



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

STANDARDS

IEEE Power and Energy Society

Developed by the
Substations Committee

IEEE Std C37.123™-2023
(Revision of IEEE Std C37.123-2016)



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

Developed by the

Substations Committee
of the
IEEE Power and Energy Society

Approved 6 December 2023

IEEE SA Standards Board

Recognized as an American National Standard

This is a Redline document produced by Accuris.

Redlines are designed to save time and improve productivity by using the latest software technology to find and highlight document changes from one edition to the next. It includes a full-text version of the new document, plus an indication of changes from the previous version.

Because it may not be technically possible to capture all changes accurately, it is recommended that users consult previous editions as appropriate. In all cases, only the current base version of this publication is to be considered the official document. This Redline is produced solely by Accuris. The publisher has not prepared this Redline and is not responsible for its accuracy.

Contact:

<https://store accuristech.com/pages/contact.html>

Redline Processing Notes:

1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

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™, insulating gas, SF₆, sulfur hexafluoride

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2024 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 12 April 2024. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 979-8-8557-0659-8 STD26890
Print: ISBN 979-8-8557-0660-4 STDPD26890

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <https://www.ieee.org/about/corporate/governance/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (<https://standards.ieee.org/ipr/disclaimers.html>), appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents are developed within IEEE Societies and subcommittees of IEEE Standards Association (IEEE SA) Board of Governors. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. IEEE Standards documents do not guarantee safety, security, health, or environmental protection, or guarantee against interference with or from other devices or networks. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity, nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon their own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus balloting process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE is the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group. Statements made by volunteers may not represent the formal position of their employer(s) or affiliation(s).

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, consulting information, or advice pertaining to IEEE Standards documents.**

Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its Societies and subcommittees of the IEEE SA Board of Governors are not able to provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile and Interests area of the [IEEE SA myProject system](#).¹ An IEEE Account is needed to access the application.

Comments on standards should be submitted using the [Contact Us](#) form.²

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

¹Available at: <https://development.standards.ieee.org/myproject-web/public/view.html#landing>.

²Available at: <https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html>.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400; <https://www.copyright.com/>. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit [IEEE Xplore](#) or [contact IEEE](#).³ For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the [IEEE SA Website](#).⁴ Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in [IEEE Xplore](#). Users are encouraged to periodically check for errata.

Patents

IEEE standards are developed in compliance with the [IEEE SA Patent Policy](#).⁵

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has

³Available at: <https://ieeexplore.ieee.org/browse/standards/collection/ieee>.

⁴Available at: <https://standards.ieee.org/standard/index.html>.

⁵Available at: <https://standards.ieee.org/about/sasb/patcom/materials.html>.

filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE SA Website at <https://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

IMPORTANT NOTICE

Technologies, application of technologies, and recommended procedures in various industries evolve over time. The IEEE standards development process allows participants to review developments in industries, technologies, and practices, and to determine what, if any, updates should be made to the IEEE standard. During this evolution, the technologies and recommendations in IEEE standards may be implemented in ways not foreseen during the standard's development. IEEE standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

Participants

At the time this IEEE guide was completed, the Specifications for High-Voltage Gase-Insulated Substations Rated 52kV and Above Working Group had the following membership:

George Becker, *Chair*
David Solhtalab, *Vice Chair*
Patrick Fitzgerald, *Secretary*

Eldridge Byron
Vince Chiodo
Edward Crockett
Peter Grossmann

Charlie Li
Jorge Marquez Sanchez
Nicholas Matone
Jeremy McNutt
William Munn

Michael Novev
Scott Scharf
Devki Sharma
Ryan Stone

The following members of the individual Standards Association balloting group voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

Ficheux Arnaud
Michael Bayer
George Becker
Steven Bezner
Vipul Bhagat
Eldridge Byron
Thomas Callsen
Ritwik Chowdhury
Randy Clelland
Lucas Collette
Robert Dempsey
Neal Dowling
Douglas J. Edwards
Jorge Fernandez Daher
Carl Fredericks
Kamal Garg
Shubhanker Garg
Jalal Gohari
S. Gohil
Steven Hensley
Thang Hochanh
Werner Hoelzl

