

IEEE Standard for Pad-Mounted Dry Vault, Submersible, and Overhead Fault Interrupters for Alternating Current Systems Up to and Including 38 kV

IEEE Power and Energy Society

Developed by the
Switchgear Committee

IEEE Std C37.62™-2020

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of the
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Abstract: Required definitions, ratings, procedures for performing design tests and production tests, and construction requirements for pad-mounted, dry vault, submersible, and overhead fault interrupters for alternating current systems up to and including 38 kV are provided in this standard.

Keywords: dry vault, fault interrupter, FI, IEEE C37.62™, medium voltage, overhead, pad-mounted, submersible, switchgear

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Introduction

This introduction is not part of IEEE Std C37.62-2020, IEEE Standard for Pad-Mounted, Dry Vault, Submersible, and Overhead Fault Interrupters for Alternating Current Systems Up to and Including 38 kV.

Fault interrupter (FI) and automatic recloser switchgear have shared the same standard, IEEE Std C37.60™, for many decades.¹ Because reclosers are used extensively throughout the world, IEEE coordinated with the International Electrotechnical Commission (IEC) to publish a dual logo standard, IEEE Std C37.60/IEC 62271-111, in 2005 and revised in 2012. A second revision started shortly after the 2012 publication. As part of that revision, it was decided that the fault interrupter, which is not used extensively throughout the world, should have its own IEEE non-dual logo standard, to be designated IEEE Std C37.62. As FIs are primarily used in regions where equipment is specified to IEEE standards, it was considered to be appropriate for this to be an IEEE standard and not have a dual logo, the intent being that the new standard will maintain its focus on FIs without being influenced by the requirements of other switchgear.

This standard is an extraction from IEEE Std C37.60-2012/IEC 62271-111:2012 of the rating structure, preferred ratings, construction requirements, and design and routine test requirements that are relevant to FIs. Changes made to the 2018 revision of IEEE Std C37.60/IEC 62271-111 have been included in this standard as they are relevant to FIs.

The principle technical changes, with respect to IEEE Std C37.60-2012/IEC 62271-111:2012, are as follows:

- The clause numbering was changed from the IEC style as used in IEEE Std C37.60-2012/IEC 62271-111:2012 to the preferred IEEE style.
- The temperature rise limits were lowered for tin-coated contacts (see 5.4.2).
- An oil sampling provision for sampling from the bottom of the tank is required of all pad-mounted units, not just submersible units (see 6.1.3).
- The power frequency voltage withstand wet test method was changed from the traditional ten second wet test to the one minute wet test per the IEEE Std 4™ “standard test procedure” (see 7.3.7.2).
- A limitation on preliminary impulse test shots was added to impulse voltage withstand testing of vacuum interrupters (see 7.3.7.3).
- A procedure for testing line- and cable-charging current interruption in three-phase FI with three independently controlled poles was added (see 7.13.4.1).
- The handling of restrikes in line- and cable-charging current interruption tests was changed to a limitation of no more than three operations with restrikes rather than three restrikes (see 7.13.6.2).
- The T100 test duty current range was changed from 90% to 100% of rated symmetrical interrupting current to 100% to 105% (see Table 9).
- The critical current interrupting test was replaced by a low current interrupting test at 5% and 10% of rated symmetrical interrupting current (see 7.16).
- A thermal runaway test was specified for verifying current carrying capability following current interrupting tests if resistance measurements are not conclusive (see 7.25).
- A sealed tank pressure test to verify proper mechanical operation was specified (see 7.26).
- An operations endurance test, performed with the switchgear under rated pressure, was added for submersible units (see 7.27).

¹ Information on references can be found in Clause 2.

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IEEE Standard for Pad-Mounted, Dry Vault, Submersible, and Overhead Fault Interrupters for Alternating Current Systems Up to and Including 38 kV

1. Overview

1.1 Scope

This standard applies to all pad-mounted, dry vault, submersible, and overhead single- or multi-pole alternating current fault interrupters (FIs) for rated maximum voltages above 1000 V and up to and including 38 kV.

Devices that require a dependent manual operation are not covered by this standard.

In order to simplify this standard where possible, the term FI (FIs) has been substituted for fault interrupter (fault interrupters).

1.2 Purpose

The purpose of this standard is to define the rating structure, preferred ratings, test, and construction requirements for pad-mounted, dry vault, submersible, and overhead single- or multi-pole alternating current FIs for maximum voltages above 1000 V and up to 38 kV.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (shall equals is required to).^{2, 3}

² The word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

³ The word *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (should equals is recommended that).

