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PERFORMANCE SPECIFICATION

PROTECTIVE RELAYS AND ATTACHMENTS, MEDIUM VOLTAGE VACUUM CIRCUIT BREAKER APPLICATIONS

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This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers protective relays and attachments used with medium voltage vacuum circuit breakers for shipboard use.

1.2 Classification. Protective relays are of the following types, as specified (see 6.2).

a. Type I - Type I protective relays are hard-mounted (without shock isolators) within a hard-mounted switchboard.

b. Type II - Type II protective relays are installed on shock isolators within a hard-mounted switchboard or hard-mounted within a shock isolated switchboard.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-S-901	-	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-E-917	-	Electric Power Equipment Basic Requirements
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-P-15024/5	-	Plates, Identification
MIL-PRF-85045	-	Cables, Fiber Optics, (Metric), General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	-	Identification Marking of U.S. Military Property
MIL-STD-167-1	-	Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)
MIL-STD-202	-	Electronic and Electrical Component Parts
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-1399-300	-	Electric Power, Alternating Current

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-454	-	General Guidelines for Electronic Equipment

(Copies of these documents are available online at http://quicksearch.dla.mil/ or https://assist.dla.mil.)

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2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE C37.2	-	IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations
IEEE C37.90	-	IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

(Copies of these documents are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or online at www.ieee.org.)

IPC

IPC-CC-830	-	Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies

(Copies of this document are available from IPC, 3000 Lakeside Drive, 309 S, Bannockburn, IL 60015 or online at www.ipc.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Protective relays furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.3).

3.2 General requirements. Protective relays and attachments shall comply with the applicable requirements of IEEE C37.90 except as modified or added to by the requirements of this specification.

3.3 Materials of construction. Materials in accordance with MIL-E-917 requirements are preferred. The following materials and coatings are non-preferred and shall be identified to the NAVSEA materials Technical Warrant Holder (TWH) or TWH representative prior to the start of qualification or comparison testing:

a. Insulating materials which contain halogens, e.g. chlorine, fluorine, and bromine, which evolve gases during combustion including estimated maximum weight.

b. Corrosion-susceptible materials and coatings not in accordance with MIL-E-917 requirements.

c. Organic materials not inherently fungus-resistant or validated to be fungus-resistant. Refer to MIL-HDBK-454, Guideline 4.

d. Lead-free solder used in printed circuit boards.

3.3.1 Aluminum conductors. Aluminum conductors or terminals shall not be used.

3.3.2 Conformal coat. All circuit boards shall be conformal coated in accordance with IPC-CC-830.

3.3.3 Insulation.

3.3.3.1 Type. Insulation shall be Series C as defined by IEEE C37.90 and meet the requirements of IEEE C37.90.

3.3.3.2 Creepage and clearance distances. Unless otherwise specified (see 6.2), creepage and clearance distances shall be in accordance with MIL-E-917. Creepage and clearance distances that are not in accordance with MIL-E-917 requirements shall be identified to the NAVSEA electrical systems TWH or TWH representative prior to the start of qualification or comparison testing.

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3.4 Environmental performance requirements.

3.4.1 Temperature range.

3.4.1.1 Operational temperature range. Operational temperature range at full loading as defined by IEEE C37.90 shall be 0 to +70 °C.

3.4.2 Heating limits of temperature rise for coils. Temperature rise of relay coils shall meet the requirements of IEEE C37.90.

3.4.3 Relative humidity. Relays shall meet relative humidity requirements of IEEE C37.90.

3.4.4 Electromagnetic interference (EMI). Relays shall meet and demonstrate compliance with the EMI requirements of MIL-STD-461 for surface ship, below deck, metallic hull installations.

3.4.4.1 EMI test procedures and results. EMI test procedures and results shall be in accordance with the Electromagnetic Interference Test Procedures (EMITP) and Electromagnetic Interference Test Report (EMITR) requirements of MIL-STD-461. Test procedures shall be approved by the NAVSEA EMI TWH or TWH representative prior to the start of testing. Test results shall be approved by the NAVSEA EMI TWH or TWH representative.

3.4.5 Shock.

3.4.5.1 Type I protective relays. Type I protective relays shall withstand Grade A, Class I, Type C shock requirements of MIL-S-901.

3.4.5.2 Type II protective relays. Type II protective relays shall be able to withstand shock fragility testing in accordance with MIL-STD-202, Method 213B, half-sine, 11 ms, 3 axis.

3.4.6 Vibration. Relays shall withstand Type I vibration tests specified in MIL-STD-167-1.

3.4.7 Inclined operation. The protective relay shall operate when inclined, forward, backward, and to each side at an angle of 30 degrees from the vertical position.