Robert Hoerauf
Richard Jackson
John John
Kurt Kaineder
Yuri Khersonsky
James Kinney
Boris Kogan
Chiranjeevi Bala
Kotharu
Jim Kulchisky
Wang Lei
Greg Luri
Jorge Marquez Sanchez
Nicholas Matone
Jeremy McNutt
Daleep Mohla
Melvin Moncey Joseph
Thomas Mulcahy
Michael Novev
Miklos Orosz
Lorraine Padden

Bansi Patel
Shashikant Patel
Craig Polchinski
Craig Preuss
Farnoosh Rahmatian
Benito Ramos
John Randolph
Charles Rogers
Bartien Sayogo
Steven Scharf
Devki Sharma
Hyeong Sim
P. Sivaraman
Andrew Steffen
Ryan Stone
Benton Vandiver
Roger Verdolin
John Vergis
Lanyi Wang
Kenneth White
David Wilson
Terry Woodyard

When the IEEE SA Standards Board approved this guide on 6 December 2023, it had the following membership:

David J. Law, *Chair*
Ted Burse, *Vice Chair*
Gary Hoffman, *Past Chair*
Konstantinos Karachalios, *Secretary*

Sara R. Biyabani
Doug Edward
Ramy Ahmed Fathy
Guido R. Hiertz
Yousef Kimiagar
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick

Joseph S. Levy
Howard Li
Johnny Daozhuang Lin
Gui Lin
Xiaohui Liu
Kevin W. Lu
Daleep C. Mohla
Andrew Myles

Paul Nikolich
Annette D. Reilly
Robby Robson
Lei Wang
F. Keith Waters
Karl Weber
Philip B. Winston
Don Wright

*Member Emeritus

Introduction

This introduction is not part of IEEE Std C37.123-2023, IEEE Guide for Specifications for High-Voltage Gas-Insulated Substations Rated 52 kV and Above.

This guide is a revision of IEEE Std C37.123-2016. It reflects changes needed to coordinate with 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 GISs 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 GISs 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 should be done with sufficient technical knowledge and understanding. Users of this guide are expected to have become familiar with IEEE Std C37.122, and are encouraged to review IEEE Std C37.122.1™.

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.

Contents

1. Overview	12
1.1 Scope	12
1.2 Purpose	12
1.3 Word usage	12
1.4 Application	13
1.5 Specification format	13
2. Normative references	14
3. Definitions	15
4. Service conditions	15
5. Scope of supply	16
5.1 General	16
5.2 Equipment and services furnished by the user	18
5.3 Equipment and services furnished by the supplier	19
6. Information required with proposal	20
6.1 General	20
6.2 Information to be furnished after award	21
7. GIS design	22
7.1 GIS layout and equipment ratings	22
7.2 GIS general requirements	23
8. GIS components detailed requirements	28
8.1 GIS bus and enclosures	28
8.2 Circuit breakers	28
8.3 Disconnect and grounding switches	30
8.4 Gas system	32
8.5 Insulating gas-to-air bushings	34
8.6 Cable connections	35
8.7 Transformer connections	35
8.8 Current transformers	36
8.9 Voltage transformers	36
8.10 Metal-enclosed surge arresters	37
8.11 Capacitive voltage couplers	38
8.12 Local control, bay controllers, or marshalling cabinets	39
8.13 Nameplates	42
8.14 Documentation	43
9. Tests	43
9.1 Design tests (type tests)	43
9.2 Routine production tests	46
9.3 Factory acceptance tests	46
9.4 Field tests	46
10. Quality and shop inspections	47
11. Packing, shipping, and storage	47
Annex A (normative) GIS specific requirements	49

Annex B (normative) Typical proposal data for GIS requirements and services, to be provided by the supplier
with bid..... 54

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

~~IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.~~

~~This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>~~

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 [GIS](#) ~~gas-insulated substation~~ equipment. This guide applies specifically to all types of high-voltage [GIS](#) ~~gas-insulated substation~~ equipment rated above 52 kV ac. 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 C37.122™ and IEEE Std C37.122.1™.⁶⁺

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.

