Technical Publication

ESC-Std-1000

Rev. 6 Effective 1/1/97

GENERAL SPECIFICATIONS
for
ROTARY SWITCHES
and
AUXILIARY RELAYS
for
UTILITY APPLICATIONS
including
CLASS IE EQUIPMENT REQUIREMENTS FOR NUCLEAR POWER GENERATING STATIONS

ELECTROSWITCH
• SWITCHES & RELAYS
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SPECIFICATION SUMMARY

Dielectric Withstanding Voltage - 2200VRMS, 60Hz for one minute with a maximum of 100 microamps leakage.

Insulation Resistance - 100 megohms minimum at 500VDC for one minute (50 megohms minimum after endurance and aging).

Contact Resistance - 10 milliohms maximum at rated current.

Radiation Aging - 10 megarads (10^7) minimum using a cobalt 60 (Co^{60}) gamma radiation source at the dose rate of 500-600 kilorads per hour.

Elevated Temperature - 120 hours at 80°C.

Elevated Humidity - 96 hours at 90 - 95% RH.

Temperature Rise - 50°C maximum at rated current.

Aging - 10,000 cycles at full load.

Seismic Vibration -ZPA of 5g's.

Quality Assurance - ANSI/ASME NQA-1-1986

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AMENDMENTS

REV. 1 (2/15/78)

Sheet 3 changed 3.10.1 to 10,000 rads from 1,000 rads
Sheet 8 corrected 4.6.4 to refer to paragraph 3.8 rather than 3.9
Sheet 8 corrected 4.6.5 line 12 to "shall be" rather than "are" and removed "indirectly"
Sheet 8 changed 4.6.6 (c) to 10,000 rads from 1,000 rads
Sheet 8 corrected paragraph 4.6.7 by removing the sentence "...The test shall be made...." REASON: air circulation is needed for safety purposes, to insure uniform temperature, and for more accurate control and instrumentation
Sheet 8 clarified paragraph 4.6.7 (b) changing "load" to "one of the tested loads"

REV. 2 (6/1/81)

Sheet 1 updated specifications, removed UL508, added IEEE Std 798-19XX

Sheet 2 added 31 to CSR, added 24 to LSR, removed series 10

Sheet 3 added "...50 megohms..." to par. 3.8

Sheet 4 changed 3.10.1 to 10 megarads, changed 3.13.1 (was 3.11.1), 3.11 (was 3.12), 3.12 (was 3.13)

Sheet 5 added ANSI/ASME NQA-1-1979 to 4.1.1, changed par. 4.4, e.g., 3 samples of sample 1

Sheet 6 rearranged paragraphs 3.13 (was 3.11), 3.11 (was 3.12), 3.12 (was 3.13), etc.

Sheet 8 updated P313 to ANSI/IEEE C37.90-1978, added "...after all aging..." to par. 4.6.3 (a)

Sheet 9 paragraph 4.6.9 (was 4.6.7), 4.6.7 (was 4.6.8); changed 4.6.9, added 4.6.9 (e), 4.6.8 (was 4.6.7), changed 4.6.6 (c) to 10 megarads added 4.6.9, changed P313 to ANSI/IEEE C37.98-1978 added 4.6.10 (d), changed P501 to ANSI/IEEE C37.98-1978 (2 places)

REV. 3 (9/3/84) - basic update to conform to ANSI/IEEE 323-1983

REV. 4 (8/1/85) - revision of ANSI/IEEE 323-1983 to ANSI/IEEE 323-1984

REV. 5 (6/15/91) - update to latest revisions to various specifications

REV. 6 (1/1/97) - update to latest revisions to various specifications

							5	5	5	3	3	5	5	5	5	5	REV	SHEET INDEX
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STANDARD ESC-STD-1000	REV	3	SHEET	111

GENERAL SPECIFICATIONS
FOR ROTARY SWITCHES AND AUXILIARY RELAYS
FOR UTILITY APPLICATIONS
INCLUDING CLASS 1E EQUIPMENT REQUIREMENTS
FOR NUCLEAR POWER GENERATING STATIONS

ELECTROSWITCH
Weymouth, Massachusetts

This standard is approved for use by Electro Switch Corp. and is available for users and specifiers of the products outlined.

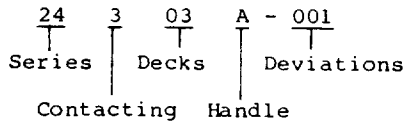
1. SCOPE

1.1 Scope. This standard covers the general requirements for closed construction rotary multipole switches and auxiliary relays capable of making, breaking, and carrying electrical loads up to, and including 30 amperes, and which are for use in a variety of power industry applications, including Nuclear Power Generating Stations under mild environment conditions as defined by IEEE-Std-323-1984. The products are also used in harsh environments where the product is suitably protected by the user from the harsh conditions other than radiation.