3.5 Electrical ratings/requirements.

3.5.1 Current and voltage ratings.

3.5.1.1 Standard. Standard voltage ratings shall be 120VAC or less or 125VDC or less as specified (see 6.2). Standard current for AC and DC voltage ratings shall be in accordance with IEEE C37.90.

3.5.1.2 Maximum design ratings. Maximum design voltage and current ratings as defined by IEEE C37.90 shall be as specified (see 6.2). Maximum design voltage or current shall be equal to or greater than the rated voltage or current in accordance with IEEE C37.90.

3.5.1.3 Measuring input with AC voltage rating. Protective relays shall meet IEEE C37.90 requirements for measuring input with AC voltage rating.

3.5.1.4 Measuring input with current rating. Protective relays shall meet IEEE C37.90 requirements for measuring input with current rating.

3.5.2 AC and DC auxiliary relays.

3.5.2.1 DC. DC auxiliary relays shall meet the requirements of IEEE C37.90.

3.5.2.2 AC. AC auxiliary relays shall meet the requirements of IEEE C37.90.

3.5.2.3 Contact and operating ratings. Contact and operating ratings as defined by IEEE C37.90 shall be as specified (see 6.2).

3.5.3 Control power inputs. Control power inputs shall meet the requirements of IEEE C37.90.

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3.5.4 Contact inputs.

3.5.4.1 Externally energized. The minimum pickup and dropout voltage of all input circuits as defined by IEEE C37.90 shall be as specified (see 6.2).

3.5.4.2 Internally energized (wetted). The maximum open circuit voltage and short circuit current of the contact input as defined by IEEE C37.90 shall be as specified (see 6.2).

3.5.5 Short time thermal withstand. The short time thermal withstand as defined by IEEE C37.90 shall be as specified (see 6.2).

3.5.6 Output circuits.

3.5.6.1 Make, carry, and interrupt ratings (load endurance) for tripping output circuits. Tripping output circuits shall meet the requirements of IEEE C37.90. The following ratings/characteristics as applicable shall be as specified (see 6.2):

a. Make, carry, and interrupting ratings as defined by IEEE C37.90.

b. Tripping output contacts intended for tripping duty only.

c. Tripping output contacts intended for continuous duty, for interrupting duty, or both types of duty as defined by IEEE C37.90.

d. Holding current and latching current as defined by IEEE C37.90.

3.5.6.2 Make, carry, and interrupt ratings (load endurance) for output circuits not rated for tripping. Output circuits not rated for tripping shall meet the requirements of IEEE C37.90. The following ratings/characteristics as applicable shall be as specified (see 6.2):

a. Make, carry, and interrupting ratings as defined by IEEE C37.90.

b. Tripping output contacts intended for continuous duty, for interrupting duty, or both types of duty as defined by IEEE C37.90.

c. Holding current and latching current as defined by IEEE C37.90.

3.5.7 Voltage spike. Relays shall be able to withstand voltage spike testing in accordance with MIL-STD-1399-300.

3.6 Mechanical (no load) endurance requirements.

3.6.1 Mechanical (no load) endurance of relay operation. Relays shall meet the IEEE C37.90 requirements for mechanical (no load) endurance of relay operation.

3.6.2 Mechanical (no load) endurance of plug-in relays. Plug-in relays shall meet the requirements of IEEE C37.90.

3.6.3 Mechanical (no load) endurance of relay setting controls. Relays' setting controls shall meet the requirements of IEEE C37.90.

3.7 Functions.

3.7.1 Protection. All protective relays shall be coordinated to achieve selective operation of circuit breakers under operating system configurations. Available protective features shall be designated in accordance with IEEE C37.2. See 3.8 for recommended protective features.

3.7.2 Metering. Metering shall be provided for three phase voltages, currents, power factor, frequency, phase angles, harmonics, power, and energy. Accuracy shall be ±2 percent metering or better for current, voltage, and frequency, and ±5 percent or better for power and energy.

3.7.3 Data logger and event register. All settings shall be stored in nonvolatile memory. Data shall synchronize to a common clock for time stamping purposes. Trip event data shall be stored in nonvolatile memory within the relay.

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3.7.4 Monitoring. Monitors shall be provided for alarm generation, circuit breaker fault trip supervision, and circuit breaker coil supervision.

3.7.5 Communications. Multiple communications ports, including fiber optic and remote control communication capabilities, shall be provided.