The word *may* is used to indicate a course of action permissible within the limits of the standard (may equals is permitted to).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (can equals is able to).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI C37.85, American National Standard for Switchgear—Alternating Current High-Voltage Power Vacuum Interrupters—Safety Requirements for X-Radiation Limits.⁴

IEC 60059, IEC standard current ratings.⁵

IEC 60255-26:2013, Measuring relays and protection equipment—Part 26: Electromagnetic compatibility requirements

IEC 61000-4-18:2006, Electromagnetic compatibility (EMC)—Part 4-18: Testing and measurement techniques—Damped oscillatory wave immunity test.

IEEE Std 4™, IEEE Standard for High Voltage Testing Techniques.^{6, 7}

IEEE Std 386™, IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV.

IEEE Std C37.09™, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V.

IEEE Std C37.41™, IEEE Standard Design Tests for High-Voltage (>1 000 V) Fuses and Accessories.

IEEE Std C37.60™/IEC 62271-111, IEEE/IEC International Standard—High-voltage switchgear and controlgear—Part 111: Automatic circuit reclosers for alternating current systems up to and including 38 kV.

IEEE Std C37.74™-2014, IEEE Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.

⁴ ANSI publications are available from the American National Standards Institute (<https://www.ansi.org/>).

⁵ IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

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IEEE Std C37.90.1™-2012, IEEE Standard for Surge Withstand Capability (SWC) for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.100.1™-2018, IEEE Standard of Common Requirements for High-Voltage Power Switchgear Rated Above 1000 V.

IEEE Std C37.100.2™, IEEE Standard of Common Requirements for Testing of AC Capacitive Current Switching Devices over 1000 V.

IEEE Std C37.301™-2009, IEEE Standard for High-Voltage Switchgear (Above 1000 V) Test Techniques—Partial Discharge Measurements.

IEEE Std C57.12.28™-2005, IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁸

cable-charging current: The rms current in amperes flowing in an energized insulated high-voltage cable operating at no-load.

closed pressure system for gas: Volume that is replenished only periodically by manual connection to an external gas source.

NOTE—Example of closed pressure systems are SF₆ single pressure circuit-breakers.⁹

controlled pressure system for gas: Volume that is automatically replenished from an external compressed gas supply or internal gas source.

NOTE 1—Examples of controlled pressure systems are air-blast circuit-breakers or pneumatic operating mechanisms.

NOTE 2—A volume may consist of several permanently connected gas-filled compartments.

cutout mounted fault interrupter: Single-phase fault interrupter (FI) consisting of an interrupter that mounts in a cutout fuse support or fuse base as defined in IEEE Std C37.41.

NOTE—See IEEE Std C37.41.¹⁰

dry vault: Ventilated, enclosed area not subject to flooding.

fault interrupter (FI): Self-controlled mechanical switching device capable of making, carrying, and switching continuous current, and making and automatically interrupting fault current without auto-reclosing capability. It includes an assembly of control elements to detect overcurrents and control the FI.

line-charging current: The rms current in amperes flowing in an energized high-voltage overhead line operating at no-load.

⁸IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

⁹Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

¹⁰Information on references can be found in Clause 2.

non-sustained disruptive discharge (NSDD): Disruptive discharge associated with current interruption that does not result in the resumption of power frequency current or, in the case of capacitive current interruption, does not result in current in the main load circuit.

pad-mounted equipment: Enclosed equipment, the exterior enclosure of which is at ground potential, positioned on a surface-mounted pad.

NOTE—The term *pad-mounted enclosure* is also defined in 3.9 of IEEE Std C57.12.28-2005 as follows: “An enclosure containing electrical apparatus, typically located outdoors at ground level where the general public has direct contact with the exterior surfaces of the equipment. The general construction of this equipment is such that authorized personnel may obtain direct access to the apparatus inside the equipment compartment(s).”

partial discharge extinction voltage (U_e): Applied voltage at which repetitive partial discharges cease to occur in the test object when the voltage applied to the object is gradually decreased from a higher value at which partial discharge pulse quantities are observed.

NOTE—In practice, the extinction voltage U_e is the highest applied voltage at which the magnitude of a chosen partial discharge pulse quantity becomes equal to, or less than, a specified low value.

partial discharge inception voltage (U_i): Applied voltage at which repetitive partial discharges are first observed in the test object when the voltage applied to the object is gradually increased from a lower value at which no partial discharges are observed.

