuclear .....	C-27
INI-1 – Mantenimiento/Prueba de Instalación .....	C-27
INI-2 – Channel Calibration .....	C-27
INI-3 – Detector Calibration .....	C-27
INI-4 – Prueba Funcional.....	C-28
IPC Prueba de Componente del Controlador de Proceso .....	C-29
IPC-1 – Mantenimiento/Prueba de Instalación .....	C-29

*Translated Table of Contents*

IPC-2 – Prueba Operacional .....	C-29
IPC-3 – Calibración de Dispositivo .....	C-30
IPC-4 – Calibración de Canal .....	C-30
IPC-5 – Prueba Funcional de Canal .....	C-30
IR Prueba de Componente del Registrador .....	C-32
IR-1 – Mantenimiento/Prueba de Instalación .....	C-32
IR-2 – Prueba de Integridad de Terminación .....	C-32
IR-3 – Prueba Funcional.....	C-32
IR-4 – Calibración.....	C-32
IRM Prueba de Componente del Monitor de Radiación .....	C-33
IRM-1 – Mantenimiento/Prueba de Instalación .....	C-33
IRM-2 – Prueba de Fuga .....	C-33
IRM-3 – Prueba de Integridad de Terminación .....	C-33
IRM-4 – Prueba Funcional.....	C-34
IRM-5 – Calibración.....	C-34
IRT RTD/Prueba de Componente del Termopar .....	C-35
IRT-1 – Mantenimiento/Prueba de Instalación .....	C-35
IRT-2 – Prueba de Fuga.....	C-35
IRT-3 – RTD ó Prueba de Integridad de Terminación del Termopar .....	C-35
IRT-4 – Prueba Funcional .....	C-36
IRT-5 – Calibración.....	C-36
IT Prueba de Componente del Transmisor .....	C-37
IT-1 – Mantenimiento/Prueba de Instalación .....	C-37
IT-2 – Prueba de Fuga .....	C-37
IT-3 – Prueba de Integridad de Terminación.....	C-37
IT-4 – Prueba Funcional .....	C-38
IT-5 – Calibración .....	C-38

<b>DGUIAS DE PRUEBAS MECÁNICAS Y DEFINICIONES DE PRUEBAS .....</b>	<b>D-1</b>
MG Prueba General del Equipo Mecánico .....	D-3
MG-1 – Mantenimiento Mecánico General / Verificación de Instalación .....	D-3
A. Prueba de Inspección .....	D-3
MG-2 – Corrida Mecánica General/Prueba Operacional.....	D-4
MG-3 – Prueba Funcional Mecánica General .....	D-5
MG-4 – Prueba Especial Mecánica General .....	D-7
A. Prueba de Vibración.....	D-7
MAH Unidad de Manejo de Aire/Ventilador/Blower Component Testing .....	D-8
MAH-1 – Mantemineto/Verificación de Instalación.....	D-8
MAH-2 – Prueba Funcional .....	D-8
MAH-3 – Prueba Especial - Prueba de Vibración .....	D-9
MC Prueba de Componente de Acoplamiento .....	D-10
MC-1 – Mantemineto/Verificación de Instalación .....	D-10
MC-2 – Prueba Funcional.....	D-10
MCD Prueba de Componente de Condensador .....	D-11
MCD-1 – Mantemineto/Verificación de Instalación.....	D-11
MCD-2 – Prueba de Fuga .....	D-11
A. Prueba de Fuga de Tubo .....	D-11
B. Prueba de Fuga del Condensador .....	D-12
MCD-3 – Prueba Funcional .....	D-12
MCH Prueba de Componente de Grúa/Montacargas .....	D-13
MCH-1 – Mantemineto/Verificación de Instalación.....	D-13
MCH-2 – Operational Check - Unloaded.....	D-13
MCH-3 – Prueba Funcional .....	D-14
MCP Prueba de Componente del Compresor .....	D-15
MCP-1 – Mantemineto/Verificación de Instalación.....	D-15
MCP-2 – Prueba Operacional- Descargado.....	D-15
MCP-3 – Prueba Funcional .....	D-16
MD Prueba de Comonente de Secador.....	D-17
MD-1 – Mantemineto/Verificación de Instalación .....	D-17
MD-2 – Prueba de Fuga .....	D-17
MD-3 – Prueba Funcional.....	D-17
MD-4 – Prueba Punto de Rocío .....	D-18

