

IEEE Standard for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus

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of the
IEEE Power Engineering Society**

Cosecretariat

**Institute of Electrical and Electronics Engineers
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Foreword

(This Foreword is not a part of ANSI/IEEE C37.23-1987, IEEE Guide for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus.)

This revision of ANSI/IEEE C37.23-1969, IEEE Guide for Calculating Losses in Isolated-Phase Bus, includes updated information from ANSI/IEEE C37.20-1969, Switchgear Assemblies Including Metal-Enclosed Bus, and additional data concerning flexible bus (cable).

The major work in preparing this standard was accomplished by a working group of the National Electrical Manufacturers Association (NEMA) Power Switchgear Assemblies Technical Committee.

The initial work on Section 8. of this standard, Calculating Losses in Isolated-Phase Bus, was accomplished over a period of years by a working group of the IEEE Switchgear Assemblies Subcommittee of the IEEE Power Engineering Society and published as ANSI/IEEE C37.23-1969. Section 8. reflects changes made since the 1969 edition. These changes are those that were issued to 1970 as corrections and clarifications, and the working group included Fig 5: Curves For Skin Effect of Isolated Round Rod and Tubular Conductors.

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An American National Standard

IEEE Standard for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus

1. Scope

This standard covers assemblies of metal-enclosed conductors along with associated interconnections, enclosures, and supporting structures. When switches and disconnecting links are included, they shall conform to this standard.

Basically, this standard is concerned with performance characteristics of enclosed, rather than open, conductor assemblies. It does not pertain to busways or bus assemblies for distribution of electric power less than 600 V consisting of enclosed sectionalized prefabricated bus bars or associated structures and fittings, such as feeder busways (indoor or outdoor) and plug-in busways (indoor only). It does not include enclosed bus assemblies utilized at voltages in excess of 38.0 kV (see ANSI/UL 857-1981 [9]).¹

2. Definitions

2.1

The definitions of terms contained in this document, or in other standards referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard.

2.1.1 Metal-Enclosed Bus: An assembly of conductors with associated connections, joints, and insulating supports within a grounded metal enclosure. The conductors may be either rigid or flexible.

¹The numbers in brackets correspond to those of the references listed in Section 3.; when preceded by B, they correspond to the bibliography in Section 10.

2.1.1.1 Types of Metal-Enclosed Bus Assemblies: (See Fig 1.) In general, three basic types of construction are used: nonsegregated-phase, segregated-phase, and isolated-phase.

1 **nonsegregated-phase bus:** One in which all phase conductors are in a common metal enclosure without barriers between the phases.

When associated with metal-clad switchgear, the primary bus and connections shall be covered with insulating material equivalent to the switchgear insulation system.

2 **segregated-phase bus:** One in which all phase conductors are in a common metal enclosure but are segregated by metal barriers between phases.

3 **isolated-phase bus:** One in which each phase conductor is enclosed by an individual metal housing separated from adjacent conductor housing by an air space.

The bus may be self-cooled or may be forced-cooled by means of circulating a gas or liquid.

2.1.2 Metal-Enclosed (As Applied to Metal-Enclosed Bus): Surrounded by a metal case or housing, with provisions for grounding.

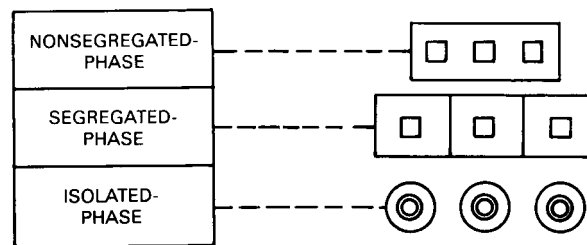


Figure 1—Types of Bus Assemblies

2.1.3 Enclosure: A surrounding case or housing used to protect the contained conductor and prevent personnel from accidentally contacting live parts.

2.1.3.1 Ventilated Enclosure: An enclosure so constructed as to provide for the circulation of external air through the enclosure to remove heat, fumes, or vapors.

2.1.3.2 Nonventilated Enclosure: An enclosure so constructed as to provide no intentional circulation of external air through the enclosure.

2.1.3.4 Dripproof Enclosure: An enclosure usually for indoor application, so constructed or protected that falling drops of liquid or solid particles that strike the enclosure at any angle not greater than 15 degrees from the vertical shall not interfere with the successful operation of the metal-enclosed bus.

2.1.4 Ambient Air Temperature: The temperature of the surrounding air that comes in contact with equipment.

NOTE — Ambient air temperature, as applied to enclosed bus assemblies, is the average temperature of the surrounding air that comes in contact with the enclosure.

2.1.5 Design Tests: Those tests made to determine the adequacy of a particular type, style, or model of metal-enclosed bus or its component parts to meet its assigned ratings and to operate satisfactorily under normal service conditions or under special conditions, if specified.

NOTE — Design tests are made only on representative apparatus to substantiate the ratings assigned to all other apparatus of basically the same design. These tests are not intended to be used as a part of normal production. The applicable portion of these design tests may also be used to evaluate modifications of a previous design and to assure that performance has not been adversely affected. Test data from previous similar designs may be used for current designs, where appropriate.