NOTE—In practice, the inception voltage U_i is the lowest applied voltage at which the magnitude of a partial discharge pulse quantity becomes equal to or exceeds a specified low value.

prospective transient recovery voltage (of a circuit): Transient recovery voltage following the breaking of the prospective symmetrical current by an ideal switching device.

NOTE 1—This definition assumes that the switching device or the fuse, for which the prospective transient recovery voltage is sought, is replaced by an ideal switching device, i.e., having instantaneous transition from zero to infinite impedance at the very instant of zero current, i.e., at the “natural” zero. For circuits where the current can follow several different paths, e.g., a polyphase circuit, the definition further assumes that the breaking of the current by the ideal switching device takes place only in the pole considered.

NOTE 2—The terms *prospective transient recovery voltage* and *inherent transient recovery voltage* are often used interchangeably.

re-ignition: Resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of less than a quarter cycle of power frequency.

restrike (of an ac mechanical switching device): Resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current for a quarter cycle of power frequency or longer.

submersible: Constructed to be successfully operable when submerged in water under specified conditions of pressure and time.

sealed pressure system: Volume for which no further gas or vacuum processing is required during its expected operating life.

NOTE 1—Examples of sealed pressure systems are tubes of vacuum circuit-breakers or some SF₆ circuit-breakers.

NOTE 2—Sealed pressure systems are completely assembled and tested in the factory.

unit operation of a fault interrupter: A single interrupting operation as illustrated in Figure 1.

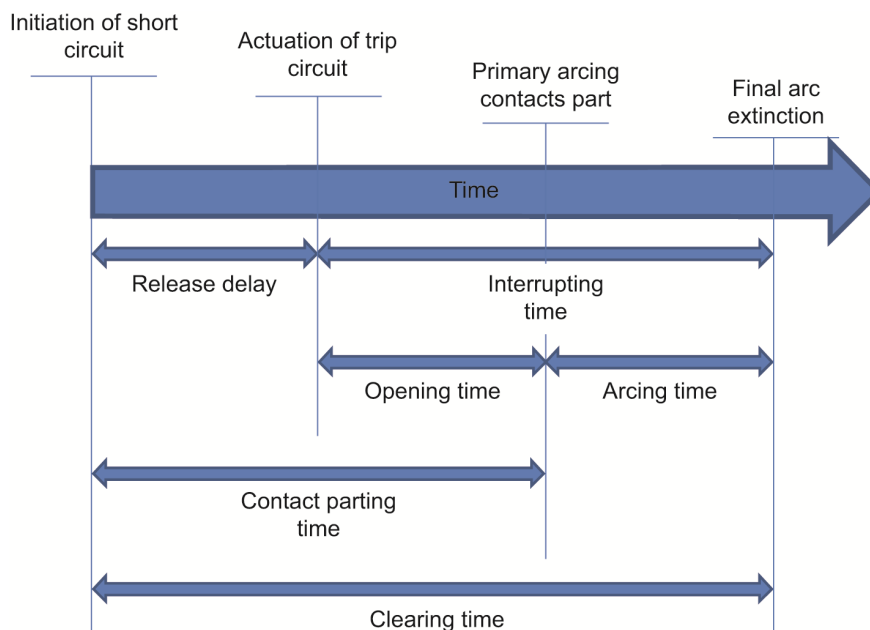


Figure 1—Unit operation of a fault interrupter

4. Normal (usual) and special (unusual) service conditions

4.1 Normal (usual) service conditions

Unless otherwise specified, switchgear, including the operating devices and the auxiliary equipment that form an integral part of them, are intended to be used in accordance with their rated characteristics and the normal (usual) service conditions as listed in this subclause.

Subclause 3.2 of IEEE Std C37.100.1-2018 is applicable for FI equipment with the following additions.

Normal (usual) conditions for submersible equipment include the following:

- Water head does not exceed 3 m above the base of the unit for a duration not to exceed 10 days.
- Exposure to chemical or electrochemical reactions may be encountered in a subgrade environment. These chemicals may contribute to mild corrosive reactions.

4.2 Special (unusual) service conditions

If any of the actual service condition requirements differ from the normal (usual) service conditions, switchgear and associated operating devices and auxiliary equipment shall be designed to comply with any special (unusual) conditions required by the user, or appropriate arrangements shall be made as stated in this subclause.

Subclause 3.3 of IEEE Std C37.100.1-2018 is applicable.

