C37.90™

IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Power Engineering Society

Sponsored by the
Power System Relaying Committee

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Abstract: Service conditions, electrical ratings, thermal ratings, and testing requirements are defined for relays and relay systems used to protect and control power apparatus. This standard establishes a common reproducible basis for designing and evaluating relays and relay systems.
Keywords: ac component in dc, contact rating, current range, derating, dielectric test, humidity, impulse test, insulation test, power apparatus, protection relay, temperature range, temperature rise, voltage range

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Introduction

This introduction is not part of IEEE Std C37.90-2005, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

This revision of IEEE Std C37.90 contains significant changes in content and organization so it will harmonize more closely with currently published IEC standards whenever possible. The standard has also been updated to include many changes to provide for a more effective document that is now representative of currently manufactured relay products used in the industry. The changes are as described in the following list.

a) Clause 2, Normative references, has been added where required.

b) Clause 3, Definitions, has been revised to provide for alphabetical classification by function.

c) Clause 4, Service conditions, has been revised to provide categories for specific temperature ranges and differentiation of ambient and extreme temperature ranges. Relative humidity now specifies relay or relay systems. Other conditions have been changed to show numeric designations.

d) Clause 5, Electrical ratings, specifies additional standard current and voltage ratings and notes, applicable to Table 3. Table 4 specifies additional maximum design voltages for dc control. Table 7 and Table 8 specify coil resistance/burden at ambient temperature 25 °C. A subclause has been added to address latching current requirements.

e) Clause 6, Heating limits of temperature rise for coils, has been revised to add information on how the temperature rise of the coils is to be determined.

f) Clause 7, Mechanical requirements, has been added to provide information on the mechanical durability of relays, plug-in feature requirements, and relay setting controls to harmonize with current IEC requirements.

g) Clause 8, Insulation tests, was changed from Dielectric tests and now includes the requirement for an impulse voltage test as a design test. Table 9 and Figure 1 have been added to this clause.

h) An annex of International Electrotechnical Commission (IEC) standards, relevant to IEEE Std C37.90, has been added to provide additional information for clarification and harmonization with IEC standards. In preparing this standard, consideration has been given to the work of other committees, and especially to international standards that have been published or that are under preparation by Technical Committee 95 of IEC.

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Contents

IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

1. Overview

This standard specifies standard service conditions, standard ratings, performance requirements, and testing requirements for relays and relay systems used to protect and control power apparatus. The standard establishes a common reproducible basis for designing and evaluating relay and relay systems. Annex A provides a cross-reference to the applicable IEC standards. Certain specific tests required for relays and relay systems are covered in separate IEEE standards as noted below.

Required surge tests are documented in IEEE Std C37.90.1™-2002[1]. Standardized test waveforms that are representative of surges observed and measured in actual installations are applied to the terminals of the system. The relay or relay system must be able to withstand the applied surges without damage to components and without operating incorrectly.

Required susceptibility tests are documented in IEEE Std C37.90.2™-1995. The tests establish a method to evaluate the susceptibility of the relay under test to single frequency electromagnetic fields in the radio frequency domain, such as those generated by portable or mobile radio transceivers.

Required electrostatic discharge tests are documented in IEEE Std C37.90.3™-2001. Generators which that produce a standard waveform are used to apply discharges to conductive and non-conductive points on equipment under test. The test is performed to confirm that relays and relay systems will not misoperate or be damaged when installed, energized, and/or subjected to a specified electrostatic discharge.

1.1 Scope

This standard specifies standard service conditions, standard ratings, performance requirements, and testing requirements for relays and relay systems used to protect and control power apparatus. A relay system may include computer interface equipment and/or communications interface equipment, such as a carrier transmitter/receiver or audio tone equipment. It does not cover relays designed primarily for industrial control, for switching communication or other low-level signals, or any other equipment not intended for control of power apparatus.

[1] Information about the documents referenced in this clause can be found in Annex A.

1.2 Purpose

The purpose of this standard is to establish a common reproducible basis for designing and evaluating relays and relay systems.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std C37.100™, IEEE Standard Definitions for Power Switchgear.[2,3]

3. Special terms

A relay is an electric device designed to respond to input conditions in a prescribed manner and, after specified conditions are met, to cause contact operation or similar abrupt change in associated electric control circuits. A relay may consist of several relay units, each responsive to a specified input, with the combination of units providing the desired overall performance characteristic of the relay. Inputs are usually electrical but may be mechanical, thermal, other quantities, or a combination of quantities. Limit switches and similar simple devices are not relays.