2.1.6 Field Tests: Tests made after the assembly has been installed at its place of utilization.

2.1.7 Termination (Terminal Chamber): A metal enclosure that contains all necessary mechanical and electrical items to complete the connections to other equipment.

2.1.8 Rated Short-Time Current (Rated for Isolated-Phase Bus): The maximum symmetrical current that the bus must carry without exceeding a specified total temperature in a given time interval.

2.1.9 Rated Short-Circuit Withstand Current: The rated short-circuit withstand current of metal-enclosed bus is the maximum rms total current that it can carry momentarily without electrical, thermal, or mechanical damage or permanent deformation. The current shall be the rms value, including the direct-current (dc) component, at the major peak of the maximum cycle as determined from the envelope of the current wave during a given test time interval.

2.1.10 Dew Withstand Voltage Test: A test to determine the ability of the insulating system to withstand specified overvoltages for a specified time without flashover or puncture while completely covered with dew.

2.1.11 Support Components: The components that add additional strength and rigidity or both to the bus enclosure and are basic subassemblies of the enclosure.

2.2

The following terms are defined in ANSI/IEEE C37.100-1981 [5] , and the user is referred to the definitions given therein. For additional definitions, see ANSI/IEEE Std 100–1984 [7] .

- barrier
- basic impulse insulation level (BIL)
- bus
- bus structure
- conducting mechanical joint
- conformance tests
- continuous-current tests
- control bus
- dielectric withstand voltage tests
- direct-current component (of a total current)
- fault bus
- ground bus
- ground contact
- impulse withstand voltage
- live parts
- production tests
- silver-surfaced or equivalent
- symmetrical component (of a total current) (ac component)
- terminal
- total (asymmetrical) current
- withstand voltage

3. References

The following publications shall be used in conjunction with this standard:

- [1] ANSI C29.1-1982, American National Standard Test Methods for Electrical Power Insulators.²
- [2] ANSI Z55.1-1967 (R 1973), American National Standard Gray Finishes for Industrial Apparatus and Equipment.
- [3] ANSI/IEEE C37.20.2-1987, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear.

²ANSI publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[4] ANSI/IEEE C37.24-1971 (R 1984) IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Clad Switchgear.

[5] ANSI/IEEE C37.100-1981 IEEE Standard Definitions for Power Switchgear.

[6] ANSI/IEEE Std 4-1978, IEEE Standard Techniques for High-Voltage Testing.³

[7] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.

[8] ANSI/UL 857-1981, Safety Standard for Bus-ways and Associated Fittings.⁴

[9] ASTM D1535-80, Method for Specifying Color by the Munsell System.⁵

[10] Federal Specification No A-A-1492, Tape, Gummed, Mending and Reinforcing (Paper and Cloth), General Services Administration.⁶

4. Service Conditions

4.1 Usual Temperature and Altitude Service Conditions

Metal-enclosed bus assemblies conforming to this standard shall be suitable for operation at the nameplate rating provided that

- 1) Ambient air temperature is within the limits of minus 30 °C and plus 40 °C.
- 2) The altitude does not exceed the value for which the voltage and current correction factors (shown in 4.2.1) are equal to 1.00.
- 3) The effect of solar radiation can be neglected.

4.2 Unusual Temperature and Altitude Service Conditions

The application of metal-enclosed bus assemblies at higher or lower ambient temperatures or at higher altitudes than specified in 4.1 shall be considered as special.

Standard assemblies may be applied at higher ambient temperatures or at higher altitudes than specified in 4.1 but performance may be affected and special consideration should be given to these applications, some of which are stated below.

4.2.1 Altitudes

Metal-enclosed bus that depends on air for an insulating and cooling medium will have a higher temperature rise and a lower dielectric strength when operated at altitudes above 3300 ft (1000 m) or 6600 ft (2000 m), as shown below.

³ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.

⁴ANSI/UL publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018 or from Publication Stock, Underwriters Laboratories, Inc, 333 Pfingsten Rd, Northbrook, IL 60020.

⁵ASTM publications can be obtained from Sales Service, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

⁶Federal Specifications can be obtained from the Standardization Division, Federal Supply Service, General Services Administration, Washington, DC 20406.

For application at higher altitudes, the rated 1 min power frequency withstand voltage, the impulse withstand voltage, and continuous current rating of the assemblies shall be multiplied by the following correction factors to obtain the modified ratings:

For bus with rigid conductors, in air		
Altitude in Feet	Correction Factors	
	Voltage	Current
3 300 (1000 m)*	1.00	1.00
5 000 (1500 m)	0.95	0.99
10 000 (3000 m)	0.80	0.96

*And below

For bus with insulated flexible conductors		
Altitude in Feet	Correction Factors	
	Voltage	Current
6 600 (2000 m)	1.00	1.00
8, 500 (2600 m)	0.95	0.99
13 000 (3900 m)	0.80	0.96

NOTES:

- 1 — Intermediate values may be obtained by interpolation.
 2 — Correction factors for higher voltages are under study.