3.7.5.1 Fiber optic. Fiber optic communications ports shall be compatible with MIL-PRF-85045 fiber optic cable and shall have dual redundant fiber optic interfaces.

3.7.6 Display. Relays shall have the following:

a. An alphanumeric display.

b. Indicating lights to display if a trip or alarm setpoint has been exceeded.

c. A green indicating light for normal operation status.

d. The interface shall display the last trip signal until reset even after a power cycle.

3.7.7 Self-check/degradation. The self-check function shall check operation of the relay. The protection package shall have the capability of providing a trip signal to specified protective devices if the self-checking capability of the relay detects a problem.

3.8 Recommended protective features/suffixes. At a minimum, families of protective relays should include the following features/suffixes in accordance with IEEE C37.2.

3.8.1 Feature numbers.

24 - Over-excitation protection

25 - Synchronizing

27 - Undervoltage

32 - Directional power

40 - Loss of excitation (field)

46 - Phase balance (current balance, negative sequence current)

47 - Phase-sequence voltage (reverse phase voltage)

50 - Instantaneous overcurrent

51 - Time-overcurrent

59 - Overvoltage

60 - Voltage balance (between two circuits)

67 - Directional overcurrent

81 - Frequency (generally underfrequency)

86 - Lockout

87 - Differential

3.8.2 Suffixes.

A - Alarm only

B - Bus protection

F - Forward

G - Ground-fault protection (relay CT in a system neutral circuit) or generator protection

L - Line protection

N – Ground-fault protection (relay coil connected in residual CT circuit)

P - Phase comparison

Q - Reverse reactive

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R - Reverse real

S - Sending

T - Transformer protection

V - Voltage

3.9 Designation and markings. Identification plates and other designating markings for relays shall be in accordance with MIL-STD-130 and Type A, B, or C of MIL-DTL-15024 and MIL-P-15024/5.

3.9.1 Location. Information shall be marked on identification plate(s) attached to the equipment. Plates shall be installed on and furnished as part of the equipment. Plates shall be attached to the part of the equipment which will not ordinarily be renewed during normal service life and shall be located in a readily accessible position where they can be read at all times without danger to personnel.

3.9.2 Identification marking. Information marked on equipment shall include the following for each type of equipment:

a. Manufacturer's name and catalog or part number.

b. Serial number, date code, or objective evidence number (number may be on the identification plate or on the relay housing).

c. Year of manufacture.

d. Nomenclature.

e. National stock number.

f. Blank space for inspector's stamp.

g. Identification and rating(s) of all installed attachments (may be on separate identification plate(s) attached to the relay).

h. Lead free solder present (if applicable).

i. Shock fragility rating in g's (if applicable).

j. Rated voltage.

k. Rated current.

3.9.3 Item unique identification (IUID). An IUID marking system in accordance with MIL-STD-130 shall be used to allow the Department of Defense to track and manage identically made items.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

c. Comparison inspection (see 4.4).

4.2 Qualification inspection. The following criteria shall be met for qualification inspection:

a. One relay sample shall be subjected to the tests specified in table I in the order shown. Any exceptions or changes to the test order shall be addressed in the qualification package.

b. No adjustments shall be made to the relay during or between qualification tests. One or more failures shall be cause for refusal to grant qualification.

4.2.1 Periodic retention of qualification. At a maximum of five-year intervals after qualification, the manufacturer shall provide sample production protective relays with all attachments and conduct a comparison inspection (see 4.4).

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TABLE I. Qualification inspection test sequence.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Creepage and clearance	3.3.3.2	4.5.2
3	Voltage and current range/operating characteristics	3.5	4.5.3
3A	Allowable variations from rated voltage for auxiliary relays	3.5.2	4.5.3.1
3A(1)	DC relays	3.5.2.1	4.5.3.1.1
3A(2)	AC relays	3.5.2.2	4.5.3.1.2
3A(3)	Operation at minimum voltage	3.5.2.1 3.5.2.2	4.5.3.1.3
3B	Allowable variation from rated voltage and current for protective relays	3.5	4.5.3.2
3B(1)	Measuring input with AC voltage rating	3.5.1.3	4.5.3.2.1
3B(2)	Measuring input with current rating	3.5.1.4	4.5.3.2.2
3C	Control power inputs	3.5.3	4.5.3.3
3C(1)	DC rated control power inputs	3.5.3	4.5.3.3.1
3C(2)	AC rated control power inputs	3.5.3	4.5.3.3.2
3D	Contact inputs	3.5.4	4.5.3.4
3D(1)	Externally energized	3.5.4.1	4.5.3.4.1
3D(2)	Internally energized (wetted)	3.5.4.2	4.5.3.4.2
4	Insulation tests	3.3.3.1	4.5.4
4A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
4B	Impulse voltage tests	3.3.3.1	4.5.4.2
5	Make, carry, and interrupt ratings (load endurance) for output circuits	3.5.6	4.5.5
5A	Tripping output circuits	3.5.6.1	4.5.5.1
5B	Output circuits not rated for tripping	3.5.6.2	4.5.5.2

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TABLE I. Qualification inspection test sequence - Continued.