Relay terminology covers a wide area from the detailed relay structural principles through complex power system relay applications. The following basic areas of power system relay applications provide a convenient method of classification by function:

a) Protective
b) Monitoring
c) Regulating
d) Auxiliary
e) Reclosing
f) Sync check

Definitions of other relay terms are not included in this standard. Refer to IEEE Std C37.100™[4].

4. Service conditions

4.1 Usual service conditions

Relays and relay systems conforming to this standard shall be suitable for operation under the conditions described in 4.1.1, 4.1.2, 4.1.3, and 4.1.4.

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[3] IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

[4] Information on references can be found in Clause 2.

4.1.1 Operational temperature range

This is the temperature of the still air (i.e., no forced-air movement) measured 30 cm from the front surface of the unit (relay or relay system) enclosure and cover. The manufacturer shall declare the operational range of ambient temperature for which the relay or relay system is rated. The temperature range shall be selected from the following:

a) −40 °C to +70 °C

b) −30 °C to +65 °C

c) −20 °C to +55 °C

d) Range defined by manufacturer, but must encompass −20 °C to +55 °C

The characteristics of the relay shall not vary more than the published tolerances for temperatures in the selected range. The manufacturer shall declare the effects of temperature on component parts of the relay or relay system that may result in a visual change but not the operational accuracy of the functions included within the package (i.e., an LCD display may become dark, or unreadable due to the ambient temperature; however, this condition does not affect the proper operation of the included protection or other packaged functions.)

The manufacturer shall declare whether operation at the specified accuracy of the relay or relay system can be achieved when power is initially applied to the unit after all internal components have been stabilized at the temperature at each end of the selected temperature range. If the specified accuracy is achieved only after the unit is energized to its normal nontransitional state for a period of time, the manufacturer shall specify that this condition exists and shall also specify the required internal enclosure temperature and/or estimated stabilization time required to achieve specified accuracy.

4.1.2 Non-operational temperature range

Relays shall be capable of withstanding temperatures within one of the following temperature ranges for conditions of transport, storage, and installation. The manufacturer shall declare the temperature range for which the relay or relay system is rated.

The temperature range shall be selected from the following:

a) −50 °C to +85 °C

b) −40 °C to +75 °C

c) −30 °C to +65 °C

d) Range defined by manufacturer, but must encompass −30 °C to +65 °C

4.1.3 Relative humidity

Relays and relay systems withstand an average relative humidity up to 55%, with excursions up to 95% for a maximum of 96 h, without internal condensation. Testing shall be performed with the relay or relay system enclosure or cover installed (when applicable) at defined operational and non-operational temperature ranges.

4.1.4 Altitude

The usual condition of altitude shall be less than 1500 m.

4.2 Unusual service conditions

The use of relays and relay systems at conditions other than specified (see 4.1) shall be considered as unusual conditions.

4.2.1 Derating for altitude

The dielectric strength and the cooling effect of air insulation are affected by the decrease in relative air density at higher altitudes. Therefore, the insulation and temperature ratings of relays tested and/or applied at higher altitudes will be derated according to the information provided in 4.2.1.1 and 4.2.1.2 and Table 1 and Table 2.

4.2.1.1 Derating of air insulation for altitude

Relays shall withstand the insulation tests specified (see Clause 8) at altitudes of 1500 m and lower. Insulation tests performed at altitudes higher than 1500 m shall have the test voltages reduced per the factors given in Table 1.

Table 1— Derating of dielectric strength for the effect of altitude

Altitude above sea level (m)	Dielectric strength derating factor
1500 and lower	1.00
2000	0.95
3000	0.84
4000	0.75
5000	0.67
6000	0.59

4.2.1.2 Derating of maximum ambient temperature for altitude

Relays shall comply with the defined operational temperature range (see 4.1.1) at altitudes of 1500 m and lower. The maximum ambient temperature declared by the manufacturer (see 4.1.1) shall be reduced by the factors in Table 2 for higher altitudes.

