



IEEE Standard for High-Voltage Gas-Insulated Substations Rated Above 52 kV

IEEE Power and Energy Society

Developed by the
Substations Committee
and the
Switchgear Committee

IEEE Std C37.122™-2021
(Revision of IEEE Std C37.122-2010)



STANDARDS

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Substations Committee
and the
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of the
IEEE Power and Energy Society

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IEEE SA Standards Board

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Abstract: The technical requirements for the design, fabrication, testing, and installation of a gas-insulated substations are covered. The parameters to be supplied by the purchaser are set, and the technical requirements for the design, fabrication, testing, and installation details to be furnished by the manufacturer are established.

Keywords: gas-insulated metal enclosed switchgear, gas-insulated substation, gas-insulated switchgear, GIS, GIS design, GIS equipment, GIS installation, GIS testing, IEEE C37.122™, SF₆, sulfur hexafluoride

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Introduction

This introduction is not part of IEEE Std C37.122-2021, IEEE Standard for High-Voltage Gas-Insulated Substations Rated Above 52 kV.

This issue of IEEE Std C37.122™ is a revision of IEEE Std C37.122-2010™. In this revision, the clauses were updated to refer to IEEE Std C37.100.1-2018™, normative references and definitions were updated, clarity was given for the requirements for primary switches, and other editorial changes were made.

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IEC 62271-102: Subclause 6.103, Annex B, Annex C, and Annex F.

IEC 62271-203: Subclauses: 6.101; 6.102; 6.103; 6.104; and 6.105.

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IEEE Standard for High-Voltage Gas-Insulated Substations Rated Above 52 kV

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1. Overview

1.1 Scope

~~This standard establishes ratings and~~ The requirements for ~~planning, design, testing, installation, and operation of~~ gas-insulated substations (GIS) for alternating-current (ac) applications above 52 kV. ~~Typical installations~~ are assemblies contained in this standard. GIS is an assembly of switching and bus components and may contain a number of ~~specialized devices such as buses,~~ circuit breakers, switches, ~~bushings, buses,~~ instrument transformers, ~~cable~~ arresters, and primary terminations, ~~instrumentation and controls, and the gas-insulating system. It does not include certain items that may be directly connected to gas-insulated substations, such as power transformers and protective relaying.~~ This standard ~~does not apply to gas-insulated transmission lines.~~ includes all the requirements (including switching requirements) of disconnect switches, ground switches, and fault making ground switches included in a GIS. For the other components comprising the GIS, the additional and/or specific GIS requirements are contained in this standard.

1.2 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*).^{1,2}

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/ASME Boiler and Pressure Vessel Code, Section VIII: Pressure Vessels, Division 1.~~^{1,2}

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

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~~ANSI/ASME B31.1, Power Piping.~~

ANSI/NEMA CC 1, Electric Power Connection for Substations.³

CENELEC EN 50052, ~~Specification for Cast Aluminum Alloy Enclosures for High-voltage switchgear and controlgear—Gas-Filled High Voltage~~ filled cast aluminium alloy enclosures Switchgear and Controlgear^{3,4}

CENELEC EN 50064, ~~Specification for~~ Wrought Aluminum and Aluminum-Alloy Enclosures for Gas-Filled High-Voltage Switchgear and Controlgear.

CENELEC EN 50069, ~~Specification for Welded Composite Enclosures of Cast and Wrought Aluminum Alloys for High-voltage switchgear and controlgear—Gas-Filled High Voltage Switchgear and Controlgear.~~ filled welded composite enclosures of cast and wrought aluminium alloys.

~~IEC 60044-1, Instrument transformers—Part 1: Current transformers.~~⁴

~~IEC 60044-2, Instrument transformers—Part 2: Inductive voltage transformers.~~

~~IEC 61180-1, High-voltage test techniques for low-voltage equipment—Part 1: Definitions, test and procedure requirements.~~

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~~IEC 61462, Composite hollow insulators—Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1000 V—Definitions, test methods, acceptance criteria and design recommendations.~~

~~IEC 61639, Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72,5 kV and above.~~

~~IEC 62155, Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V.~~

~~IEC 62262, Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).~~

IEC 62271-1:[2017](#), High-voltage switchgear and controlgear—Part 1: Common specifications ~~for alternating current switchgear and controlgear.~~⁵

IEC 62271-102:[2018](#), High-voltage switchgear and controlgear—Part 102: Alternating current disconnectors and earthing switches.

IEC 62271-203:[2011](#), High-voltage switchgear and controlgear—Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV.

IEC 62271-209, High-voltage switchgear and controlgear—Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV—Fluid-filled and extruded insulation cables— Fluid-filled and dry-type cable-terminations.

IEC 62271-~~303~~[211](#), High-voltage switchgear and controlgear—Part ~~303: Use~~[211: Direct connection between power transformers and handling of sulfur hexafluoride \(SF₆\)](#) gas-insulated metal-enclosed switchgear for rated voltages above 52 kV.

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

IEEE Std C37.04TM, IEEE Standard ~~Rating Structure~~[for Ratings and Requirements](#) for AC High-Voltage Circuit Breakers ~~Rated on a~~[with Symmetrical Current Basis](#).⁵ [Rated Maximum Voltage Above 1000 V](#).^{6,7}

IEEE Std C37.06TM,⁹~~09TM~~, IEEE Standard [Test Procedures](#) for AC High-Voltage Circuit Breakers ~~with Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities for Voltages~~[Maximum Voltage](#) Above 1000 V.