1.2 Classification.

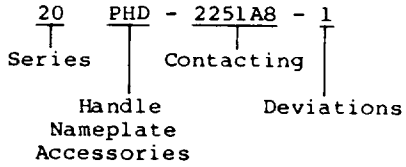
1.2.1 Series designation. Unless otherwise specified, the series designation shall be generally in the following form and further outlined in Technical Publications.

1.2.1.1 Double-wiping knife type contact switches shall have the following form:



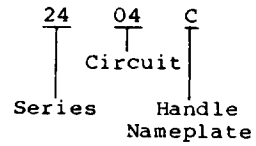
The A may be replaced with LA, LB, etc. for some specials. The -001 shall be eliminated on standards or those numbers with LA, LB, etc. suffix.

1.2.1.2 Cam-actuated butt-contact type rotary switches shall have the following form:

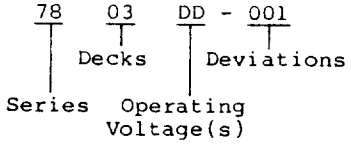


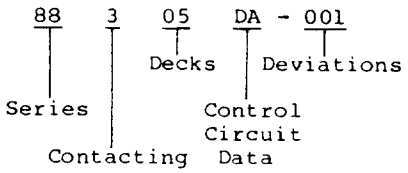
The -1 may be replaced with LA, LB, etc. for some specials.

1.2.1.3 Instrument and control switches of both types (see 1.2.1.1, and 1.2.1.2) may also have the following form:

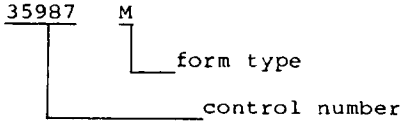


1.2.1.4 Auxiliary relays shall have the following forms:





1.2.1.5 Modules shall have the following form:



2. APPLICABLE DOCUMENTS

2.1 The following documents become a part of this standard to the extent specified herein.

2.1.1 Materials

FED-STD-H28 - Screw Thread Standard
ASTM-B700/QQ-S-365C - Silver Plating, Electrodeposited
ASTM-B633/QQ-Z-325B - Zinc Coating, Electrodeposited
ASTM-B689/QQ-N-290A - Nickel Plating, Electrodeposited
ASTM-B449/MIL-C-5541C - Chemical conversion coating
MIL-A-8625C - Anodic Coatings
MIL-P-15035 - Plastic Sheet, Laminated

2.1.2 Products

ANSI/IEEE 323-1984 Qualifying Class 1E Equipment for Nuclear Power Generating Stations

IEEE Std 344-1987-IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

ANSI/IEEE C37.105-19XX Standard for Qualifying Class 1E Protective Relays and Auxiliaries for Nuclear Power Generating Stations

ANSI/IEEE C37.98-1987 IEEE Standard Seismic Testing of Relays

ANSI/IEEE C37.90-1989 Relays and Relay Systems Associated with Electric Power Apparatus

2.1.3 Quality

ANSI/ASME NQA-1-1986 Quality Assurance Program Requirements for Nuclear Power Plants

2.1.4 Standards

2.1.4.1 Procedure E6-Product Control and Review

2.1.4.2 Technical Publications on following:

TECHNICAL PUBLICATION	PRODUCT
MIN-1	Series 20 Instrument & Control switches
24-1	Series 24 Instrument & Control switches
MOD-1	Series 20 Modular Plug-in switches
LOR-1	Series 24 Lock-out Relays
CSR-1	Control Switch Relays
LSR-1	Latching Switch Relays
SSR-1	Selector Switch Relays

3. REQUIREMENTS

3.1 Detail requirements. The individual part requirements shall be as specified herein and in accordance with the applicable Technical Publications. These requirements shall be in accordance with Procedure E-6 Product Control and Review. In the event of any conflict between this standard and the Technical Publications, the latter shall govern.

3.2 Product types. Products furnished under this standard shall be as defined in 3.2.1 and 3.2.2.

3.2.1 Products covered by Technical Publications. Products which are completely defined by a Technical Publication shall be ordered in accordance with 6.2.1.

3.2.2 Products not covered by Technical Publications. Where there is no Technical Publication, the detail requirements shall be as specified in complementary documents such as Electro Switch or customer drawings and data sheets (see 6.2.2). These products shall be of the same basic design and construction as the products shown on the Technical Publication and which have been tested and have passed the inspections specified in 4.6.