Table 2— Derating of maximum ambient temperature for altitude

Altitude above sea level (m)	Temperature derating factor
1500 and lower	1.0
2000	0.96
3000	0.87
4000	0.78
5000	0.69
6000	0.60

4.2.2 Other conditions

Other conditions may require special construction, treatment, or operation considerations, and these shall be brought to the attention of those responsible for the application, manufacture, and operation of relays and relay systems. Among such conditions are exposure to the following:

a) Damaging smoke, fumes, or vapors
b) Moisture or dripping water
c) Dust (abrasive, magnetic, conductive, obstructive, etc.)
d) Explosive mixtures of dust and gases
e) Steam
f) Salt air
g) Shock, vibration, and seismic disturbances
h) Transportation or storage conditions
i) Extreme temperature or sudden change in temperature
j) Extreme variations of supply voltage
k) Excessive electrical wave distortion
l) Excessive electrical noise
m) Electromagnetic radiation
n) Nuclear radiation
o) X-ray radiation

5. Electrical ratings

5.1 Standard current and voltage ratings for relays

The standard current and voltage ratings for relays shall be as shown in Table 3.

Table 3— Standard current and voltage ratings for relays [a]

V rms	V dc	A rms
12/24/48	12	1
100/110/120[b]	24	2
220/240[c]	40/48/60	5
480[c]	110/125	10
600[c]	220/250	15

[a] Other values are also acceptable, but are not preferred.
[b] and values multiplied by $\sqrt{3}$ or $1/\sqrt{3}$
[c] and values multiplied by $1/\sqrt{3}$

5.2 Maximum design voltage and current for relays

5.2.1 Voltage

Maximum design voltage is the highest rms alternating voltage or direct voltage at which the equipment is designed to be energized continuously.

5.2.2 Current

Maximum design current is the highest rms alternating current or direct current at which the equipment is designed to be energized continuously.

5.3 Allowable variations from rated voltage for voltage operated auxiliary relays

5.3.1 DC auxiliary relays

Direct current auxiliary relays that may be continuously energized for indefinite periods shall be able to withstand the maximum design voltage shown in Table 4 without exceeding the temperature rises shown in Table 5. These relays shall operate over a range from 80% of rated voltage to the maximum design voltage.

NOTE—Typically, electromechanical auxiliary relays that pick up at 80% or less of rated voltage when hot will pick up at 72% or less of rated voltage when cold.[5]

Table 4— Maximum design voltage for dc control power

Rated volts	Maximum design volts
12	14
24	28
40 / 48 / 60	46 / 56 / 70
110	123
125	140
220	246
250	280

[5] Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

Table 5— Limits of temperature rise for coils

	Insulation class, °C [a]					
	105	**120**	**130**	**155**	**180**	**220**
Method of temperature determination	**Limits of observable temperature rise above 55°C ambient temperature**					
Thermometer	40	55	65	90	115	155
Applied thermocouple	45	60	70	95	120	160
Resistance method	50	65	75	100	125	165

[a] Other insulation classes may be added, as necessary.

5.3.2 AC auxiliary relays

Alternating current auxiliary relays that may be continuously energized for indefinite periods should be able to withstand 110% of rated voltage without exceeding the temperature rises shown in Table 5. These relays shall operate over a range of 85% to 110% of rated voltage.

5.3.3 Test for operation at minimum voltage

For successful operation at the minimum voltage for continuous duty, the auxiliary relay coil should be subjected to the rated voltage until constant temperature is reached, and then tested for successful operation at the minimum voltage.

Relays may be tested cold with proper allowance for the increase in impedance due to temperature rise as established by temperature tests on duplicate relays.

5.4 Allowable variation from rated voltage and current for protective relays

5.4.1 Measuring input

The maximum design voltage or current for protective relays shall be equal to or greater than the rated voltage or current of the relay.

5.4.1.1 Measuring input with ac voltage rating

Protective relays that are designed to be energized with ac voltage shall operate without damage at rated frequency with voltage not more than 10% above the rated voltage, but not necessarily in accordance with the temperature rise limits established for operation at rated voltage (see Clause 6).

5.4.1.2 Measuring input with current rating

The manufacturer shall state the highest rms value that the relay can carry continuously while satisfying the temperature rise requirements (see Clause 6).

5.4.2 Protective relay control power inputs

5.4.2.1 DC rated control power inputs

DC power supplies and auxiliary circuits with dc voltage ratings shall be able to continuously withstand the maximum design voltage shown in Table 4. They shall be capable of operating successfully over a range from 80% of rated voltage to the maximum design voltage.

5.4.2.2 AC rated control power inputs

AC power supplies and auxiliary circuits with ac voltage rating shall be capable of operating successfully over a range of 85% to 110% of rated voltage.

5.4.3 Contact inputs

The manufacturer shall state the minimum pick-up and dropout voltage of all contact input circuits. These inputs are typically used to interface the open or closed state of external contacts into the relay logic.