Test number	Inspection	Requirement	Verification
6	Auxiliary relay contact and operating ratings	3.5.2.3	4.5.6
7	Mechanical (no load) endurance	3.6	4.5.7
7A	Relay operation	3.6.1	4.5.7.1
7B	Plug-in relays	3.6.2	4.5.7.2
7C	Relay setting controls	3.6.3	4.5.7.3
8	Temperature rise, relative humidity, and heating limits for coils	3.4.1	4.5.8
8A	Temperature ranges and relative humidity	3.4.3	4.5.8.1
8B	Temperature rise for coils	3.4.2	4.5.8.2
9	Short time thermal withstand	3.5.5	4.5.9
10	Insulation tests	3.3.3.1	4.5.4
10A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
10B	Impulse voltage tests	3.3.3.1	4.5.4.2
11	Inclined operation	3.4.7	4.5.10
12	Shock	3.4.5	4.5.11
13	Vibration	3.4.6	4.5.12
14	Insulation tests	3.3.3.1	4.5.4
14A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
14B	Impulse voltage tests	3.3.3.1	4.5.4.2
15	EMI	3.4.4	4.5.13
16	Voltage spike	3.5.7	4.5.14
17	Insulation tests	3.3.3.1	4.5.4
17A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
17B	Impulse voltage tests	3.3.3.1	4.5.4.2

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4.3 Conformance inspection. Each production unit shall be subjected to the tests specified in table II in the order shown.

TABLE II. Conformance inspection test sequence.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Insulation tests	3.3.3.1	4.5.4
2A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
3	Voltage and current range/operating characteristics	3.5	4.5.3
3A	Allowable variations from rated voltage for auxiliary relays	3.5.2	4.5.3.1
3A(1)	DC relays	3.5.2.1	4.5.3.1.1
3A(2)	AC relays	3.5.2.2	4.5.3.1.2
3A(3)	Operation at minimum voltage	3.5.2.1 3.5.2.2	4.5.3.1.3
3B	Allowable variation from rated voltage and current for protective relays	3.5	4.5.3.2
3B(1)	Measuring input with AC voltage rating	3.5.1.3	4.5.3.2.1
3B(2)	Measuring input with current rating	3.5.1.4	4.5.3.2.2
3C	Control power inputs	3.5.3	4.5.3.3
3C(1)	DC rated control power inputs	3.5.3	4.5.3.3.1
3C(2)	AC rated control power inputs	3.5.3	4.5.3.3.2
3D	Contact inputs	3.5.4	4.5.3.4
3D(1)	Externally energized	3.5.4.1	4.5.3.4.1
3D(2)	Internally energized (wetted)	3.5.4.2	4.5.3.4.2

4.4 Comparison inspection of protective relays and attachments. At intervals of not more than 5 years during which protective relays of a type have been acquired under this specification, the manufacturer shall provide sample production protective relays with all attachments and conduct comparison inspection test sequences as described in 4.4.1, 4.4.2, and 4.4.3. At an interval of 5 years after comparison test sequence 3 has been completed, the test cycle shall start over with comparison test sequence 1. Any exceptions or changes to the test order shall be addressed in the qualification package. Protective relays of a type which have not been supplied within the 5-year period shall be tested as a part of the subsequent order for production line units. Failure of a sample to meet the requirements of this specification shall be cause for removal from the qualified products list.

4.4.1 Comparison test sequence 1. Tests shall be conducted in the order shown in table III at an interval of 5 years after the initial qualification.

4.4.2 Comparison test sequence 2. Tests shall be conducted in the order shown in table IV at an interval of 5 years after protective relay has been subjected to comparison test sequence 1.

4.4.3 Comparison test sequence 3. Tests shall be conducted in the order shown in table V at an interval of 5 years after protective relay has been subjected to comparison test sequence 2.

