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(Project 6120-0031)

FSC 5950

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A-39-05

American National Standard

conformance requirements for liquid-filled transformers used in unit installations,including unit substations

american national standards institute, inc.
1430 broadway, new york, new york 10018

ANSI C57.12.13-1982

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C57.12.13-1982

American National Standard Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations

Secretariat

Institute of Electrical and Electronics Engineers
National Electrical Manufacturers Association

Approved September 2, 1981

American National Standards Institute, Inc

American National Standard

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Published by

American National Standards Institute
1430 Broadway, New York, New York 10018

Printed in the United States of America

A7C782/675

Foreword

(This Foreword is not a part of American National Standard Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations, ANSI C57.12.13-1982.)

The High Voltage Apparatus Coordinating Committee (HVACC) was established July 24, 1973, by the Electrical and Electronic Technical Advisory Board (later superseded by the Electrical and Electronics Standards Management Board) of the American National Standards Institute. The responsibility assigned to HVACC was to review and evaluate existing ANSI and other related standards for the purpose of developing a draft standard for unit substations and to develop recommendations for (1) correlating requirements of these standards and (2) adding requirements appropriate for product evaluation.

This standard results from the evaluation of existing American National Standards and the need to add requirements for the evaluation and conformance certification of liquid-filled transformers. It is not intended to cover application, installation, or operation of liquid-filled transformers. This document includes an Appendix outlining procedures recommended for qualifying the internal insulation system.

The intent of this standard is to allow qualification of liquid-filled transformers for use in accordance with the American National Standard National Electrical Code, ANSI/NFPA 70-1981. However, this standard does not cover transformers specifically excluded by the provisions of Section 90-2(b) of that document.

Transformers certified under this standard may contain accessories necessary for the installation. For the conformance requirements for such accessories, reference should be made to the American National Standard for each specific accessory involved. Typical accessories include fuses, lightning arresters, circuit breakers, motor starter controls, etc.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Transformers, Regulators, and Reactors, C57. Committee approval does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C57 Committee had the following members:

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The HVACC Subcommittee on High Voltage Transformers, which reviewed and approved this standard, had the following members:

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SECTION PAGE

American National Standard Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations

1. General

1.1 Scope. This standard covers conformance tests and requirements for liquid-filled transformers. Such transformers may be remotely or integrally associated with either primary and secondary switchgear or substations, or both, and rated not greater than 2500 kVA, with voltages not exceeding 38 kV (35-kV voltage class). Insulating liquids are limited to those specified in ANSI/IEEE C57.12.00-1980 unless otherwise noted herein.

This standard does not cover the following types of liquid-filled transformers:

(1) Overhead-type distribution transformers, including those mounted in surface enclosures

(2) Pad-mounted compartmental-type transformers as described and defined in the following standards:

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Single-Phase Distribution Transformers with High-Voltage Bushings (High-Voltage, 34 500 GrdY/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller), ANSI C57.12.21-1980

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Three-Phase Distribution Transformers with High-Voltage Bushings (34 500 GrdY/19 920 Volts and Below; 2500 kVA and Smaller), ANSI C57.12.22-1980

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors, High-Voltage 34 500 GrdY/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller, ANSI C57.12.25-1981

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 24 940 GrdY/14 400 Volts and Below; 2500 kVA and Smaller, ANSI C57.12.26-1975

(3) Subsurface or submersible-type transformers as described and defined in the following standards:

American National Standard Requirements for Underground-Type Single-Phase Distribution Transformers, with Separable Insulated High-Voltage Connectors, High Voltage 24 940 GrdY/14 400 Volts and Below, Low Voltage 240/120, 100 kVA and Smaller, ANSI C57.12.23-1978

American National Standard Requirements for Underground-Type Three-Phase Distribution Transformers, 2500 kVA and Smaller; High Voltage 24 940 GrdY/14 400 Volts and Below; Low Voltage 480 Volts and Below, ANSI C57.12.24-1982

American National Standard Requirements for Secondary Network Transformers, Subway and Vault Types (Liquid Immersed), ANSI C57.12.40-1982

(4) Rectifier transformers

(5) Mobile transformers

(6) All transformers for use in ships and other watercraft, railway rolling stock, aircraft, and automotive vehicles other than mobile home and recreational vehicles

(7) Transformers used in mines

(8) Transformers installed in railways for the generation, transformation, transmission, or distribution of power and used exclusively for operation of rolling stock, or transformers installed in railways and used exclusively for signaling, or communication purposes

(9) Instrument transformers

(10) Step-voltage regulators and induction voltage regulators

(11) Arc furnace transformers

(12) Transformers installed with communication equipment under the exclusive control of communication utilities, located outdoors or in building spaces used exclusively for such installations

(13) Transformers that are used under the exclusive control of electric utilities for the purpose of communication or metering, or for the generation, control, transformation, transmission, and distribution of elec-

tric energy and that are located in buildings used exclusively for such purposes or located outdoors on property owned or leased by the utility, or on public highways, streets, roads, etc, or by established rights on private property

1.2 Reference Standards. Transformers covered by this standard shall conform to relevant sections of the latest revision of applicable industry standards, except as otherwise indicated in this standard. Included among these standards are the following:

American National Standard Requirements for Transformers 230 000 Volts and Below, 833/958 through 8333/10 417 kVA, Single Phase and 750/862 through 60 000/80 000/100 000 kVA Three Phase (includes supplement ANSI C57.12.10a-1978), ANSI C57.12.10-1977

American National Standard Terminal Markings and Connections for Distribution and Power Transformers, ANSI C57.12.70-1978

American National Standard Transformer Terminology, ANSI C57.12.80-1978

American National Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers, ANSI/IEEE C57.12.00-1980

American National Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers, ANSI/IEEE C57.12.90-1980

American National Standard National Electrical Code, ANSI/NFPA 70-1981

American National Standard Safety Standard for High Voltage Industrial Control Equipment, ANSI/UL 347-1978

NEMA Standards Publication for Transformers, Regulators, and Reactors, NEMA TR 1-1980[1]

1.3 Definitions

1.3.1 Routine Tests. Tests made for quality control by the manufacturer on every device or representative samples, or on parts or materials as required to verify during production that the product meets the design specifications and applicable standards.

NOTES:
(1) Certain quality assurance tests on identified critical parts of repetitive high-production devices may be tested on a planned statistical sampling basis.
(2) "Routine tests" are sometimes called "production tests."

[1] Available from the National Electrical Manufacturers Association, 2101 L Street NW, Washington, D.C. 20037.

1.3.2 Design Tests. Tests made by the manufacturer to determine the adequacy of the design of a particular type, style, or model of equipment or its component parts to meet its assigned ratings and to operate satisfactorily under normal service conditions or under special conditions if specified. These tests may be used to demonstrate compliance with applicable standards of the industry.

NOTES:
(1) Design tests are made on representative apparatus or prototypes to verify the validity of design analysis and calculation methods and to substantiate the ratings assigned to all other apparatus of basically the same design. These tests may also be used to evaluate modifications of a previous design and to ensure that performance has not been adversely affected. Test data from previous similar designs may be used for current designs, where appropriate. Once made, the tests need not be repeated unless the design is changed so as to modify performance.
(2) "Design tests" are sometimes called "type tests."

1.3.3 Other Tests. Tests so identified in individual product standards that may be specified by the user in addition to routine tests. (Examples include impulse, insulation power factor, and audible sound tests.)

1.3.4 Conformance Tests. Certain performance tests conducted to demonstrate compliance with the applicable standards. The test specimen is normally subjected to all planned routine tests prior to initiation of the conformance test program.

NOTE: The conformance tests may, or may not, be similar to certain design tests. Demonstration of margin (capabilities) beyond the standard requirements is unnecessary.

2. Insulation System Requirements

2.1 Internal Insulation System. The transformer shall utilize a qualified internal insulation system, as described in the Appendix to this standard.

2.2 External Electrical Clearances. External electrical clearances for high-voltage bushings and low-voltage terminals with exposed conducting parts shall be as shown in Table 1. The clearances shown apply to a completely assembled unit including enclosure, if any, and are minimum values for the rating given.

3. Optional Accessory Devices

3.1 General. Accessory devices are those devices that are not basically required for proper operation of a transformer but perform a secondary or minor function as an adjunct or refinement to the primary func-

Table 1
Minimum External Electrical Clearances

A Nominal System Voltage (kV rms)	B Transformer Basic Impulse Insulation Level, (kV)	C Transformer Low Frequency Insulation Level, (kV rms)	D Minimum Clearance Live Parts to Ground, Inches (millimeters)	E Minimum Live Part Clearance Phase to Phase, Inches (millimeters)
1.2	30	10	1 (25)	1 (25)
1.2	45	10	2 (51)	2 (51)
2.5	45	15	2 (51)	2 (51)
2.5	60	15	3 (76)	3 (76)
5.0	60	19	2.5 (63.5)	2.5 (63.5)
5.0	75	19	3.5 (89)	4 (102)
8.7	75	26	3.5 (89)	4 (102)
8.7	95	26	4.5 (114)	5 (127)
15	95	34	5 (127)	5.5 (140)
15	110	34	6 (152)	6.5 (165)
25	125	40	5.75 (146)	6.25 (159)
25	150	50	8 (203)	9 (229)
34.5	150	50	8 (203)	9 (229)
34.5	200	70	12 (305)	13 (330)

NOTES:
(1) Where clearances are less than those given in columns D and E, an insulating barrier shall be provided, but in no case shall the dimension between live parts and the barrier be less than 3 inches (76 mm). Where such barriers are used, the conformance impulse test shall be performed either with all normal ground planes in place or by simulating those ground planes nearest the live parts.
(2) These clearances are for application at 3300 ft (1000 m) above sea level or less. Where application is above 3300 ft, refer to ANSI/IEEE C57.12.00-1980.
(3) Where mechanical clearances listed in referenced standards exceed those given in columns D and E, those listed in the referenced standards shall apply.

tion of the transformer. Although the intent of this standard is to define basic transformer requirements only, certain accessory devices are commonly integral components of the transformer.

3.2 Device Type. Typical accessory devices are considered to fall into the following two categories:

(1) *Non-current-interrupting devices.* Examples include, but are not limited to, the following: pressure-relief devices; vacuum pressure gages; forced-air cooling equipment; alarm devices on thermometers, oil gages, pressure gages, pressure-relief devices, etc; and surge arresters. These devices may be qualified under this standard as a part of the transformer. Their successful operation throughout transformer testing shall constitute sufficient proof of their design, and no further testing is necessary except as noted herein.

(2) *Current-interrupting devices.* These devices, such as fuses, switches, circuit breakers, and load-break separable connectors may also be included in a transformer package. They shall, however, be individually certified by their own conformance standards. Transformers containing such devices shall not be certified as being in conformance with this standard unless all current-interrupting devices meet required conformance standards. Application to the transformer package shall be in accord with guidelines established by the device conformance standard. Successful (non-current-interruption) operation of these devices throughout transformer testing shall constitute sufficient proof of their proper application to the transformer without further testing.