5.4.3.1 Externally energized

For externally energized contact inputs, the manufacturer shall state the minimum pickup and dropout voltage of all input circuits.

5.4.3.2 Internally energized (wetted)

For internally energized contact inputs, the manufacturer shall state the maximum open circuit voltage and short circuit current of the contact input.

5.5 Allowable ac component in dc control voltage supply

An alternating component (ripple) of 5% peak or less in the dc control voltage supply to protective or auxiliary relays shall be permitted, provided the minimum instantaneous voltage is not less than 80% of rated voltage. The ripple content of dc supply expressed as percentage is defined :

$$\frac{(\text{peak value} - \text{dc component})}{(\text{dc component})} \times 100 \quad (1)$$

NOTE—Equation (1) refers to low frequency ripple as might typically be introduced on the dc control power bus by a battery charger. Higher frequency effects, such as might be introduced by a dc-dc converter within the relay itself, are not sufficiently defined at this time to be included in this standard.

5.6 Short time thermal withstand

The limiting short time thermal withstand is the highest value of an energizing quantity that the relay can withstand for a specified time without permanent degradation of its operating characteristics, but possibly with some loss of life.

5.6.1 Continuously energized

Relays designed to be energized continuously shall withstand the application of the limiting short time thermal withstand stated by the manufacturer for the following times:

a) Current relays: 1 s

b) Voltage relays: 10 s

5.6.2 Intermittent duty

Relays designed for intermittent duty shall withstand the application of the limiting short time thermal withstand value. The manufacturer shall state this value and also the duration.

5.7 Make, carry, and interrupt ratings for tripping output circuits

A tripping output consists of relay contacts or a relay output circuit designed for the purpose of energizing power circuit breaker trip coils.

5.7.1 Tripping output performance requirements

Tripping output circuits shall meet the following performance specifications:

a) The contacts or output circuit shall make and carry 30 A for at least 2000 operations in a duty cycle as described in item d).

b) The load shall be resistive for both dc and ac and the current shall be interrupted by independent means.

c) The voltage value applied will be one of the standard voltage ratings (see Table 3). Design tests to prove this rating shall be made at room ambient temperature (not less than 20 °C) with the relay in its case and with its cover (if any) in position.

d) One duty cycle shall consist of the sequence: 200 ms on, 15 s off. (Current is interrupted by independent means at the end of each “on” interval.)

5.7.2 Continuous and interrupting ratings of tripping output circuits

Tripping output contacts intended by the manufacturer to be for tripping duty only shall be identified as such and may have no continuous or interrupting duty. If a manufacturer intends for tripping output contacts to be used for continuous and /or interrupting duty, then the rating information as required in Table 6 and its associated notes shall be provided. (In this case, the ratings for double contacts are optional.)

5.7.3 Holding current

If a tripping output requires a certain value of holding current to remain conducting, as is generally the case with thyristor circuits, the manufacturer shall state this requirement.

5.7.4 Latching current

If a tripping output requires that a value of latching current be reached within less than a specified time in order to establish conduction (as is generally the case with pulse-gated thyristor circuits), the manufacturer shall state these requirements.

NOTE—In some applications, the inductance of the trip coil can create a trip circuit time-constant that prevents the thyristor current from establishing a level of conduction current during the short on-duration of the gate.

5.8 Make, carry, and interrupt ratings for output circuits not rated for tripping

The manufacturer shall state the capability of output circuits which are not rated for tripping duty. This shall include, where applicable, the ratings when the output circuits are used in various voltage levels of both ac and dc control circuits, including their make, carry, and interrupting ratings.

5.9 Published data for auxiliary relays

Table 6, Table 7, and Table 8 show the performance information concerning contact ratings, operating time, pickup and dropout values, etc., that shall be provided by the manufacturer in literature describing these relays. The format shown in these tables shall be used as a guide when publishing this information. Manufacturers of solid-state auxiliary relays shall provide similar data as is appropriate to their devices.

Table 6— Contact rating for all auxiliary relays

	Interrupting rating in amperes [a]				**Carry rating in amperes [d]**	
	Resistive		**Inductive [b]**			
Contact circuit voltage	**Single contact**	**Double contacts [c]**	**Single contact**	**Double contacts [c]**	**Short time (1 min.)**	**Continuous**
dc 24 48 125 250						
ac 50/60 Hz 120 240 480						

[a] Interrupting rating should be based on at least 100 operations at rated value, with no significant burning of contacts, using suddenly applied (or removed) rated voltage on coil. Electrical life for all ratings or for each interrupting rating should also be incorporated into the table.