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TABLE III. Comparison test sequence 1.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Creepage and clearance	3.3.3.2	4.5.2
3	Voltage and current range/operating characteristics	3.5	4.5.3
3A	Allowable variations from rated voltage for auxiliary relays	3.5.2	4.5.3.1
3A(1)	DC relays	3.5.2.1	4.5.3.1.1
3A(2)	AC relays	3.5.2.2	4.5.3.1.2
3A(3)	Operation at minimum voltage	3.5.2.1 3.5.2.2	4.5.3.1.3
3B	Allowable variation from rated voltage and current for protective relays	3.5	4.5.3.2
3B(1)	Measuring input with AC voltage rating	3.5.1.3	4.5.3.2.1
3B(2)	Measuring input with current rating	3.5.1.4	4.5.3.2.2
3C	Control power inputs	3.5.3	4.5.3.3
3C(1)	DC rated control power inputs	3.5.3	4.5.3.3.1
3C(2)	AC rated control power inputs	3.5.3	4.5.3.3.2
3D	Contact inputs	3.5.4	4.5.3.4
3D(1)	Externally energized	3.5.4.1	4.5.3.4.1
3D(2)	Internally energized (wetted)	3.5.4.2	4.5.3.4.2
4	Insulation tests	3.3.3.1	4.5.4
4A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
4B	Impulse voltage tests	3.3.3.1	4.5.4.2
5	Make, carry, and interrupt ratings (load endurance) for output circuits	3.5.6	4.5.5
5A	Tripping output circuits	3.5.6.1	4.5.5.1
5B	Output circuits not rated for tripping	3.5.6.2	4.5.5.2
6	Auxiliary relay contact and operating ratings	3.5.2.3	4.5.6
7	Mechanical (no load) endurance	3.6	4.5.7
7A	Relay operation	3.6.1	4.5.7.1
7B	Plug-in relays	3.6.2	4.5.7.2
7C	Relay setting controls	3.6.3	4.5.7.3
8	Temperature rise, relative humidity, and heating limits for coils	3.4.1	4.5.8
8A	Temperature ranges and relative humidity	3.4.3	4.5.8.1
8B	Temperature rise for coils	3.4.2	4.5.8.2
9	Short time thermal withstand	3.5.5	4.5.9
10	Insulation tests	3.3.3.1	4.5.4
10A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
10B	Impulse voltage tests	3.3.3.1	4.5.4.2
11	Voltage spike	3.5.7	4.5.14

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TABLE III. Comparison test sequence 1 - Continued.

Test number	Inspection	Requirement	Verification
12	Insulation tests	3.3.3.1	4.5.4
12A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
12B	Impulse voltage tests	3.3.3.1	4.5.4.2

TABLE IV. Comparison test sequence 2.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Creepage and clearance	3.3.3.2	4.5.2
3	Voltage and current range/operating characteristics	3.5	4.5.3
3A	Allowable variations from rated voltage for auxiliary relays	3.5.2	4.5.3.1
3A(1)	DC relays	3.5.2.1	4.5.3.1.1
3A(2)	AC relays	3.5.2.2	4.5.3.1.2
3A(3)	Operation at minimum voltage	3.5.2.1 3.5.2.2	4.5.3.1.3
3B	Allowable variation from rated voltage and current for protective relays	3.5	4.5.3.2
3B(1)	Measuring input with AC voltage rating	3.5.1.3	4.5.3.2.1
3B(2)	Measuring input with current rating	3.5.1.4	4.5.3.2.2
3C	Control power inputs	3.5.3	4.5.3.3
3C(1)	DC rated control power inputs	3.5.3	4.5.3.3.1
3C(2)	AC rated control power inputs	3.5.3	4.5.3.3.2
3D	Contact inputs	3.5.4	4.5.3.4
3D(1)	Externally energized	3.5.4.1	4.5.3.4.1
3D(2)	Internally energized (wetted)	3.5.4.2	4.5.3.4.2
4	Insulation tests	3.3.3.1	4.5.4
4A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
4B	Impulse voltage tests	3.3.3.1	4.5.4.2
5	Make, carry, and interrupt ratings (load endurance) for output circuits	3.5.6	4.5.5
5A	Tripping output circuits	3.5.6.1	4.5.5.1
5B	Output circuits not rated for tripping	3.5.6.2	4.5.5.2
6	Auxiliary relay contact and operating ratings	3.5.2.3	4.5.6
7	Mechanical (no load) endurance	3.6	4.5.7
7A	Relay operation	3.6.1	4.5.7.1
7B	Plug-in relays	3.6.2	4.5.7.2
7C	Relay setting controls	3.6.3	4.5.7.3

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TABLE IV. Comparison test sequence 2 - Continued.