3.3 Mounting. Each accessory device shall be mounted in its normal position in the transformer during applicable testing when its installation may affect the performance of the transformer package.

4. Construction Requirements

4.1 General. It is intended that the transformer be installed by qualified personnel.

4.2 Operating Instructions. The transformer shall be supplied with operating instruction that include warnings concerning potential operating hazards.

4.3 Grounding and Bonding

4.3.1 Grounding. The transformer tank shall have provision for grounding to the system as specified in the applicable product standards. When transformer neutral terminals are grounded to the transformer

Table 2
Grounding Conductor Sizes

Maximum Rated Line Current (amperes)	Copper Wire Size (AWG or kcmil)	Aluminum or Copper-Clad Aluminum Wire Size (AWG or kcmil)
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
400	3	1
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	500
3000	400	600
4000	500	800
5000	700	1000
6000	800	1200

tank, the grounding conductor shall have a current-carrying capacity equivalent to that given in Table 2.

4.3.2 Bonding. Exposed conductive non-current-carrying parts shall be reliably bonded to the transformer tank.

4.4 Pressure Bleeder Device. A transformer larger than 500 kVA shall include a pressure-vacuum bleeder device for automatic relief of excessive positive or negative static pressures, which conforms to the requirements specified in ANSI C57.12.10-1976. This does not include a transformer with distribution BIL characteristics of 10.4.1 in ANSI C57.12.10-1976.

5. Enclosure Requirements

5.1 General

5.1.1 An enclosure is a surrounding case or housing used to provide a degree of protection to the enclosed conductors and equipment and to provide a degree of protection to personnel against incidentally contacting live parts.

5.1.2 Enclosures are categorized in accordance with 5.1.3 through 5.1.5.

5.1.3 Category A indoor or outdoor enclosures are intended for ground level use in installations subject to deliberate, unauthorized acts by members of the unsupervised general public primarily to provide a degree of protection against contact with the enclosed equipment. The enclosure shall meet the requirements given in Table 3.

5.1.4 Category B indoor or outdoor enclosures are intended for use in installations not subject to deliberate, unauthorized acts by members of the unsupervised general public primarily to provide a degree of protection to unauthorized and untrained personnel against incidental contact with the enclosed equipment. The enclosures shall meet the requirements given in Table 3.

5.1.5 Category C indoor or outdoor enclosures are intended for use in installations in secured areas generally inaccessible to unauthorized and untrained persons to provide a degree of protection against contact with the enclosed equipment. The enclosures shall meet the requirements given in Table 3.

5.2 Basic Enclosure Requirements

5.2.1 Construction

5.2.1.1 If of metal, enclosures shall be suitably supported, constructed, and assembled so that they will have the strength and rigidity necessary to resist the abuses to which they are likely to be subjected, without total or partial collapse resulting in an increased fire hazard due to reduction of spacings, loosening or displacement of parts, or other serious defects. Nonmetallic materials may be used as all or part of an enclosure if found suitable for the application and shall otherwise comply with the requirements of this paragraph. Among the factors to be taken into consideration when a nonmetallic material is being judged for acceptability are its (1) physical strength, (2) resistance to impact, (3) moisture-absorptive properties, (4) combustibility, (5) ground plane between high voltage and enclosure, and (6) resistance to distortion at temperatures to which it may be subjected under conditions of normal and abnormal use. These factors are considered with respect to thermal aging. An enclosure shall be capable of withstanding the tests of this standard that are applicable to the location and environmental conditions to which it will be exposed.

5.2.1.2 Lifting provisions shall provide a distributed balanced lift in a vertical direction for the assembled transformer and shall be designed to provide a safety factor of 5.[2]

5.2.1.3 Unless the enclosure is of a material that will resist corrosion, both inside and outside surfaces shall be suitably protected by painting, galvanizing, plating, or other equivalent means.

5.2.1.4 An enclosure cover, if not of the drawout construction, shall be hinged if it gives access to fuses or any other overload protective devices, the normal functioning of which requires renewal, or if it is neces-

[2] The safety factor of 5 is the ratio of the ultimate stress of material used to the working stress; the working stress is the maximum combined stress developed in the lifting provisions by the static load of the completely assembled transformer.

Table 3
Requirements Applicable to Indoor and Outdoor Enclosures

Feature	Reference Paragraphs	Required for Categories A	B	C
All enclosures				
Enclosure security	5.2.3	Yes	–	–
Basic enclosure requirements	5.2			
Rigidity (sheet metal)	5.2.2.1–5.2.2.4	Yes	Yes	–
Exposed live parts permissible	5.2.1.17.2	No	No	Yes
Operating handles	5.2.1.24.1–5.2.1.24.4	Locked cover	No requirements	No requirements
Operating handles – height (max)	5.2.1.24.2	78 in	78 in	78 in
Vent openings – "line of sight" restriction	5.2.1.18.1–5.2.1.18.2	–	Yes	No
Doors (if supplied)	5.2.1.5–5.2.1.6	Yes	Yes	Yes
Doors – handles lockable	5.2.1.5	Yes	Yes*	No
Doors – captive fasteners	5.2.1.5	–	Yes*	No
Hinged pins – no removable door	5.2.1.5	Yes	No	No
Lifting provisions	5.2.1.2	Yes	Yes	Yes
Gage, valves, etc – locked cover	5.2.1.26.1	Yes	No	No
Guards for exposed fan blades	5.2.1.26.2	Yes	Yes	Yes
Caution and warning signs	5.4	Yes	Yes	Yes
Outdoor Enclosures				
Material	5.3.1–5.3.3	Yes	Yes	Yes
Hinges	5.3.4	Yes	Yes	Yes
Gaskets	5.3.6–5.3.9	Yes	Yes	Yes
Doorstop	5.3.10	Yes	Yes	Yes
Types and design tests	5.3.11–5.3.20	Yes	Yes	Yes
Tests				
Spray	5.3.16	All types	All types	All types
Dust	5.3.17	Types 103, 103S, 104	Types 103, 103R, 104	Types 103, 103S, 104
External icing	5.3.18	All types	All types	All types
Hose-down	5.3.19	Type 104	Type 104	Type 104
Corrosion resistance	5.3.20	Type 103	Type 103S	Type 104

*Either lockable handles or captive fasteners, but not both, are required.

sary to open the cover in connection with the normal operation of the device. (Exception: Fuses for instrument transformers, internal fans, etc, may be behind bolted covers.)

5.2.1.5 A part of the enclosure such as a door, cover, or tank shall be provided with a means (such as latches, locks, interlocks, or captive fasteners) for firmly securing it in place. Such fasteners shall be located or used in multiple so as to hold the door or cover closed over its entire length. A hinged cover more than 48 inches (1219 mm) long on the hinged side shall have at least a two-point latch operated by a single knob or handle, or have at least two captive fasteners.

The opening handles for doors of enclosures of Categories A and B shall be lockable. However, captive fasteners are permitted on Category B enclosures. Exposed hinge pins shall be nonremovable on doors of Category A enclosures or, as an alternate, the door shall be nonremovable in the closed position.

5.2.1.6 A door or cover shall shut closely against a 1/4-inch (6.4-mm) rabbet (as shown in Fig. 1) or the equivalent, or minimum 1/2-inch (12.7-mm) overlap, or shall have flanges for the full length of the four edges. Flanges on a door or cover shall fit closely with the outside walls of the enclosure proper and shall be not less than 7/16 inch (11.1 mm) in depth. A suitable combination of flange and rabbet is acceptable. Fig. 2 illustrates typical constructions that are considered to comply with this paragraph. Other constructions may be suitable.

5.2.1.7 Cover plates intended to be removed for inspection and maintenance of energized parts and wiring shall not exceed 12 ft^2 (1.11 m^2) in area or 60 lb (27.2 kg) in weight unless they are equipped with lifting means or hinges.

5.2.1.8 An enclosure of cast metal shall be at least 1/8 inch (3.2 mm) thick at every point, greater than 1/8 inch (3.2 mm) thick at reinforcing ribs and door edges, and not less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception: At other than at plain or threaded conduit holes, die-cast metal shall be as follows:

(1) Not less than 3/32 inch (2.4 mm) thick for an area greater than 24 in^2 (0.015 m^2) or having any di-

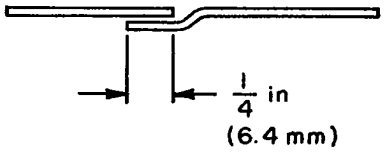


Fig. 1
Rabbet for Door or Cover

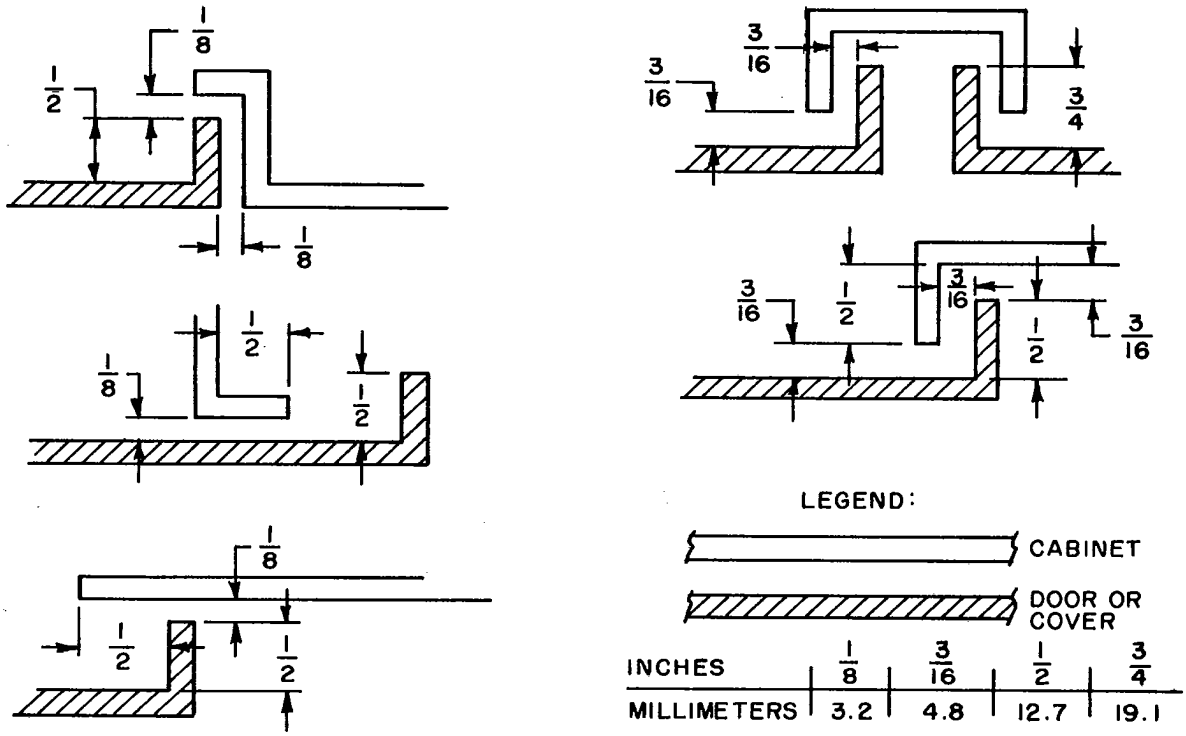


Fig. 2
Typical Constructions for Doors or Covers

mensions greater than 6 inches (152 mm).

(2) Not less than 1/16 inch (1.6 mm) thick for an area of 24 in^2 (0.015 m^2) or less and having no dimensions greater than 6 inches (152 mm). The area limitation may be obtained by the provision of suitable reinforcing ribs subdividing a larger area.

5.2.1.9 The thickness of a sheet metal enclosure shall be not less than that indicated in Tables 4 and 5, except (1) that uncoated steel shall be not less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall be not less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall be not less than 0.045 inch (1.14 mm) thick at points at which a wiring system is to be connected, and (2) as indicated in 5.2.2.1 and 5.2.2.4.

5.2.1.10 Tables 4 and 5 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

5.2.1.11 A supporting frame shall be formed of angles, channels, folded rigid sections of sheet metal, or the equivalent, rigidly fastened together and having essentially the same outside dimensions as the enclosure surfaces.

5.2.1.12 With reference to 5.2.1.13 and Tables 4 and 5, a construction is not considered to have a supporting frame if it is one of the following:

(1) A single sheet with single formed flanges (formed edges)

Table 4
Minimum Thickness of Sheet Metal
for Enclosures of Carbon Steel or Stainless Steel

Without Supporting Frame*		With Supporting Frame or or Equivalent Reinforcing*		Minimum Thickness in Inches (millimeters)	
Maximum Width† in Inches (millimeters)	Maximum Length‡ in Inches (millimeters)	Maximum Width† in Inches (millimeters)	Maximum Length in Inches (millimeters)	Uncoated	Zinc-Coated
4.0 (101)	Not limited§	6.25 (159)	Not limited§	0.020** (0.51)**	0.023** (0.058)**
4.75 (121)	5.75 (146)	6.75 (171)	8.25 (210)		
6.0 (152)	Not limited	9.5 (241)	Not limited	0.026** (0.66)**	0.029** (0.74)**
7.0 (178)	8.75 (222)	10.0 (254)	12.5 (318)		
8.0 (203)	Not limited	12.0 (305)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (229)	11.5 (292)	13.0 (330)	16.0 (406)		
12.5 (318)	Not limited	19.5 (495)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (356)	18.0 (457)	21.0 (533)	25.0 (635)		
18.0 (457)	Not limited	27.0 (686)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (508)	25.0 (635)	29.0 (737)	36.0 (914)		
22.0 (559)	Not limited	33.0 (838)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (635)	31.0 (787)	35.0 (889)	43.0 (1092)		
25.0 (635)	Not limited	39.0 (991)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (737)	36.0 (914)	41.0 (1041)	51.0 (1295)		
33.0 (838)	Not limited	51.0 (1295)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (965)	47.0 (1194)	54.0 (1372)	66.0 (1676)		
42.0 (1067)	Not limited	64.0 (1626)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (1194)	59.0 (1499)	68.0 (1727)	84.0 (2134)		
52.0 (1321)	Not limited	80.0 (2032)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (1524)	74.0 (1880)	84.0 (2134)	103.0 (2616)		
63.0 (1600)	Not limited	97.0 (2464)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (1854)	90.0 (2286)	103.0 (2616)	127.0 (3226)		

*See 5.2.1.11 for supporting frame and 5.2.1.26 for equivalent construction.

†The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made from a single sheet.

‡For panels that are not supported along one side (for example, side panel of boxes) the length of the unsupported side shall be limited to the dimensions specified.

§"Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

**Sheet steel for an enclosure for outdoor use (rainproof or raintight) is required to be not less than 0.034 inch (0.86 mm) in thickness if zinc-coated and not less than 0.032 inch (0.81 mm) in thickness if uncoated.

(2) A single sheet that is corrugated or ribbed

(3) An enclosure surface loosely attached to a frame – that is, with spring clips

5.2.1.13 A tapped hole for the attachment of threaded rigid conduit shall be provided with:

(1) An end stop, or shall be so located that a standard bushing may be attached to the end of the conduit, and

(2) A tapered thread in equipment for outdoor use, if not provided with an end stop, and

(3) At least three full threads when tapped all the way through the wall of an enclosure, or with at least 3-1/2 full threads and a smooth, well-rounded inlet hole having a diameter approximately the same as the internal diameter of a standard bushing to provide protection for the conductors equivalent to that provided by such a bushing.

5.2.1.14 A knockout in a sheet metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

5.2.1.15 Where a knockout is provided, it shall have a flat surrounding surface adequate for proper seating of a conduit bushing and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than the minimum dielectric requirements in this standard.

5.2.1.16 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum required in this standard shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a drawing furnished with the device may be used to limit such a location.

Table 5
Minimum Thickness of Sheet Metal
for Enclosures of Aluminum, Copper, or Brass

Without Supporting Frame*		With Supporting Frame or Equivalent Reinforcing*		
Maximum Width† in Inches (millimeters)	Maximum Length‡ in Inches (millimeters)	Maximum Width† in Inches (millimeters)	Maximum Length in Inches (millimeters)	Minimum Thickness in Inches (millimeters)
3.0 (76)	Not limited§	7.0 (178)	Not limited§	0.023** (0.58)**
3.5 (89)	4.0 (101)	8.5 (216)	9.5 (241)	
4.0 (101)	Not limited	10.0 (254)	Not limited	0.029 (0.74)
5.0 (127)	6.0 (152)	10.5 (267)	13.5 (343)	
6.0 (152)	Not limited	14.0 (356)	Not limited	0.036 (0.91)
6.5 (165)	8.0 (203)	15.0 (381)	18.0 (457)	
8.0 (203)	Not limited	19.0 (483)	Not limited	0.045 (1.14)
9.5 (241)	11.5 (292)	21.0 (533)	25.0 (635)	
12.0 (305)	Not limited	28.0 (711)	Not limited	0.058 (1.47)
14.0 (356)	16.0 (406)	30.0 (762)	37.0 (940)	
18.0 (457)	Not limited	42.0 (1067)	Not limited	0.075 (1.90)
20.0 (508)	25.0 (635)	45.0 (1143)	55.0 (1397)	
25.0 (635)	Not limited	60.0 (1524)	Not limited	0.095 (2.41)
29.0 (737)	36.0 (914)	64.0 (1626)	78.0 (1981)	
37.0 (940)	Not limited	87.0 (2210)	Not limited	0.122 (3.10)
42.0 (1067)	53.0 (1346)	93.0 (2362)	114.0 (2896)	
52.0 (1321)	Not limited	123.0 (3124)	Not limited	0.153 (3.87)
60.0 (1524)	74.0 (1880)	130.0 (3302)	160.0 (4064)	

*See 5.2.1.11 for supporting frame and 5.2.1.26 for equivalent construction.

†The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made from a single sheet.

‡For panels that are not supported along one side (for example, side panels of boxes) the length of the unsupported side shall be limited to the dimensions specified.

§"Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

**Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (rainproof or raintight) is required to be not less than 0.029 inch (0.74 mm) in thickness.

5.2.1.17

5.2.1.17.1 In measuring a spacing between an uninsulated live part and a conduit bushing installed in the knockout referred to in 5.2.1.14 and 5.2.1.15, it is to be assumed that a bushing having the dimensions indicated in Table 6 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

5.2.1.17.2 An indoor or outdoor unit substation enclosure shall have no exposed live conductors (such as entrance bushing studs, terminal connections, or bus bars) unless it is designated as Category C.

5.2.1.18

5.2.1.18.1 A ventilating opening in an enclosure shall prevent the insertion of a straight rod having a diameter of 0.500 inch (12.7 mm) except that if the distance between the opening and the nearest not fully insulated live part is greater than indicated in Table 7, the opening may permit the entry of a rod having a diameter greater than 0.500 inch (12.7 mm) but not greater than 0.750 inch (19.1 mm). A barrier may be placed between an opening and live parts to comply with this requirement.

5.2.1.18.2 For Category B enclosures, a barrier or equivalent shall be so located that it intercepts all live parts from line of sight through the opening protected. Exception: An opening above the upper edge of the enclosure sidewall, but under the overhang of the top, is acceptable if, by means of its size, barrier, etc, it will prevent a straight rod 0.500 inch (12.7 mm) in diameter from approaching any uninsulated live part inside the enclosure by a distance not less than that indicated in Table 7.

5.2.1.19 In determining the suitability of a barrier as mentioned in 5.2.1.18.1 and 5.2.1.18.2, consideration shall be given to the following:

(1) The barrier shall be reliably secured in place.

(2) The barrier shall be capable of withstanding the forces to which it may be subjected in service.

(3) A component so located or an enclosure so formed as to meet the foregoing requirements is considered suitable.

Table 6
Dimensions of Conduit Bushings

Trade Size of Conduit in Inches	Bushing Dimensions in Inches (millimeters)			
	Overall Diameter		Height	
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(29.8)	27/64	(10.7)
1	1-19/32	(41.3)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(55.9)	19/32	(15.1)
2	2-45/64	(69.1)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(113)	15/16	(23.8)
4	4-31/32	(126)	1	(25.4)
4-1/2	5-35/64	(141)	1-1/16	(27.0)
5	6-7/32	(158)	1-3/16	(30.2)
6	7-7/32	(183)	1-1/4	(31.8)

Table 7
Clearance Requirements

kV Class	Minimum Clearance, Inches (millimeters)	
1.2	4	(101)
2.4	5	(127)
5	5.5	(140)
8.66	6.5	(165)
15	8	(203)
24	11	(279)
34	15	(381)

NOTE: The above clearances are based on the strike distances published in NEMA TR 1-1980 (Part O, page 6), plus 3 inches.

5.2.1.20 The diameter of the wires of a screen shall be not less than 0.051 inch (1.30 mm) if the screen openings are 1/2 in^2 (322 mm^2) or less in area, and shall be not less than 0.081 inch (2.06 mm) for larger screen openings.

5.2.1.21 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall be not less than 0.042 inch (1.07 mm) thick if uncoated and not less than 0.046 inch (1.17 mm) if zinc-coated for mesh openings or perforations 1/2 in^2 (322 mm^2) or less in area, and shall be not less than 0.080 inch (2.03 mm) thick if uncoated and not less than 0.084 inch (2.13 mm) if zinc-coated for larger openings.

5.2.1.22 Enclosures shall provide a degree of protection against limited amounts of falling dirt. If ventilating openings are provided in the top of the enclosure, they shall be provided with a protective shield so spaced with respect to the opening that they will prevent falling dirt from impairing operation of the internal unit.

5.2.1.23

5.2.1.23.1 Secondary devices and their wiring shall be isolated by ground metal barriers, or by the clearance described in Table 7, from all primary circuit elements (with the exception of fans, fan motor terminals, short lengths of wire at instrument transformers, or temperature-sensing elements).