3.3 Qualification. Products furnished under this standard shall be products that have been successfully tested to this standard (see 4.5 and 6.2).

3.4 Material. Material shall be as specified herein. When a definite material is not specified, a material shall be used which will enable the products to meet the performance requirements of this standard (see 6.2.2). The use of any materials detailed herein shall not be construed as a guarantee of the acceptance of the finished product (see 3.3).

3.4.1 Metals. Metals shall be of sea water corrosion-resistant alloys or shall be zinc plated in accordance with class 2, type II of ASTM-B633/QQ-Z-325B; nickel plated in accordance with class 1, grade G of ASTM-B689/QQ-N-290; or anodized in accordance with MIL-A-8625 or treated in accordance with MIL-C-5541 (aluminum alloys only).

3.4.1.1. Contact surface. Unless otherwise specified (see 3.1 and 6.2.2), electrical contact surfaces shall be silver or silver alloy with a minimum thickness of 0.002 inches. Terminal surfaces shall be of the same material as the contact surfaces or shall be silver plated to a minimum thickness of 0.0001 inches in accordance with ASTM-8700/QQ-S-365.

3.4.1.2 Ferrous material. Ferrous material shall not be used for current carrying parts.

3.4.1.3 Lubrication. Lubrication when used shall be Texaco Unitemp or Lowtemp unless otherwise specified (see 3.1 and 6.2.2).

3.4.2 Nonmetallic parts.

3.4.2.1 Plastic laminates. Unless otherwise specified (see 3.1 and 6.2.2), plastic laminates shall be in accordance with MIL-P-15035.

3.4.2.2 Thermoplastic molding. Unless otherwise specified (see 3.1 and 6.2.2), thermoplastic molding materials shall be Underwriters' Laboratories, Inc. (UL) Recognized Component plastic materials, electrical grade, with temperature index of 105°C minimum and flammability class 94V-2 per UL94 as a minimum.

3.4.2.3 Thermosetting molding. Unless otherwise specified (see 3.1 and 6.2.2), thermosetting plastic molding materials shall be commercial grade cellulose-filled phenolics or mineral-filled melamine.

3.4.2.4 Flammable material. Insulation material shall be flammability class 94V-2 per UL94 as a minimum.

3.4.2.5 Toxic and hazardous material. Unless otherwise specified (see 3.1 and 6.2.2), toxic and hazardous materials shall not be used.

3.4.2.6 Teflon material. Teflon and other fluoroplastic materials shall not be used with the exception of 5% Teflon added as a lubricant to Series 20 Cam followers.

3.5 Design and construction. Products shall be constructed to ensure proper operation when mounted in any position. The products shall be of the design, construction, and physical dimensions specified (see 3.1) and the circuit configuration shall conform to the specification sheet (see 3.1 and 6.2.2). The applicable drawings (see 2.1) shall be as specified (see 3.1).

3.5.1 Threaded parts. Unless otherwise specified (see 3.1 and 6.2.2), threaded parts shall be in accordance with FED-STD-H28. Wherever possible, unified screw threads shall be used.

3.5.1.1 Engagement of threaded parts. Threaded parts shall engage at least three full threads in soft metals like aluminum and its alloys, or a minimum of two full threads in harder materials such as brass or steel. When a screw mates with a plastic part, a metal insert shall be used.

3.5.2 Operating shaft. The operating shaft shall be insulated from current carrying parts.

3.5.3 Indexing. Products shall have a positive detent or indexing mechanism, locating each contact position, except where spring-return action is specified (see 3.1). The positive detent or indexing mechanism shall be designed to minimize the possibility of hanging-up between positions. Products with spring-return mechanisms shall return to the specified fixed position when the operating force is removed.

3.6 Contact and circuit configuration. When the products are tested as specified (see 4.6.2), the circuit configuration shall be as required (see 3.1).

3.6.1 Switch contacts. Operation of the product shall make and break the specified circuits in all positions of all decks. The making and breaking of circuits, in both momentary and detented positions, shall be positive. In switching break-before-make (BBM) contacts, the first contact of all decks shall fully break before any contact of any deck makes in the next position. In switching make-before-break (MBB) contacts, all contacts in the second position shall make before any contacts in the first position breaks.

3.6.2 Auxiliary relay circuits. The circuit parameters and operation of the auxiliary relays shall be as specified (see 3.1) when tested under service conditions defined by ANSI/IEEE C37.90-1989. They shall operate successfully at -20°C to +55°C over the standard operating voltage range.