5. Ratings

The ratings of the FI and cutout mounted FI shall be as specified in Table 1.

Table 1—Ratings for fault interrupters

Item	Rating description	Reference
1	Rated maximum voltage (V) or (U_r)	5.1
2	Rated insulation level (U_d), (U_p)	5.2 ^{b, c}
3	Rated power-frequency (f_r)	5.3
4	Rated continuous current (I_r)	5.4
5	Rated short-time withstand current (I_k)	5.5
6	Rated peak withstand current (I_p)	5.6
7	Rated duration of short-time withstand current (t_k)	5.7
8	Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)	5.8
9	Rated supply frequency of closing and opening devices and of auxiliary and control circuits	5.9
10	Rated pressure of compressed gas supply for insulation and/or operation	5.10
11	Rated filling levels for insulation and/or operation	5.11
12	Rated minimum tripping current ($I_{>min}$)	5.12
13	Rated symmetrical interrupting current	5.13
14	Rated symmetrical (fault) making current	5.14
15	Rated operating sequence	5.15
16	Rated line-charging and cable-charging interrupting currents	5.16 ^{a, d}

^a Line-charging and cable-charging switching are related required capabilities.

^b The rated insulation level for a cutout mounted FI is derived in part from the cutout fuse support or base in which it is installed. The cutout fuse support or base shall be considered a part of the cutout mounted FI for the purpose of design testing.

^c Open position tests for a cutout mounted FI is given for the device in the “dropped-out” position unless an operating sequence allows the device to rest with an open interrupter gap and a closed isolation gap in which case, both the isolation gap alone and the interrupter gap alone shall be tested for the open position test cases.

^d Switching capability for a cutout mounted FI may require the use of an auxiliary open and closing device. The auxiliary open and closing device shall be considered a part of the cutout mounted FI for the purpose of design testing. Consult manufacturer for operating details.

5.1 Rated maximum voltage (V) or (U_r)

The rated voltage (rated maximum voltage) indicates the upper limit of the highest voltage of the system for which FIs are intended to operate.

The preferred values of rated voltage of FIs are those shown in Column (2) of Table 2.¹¹

¹¹ The numbers in brackets correspond to those of the bibliography in Annex A.

5.2 Rated insulation level (U_d), (U_p)

The preferred values for rated insulation levels of the FI shall be as specified in Table 2.

Table 2—Preferred voltage ratings and related test requirements^a

Line No.	Rated maximum voltage, V or U_r	Rated lightning impulse withstand voltage, U_p ^b	Rated short-duration power-frequency withstand voltage, U_d ^b		DC withstand test ^{b, c} (See NOTE 1)
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
			1 min dry	1 min wet ^d	15 min
	kV, rms	kV, peak	kV, rms	kV, rms	kV
Pad-mounted, dry vault, submersible FIs					
1	15.5	95	35	—	53
2	27	125	40	—	78
3	38	150	50	—	103
Overhead FIs					
4	15.5	110	50	50	—
5	27	125	60	60	—
6	38	150	70	70	—
7	38	170	70	70	—

NOTE 1—DC withstand testing of 36/38 kV cables is not a recommended practice. Very low frequency (VLF) testing is used as an alternative to the dc withstand test in cable systems. Reference IEEE Std 400.2™ [B7].

^a The test values shown in Table 2 are for design tests; refer to 9.1 for field-testing.

^b These are performance characteristics specified as test requirements in this standard.

^c DC withstand tests are required for pad-mounted, dry vault, and submersible gear since this type of equipment is interfaced to the power system via separable connectors. The test requirements of separable connectors are specified in IEEE Std 386 and these values are reproduced here in column (6). The dc withstand test requirement on the FI demonstrates its capability to withstand either dc withstand or very low frequency (VLF) testing of connected cables.

^d Wet tests are not required for pad-mounted, dry vault, and submersible FI.

5.3 Rated power frequency (f_r)

The rated power frequency shall be the frequency at which the FI and its components are designed to operate. The values of the rated power frequency are 60 Hz or 50 Hz.

5.4 Rated continuous current (I_r) and temperature rise

5.4.1 Rated continuous current (I_r)

Subclause 5.5.1 of IEEE Std C37.100.1-2018 is applicable with the following addition:

The historic values of 560 A, 600 A, and 1200 A, while not part of the R10 series (see 5.13), are also recognized as accepted commonly used values.

5.4.2 Temperature rise

Subclause 5.5.2 of IEEE Std C37.100.1-2018 is applicable.