5.2.1.23.2 Low-voltage control equipment, relays, motors, and the like (except instrument or control transformers that are connected to the high-voltage fan motors) shall not be located in compartments with exposed high-voltage parts or high-voltage wiring unless the access door or cover is interlocked with the high-voltage switch or disconnecting means to prevent the door or cover from being opened or removed unless the switch or disconnecting means is in its isolating position.

5.2.1.24

5.2.1.24.1 Operating handles on the external surface of unit substations shall be provided with a lockable cover for Category A enclosures.

5.2.1.24.2 External handles and push buttons shall be located in accordance with the following:

(1) Control and transfer switch handles of push buttons shall be located in a readily accessible location at an elevation above the mounting surface not in excess of 78 inches (1.98 m).

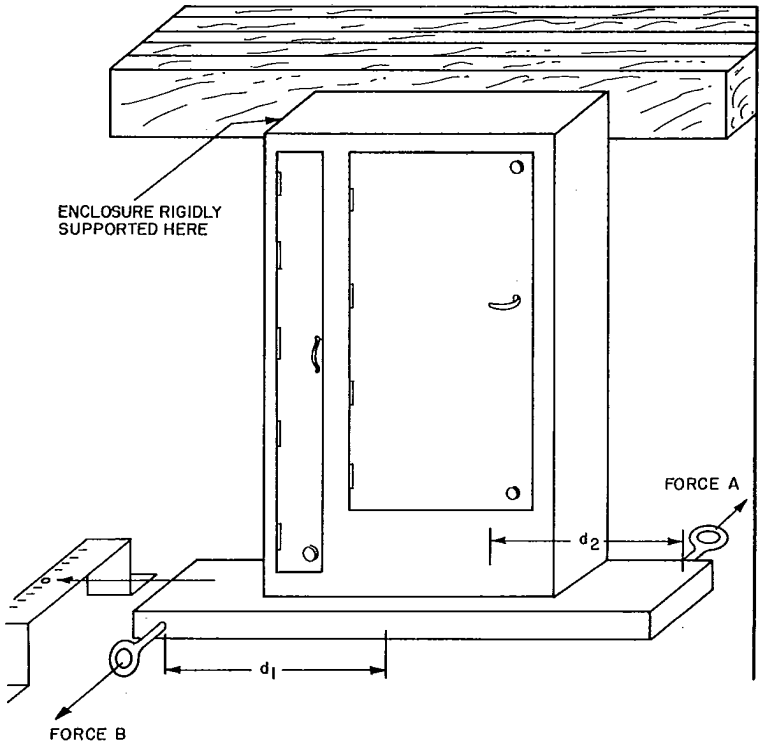
(2) Operating handles requiring a force of more than 50 lbf (222.4 N) of force to operate shall be not higher than 66 inches (1.67 m) in either the open or closed position.

(3) Operating handles for infrequently operated devices such as drawout fuses, fused potential or control transformer primary disconnects, and bus transfer switches, need not comply with (1) and (2).

5.2.1.24.3 In determining compliance with 5.2.1.24.2, measurements shall be made from the mounting surface to the center of the handle grip with the handle in its highest possible position. If the handle grip is not clearly defined, the center of the handle grip shall be considered to be at a point 3 inches (76 mm) in from the end of the handle.

5.2.1.24.4 If the mechanism of a switching device is such that operation of a remote or automatic tripping device will permit sudden movement of an operating handle, the motion of the handle shall be restricted or the handle shall be guarded to prevent injury to persons in the vicinity of the handle.

5.2.1.25 The viewing pane shall consist of a transparent material covering an observation opening and forming a part of the enclosure and shall be reliably secured in such a manner that it cannot be readily displaced in service. It shall meet the requirements of 5.2.2.5 through 5.2.2.8.



NOTE: Forces A and B are equal and applied simultaneously, $d_1 = d_2$.

Fig. 3
Torsion Test Setup

5.2.1.26

5.2.1.26.1 Valves, gages, and other accessories shall have a lockable cover over them on enclosures designated Category A.

5.2.1.26.2 The blades of cooling fans shall not be exposed on Category A enclosures. Fans on Category B enclosures may be exposed if provided with guards. Fans on Category C enclosures may be exposed if provided with guards, unless other means are provided to protect personnel from contacting rotating blades.

5.2.2 Construction Tests

5.2.2.1 The minimum thickness of an enclosure (without supporting frame) may be less than shown in Table 4 and 5 if the enclosure is reinforced so that if subjected to deflection forces (see 5.2.2.2) and torsional forces (see 5.2.2.3) its strength and rigidity are shown to be not less than an enclosure of the same maximum length and width having the required thickness shown in Tables 4 and 5.

5.2.2.2 For determining deflection the test described in 5.2.2.4(2) shall be applied to the end, side, and rear walls of each enclosure except that the forces and limits are not specified. The force on each wall of both the test and reference enclosures shall be sufficient to result in a measurable deflection of the test enclosure.

5.2.2.3 For the torsion test, with each test enclosure in a vertical position, one end wall shall be secured to a rigid surface. The opposite end wall shall then be twisted around the vertical axis of the enclosure. The force used on both the test and reference enclosures shall be sufficient to result in a measurable angle of rotation of the test enclosure (see Fig. 3).

5.2.2.4 A door, panel, or cover that has a supporting frame may employ metal having a thickness not less than 0.056 inch (1.42 mm) if zinc-coated steel, 0.053 inch (1.35 mm) if uncoated steel, or 0.075 inch (1.90 mm) if aluminum, copper, or brass, provided that:

(1) The door, front, panel, or cover has the strength and rigidity to maintain its shape when open or unmounted, and

(2) The inward deflection is not more than 1/4 inch (6.4 mm) when a force of 100 lbf (445 N) is applied perpendicular to the surface at any point on the door, front, panel, or cover through a rod having a 1/2-by 1/2-inch (12.7- by 12.7-mm) square steel face. For the test, the enclosure may be laid on its back on a smooth, solid, horizontal surface with the door closed and the front, panel, or cover secured as intended. The test

force shall be applied at various points on the door likely to cause deflection. The same sample may be used for more than one test, provided that there is no permanent deflection due to a previous test.

5.2.2.5 Viewing panes as inciated in 5.2.1.25 shall not shatter, crack, or become dislodged when both sides of the viewing pane in turn are subjected to the tests described in 5.2.2.6 and 5.2.2.7.

5.2.2.6 A force of 200 lbf (890 N) shall be exerted perpendicularly to the surface in which the viewing pane is mounted. This force shall be evenly distributed over an area of 16 in^2 (0.010 m^2) as nearly square as possible and as near the geometric center of the viewing pane as possible. If the viewing pane has an area less than 16 in^2 (0.010 m^2), the force shall be evenly distributed over the entire viewing area. The 200-lb (890-N) force shall be sustained for a period of 1 minute.

5.2.2.7 The viewing pane shall be subjected to an impact of 5 ft·lbf (6.8 J) using a steel ball weighing approximately 1.8 lb (0.535 kg) and approximately 2 inches (51 mm) in diameter.

5.2.2.8 Separate samples may be used for each of the tests described in 5.2.2.6 and 5.2.2.7.

5.2.3 Enclosure Security

5.2.3.1 Enclosure security tests shall be conducted with the equipment described in 5.2.3.2 through 5.2.3.6.

5.2.3.2 A pry bar, constructed in accordance with Fig. 4, is used for the pry tests. The equipment consists of the specified pry tip welded to a pry bar. The handle is mounted so that it can slide only in an axial direction restrained by a stack of Belleville washers. The forces described in 5.2.3.3 and 5.2.3.4 are applied to the handle.

5.2.3.3 When an axial force is applied to the handle, the stack of Belleville washers is compressed. The amount of compression is a measure of the magnitude of the axial force applied. Using a scale of other force-measuring devices, the pry bar can be calibrated to measure the axial force used to force the tip into the joint under test.

5.2.3.4 The prying leverage applied can be measured indirectly by measuring the deflection of the pry bar. The dial indicator is mounted on the pry bar and set to measure deflection of a certain length of the bar. A calibration can be made that will result in a table or curve showing prying leverage versus reading of the dial indicator.

5.2.3.5 The pull bar shown in Fig. 5 is used in the pull tests. The pulling means is designed to measure the axial pull in pounds and is constructed in accordance with Fig. 5.

5.2.3.6 The probing wire is bare no. 10 AWG hard-drawn solid copper wire 10 ft (0.305 m) long.

5.2.4 Enclosure Security Tests

5.2.4.1 General. The completely assembled transformer shall be mounted on a flat surface according to the manufacturer's specification. With the doors closed and locked, the following sequence of tests shall be performed.

(1) Pry tests
(2) Wire probe tests
(3) Pull tests
(4) Wire probe tests
(5) Operation test

5.2.4.2 Pry Tests. The pry bar is to be used on all joints, crevices, hinges, locking means, etc, that exist between the enclosure components – that is, doors, sills, etc. The pry bar may be placed at any angle to the enclosure surface. The tip of the bar shall first be inserted in the opening being tested using the value of axial force specified in Table 8. Then, with that axial force being maintained, the prying force specified in Table 8 shall be applied. This force may be applied alternately, first in one direction and then in the opposite direction (once in each direction). Application of either or both axial and prying force shall be maintained so long as relaxation is occurring in the enclosure assembly. When relaxation ceases, or if no relaxation occurs, the pry bar shall be removed and applied at an untested location.

NOTE: If hinge pins are removable with the door closed, this test shall also be made with the hinge pins removed.

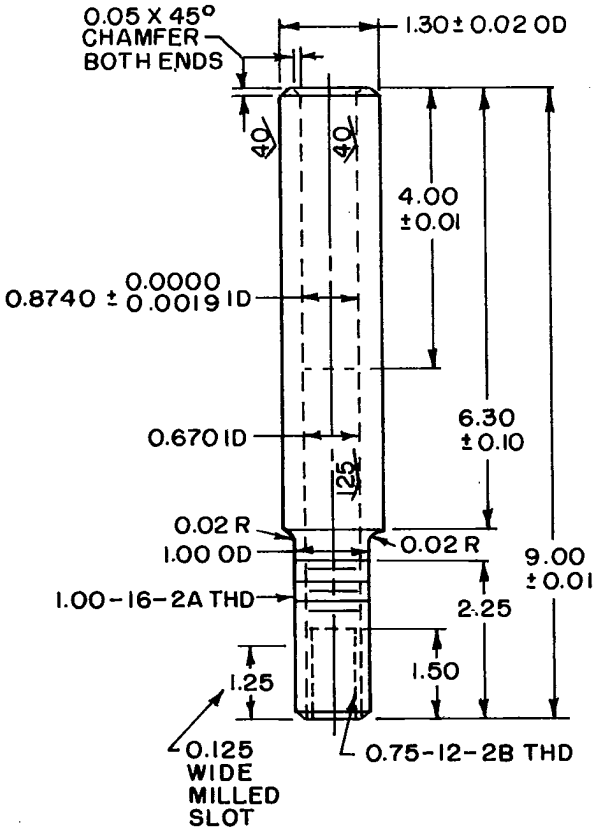
5.2.4.3 Pull Tests. A pulling force is to be applied to all handles and other parts that can be engaged by the pulling hook. A pulling force not exceeding the values in Table 8 may be exerted at any angle to the compartment surface. This force shall be maintained during any relaxation of the enclosure assembly. When relaxation ceases, or if no relaxation occurs, the pull test shall be terminated. The hook shall then be inserted into any handle or other part that it can engage, and the test shall be repeated. Any handle or part shall be tested only once.