3.6.3 Lighted units. The lamp circuits shall operate successfully when tested as specified (see 4.6.2).

3.7 Dielectric withstanding voltage. When tested as specified (see 4.6.3), products shall withstand the specified voltages (see 3.1) without arcing, breakdown of insulation, or damage, and there shall be no leakage current greater than 100 microamperes.

3.7.1 Purpose. The dielectric withstanding voltage test (also called high-potential, over potential, voltage-breakdown, or dielectric-strength test) consists of the application of a voltage higher than rated voltage for a specific time between mutually insulated positions of a component part or between insulated positions and ground. This is used to prove that the component part can operate safely at its rated voltage and withstand momentary over potentials due to switching surges, and other similar phenomena. Although this test is often called a voltage-breakdown or dielectric-strength test, it is not intended that this test cause insulation breakdown or that it be used for detecting corona, rather it serves to determine whether insulating materials and spacings in the component parts are adequate. When a component part is faulty in these respects, application of the test voltage will result in either disruptive discharge or deterioration. Disruptive discharge is evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge). Deterioration due to excessive leakage currents may change electrical parameters or physical characteristics.

3.8 Insulation resistance. When products are tested as specified (see 4.6.4), the insulation resistance shall be greater than 100 megohms at end of life testing, unless otherwise specified (see 3.1 and 6.2.2).

3.8.1 Purpose. This test is to measure the resistance offered by the insulating members of a component part to an impressed direct voltage tending to produce a leakage of current through or on the surface of these members. A knowledge of insulation resistances is important, even when the values are comparatively high, as these values may be limiting factors in the design of high impedance circuits. Low insulation resistances, by permitting the flow of large leakage currents, can disrupt the operation of circuits intended to be isolated, for example, by forming feedback loops. Excessive leakage currents can eventually lead to deterioration of the insulation by heating or by direct current electrolysis. Insulation resistance measurements should not be considered the equivalent of dielectric withstanding voltage or electric breakdown tests. A clean, dry insulation may have a high insulation resistance, and yet possess a mechanical fault that would cause failure in the dielectric withstanding voltage test. Conversely, a dirty deteriorated insulation with a low insulation resistance might not breakdown under a high-potential. Since insulating members composed of different materials or combinations of materials may have inherently different insulation

resistances, the numerical values of measured insulation resistance cannot properly be taken as a direct measure of the degree of cleanliness or absence of deterioration. The test is especially helpful in determining the extent to which insulating properties are affected by deteriorative influences, such as heat, moisture, radiation, dirt, oxidation, or loss of volatile materials.

3.9 Contact resistance. Unless otherwise specified (see 3.1 and 6.2.2), when products are tested as specified (see 4.6.5), the contact resistance shall not exceed 10 milliohms.

3.9.1 Purpose. The purpose of the contact resistance test is to determine the resistance offered to a flow of current during its passage between the electrical contacts of current carrying components, such as switches and relays. For practical reasons, lead and terminal resistances may be included in the actual measurement, as well as the contact resistance proper. In many applications it is required that the contact resistance be low and stable, so that the voltage drop across the contacts does not affect the accuracy of the general circuit conditions. If large currents are passed through high-resistance contacts, excessive energy losses and dangerous overheating of the contacts may occur.

3.10 Radiation. The product shall operate satisfactorily, and there shall be no detrimental changing of color or physical characteristics after radiation cycling as specified (see 4.6.6).

3.10.1 Purpose. Although components like switches and relays will normally be used in mild environments and not subjected to severe radiation conditions, the accumulative effects of the expected 10 kilorads (10^4) radiation exposure, expected to occur during normal service over the planned forty years of a nuclear power plant, may cause material or component degradation to a degree that may adversely affect performances of class 1E functions. To facilitate the use of a reasonable test time, an accelerated exposure rate of 500-600 kilorads per hour is used. To allow margin, and to allow the use of these products in a harsh environment where the product is protected by the user, except for radiation, a dose of 10 megarads (10^7) was chosen.

3.11 Elevated humidity. The products shall operate satisfactorily after elevated humidity testing as specified (see 4.6.7).

3.11.1 Purpose. Although components like switches and relays will generally be used in mild environments where the humidity is controlled, a short period of immersion in a high humidity environment is an attempt at simulating a failure of the environment control equipment that causes an unusually high humidity condition. The test humidity value and time were chosen to provide a margin over expected conditions.

3.12 Temperature rise. When the product is tested as specified (see 4.6.8), the temperature rise shall be no greater than 50°C when measured in an ambient no greater than 55°C.

