ANSI/IEEE Std 386-1985
(Revision of ANSI/IEEE Std 386-1977)

American National Standard

separable insulated connector systems for power distribution systems above 600V

ANSI/IEEE Std 386-1985

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(Revision of ANSI/IEEE
Std 386-1977)

An American National Standard

IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

Sponsor

Transmission and Distribution Committee of the
IEEE Power Engineering Society

Secretariat

National Electrical Manufacturers Association

Approved September 22, 1983

IEEE Standards Board

Approved March 22, 1985

American National Standards Institute

Foreword

(This Foreword is not a part of ANSI/IEEE Std 386-1985, IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.)

This standard was developed in response to a need created by the rapid expansion of underground distribution systems. A key element that allowed this expansion to become a reality is the separable insulated connector. This device provides for simple and inexpensive connection and switching to transformers and other equipment used in underground distribution.

When separable insulated connectors become available, the Institute of Electrical and Electronics Engineers and the National Electrical Manufacturers Association work cooperatively to develop a document that will define the interfaces, ratings, and test conditions for the device. The success of that cooperative effort is apparent from both the vast number of these devices now in interchangeable use in the field and their enviable safety record.

Because the technology within the field of underground distribution is under constant development, with accompanying new products and distribution schemes, it is necessary to provide for constant review of these connector requirements and to make participation in this ongoing activity available to all concerned organizations. To accomplish this purpose and provide a mechanism for development of additional related standards, American National Standards Committee C119 (now Accredited Standards Committee C119) was organized with a balanced representation of users, manufacturers, and general interest expertise. It is the hope and the expectation of C119 that those who have comments and additions may assist in the revision activity by forwarding their comments to C119, American National Standards Institute, 1430 Broadway, New York, NY 10018.

This revision was developed by ANSI Subcommittee C119.2 under auspices of the Distribution Subcommittee of the Transmission and Distribution Committee of the IEEE Power Engineering Society. To the extent available, data used in it were gathered from pertinent existing industry standards for power cable, distribution transformers, and other electrical apparatus.

One of the primary objectives of this standard is to provide a basis for electrical interchangeability of corresponding 8.3 and 14.4 kV interfaces and mechanical interchangeability of operating interfaces between connector elements supplied by different manufacturers. However, to avoid exclusion of any connector design, a multiplicity of interfaces which are not interchangeable with each other is included. Hence, a purchaser must select a design for his particular need. Users and manufacturers are encouraged to use the designs illustrated.

At the time this standard was approved the membership of Accredited Standards Committee C119 was as follows:

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At the time this standard was approved the membership of the Working Group of the Distribution Subcommittee on Separable Connectors was as follows:

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An American National Standard

IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

1. Scope

This standard establishes definitions, service conditions, ratings, interchangeable construction features and tests for load-break and dead-break separable insulated connector systems rated 601 V and above, 600 A or less, for use on power distribution systems.

2. References

When the following standards are superseded by an approved revision, the latest revision shall apply.

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

[2] ANSI/IEEE C37.09-1979, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

[3] ANSI/IEEE C62.1-1984, IEEE Standard for Surge Arresters for AC Power Circuits.

[4] ANSI/NEMA CC3-1973, Connectors for Use Between Aluminum or Aluminum-Copper Overhead Connectors.[1]

[5] IEEE Std 592-1977, IEEE Standard for Exposed Semiconducting Shields on Premolded High-Voltage Cable Joints and Separable Insulated Connectors.

[6] MIL-STD 105D-1963, Sampling Procedures and Tables for inspection by Attributes.[2]

[1] This publication is available from the National Electrical Manufacturers Association (NEMA), 2101 L. Street, N.W., Washington, DC 20037. It is also available from the Sales Department of American National Standards Institute, 1430 Broadway, New York, NY 10018.

[2] MIL publications are available from the Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

3. Definitions

The following definitions are the intended meanings of terms used in this standard or associated with separable insulated connectors systems. Figures 1 and 2 show typical components of separable insulated connectors. The term *connector* as used in this standard means separable insulated connector.

bushing insert. A connector component intended for insertion into a bushing well (see Fig 1).

bushing well. An apparatus bushing having a cavity for insertion of a connector component, such as a bushing insert (see Fig 1).

continuous current rating. The designated rms alternating or direct current which the connector can carry continuously under specified conditions.

dead-break connector. A connector designed to be separated and engaged on de-energized circuits only.

elbow. A connector component for connecting a power cable to a bushing, so designed that when assembled with the bushing, the axes of the cable and bushing are perpendicular (see Fig 1).

environmental temperature. The temperature of the surrounding medium, such as air, water, and earth, into which the heat of the connector is dissipated directly, including the effect of heat dissipation from associated cables and apparatus.

fault-closure current rating. The designated rms fault current which a load-break connector can close under specified conditions.

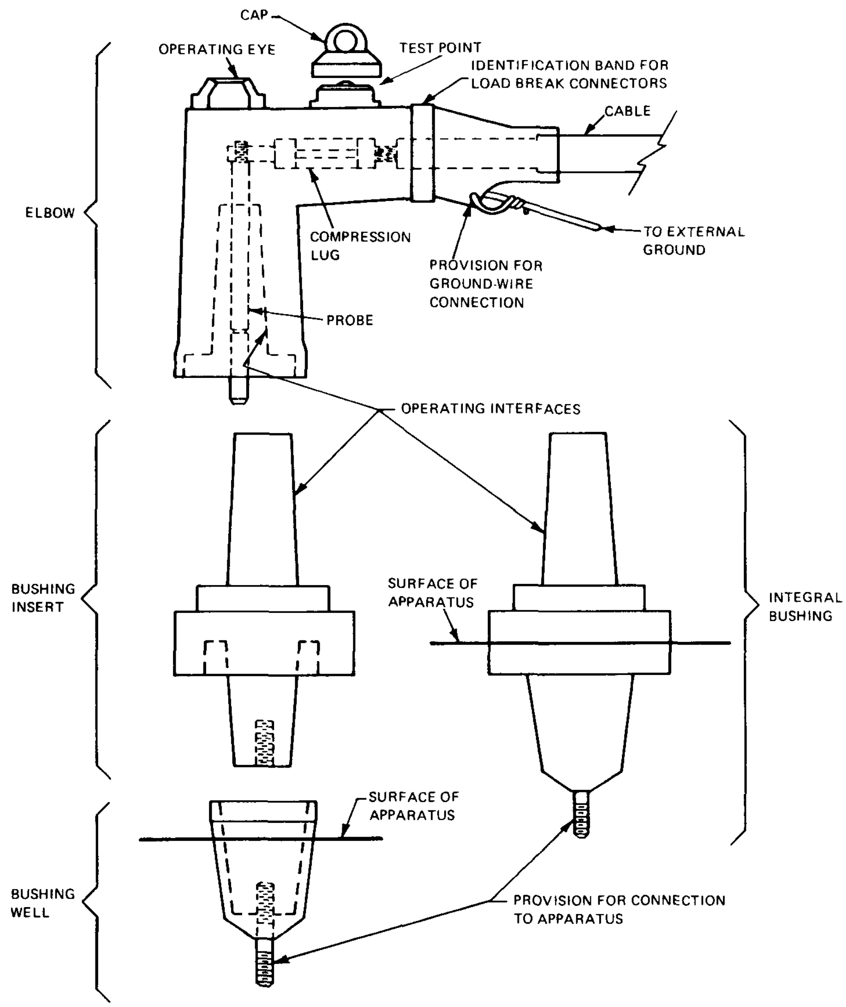


Fig 1
Typical Components of 200 A Separable Insulated Connector System

ground bushing. An accessory device designed to electrically ground and mechanically seal a de-energized power cable terminated with an elbow.

grounding elbow. An accessory device designed to electrically ground and mechanically seal a bushing insert, or integral bushing.

hold-down bail. An externally mounted device designed to prevent separation at the operating interface of an elbow and an apparatus bushing.

insulated parking bushing. An accessory device designed to electrically insulate and shield and mechanically seal a power cable terminated with an elbow.

insulated cap. An accessory device designed to electrically insulate and shield and mechanically seal a bushing insert or integral bushing.

integral bushing. An apparatus bushing designed for use with another connector component, such as an elbow (see Fig 1).

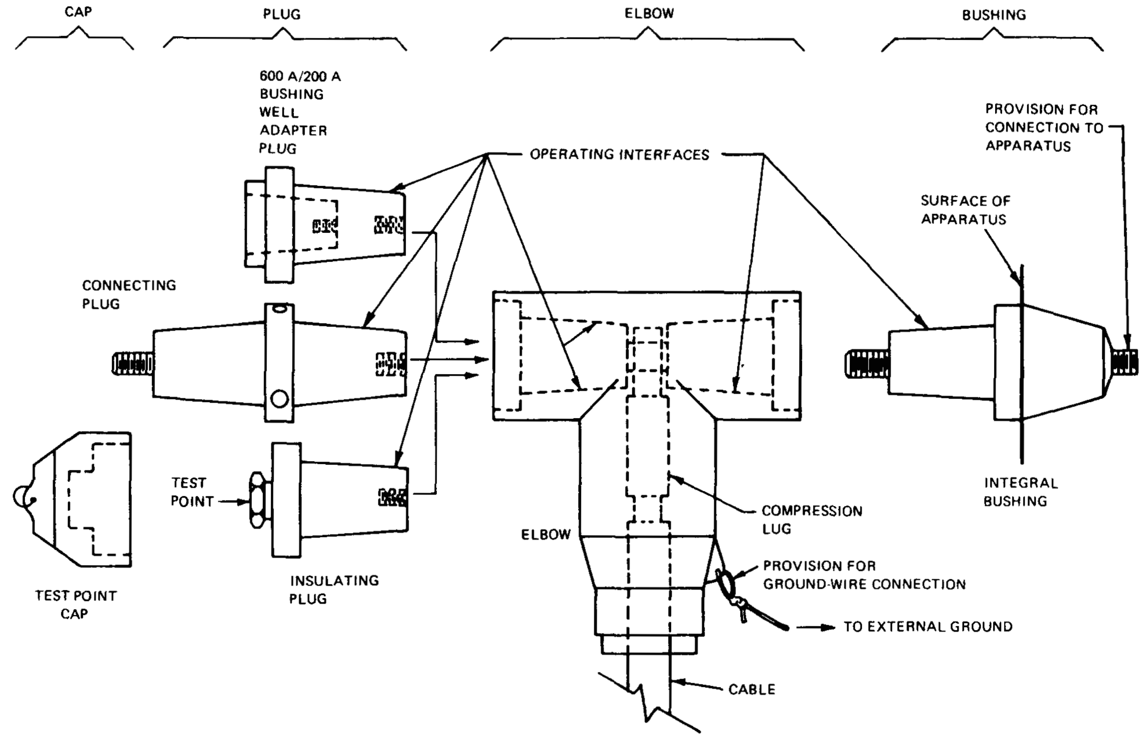


Fig 2
Typical Components of 600 A Separable Insulated Connector System

load-break connector. A connector designed to close and interrupt current on energized circuits.