[b] Inductive rating should be based on tests using an impedance with L/R = 0.04 s for dc and power factor that equals 0.4 for ac.

[c] "Double contacts" means two contacts in series.

[d] Short-time and continuous ratings are based on temperature rise in contact members and supporting parts. Limiting temperatures are to be determined by the manufacturer and should be incorporated into the table.

Table 7—Operating data for auxiliary relays with continuous rating

			Typical operating time in ms [a, b]		Operating voltage [b, c, e]	
Coil circuit voltage dc	**Coil resistance in Ω at 25 °C**		**Pickup**	**Dropout**	**Must pickup**	**Must dropout**
24 48 125 250						
ac	**Coil impedance in Ω at rated frequency [d]**					
(rated frequency)	**Armature open**	**Armature closed**				
120 240 480						

[a] All operating times are measured with rated voltage suddenly applied or removed.

[b] Operating time values and pickup/dropout values in this table are measured with relay "hot" [i.e., energized at rated voltage until thermal equilibrium has been reached at room ambient temperature (20 °C to 25 °C)].

[c] Operating voltage data columns in this table have the following meanings:

— "Must pickup" means that actual pickup is less than the value given, and applied voltage should be greater than this value for reliable operation.

— "Must dropout" means that actual dropout is greater than value given, and applied voltage should be less than this value for reliable dropout.

[d] Impedance data for ac relays should include ohms and power factor at rated frequency.

[e] For current operated auxiliary relays, substitute amperes for volts in the tables.

Table 8—Operating data for auxiliary relays with intermittent ratings

dc circuit voltage	Coil voltage continuous rating (if applicable)	Coil resistance in Ω @ rated voltage 25 °C	Series resistor (if used)	Withstand in seconds (if applicable) [a]	Operating time in ms [a]

[a] Operating time and withstand values in this table are measured with relay "cold" [i.e., coil at room ambient temperature (20 °C to 25 °C) before measurement is made].

6. Heating limits of temperature rise for coils

The temperature rise of relay coils as installed in a relay case or other enclosure and tested at the maximum design voltage or current per usual service conditions (see 4.1) shall not exceed the values given in Table 5.

The temperature rise of the coil shall be determined as follows:

a) For relays for continuous duty—after thermal equilibrium has been reached

b) For relays for short-time or intermittent duty—at the highest temperature attained during such operation

7. Mechanical requirements

7.1 Mechanical durability of relay operation

Unless otherwise specified by the manufacturer, the relay shall be capable of performing 10 000 operations with no load in the output circuit when tested under the conditions noted in the following list:

a) Mounted as for normal service

b) At rated values of the auxiliary energizing quantity(ies)

c) At the following reference conditions:

   1) Ambient temperature: 20 °C to 25 °C
   2) Relative humidity: 45% to 70%
   3) Frequency of input energizing quantities: nominal rated ± 0.5%

d) At specified rates (cycles per minute) declared by the manufacturer

e) For relays with adjustable settings at the relay's most sensitive setting

7.2 Mechanical durability of plug-in relays

Relays that break their electrical connections when removed from their cases shall be subject to 200 withdrawals and insertions under de-energized conditions. After the tests, the contacts shall still be capable of performing their intended duty.

7.3 Mechanical durability of relay setting controls

Relay setting controls (potentiometers, plugs, sockets, switches, etc.) shall be subjected to 200 adjustments under de-energized conditions. After the tests, the controls shall still be capable of performing their intended duty within their specified tolerances.

7.4 Shock and vibration

Relays shall be packaged for shipment by the manufacturer to withstand the shock and vibration commonly encountered during shipment by common parcel carriers. Parcel carriers have established uniform tests and pass/fail criteria for packaged products that minimize shipment damage. Seismic withstand capability requirements are considered to be unusual service conditions and the testing requirements are covered by IEEE Std C37.98™-1998.

8. Insulation tests

Insulation tests include dielectric power frequency tests and impulse tests.

8.1 General requirements

8.1.1 Atmospheric conditions for insulation tests

Atmospheric conditions for insulation tests shall be within the following ranges:

— Ambient air temperature: 15° C to 35° C

— Relative humidity: 45% to 75%

— Air pressure: 860 mbar to 1060 mbar

8.2 Dielectric power frequency tests

These tests consist of applying a specified voltage to the insulation systems of the relay under test to prove that it is in accordance with the rated insulation voltage stated by the manufacturer.