NOTE: If hinge pins are removable with the door closed, this test shall also be made with the hinge pins removed.

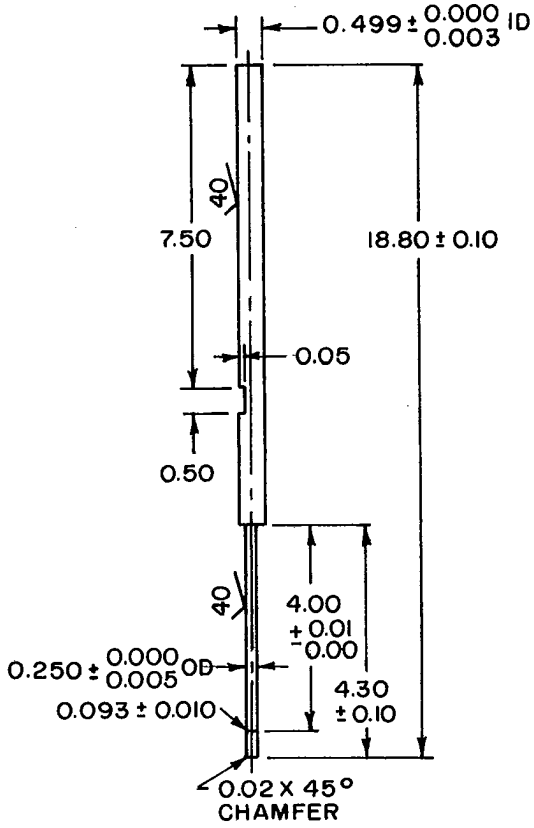
5.2.4.4 Wire Probe Tests. Following the pry and pull tests described in 5.2.4.2 and 5.2.4.3, penetration of the enclosure shall be attempted with the probe

Table 8
Test Values to Prevent Entry

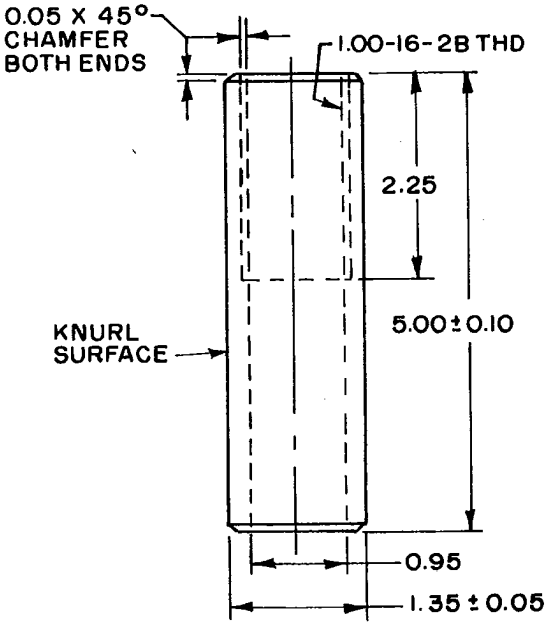
Inward axial force	50 lbf (222 N)
Prying leverage tests	300 lbf·in (33.9 N·m)
Pull test	100 lbf (444 N)



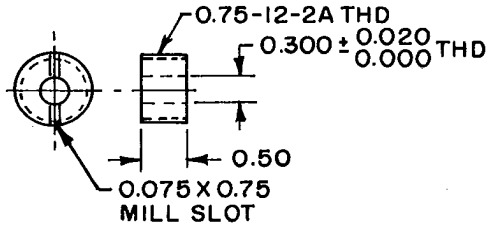
Part Number 02 – Steel 1.30 × 9.00



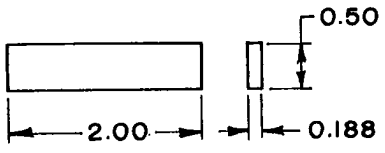
Part Number 07 – Drill Rod 0.50 × 18.80



Part Number 01 – Steel 1.35 OD × 5.00

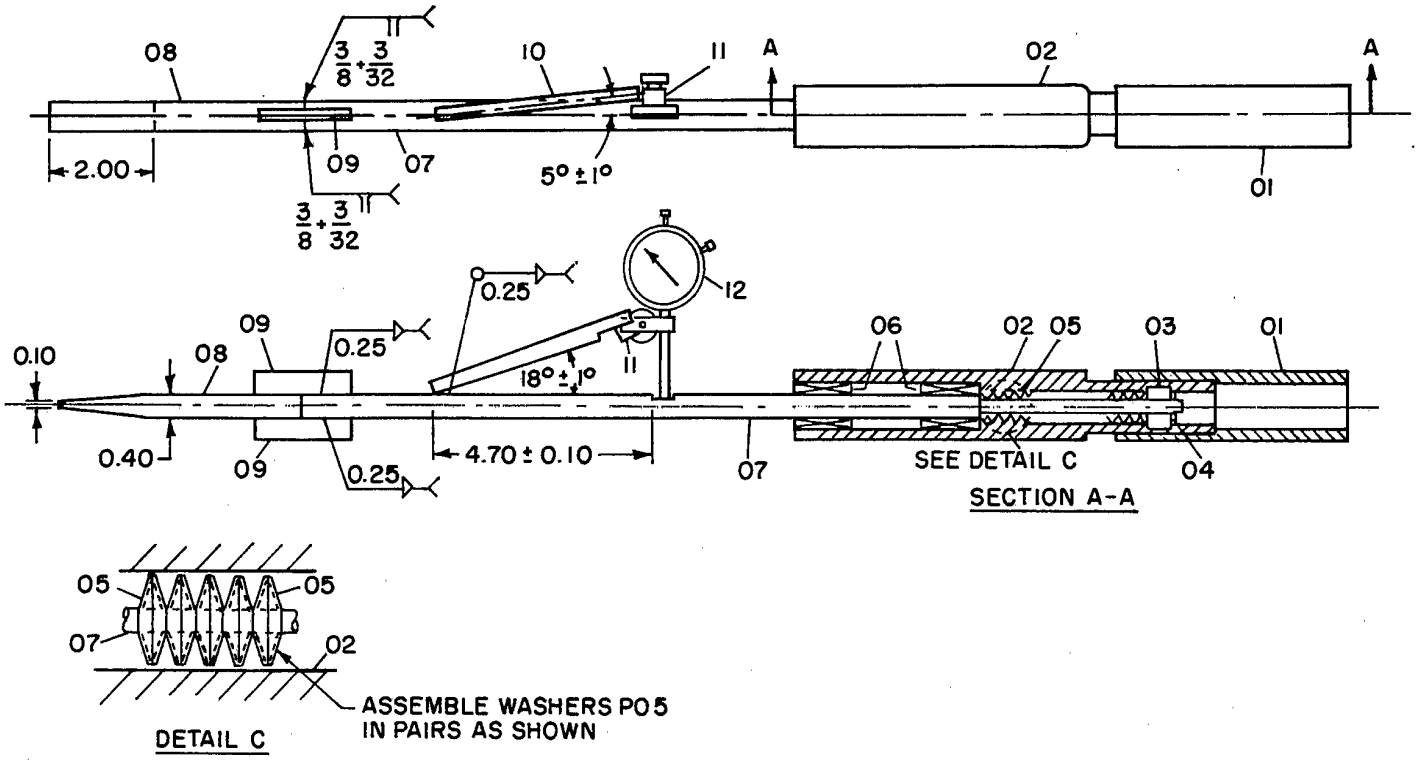


Part Number 03 – Steel 0.75 OD × 0.50



Part Number 09 – Steel 0.188 × 0.50 × 2.00

Fig. 4
Pry Test Bar



NOTES:

(1) Quantity of Part Number 05 may vary from 90 to 100.

(2) Part Number 04 must extend into slot to restrict turning motion of Part Number 07.

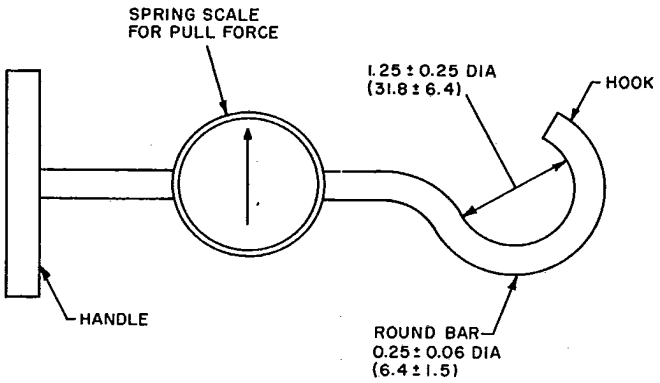
(3) Calibration Instruction – Before the pry (test) bar can be used to measure the axial and prying leverage forces described in the standard, the bar must be calibrated. This calibration is accomplished for the axial force by applying standard forces at the end of the handle (Part Number 01) and marking the compression of the pry bar handle along the pry bar shaft (Part Number 07). Suggested markings would be in 25-pound steps.

Next, the prying leverage must be calibrated by holding the pry bar tip (Part Number 08) in place and applying a standard force on the handle (Part Number 02). The deflection of the dial indicator (Part Number 12) is recorded for steps in force on the handle. The results can be used to develop a calibration curve of deflection versus prying leverage. So, when the pry bar is used in a test, the calibration curve is used to determine the inch pounds of force.

Bill of Materials

Part No.	Name	Quantity	Description
01	Handle	1	–
02	Spring Housing	1	–
03	Spring Housing	1	–
04	Roll Pin	1	Steel 0.093 OD × 0.750 Long
05	Spring Washer	100	Belleville Catalog #1B0500-022
06	Ball Bushing	2	Thompson Ball Bushing Catalog #A-81420
07	Shaft	1	–
08	Chisel	1	1/2 inch (J. C. Penney Catalog #9253 or equivalent)
09	Weld Pad	2	–
10	Hold Rod	1	Brown & Sharpe Catalog #599-7900
11	Slide Swivel	1	Brown & Sharpe Catalog #599-7906
12	Torque Indicator	1	Brown & Sharpe Catalog #8241-942

Fig. 4 (*Continued*)



NOTES:
(1) All dimensions are in inches (millimeters).
(2) Typical device: Iron Man scales, capacity: 200 lb, No. 1756T4, or the equivalent.

Fig. 5
Pull Hook

wire. This penetration may be tried at any enclosure crevice or joint. The wire must be gripped by the tester with bare hands. If the wire enters the joint, the wire should be continually pushed until it can no longer be pushed or it has entered the enclosure. This test is passed if an inspection determines that the probing wire either has not entered the enclosure or the probing wire is visibly restricted by a barrier from intrusion into the enclosure's interior.

