

IEEE Guide for Specifications for High-Voltage Gas-Insulated Substations Rated 52 kV and Above

IEEE Power and Energy Society

Sponsored by the
Substations Committee

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USA

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(Revision of IEEE Std C37.123-1996)

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Abstract: The development of specifications for the technical requirements for the design, fabrication, testing, installation, and in-service performance of a high-voltage gas-insulated substation (GIS) are covered in this guide.

Keywords: gas-insulated metal-enclosed switchgear, gas-insulated substation, GIS equipment, GIS specification, IEEE C37.123™, SF₆, sulfur hexafluoride

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Introduction

This introduction is not part of IEEE Std C37.123–2016, IEEE Guide for Specifications for High-Voltage Gas-Insulated Substations Rated 52 kV and Above.

This guide is a revision of IEEE Std C37.123–1996. It reflects changes needed to coordinate with the IEEE Std C37.122™. It also reflects the present gas-insulated substation (GIS) manufacturing technology. This guide applies to all indoor and outdoor ac high-voltage gas-insulated substations rated above 52 kV and is issued as a guide for use in compiling technical specifications for the purchase of ac high-voltage gas insulated switchgear.

This guide is not a tutorial. This guide is intended to assist the user in developing and preparing specifications for gas-insulated substations and equipment. The user of this guide should evaluate how, and to what extent, each clause applies to the development of the GIS specification. Application of this guide shall be done with sufficient technical knowledge and understanding. Users of this guide are expected to have become familiar with IEEE Std C37.122, IEEE Standard for High Voltage Gas-Insulated Substations Rated Above 52 kV, and are encouraged to review IEEE Std C37.122.1, IEEE Guide for Gas-Insulated Substations Rated Above 52 kV.

The structure of this guide is similar to that of a typical utility GIS specification. From the very beginning it was obvious to the working group that while most of the GIS projects are executed as a turnkey project, this guide would have to be limited in scope to a “procurement specification” and provide guidance for the design, fabrication, testing, installation, and in-service performance requirements of the equipment only. General commercial terms and conditions that form part of a specification for a project are not discussed in this guide. The imperative mode of the language used for example clauses is illustrative of that used in specifications. It does not imply that this document is anything other than advisory in its scope. This guide contains clauses that may be used directly in a purchaser’s specification. Alternately, users may modify example clauses to form the basis of their own specification. This guide does not contain all of the clauses that a purchaser may require for the purchase of a GIS for each and every conceivable application or physical installation. For example, this guide makes no reference to commercial conditions that might be included in a purchaser’s complete specification. The guide also does not contain example clauses that would provide all necessary requirements for every system application or physical installation. Users of the guide are cautioned to thoroughly review each individual application when preparing a GIS specification. Ultimately the user specification will have to be influenced by the user’s own system requirements, and operating and maintenance practices.

This guide was prepared by the High-Voltage Gas-Insulated Substation Working Group K12 of the IEEE Substations Committee.

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1. Overview

1.1 Scope

This guide is for the development of specifications for the technical requirements for the design, fabrication, testing, installation, and in-service performance of a high-voltage gas-insulated substation (GIS).

1.2 Purpose

This document is issued as a guide for use in compiling procurement specifications for the design, fabrication, testing, installation and in-service performance of high-voltage gas-insulated substation equipment. This guide applies specifically to all types of high-voltage gas-insulated substation equipment rated above 52 kVac. The imperative mode of the language is illustrative of that used in design and procurement specifications. It does not imply that this document is anything other than advisory in its scope. Specifically, this revision will align the text with IEEE Std C37.122TM and IEEE Std C37.122.1TM.¹

This guide is not intended to develop a complete specification for a turnkey project. General terms and conditions forming the commercial part of a specification for a particular project are outside the scope of this document.

¹Information on references can be found in [Clause 2](#).

1.3 Application

This guide should be considered as a general purpose resource and does not include all details needed for a specific project.

This guide includes several clauses that use the word “shall”. These clauses are included as typical sample clauses that may directly be used by the users in their specification (see [Clause 5](#), [5.3](#), [Clause 6](#), [Clause 7](#), [7.1](#), [7.2](#), [Clause 8](#), [8.1](#), [8.2](#), [8.3](#), [8.4](#), [8.5](#), [8.6](#), [8.7](#), [8.8](#), [8.9](#), [8.10](#), [8.11](#), [8.12](#), [8.13](#), [8.14](#), [Clause 9](#), [9.1](#), [9.2](#), [9.3](#), [9.4](#), [Clause 10](#), [Clause 11](#), and [A.2](#)). The other clauses with the word “should” may be used to form the basis of a user’s own worded clause for that user’s specification.

This guide includes [Annex A](#) intended for the user to specify project-specific technical and other requirements, and [Annex B](#) intended for the GIS manufacturer to provide proposal data.

In this guide, the words “user” and “purchaser” are used interchangeably. In many cases, however, the purchaser may not be the same as the end-user. In such cases, the specification should differentiate between the two.

1.4 Specification format

A GIS specification set consists of several documents that include, in addition to general commercial terms and conditions, a general specification for the project, a supplementary specification listing equipment ratings and deliverables, schedule, etc., and a list of technical data and other information that should be provided by the manufacturer or GIS supplier with the bid for evaluation purposes. A typical GIS specification structure usually consists of the following clauses, not necessarily in the same sequence or with the same title:

- a) Project scope and description
- b) References
- c) Definitions
- d) Service conditions (environment, location)
- e) Division of responsibilities
- f) Engineering studies
- g) Electrical characteristics of GIS design
- h) Detailed requirements of GIS components
- i) Control and monitoring
- j) Accessories and appurtenances
- k) Supervision of installation
- l) Tests
- m) Drawings and instruction manuals
- n) Technical training
- o) Shipping and receiving
- p) GIS specific requirements, component ratings, quantities, special requirements ([Annex A](#))
- q) Schedule ([Annex A](#))
- r) Information to be furnished by manufacturer or supplier with bid for bid evaluation ([Annex B](#))

The specification generally should include a statement that requires the supplier to supply the GIS in accordance with the Purchaser's specification and the referenced standards. The specification should also state which standards should be applicable in the event of conflict between standards, and indicate which takes precedence in the event of conflict between the purchaser's specification and the referenced standards. The specification should identify the standards, including purchaser's own in-house standards, practices, and drawings that must be complied with by the supplier during the provision of the GIS.

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.

ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.²

ASTM D2472, Specification for Sulfur Hexafluoride.

IEC 60376, Specification of technical grade sulfur hexafluoride (SF₆) for use in electrical equipment. Edition 2.³

IEC 60480, Guidelines for the checking and treatment of sulfur hexafluoride (SF₆) taken from electrical equipment and specification for its re-use—Edition 2.0.

IEC 62271-102, High-Voltage Switchgear and Controlgear: Part 102: Alternating Current disconnectors and earthing switches.

IEC 62271-209, Cable Connections for Gas-insulated Metal-Enclosed Switchgear for Rated Voltages above 52 kV.

IEC 62271-211, Direct Connections Between Power Transformers and Gas-Insulated Metal-Enclosed Switchgear for Rated Voltages of 72.5 kV and Above.

IEEE Std 525™, IEEE Guide for the Design and Installation of Cable Systems in Substations.^{4,5}

IEEE Std 1300™, IEEE Guide for Cable Connections for Gas-Insulated Substations.

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

IEEE Std C37.04™, IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers.

IEEE Std C37.06™, IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V.

²ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

³IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, 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, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

⁴IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

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IEEE Std C37.09™, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.010™, IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.011™, IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers.

IEEE Std C37.012™, IEEE Guide for the Application of Capacitance Current Switching for AC High-Voltage Circuit Breakers Above 1000 V.

IEEE Std C37.015™, IEEE Guide for the Application of Shunt Reactor Switching.

IEEE Std C37.017™, IEEE Standard for Bushings for High-Voltage [over 1000 V(ac)] Circuit Breakers and Gas-Insulated Switchgear.

IEEE Std C37.11™, IEEE Standard for Requirements for Electrical Control for AC High-Voltage (>1000V) Circuit Breakers.

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

IEEE Std C37.122™, IEEE Standard for Gas-Insulated Substations rated above 52 kV.

IEEE Std C37.122.1™, IEEE Guide for Gas-Insulated Substations Rated Above 52 kV.

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

IEEE Std C62.11™, IEEE Standard for Metal-Oxide Surge Arrestors for AC Power Circuits.

ISO 9000, Quality Management Systems—Fundamentals and Vocabulary—Third Edition.⁶

NEMA CC 1, Electric Power Connection for Substations.⁷

NFPA 70, National Electrical Code® (NEC®).⁸

3. Definitions

For the purposes of this document, the following terms and definitions apply. IEEE Std C37.122, IEEE Std C37.122.1, and *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁹

⁶ISO publications are available from the ISO Central Secretariat, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

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⁹*IEEE Standards Dictionary Online* subscription is available at: <http://ieeexplore.ieee.org/xpls/dictionary.jsp>.

4. Service conditions

Usual and unusual service conditions are described in Clause 2 of IEEE Std C37.122, and Clause 2 of IEEE Std C37.100.1. The users should review these clauses for the unusual service conditions to determine if any apply to their system. If any of the actual service conditions differ from these normal (usual) service conditions, these should be specified in [Annex A](#).

5. Scope of supply

5.1 General

The user specification should clearly indicate what is to be supplied by the GIS manufacturer. It should also clearly indicate what is not to be supplied by the manufacturer, and the services that will be furnished by the user at the project site. The following is a typical scope of the equipment and services to be furnished by the user and the supplier. [Annex A](#) should be used to provide a detailed listing of the scope of supply. The user should indicate the application of the equipment (i.e., type of substation for which the GIS will be used).

Project teams benefit from clear definition of project scope. This part of the specification defines the deliverables and the constraints for the project, and facilitates communication and cooperation toward the project goals. The deliverables are engineering studies and services, documentation, equipment supply, installation services, and testing services. The major constraints are as follows:

- a) Substation one-line diagram (including any applicable future provisions).
- b) Physical constraints for the GIS: areas and heights available for the GIS and definition of areas excluded from use along with any construction access restrictions. These will include the locations of physical barriers like retaining walls and unmovable conduit or cable trough.
- c) Direction of connected lines/cables.
- d) Any fixed locations for primary voltage terminations including phasing.
- e) Schedule for the project including time when the jobsite will be ready to receive equipment and any sequencing or outage planning restrictions that would change the normal progression of the work.
- f) Scope boundaries for the engineering, supply, installation, verification and testing of the GIS. A pictorial example of scope division for equipment supply is shown in [Figure 1](#).

In addition to the GIS equipment specifications and ratings, site description, GIS interfaces (e.g., transmission lines, transformers, cables), control and monitoring requirements, etc., the user and potential suppliers should discuss the following as part of the project pre-bid process.

The user and supplier should agree on the engineering studies to be performed and the calculations to be provided as part of the project. The studies and calculations may include but are not limited to the following:

- Insulation coordination, transient recovery voltages (TRV), temporary overvoltages (TOV), and very fast transients (VFT)
- Ferroresonance interactions between the GIS bus or interconnected cables and wound voltage transformers
- Grounding—touch, step, and transfer potentials
- Calculated bus resistance
- Calculated trip and close coil burdens and dc circuit loads

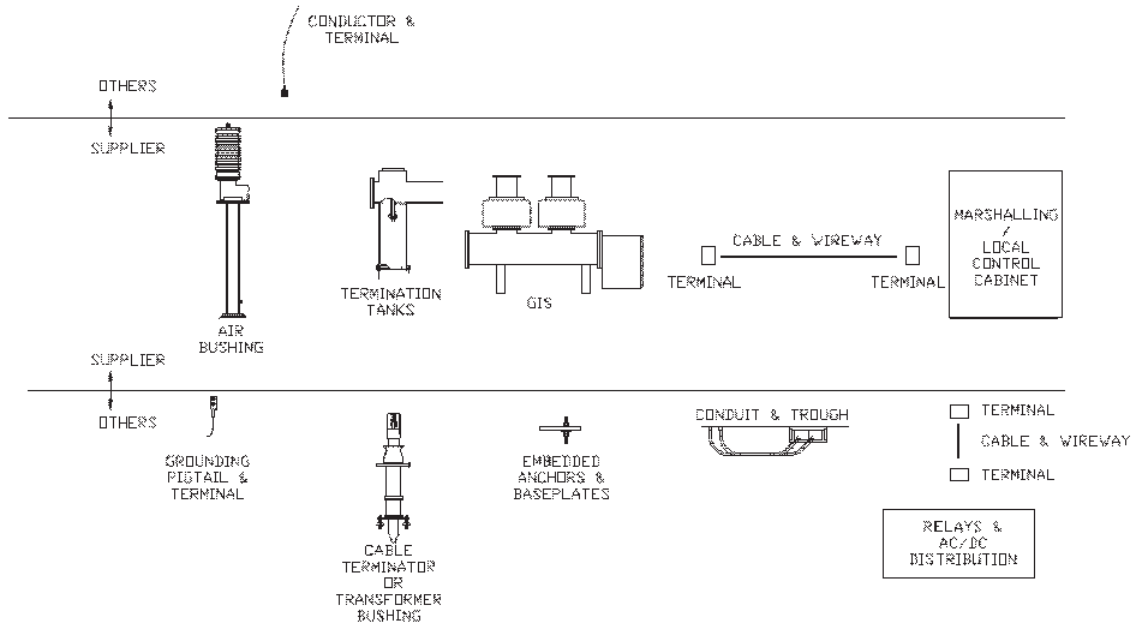


Figure 1—Scope division for equipment supply

- Required ac station service loads (e.g., heaters, cabinet lighting, convenience receptacles, compressors, or hydraulic operators)
- Overall installation lighting provisions
- Accessibility to devices, operating mechanisms, viewports, and gauges/instrumentation

The user and supplier should agree on the level of training to be provided to operations, maintenance, and dispatch personnel. The training should consist of classroom work describing the nature of GIS equipment, SF₆ gas handling, features of the various devices (e.g., circuit breakers, disconnects, grounding and fast-acting grounding switches, and instrument transformers), interlocking or control permissive schemes, methods to determine device position, alarm descriptions and required actions, routine maintenance inspection requirements and checks, maintenance procedures for breaker-timing and travel checks, integration of one-line and gas zone diagrams, etc. Also included in the training session before the equipment is placed in service should be hands-on activities such as operating the devices, using viewports, bore scopes or other equipment to check device positions, sampling SF₆ gas, etc.

The user and supplier should agree on the project administrative procedures and practices including the following:

- Required meeting attendance and status or schedule updates.
- The quantity and format of the documentation, what design platforms should be used (e.g., AutoCAD, Microstation), how will drawing control be administered (e.g., the review process, modifications, issues for construction, and as-built drawings).
 - 1) Special security protocols or access requirements.
 - 2) Acceptable material delivery times and any construction noise level limitations (residential areas).

- 3) Daily progress reports and photographs including records of safety training and incidents.
- 4) The user and supplier should agree on the responsible party to provide and administer.
 - i) Environmental (wetland) permits and reports (SF₆ gas usage).
 - ii) Crane or material handling and construction (electrician) licenses.
 - iii) Building, fire protection, or construction permits.
 - iv) Interfaces and the division of responsibility with other interconnected parties, e.g., a separate party owns a transmission line or cable to be connected to the user's GIS.
 - v) Interfaces in a user's facility between equipment provided by different suppliers.
 - vi) The extent of support to be provided by the supplier's on-site representative and that representative's level of communication skills.

The user and supplier should also discuss and agree on the procedures for gas handling and test equipment. Who will supply the gas cart or processing equipment? Should a gas cart be included in the scope of supply? What is the largest GIS zone to be processed? How will the gas be tested to verify purity? What maintenance records will be provided before the equipment is placed in service to provide a historical basis for future condition monitoring? The supplier generally conducts the high-voltage conditioning tests using a series resonant set. The parties should agree whether a generator is needed or station service power has adequate capacity. Where will test bushings be provided?

The user and supplier should also agree on any special tools, spare parts, routine maintenance products (lubricants), or similar materials. In the case of special tools, two new sets with a detailed inventory and labeled for the user should be included in the scope of supply. The supplier should provide the user with the ordering information and contact information for special items such as o-rings and sealants that have a defined shelf life.

5.2 Equipment and services furnished by the user

Unless otherwise specified or agreed upon, the user should receive, install, and field-test the apparatus specified herein. Installation and field testing of the GIS should be completed under the supervision of the supplier to help ensure correct installation. Unless otherwise specified, the following equipment and services are often furnished by the user:

- a) Concrete foundations
- b) Power transformers or reactors, including bushings
- c) Surge arresters outside the GIS
- d) The station ground grid, below ground, and jumpers of adequate length to structures
- e) Ac and dc auxiliary power to furnished equipment
- f) Hoist or crane
- g) Supervisory control and data acquisition (SCADA) equipment
- h) Conduit or troughs and wiring to supplier-furnished equipment
- i) Gas handling equipment
- j) Batteries and battery chargers
- k) Protective relaying systems
- l) Transmission-line dead-end terminations
- m) Control and power cable trenches

- n) Erection labor, with the supervision and assistance of the GIS supplier
- o) Control house and related equipment or building in case of indoor installation, including crane, if applicable
- p) Job-site unloading and storage
- q) Field welding, if required, with the supervision and assistance of the GIS supplier
- r) Test equipment, coordinated with the GIS supplier
- s) Tertiary bus, tertiary reactors, and other related equipment
- t) High-voltage power cables and terminations
- u) Anchor bolts and/or embedded steel, if part of foundation pouring
- v) Instrument transformers and capacitor voltage transformers not included in the GIS
- w) Substation fence, lighting, and direct stroke lightning protection

5.3 Equipment and services furnished by the supplier

The supplier shall design, manufacture, test, deliver, and guarantee the following GIS components and services as recommended by this guide: The complete GIS based on the one-line diagram provided by the user and including direct connections to power transformers and line exits with associated circuit breakers, disconnect and grounding switches (maintenance or high-speed), instrument voltage, current transformers, and surge arresters.

- a) All metal-enclosed gas-insulated buses for interconnecting various assemblies, including flexible joints to help ensure service continuity during thermal cycling and vibration.
- b) All high-voltage SF₆-to-air bushings with proper terminal pad should be specified according to IEEE Std C37.017.
- c) All cable connections, including SF₆ enclosures, terminator support structures, and mounting insulators should be as specified in IEC 62271-209 and IEEE Std 1300.
- d) All power transformer and shunt reactor bushing sulfur hexafluoride (SF₆) enclosures, complete with vibration dampers and/or alignment bellows, if required in accordance with IEC 62271-211.
- e) All coordination with power transformer, shunt reactor, cable, and cable termination suppliers to assure proper electrical and mechanical interface, in accordance with IEC 62271-209 and IEC 62271-211.
- f) All necessary supports, platforms, stairways, and walkways, for operation and maintenance functions including fasteners to foundation. Final design of platforms and walkway systems is to be by mutual agreement between the user and the supplier.
- g) All operating mechanisms installed in suitable cabinets.
- h) All local control or marshalling cabinets.
- i) All wiring of devices and terminations internal to the switchgear and all shielded control cables (and associated raceways), above foundation, between the equipment and the GIS local control or marshalling cabinets.
- j) Ground buses and ground connection pads for connection to the ground grid.
- k) Gas density monitors, pressure relief devices, and gas-filling connections.
- l) All necessary gaskets, O-rings sealants, and desiccant.
- m) Initial filling of SF₆ gas.