IEEE Std C37.09TM,¹⁰~~010TM~~, IEEE ~~Standard Test Procedure~~[Application Guide](#) for AC High-Voltage Circuit Breakers [≥ 1000 Vac](#) Rated on a Symmetrical Current Basis.

IEEE Std C37.010TM,¹¹~~011TM~~, IEEE [Guide for the Application](#) ~~Guide~~[of Transient Recovery Voltage](#) for AC High-Voltage Circuit Breakers [with Rated on a Maximum Voltage Above 1000 V Symmetrical Current Basis](#).

~~IEEE Std C37.011TM, IEEE Application Guide for Transient Recovery Voltage for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.~~

IEEE Std C37.012TM, IEEE Application Guide for [of](#) Capacitance Current Switching for AC High-Voltage Circuit Breakers ~~Rated on a Symmetrical Current Basis~~[Above 1000 V](#).

IEEE Std C37.015TM,¹⁵~~015TM~~, IEEE Guide for the Application ~~for~~[of](#) Shunt Reactor Switching.

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⁵~~IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.~~

~~IEEE P1712TM, Draft 7, August 2007, Draft Guide for Sulfur Hexafluoride (SF₆) Gas Handling for High Voltage (over 1000 Vac) Equipment.~~⁶

IEEE Std C37.017TM, [IEEE](#), ~~Draft 4, February 2010, Draft~~ Standard for Bushings for High-Voltage (Over 1000 ~~Volts ac~~ [Vac](#)) Circuit Breakers and Gas-Insulated Switchgear.⁷

IEEE Std C37.21TM, IEEE Standard for Control Switchboards.

IEEE Std C37.24TM, IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear.

IEEE Std C37.100TM, IEEE Standard Definitions for Power Switchgear.

IEEE Std C37.100.1TM-~~2007~~[2018](#), IEEE Standard ~~of~~[for](#) Common Requirements for High Voltage Power Switchgear Rated Above 1000 V.

[IEEE Std C37.122.3TM-2011, IEEE Guide for Sulphur Hexafluoride \(SF₆\) Gas Handling for High-Voltage \(over 1000 Vac\) Equipment.](#)

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

~~IEEE Std C57.13TM, IEEE Standard Requirements for Instrument Transformers.~~

~~IEEE Std 48TM, IEEE Standard Test Procedures and Requirements for Alternating Current Cable Terminations 2.5 kV through 765 kV.~~

~~IEEE Std 80TM, IEEE Guide for Safety in AC Substation Grounding.~~

⁶Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE-SA.

⁷IEEE PC37.017, Draft 6, was approved as a standard by the IEEE Standards Board on 8 December, 2010 (IEEE Std C37.017-2010).

~~IEEE Std 315TM, IEEE Standard/American National Standard/Canadian Standard: Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters).~~

~~IEEE Std 367TM, IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage From a Power Fault.~~

~~IEEE Std 693TM, IEEE Recommended Practices for Seismic Design of Substations. IEEE Std 1300TM, IEEE Guide for Cable Connections for Gas-Insulated Substations.~~

IEEE Std [C37.122.61416TM](#), IEEE Recommended Practice for the Interface of New Gas-Insulated Equipment in Existing Gas-Insulated Substations [Rated above 52 kV](#).

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

[IEEE Std C57.13TM, IEEE Standard Requirements for Instrument Transformers.](#)

[IEEE Std 48TM, IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.](#)

[IEEE Std 80TM, IEEE Guide for Safety in AC Substation Grounding.](#)

[IEEE Std 315TM, IEEE Standard/American National Standard/Canadian Standard: Graphic Symbols for Electrical and Electronics Diagrams \(Including Reference Designation Letters\).](#)

[IEEE Std 693TM, IEEE Recommended Practices for Seismic Design of Substations.](#)

[IEEE Std 837TM, IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding. IEEE Std 1300TM, IEEE Guide for Cable Connections for Gas-Insulated Substations.](#)

~~2. Normal (usual) and special (unusual) service conditions~~

~~2.1 Normal (usual) service conditions~~

~~Subclause 2.1 of IEEE Std C37.100.1-2007 applies with the following additions:~~

~~Vibration and shock. The equipment shall withstand for its service life the vibration of any directly connected equipment, such as transformers, and the shock caused by the operation or maintenance of the equipment.~~

~~2.1.1 Indoor switchgear~~

~~Subclause 2.1.1 of IEEE Std C37.100.1-2007 applies. Many indoor applications do not require -30°C low temperature capability. In these cases -25 or -5°C are common values specified.~~

~~2.1.2 Outdoor switchgear~~

~~Subclause 2.1.2 of IEEE Std C37.100.1-2007 applies with following additions and modifications:~~

~~Wind speed value of 40 m/s stated in 2.1.2 f) of IEEE Std C37.100.1-2007 is applied in some specific regions as in North America. Lower wind speed value of 34 m/s may be applied in some specific regions, as stated in corresponding clause of IEC 62271-1.~~