5.2.4.5 Operation Test. Following the tests described in 5.2.4.2 through 5.2.4.4, the enclosure should unlock and open and should also close and lock easily without loss of security. The minimum test values for which entry must be prevented are given in Table 8.

5.3 Outdoor Enclosure Construction Requirements

5.3.1 A nonmetallic enclosure is to be considered on the basis of the effect of its exposure to ultraviolet light and water.

5.3.2 Copper, bronze, brass containing not less than 80% copper, or stainless steel may be used without additional protection against corrosion. Aluminum (sheet, extrusion, or casting), die-cast zinc, or another metal shall be of a grade or alloy known to be nonsusceptible to corrosion, shall be subjected to appropriate tests, or shall be additionally protected from corrosion.

5.3.3 Aluminum in an outdoor enclosure shall be so located that it will not be in contact with the mounting pad.

5.3.4 Hinges and other attachments shall be resistant to corrosion. Metals shall not be used in combinations that result in galvanic action that could adversely affect any part of the device.

5.3.5 If an outdoor enclosure has any opening for passage of a wire or bus bar to a switchboard section or to a wireway, auxiliary gutter, or busway, a suitable gasket or other means shall be provided that will prevent the entrance of water at such opening. If the opening is for attachment of a busway, the outdoor enclosure and the busway shall be investigated together to determine that water does not enter along the bus bars.

5.3.6 Outdoor construction requiring a gasketed joint shall be investigated to determine whether or not it is suitable for the particular application (see 5.3.7 through 5.3.9).

5.3.7 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to make an enclosure suitable for outdoor use shall be adequately resistant to aging as determined by the accelerated-aging tests described in 5.3.8 and 5.3.9.

5.3.8 A gasket of rubber or neoprene, or a composition thereof, shall be exposed for 96 hours to oxygen at a pressure of 300 lbf/in^2 (2068 kPa) and a temperature of 70°C (158°F). The gasket is considered adequately resistant to aging if there is no visible evidence of deterioration such as softening, hardening, or cracking after flexing (see Section 32 of ANSI/UL 347-1978).

5.3.9 A gasket of thermoplastic material, or a composition thereof, may be accepted after consideration of the effects of heat aging, distortion under conditions of use, and the means of securing the gasket to the cover or enclosure.

5.3.10 External hinged doors or covers for outdoor equipment shall be provided with stops to hold them in the open position or shall be removable.

Table 9
Enclosures for Outdoor Nonhazardous Locations

Provides a Degree of Protection against	Type 103	Type 103R*	Type 103S	Type 104X
Incidental contact with the enclosed equipment	X	X	X	X
Rain, snow, and sleet†	X	X	X	X
Sleet‡	–	–	X	–
Windblown dust	X	–	X	X
Hosedown	–	–	–	X

*These enclosures may be ventilated.

†External operating mechanisms are not required to be operable when the enclosure is ice-covered.

‡External operating mechanisms are operable when the enclosure is ice covered.

5.3.11 An outdoor enclosure shall comply with the preceding sections and shall also meet the requirements of its type designation as indicated in Table 9.

5.3.12 Type 103 Enclosures

5.3.12.1 Type 103 enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, and external ice formation. They shall meet rain, external icing, dust- and rust-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

5.3.12.2 When completely and properly installed, Type 103 enclosures:

(1) May have a conduit hub or equivalent provision to exclude water at the conduit entrance and may have mounting means external to the equipment cavity.

(2) Shall require the use of a tool to gain access to the equipment cavity, or have provisions for locking.

(3) Exclude water when subjected to a simulated heavy rainfall.

(4) Exclude dust under test conditions.

(5) Are undamaged after being encased in ice under test conditions.

(6) Shall not corrode when subjected to a salt-spray test for 200 hours.

5.3.12.3 Type 103 enclosures shall be tested and evaluated by the following:

(1) Spray test described in 5.3.16

(2) Dust test described in 5.3.17

(3) External icing test described in 5.3.18

(4) Corrosion resistance test described in 5.3.20

5.3.13 Type 103R Enclosures

5.3.13.1 Type 103R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain, sleet, and external ice formation. They shall meet rod entry, rain, external icing, and rust resistance design tests. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing.

5.3.13.2 When completely and properly installed, Type 103R nonventilated enclosures:

(1) Shall not permit water to enter the equipment cavity at a level higher than the lowest live part unless constructed to divert water from live parts, insulation, and wiring and shall have provision for drainage.

(2) Shall be undamped after being encased in ice under test conditions that are intended to simulate freezing rain.

(3) May have a conduit hub or equivalent provision to exclude water at the conduit entrance if the entrance is above the lowest live part.

(4) Shall require the use of a tool to gain access to the equipment cavity or have provisions for locking.

(5) Shall prevent the entrance of a rod having a diameter of 0.125 inch (3.2 mm) except that if the distance from the opening to the nearest live part is greater than that in Table 7, the opening may permit the entry of a rod having a diameter not greater than 0.500 inch (12.7 mm).

(6) Shall not rust when subjected to a salt-spray test for 200 hours.

Type 103R ventilated enclosures have the same provisions as nonventilated enclosures except that they have ventilated openings. These openings shall prevent the entrance of a rod having a diameter of 0.500 inch (12.7 mm) except that, if the distance from the opening to any live part is greater than that in Table 7, the opening may permit the entry of a rod not greater than 0.750 inch (19.1 mm).

5.3.13.3 Type 103R enclosures shall be tested and evaluated by the following:

(1) Rod entry test described in 5.3.13.2

(2) Spray test described in 5.3.16

(3) External icing test described in 5.3.18

(4) Corrosion resistance test described in 5.3.20

5.3.14 Type 103S Enclosures

5.3.14.1 Type 103S enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, and sleet and to provide for operation of external mechanisms when ice-laden. They shall meet rain, external icing, dust, and rust resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

5.3.14.2 When completely and properly installed, Type 103S enclosures:

(1) Exclude water when subjected to a simulated heavy rainfall.

(2) Exclude dust under test conditions that are intended to simulate windblown dust.

(3) May have a conduit hub or equivalent provisions to exclude water at the conduit entrance.

(4) If wall-mounted, shall have mounting means external to the equipment cavity.

(5) Shall require the use of a tool to gain access to the equipment cavity or have provisions for locking.

(6) Have external operating mechanisms with the ability to withstand removal of ice by a hand tool. Auxiliary means may be provided to break the ice.

(7) Shall not rust when subjected to a salt-spray test for 200 hours.

5.3.14.3 Type 103S enclosures shall be tested and evaluated by the following:

(1) Spray test described in 5.3.16

(2) Dust test described in 5.3.17

(3) External icing test described in 5.3.18

(4) Corrosion resistance test described in 5.3.20

5.3.15 Type 104X Enclosures

5.3.15.1 Type 104X enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, splashing water, and hose-directed water. They shall meet hose-down, dust, external icing, and corrosion design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

5.3.15.2 When completely and properly installed, Type 104X enclosures:

(1) Exclude water when subject to a stream of water from a 1-inch (25.4-mm) nozzle at a rate of 65 gallons (246 liters) per minute for a length of time dependent on the enclosure size.

(2) Exclude dust under test conditions.

(3) Shall not corrode when subjected to a salt-spray test for 200 hours.

(4) May have a conduit hub or equivalent provisions to exclude water at the conduit entrance.

(5) If wall-mounted, shall have mounting means external to the equipment cavity. External operating mechanisms are not required to be operable when enclosure is ice-covered.

5.3.15.3 Type 104 enclosures shall be tested and evaluated by the following:

(1) Dust test described in 5.3.17

(2) External icing test described in 5.3.18

(3) Hose-down test described in 5.3.19

(4) Corrosion resistance test described in 5.3.20

5.3.16 Spray Test. An enclosure marked for outdoor use shall be subjected to the spray test described in 5.3.16.1 and shall be evaluated in accordance with 5.3.16.2.

5.3.16.1 The enclosure to be tested shall be fully equipped and complete with all appurtenances such as roof bushings, conduits, etc, and mounted in the intended manner in the area to be supplied with artificial precipitation. For multiple-unit construction, a minimum of two units shall be used to test the joints between units including a roof joint.

The tightening torque for rigid conduit threaded into the opening in the enclosure shall be 800 lbf·in (90.4 N·m) for 3/4-inch and smaller trade sizes, 1000 lbf·in (113 N·m) for 1-, 1-1/4-, and 1-1/2-inch trade sizes, and 1600 lbf·in (980.8 N·m) for 2-inch and larger trade sizes.

The artificial precipitation shall be supplied by a sufficient number of nozzles to produce a uniform spray over the entire surface or surfaces under test. The various vertical surfaces of an enclosure may be tested separately or collectively, provided that a uniform spray is simultaneously applied to both of the following:

(1) The roof surface, from nozzles located at a suitable height.

(2) The floor outside the enclosure for a distance of approximately 3 ft (0.91 m) in front of the surface under test with the enclosure located at its normal height above the floor level.

The nozzles used for this test shall deliver a square-shaped spray pattern with uniform spray distribution and shall have a capacity of at least 7.1 gal/min (0.45 L/s) at 60-lbf/in^2 (414-kPa) pressure, and a spray angle spread of approximately 75 degrees. The centerline of the nozzles shall be inclined downward so that the top of the spray is horizontal as it is directed toward the vertical and roof surfaces being tested.

The pressure at the nozzles shall be a minimum of 60 lbf/in^2 (414 kPa) under flow conditions. (This is approximately equivalent to rain driven by a 65-mi/h (29-m/s) wind.) The quantity of water applied to each surface under test shall be at least 0.2 inch (5.1 mm) per unit surface per minute, and each surface so tested shall receive this rate of artificial precipitation for a duration of 5 minutes. The spray nozzle shall be not more than 10 feet (3.05 m) from the nearest vertical surface under test.

5.3.16.2 At the conclusion of the test, an enclosure shall be considered to have met the requirements of this test if there is:

(1) No water visibly observable on primary or secondary insulation.

(2) No water visibly observable on any electrical components or mechanisms of the assembly.

(3) No significant accumulation of water retained by the structure or other noninsulating parts (to minimize corrosion).

5.3.17 Dust Test

5.3.17.1 Either of two alternative methods may be applied:

(1) If the dust-blast method is used, the enclosure

shall be subjected to a blast of compressed air mixed with dry Type 1 general-purpose Portland cement[3] or talc or other equivalent material having the same particle size, using a suction-type sandblast gun that is equipped with a 3/16-inch-diameter air jet and a 3/8-inch-diameter nozzle. The air shall be dry and at a pressure of 90 to 100 lbf/in² (620 to 690 kPa). The cement shall be supplied by a suction feed. Not less than 4 pounds of cement per linear foot (5.94 kg/m) of test length[4] of the test specimen shall be applied at a rate of 5 pounds (2.27 kg) per minute. The nozzle shall be held from 12 to 15 inches (0.31 to 0.46 m) away from the enclosure, and the blast of air and cement shall be directed at all points of potential dust entry, such as seams, joints, external operating mechanisms, etc. A conduit may be installed to equalize the internal and external pressures.