maximum voltage rating. The highest phase-to-ground or phase-to-ground and phase-to-phase voltage (rms) at which a connector is designed to operate.

operating interface. The surfaces at which a connector is normally separated (see Figs 1 and 2).

parking stand. A bracket, designed for installation on an apparatus, suitable for holding accessory devices, such as insulated parking bushing and grounding bushing.

separable insulated connector. A fully insulated and shielded system for terminating and electrically connecting an insulated power cable to electrical apparatus, other power cables, or both, so designed that the electrical connection can be readily established or broken by engaging or separating the connector at the operating interface (see Figs 1 and 2).

short-time current rating. The designated rms current which a connector can carry for a specified time under specified conditions.

switching current rating. The designated rms current which a load-break connector can connect and disconnect for a specified number of times under specified conditions.

test point. A capacitively coupled terminal for use with voltage sensing devices (see Figs 1 and 2).

withstand voltage. The specified voltage that, under specified conditions, can be applied to insulation without causing flash-over or puncture.

4. Service Conditions

4.1 Usual Service Conditions. Connectors shall be suitable for use under the following service conditions:

(1) In air, including exposure to direct sunlight

(2) Buried in earth

(3) Intermittently or continuously submerged in water at a depth not exceeding 2 m (6 ft)

(4) Environmental temperatures within the range of − 40 °C to + 65 °C (load-break connectors can be closed and separated within the range of − 20 °C to + 65 °C)

(5) Altitudes not exceeding 1800 m (6000 ft) above sea level (applicable to load-break connectors only)

4.2 Unusual Service Conditions. Conditions other than those listed in 4.1 are considered to be unusual. (The manufacturer should be consulted for recommendations.)

5. Ratings and Characteristics

5.1 Voltage Ratings. The voltage ratings and characteristics of connectors shall be in accordance with Table 1.

5.2 Current Ratings. The current ratings and characteristics of connectors shall be in accordance with Table 2.

Table 1
Voltage Ratings and Characteristics

Maximum Voltage Rating (kV rms)*	Withstand Voltages: BIL and Full Wave (kV Crest)	Withstand Voltages: Alternating Current 60 Hz for 1 min (kV rms)	Withstand Voltages: Direct Current for 15 min (kV)	Minimum Corona Voltage Level (kV rms)†
8.3‡	95	34	53	11
8.3/14.4§	95	34	53	11
15.2‡	125	40	78	19
15.2/26.3§	125	40	78	19
21.1‡	150	50	103	26
21.1/36.6§	150	50	103	26

*The highest steady state voltage across the open contacts that a loadbreak connector is rated to switch is:
(1) The maximum phase-to-ground rms voltage for phase-to-ground rated devices
(2) The maximum phase-to-phase rms voltage for phase-to-ground/phase-to-phase rated devices

†Based on a sensitivity of 3 pC (see 7.4).

‡Phase-to-ground

§Phase-to-ground/phase-to-phase

Table 2
Current Ratings and Characteristics

Continuous Current Rating (A rms*)	Switching Current Rating (A rms)	Fault-Closure Current Rating†: Amperes rms, Symmetrical	Fault-Closure Current Rating†: Duration (s)‡	Fault-Closure Current Rating†: Minimum x/r	Short-Time Current Rating: Amperes rms Symmetrical	Short-Time Current Rating: Duration (s)	Short-Time Current Rating: Minimum x/r
200	200	10 000	0.05	6	10 000	0.17	6
					3500	3.00	6
200	200	10 000	0.17	6	10 000	0.17	6
					3500	3.00	6
600	—	—	—	—	25 000	0.17	20
					10 000	3.00	20

* In general, the overload capability of a connector exceeds its continuous current rating. Overload capability varies with environment, cable sizes, etc. The connector manufacturer's recommendations should be obtained for the particular combination involved.

† Applicable to loadbreak connectors only. Fault-closure current ratings have not been established for 21.1 kV/36.6 kV load-break connectors. Equipment to which these assemblies are affixed may have lower safe limits of fault current performance.

‡ The manufacturer shall designate the fault-closure duration.

6. Construction

6.1 Identification. Mating components of a separable insulated connector shall be permanently (for example, ink stamp, brand, or molded in) and legibly identified with the following information:

(1) Manufacturer's identification

(a) Company name or logo

(b) Part identification

(c) Date of manufacture

(2) Continuous current rating (when applicable)

(3) Maximum voltage rating

(4) Cable insulation diameter range (when applicable)

(5) Whether load-break or dead-break (when applicable). In addition, elbows of load-break connectors shall have the following marking:

(a) Connectors with a phase-to-ground voltage rating shall be identified with a removable white band 13 mm – 32 mm (0.5 in – 1.25 in) wide, located on the cable entrance portion of the connector not less than 25 mm (1.00 in) from the cable entrance. The removable band shall be clearly visible from the normal operating position, and affixed to minimize its accidental dislodgement.

(b) Connectors with both phase-to-ground and phase-to-phase voltage ratings shall be identified with a removable white band 13 mm – 32 mm (0.5 in – 1.25 in) wide, having a centered black stripe 4.8 mm ± 1.6 mm (0.188 in ± 0.062 in) in width located on the cable entrance portion of the connector not less than 25 mm (1.00 in) from the cable entrance. The removable band shall be clearly visible from the normal operating position, and affixed to minimize its accidental dislodgement.

6.2 Operating Means. Connectors shall be operable by means of a suitable live-line tool which clamps the elbow so that operation is along the probe axis. The required operating force over the environmental range of – 20 °C to + 65 °C shall be as follows (see 7.14):

(1) 225 N – 900 N (50 lbf – 200 lbf) for connectors without hold-down bails

(2) 45 N – 900 N (10 lbf – 200 lbf) for connectors with hold-down bails

If an operating eye is provided, it shall support a 1300 N (300 lbf) static operating force and a 14 N • m (120 lbf • in) rotational force.

6.3 Shielding. Connectors shall have an electrically conductive shield and, where required, shall have provision for connecting an external ground to the shield. Except for nonelastomeric components, connectors shall meet the requirements of IEEE Std 592-1977 [5].

6.4 Interchangeability

6.4.1 Complete Interchangeability. Intermixed bushings and elbows of different manufacture shall be considered interchangeable provided they meet all applicable requirements of this standard.

6.4.2 Limited Interchangeability. Intermixed bushings and elbows of different manufacture meeting all the requirements of this standard, except 7.7 and 7.8, shall be considered interchangeable, except for switching and fault closure.

The dimensions of operating and bushing well interfaces shall be in accordance with Figs 3 through 11.

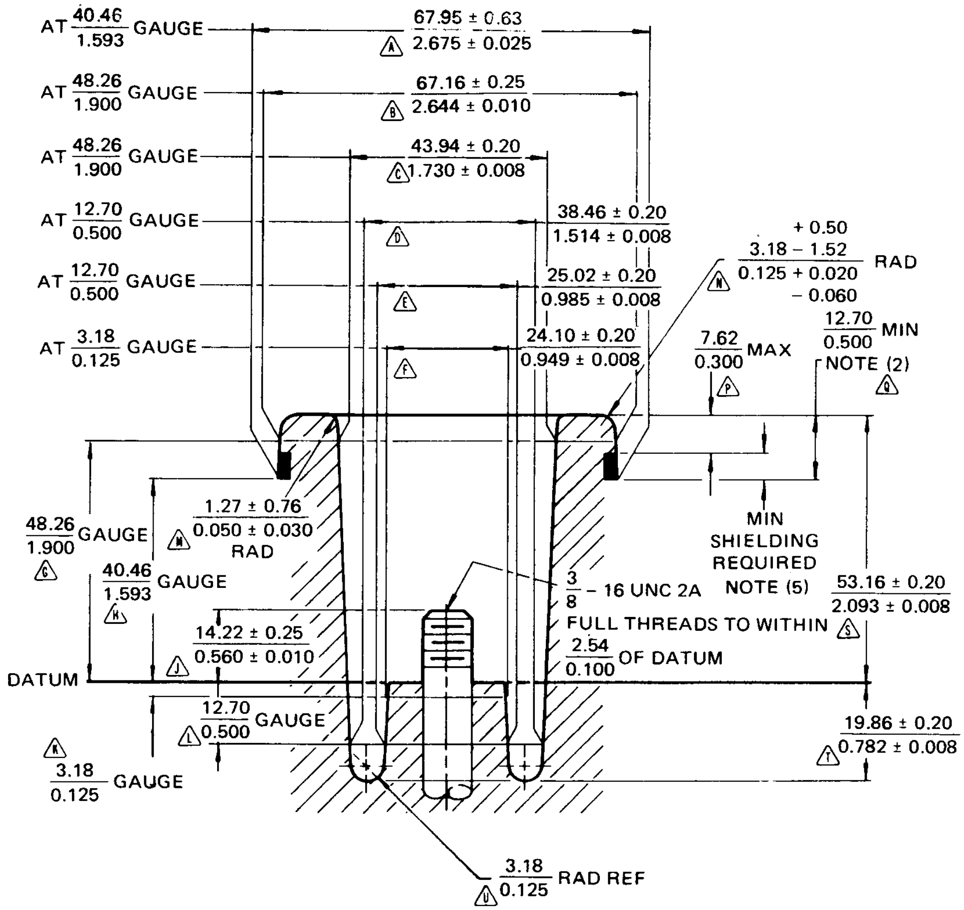
6.5 Test Point. Test points are optional and may be specified on either load-break or dead-break elbows.