~~For installations in a location where the ice loading can be outside the normal (usual) service condition as stated in 2.1.2 of IEEE Std C37.100.1-2007, the preferred maximum ice loading values are:~~

~~a) — 10 mm for class 10~~

~~b) — 20 mm for class 20~~

~~2.2 Special (unusual) service conditions for both indoor and outdoor switchgear~~

~~2.2.1 Altitude~~

~~Subclause 2.2.1 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.2 Exposure to excessive pollution~~

~~Subclause 2.2.2 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.3 Temperature and humidity~~

~~Subclause 2.2.3 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.4 Exposure to abnormal vibration, shock, or tilting~~

~~Subclause 2.2.4 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.5 Other special (unusual) service conditions~~

~~2.2.5.1 Exposure to damaging fumes, vapor, steam, oil vapors, salt air, and hot and humid climate~~

~~Subclause 2.2.5.1 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.5.2 Exposure to excessive dust or abrasive, magnetic, or metallic dust~~

~~Subclause 2.2.5.2 of IEEE Std C37.100.1-2007 applies.~~

~~2.2.5.3 Exposure to explosive mixtures of dust or gases~~

~~Subclause 2.2.5.3 of IEEE Std C37.100.1-2007 applies.~~

2.2.5.4 Unusual space limitations

~~Subclause 2.2.5.4 of IEEE Std C37.100.1-2007 applies.~~

3. Definitions

For the purposes of this ~~standard~~[document](#), the following terms and definitions apply. ~~The IEEE Std C37.100~~[Standards Dictionary Online](#) should be ~~referenced~~[consulted](#) for terms not defined in this clause. ~~For terms that are not listed in IEEE Std C37.100 users should refer to The IEEE Standards Dictionary: Glossary of Terms & Definitions.~~⁸

alarm pressure p_{ae} (or density ρ_{ae}): For insulation and/or switching pressure (Pa), referred to the standard atmospheric air conditions of +20 °C and 101.3 kPa (or density), which may be expressed in relative or absolute terms, at which a monitoring signal may be provided.

bus-charging current (rated): Current expressed as steady-state rms value, which a disconnect switch is capable of switching when energizing or de-energizing parts of a bus system or similar capacitive loads.

bus-transfer current: The current that flows in a disconnect switch when it transfers load from one bus system to another.

bus-transfer voltage: The power-frequency voltage across the open disconnect switch gap after breaking or before making the bus-transfer current.

class A grounding switch: A grounding switch designated to be used in circuits having relatively short sections of line or low coupling to adjacent energized circuits.

class B grounding switch: A grounding switch designated to be used in circuits having relatively long lines or high coupling to adjacent energized circuits.

⁸IEEE Standards Dictionary: ~~Glossary of Terms & Definitions~~ [Online](http://dictionary.ieee.org) is available at: <http://dictionary.ieee.org>. ~~<http://shop.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.](#)

compartment (GIS): A section of a gas-insulated switchgear assembly that is enclosed except for openings necessary for interconnection providing insulating gas isolation from other compartments. A compartment may be designated by the main components in it, ~~e.g.,~~ [for example](#), circuit breaker compartment, disconnect switch compartment, [or](#) bus compartment, ~~etc.~~

design pressure of enclosures: The maximum gas pressure to which a gas-insulated switchgear enclosure will be subjected under normal service conditions, including the heating effects of rated continuous current.

electromagnetically induced current (grounding switch): The inductive current that a grounding switch is capable of switching when it connects to and disconnects from ground one termination of a de-energized transmission line, with the other termination grounded, and with an energized line carrying current in parallel with, and in proximity to, the grounded line.

electrostatically induced current (grounding switch): The capacitive current that a grounding switch is capable of switching when it connects to or disconnects from ground one termination of a de-energized transmission line, with the other termination open, and with an energized line in parallel with, and in proximity to, the grounded line.

gas monitoring systems: Any instrumentation for measuring, indicating, or giving remote warning of the condition or change in condition of the gas in the enclosure, such as pressure, density, moisture content, etc.

gas-insulated ~~switchgear-substation~~ (GIS): A compact, multi-component [switchgear](#) assembly, enclosed in ~~a~~-grounded metallic ~~housing~~ [housings](#) in which the primary insulating medium is [gas](#), [typically](#) SF₆, and which normally includes buses, switches, circuit breakers, and other associated equipment. ([Also commonly known as gas-insulated switchgear.](#))

gas-insulated switchgear enclosure: A grounded part of gas-insulated metal-enclosed switchgear assembly retaining the insulating gas under the prescribed conditions necessary to maintain the required insulation level, protecting the equipment against external influences and providing a high degree of protection from approach to live energized parts.

gas-insulated switchgear enclosure currents: Currents that result from the voltages induced in the metallic enclosure by effects of currents flowing in the enclosed conductors.

gas leakage rate (absolute): Amount of gas escaped by time unit expressed in units $\text{Pa} \times \text{m}^3/\text{s}$.

gas leakage rate (relative): Absolute leakage rate related to the total amount (mass or volume) of gas in each compartment at rated filling pressure (or density). It is expressed in percentage per year.

gas pass through insulator: An internal insulator supporting one or more conductors specifically designed to allow the passage of gas between adjoining compartments.