8.2.1 Test voltages and waveform

Manufacturers shall declare relay products as Series B or Series C, and shall select test voltage from Table 9. Series B is provided to allow for products that were designed when this was the highest voltage specified by previous revisions of this standard. Series C is intended for all newer products.

Table 9—Dielectric test voltages, V rms

Product rated voltage	Test voltage [a]	Test voltage [a]
	Series B	Series C
50 and below	500[b]	500[b]
250 and below	1500	2000
500	2000	2500
660	2500	3000
1000	3000	3000

[a] Except for open contacts that are rated for tripping, test at twice rated plus 1000 V rms (minimum of 1500 V), and for open contacts that are not rated for tripping, test at a minimum of 1000 V rms.

[b] Circuits rated 50 V or less (generally utilized for communications or low-level input/output); test at 500 V rms minimum where such circuits are isolated from ground.

The test source shall be substantially sinusoidal and at a frequency between 45 Hz and 65 Hz.

The source voltage shall be verified with an accuracy better than 5%.

The test voltage source shall be such that, when applying the specified value to the relay under test, the voltage drop observed is less than 10%.

These dielectric tests may be conducted using a dc source. For dc testing the test voltages shall be 1.4 times the values given for ac tests.

8.2.2 Test requirements

Dielectric power frequency tests are considered to be both type tests and production tests to be performed by the manufacturer.

Dielectric tests, in accordance with this standard, may be performed once by the user on new relays to determine whether specifications are fulfilled. New relays, for the purpose of this test, are defined as those that have not been in service, that are not more than one year old from the date of shipment, and that have been suitably stored to prevent deterioration.

Additional dielectric tests may be made using 75% of the test voltage determined in accordance with Table 9 at the point of installation to determine the practicality of placing or continuing the equipment in service.

8.2.3 Points to be tested

Dielectric tests shall be performed as follows:

a) Between each independent circuit and the ground circuit. The terminals of each independent circuit may be connected together. For relays with an insulating enclosure, the ground circuit shall be represented by a metal foil covering the entire enclosure except the terminals around which a suitable gap shall be left so as to avoid flashover to the terminals. Insulation tests requiring this metal foil shall be performed as design tests only.

b) Between independent circuit groups, with the terminals of each independent circuit in the group being connected together. Independent circuit groups are to be defined by the manufacturer.

c) Between the terminals of open contacts—only as a design test. Dielectric tests are not required across contacts with surge-suppression components, or across solid-state output circuits. When these are used, the Surge Withstand Capability (SWC) test (see IEEE Std C37.90.1-2002) is to be substituted for the dielectric test.

8.2.4 Test method

During the testing, no input or auxiliary energizing quantity shall be applied to the relay.

Test voltage shall be applied directly to the relay terminals.

The open circuit voltage of the testing equipment is initially set to not more than 50% of the specified voltage. It is then applied to the relay under test. From this initial value, the test voltage shall be raised to the specified value, in such a manner that no appreciable transients occur, and then maintained for 1 min. It shall then be reduced smoothly to zero as rapidly as possible.

As an alternate, to be used at the point of manufacture only, it is permissible to test any relay for 1 s at a value 20% higher than the standard 1 min test voltage.

8.2.5 Criteria for acceptance

During the dielectric tests, no breakdown or flashover shall occur and no components shall be damaged.

8.3 Impulse voltage tests

The impulse voltage tests consist of applying a specified impulse voltage (see Figure 1) to the insulation to prove the ability of the relay to withstand, without damage, transient voltages of very high values and very short duration. This test shall apply only to those units declared as Series C (see 8.2.1)