6.5.1 Capacitance. Test points shall be capacitively coupled to the conductor system and shield of the connector.

The capacitance between the test point and the conductor system shall be at least 1.0 pF. The ratio of the capacitance between test point and shield to the capacitance between test point and conductor system shall not exceed 12.0. These values shall be verified by tests when conducted in accordance with 7.17.1.

6.5.2 Cap Removal Force. The force required to remove the test-point cap shall be within the range of 36 N – 219 N (8 lbf – 49 lbf). The cap operating eye shall be capable of withstanding a static operating force of 433 N (100 lbf) over the environmental temperature range of – 20 °C to + 65 °C (see 7.16.1).

6.6 Hold-Down Bails. Dimensions, materials, and performance criteria are not specified in this standard.



NOTES: (1) Diameters C, D, E, and F to be concentric with pitch diameter of threads on stud within 0.25/0.010 TIR (total indicator reading)

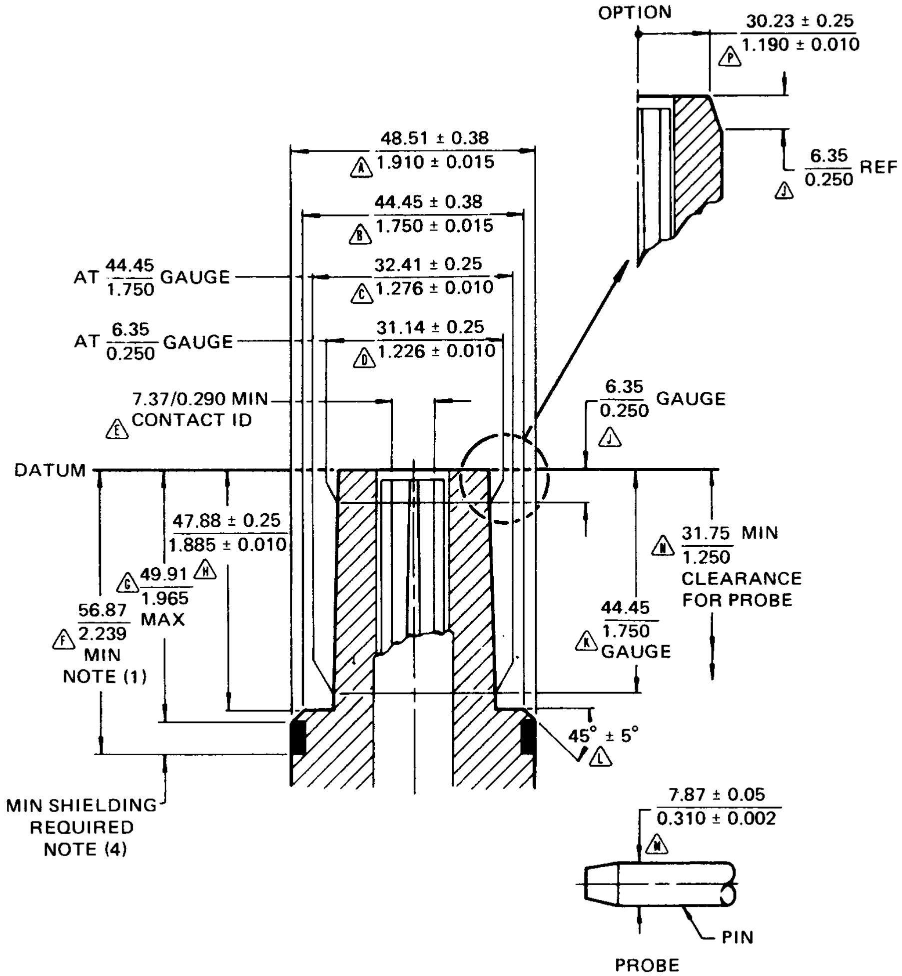
(2) Clearance for mating parts

(3) Dimension: mm/in; $\frac{\text{mm}}{\text{in}}$

(4) Δ—alphabetical dimensional identification

(5) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 3
200 A Bushing-Well Interface, 8.3 kV, 15.2 kV, and 21.1 kV



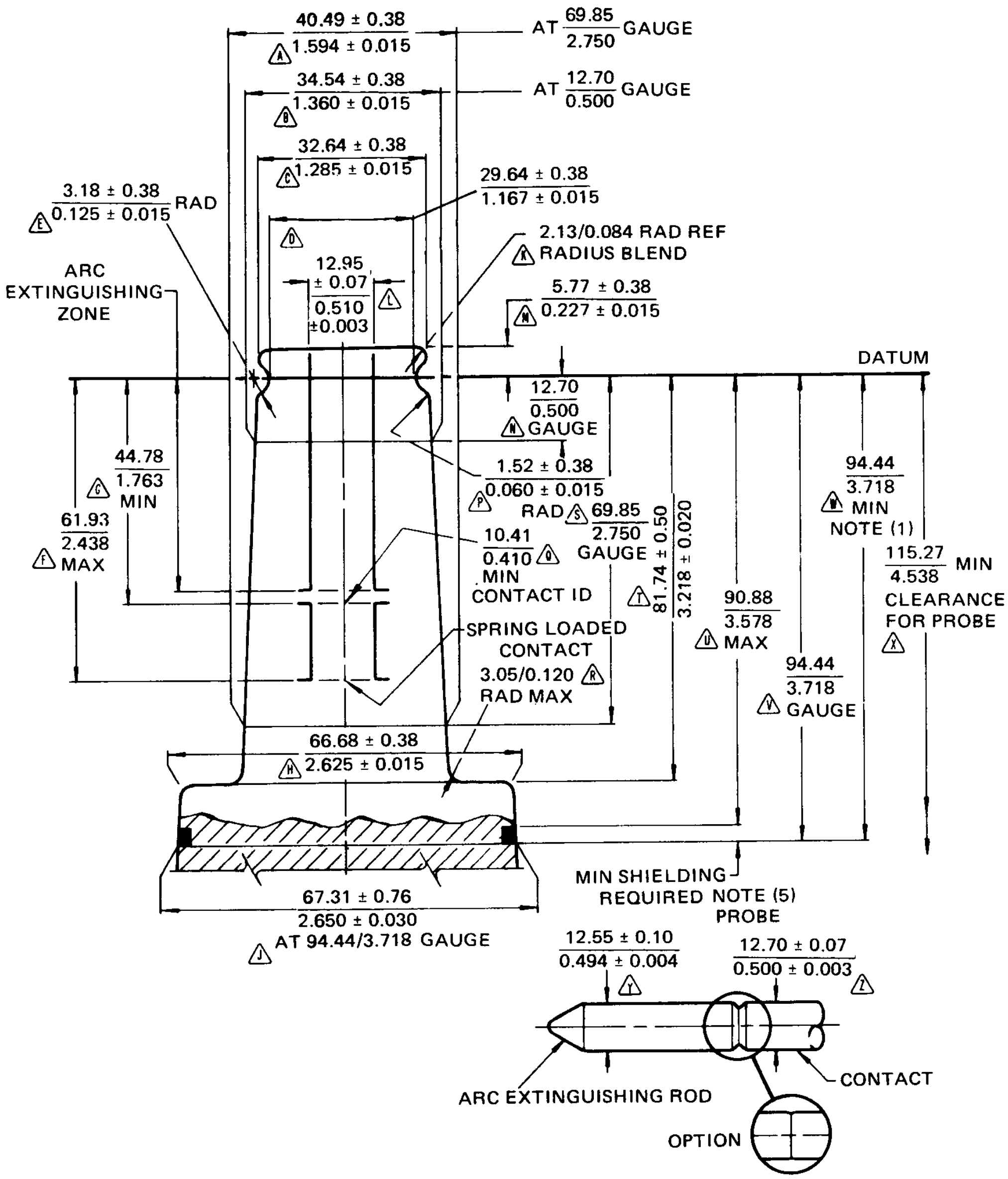
NOTES: (1) Clearance for mating parts

(2) Dimensions: mm/in; $\frac{mm}{in}$

(3) Δ—alphabetical dimensional identification

(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 4
200 A Dead-Break Interface,
8.3 kV and 15.2 kV