5.5 Rated short-time withstand current (I_k)

Subclause 5.6 of IEEE Std C37.100.1-2018 is applicable.

5.6 Rated peak withstand current (I_p)

Subclause 5.7 of IEEE Std C37.100.1-2018 is applicable with the following additions.

An FI is required, by definition, to open and interrupt any current within its symmetrical interrupting current rating with peak currents determined by the X/R of the defined test circuits. This capability is demonstrated by the standard operating duty test defined in 7.15.4.

5.7 Rated duration of short-time withstand current (t_k)

The standard rated duration of short-time withstand current (t_k) is 0.5 s unless otherwise stated by the manufacturer and listed on the nameplate. Optional preferred values are 1 s, 2 s, and 3 s.

5.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)

Subclause 5.9 of IEEE Std C37.100.1-2018 is applicable.

5.9 Rated supply frequency of closing and opening devices and of auxiliary and control circuits

Subclause 5.10 IEEE Std C37.100.1-2018 is applicable.

5.10 Rated pressure of compressed gas supply for insulation and/or operation

For devices that use a compressed gas supply, the rated pressure of compressed gas supply for insulation and/or operation shall be stated by the manufacturer.

5.11 Rated filling levels for insulation and/or operation.

The pressure in Pa or psi (or density) or liquid mass shall be assigned by the manufacturer and referred to atmospheric air conditions of 20 °C at which the gas-filled or liquid-filled switchgear is filled before being put into service.

5.12 Rated minimum tripping current ($I_{tr min}$)

The minimum tripping current shall be stated by the manufacturer, with a tolerance not to exceed the greater of $\pm 10\%$ or ± 3 A.

NOTE—The minimum tripping current for shunt-trip FIs is variable and is independent of the rated continuous current. Information on specific FIs should be obtained from the manufacturer.

5.13 Rated symmetrical interrupting current

The rated symmetrical interrupting current is the highest value of the symmetrical component of the short circuit current that the FI shall be capable of breaking under the conditions of use and behavior prescribed in this standard.

NOTE—The term *rated symmetrical interrupting current* as used in this standard is equivalent to the term rated short-circuit current as used in IEEE Std C37.04 [B8].

An FI is required, by definition, to open and interrupt any current within its symmetrical interrupting current rating with the duration of the current defined by its automatic control. This capability is demonstrated by the standard operating duty test defined in 7.15.4.

The preferred rated symmetrical interrupting currents of FIs shall be selected from the R10 series specified in IEC 60059. The R10 series comprises the numbers 1 – 1.25 – 1.6 – 2 – 2.5 – 3.15 – 4 – 5 – 6.3 – 8 and their products by 10^n .

The rated symmetrical interrupting current shall be based on the capability of the FI to interrupt the corresponding asymmetrical current in circuits having X/R values as given in columns (4), (8), and (12) of Table 9 and with a power-frequency recovery voltage equal to the rated maximum voltage and with transient recovery voltages as defined in Table 11, Table 12, Table 13, and Table 14.

5.14 Rated symmetrical (fault) making current

FIs shall be capable of making, at any applied voltage up to and including that corresponding to their rated voltage, any current up to and including their rated symmetrical making current.

The rated symmetrical making current shall be the same value as the rated symmetrical interrupting current, with maximum asymmetry corresponding to the X/R ratio in column (12) of Table 9.

5.15 Rated operating sequence

The rated operating sequence for FIs is CO.

Where CO represents a closing operation followed by an opening operation with a time delay controlled by the automatic control of the device.

5.16 Rated line-charging and cable-charging interrupting currents

The preferred line- and cable-charging interrupting current ratings for FIs are as given in Table 3.

Table 3—Preferred line- and cable-charging interrupting current ratings

Rated maximum voltage kV	Rated interrupting current A (rms)	
	Line charging	Cable charging
15.5	2	10
27	5	25
38	5	40

6. Design and construction

6.1 Requirements for liquids in switchgear

Subclause 6.1.1 of IEEE Std C37.100.1-2018 is applicable.

6.1.1 Liquid level

Subclause 6.1.2 of IEEE Std C37.100.1-2018 is applicable.

6.1.2 Liquid quality

Subclause 6.1.3 of IEEE Std C37.100.1-2018 is applicable.

6.1.3 Oil sampling provision

When oil is used as the insulating medium, provision shall be made to obtain a bottom oil sample.