3.12.1 Purpose. Materials used in intimate or close proximity to components like switches and relays may have temperature limitations or are chosen to operate within certain temperatures. Such materials include hook-up wire and thermoplastic insulation. In addition, the use of many contacts or many products within a single enclosure could cause a detrimental heat problem or require forced ventilation if the temperature of the individual contacts was not controlled.

3.13 Elevated temperature. The products shall operate satisfactorily after a period of elevated temperature as specified (see 4.6.9).

3.13.1 Purpose. Although components like switches and relays will generally be used in mild environments where the service conditions are within the limits of -20°C to 55°C (reference ANSI/IEEE C37.90-1989), a short period of accelerated elevated temperature is an attempt at simulating the accumulating effects of forty years service life. It produces some deterioration and when followed by seismic vibration may produce realistic failure modes.

3.14 Aging. When the product is tested as specified (see 4.6.10), it shall be electrically and mechanically operable before, during, and after the test. Each mating contact shall make and break at the proper time throughout the test. After the test, there shall be no evidence of broken, loose, deformed, or displaced parts.

3.14.1 Purpose. Electromechanical aging of components such as switches and relays is generally the most indicative test of the ability of these devices to perform their intended function over the expected service life of forty years. This electromechanical aging simulates the expected mechanical wear and electrical contact degradation (like contact pitting) of the device that is tested. The number of operations were chosen to provide a margin over expected use.

3.15 Seismic vibration. When the aged product is tested as specified (see 4.6.11), it shall be electrically and mechanically operable. After the test, there shall be no evidence of broken, loose, deformed, or displaced parts.

3.15.1 Purpose. The seismic vibration tests are intended to verify that the product can meet its performance requirements during and following one SSE (safe shutdown earthquake) preceded by a number of OBE's (operating base earthquakes) as required by IEEE Std 344-1987 and ANSI/IEEE C37-98-1987. The product is aged to simulate forty years service life prior to seismic vibration

testing. The ZPA of 5g's was chosen to envelop known seismic conditions.

3.16 Identification of product. Unless otherwise specified (see 3.1 and 6.2.2), the product shall have a paper label approved by UL and/or an aluminum foil label that includes the following information:

company name and address
electrical ratings
applicable approvals (UL, CSA. etc.)
product designation
catalog number
date of manufacture code (year and week)

3.17 Workmanship. Products shall be processed in such a manner as to be uniform in quality and shall be free from cracked or displaced parts and other defects that will affect life, serviceability, or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in a contract or purchase order, Electroswitch is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in a contract or purchase order, Electroswitch may use its own or any other facilities suitable for the performance of the inspection requirements specified herein.

4.1.1 Inspection system. Electroswitch shall provide and maintain an inspection system as outlined in the QUALITY CONTROL MANUAL in accordance with the following specifications:

ANSI/ASME NQA-1-1986
NRC Regulation 10CFR50 Appendix B
MIL-Q-9858A

4.2 Classification of inspections. The inspections specified herein are classified as follows:

(a) Materials inspection (see 4.3)
(b) Qualification inspection (see 4.4)
(c) Quality conformance inspection (see 4.5)

4.3 Materials inspection. Materials inspection shall be in accordance with the QUALITY CONTROL MANUAL as specified on the detail parts and assembly drawings.

4.4 Qualification inspection. A minimum of four sample products of each type shall be subjected to the examination and tests specified in TABLE I on page 6 in the order shown. Samples are intended to show comparative results using fewer aging parameters. The samples shall be of the maximum number of decks available. They shall be fabricated from production parts from production tools and shall have no special preparation.

4.5 Quality conformance inspection. Inspection of product for delivery shall consist of Class I, II, and III inspections.

4.5.1 Class I inspection. Class I inspection shall be conducted in accordance with the QUALITY CONTROL MANUAL. Unless otherwise specified by a customer, Class I inspection shall be conducted on 100% of the product. Any defect shall be corrected. No defective products or products with deviations from the specifications shall be delivered without customer knowledge and acceptance. The examinations and tests are shown below in TABLE II. Typical defects are outlined in TABLE III on page 7.

TABLE II - CLASS I INSPECTION

Examination or Test	Requirement Paragraph	Examination and Test Paragraph
Visual and Mechanical Examination	3.1, 3.2, 3.4 3.5, 3.16, 3.17	4.6.1
Contact and Circuit Configuration	3.6	4.6.2

4.5.2 Class II inspection. One sample product produced during each twelve month period following qualification shall be subjected to the examination and tests specified in TABLE IV below in the order listed. No Class II testing shall be required during the year Class III testing is performed. No Class II testing shall be required if the volume of production is less than 5,000 units per year. In the event that fewer than 5,000 units are produced in a given year the quantity of units shall be accumulated and Class II testing shall be performed when the accumulated quantity equals 5,000 units.