gas zone: A section of the GIS ~~which~~that may consist of one or several gas compartments ~~which~~that have a common gas monitoring system. The enclosure can be single-phase or three-phase.

local control cubicle (or cabinet) (LCC): Cubicle or cabinet typically containing secondary equipment including control and interlocking, measuring, indicating, alarm, annunciation, and mimic one-line diagram associated with the primary equipment. It may also include protective relays if specified by the user.

minimum functional pressure p_{me} (or density ρ_{me}): Insulation and/or switching pressure (in Pa), at and above which rated characteristics of switchgear are maintained. It is referred to at the standard atmospheric air conditions of +20 °C and 101.3 kPa (or density) and may be expressed in relative or absolute terms.

partition: Part of an assembly separating one compartment from other compartments. It provides gas isolation and support for the conductor (gas barrier insulator).

power kinematic chain: Mechanical connecting system from and including the operating mechanism up to and including the moving contacts.

NOTE—~~(Figure A.8).~~—See 7.23.⁹

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

rated filling pressure p_{re} : Insulation and/or switching pressure (in Pa), to which the assembly is filled before putting into service. It is referred to at the standard atmospheric air conditions of +20 °C and 101.3 kPa (or density) and may be expressed in relative or absolute terms.

rated pressure of compressed gas supply controlled pressure systems: Rated pressure of a volume ~~which~~[that](#) is automatically replenished from an external compressed gas supply or internal gas source.

rated supply frequency of closing and opening devices and of auxiliary circuits: The frequency of the rated supply voltage, either dc, 50 Hz [ac](#), or 60 Hz ac.

rated supply voltage of closing and opening devices and of auxiliary circuits (U_a): The supply voltage of closing and opening devices and auxiliary and control circuits shall be understood to mean the voltage measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors for the connection to the electricity supply.

transient voltage to ground (TVE): Voltage from conductor to enclosure, [which](#) appears at the first prestrike during a closing operation.

very fast transient (VFT): A class of transients generated internally within GIS characterized by short duration and very high frequency.

water vapor (moisture) content: The amount of water in parts per million by volume (ppmv) that is in the gaseous state and mixed with the insulating gas at 20 °C and rated filling pressure.

NOTE—The terms *pressure* and *density* are often used interchangeably, but are not interchangeable. In general, pressure is used in relation to the mechanical properties of the enclosure and density in relation to electrical characteristics and performance. Often when the term pressure is used (fill pressure for example) it is referenced to a specific temperature and ~~is~~, [therefore](#), [actually](#) specifies a gas density.

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

4.1 General

Subclause 3.1 of IEEE Std C37.100.1™-2018 applies.¹⁰

4.2 Normal (usual) service conditions

4.2.1 Indoor switchgear

Subclause 3.2.1 of IEEE Std C37.100.1-2018 applies with the following additions and modifications:

- The equipment shall withstand for its service life the vibration of any directly connected equipment, such as transformers, and the shock caused by the operation or maintenance of the equipment.
- Many indoor applications do not require –30 °C low temperature capability. In these cases –25 °C or –5 °C are common values specified.

4.2.2 Outdoor switchgear

Subclause 3.2.2 of IEEE Std C37.100.1-2018 applies with following additions and modifications:

- The equipment shall withstand for its service life the vibration of any directly connected equipment, such as transformers, and the shock caused by the operation or maintenance of the equipment.
- Wind speed value of 40 m/s stated in 3.2.2 f) of IEEE Std C37.100.1-2018 is applied in some specific regions as in North America. Lower wind speed value of 34 m/s may be applied in some specific regions, as stated in the corresponding clause of IEC 62271-1.

¹⁰Information on references can be found in Clause 2.

- [For installations in a location where the ice loading can be outside the normal \(usual\) service condition as stated in 3.2.2 e\) of IEEE Std C37.100.1-2018, the preferred maximum ice loading values are:](#)
- [10 mm for class 10](#)
- [20 mm for class 20](#)

[4.3 Special \(unusual\) service conditions for both indoor and outdoor switchgear](#)

[4.3.1 General](#)

[Subclause 3.3 of IEEE Std C37.100.1-2018 applies.](#)

5. Ratings

[5.1 General](#)

The following are electrical ratings that all components within a GIS shall meet or exceed:

The following are electrical ratings that all components within a GIS shall meet or exceed:

- a) Rated maximum voltage (V) or (U_r)
- b) Rated insulation level (U_d), (U_s), (U_p)
- c) Rated power frequency (f_r)
- d) Rated continuous current (I_r)
- e) Rated short-time withstand current (I_k)
- f) Rated peak withstand current (I_p)

- g) Rated duration of short-circuit (t_k)
- h) Rated supply voltage of closing and opening devices and of auxiliary circuits (U_d)
- i) Rated supply frequency of closing and opening devices and of auxiliary circuits

For list and definition of symbols, refer to Table H.1 of IEEE Std C37.100.1-~~2007~~[2018](#).

5.2 Rated maximum voltage (V) or (U_r)

Subclause ~~4.1~~[5.2](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following addition:

Components forming part of the GIS may have individual values of rated voltage in accordance with the relevant standards (e.g., voltage transformers).