NOTES: (1) Clearance for mating parts

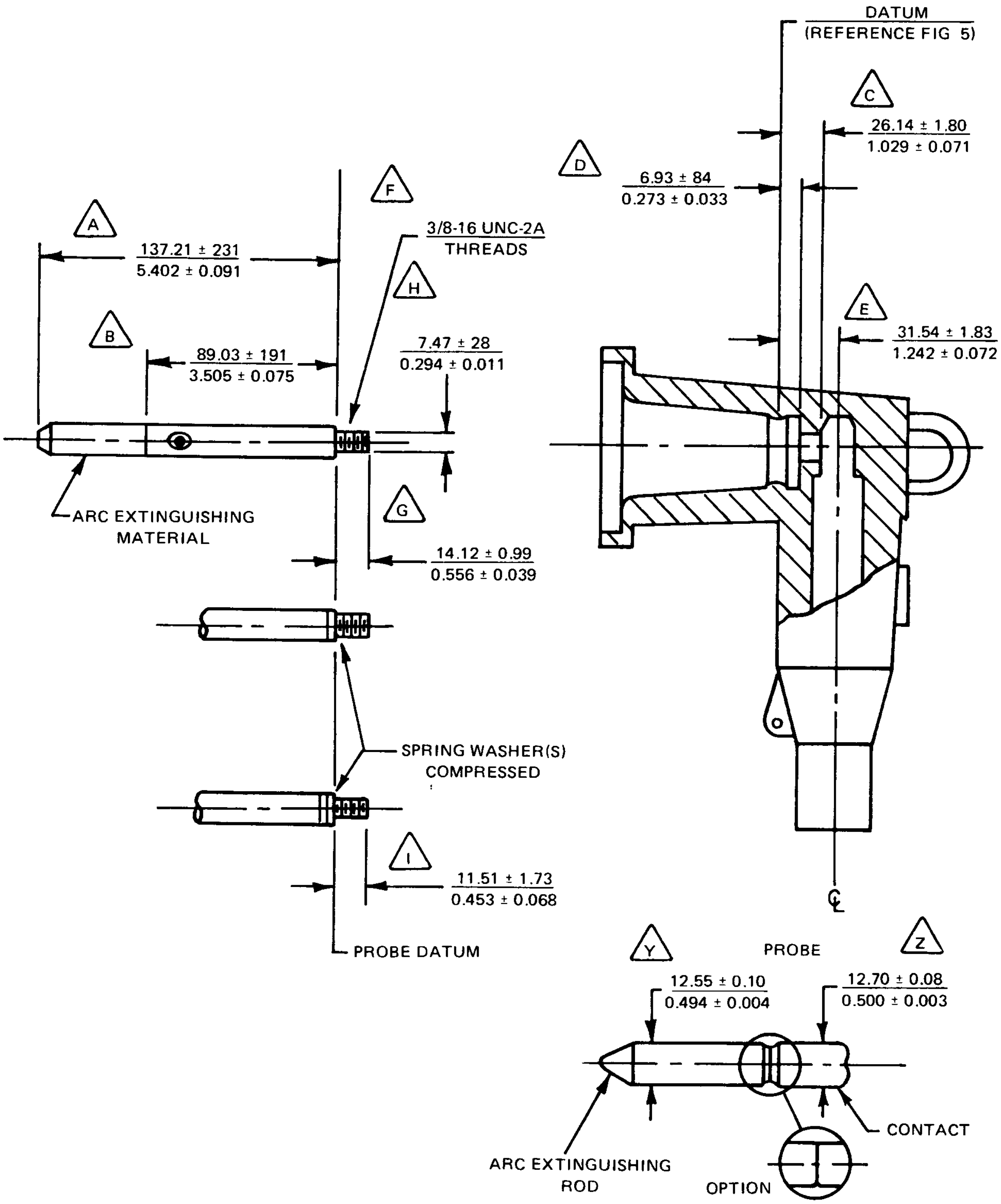
(2) Dimensions: mm/in; $\frac{\text{mm}}{\text{in}}$

(3) Δ—alphabetical dimensional identification

(4) Probe and elbow—see Fig 6

(5) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 5
200 A Load-Break Interface,
8.3 kV and 8.3 kV/14.4 kV