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*).^{7,8}

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*).

⁶⁺ Information on references can be found in Clause 2.

⁷The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁸The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

1.4 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.

1.5 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.^{9,2}

ASTM D2472, Specification for Sulfur Hexafluoride.

IEC 60376, Specification of technical grade ~~sulphur~~ ~~sulfur~~ hexafluoride (SF₆) and complementary gases to be used in its mixtures for use in electrical equipment.¹⁰ ~~Edition 2.~~³

IEC 60480, Specifications ~~Guidelines~~ for the re-use ~~checking and treatment~~ of ~~sulphur~~ ~~sulfur~~ hexafluoride (SF₆) and its mixtures in ~~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, 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.

^{9,2} ASTM publications are available from the American Society for Testing and Materials (<https://www.astm.org/>). ~~100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA~~ (<http://www.astm.org/>).

^{10,3} IEC publications are available from the ~~Sales Department of the~~ International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>). ~~Case Postale 131, 3, rue de Varembe, CH 1211, Geneve 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/>).

IEC 62271-211, [High-Voltage Switchgear and Controlgear: Part 211: Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages above 52 ~~of 72.5~~ kV ~~and Above~~](#).

IEEE Std 525TM, IEEE Guide for the Design and Installation of Cable Systems in Substations.^{11,12}

[IEEE Std 693TM, IEEE Recommended Practice for Seismic Design of Substations](#).^{4,5}

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

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

IEEE Std C37.04TM, IEEE Standard [for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V](#). ~~Rating Structure for AC High Voltage Circuit Breakers.~~

[IEEE Std C37.09TM, IEEE Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V](#).

IEEE Std [C37.010TM, IEEE Application Guide](#) ~~C37.06TM, IEEE Standard~~ for AC High-Voltage Circuit Breakers [> 1000 Vac](#) Rated on a Symmetrical Current Basis ~~Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V~~.

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

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

¹¹ ⁴ IEEE publications are available from The Institute of Electrical and Electronics Engineers (<https://standards.ieee.org/>), Inc., 445 Hoes Lane, Piscataway, NJ 08854, US A (<http://standards.ieee.org/>).

¹² ⁵ The IEEE standards or products referred to in ~~this~~ Clause [2](#) are trademarks [owned by](#) ~~of~~ The Institute of Electrical and Electronics Engineers, [Incorporated](#) Inc.

IEEE Std C37.011™, IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers [with Rated Maximum Voltage above 1000 V](#).

IEEE Std C37.012™, IEEE Guide for the Application of [Capacitive](#) ~~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 (~~for~~ over 1000 [Vac](#)) ~~V(ac)~~ Circuit Breakers and Gas-Insulated Switchgear.

IEEE Std C37.11™, IEEE Standard ~~for~~ Requirements for Electrical Control for AC High-Voltage (> 1000 V) 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 [High-Voltage](#) Gas-Insulated Substations Rated Above 52 kV.

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

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

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

IEEE Std C62.11™, IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits [\(>1 kV\)](#).

ISO [9001](#) ~~9000~~, Quality Management Systems— [Requirements](#).¹³ ~~Fundamentals and Vocabulary—
Third Edition.~~⁶

¹³ ⁶ ISO publications are available from the [International Organization for Standardization \(https://www.iso.org/\)](https://www.iso.org/) and the American National Standards Institute (<https://www.ansi.org/>). ~~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/).~~

NEMA CC 1, Electric Power Connection for Substations.^{14 7}

NFPA 70 , National Electrical Code® (NEC®).^{15,16 8}

3. Definitions

This guide does not include any specific definitions.

The IEEE Standards Dictionary Online should be consulted for terms as needed.¹⁷

~~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~~

4. Service conditions

Usual and unusual service conditions are described in Clause 2 of IEEE Std C37.122^{TM-2021}, and Clause ~~3~~ ² of IEEE Std C37.100.1 ^{TM-2018}. ~~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.