5.3 Rated insulation level (U_d , U_s , U_p)

Table 1 gives the preferred values for GIS.

In the event of a conflict in circuit breaker dielectric test levels between this document and IEEE Std [C37.04™](#), ~~C37.06~~, this document shall take precedence.

For GIS application, the dielectric characteristics of the internal insulation are identical whatever the altitude with those measured at sea level. Specific requirements concerning altitude are not applicable except for external insulation (air to gas bushings).

Table 1—Preferred rated insulation values

Rated max. voltage $V(U_r)$ (kV rms)	Rated power-frequency withstand voltage (kV rms)		Rated switching impulse withstand voltage (kV peak)			Rated lightning impulse withstand voltage (kV peak)		
	Test levels U_r	Disconnect switch open gap	Test levels (phase to ground) U_r	Test levels (phase to phase)	Disconnect switch open gap (+ bias)	Test levels U_r	Disconnect switch open gap	Disconnect switch open gap (+ bias)
72.5	140	160	—	—	—	325	375	—
100	185	210	—	—	—	450	520	—
123	230	265	—	—	—	550	630	—
145	275	315	—	—	—	650	750	—
170	325	375	—	—	—	750	860	—
245a	425	490	—	—	—	900	1035	—
245	460	530	—	—	—	1050	1200	—
300	460	595	850	1275	700(+245)	1050	—	1050(+170)
362a	500	650	850	1275	700(+295)	1050	—	1050(+205)
362	520	675	950	1425	800(+295)	1175	—	1175(+205)
420	650	815	1050	1575	900(+345)	1425	—	1425(+240)
550	740	925	1175	1760	900(+450)	1550	—	1550(+315)
800	960	1270	1425	2420	1100(+650)	2100	—	2100(+455)

(New)

Rated max. voltage $V(U_f)$ (kV rms)	Rated power-frequency withstand voltage (kV rms)		Rated switching impulse withstand voltage (kV peak)			Rated lightning impulse withstand voltage (kV peak)		
	Test levels U_{fL}	Disconnect switch open gap	Test levels (phase to ground) U_L	Test levels (phase to phase)	Disconnect switch open gap (+ bias)	Test levels U_P	Disconnect switch open gap	Disconnect switch open gap (+ bias)
72.5	140	160				325	375	
100	185	210				450	520	
123	230	265				550	630	
145	275	315				650	750	
170	325	375				750	860	
245 ^a	425	490				900	1035	
245	460	530				1050	1200	
300	460	595	850	1275	700(+245)	1050		1050(+170)
362 ^a	500	650	850	1275	700(+295)	1050		1050(+205)
362	520	675	950	1425	800(+295)	1175		1175(+205)
420	650	815	1050	1575	900(+345)	1425		1425(+240)
550	740	925	1175	1760	900(+450)	1550		1550(+315)
800	960	1270	1425	2420	1100(+650)	2100		2100(+455)

^a These rows represent additional ratings not harmonized with other international standards.

NOTE—The rated values of this table differ from previous IEEE Std C37.122 and IEEE Std C37.06 values in the interest of harmonization with IEC values and increasing withstand margins across open disconnect switch gaps. AC open gap withstands have been increased from approximately 110% of line to ground withstand for all ratings, to approximately 115% for 245 kV and below and approximately 130% for ratings above 245 kV. This does not imply that equipment in presently in service needs to be replaced as older levels have proven adequate.

(Deleted)

^aThese rows represent additional common historical ratings not harmonized with other international standards.

5.3.1 Rated switching impulse withstand voltage

Bias values in ~~parenthesis~~ parentheses in Table 1 are the peak values of the power-frequency voltage of opposite polarity of the applied impulse applied to the opposite terminal (combined voltage)~~)~~, which is $V \times \sqrt{2}/\sqrt{3}$.

5.3.2 Rated lightning impulse withstand voltage

Bias values in parenthesis in Table 1 are ~~the~~ 70% of the peak values of the power-frequency voltage of opposite polarity of the applied impulse applied to the opposite terminal (combined voltage), which is $0.7 \times V \times \sqrt{2}/\sqrt{3}$.

5.3.3 Chopped wave test

The chopped wave test requirements specified in IEEE Std C37.100.1-~~2007~~[2018](#) do not apply to GIS equipment.

5.4 Rated power frequency (f_r)

Subclause ~~5.4.3~~ of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following addition: Special application power frequencies include 16 2/3 Hz and 25 Hz.

5.5 Rated continuous (normal) current and temperature rise

5.5.1 Rated continuous (normal) current (I_r)

Subclause ~~4.4~~[5.5.1](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following addition:

Some main circuits of GIS (e.g., buses, feeder circuits, ~~etc.~~) may have different values of rated continuous current. These values shall also be selected as per ~~4.4~~[5.5.1](#) of IEEE Std C37.100.1-~~2007~~[2018](#).

5.5.2 Temperature rise

Subclause ~~4.4~~[5.5.2](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following exceptions to IEEE Std C37.100.1-~~2007~~ [2018](#), Table 3, Item 9:

- Solar effects are included in outdoor applications. [115 °C total temperature is allowed for silver plated contacts.](#)

— Allowable maximum temperatures and allowable temperature rises are shown in Table 2.