8.3.1 Test voltage and waveform

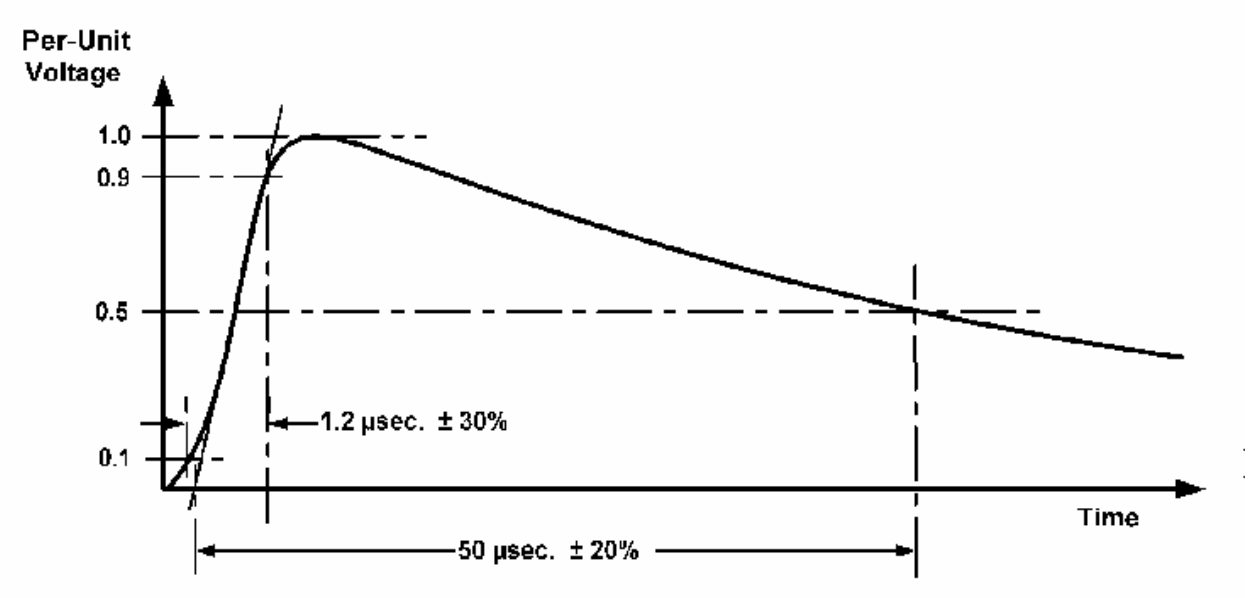

Figure 1—Impulse voltage waveform

a) **Waveform polarity:** Positive and negative

b) **Rise Time:** 1.2 µs ± 30%

c) **Magnitude:** 5 kV +0/−10%

d) **Time to half value:** 50 µs ± 20%

e) **Source impedance:** 500 Ω ±10%

f) **Output energy:** 0.5 J ± 10%

8.3.2 Test requirements

Impulse voltage tests are considered design tests.
If there is a requirement to demonstrate compliance with this design test using a relay intended for service, the impulse voltage design test can be performed only once using a new relay. New relays, for the purpose of this test, are defined as those that have not been in service, that are not more than one year old from the date of shipment, and that have been suitably stored to prevent deterioration.

8.3.3 Points to be tested

Impulse voltage tests shall be applied as follows:

a) Between each independent circuit and the ground circuit. The terminals of each independent circuit may be connected together. For relays with an insulating enclosure, the ground circuit shall be represented by a metal foil covering the entire enclosure except the terminals around which a suitable gap shall be left so as to avoid flashover to the terminals.

b) Between independent circuit groups, with the terminals of each independent circuit in the group being connected together. Independent circuit groups are to be defined by the manufacturer.

c) Between the terminals of a given circuit unless otherwise specified by the manufacturer.

d) Circuits rated 50 V or less and not intended for connection to voltage transformers, current transformers, or the dc battery source shall be excluded from impulse testing. These circuits shall be tested per IEEE Std C37.90.1-2002.

NOTE—When testing equipment incorporating components across the test circuit, e.g., voltage suppression, the test voltage may be noticeably distorted or chopped according to the characteristics of the voltage limiting components.

8.3.4 Test method

During the impulse testing, no input or auxiliary energizing quantity shall be applied to the relay.

Test voltage shall be directly applied to the relay terminals through test leads that do not exceed 2 m in length.

Three positive and three negative impulses shall be applied. The interval between each impulse shall be 1 s or greater.

8.3.5 Criteria for acceptance

During the impulse test, no breakdown or flashover shall occur and no components shall be damaged.

After the test, the relay shall still comply with all relevant performance requirements.