(2) If the atomized-water method is used, the enclosure shall be subjected to a spray of atomized water, using a nozzle that produces a round pattern 3 to 4 inches (76 to 102 mm) in diameter when measured 12 inches (305 mm) from the nozzle. The air pressure shall be 30 lbf/in² (207 kPa). The water shall be supplied by a suction feed with a siphon height of 4 to 8 inches (102 to 203 mm). Not less than 5 ounces per linear foot (0.43 kg/m) of test length[4] of the test specimen shall be applied at a rate of 3 gallons (11.35 liters) per hour. The nozzle shall be held from 12 to 15 inches (0.31 to 0.46 m) away from the enclosure, and the spray of water shall be directed to all points of potential dust entry, such as seams, joints, external operating mechanisms, etc.[5] A conduit may be installed to equalize the internal and external pressures but should not serve as a drain.

5.3.17.2 The enclosure shall be considered to have met the requirements of this test if no dust has entered the enclosure from the method given in 5.3.17.1(1) or water from the method given in 5.3.17.1(2).

5.3.18 External Icing (Sleet) Test

5.3.18.1 The enclosure shall be mounted in a room that can be cooled to 20°F (–7°C). A metal test bar that is 1 inch (25.4 mm) in diameter and 2 feet (0.61 m) long shall be mounted in a horizontal position in a location where it will receive the same general water spray as the enclosure under test.

5.3.18.2 Provision shall be made for spraying the entire enclosure from above with water at an angle of approximately 45 degrees from the vertical. The water shall be between 32°F (0°C) and 37°F (3°C). As a guide, spraying facilities that provide between 1 and 2 gallons per hour per square foot of area (40.7 to 81.5 liters per hour per square meter) to be sprayed have been found effective.

5.3.18.3 The room temperature shall be lowered to 35°F (2°C). The spray of water shall be started and continued for at least 1 hour, maintaining the room temperature between 33°F (1°C) and 37°F (3°C).

5.3.18.4 At the end of this time, the room temperature shall be lowered to between 20°F (–7°C) and 27°F (–3°C) without discontinuing the water spray. (The rate of change in the room temperature is not critical and shall be whatever is obtainable with the cooling means employed.) The water spray shall be controlled so as to cause ice to build up on the bar at a rate of approximately 1/4 inch (6.4 mm) per hour and shall be continued until 3/4 inch (19.1 mm) of ice has formed on the top surface of the bar. The spray shall then be discontinued, but the room temperature shall be maintained between 20°F (–7°C) and 27°F (–3°C) for 3 hours to ensure that all parts of the enclosure and ice coatings have been equalized to a constant temperature.

5.3.18.5 The enclosure and its external mechanisms shall be considered to have met the requirements of this test if:

(1) While ice-laden, they can be manually operated by one person without any damage to the enclosure, the enclosed equipment, or mechanism. When an auxiliary mechanism is provided to break the ice, it shall be included and utilized in the test. A separate test is required for each maintained position of each external operator; if necessary, it should be possible to gain access to the enclosure interior using an appropriate hand tool without causing functional damage to the enclosure.

(2) They are found to be undamaged after the ice has melted. Enclosures that have no external cavitities to trap water need not be tested.

5.3.19 Hose-Down Test

5.3.19.1 The enclosure and its external mechanisms shall be subjected to a stream of water from a

[3] Type 1 general-purpose Portland cement is readily available and has a controlled maximum particle size. The analysis of a typical sample is given as follows:

Mesh	Particle Size in Inches (millimeters)	Content
Coarser than 200	> 0.0029 (> 0.074)	3%
200	0.0029 (0.074)	8%
325	0.0017 (0.043)	7%
400	⩽ 0.0015 (⩽ 0.038)	82%

[4] Test length is the summation of the height plus the width plus the depth; that is, test length = $H + W + D$.

[5] Ungasketed shaft openings that have a path length of not less than 1/2 inch (12.7 mm) shall not be tested if the total (diametric) clearance between the shaft and the opening is not more than 0.005 inch per 1/2 inch (1 mm per 100 mm) length of path. These joints and openings shall be protected by suitable external means during the atomized water test.

hose that has a 1-inch nozzle and delivers at least 65 gallons (246 liters) per minute. The water shall be directed at all joints from all angles from a distance of 10 to 12 ft (3 to 3.7 m) for a period of time equal to 48 seconds times the test length in feet.[4] A conduit may be installed to equalize internal and external pressures but should not serve as a drain.

5.3.19.2 The enclosure shall be considered to have met the requirements of this test if no water has entered the enclosure.

5.3.20 Corrosion Resistance Test. The corrosion resistance test applies to all enclosures incorporating external ferrous parts. Nonferrous enclosures with no external ferrous parts need not be tested.

5.3.20.1 The enclosures or representative parts of enclosures shall be subjected to salt spray (fog) as follows:

(1) The test apparatus shall:

(a) Consist of a fog chamber, a salt solution reservoir, a supply of suitably conditioned compressed air, atomizing nozzles, support for the enclosure, provision for heating the chamber, and means of control.

(b) Not permit drops of solution that accumulate on the ceiling or cover of the chamber to fall on the enclosure being tested.

(c) Not permit drops of solution that fall from the enclosure to be returned to the solution reservoir for respraying.

(d) Be constructed of materials that will not affect the corrosiveness of the fog.

(2) The salt solution shall be prepared by dissolving 5 ± 1 parts by weight of salt in 95 parts of either distilled water or water containing not more than 200 parts per million of total solids. The salt shall be sodium chloride that is substantially free of nickel and copper and that contains, when dry, not more than 0.1% of sodium iodide and not more than 0.3% of total impurities.

(3) The compressed-air supply to the nozzle(s) for atomizing the salt solution shall be free of oil and dirt and maintained between 10 and 25 lbf/in^2 (69 and 172 kPa).

(4) The temperature of the salt-spray chamber shall be maintained at 95°F, + 2°F, − 3°F (35°C, + 1°C, − 2°C). The nozzle(s) shall be directed or baffled so that none of the spray can impinge directly on the enclosure being tested.

(5) The test shall be run continuously for 200 hours; that is, the chamber shall be closed and the spray operated continuously except for the short daily interruption necessary to inspect, rearrange, or remove the test specimens, to check and replenish the solution in the reservoir, and to make necessary recordings.

(6) At the end of the test, the specimens shall be removed from the chambers and washed in clean running water that is not warmer than 100°F (38°C) to remove salt deposits from their surface, and then dried immediately. Corrosion products, other than rust, may be removed by light brushing if required, to permit observation of the condition of the underlying stratum.

5.3.20.2 The enclosure shall be considered to have met the requirements of this test if there is no pitting, cracking, or other deterioration more severe than that resulting from a similar test on passivated AISI Type 304 stainless steel after 200 hours of exposure.

5.4 Markings

5.4.1 Transformer enclosures shall be marked with the following:

(1) A nameplate in accordance with ANSI/IEEE C57.12.00-1980

(2) The exposure category (see 5.1.3 through 5.1.5)

(3) The type designation (see 5.3.11), for outdoor enclosures only

5.4.2 Category A and B enclosures shall have appropriate caution signs in accordance with the National Electrical Code (ANSI/NFPA 70-1981).

5.4.3 The front and rear of all equipment enclosures, not exceeding 15 ft (4.6 m) in length, having doors or removable covers permitting access to high-voltage compartments, shall be marked with a caution or warning sign. Longer equipment enclosures shall be so marked at 15-ft (4.6-m) intervals.

5.4.4 Enclosures containing high voltages (over 600 V) shall be permanently marked by the manufacturer with an exterior warning, "High Voltage" or "Warning – High Voltage."

5.4.5 The operating voltages of exposed live parts shall be permanently marked on the equipment.

5.4.6 Non-load-break devices shall be interlocked or have a caution sign: "Warning – Do Not Open under Load."

5.4.7 Fuses that can be energized by backfeed shall have a caution sign: "Warning – Fuses May Be Energized by Backfeed."

6. General Test Conditions

Except as modified for specific tests, the test conditions shall be those prevailing at the test site.

7. Routine Test Requirements

Each transformer manufactured for compliance with this standard shall be subjected to the routine tests

specified in ANSI/IEEE C57.12.00-1980 except as modified by the applicable product standards. All such tests are defined by and shall be made in accordance with ANSI/IEEE C57.12.90-1980.

8. Conformance Test Requirements

8.1 General. The conformance tests listed in this section shall be performed on a representative sample as defined by Section 9, Certification Guidelines. The test values shall be as specified in ANSI/IEEE C57.12.00-1980 (in accordance with the unit rating), except as noted. These tests shall be made in accordance with ANSI/IEEE C57.12.90-1980, except as otherwise noted. These tests shall be made in accordance with ANSI/IEEE C57.12.90-1980, except as otherwise noted. Each sample shall first be subjected to the routine tests specified in Section 7, Routine Test Requirements.

8.2 High-Voltage Impulse Test. An impulse test shall be performed on the high-voltage winding(s) of the transformer at the phase bushings.

8.3 Low-Voltage Impulse Test. An impulse test shall be performed on the low-voltage winding(s) of the transformer at the phase terminals.

8.4 Short-Circuit Test. A short-circuit test shall be performed.

8.5 Temperature-Rise Test. A temperature-rise test shall be performed.

8.6 Radio-Influence-Voltage Test. A radio-influence voltage test shall be performed in accordance with NEMA TR 1-1980.

9. Certification Guidelines

9.1 Samples. Transformers from each design family, based on winding design, capacity, internal connections, and clearances, shall be selected for certification. The sample size is dependent on the number of units required to demonstrate maximum electrical, mechanical, and thermal stresses to be realized by the conformance tests of Section 8 for the design family.

9.2 Treatment of Test Failures. Failures that occur during or as a result of a conformance test should be evaluated and corrections made prior to retesting. Any such correction shall be evaluated for its effect on preceding tests.

9.3 Audit Procedure. After certification, the certifying agency shall establish a monitoring frequency to audit production. Modifications shall be reviewed by the certifying agency to determine whether retest is required.

9.4 Test Records. The manufacturer shall record and retain the results of all calculations and tests required for certification.

Appendix

(This Appendix is not a part of American National Standard Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations, ANSI C57.12.13-1982, but is included for information purposes only.)

Conformance Guide for Insulating Systems and Materials for Liquid-Filled Transformers

A1. General

A1.1 Scope. This appendix covers conformance tests and requirements for the insulation systems used in liquid-filled distribution transformers to be used in pad-mounted unit substations that may be exposed to the public, and rated not greater than 2500 kVA, with a primary voltage not exceeding 600 V. Insulating liquids are limited to those specified in ANSI/ASTM D3487-79. This appendix will be expanded to include other insulating fluids as they become available.

All manufacturers seeking certification under this guide should demonstrate that performance requirements have been met by performing the tests herein, by submitting data from earlier tests, by exhibiting proof of satisfactory field service, or by an appropriate combination of these methods. Families of insulation systems may be certified on the basis of tests performed on one representative model.