6.2 Requirements for gases in switchgear

Subclause 6.2 of IEEE Std C37.100.1-2018 is applicable.

6.3 Grounding provisions

An FI with a metal housing shall have provisions for the connection of a ground lead.

The ground connector shall accommodate a ground conductor of a size adequate to conduct the rated symmetrical interrupting current of the FI for the duration of at least 1.5 t_k without damage to the conductor or connector. The peak current of the first major loop shall be as defined in 5.7 of IEEE Std C37.100.1-2018.

An FI control housing that may be mounted separately from the FI or that contains control elements that rely on solid grounding for surge immunity shall also have provisions for the connection of a ground lead.

Pad-mounted, dry vault and submersible FIs shall have an additional grounding connection for each three-phase set of cable entrances.

6.4 Auxiliary and control equipment

No requirements are specified at this time.

6.5 Dependent power operation

Subclause 6.5 of IEEE Std C37.100.1-2018 is applicable.

6.6 Stored energy operation

Subclause 6.6 of IEEE Std C37.100.1-2018 is not applicable.

When indicators are used on stored energy operating mechanisms, the following colors shall be used subject to any local codes or indicator requirements:

- a) Yellow background with CHARGED in black letters for charged mechanisms
- b) White background with DISCHARGED in black letters for discharged mechanisms

As an alternative, red letters on a white background for both indicators may be used.

NOTE—Customer (user) preferences or local codes for indicators should be specified by the user.

6.7 Independent manual operation

Subclause 6.7 of IEEE Std C37.100.1-2018 is applicable with the following addition.

FIs shall be provided with a manual operating lever to open the FI. The opening operation shall be an independent manual operation. For overhead FIs the operating lever shall be suitable for operation with a hot line stick.

NOTE—Some applications may require that the operating lever on a submersible FI be located such that one person standing on the surface can operate it without standing directly over the FI. These special applications should be specified by the user.

6.8 Manually operated actuators

Devices that require a dependent manual operation are not covered by this standard.

6.9 Operation of releases

6.9.1 Shunt closing release

If shunt closing releases are supplied, a shunt closing release shall operate correctly within the minimum and maximum operating voltage range specified in 5.8.

6.9.2 Shunt opening release

A shunt opening release shall operate correctly under all operating conditions of the switching device up to its rated symmetrical interrupting current.

The opening release shall operate correctly within the minimum and maximum operating voltage range specified in 5.8.

6.9.3 Capacitor operation of shunt releases

When, for stored energy operation of a shunt release, a rectifier-capacitor combination is provided as an integral part of the switching device, the charge of the capacitors is derived from the voltage of the main circuit or the auxiliary supply, the capacitors shall retain a charge sufficient for satisfactory operation of the release for a minimum of 5 s after the loss of or the shorting of the voltage supply.

The voltages of the main circuit before disconnection shall be taken as the lowest voltage of the system associated with the rated voltage of the switching device.

6.9.4 Under-voltage release

If under-voltage releases are supplied, an under-voltage release shall operate to open the switching device when the voltage at the terminals of the release falls below 35% of its rated voltage, even if the fall is slow and gradual.

On the other hand, it shall not operate the switching device when the voltage at its terminals exceeds 70% of its rated supply voltage.

The closing of the switching device shall be possible when the values of the voltage at the terminals of the release are equal to or higher than 85% of its rated voltage. Its closing shall be impossible when the voltage at the terminals is lower than 35% of its rated supply voltage.

6.10 Low- and high-pressure interlocking and monitoring devices

Subclause 6.9 of IEEE Std C37.100.1-2018 is applicable.

NOTE—Low- and high-pressure interlocking devices are generally applicable to FIs using a closed pressure system for compressed air or SF₆ for insulating or interrupting purposes. For sealed-pressure systems, these devices are not required.

6.11 Nameplate markings

Subclause 6.10 of IEEE Std C37.100.1-2018 is applicable, with the following additions.

The nameplates for FIs shall be marked in accordance with Table 4.

NOTE—It should be stated whether pressures (or densities) are absolute or relative values.

If the switchgear consists of several poles with independent operating mechanisms, each pole shall be provided with a nameplate. This requirement is not applicable if all of the pole mechanisms are mounted to a common structure.

For submersible FIs, a nameplate of stainless steel or other corrosion-resistant material shall be provided. The nameplate shall be securely attached to the tank by means of stainless-steel screws, rivets, or other corrosion-resistant fasteners. All letters, schematics, and numbers shall be permanently stamped, embossed, or engraved on the nameplate.