¹⁴ NEMA publications are available from the National Electrical Manufacturers Association (<https://www.nema.org/>).

~~⁷NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).~~

^{15 8} National Electrical Code and NEC are both registered trademarks of the National Fire Protection Association, Inc.

¹⁶ NFPA publications are published by the National Fire Protection Association (<https://www.nfpa.org/>).

¹⁷ IEEE 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.

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

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 scopes ~~scope~~ of the equipment and services to be furnished by the user and the supplier are provided in 5.2 and 5.3, respectively. 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: area ~~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 retraining 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.

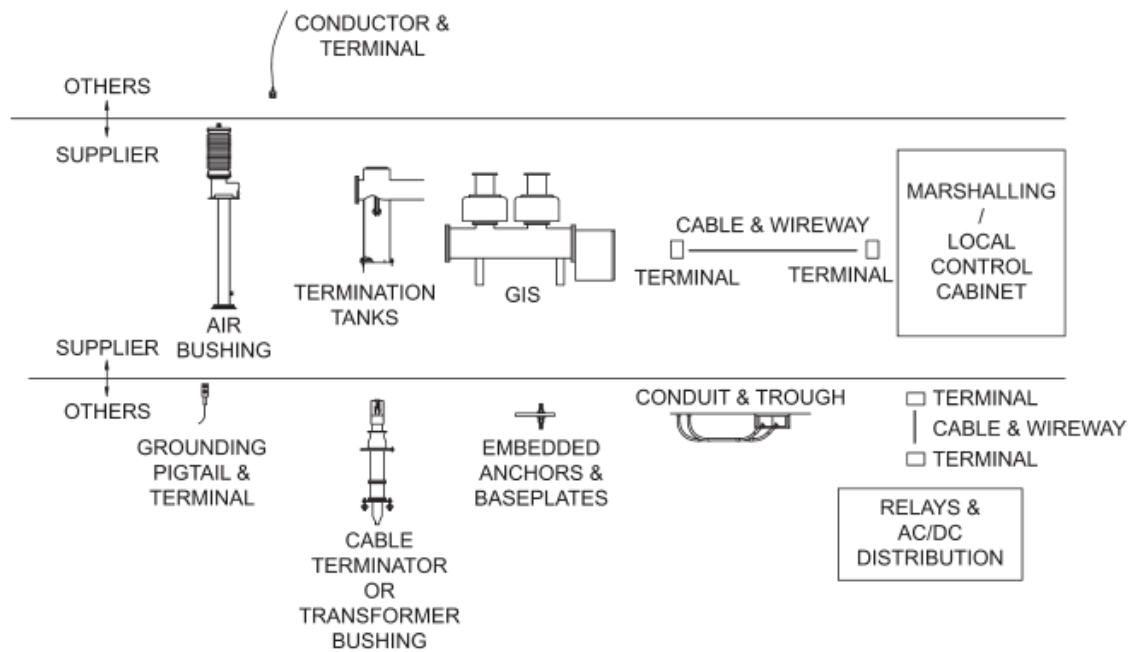


Figure 1—Scope division for equipment supply

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 (TRVs TRV), temporary over voltages (TOV), and very fast transients (VFTs 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
- Required ac station service loads (e.g., heaters, cabinet lighting, convenience receptacles, compressors, or hydraulic operators) [and thermal calculations for heating, ventilation, and air conditioning system for indoor GIS](#)
- 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, [insulating 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 [circuit](#) breakertiming 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 [insulating SF₆](#) gas, etc.

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

- a) Required meeting attendance and status or schedule updates.
- b) The quantity and format of the documentation, what design platforms should be used (e.g., [CAD software](#) ~~AutoCAD, Microstation~~), how will drawing control be administered (e.g., the review process, modifications, issues for construction, and as-built drawings).
- c) Special security protocols or access requirements.

- d) Acceptable material delivery times and any construction noise level limitations (residential areas).
- e) Daily progress reports and photographs including records of safety training and incidents.
- ~~3) The user and supplier should agree on the responsible party to provide and administer;~~
- f) Environmental (wetland) permits and reports (insulating ~~SF₆~~ gas usage).
- g) Crane or material handling and construction (electrician) licenses.
- h) Building, fire protection, or construction permits.
- i) 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.
- j) Interfaces in a user's facility between equipment provided by different suppliers.
- k) 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. If required, 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 [and concrete or steel plate floors](#)
- 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 [from local control cabinets \(LCCs\) to user's relay/control](#)
~~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 [and/or trays](#)
- 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) Jobsite 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:

- a) 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.
- b) All metal-enclosed gas-insulated buses ([GIBs](#)) for interconnecting various assemblies, including flexible joints to help ensure service continuity during thermal cycling and vibration.
- c) All high-voltage [insulating gas](#) ~~SF₆~~-to-air bushings with proper terminal pad should be specified according to IEEE Std C37.017TM.

- d) All cable connections, including insulating gas ~~SF₆~~ enclosures, terminator support structures, and mounting insulators should be as specified in IEC 62271-209 and IEEE Std 1300TM.
- e) All power transformer and shunt reactor bushing insulating gas ~~sulfur hexafluoride (SF₆)~~ enclosures, complete with vibration dampers and/or alignment bellows, if required in accordance with IEC 62271-211.
- f) 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.
- g) 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.
- h) All operating mechanisms installed in suitable cabinets. ⁷
- i) All local control or marshalling cabinets.
- j) 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.
- k) Ground buses and ground connection pads for connection to the ground grid. ⁷
- l) Gas density monitors, pressure relief devices, and gas-filling connections.
- m) All necessary gaskets, O-ring's ~~rings~~ sealants, and desiccant.
- n) Initial filling of insulating ~~SF₆~~ gas.
- o) Any other parts or equipment that is not specifically noted herein but that is necessary for trouble-free operation, installation, and maintenance of the GIS.
- p) Technical services for site assembly and testing by a competent service engineer. Indicate days included in the base bid and give a per diem rate for additional time.

- q) Any special tools, lifting devices, and gas manifolds necessary for erection that should be retained by the user for maintenance purposes.
- r) External surface preparation and coating, if specified. Color may affect the rating and the user shall be informed in the proposal of the new rating. Sufficient amount of touch-up paint is to be provided.
- s) Nameplates for each main component and operating device
- t) User may require a scale model of the GIS for use as a design and training aid.
- u) Documents to be provided as required by 8.14.

6. Information required with proposal

6.1 General

The proposal for a new or an addition to an existing GIS shall include [the following documents](#):

- a) General arrangement drawings and one-line diagrams, gas schematic diagrams, gas zone drawing, typical control diagrams, weights and dimensions, anchor requirements, appropriate technical data, the bill of material, and a description of system components. A suggested listing of data required with the proposal is shown in Annex B.

~~The proposal should also include the following documentation:~~

- b) Type test report, if required by the user. [List of production and field tests. List of existing factory design and production test data and documentations for the GIS system proposed.](#)
- c) [Prices of](#) insulation coordination, ~~transient recovery voltage (TRV, VFTs), very fast transients (VFT)~~, and electromagnetic transients program studies prices, if required by the user.
- d) Seismic qualification plan and price, if required by the user.

- e) Grounding and bonding study price, if required by the user.
- f) Drawings showing full details of locations where future expansion is to take place.
- g) Documentation on installation procedure and sequence, operation, and maintenance of the GIS.
- h) Data on allowable misalignment at the installation or required accuracy of foundations and anchors.
- i) List of recommended spare parts, including price and delivery for normal and catastrophic failure conditions.
- j) List and price of special tools, fixtures, and lifting devices required for installation, operation, and maintenance.
- k) Availability and price of high-voltage test equipment, if required by the user. ⁷
- l) List of previously supplied GIS facilities and their performance to date.
- m) Estimated time required to install and to test the equipment.
- n) User should indicate any limits on manpower available for installation that could have an effect on the supplier's time estimate. In the absence of any limitations, the supplier time estimate should indicate manpower loading assumed plus any specific tasks that may require higher manpower loading than the majority of the installation.
- o) Field service engineer price.
- p) Training for personnel of the user, including price, duration, and material covered.
- q) Filled-out data sheets provided in Annex A ~~of this guide~~. Separate data sheets should be provided for each alternative proposal.