Table 2— Allowable maximum temperature and allowable temperature rise

Nature of the part	Maximum temperature (°C)	Maximum temperature rise at ambient air temperature not exceeding 40 °C (°C)
Accessible parts:	—	—
— Points contacted during routine operation and inspection specifically the local control cabinet	50	na
— Which are expected to be contacted in normal operation and routine maintenance	70	30
— Which need not to be contacted in normal operation	80	40
NOTE—These temperatures are rarely reached in typical applications except under peak load/outage conditions.		

(New)

Nature of the part	Maximum temperature (°C)	Maximum temperature rise at ambient air temperature not exceeding 40 °C (°C)
Accessible parts:		
— Points contacted during routine operation and inspection specifically the local control cabinet	50	na
— Which are expected to be contacted in normal operation and routine maintenance	70	30
— Which need not to be contacted in normal operation	80	40
NOTE—These temperatures are rarely reached in typical applications except under peak load/outage conditions.		

(Deleted)

5.6 Rated short-time withstand current (I_k)

Subclause 4.5.6 of IEEE Std C37.100.1-2007/2018 applies.

5.7 Rated peak withstand current (I_p)

Subclause 4.6/5.7 of IEEE Std C37.100.1-2007/2018 applies.

5.8 Rated duration of short-circuit (t_k)

Subclause ~~4.7~~[5.8](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the standard duration for the short-time current as 1 ~~seconds~~[s](#).

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

Subclause ~~4.8~~[5.9](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies.

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

Subclause ~~4.9~~[5.10](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies.

5.11 Rated bus-transfer voltage and current of disconnect switches¹¹~~10~~

[The ratings of IEC 62271-102: 2018, 5.108 apply.](#)

~~Rated bus transfer voltages are given in Table 3. Other rated bus transfer voltages may be assigned by the manufacturer.~~

~~The value of the rated bus transfer current for disconnect switches shall be 80% of the rated continuous current. It will normally not exceed 1600 A, irrespective of the rated continuous current of the disconnect switch.~~

¹¹ Extracts used from Annex B of IEC 62271-102 with permission. Copyright © 2001 IEC Geneva, Switzerland. www.iec.ch.

~~NOTE—A maximum rated bus transfer current of 1600 A was chosen as being typically the highest current which can be switched even though the rated normal current of the disconnect switch may be substantially greater. It is required to select disconnect switches based on the short-time current ratings as well as the rated normal current. The maximum continuous current carried by the disconnect switch, therefore, may be considerably less than the rated normal current. Rated bus transfer currents greater than 80% of the rated normal current or greater than 1600 A may be assigned by the manufacturer.~~

Table 3—Bus transfer voltage

Rated voltage U_r	Gas-insulated disconnect switches
kV	V rms
72.5	10
100	
123	
145	
170	
245	20
300	
362	
420	
550	
800	40

(Deleted)

5.12 Classification and rated values for disconnect switches with bus-charging

The classification and ratings of IEC 62271-102: 2018, 5.110 apply.

5.13 Classification and rated induced current and voltage for grounding switches¹²~~11~~

Separate ratings for electromagnetically induced and electrostatically induced currents shall be assigned. The rated induced current is the maximum current that the grounding switch is capable of switching at the rated induced voltage.

¹²Extracts used from Annex C of IEC 62271-102 with permission. Copyright © 2001 IEC Geneva, Switzerland. www.iec.ch.

The rated induced voltage is the maximum power-frequency voltage at which the grounding switch is capable of switching the rated induced current.

Rated induced currents for the two classes (A and B) of grounding switches are given in Table 4.3. The grounding switch shall be capable of carrying the rated induced current indefinitely.

Separate ratings for electromagnetically and electrostatically induced voltages shall be assigned. Rated induced voltages for the two classes (A and B) of grounding switches are given in Table 4.3.

Table 3—Standardized values of rated induced currents and voltages for grounding switches

Rated voltage U_r , kV	Electromagnetic coupling				Electrostatic coupling			
	Rated induced current A (rms)		Rated induced voltage kV (rms)		Rated induced current A (rms)		Rated induced voltage kV (rms)	
	Class				Class			
	A	B	A	B	A	B	A	B
72.5	50	80	0.5	2	0.4	2	3	6
100	50	80	0.5	2	0.4	2	3	6
123	50	80	0.5	2	0.4	2	3	6
145	50	80	1	2	0.4	2	3	6
170	50	80	1	2	0.4	3	3	9
245	80	80	1.4	2	1.25	3	5	12
300	80	160	1.4	10	1.25	10	5	15
362	80	160	2	10	1.25	18	5	17
420	80	160	2	10	1.25	18	5	20
550	80	160	2	20	2	25	8	25
800	80	160	2	20	3	25	12	32

NOTE 1—Class A grounding switches: low coupling or relatively short parallel lines. Class B grounding switches: high coupling or relatively long parallel lines.

NOTE 2—In some situations (very long sections of the grounded line in proximity to an energized line; very high loading on the energized line; energized line having a service voltage higher than the grounded line, etc.), the induced current and voltage may be higher than the given values. For these situations, the rated values should be subject to agreement between manufacturer and user. The rated induced voltages correspond to line-to-ground values for both single-phase and three-phase tests (see A.3.4).