Annex A

(informative)

Applicable IEC standards

IEEE Std C37.90 Clause(s)	IEC Standard	Comments
1. Overview Surge withstand capability tests See IEEE Std C37.90.1™-2002,[6,7] IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.	IEC 60255-22-1 (2005-03)[8] Electrical relays—Part 22-1: Electrical disturbance tests for measuring relays and protection equipment—1 MHz burst immunity tests.	IEC 60255-22-1 defines high frequency voltage disturbance test requirements, including three severity classes.
	IEC 60255-22-4 (2002-04) Electrical relays—Part 22-4: Electrical disturbance tests for measuring relays and protection equipment—Electrical fast transient/burst immunity test.	IEC 60255-22-4 defines fast transient disturbance test requirements, including five severity classes. These IEC standards refer to IEC 61000-4-12 Electromagnetic compatibility (EMC)— Part 4-12: Testing and measurement techniques—Oscillatory waves immunity test and IEC 61000-4-4, Electromagnetic compatibility (EMC) —Part 4-4: Testing and measurement techniques—Electrical fast transient/burst immunity test, respectively.
Radiated electromagnetic interference tests See IEEE Std C37.90.2™-1995, IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.	IEC 60255-22-3 (2000-07) Electrical relays—Part 22-3: Electrical disturbance tests for measuring relays and protection equipment—Radiated electromagnetic field disturbance tests.	IEC 60255-22-3 defines three radiated electromagnetic field disturbance test methods for four severity classes. This standard refers to IEC 61000-4-3 Electromagnetic compatibility (EMC)—Part 4-3: Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test.
Electrostatic discharge tests See IEEE Std C37.90.3™-2001, IEEE Standard Electrostatic Discharge Tests for Protective Relays.	IEC 60255-22-2 (1996-09) Electrical relays—Part 22: Electrical disturbance tests for measuring relays and protection equipment—Section 2: Electrostatic discharge tests.	IEC 60255-22-2 defines electrostatic discharge test requirements. This standard refer to IEC 61000-4-2 (2001-04) Electromagnetic compatibility (EMC), Part 4-2: Testing and measurement techniques—Electrostatic discharge immunity test.

[6] The IEEE standards or products referred to in this annex are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

[7] IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

[8] IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

IEEE Std C37.90 Clause(s)	IEC Standard	Comments
3. Definitions IEEE Std C37.100™-1992, IEEE Standard Definitions for Power Switchgear.	IEC 60050-446 (1983-01) International Electrotechnical Vocabulary. Electrical relays and IEC 60050-448 (1995-12) International Electrotechnical Vocabulary—Chapter 448: Power system protection.	
4. Service conditions 5. Electrical ratings	IEC 60255-6 (1988-12) Electrical relays—Part 6: Measuring relays and protection equipment.	IEC 60255-6 is the general relay standard. It defines preferred ratings and operating ranges for electrical circuits. It includes temperature limits and mechanical requirements.
5.7 Make and carry and interrupting ratings for tripping output circuits	IEC 60255-14 (1981-01) Electrical relays. Part 14: Endurance tests for electrical relay contacts—Preferred values for contact loads. IEC 60255-15 (1981-01) Electrical relays. Part 15: Endurance tests for electrical relay contacts—Specification for the characteristics of test equipment. IEC 60255-23 (1994-10) Electrical relays. Part 23: Contact performance.	Note: IEC 60255-14 (1981-01) was withdrawn and replaced with: IEC 61810-2 Electromechanical Elementary Relays—Part 2. IEC 60255-15 (1981-01) was withdrawn and replaced with: IEC 61810-2 Electromechanical Elementary Relays—Part 2. IEC 60255-23 (1994-10) was withdrawn and replaced with: IEC 61810-2 Electromechanical Elementary Relays—Part 2. IEC 60255-23 defines preferred ratings, test requirements, and failure criteria for relay contact assemblies.
6. Heating limits of temperature rise for coils	IEC 60255-6 (1988-12) Electrical relays—Part 6: Measuring relays and protection equipment. IEC 60085 (1984-01) Thermal evaluation and classification of electrical insulation.	IEC 60255-6 is the general relay standard. It includes temperature limits and mechanical requirements. Note: IEC 60085 (1984-01) is superseded by IEC 60085 (2004-06) Electrical insulation—Thermal classification.
7. Mechanical requirements	IEC 60255-6 (1988-12) Electrical relays—Part 6: Measuring relays and protection equipment.	IEC 60255-6 includes mechanical requirements in Clause 5.

IEEE Std C37.90 Clause(s)	IEC Standard	Comments
8. Insulation tests	IEC 60255-5 (2000-12) Electrical relays—Part 5: Insulation coordination for measuring relays and protection equipment—Requirements and tests.	IEC 60255-5 defines dielectric test plus insulation resistance and impulse voltage requirements and test methods.
8.2 Power frequency tests		IEC 60255-5 defines power frequency test requirements and three test voltage series in Clause 6.
8.3 Impulse voltage tests (Applicable to Series C units only)		IEC 60255-5 defines impulse test requirements and two voltage levels in Clause 6.