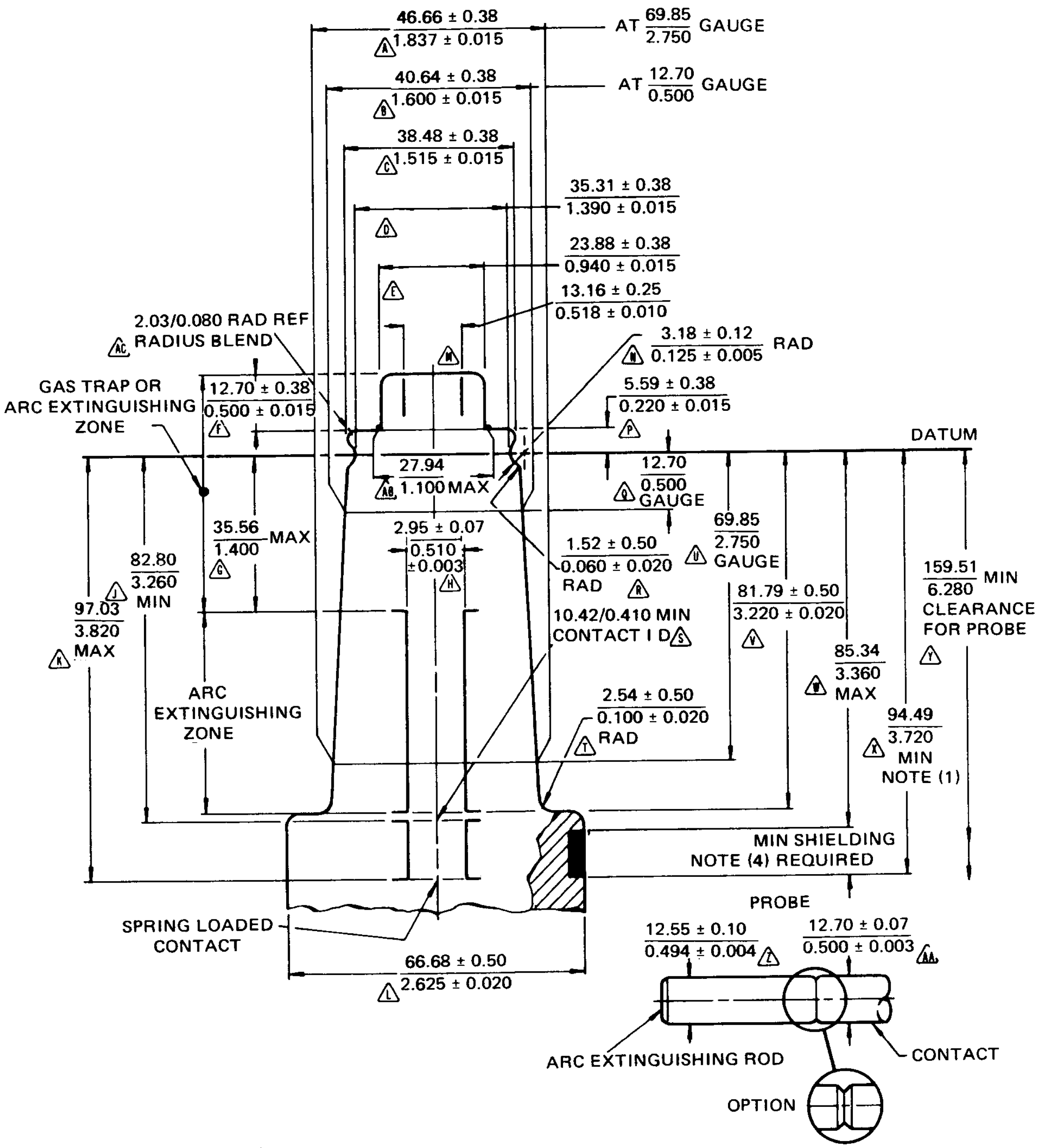


NOTES: (1) For bushing, see Fig 5

(2) Dimensions: mm/in; $\frac{mm}{in}$

(3) Δ—alphabetical dimensional identification

Fig 6
200 A Load-Break Probe and Elbow
8.3 kV and 8.3 kV/14.4 kV



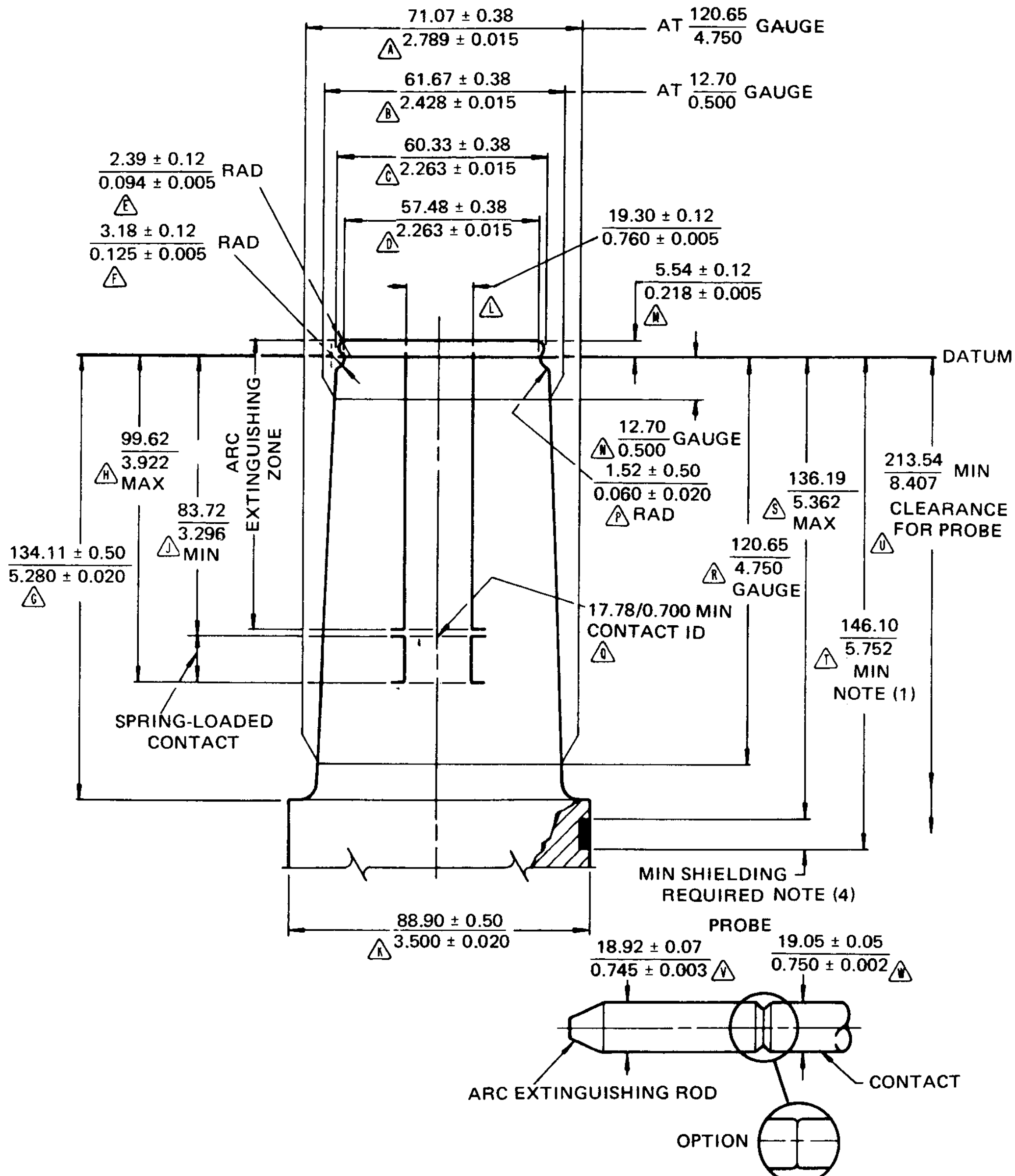
NOTES: (1) Clearance for mating parts

(2) Dimensions: mm/in; $\frac{\text{mm}}{\text{in}}$

(3) Δ—alphabetical dimensional identification

(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 7
200 A Load-Break Interface, 15.2 kV and 15.2 kV/26.3 kV, 200 A Load-Break Interface No 2, 21.1 kV and 21.1 kV/36.6 kV



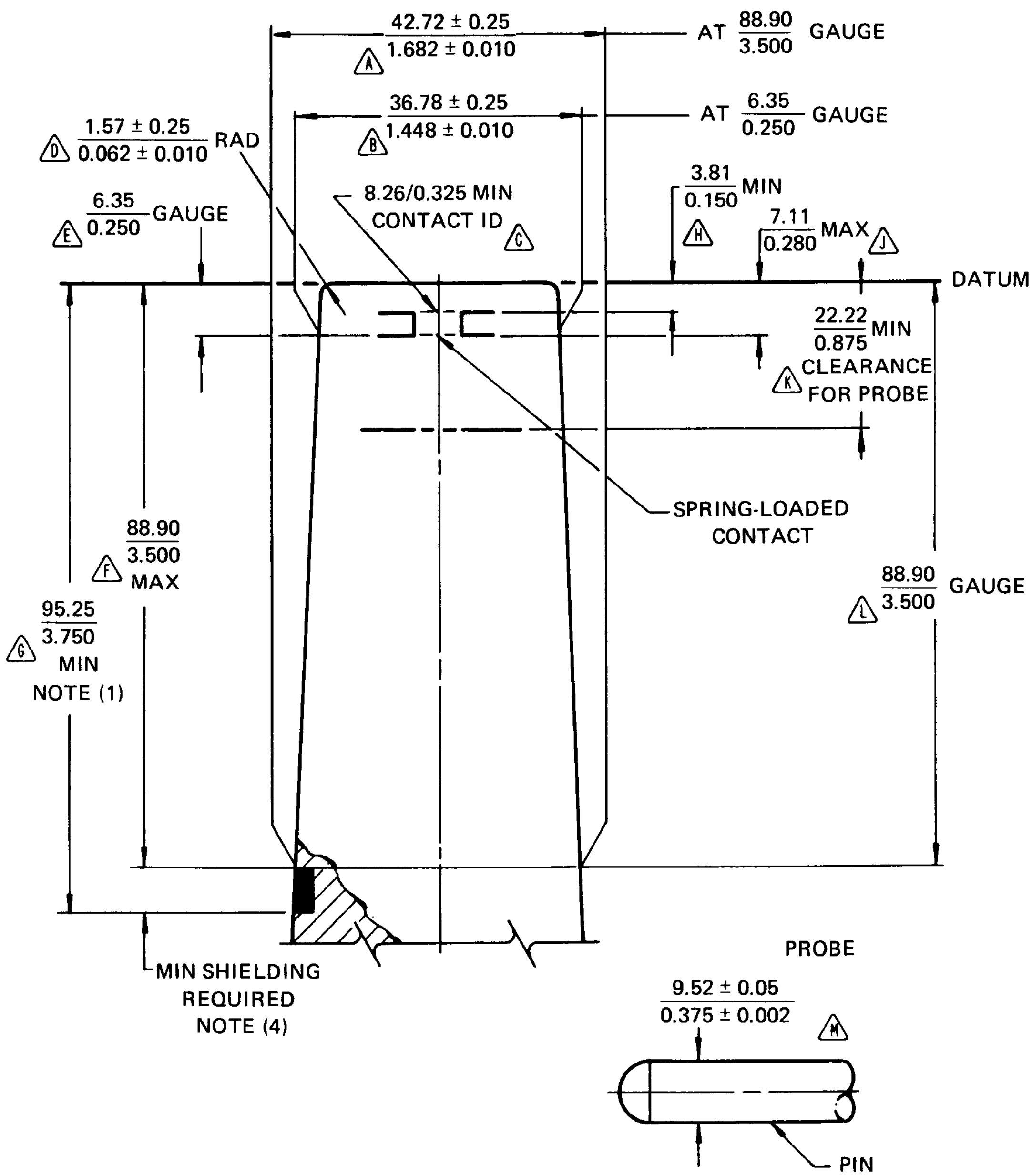
NOTES: (1) Clearance for mating parts

(2) Dimensions: mm/in; $\frac{\text{mm}}{\text{in}}$

(3) Δ—alphabetical dimensional identification

(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 8
200 A Load-Break Interface No 1, 21.1 kV and 21.1 kV/36.6 kV