TABLE IV - CLASS II INSPECTION

Examination or Test	Requirement Paragraph	Examination and Test Paragraph
Visual and Mechanical Examination	3.1, 3.2, 3.4 3.5, 3.16, 3.17	4.6.1
Contact and Circuit Configuration	3.6	4.6.2
Aging	3.14	4.6.10
Temperature Rise	3.13	4.6.9
Contact Resistance	3.9	4.6.5
Dielectric Withstanding Voltage	3.7	4.6.3
Insulation Resistance	3.8	4.6.4
Contact and Circuit Configuration	3.6	4.6.2
Visual and Mechanical Examination	3.1, 3.2, 3.4 3.5, 3.16, 3.17	4.6.1

TABLE I - QUALIFICATION INSPECTION

INSPECTION	Requirement Paragraph	Examination and Test Paragraph	Sample Number 1	2	3	4
Visual and Mechanical Examination	3.1, 3.2, 3.4 3.5, 3.16, 3.17	4.6.1	1	1	1	1
Contact and Circuit Configuration	3.6	4.6.2	2	2	2	2
Dielectric Withstanding Voltage	3.7	4.6.3	3	3	3	3
Insulation Resistance	3.8	4.6.4	4	4	4	4
Contact Resistance	3.9	4.6.5	5	5	5	5
Radiation Aging	3.10	4.6.6	6	6	6	
Elevated Humidity	3.11	4.6.7	7	7	7	
Temperature Rise	3.12	4.6.8	8	8	8	6
Elevated Temperature	3.13	4.6.9	9	9		
Aging	3.14	4.6.10	10	10	9	7
Seismic Vibration	3.15	4.6.11	11	11	10	
Dielectric Withstanding Voltage	3.7	4.6.3	12	12	11	8
Insulation Resistance	3.8	4.6.4	13	13	12	9
Contact Resistance	3.9	4.6.5	14	14	13	10
Temperature Rise	3.13	4.6.8	15	15	14	11
Contact and Circuit Configuration	3.6	4.6.2	16	16	15	12
Visual and Mechanical Examination	3.1, 3.2, 3.4 3.5, 3.16, 3.17	4.6.1	17	17	16	13

TABLE III - Classification of defects

Items	Defects	Requirement Paragraph	Categories		
			Critical	Major	Minor
1	Operating shaft not insulated from line circuits	3.5.2	✓		
2	Type not as specified	1.1.1		✓	
3	Failure to comply with performance requirements	3.		✓	
4	Silver materials not as specified	3.4.1.1		✓	
5	Product/mounting arrangement incorrect	3.1		✓	
6	Unit damaged or incomplete	3.1		✓	
7	Product marking not as specified, missing, incorrect, illegible, not permanent, or not located as specified	3.16		✓	
8	Evidence of machining, drilling, tapping, etc. after plating or finishing	3.4.1		✓	
9	Materials less than minimum requirements; evidence of unauthorized materials used; evidence of cracks, splits, seams or pitting	3.1		✓	
10	Threads nonconforming, form not as specified, not to size, missing, chipped, crossed, stripped or damaged	3.5.1		✓	
11	Terminal screws and lockwashers missing, damaged, nonconforming, or of incorrect material or platings	3.1		✓	
12	Sharp corners not rounded as required	3.1		✓	
13	Plating nonconforming, missing, or incomplete; not smooth or uniform, evidence of peeling, nonadherent or uncoated areas; evidence of oxide scale or rust	3.4.1		✓	
14	Unit operation, number of poles or contacts, positions, voltage and other ratings not specified	3.1		✓	
15	Handle, shaft, blade action, rotation and direction not as required; stops incorrect, not positive or not easily adjustable	3.1		✓	
16	Unit not positive acting; spring assembly or detent assembly not as specified, damaged, or fails to operate as required; evidence of misalignment of shaft, evidence of sticking, binding, or excessive loosseness	3.1		✓	
17	Drive mechanisms, working parts of switching mechanisms, and contact areas of blades and terminals not lubricated as specified	3.5		✓	
18	Mounting characteristics not as specified	3.5		✓	
19	Handle and nameplates missing, damaged, non-conforming, incorrectly marked, not furnished properly	3.1		✓	
20	Parts missing, damaged, nonconforming, improperly fitted, and assembled	3.1		✓	
21	Hardened parts not hardened correctly	3.1		✓	
22	Solenoid and relay devices not as specified, damaged, not positive in action, or poor quality and workmanship	3.5		✓	
23	Packaging and packing not as specified	5.1			✓

4.5.3 Class III qualification verification inspection. Three sample products shall be subjected to the examination and tests of sample 1 to 3 as shown on TABLE I. This inspection shall only be performed upon the following happening(s):

(a) Design change that affects any of the test parameters
(b) Specification changes that affect any of the test parameters
(c) Failure of Class II inspection indicating tool wear, manufacturing process change, or other change that affects the test parameters
(d) Request of a customer

4.5.4 Noncompliance. If a sample fails to pass Class II or Class III inspection, corrective action shall be taken on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance and delivery of the product shall be discontinued until acceptable corrective action has been taken.