Table 4—Nameplate markings

	Abbreviation ^b	Unit	Condition: Marking only required if	Marking requirement (see NOTE)
(1)	(2)	(3)	(4)	(5)
Manufacturer's name or trademark				X
Manufacturer's type designation				X
Equipment type ^a				X
Rated maximum voltage	V or U_r	kV		X
Rated lightning impulse withstand voltage	U_p	kV		X
Rated power-frequency	F_r	Hz	Rating is not applicable at both 50 Hz and 60 Hz	y
Rated continuous current	I_r	A		X
Rated duration of short-time withstand current	T_k	S	Different from 0.5 s	y
Rated symmetrical interrupting current		A or kA		X
Rated line-charging and cable-charging interrupting currents	I_c	A	Suitable only for applications in solidly grounded power systems	y
Rated minimum tripping current	$I_{>min}$	A	Non-adjustable series-trip-fault interrupters	y
Rated operating sequence			Different from the preferred sequences (see 5.15)	y
Rated ice breaking capability			Greater than 1 mm and if type testing is required (see 7.22.1)	(X) y

Table 4—Nameplate markings (continued)

	Abbreviation ^b	Unit	Condition: Marking only required if	Marking requirement (see NOTE)
(1)	(2)	(3)	(4)	(5)
Type and quantity (volume of liquid or mass of gas) of insulating material		l (gal) or kg (lb) ^c	Contains fluid or gas	y
Mass (including oil for oil-filled devices)		kg (lb) ^c		X
Serial number and date of manufacture				X
NOTE—In column (5): X = the marking of these values is mandatory; blanks indicate the value zero; (X) = the marking of these values is optional; y = the marking of these values to the conditions in column (4).				

^a Equipment type: the nameplate shall also contain the word(s) “fault interrupter” or “cutout mounted fault interrupter” in accordance with its capability as defined by this standard.

^b The abbreviation in column (2) may be used instead of the term in column (1). When the term in column (1) is used, the word “rated” is not required.

^c SI metric units are preferred; alternate units in parentheses () are acceptable.

6.12 Interlocking devices

Subclause 6.11 of IEEE Std C37.100.1-2018 is applicable.

6.13 Position indicator

Subclause 6.12 of IEEE Std C37.100.1-2018 is applicable with the following additions.

For pad-mounted, dry vault or submersible FIs viewing of the position indicator may require opening of the pad-mounted or underground enclosure.

In the absence of user specifications, the preferred colors to indicate an open or closed position are red to signify closed and green to signify open.

6.14 Degrees of protection provided by enclosures

Subclause 6.13 and all of its subclauses in IEEE Std C37.100.1-2018 are not applicable to FIs designed to be mounted on an overhead structure (e.g., pole or frame), within a dry vault or submersible location.

Subclause 6.13 of IEEE Std C37.100.1-2018 is applicable to pad-mounted FIs with the additions in 6.14.1, 6.14.2, and 6.14.3.

6.14.1 Protection of persons against access to hazardous parts and protection of the equipment against ingress of solid foreign objects (IP coding)

Pad-mounted FIs shall conform to the degree of protection level IP4X or higher. Conformance to Clause 4 of IEEE Std C57.12.28-2005 shall constitute fulfillment of this requirement.

NOTE—The IP45 protection level specifies a probe >1 mm in diameter, which is slightly smaller than the number 14-gauge wire (1.63 mm) specified in IEEE Std C57.12.28-2005.

6.14.2 Protection against ingress of water (IP coding)

Pad-mounted FIs shall conform to the degree of protection level IPX5 or higher. Conformance to IEEE Std C57.12.28-2005 shall constitute fulfillment of this requirement.

6.14.3 Protection of equipment against mechanical impact under usual service conditions (IK coding)

C37.100.1-2018 does not apply. Subclause 5.5.3 of IEEE Std C57.12.28-2005 is applicable.

6.15 Creepage distances for outdoor insulators

Subclause 6.14 of IEEE Std C37.100.1-2018 is applicable with the following addition:

The minimum creepage distances apply to glass and ceramic insulators. Values for other materials are under consideration.

6.16 Gas and vacuum tightness

The following specifications apply to all FIs that use vacuum or gas, other than ambient air, as an insulating, combined insulating and interrupting, or operating medium. IEEE Std C37.100.1-2018, Annex G, gives some information, examples, and guidance for tightness.