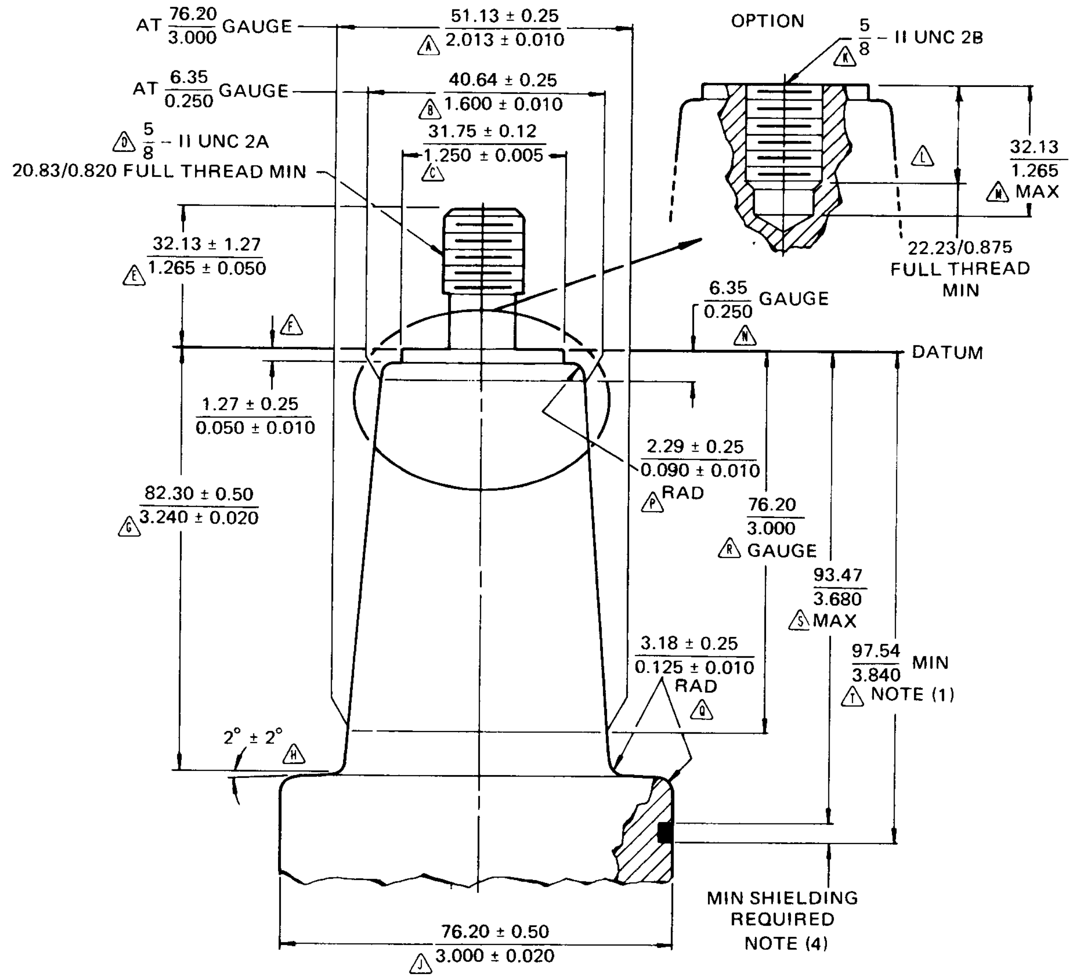
NOTES: (1) Clearance for mating parts

(2) Dimensions: mm/in; $\frac{mm}{in}$

(3) Δ—alphabetical dimensional identification

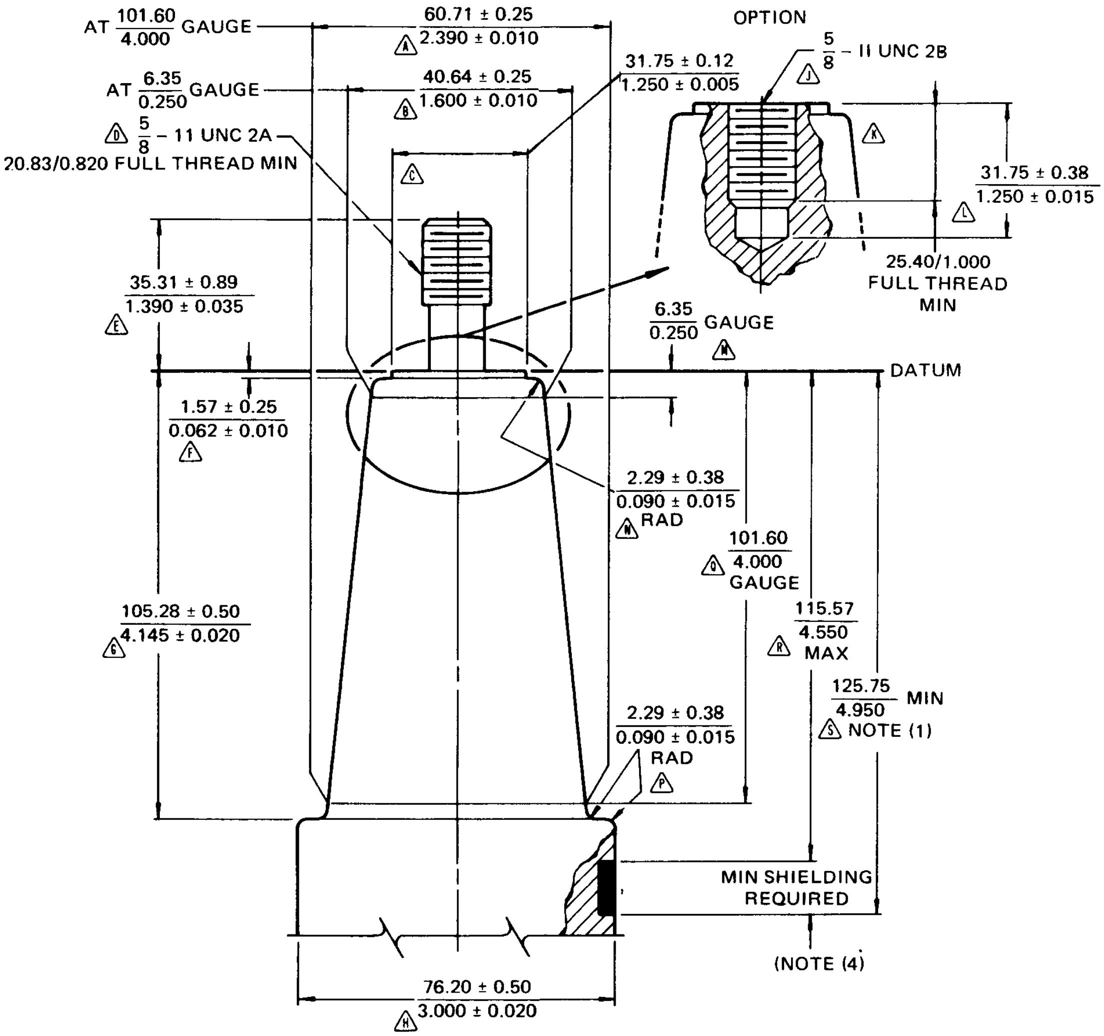
(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion

Fig 9
200 A Dead-Break Interface, 21.1 kV



NOTES: (1) Clearance for mating parts
(2) Dimensions: mm/in; $\frac{mm}{in}$
(3) Δ—alphabetical dimensional identification
(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion except for bushings which have internal shielding

Fig 10
600 A Dead-Break Interface, 8.3 kV and 15.2 kV



NOTES: (1) Clearance for mating parts

(2) Dimensions: mm/in; $\frac{\text{mm}}{\text{in}}$

(3) Δ—alphabetical dimensional identification

(4) The diameter of the shielded portion shall at no point be less than the largest diameter of the insulated portion except for bushings which have internal shielding

Fig 11
600 A Dead-Break Interface, 21.1 kV

7. Testing

7.1 Production Tests. The following production tests shall be performed by the manufacturer on all connector components except bushing well, ground bushing, and grounding elbow:

(1) Corona voltage level (see 7.4)

(2) Alternating-current withstand or full-wave impulse withstand voltage (see 7.5.1 and 7.5.3)

(3) Test-point voltage test if applicable (see 7.17.2)

Bushing wells shall be tested in accordance with MIL-STD-105D-1963 [6] with acceptable quality level of 2.5% using the normal inspection level.

7.2 Design Tests. The design tests listed in Table 3 shall be performed by the manufacturer to demonstrate compliance of the design with this standard.

7.3 Test Conditions. The following test conditions shall apply unless otherwise specified:

(1) Connectors shall be properly assembled with actual or simulated components. All parts which are normally grounded shall be connected to the ground of the test circuit

(2) Ambient temperature shall be in the range of 0 °C − + 40 °C

(3) All alternating-current voltages shall have a frequency of 60 Hz ± 5% and sine wave shape of acceptable commercial standards as defined in ANSI/IEEE Std 4-1978 [1].

(4) Voltages shall be measured in accordance with ANSI/IEEE Std 4-1978 [1].

7.4 Corona Voltage Level. The purpose of this test is to verify that the corona voltage level of the test specimen is not less than the value given in Table 1.

The test voltage shall be raised to 20% above the corona voltage level specified in Table 1. If corona exceeds 3 pC, the test voltage shall be lowered to the corona voltage level specified in Table 1 and shall be maintained at this level for at least 3 s but not more than 60 s. Corona readings taken during this period shall not exceed 3 pC.

7.5 Dielectric Tests. The purpose of these tests is to verify that the insulation of the test specimen will withstand the voltages shown in Table 1.

The test voltage shall be applied to the parts of the connector which is energized in service.

The test point, if any, shall be grounded during these tests.

7.5.1 Alternating-Current Withstand Voltage Test. The test voltage shall be raised to the value specified in Table 1 in not more than 30 s. The connector shall withstand the specified test voltage for 1 min without flashover or puncture.

Table 3
Design Tests

Design Test	Section	Number of Samples *
Corona voltage level	7.4	10
Alternating-current withstand voltage	7.5.1	10
Direct-current withstand voltage	7.5.2	10
Impulse withstand voltage	7.5.3	10
Short-time current	7.6	4
Switching	7.7	30 (max)
Fault-closure	7.8	30 (max)
Current cycling	7.9 – 7.11† and 7.12	4
Accelerated sealing life test	7.12	4
Cable pull-out (tensile strength)	7.13	4
Operating force	7.14	4
Operating eye	7.15	4
Test-point cap	7.16	4
Test point	7.17	10
Shielding	7.18	4

* No failures permitted except for switching and fault-closure tests in which none are permitted in ten consecutive samples of a maximum lot size of 30.

† *Option A* or *Option B. (see 7.10)*

7.5.2 Direct-Current Withstand Voltage Test. The test voltage shall have a negative polarity (that is, negative terminal connected to test specimen) and shall be raised to the value specified in Table 1. The connector shall withstand the specified test voltage for 15 min without flashover or puncture.

7.5.3 Impulse Withstand Voltage Test (BIL). The test voltage shall be 1.2/50 μs wave having the crest value (BIL) specified in Table 1. The wave shape shall meet the requirements of ANSI/IEEE C62-1-1984 [3]. The wave-shape tolerance shall be as shown in the following table:

Measured Quantity	Tolerance (±%)
Crest value	3
Front time	30
Time to half value	20
Nominal rate of rise of wave front	20

The closed connector shall withstand three positive and three negative full-wave impulses without flashover or puncture. When the impulse withstand test is used as a production test, the connector shall withstand one full-wave impulse of each polarity.

7.6 Short-Time Current Test. The purpose of this test is to verify that the connector is capable of withstanding short-time current of the magnitudes and durations shown in Table 2.

The connector shall be mounted in a manner approximating service conditions. Hold-down bails shall be used with 200 A dead-break elbows.

Short-time current tests may be made at any voltage up to the rated voltage of the connector.

The rms value of the first major loop of a current wave shall be not less than the value specified in Table 2 times 1.3 ($X/R=6$) for 200 A connectors or 1.6 ($X/R=20$) for 600 A connectors. The magnitude shall be measured in accordance with ANSI/IEEE C37-09-1979 [2].

Connectors shall withstand the current without separation of interfaces or impairing the ability to meet the other requirements of the standard.

7.7 Switching Test. (Applicable to load-break connectors only.) The purpose of this test is to verify that the load break connector is capable of closing and interrupting the rated switching current given in Table 2.

The connector shall withstand ten complete switching operations under the conditions listed in Fig 12 and Table 4 without arcing to ground or impairing its ability to meet the other requirements of this standard. A complete switching operation shall consist of connecting and disconnecting. Appropriate ground-fault detection equipment shall be used for all tests. The last switching operation shall be recorded by an oscillogram.