- r) Listing of exceptions to and deviations from this guide and specific user requirements. All exceptions should be clearly and separately itemized. It should not be necessary for the user to examine the standard literature and documents of the supplier to determine the existence and extent of any exceptions or deviations from this guide.
- s) Weight and dimensions of largest removable component (for use by the user in designing permanent hoist or crane). Recommended crane capacity and height to hook. Load data (kg) for the assembly for the foundation design. Turning radius needed to be able to rotate the largest removable component for assembly/dis-assembly. (This is needed for designing the dimensions of the switchgear hall for an indoor installation.)
- t) Maximum weight of insulating ~~SF₆~~ gas in largest compartment. If suppliers gas barrier design requires that adjacent compartments have the insulating ~~SF₆~~ gas pressure reduced during maintenance, supplier should explain this and give the maximum amount of gas to be handled as a result.
- u) Static and dynamic foundation loading for the circuit breaker.
- v) A table of normal operating pressure, minimum operating pressure and alarm level pressure for each gas zone or type of equipment.
- w) Total amount of insulating gas ~~SF₆~~ in the GIS.
- x) Location of the switch view ports, ~~and~~ mechanism boxes, gas density monitors, pressure relief devices, and gas-filling connections.
- y) Outline drawings with dimensions of all major components. Drawing shall include all GIS view port locations.
- z) Data of corrosion protection (paint) system.
- aa) Voltage and current transformer magnetization and excitation curves.
- bb) Statement indicating the country of origin of major materials and components not originating in or manufactured in the user's country.

- cc) Local control or marshalling cabinet supplier name.
- dd) Identify drawing labeling format for local control or marshalling cabinets, ANSI, and/or IEC.

6.2 Information to be furnished after award

The GIS manufacturer shall furnish the user with complete documentation that would be used for the engineering, procurement, construction, operation, and maintenance of the GIS equipment. At a minimum, the documentation shall consist of the following:

- a) A design criteria thoroughly covering all aspects of the equipment scope.
- b) GIS grounding study and analysis. GIS grounding shall be designed to meet requirements of IEEE Std 80™ and IEEE Std C37.122.1™ with regards to step and touch potential as well as VFTs created by circuit breaker or disconnect switch switching.
- c) Construction drawings.
- d) Operation and maintenance manuals.
- e) Project schedule.
- f) Structural and seismic design analyses and seismic qualification requirements signed and certified by licensed professional engineer, if required by the user.
- g) Structural design and calculations for any platforms, catwalks, and stairs.
- h) Ac and dc circuit ampacity and voltage drop calculations.
- i) GIS equipment heat loss calculations, if required by the user.
- j) GIS description of operation, if required by the user.
- k) Training manuals.

- l) [3-D views of the GIS equipment in the GIS building showing safe personnel access to view port, pressure monitor, gas fill port, and mechanism box access locations, including any camera leads, adjacent fixed platforms, stairways, guardrails, wireways/trays, or overhead lighting.](#)
- m) [Views showing effective access routes, sizing, and storage for any mobile/portable stairways, platforms, or ladder.](#)

7. GIS design

7.1 GIS layout and equipment ratings

The station layout and equipment rating shall be based on the one-line diagram furnished by the user. Depending on the station rating and the user's preference, single- or three-phase enclosures may be furnished. The user shall also provide the GIS electrical ratings and any special requirements, seismic requirements, or protective measures in particularly harsh operating environments. The one-line diagrams should show interfaces with transmission lines, power cables, power transformer(s), locations for future extension, and interface with existing GIS, if any.

The one-line diagram should include as a minimum the following components and information as applicable:

- Feeder (transmission line, power transformer), ratings
- GIS bus, rating
- Power transformers, rating
- Circuit breakers, rating
- Disconnect switches, rating
- Grounding switches (maintenance or high-speed)
- Voltage transformers, rating