6.16.1 Controlled pressure systems for gas

The tightness of controlled pressure systems for gas is specified by the number of replenishments per day (N) or by the pressure drop per day (D_p). The permissible values shall be given by the manufacturer.

6.16.2 Closed pressure systems for gas

The tightness characteristic of a closed pressure system and the time between replenishment under usual service conditions shall be stated by the manufacturer and shall be consistent with a minimum maintenance and inspection philosophy.

The tightness of closed pressure systems for gas is specified by the relative leakage rate F_{rel} of each compartment; standardized values are as follows:

- For SF₆ and SF₆ mixtures, the standardized values are 0.5% and 1% per year
- For other gases, the standardized values are 0.5%, 1%, and 3% per year.

The maximum gas leak rate shall not exceed the rate corresponding to a minimum 10-year replenishment period for SF₆ systems and for other gases should be consistent with the tightness values.

The possible leakages between subassemblies having different pressures shall also be taken into account. In the particular case of maintenance in a compartment when adjacent compartments contain gas under pressure, the permissible gas leakage rate across partitions should also be stated by the manufacturer, and the time between replenishments shall be not less than one month.

Means shall be provided to enable gas systems to be safely replenished while the equipment is in service.

6.16.3 Sealed pressure systems

The tightness of sealed pressure systems is specified by their expected operating life.

The expected operating life with regard to leakage performance shall be specified by the manufacturer. Preferred values are 20 years, 30 years, and 40 years.

NOTE—To fulfill the expected operating life requirement, the leakage rate for SF₆ systems is considered to be 0.1% per year.

6.16.4 Design and withstand pressure

FIs with operating pressure greater than 101.3 kPa (1 atm) (absolute) shall adhere to the requirements of local jurisdictional codes as applicable.

6.17 Liquid tightness

Subclause 6.16 of IEEE Std C37.100.1-2018 is applicable with the following addition.

Tank construction for liquid filled or non-pressurized devices shall be such that leaks will not occur and the FI will remain mechanically operable at the maximum operating pressure generated by the normal operation of the FI (for example, at continuous current, load interrupting and fault closing).

6.18 Flammability

No requirements are specified for flammability in this standard at this time.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.18 of IEEE Std C37.100.1-2018 is not applicable.

The auxiliary and control circuits shall be able to withstand electromagnetic disturbances stated in 7.23 without damage or malfunction

6.20 X-ray emission

Subclause 6.19 of IEEE Std C37.100.1-2018 applies.

6.21 Enclosure construction—submersible and pad-mounted equipment

The requirements of IEEE Std C37.74-2014, 9.9, shall apply.

6.22 Enclosure construction —pad-mounted equipment security

The requirements of IEEE Std C37.74-2014, 9.10, shall apply.

6.23 Conductor terminal sizes

For connection of bare conductors, terminals shall accommodate conductors of a size adequate to conduct the rated continuous current of the FI without exceeding the appropriate temperature rise shown in IEEE Std C37.100.1-2018, 5.5.2.

NOTE—For FIs fitted with cable terminations, bushings should accommodate cable terminations in accordance with the IEEE Std 386 or IEC 60502 series [B3] unless otherwise specified by the user.

7. Design tests

7.1 General

FIs shall be capable of meeting the design tests described in 7.3 through 7.27 inclusive as applicable. Once made, the type tests need not be repeated unless the design is changed so as to modify the performance characteristics of the FI.

Refer to Annex E for tolerances applied to test values.

7.1.1 Grouping of tests

Subclause 7.2 of IEEE Std C37.100.1-2018 is applicable with the following addition and modification:

It is not required that the design (type) tests be carried out on a maximum of four test specimens. The manufacturer shall identify the number of test samples used in the design (type) tests.

Reconditioning is not permitted during any individual type test. The complete standard operating duty test specified in 7.15 is considered as one type test.

7.1.2 Information for identification of specimens

Subclause 7.2.2 of IEEE Std C37.100.1-2018 is applicable with the following addition:

The definition of an FI includes its automatic control. Manufacturer shall include in the information provided to the testing laboratory sufficient information to identify the control used in the design tests. Where appropriate, this information shall include model number, serial number, firmware revision, software revision, and other appropriate control software information.

A cutout mounted FI also has a cutout fuse type mounting or support that is considered part of the device. This mounting or support is integral to the dielectric capability of the device. Manufacturer shall include in the information provided to the testing laboratory sufficient information to identify the cutout fuse mounting or support used in the design tests. Where appropriate, this information shall include make, model number, and rating.