Test number	Inspection	Requirement	Verification
8	Temperature rise, relative humidity, and heating limits for coils	3.4.1	4.5.8
8A	Temperature ranges and relative humidity	3.4.3	4.5.8.1
8B	Temperature rise for coils	3.4.2	4.5.8.2
9	Short time thermal withstand	3.5.5	4.5.9
10	Insulation tests	3.3.3.1	4.5.4
10A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
10B	Impulse voltage tests	3.3.3.1	4.5.4.2
11	Shock	3.4.5	4.5.11
12	Insulation tests	3.3.3.1	4.5.4
12A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
12B	Impulse voltage tests	3.3.3.1	4.5.4.2
13	EMI	3.4.4	4.5.13

TABLE V. Comparison test sequence 3.

Test number	Inspection	Requirement	Verification
1	General examination	-	4.5.1
2	Creepage and clearance	3.3.3.2	4.5.2
3	Voltage and current range/operating characteristics	3.5	4.5.3
3A	Allowable variations from rated voltage for auxiliary relays	3.5.2	4.5.3.1
3A(1)	DC relays	3.5.2.1	4.5.3.1.1
3A(2)	AC relays	3.5.2.2	4.5.3.1.2
3A(3)	Operation at minimum voltage	3.5.2.1 3.5.2.2	4.5.3.1.3
3B	Allowable variation from rated voltage and current for protective relays	3.5	4.5.3.2
3B(1)	Measuring input with AC voltage rating	3.5.1.3	4.5.3.2.1
3B(2)	Measuring input with current rating	3.5.1.4	4.5.3.2.2
3C	Control power inputs	3.5.3	4.5.3.3
3C(1)	DC rated control power inputs	3.5.3	4.5.3.3.1
3C(2)	AC rated control power inputs	3.5.3	4.5.3.3.2
3D	Contact inputs	3.5.4	4.5.3.4
3D(1)	Externally energized	3.5.4.1	4.5.3.4.1
3D(2)	Internally energized (wetted)	3.5.4.2	4.5.3.4.2
4	Insulation tests	3.3.3.1	4.5.4
4A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
4B	Impulse voltage tests	3.3.3.1	4.5.4.2

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TABLE V. Comparison test sequence 3 - Continued.

Test number	Inspection	Requirement	Verification
5	Make, carry, and interrupt ratings (load endurance) for output circuits	3.5.6	4.5.5
5A	Tripping output circuits	3.5.6.1	4.5.5.1
5B	Output circuits not rated for tripping	3.5.6.2	4.5.5.2
6	Auxiliary relay contact and operating ratings	3.5.2.3	4.5.6
7	Mechanical (no load) endurance	3.6	4.5.7
7A	Relay operation	3.6.1	4.5.7.1
7B	Plug-in relays	3.6.2	4.5.7.2
7C	Relay setting controls	3.6.3	4.5.7.3
8	Temperature rise, relative humidity, and heating limits for coils	3.4.1	4.5.8
8A	Temperature ranges and relative humidity	3.4.3	4.5.8.1
8B	Temperature rise for coils	3.4.2	4.5.8.2
9	Short time thermal withstand	3.5.5	4.5.9
10	Insulation tests	3.3.3.1	4.5.4
10A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
10B	Impulse voltage tests	3.3.3.1	4.5.4.2
11	Inclined operation	3.4.7	4.5.10
12	Shock	3.4.5	4.5.11
13	Vibration	3.4.6	4.5.12
14	Insulation tests	3.3.3.1	4.5.4
14A	Dielectric power frequency tests	3.3.3.1	4.5.4.1
14B	Impulse voltage tests	3.3.3.1	4.5.4.2

4.5 Tests. All tests shall be conducted with the protective relay and all applicable attachments installed. Features and attachments with multiple ratings shall be rotated over multiple comparison cycles.

4.5.1 General examination. Protective relays shall be subjected to a thorough examination to determine that the material, workmanship, safety to operating personnel, design, and construction are in conformance with this specification and applicable drawings and catalog data. Examination shall include, but need not be limited to, the following:

a. The 100-hour burn-in test shall be conducted by energizing the equipment for 100 hours at nominal voltage and frequency, ambient temperature, and with all inputs and outputs connected to effect maximum rated loading.

b. Electrical connections and wiring in conformance with applicable documents. An operational check of all protective relay and all attachment operation with a ring out.

c. Outline and mounting dimensions in conformance with applicable documents.

d. Designation and marking including safety warnings are as specified.

e. Weights and centers of gravity are in conformance with applicable documents.

f. Check of workmanship, fastener integrity, damage to platings or components.

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g. Protective relay shall incorporate built-in-test (BIT). The relay's BIT shall detect fatal faults and shall execute automatically on power-up condition or when initiated by an operator. The maximum time for this to be completed is 1 minute.