Based on Paragraph 90-2(b)(5) of the National Electrical Code, ANSI/NFPA 70-1981, this appendix is not intended to cover "installations under the exclusive control of electric utilities for the purpose of communication, or metering; or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or located outdoors on property owned or leased by the utility or on public highways, streets, roads, etc, or outdoors by established rights on private property."

A1.2 References. The insulation materials should conform to the latest revision of applicable industry standards except as otherwise indicated in this standard. Included among these standards are the following:

American National Standard Requirements for Transformers 230 000 Volts and Below, 833/958 through 8333/10 417 kVA, Single Phase and 750/862 through 60 000/80 000/100 000 kVA Three Phase (includes supplement ANSI C57.12.10a-1978), ANSI C57.12.10-1977

American National Standard Requirements for Overhead-Type Distribution Transformers 67 000 Volts and Below, 500 kVA and Smaller, ANSI C57.12.20-1980

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Single-Phase Distribution Transformers with High-Voltage Bushings (High-Voltage, 34 500 GrdY/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller), ANSI C57.12.21-1980

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Three-Phase Distribution Transformers with High-Voltage Bushings (34 500 GrdY/19 920 Volts and Below; 2500 kVA and Smaller), ANSI C57.12.22-1980

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors, High-Voltage 34 500 GrdY/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller, ANSI C57.12.25-1981

American National Standard Requirements for Pad-Mounted Compartmental-Type Self-Cooled Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 24 940 GrdY/14 400 Volts and Below; 2500 kVA and Smaller, ANSI C57.12.26-1975

American National Standard Terminal Markings and Connections for Distribution and Power Transformers, ANSI C57.12.70-1978

American National Standard Transformer Terminology, ANSI C57.12.80-1978

American National Standard Method of Test for Effects of Construction Material on Uninhibited Elec-

trical Insulating Oil of Petroleum Origin, ANSI/ASTM D3455-78

American National Standard Specifications for Mineral Insulating Oil Used in Electrical Apparatus, ANSI/ASTM D3487-79

American National Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers, ANSI/IEEE C57.12.00-1980

American National Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers, ANSI/IEEE C57.12.90-1980

American National Standard Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers, ANSI/IEEE C57.100-1972

American National Standard National Electrical Code, ANSI/NFPA 70-1981

NEMA Standards Publication for Transformers, Regulators, and Reactors, NEMA TR 1-1980

A1.3 Definitions

A1.3.1 Accessory Devices. These devices include load interruption devices, tap changers, series multiple switches, liquid-level gages, thermometers, vacuum pressure gages, etc.

A1.3.2 Families of Transformer Insulation Systems. A family of liquid-filled transformers insulation systems is identified as follows:

(1) The internal parts (that is, turn to turn, layer to layer, section to section, coil to coil) should be designed so that they will not exceed a particular limit in volts per mil under rated conditions (60 Hz and impulse voltage insulation class). Specification of a new design limit would create a new family of transformers.

(2) Redesign of a group of transformers to operate at a different temperature (for instance, a change from 55°C rise to 65°C rise) would create a new family of transformers.

(3) A new type of insulation would create a new family of transformers.

A2. Materials Classifications

A2.1 Insulation. Insulation between primary and ground, secondary and ground, secondary and core, turn and turn, layer and layer, and coil and core.

A2.2 Miscellaneous Materials. Any other materials that are exposed to oil or oil vapor not previously included under insulation.

A2.2.1 Materials that have the potential for flaking (such as hot-dip galvanized zinc coatings) or for formation of conductive compounds (such as cadmium and certain chloride-containing smoldering or brazing fluxes) are precluded from use in direct contact with oil or oil vapor.

A2.2.2 The materials used in accessory devices that are exposed to oil or its vapors should meet the requirements specified in A3.2 for miscellaneous materials.

A3. Requirements for Insulation

A3.1 New Families of Insulation Systems. New families would include insulation systems and materials that have not been used previously as insulation systems by the given manufacturer, or have not been used previously in combination as insulation systems by the given manufacturer. See A3.4 for recommended test requirements.

A3.2 Substitution of Closely Related Insulation Materials. The transformer manufacturer will bear the burden of satisfying the certifier that data exist to show that one material may be substituted for another in an insulation system. In any case, the extent of testing for functional life should not exceed one test at one temperature in accordance with Section 6 of ANSI/IEEE C57.100-1972.

A3.3 Decrease or Increase in Existing Insulating Materials. Where a significant decrease in insulation is introduced, the test requirements for insulation systems (see A3.4) should be used. Where a significant increase in insulation is introduced, the oil compatibility test should be used.

A3.4 Insulation Tests

A3.4.1 The insulation components should meet compatibility requirements as given in ANSI/ASTM D3455-78.

A3.4.2 The insulating components should be tested in representative transformers in accordance with ANSI/IEEE C57.100-1972.

A3.4.3 Accessory devices containing insulation materials should be included in a "thermal test" in accordance with ANSI/IEEE C57.100-1972 or should be subjected to the same conditions of aging that have been established for the family of transformers in which they will be used. Simulated test conditions may be acceptable. Accessories should be fully functional after thermal tests. Families of insulation systems can be certified on the basis of one transformer representative of that family.

APPENDIX

A4. Transformer Tests

A4.1 Conformance Tests (One-Time Tests)

A4.1.1 Conformance testing of the complete unit should also be used to verify the integrity of the insulation system when tested in accordance with Section 8 of this standard.

A4.1.2 Additional conformance test requirements for insulation systems are shown in Section A3 of this appendix.

A4.2 Routine Tests (Continuing Production Tests). The routine tests on production line units required by this conformance standard are adequate for proving the continued acceptability of a proven insulation system that has previously met conformance requirements.

A5. Audit Procedure

After certification, the certifying agency should establish a monitoring frequency to audit production. Modifications should be reviewed by the certifying agency to determine whether retest is required.

American National Standards in the C57 Series

ANSI/IEEE C57.12.00-1980 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

ANSI/IEEE C57.12.01-1979 General Requirements for Dry-Type Distribution and Power Transformers

ANSI C57.12.10-1977 Requirements for Transformers 230 000 Volts and Below, 833/958 through 8333/10 417 kVA Single-Phase and 750/862 through 60 000/80 000/100 000 kVA Three-Phase, including Supplement ANSI C57.12.10a-1978

ANSI/IEEE C57.12.11-1980 Guide for Installation of Oil-Immersed Transformers, 10 MVA and Larger, and 69 kV to 287 kV Rating

ANSI/IEEE C57.12.12-1980 Guide for Installation of Oil-Immersed EHV Transformers 345 kV and Above

ANSI C57.12.13-1982 Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations

ANSI C57.12.20-1981 Requirements for Overhead-Type Distribution Transformers 67 000 Volts and Below; 500 kVA and Smaller

ANSI C57.12.21-1980 Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings: High-Voltage, 34 500 GrdY/19 920 Volts and Below; Low-Voltage, 240/120 Volts; 167 kVA and Smaller

ANSI C57.12.22-1980 Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings: High-Voltage, 34 500 GrdY/19 920 Volts and Below; 2500 kVA and Smaller

ANSI C57.12.23-1978 Requirements for Underground-Type Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors, 100 kVA and Smaller: High-Voltage, 24 940 GrdY/14 400 Volts and Below; Low-Voltage 240/120

ANSI C57.12.24-1981 Requirements for Underground-Type Three-Phase Distribution Transformers; 2500 kVA and Smaller; High-Voltage, 24 940 GrdY/14 400 Volts and Below; Low-Voltage, 480 Volts and Below

ANSI C57.12.25-1981 Requirements for Pad-Mounted Compartmental-Type Self-Cooled Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors: High-Voltage, 34 500, GrdY/19 920 Volts and Below: Low-Voltage, 240/120 Volts and Below; 167 kVA and Smaller

ANSI C57.12.26-1975 Requirements for Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors: High-Voltage, 24 940GrdY/14 400 Volts and Below; 2500 kVA and Smaller

ANSI C57.12.27-1982 Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations

ANSI C57.12.30-1977 Requirements for Load-Tap-Changing Transformers 230 000 Volts and Below, 3750/4687 through 60 000/80 000/100 000 kVA, Three Phase

ANSI C57.12.40-1982 Requirements for Secondary Network Transformers, Subway and Vault Types (Liquid Immersed)

ANSI C57.12.50-1981 Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA Single-Phase and 15 to 500 kVA Three-Phase, with High-Voltage 601-34 500 Volts, Low-Voltage 120-600 Volts

ANSI C57.12.51-1981 Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts

ANSI C57.12.52-1981 Requirements for Sealed Dry-Type Power Transformers 501 kVA and Larger, Three Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts

ANSI C57.12.70-1978 Terminal Markings and Connections for Distribution and Power Transformers

ANSI/IEEE C57.12.80-1978 Terminology for Power and Distribution Transformers

ANSI/IEEE C57.12.90-1980 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

ANSI/IEEE C57.12.91-1979 Test Code for Dry-Type Distribution and Power Transformers

ANSI/IEEE C57.13-1978 Requirements for Instrument Transformers

ANSI/IEEE C57.13.1-1980 Guide for Current Transformers

ANSI C57.15-1968 Requirements, Terminology, and Test Code for Step-Voltage and Induction-Voltage Regulators

ANSI C57.16-1958 (R1971) Requirements, Terminology, and Test Code for Current-Limiting Reactors

ANSI C57.17-1965 (R1978) Requirements for Arc Furnace Transformers

ANSI/IEEE C57.21-1981 Requirements, Terminology, and Test Code for Shunt Reactors Rated Over 500 kVA

ANSI/IEEE C57.91-1981 Guide for Loading Mineral-Oil-Immersed Overhead and Pad-Mounted Distribution Transformers Rated 500 kVA and Less with 55°C or 65°C Average Winding Rise

ANSI/IEEE C57.92-1981 Guide for Loading Mineral-Oil-Immersed Power Transformers Up to and Including 100 MVA with 55°C or 65°C Winding Rise

ANSI/IEEE C57.94-1981 Recommended Practices for Installation, Application, Operation, and Maintenance of Dry-Type General-Purpose Distribution and Power Transformers

ANSI/IEEE C57.100-1974 Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers

ANSI/IEEE C57.104-1978 Guide for the Detection and Determination of Generated Gases in Oil-Immersed Transformers and their Relation to the Serviceability of the Equipment

ANSI/IEEE C57.105-1978 Guide for Application of Transformer Connections in Three-Phase Distribution Systems

ANSI/IEEE C57.106-1977 Guide for Acceptance and Maintenance of Insulating Oil in Equipment

Appendixes to C57 Standards

(Not approved as American National Standards)

C57.95 Guide for Loading Oil-Immersed Step-Voltage and Induction-Voltage Regulators, Appendix to C57.15-1968

C57.96 Guide for Loading Dry-Type Distribution and Power Transformers, Appendix to C57.12 standards

C57.99 Guide for Loading Dry-Type and Oil-Immersed Current-Limiting Reactors, Appendix to C57.16-1958 (R1971)

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July 1982