Table 4
Voltage Conditions for Switching Test

Connector Voltage Rating (kV rms)†	Fig 12 Test Voltage V_1	V_2	Test Circuit Diagram Required (see Fig 12)
8.3	8.3	—	C
8.3/14.4	14.4	8.3	A or B
15.2	15.2	—	C
15.2/26.3	26.3	15.2	A or B
21.1	21.1	—	C
21.1/36.6	36.6	21.1	A or B

† The highest steady-state voltage across the open contacts that a loadbreak connector is rated to switch is:

(1) The maximum phase-to-ground rms voltage for phase-to-ground rated devices

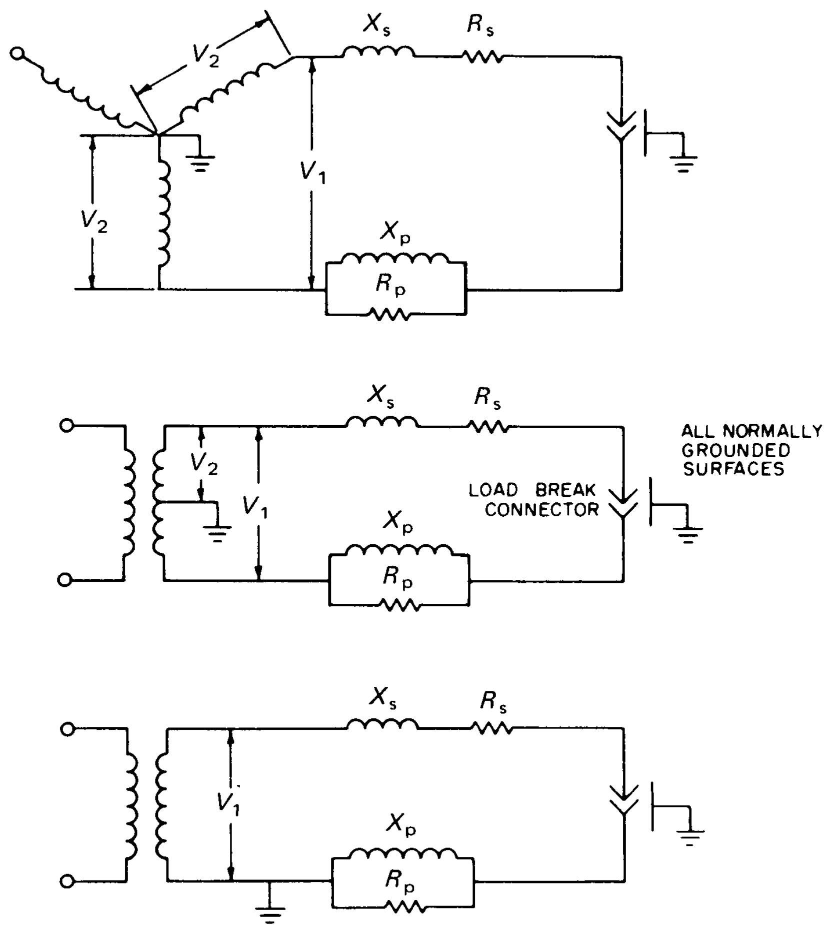
(2) The maximum phase-to-phase rms voltage for phase-to-ground/phase-to-phase rated devices.

7.7.1 Mounting Preparation of Load-Break Connectors for Switching Tests. The connector shall be mounted with all normally grounded parts grounded in a manner closely approximating normal service conditions. Adjacent grounds, in the form of connector systems of the same type as the one being tested, shall be mounted and appropriately grounded on each side of the connector under test at the distance shown in Table 5. If hold-down bails are used, these shall be installed as in normal service.

Table 5
Elbow Spacing for Switching and Fault-Closure Tests

Connector Voltage Rating (kV rms)	Maximum Center-to-Center Spacing Millimeters	Inches
8.3	82.6	3¼
8.3/14.4	82.6	3¼
15.2	101.6	4
15.2/26.3	101.6	4
21.1	139.7	5½
21.1/36.6	139.7	5½

NOTE: Tests shall be conducted with adjacent grounds *exposed* as in normal service.



$\frac{X_s}{R_s} = 5$ to 7

Power factor = 70% to 80% lagging

$Z_s = 10\% - 14\%$ of $\frac{V_1}{200\,A}$ $\qquad Z_s = X_s + R_s$

NOTE: Care shall be exercised in the selection and connection of instrument transformers to ensure that they will not significantly alter the waveshape, magnitude, or duration of transient voltages or current normally associated with the test circuit.

The switching rating may be achieved with the separating parts in either position.

Series impedance which may include source impedance may appear on either side of the load-break connector.

Transformer loading which represents normal service conditions can be used for switching.

Fig 12
Circuit Diagrams for Switching Current Tests

7.7.2 Operating Procedures for Switching Test. The loadbreak connector under test shall be operated with a suitable live-line tool. Successive switching operations shall be performed at a time interval of not less than 1 min. (A manufacturer may test his product under conditions of a reduced time interval.) The operator shall maintain a minimum dwell time of 5 s after the probe is positioned in the arc extinguishing area of its mating part. Time between closing and opening of the test connector shall allow steady-state voltage and current conditions to be achieved prior to opening. The operator shall perform the closing and opening operations with positive continuous motion so as not to *tease* the contacts.

7.8 Fault-Closure Test. (Applicable to loadbreak connectors only.) The purpose of the test is to verify that the connector is capable of closing on the fault current given in Table 2.

Fault-closure tests shall be conducted on connectors from the lot which has passed the switching test (7.7). Any connector from this lot which has successfully completed ten switching operations may be used in the fault-closure test and shall be used in the same sequence in both tests. The test conditions shall be as shown in Table 6 and Fig 13. At least one connector shall be closed at an instant when the voltage is 80% or more of its peak value.

Table 6
Voltage Conditions for Fault-Closure Test

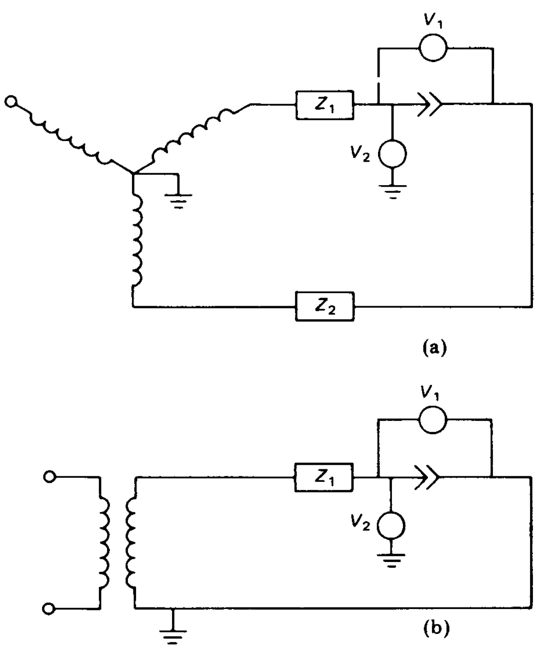
Connector Voltage Rating (kV rms)	Fig 13 Test Voltage (kV rms) V_1	V_2	Test Circuit Diagram Required (see Fig 13)
8.3	8.3	—	B
8.3/14.4	14.4	4.2	A
15.2	15.2	—	B
15.2/26.3	26.3	7.6	A
21.1	21.1	—	B
21.1/36.6	36.6	10.6	A

Fig 13
Circuit Diagrams for Fault-Closure Tests

NOTE: Any circuit that duplicates the voltages V_1 and V_2 and the conditions in Table 2 is acceptable for conducting the fault-closure test

V_1 = required voltage across contacts prior to flow of fault current

V_2 = required voltage from each contact to all normally grounded surfaces during flow of fault current



$$Z_1 + Z_2 = \frac{V_1 \text{ (Open-Circuit Voltage)}}{\text{Rated Fault-Closure Current}}$$

$$Z_1 \cong Z_2$$

$$Z_1 = \frac{V_1 \text{ (Open-Circuit Voltage)}}{\text{Rated Fault-Closure Current}}$$

The sample lot will have successfully passed the fault-closure test if ten consecutive samples meet the following criteria:

(1) Oscillograms show no external ground current

(2) All parts remain within the closed connector assembly

Connectors need not be operable after this test.

7.8.1 Mounting Preparation of Load-Break Connectors for Fault-Closure Test. Mounting preparation of the load-break connector shall be the same as specified in 7.7.1.

7.9 Current-Cycling Test for Uninsulated Components of 200 A and 600 A Connectors.

The purpose of this test is to demonstrate the ability of the uninsulated components of the connector system to maintain their required continuous current-carrying capability when subjected to cyclical loads.

Tests shall be conducted in accordance with ANSI/NEMA CC3-1973 [4]. An AWG No 1/0 aluminum conductor shall be used for 200 A connectors and a 750 kcmil aluminum conductor shall be used for 600 A connectors.

The test shall be made without insulation on the conductor or current-carrying parts of the connector to avoid any deterioration of the insulation which may otherwise occur at the maximum temperature of this test.

The conductor system shall meet the requirements given for Class A connectors in ANSI/NEMA CC3-1973 [4].

7.10 Current-Cycling Test for 200 A Insulated Connectors.

Option A. The purpose of this test is to demonstrate that 200 A insulated connectors can carry rated current under usual service conditions. Successful completion of the test listed below shall be considered as evidence that the connector meets its rating.

A control cable, used for the purpose of obtaining conductor temperature, shall be installed in the heat cycle loop between two equalizers. Its length shall be 72 in. The control cable shall be the same type and size as the cable used to join the connectors under test.

Four connectors shall be assembled in series on AWG No 1/0 insulated aluminum conductors having a length of 36 in. The cable insulation thickness shall be selected according to its voltage class.

Voltage Rating (kV rms)	Cable Insulation Thickness
15	175 mil
25	260 mil
35	345 mil

Equalizers used shall be in accordance with ANSI/NEMA CC3-1973 [4].

Heat-cycle tests shall be conducted at an ambient temperature of 20 °C − 35 °C in a space free of drafts.

The heat-cycle current shall be adjusted to result in a steady-state temperature of 90 °C ± 5 °C on the surface of the conductor at the control cable. The temperature shall be measured at the approximate center of the control cable.