(New)

Rated voltage U , kV	Electromagnetic coupling				Electrostatic coupling			
	Rated induced current A (rms)		Rated induced voltage kV (rms)		Rated induced current A (rms)		Rated induced voltage kV (rms)	
	Class				Class			
	A	B	A	B	A	B	A	B
72.5	50	80	0.5	2	0.4	2	3	6
100	50	80	0.5	2	0.4	2	3	6
123	50	80	0.5	2	0.4	2	3	6
145	50	80	1	2	0.4	2	3	6
170	50	80	1	2	0.4	3	3	9
245	80	80	1.4	2	1.25	3	5	12
300	80	160	1.4	10	1.25	10	5	15
362	80	160	2	10	1.25	18	5	17
420	80	160	2	10	1.25	18	5	20
550	80	160	2	20	2	25	8	25
800	80	160	2	20	3	25	12	32

NOTE 1—Class A grounding switches: low coupling or relatively short parallel lines. Class B grounding switches: high coupling or relatively long parallel lines. See definition, Clause 3.

NOTE 2—In some situations (very long sections of the grounded line in proximity to an energized line; very high loading on the grounded line; energized line having a service voltage higher than the grounded line, etc.), the induced current and voltage may be high or than the given values. For these situations, the rated values should be subject to agreement between manufacturer and user.

The rated induced voltages correspond to line-to-ground values for both single-phase and three-phase tests (see A.3.6).

(Deleted)

5.14 Rated short-circuit making current for grounding switches

A grounding switch ~~which~~that has a rated short-circuit making current assigned shall be capable of making at any applied voltage or current, up to and including the rated maximum voltage, and any current up to and including the rated short-circuit making current.

For a grounding switch with a rated short-circuit making current, this rating shall be equal in magnitude to the rated peak withstand current. The ground switches with this rating shall have the capability to endure two short-circuit making operations as defined in the test protocol.

6. Design and construction

6.1 Overview

High-voltage, gas-insulated switchgear primarily consists of grounded pressurized metal enclosures, containing energized high-voltage conductors, and other switchgear components. It is located in areas accessible to authorized personnel only, and operated by trained (qualified) personnel. Under certain conditions both conductors and enclosures shall be capable of carrying rated continuous current and short-circuit currents. GIS enclosures shall be filled with ~~compressed sulfur hexafluoride (SF₆)~~ insulating gas.

Gas-insulated switchgear shall be designed for safe operation in normal service, during inspection and maintenance operations, and during testing on connected cables or other apparatus. It shall also be designed such that normal grounding switch operations can be carried out safely. Components of the same rating and construction ~~which~~that may require replacement shall be interchangeable.

Components contained within the GIS enclosure are subject to their relevant standards except this standard shall take precedence where it modifies those standards.

Hollow primary conductors shall be properly vented at all times to allow for proper gas filling and gas evacuation.

6.2 Requirements for liquid in switchgear

Subclause ~~56~~.1 of IEEE Std C37.100.1-~~2007~~[2018](#) applies.

6.3 Requirements for gases in switchgear

Subclause ~~56~~.2 of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following addition: For compliance with local regulations, refer to ~~5-20~~[6.21](#).4 of this standard.

6.4 Grounding and bonding of switchgear

Subclause ~~56~~.3 of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following additions:

6.4.1 Grounding of enclosures

The metallic enclosure shall be equipped with ground pads providing for connections to the ground grid, sized for the short-circuit current at each location ~~which~~[that](#) corresponds to the current specified for the installation. The ground pad shall conform to a hole pattern in accordance with ANSI/NEMA CC 1. All metal parts that do not belong to a main or auxiliary circuit shall be grounded. For the interconnection of enclosures, frames, etc., bolting or welding is acceptable to provide electrical continuity. Connections shall meet the requirements of IEEE Std 80TM and IEEE Std ~~367~~[837](#)TM. The continuity of the grounding circuits shall be assured, taking into account the thermal and electrical stresses caused by the current they may carry. The grounding system shall prevent step and touch voltages exceeding the limits defined in IEEE Std 80.

6.4.2 Grounding of high-voltage circuit

All high-voltage parts where access is required or provided shall be capable of being grounded during maintenance.

6.4.3 Bonding of enclosures

The various sections of the enclosure shall be electrically connected (bonded) together to provide a continuous current path through the entire length.

Single-phase enclosures require bonding interconnections installed between the three-phase enclosures to provide a path for longitudinal continuous currents induced in the enclosures. Each of these bonding interconnections shall be ~~connected to the ground grid as directly as possible by conductors~~ capable of carrying the rated ~~short-circuit current and the portion of the~~ continuous current ~~that flows into the ground.~~ The bonding interconnections between single-phase enclosures are intended to significantly reduce or eliminate the continuous currents induced in the enclosures from flowing into the ground grid. ~~They are dimensioned for rated continuous current of the installation and~~ They are typically located at the extremities of the installation and at selected intermediate locations.

6.5 Auxiliary and control equipment

Control and secondary circuit devices and wiring shall comply with the requirements of IEEE Std C37.21-~~TM~~.

6.6 Dependent power operation

Subclause ~~56~~.5 of IEEE Std C37.100.1-~~2007~~2018 applies.