4.5.2 Creepage and clearance. Creepage and clearance distances to MIL-E-917 requirements for conductors shall be demonstrated by actual measurement.

4.5.3 Voltage and current range/operating characteristics.

4.5.3.1 Allowable variations from rated voltage for voltage operated auxiliary relays.

4.5.3.1.1 DC auxiliary relays. DC auxiliary relays shall be tested in accordance with IEEE C37.90.

4.5.3.1.2 AC auxiliary relays. AC auxiliary relays shall be tested in accordance with IEEE C37.90.

4.5.3.1.3 Test for operation at minimum voltage. DC and AC auxiliary relays shall be tested in accordance with IEEE C37.90.

4.5.3.2 Allowable variation from rated voltage and current for protective relays.

4.5.3.2.1 Measuring input with AC voltage rating. Relays shall be tested for measuring input with AC voltage rating in accordance with IEEE C37.90.

4.5.3.2.2 Measuring input with current rating. Relays shall be tested for measuring input with current rating in accordance with IEEE C37.90.

4.5.3.3 Protective relay control power inputs.

4.5.3.3.1 DC rated control power inputs. DC control power inputs shall be tested in accordance with IEEE C37.90.

4.5.3.3.2 AC rated control power inputs. AC control power inputs shall be tested in accordance with IEEE C37.90.

4.5.3.4 Contact inputs.

4.5.3.4.1 Externally energized. The minimum pickup and dropout voltage for externally energized contact inputs shall be verified by testing in accordance with IEEE C37.90.

4.5.3.4.2 Internally energized (wetted). The maximum open circuit voltage and short circuit current for internally energized (wetted) contact inputs shall be verified by testing in accordance with IEEE C37.90.

4.5.4 Insulation tests. Insulation tests shall be conducted at various times throughout qualification inspection as shown in table I.

4.5.4.1 Dielectric power frequency tests. Relays shall be subjected to dielectric power frequency tests in accordance with IEEE C37.90.

4.5.4.2 Impulse voltage tests. Relays shall be subjected to impulse voltage tests in accordance with IEEE C37.90.

4.5.5 Make, carry, and interrupt ratings (load endurance).

4.5.5.1 Tripping output circuits. Tripping output circuits shall be tested in accordance with IEEE C37.90.

4.5.5.2 Output circuits not rated for tripping. Make, carry, and interrupt ratings for output circuits not rated for tripping shall be verified by testing in accordance with IEEE C37.90.

4.5.6 Auxiliary relay contact and operating ratings. Auxiliary relays shall be tested in accordance with IEEE C37.90 to verify contact and operating ratings.

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4.5.7 Mechanical (no load) endurance.

4.5.7.1 Relay operation. Relays shall be subjected to mechanical (no load) endurance testing in accordance with IEEE C37.90.

4.5.7.2 Plug-in relays. Plug-in relays shall be tested in accordance with IEEE C37.90.

4.5.7.3 Relay setting controls. Relays' setting controls shall be tested in accordance with IEEE C37.90.

4.5.8 Temperature rise, relative humidity, and heating limits for coils.

4.5.8.1 Temperature ranges and relative humidity. Temperature ranges and relative humidity shall be tested in accordance with IEEE C37.90. The test shall be conducted by energizing the equipment with all inputs and outputs connected to effect maximum thermal loading.

4.5.8.2 Temperature rise for coils. Temperature rise for coils shall be tested in accordance with IEEE C37.90.

4.5.9 Short time thermal withstand. Relays shall be subjected to short time thermal withstand testing in accordance with IEEE C37.90.

4.5.10 Inclined operation. With the protective relay inclined, forward, backward and to each side at an angle of 30 degrees from the vertical position, the protective relay and attachments shall complete an operational check at each incline.

4.5.11 Shock.

4.5.11.1 Type I relays. Type I protective relays shall withstand Grade A, Class I, Type C shock requirements of MIL-S-901.

4.5.11.2 Type II relays. Type II protective relays shall be shock fragility tested in accordance with MIL-STD-202, Method 213B, half-sine, 11 ms, 3 axis. The protective relay with applicable accessories shall be tested in both "on" and "off" contact states. The fragility rating in g's shall be determined using the pass/fail criteria of 4.5.11.5.