*Translated Table of Contents*

MD-5 – Prueba de Particula .....	D-18
MDD Prueba de Componente de Amortiguador y Tubería .....	D-19
MDD-1 – Mantenimiento/Pruebas de Instalación .....	D-19
MDD-2 – Prueba Funcional .....	D-19
MDE Prueba de Componente de Motor Diesel .....	D-20
MDE-1 – Mantemineto/Verificación de Instalación .....	D-20
MDE-2 – Prueba Funcional .....	D-20
MDE-3 – Prueba de Combustible .....	D-22
MFP Prueba de Componente del Dispositivo de Protección Contra incendio .....	D-23
MFP-1 – Mantemineto/Verificación de Instalación .....	D-23
MFP-2 – Prueba de Fuga .....	D-24
MFP-3 – Prueba de Integridad de Terminación .....	D-24
MFP-4 – Ciclo de Válvula/Exercise Test .....	D-24
MFP-5 – Prueba Operacional .....	D-24
MFP-6 – Prueba Funcional .....	D-25
MFS Filtro, Tamiz y Prueba de Componente del Desmineralizador .....	D-26
MFS-1 – Mantemineto/Verificación de Instalación .....	D-26
MFS-2 – Prueba Funcional .....	D-26
MGT Caja de Engranaje/Prueba de Componente de Transmición .....	D-27
MGT-1 – Mantemineto/Verificación de Instalación .....	D-27
MGT-2 – Prueba Funcional .....	D-27
MGV Regulador, Prueba de Componente de Mando Hidráulico .....	D-28
MGV-1 – Mantemineto/Verificación de Instalación .....	D-28
MGV-2 – Prueba Funcional .....	D-28
MHD Prueba de Componente de Conductor Hidráulico .....	D-29
MHD-1 – Mantemineto/Verificaciones de Instalación .....	D-29
MHD-2 – Prueba Funcional de Mando Hidráulico .....	D-29
MHD-3 – Prueba de Vibración de Mando Hidráulico .....	D-29
MHX Prueba de Componente de Cambiador de Calor .....	D-30
MHX-1 – Mantemineto/Verificación de Instalación .....	D-30
MHX-2 – Prueba de Fuga .....	D-30
A. Prueba de Fuga de Tubo para Mantenimiento ó Reparación de Tubos .....	D-30
B. Prueba de Fuga Hidroestática .....	D-31
C. Prueba de Fuga General .....	D-31
MHX-3 – Prueba Funcional .....	D-31

MHX-4 – Requerimientos Especiales ó Pruebas - Prueba en Servicio Hidroestática...	D-31
MP Prueba de Componente de Bomba Hidráulica .....	D-32
MP-1 – Mantemineto/Verificación de Instalación .....	D-32
MP-2 – Descarga de Prueba Operacional.....	D-33
MP-3 – Prueba Funcional de Bomba Hidráulica .....	D-33
MPP Tuberías/Prueba de Componente Soldado.....	D-34
MPP-1 – Mantemineto/Verificación de Instalación .....	D-34
MPP-2 – Prueba Hidroestática .....	D-34
MPS Soporte del Conductot/Prueba de Componente del Soporte Colgante .....	D-35
MPS-1 – Pruebas de Mantenimiento/Inspección Visual de Instalación .....	D-35
MPS-2 – Verificación de Fijación del Soporte Colgante.....	D-35
MRC Unidad de Refrigeración/Prueba de Componente de Enfriador.....	D-36
MRC-1 – Mantenimiento/Pruebas de Instalación .....	D-36
MRC-2 – Verificación Operacional del Sistema de Refrigeración .....	D-36
MRC-3 – Verificación Funcional del Sistema de Refrigeración .....	D-37
MRC-4 – Prueba de Fuga del Sistema de Refrigeración .....	D-38
A. Prueba de Fuga en Tubo para el Mantenimiento ó Reparación de Tubos .....	D-38
B. Prueba de Fuga Hidroestática .....	D-38
C. Prueba de Fuga En Servicio .....	D-38
MRF Prueba de Componente de Filtro de Radiación .....	D-39
MRF-1 – Mantemineto/Verificación de Instalación .....	D-39
MRF-2 – Prueba Funcional de Filtro de Radiación .....	D-39
MS Prueba de Componente del Amortiguador .....	D-40
MS-1 – Mantemineto/Verificación de Instalación .....	D-40
MS-2 – Prueba de Fijación .....	D-40
MS-3 – Prueba de Apertura.....	D-41
MT Prueba de Componente de Turbina.....	D-42
MT-1 – Mantemineto/Verificación de Instalación.....	D-42
MT-2 – Prueba de Fuga .....	D-43
MT-3 – Prueba Operacional .....	D-43
MT-4 – Prueba Funcional .....	D-45
MTV Depósito, Vasija y Prueba de Componente Acumulador .....	D-46
MTV-1 – Mantemineto/Verificación de Instalación .....	D-46
MTV-2 – Prueba de Presión .....	D-46
MTV-3 – Prueba de Parametro .....	D-46

*Translated Table of Contents*

MV	Válvula, Pruebas de Componentes Operado Manual.....	D-47
	MV-1 – Mantenimiento/Prueba de Instalación.....	D-47
	MV-2 – Ciclado de Válvula /Prueba de Ejercicio .....	D-47
	MV-3 – Flujo y Prueba de Presión.....	D-47
	MV-4 – Prueba de Fuga .....	D-47
	MV-5 – Verificación de Indicador de Posición de Válvula Manual .....	D-48
	MV-6 – Prueba de Fugas del Asiento de Válvula Manual .....	D-48
MVA	Válvula, Aire-/Prueba de Componente Operado-Neumático .....	D-49
	MVA-1 – Mantemineto/Verificación de Instalación .....	D-49
	MVA-2 – Ciclado de Válvula/Prueba de Ejercicio.....	D-49
	MVA-3 – Prueba de Tiempo de Apertura de Válvula Operada a Aire .....	D-49
	MVA-4 – Verificación de Indicador de Posición.....	D-50
	MVA-5 – Prueba de Fuga.....	D-50
	MVA-6 – Prueba de Operacion Automatica de Valvula Operada a Aire .....	D-50
MVC	Válvula, Prueba de Componente Verificador .....	D-51
	MVC-1 – Mantemineto/Verificación de Instalación.....	D-51
	MVC-2 – Prueba de Fuga.....	D-51
	MVC-3 – Ciclado de Válvula y Verificación de Indicador de Posición.....	D-51
	MVC-4 – Prueba de Flujo Reverso.....	D-52
	MVC-5 – Flujo y Prueba de Presión .....	D-52
	MVC-6 – Prueba de Fugas del Asiento .....	D-52
MVM	Válvula, Prueba de Componente Operada a Motor .....	D-53
	MVM-1 – Mantemineto/Verificación de Instalación .....	D-53
	MVM-2 – Ciclado de Válvula/Prueba de Ejercicio .....	D-53
	MVM-3 – Prueba de Tiempo de Apertura de Válvula.....	D-54
	MVM-4 – Indicacion de Posición de Válvula y Interruptor de par de Torción .....	D-54
	MVM-5 – Prueba de Corriente de Válvula .....	D-54
	MVM-6 – Prueba de Operación Automática.....	D-54
	MVM-7 – Prueba Especial – Diagnostico de Válvula .....	D-54
MVR	Válvula, Alivio y Prueba de Componente de Seguridad .....	D-55
	MVR-1 – Mantemineto/Verificación de Instalación.....	D-55
	MVR-2 – Prueba de Punto Fijo.....	D-55
	MVR-3 – Prueba de Fuga de Empaquetadura de Válvula .....	D-56
	MVR-4 – Verificación de Indicador de Posición .....	D-56
	MVR-5 – Prueba de Fugas del Asiento .....	D-56

MVS	Válvula, Prueba de Componente Solonide .....	D-57
	MVS-1 – Mantemineto/Verificación de Instalación .....	D-57
	MVS-2 – Ciclado de Válvula/Exercise Test .....	D-57
	MVS-3 – Verificación de Indicador de Posición.....	D-57
	MVS-4 – Prueba de Fugas del Asiento .....	D-57
	MVS-5 – Prueba de Operación Automatica .....	D-57

## **LISTA DE TABLAS**

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Tabla C-1 Aplicaciones para Componentes Digitales y Asamblea en Plantas Nucleares.....	C-15
Tabla C-2 Atributos de Dispositos Digital a Menudo Verificada por Pruebas de Ante-Mantenimiento.....	C-18





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