The test shall consist of 50 current cycles, with the current on 3 h and off 3 h for each cycle. The temperature of the hottest spot of the connector shall be measured every 10 cycles and shall not exceed the temperature of the conductor of the control cable.

Option B. The purpose of this test is to demonstrate that load-break and dead-break 200 A connectors can carry rated load current after being subjected to an off-axis operating force. Successful completion of these tests shall be considered as evidence that the connector meets its rating.

Each connector shall be subjected to 6 cycles, each consisting of a mechanical operation as specified in 7.10.1 and current cycling as specified in 7.10.2.

The elbow shall be assembled with a half-inch wide pulling band, as shown in Fig 14 for application of an off-axis force. Grounding tabs or other obstructions may be removed to apply the pulling band. No provision is made for an off-axis closing force since it is not consistently reproducible.

Four connectors shall be assembled in series on unsecured AWG No 1/0 cross-linked polyethylene insulated aluminum conductors having a length of 36 in. The cable insulation thickness shall be selected according to its voltage class. The applicable voltage class cable shall be used:

Voltage Rating (kV rms)	Cable Insulation Thickness
15	175 mil
25	260 mil
35	345 mil

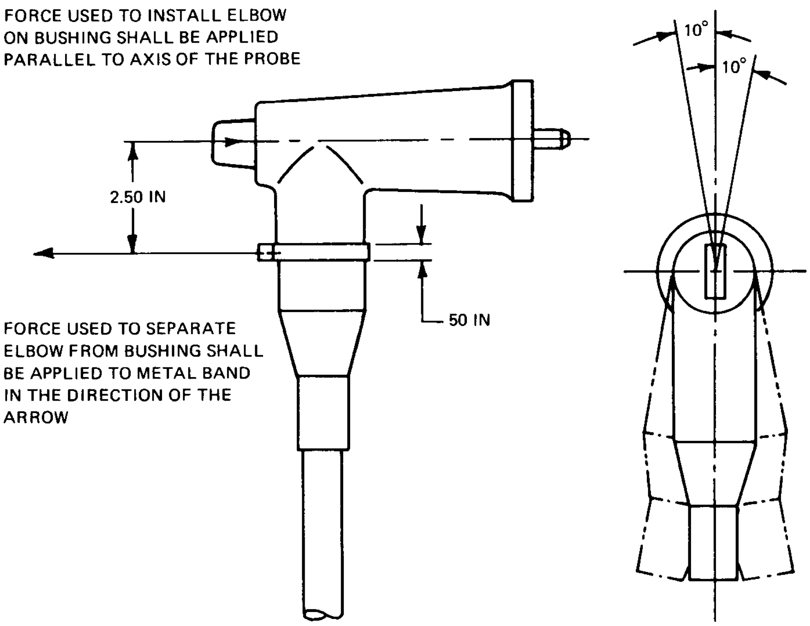


Fig 14
Operating Force Test for Option B (7.10)

7.10.1 The elbow shall be rotated about the probe axis a minimum of 10° in both clockwise and counterclockwise directions by means of a suitable live-line tool. The tool shall be approximately parallel with the axis of the probe.

The connector shall then be opened 5 times with the force applied to the pulling band and closed 5 times with the force applied to the operating eye. The force required to open or close the elbow shall be parallel to the axis of the probe. The applied force shall be sufficient to completely close the connector.

7.10.2 A control cable used for the purpose of obtaining conductor temperature, shall be installed in the heat cycle loop between two equalizers. Its length shall be 72 in. The control cable shall be the same type and size as the cable used to join the connectors under test.

The current shall be adjusted so that the temperature on the conductor of the control cable is 90 °C ± 5 °C. The current shall be applied for eight continuous cycles, each cycle consisting of 3 h on and 3 h off.

Equalizers used shall be in accordance with ANSI/NEMA CC3-1973 [4].

Heat-cycle tests shall be conducted at an ambient temperature of 20 °C − 35 °C in a space free of drafts.

The temperature shall be measured by thermocouples located at

(1) The compression lug

(2) The approximate midpoint of the bushing contact or as near thereto as practical

(3) On the conductor surface at the midpoint of the control cable

The temperature at locations (1) and (2) shall not exceed the temperature of the conductor of the cable at location (3).

7.11 Current-Cycling Test for 600 A Insulated Connectors. The purpose of this test is to demonstrate that 600 A insulated connectors can carry rated current under usual service conditions. Successful completion of the test listed below shall be considered as evidence that the connector meets its rating.

A control cable, used for the purpose of obtaining conductor temperature, shall be installed in the heat-cycle loop between two equalizers. Its length shall be 72 in. The control cable shall be the same type and size as the cable used to join the connectors under test.

Four connectors shall be assembled in series on 750 kcmil insulated aluminum conductors having a length of 36 in. The cable insulation thickness shall be selected according to its voltage class.

Voltage Rating (kV rms)	Cable Insulation Thickness
15	175 mil
25	260 mil
35	345 mil

Equalizers used shall be in accordance with ANSI/NEMA CC3-1973 [4].

Heat-cycle tests shall be conducted at an ambient temperature of 20 °C − 35 °C in a space free of drafts.

The heat-cycle current shall be adjusted to result in a steady-state temperature of 90 °C ± 5 °C on the surface of the conductor of the control cable. The temperature shall be measured at the approximate center of the control cable.

The test shall consist of 50 current cycles, with the current on 6 h and off 6 h for each cycle. The temperature of the hottest spot of the connector shall be measured every 10 cycles and shall not exceed the temperature of the conductor of the control cable.

7.12 Accelerated Sealing Life Test. The purpose of this test is to demonstrate that the connector can maintain a long-term seal at all interfaces to prevent the entrance of moisture.

Four samples shall be assembled on AWG No 1/0 aluminum conductors for 200 A connectors and 750 kcmil aluminum conductors for 600 A connectors.

The cable shall be compatible with the thermal conditions of this test. A mandrel simulating the test cable may be substituted during the oven aging portion of this test.

The four connector assemblies shall be placed in an oven having 121 °C temperature and remain there for three weeks. After this time has elapsed, the four samples shall be removed from the oven and each operated once by using the operating eye or an appropriate location on the axis of the separable interface.

The four connector assemblies shall then be subjected to 50 cycles of the following sequence of operations:

(1) The assemblies shall be heated in air using sufficient current to raise the temperature of the conductor of the control cable to 90 °C ± 5 °C for the following time period:

200 A connectors — 1 h
600 A connectors — 4 h

(2) The assemblies shall be de-energized and within 3 min, submerged in 25 °C ± 5 °C conductive water (5000 Ω, cm maximum) to a depth of 30 cm (1 ft) for the following time periods:

200 A connectors — 1 h
600 A connectors — 2 h

After the 50th cycle, the connector and cable assembly shall withstand a design impulse test, (see 7.5.3).

(3) The test point, if provided, shall be capable of passing the voltage test specified in 7.17.2.

7.13 Cable Pull-Out Test. (Tensile strength). The purpose of this test is to determine if the connection between the cable conductor and compression lug of the connector is capable of withstanding a tensile force of 900 N (200 lbf).

The compression lug shall be held in a manner which will not affect the strength of the connection. The tensile force shall be applied to the cable conductor.

The connection shall withstand the applied force for 1 min without impairing the connector's ability to meet the other requirements of this standard.

7.14 Operating-Force Test. The purpose of this test is to demonstrate that the force necessary to operate a connector meets the requirements of 6.2.

The connector shall be assembled and lubricated in accordance with the manufacturer's instructions.

The temperature of the connector shall be − 20 °C, + 25 °C, and + 65 °C respectively, for three separate tests. The force shall be gradually applied to the operating eye parallel to the axis of the probe.

The forces required to open or close the connector shall be within the ranges specified in 6.2.

7.15 Operating-Eye Test. The purpose of this test is to demonstrate that the operating eye meets the requirements of 6.2.

A tensile force shall be gradually applied to the operating eye in the direction of normal operation. The operating eye shall withstand the force for 1 min.

A rotational force shall be applied with a suitable live-line tool to the operating eye in a clockwise direction and in a counter-clockwise direction.

Some distortion of the operating eye is acceptable provided the connector is serviceable after the test and meets the corona voltage-level requirement specified in Table 1.

7.16 Test-Point Cap Test. The purpose of this test is to demonstrate that the removal force of the test-point cap meets the requirements of 6.5.2 and the cap operating eye is capable of withstanding the maximum operating force.

7.16.1 Test-Point Cap Operating-Force Test. A tensile force shall be gradually applied to the test-point cap in the direction parallel with the probe axis at − 20 °C, + 25 °C, and + 65 °C.

The force required to remove the test-point cap shall be within the ranges specified in 6.5.2.

7.16.2 Test-Point Cap Operating Withstand Test. A tensile force of 433 N (100 lb) shall be applied to the test-point cap operating eye for 1 min at − 20 °C, + 25 °C, and + 65 °C.

Some distortion of the operating eye is acceptable provided the test-point cap is serviceable after the test.

7.17 Test-Point Tests

7.17.1 Test-Point Capacitance Test. The purpose of this test is to verify that the capacitance values of the test point meet the requirements of 6.5.1.

The connector shall be installed on a cable of the type which it is designed to operate, and the shielding shall be grounded in the normal manner. The capacitances from test point to cable and test point to ground shall be measured with suitable instruments and proper shielding techniques.

The measured values shall be within the tolerances specified in 6.5.1.

7.17.2 Test-Point Voltage Test. The purpose of this test is to ensure proper operation of the test point.

A test voltage shall be applied to the conductor system of the connector. The response of a suitable sensing device on the test point shall indicate an energized condition.

7.18 Shielding Test. The purpose of this test is to demonstrate that the shielding meets the requirements of 6.3.

The test procedure shall be in accordance with IEEE Std 592-1977 [5].