4.5.11.3 Energization. Equipment shall be energized at nominal voltages.

4.5.11.4 Monitoring. All circuits where momentary contact opening or closing could take place shall be monitored. Contacts shall be monitored by oscillograph or suitable digital data acquisition system. All equipment shall have a minimum frequency response and sampling rate of 2 KHz. Digital signal processing of acquired data shall be capable of producing suitable waveform plots with 0.5 millisecond minimum resolution, and for analysis purposes shall be able to expand contact events with graphical editing to determine time increments of the individual sample points.

4.5.11.5 Pass/fail criteria.

a. No changes of state. Circuits that are closed shall remain closed. Circuits that are open shall remain open.

b. Momentary opening of contacts of less than a 0.010-second duration will be acceptable. Multiple contact bounces are acceptable providing that the total elapsed time from the beginning of the first bounce to the end of the last bounce does not exceed 0.015 seconds.

c. Settings shall not change position.

d. An operational check of all functions shall be completed at the conclusion of the test.

e. No components or pieces of components shall become adrift.

4.5.12 Vibration. The protective relay will be subjected to Type I tests of MIL-STD-167-1.

4.5.12.1 Energization. Equipment shall be energized at nominal voltages. All circuits where momentary opening or closing could take place shall be monitored.

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4.5.12.2 Monitoring. All circuits where momentary contact opening or closing could take place shall be monitored. Contacts shall be monitored by oscillograph or suitable digital data acquisition system. All equipment shall have a minimum frequency response and sampling rate of 2 KHz. Digital signal processing of acquired data shall be capable of producing suitable waveform plots with 0.5 millisecond minimum resolution, and for analysis purposes shall be able to expand contact events with graphical editing to determine time increments of the individual sample points.

4.5.12.3 Pass/fail criteria.

a. No changes of state. Circuits that are closed shall remain closed. Circuits that are open shall remain open.

b. Momentary opening of contacts shall not be acceptable.

c. Settings shall not change position.

d. An operational check of all functions shall be completed at the conclusion of the test.

e. No components or pieces of components shall become adrift.

4.5.13 EMI. Protective relays with electronic devices shall be tested in accordance with MIL-STD-461 for surface ship, below deck, metallic hull installations. Testing shall not cause false trip signals, failure of trip feature, or failure of attachments.

4.5.14 Voltage spike. Protective relays with electronic devices shall be tested in accordance with MIL-STD-1399-300. Testing shall not cause false trip signals, failure of trip feature, or failure of attachments.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Protective relays covered by this specification are used to control vacuum circuit breakers.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.

b. Type of protective relay required (see 1.2).

c. Standard voltage rating (see 3.5.1.1).

d. Maximum design voltage and current ratings as defined by IEEE C37.90 (see 3.5.1.2).

e. AC and DC auxiliary relay contact and operation ratings as defined by IEEE C37.90 (see 3.5.2.3).

f. Minimum pickup and dropout voltage of all input circuits (externally energized) as defined by IEEE C37.90 (see 3.5.4.1).

g. The maximum open circuit voltage and short circuit current of the contact input (internally energized) as defined by IEEE C37.90 (see 3.5.4.2).

h. The short time thermal withstand as defined by IEEE C37.90 (see 3.5.5).

i. Tripping output circuits – make, carry, and interrupting ratings as defined by IEEE C37.90 (see 3.5.6.1.a).

j. Tripping output circuits – tripping output contacts intended for tripping duty only (see 3.5.6.1.b).

k. Tripping output circuits – Tripping output contacts intended for continuous duty, for interrupting duty, or both types of duty as defined by IEEE C37.90 (see 3.5.6.1.c).

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l. Tripping output circuits – holding current and latching current as defined by IEEE C37.90 (see 3.5.6.1.d).

m. Output circuits not rated for tripping – make, carry, and interrupting ratings as defined by IEEE C37.90 (see 3.5.6.2.a).

n. Output circuits not rated for tripping – tripping output contacts intended for continuous duty, for interrupting duty, or both types of duty as defined by IEEE C37.90 (see 3.5.6.2.b).

o. Output circuits not rated for tripping – holding current and latching current as defined by IEEE C37.90 (see 3.5.6.2.c).

p. Packaging requirements (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 32484 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.dla.mil.

6.4 Subject term (key word) listing.

Directional power

Instantaneous overcurrent

Make rating

Overvoltage

Phase balance

Phase-sequence voltage

Time-overcurrent

Voltage balance (between two circuits)

Wetted

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Custodians:
Army – AV
Navy – SH
Air Force – 85

Review activities:
Army – CR, MI
Navy – AS, CG
Air Force – 03, 19, 99
DLA – CC

Civil agencies:
GSA – FAS
MISC – MDA
NASA – NA

Preparing activity:
Navy – SH
(Project 5925-2012-008)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.