4.6 Examination and tests.

4.6.1 Visual and mechanical examination. The products shall be examined to verify that the design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.2, 3.4, 3.5, 3.16, and 3.17).

4.6.2 Circuit configuration (see 3.6). The product shall be tested to determine conformance to the actual open and closed switch circuit condition including shorting and nonshorting functions to the applicable contact charts and drawings (see 3.1 and 6.2.2). Each contact of each deck shall be tested. In the case of auxiliary relays the drive circuit parameters shall also be inspected and the operation tested. In the case of lighted units the lighting circuit and operation shall be tested. Other circuit details shown in the Technical Publications or on the actual assembly drawing shall be inspected and tested for proper operation.

4.6.3 Dielectric withstanding voltage (see 3.7). The product shall be tested in accordance with ANSI/IEEE C37.90-1989 (paragraph 8). The following details shall apply:

(a) Unless otherwise specified (see 3.1 and 6.2.2), the test voltage shall be 2200VRMS, 60Hz, alternating current (AC), except after elevated humidity testing (see 3.11) the test voltage shall be 1000VRMS, 60Hz; after all aging tests, the test voltage shall be 600VRMS, 60Hz.
(b) The test voltage shall be applied for one minute.
(c) The test voltage shall be applied between open circuit contacts, and between closed contacts and non-currrent carrying parts.
(d) In the event solid-state components are used, the surge withstand capability (SWC) tests of ANSI/IEEE C37.90-1989 (paragraph 9) may be substituted for this test.

4.6.4 Insulation resistance (see 3.8). The product shall be tested in accordance with this standard. Insulation resistance measurements shall be made on an apparatus suitable for the characteristic to be measured such as a megohm bridge, megohmmeter, insulation resistance test set, or other suitable apparatus. The following details shall apply:

(a) The test potential shall be 500VDC ±10%.
(b) The test potential shall be applied for one minute.
(c) The test potential shall be applied between open circuit contacts, and between closed contacts and non-current carrying parts.
(d) The measurement error of the insulation resistance value required shall not exceed 10%. Proper guarding techniques shall be used to prevent erroneous readings due to leakage along undesired paths.
(e) When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, low atmospheric pressure, humidity, or immersion in water are required, they shall be specified.

4.6.5 Contact resistance (see 3.9). The product shall be tested in accordance with this standard. Contact resistance values between two contacting surfaces are influenced by such factors as the resistivities of the surface materials, contact pressure, area, shape, condition of surfaces (including relative cleanliness, smoothness, and hardness), current, open circuit voltage appearing at the contacts during interruption of current, temperature, and thermal conductivity of leads. The resistance of the contacts shall be measured using the voltmeter-ammeter method. The following details shall apply:

(a) The maximum allowable measurement error shall be 5%.
(b) The test leads shall be connected by a method suitable for the product terminals.
(c) The test current shall be rated current except 100 milliamperes (mA) may be used after endurance (see 3.14).
(d) The test voltage shall be rated voltage except four volts may be used after endurance (see 3.14).
(e) The unit is to be operated once prior to taking measurements, to cleanse the contacts.
(f) Five separate measurements shall be taken and the average value calculated.

4.6.6 Radiation aging (see 3.10). The product shall be tested in accordance with this standard. The specimens shall be

subjected to controlled irradiation in a suitable environment. The following details shall apply:

(a) Type of radiation - gamma
(b) Source of radiation - cobalt 60
(c) Radiation integrated dose - 10 megarads (10^7) minimum at 500 to 600 kilorads per hour.
(d) Post test examination shall pay particular attention to physical changes of lubricants and thermoplastic materials.

4.6.7 Elevated humidity (see 3.11). The product shall be tested in accordance with this standard. The chamber and accessories shall be constructed and arranged in such a manner as to avoid condensate dripping on the specimens under test, and such that the specimens shall be exposed to circulating air. The specimens shall be conditioned in a dry oven at a temperature of 40 ±5°C for a period of twenty-four hours prior to test.

Test conditions are:

(a) Exposure - 90 to 95% RH at 40 ±2°C.
(b) Length of test - 96 hours
(c) Measurements - no measurements need be made prior to, during, or after exposure when the testing is performed in the sequence of TABLE I.
(d) After test - the specimens shall be conditioned for more than two hours at room ambient conditions prior to the acceptance criteria of 3.12 and prior to continuing the test in accordance with TABLE I.

4.6.8 Temperature rise. (see 3.12). The temperature rise of the product stationary contacts energized during the electrical endurance tests shall be determined by means of thermocouples of small wire gage (28-32AWG). The temperature sensitive elements shall be placed on the contacts where they first emerge from the switch body. Temperature measurements shall be taken prior to and immediately following the electrical endurance test. The contacts shall be energized at rated current at any convenient voltage within the product rating. Temperature measurements shall be taken at half hour intervals until three successive measurements are within ±1°C.

The temperature rise of coils of auxiliary relays shall be measured using the resistance method. The tests of the coils shall be performed at the maximum design voltage or current (see paragraph 7 of ANSI/IEEE C37.90-1989).

4.6.9 Elevated temperature (see 3.13). The product shall be tested in accordance with this standard. A suitable chamber shall be used which will maintain the temperature at the required test temperature and tolerance to which the product will be subjected. The temperature measurement shall be made at a position where the effects of heat generated by the product have the least effect on the recorded temperature. Chamber construction shall minimize the influence of radiant heat on the products being tested. Products shall be mounted by their normal mounting means. When more than one product is tested, the mounting distance between them shall be sufficient to minimize the temperature of one specimen affecting the temperature of another. Specimens fabricated from different materials, which may have a detrimental effect on one another and alter the results of this test, shall not be tested simultaneously.

Test conditions are:

(a) Temperature: 80 ± 2°C
(b) Length of test hours 120 hours
(c) Measurements - no measurements need be made prior to, during, or after exposure when the testing is performed in the sequence of TABLE I.

4.6.10 Aging (see 3.14). Each deck or a maximum of three switching circuits in the product shall make and break the rated load. If there are several rated loads, the different ratings may add up to three or more different circuits. In qualification tests and Class III qualification verification tests all rated loads shall be tested. In Class II inspection tests only the highest AC and DC inductive loads need be tested (highest current or voltage - whichever is determined to be the most stringent). The test decks may be distributed uniformly over the entire length of the product. The following details apply:

(a) Unless otherwise specified (see 3.1 and 6.2.2), the number of cycles of operation shall be 10,000. A cycle of operation is defined as the movement of the product shaft from an open circuit position to an adjacent closed circuit position and return to the open circuit position.
(b) The cyclying rate shall be approximately thirty cycles per minute with equal periods of time in the open and close positions.
(c) The product shall be monitored to determine when any loaded contact fails to open or close in proper sequence.

Note: Switch wiring shall be sized according to load in accordance with recommendations in the National Electrical Code. All leads from product terminals to power supply or to loads shall be at least two feet long. Jumper wires shall be as short as possible.

4.6.11 Seismic vibration (see 3.15). The products shall be fragility tested in accordance with ANSI/IEEE C37.98-1987. The following details and exceptions apply:

(a) Performance monitoring shall be conducted in accordance with IEEE C37.98-1987 (per paragraph 4.3 and TABLE II).
(b) There shall be no closing of normally open (NO) contacts or opening of normally closed (NC)

contacts during the tests in excess of 2 milliseconds (chatter). Auxiliary relays shall operate when commanded. Successful units shall be subjected to the balance of tests of TABLE I.

(c) Biaxial repeatable broad-band multi-frequency response spectrum shape shall be used in accordance with Figure 1 of ANSI/IEEE C37.98-1987 with 5% damping at ZPA (zero period acceleration) of 5g.

5. PREPARATION FOR DELIVERY

5.1 Packaging, packing, and marking. The product shall be packaged in the normal commercial manner. The unit package shall be clearly marked with the catalog number. The unit packages shall be carefully packed in the normal commercial manner, clearly marked with its destination.

6. NOTES

6.1 Intended use. The products covered by this specification are intended for use in a variety of industrial and power industry applications, including use as Class 1E Equipment for Nuclear Power Generating Stations in mild environments as defined by ANSI/IEEE 323-1984 and in harsh environments where the product is suitably protected from the harsh elements other than radiation.

6.2 Ordering data.

6.2.1 Products covered by this specification are ordered in accordance with the Technical Publications (see 2.1.4).

6.2.2 Products not covered by this specification are ordered with complete descriptive information, including drawings, specification sheets, ratings tables, and items of this standard that apply.