6.7 Stored energy devices¹²

~~A switching device arranged for stored energy operation shall be capable of making and breaking all currents up to its rated values when the energy storage device is suitably charged. Closing and opening times as stated by the manufacturer shall remain within manufacturer stated limits at rated control voltage.~~

¹²~~Extracts used from 5.6 of IEC 62271-1 with permission. Copyright © 2007 IEC Geneva, Switzerland. www.iec.ch.~~

~~Except for slow operation during maintenance, the main contacts shall only move under the action of the drive mechanism and in the designed manner.~~

~~A device indicating when the energy storage device is charged shall be mounted on the switching device. It shall not be possible for the moving contacts to move from one position to the other, unless the stored energy is sufficient for satisfactory completion of the opening or closing operation. Stored energy devices shall be able to be discharged to a safe level prior to access.~~

All stored energy devices shall be controlled such that operation is prevented until sufficient stored energy is available for proper operation. For stored energy devices where the stored energy may dissipate significantly over time, this stored energy shall be monitored and controlled such that the energy is recharged in order to maintain full operating capability. Stored energy devices shall be equipped with indicators to show when they are charged or discharged. Stored energy devices shall be capable of being discharged prior to entry into the operating mechanism housing. The force required for operation of a manual charging handle shall not exceed 250 N (56 lbf.).

~~5.6.1 Energy storage in springs (or weights)~~

~~When the energy storage device is a spring (or weight), the requirements of 5.6 apply when the spring is charged (or the weight lifted).~~

~~5.6.2 Manual charging~~

~~If a spring (or weight) is charged by hand, the direction of motion of the handle shall be marked.~~

~~The manual charging facility shall be designed such that the handle is not driven by the operation of the switching device or by application of control supply voltage.~~

~~The maximum actuating force required for manually charging a spring (or weight) shall not exceed 250 N (56 lb).~~

5.6.3 Energy storage in capacitors

~~When the energy storage device is a charged capacitor, the requirements of 6.6 apply.~~

6.8 Independent manual operation

Subclause ~~56~~.7 of IEEE Std C37.100.1-~~2007~~[2018](#) applies.

6.9 Operation of releases

The operation limits of releases for circuit breakers are given in IEEE Std C37.100-~~TM~~.

For other switches, shunt closing and opening releases shall operate satisfactorily with~~in~~ the ~~rated supply voltage and rated supply frequency~~[applicable tolerance](#) given in ~~4.8~~[5.9](#) and ~~4.9~~[5.10](#) of IEEE Std C37.100.[1-2018](#).

6.10 [Gas compartment](#) ~~Low—and high-pressure~~ interlocking and monitoring devices

Subclause ~~56~~.9 of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following additions:

- The gas density or temperature compensated gas pressure in each gas zone shall be separately and continuously monitored. The monitoring device shall be capable of operating a relay contact upon descending gas density at each of two different density or pressure levels (alarm pressure and minimum functional pressure). If the device has a visual indicator, it shall be readable by the operator.
- Gas density monitors shall be capable of being functionally checked with the GIS equipment in service. Checking of gas density monitors without properly isolating contact outputs may initiate alarms and/or protective relay operations.
- Interface contacts shall be provided for first stage and lockout gas densities for each gas zone for connection to user equipment.

- When the rated filling pressure differs between adjacent zones, an additional alarm indicating over pressure may be used.
- A means to sample gas in each gas compartment shall be provided.

6.11 Nameplates

Subclause [56.10](#) of IEEE Std C37.100.1-~~2007~~[2018](#) applies with the following additions:

- The nameplates shall be durable and clearly legible for the service life of the equipment.
- Symbols on GIS nameplates shall be in accordance with IEEE Std 315-~~TM~~.

6.11.1 GIS common nameplates

Nameplates of the ~~following~~ types [found in 6.11.1.1, 6.11.1.2, and 6.11.1.3](#) shall be furnished in a convenient, central location to provide information for operation and maintenance. These nameplates shall be clearly readable and located in an appropriate and accessible location.

6.11.1.1 GIS ratings nameplate

The ratings nameplate shall state to which of the GIS equipment the ratings apply. The GIS ratings nameplate shall contain the following information:

- Manufacturer's name, type and designation, and serial number
- Year of manufacture
- Rated maximum voltage (V) or (U_r)
- Rated lightning impulse withstand voltage (U_p)
- Rated switching impulse withstand voltage (U_s) (if applicable)

- f) Rated power-frequency withstand voltage (U_d)
- g) Rated power frequency (f_r)
- h) Rated maximum and minimum ambient temperature
- i) Rated continuous current (I_r) at maximum ambient temperature
- j) Rated short-time withstand current (I_k) and duration
- k) Rated peak withstand current (I_p)
- l) Rated supply voltage of closing and opening devices and of auxiliary circuits (U_a)
- m) Rated supply frequency of closing and opening devices and of auxiliary circuits
- n) Contract order number

6.11.1.2 One-line diagram nameplate

The one-line diagram nameplate shall show the following information if applicable:

- a) Circuit breakers
- b) Disconnect switches
- c) Grounding switches
- d) Instrument transformers
- e) Bushings
- f) Power cable connections
- g) Buses
- h) Surge arresters