4.3 Other Conditions That May Affect Design and Application

Where other conditions exist, they should be brought to the attention of those responsible for the design and application of the metal-enclosed bus. Among such conditions are

- 1) Exposure to damaging fumes or vapors, steam, salt air, oil vapors, hot or humid climate, excessive dust, abrasive dust, dripping water, falling dirt, explosive mixtures of dust or gases, or extreme high or low temperature.
- 2) Unusual installation requirements, space or ventilation limitations, special duty, frequency or other operating requirements, difficulty of maintenance, building construction, abnormal vibration, shocks, or seismic disturbances.
 NOTE — The ability of a bus to withstand seismic disturbances, vibration, or shock is generally dependent on the building structure and relative motion between support points, and these considerations should be evaluated.
- 3) High wind, ice loads, and snow loads.
- 4) Installations accessible to the general public.
- 5) Refer to ANSI/IEEE C37.24-1971 [4] for solar radiation effects.
- 6) Temperature limits of connected equipment. (See Table 1.)
- 7) Installations where the rated short-circuit withstand or rated short-time current ratings or both, specified in Tables 2.A and 2.B, may be exceeded.

5. Ratings

5.1 General

The ratings of metal-enclosed bus are designations of operating limits under specified conditions of ambient temperature, temperature rise, etc.

Metal-enclosed bus shall have the following ratings shown on a nameplate:

- 1) Maximum voltage
- 2) Rated continuous current
- 3) Insulation (BIL) level
- 4) Frequency
- 5) Rated short-time current (where applicable)
- 6) Rated short-circuit withstand current
- 7) Temperature rise of conductor and enclosure

For force-cooled bus, both the force-cooled and the self-cooled continuous current rating for the same rated temperature rise shall be given.

5.2 Voltages, Current, Temperature Limits, and Insulation (BIL) Levels

5.2.1 Voltages

Maximum operating voltages and corresponding insulation levels, for ac metal-enclosed bus for general applications are listed in Tables 3.A, 3.B, and 3.C. (For dc ratings, refer to Table 3.D.)

5.2.2 Rated Continuous Current

The continuous self-cooled current ratings for metal-enclosed bus are listed in Tables 4.A and 4.B.

Table 1— Metal-Enclosed Bus Limitations of Hottest-Spot Temperature Rise Over Outside Average Ambient

Part of Metal-Enclosed Bus	Limit of Hottest-Spot Temperature Rise (°C)	Limit of Hottest-Spot Total Temperature (°C)
Bus conductor		
Unplated bus joints	30	70
Silver-surfaced (or equivalent)	65	105
Bolted joints	(unless limited by insulation)	
Welded joints	65	105
	(unless limited by insulation)	
Enclosure and support structure*	40	80
(1) For bus conductor rated 65 °C rise		
(2) For bus conductor rated 30 °C rise	20	60
Insulation	As limited by material classification (see Table 5)	—
Terminations	Same as conductor and enclosure of bus except	
Machine, transformer, etc	when modified by connected equipment bushing.	
	In such cases, maximum temperature rise is to be	
	specified by bus purchaser.	
Terminations (cable)		
Unplated bolted joints	30	70
Silver-surfaced (or equivalent)	45	85

*Where enclosure and support structure are inaccessible, 70 °C rise and 110 °C total temperature are permissible.

5.2.3 Short-Circuit Withstand Current

The short-circuit withstand current ratings of metal-enclosed bus are listed in Tables 2.A and 2.B.

5.2.4 Temperature Limitations

5.2.4.1 Limitations of Hottest-Spot Temperature Rise Over Outside Average Ambient

(See Tables 1 and 5.)

5.2.4.2 Temperature Limitations for Ambient Air

See service conditions in 4.1 and 4.2.

6. Tests

6.1 General

This section establishes physical and electrical conditions for tests and methods of determining temperature and test values. All apparatus and devices applicable for testing of the metal-enclosed bus shall be mounted in their normal locations during tests.

Tests may be classified as design tests, production tests, conformance tests, and field tests. (Refer to definitions in Section 2..)

NOTE — Except for the main switching and interrupting device, other devices, such as instrument transformers, which are mounted in the bus assemblies, should be disconnected during dielectric tests. Such devices are individually tested in accordance with standards applying to them.

6.2 Design Tests

The equipment to be tested shall be in a new and clean condition. Tests shall be made at the factory or manufacturer's test laboratory, unless otherwise specified. The bus conductors may be extended out of the enclosure to permit the attachment of test connections.

6.2.1 Dielectric Tests

The dielectric withstand tests and, where applicable, conductor insulation tests shall be made to determine the adequacy of the insulation. See 6.2.1.4 for conductor insulation tests.

The dielectric withstand tests shall consist of the application of a voltage with a value at least equal to the voltages in Table 3.A, 3.B, and 3.C.

Dielectric withstand tests shall be made under the temperature and humidity conditions normally obtained under conditions of commercial testing with appropriate correction factors applied as outlined in ANSI/IEEE Std4-1978 [6].

Dielectric withstand tests shall be made as follows: