IEEE Standards

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IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity

IEEE Power Engineering Society

Sponsored by the
Transformers Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

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IEEE Std C57.12.28™-2005

IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity

Sponsor

Transformers Committee
of the
IEEE Power Engineering Society

Approved 2 August 2005

American National Standards Institute

Approved 10 May 2005

IEEE-SA Standards Board

Abstract: Conformance tests and requirements for the integrity of above-grade pad-mounted enclosures that contain apparatus energized in excess of 600 V and that may be exposed to the public, including but not limited to the following types of equipment enclosures—pad-mounted capacitors or inductors, pad-mounted distribution transformers, pad-mounted junction enclosures, pad-mounted metering equipment, and pad-mounted switch gear—are covered.
Keywords: enclosure integrity, pad-mounted equipment, switches, transformers

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Introduction

This introduction is not part of IEEE Std C57.12.28-2005, IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity.

The Accredited Standards Committee on Transformers, Regulators, and Reactors, C57, has for a number of years been developing and correlating standards on these products. The data used in this work have been gathered from many sources, including the standards of the Institute of Electrical and Electronics Engineers and the National Electrical Manufacturers Association, reports of committees of the Edison Electric Institute, and others.

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This standard was originally prepared by the Joint C57/C37 Working Group on Enclosures, with Joseph Martin and then Robert C. Olen as chairman. This group is now the Enclosure Integrity Working Group of the IEEE Transformers Committee.

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IEEE Standard for Pad-Mounted Equipment—Enclosure Integrity

1. Overview

1.1 Scope

This standard covers conformance tests and requirements for the integrity of above-grade pad-mounted enclosures containing apparatus energized in excess of 600 V that may be exposed to the public, including but not limited to the following types of equipment enclosures:

a) Pad-mounted capacitors or inductors
b) Pad-mounted distribution transformers
c) Pad-mounted junction enclosures
d) Pad-mounted metering equipment
e) Pad-mounted switch gear

This standard does not cover installations that are under the exclusive control of electric utilities and that are located in such a manner that access to the equipment is controlled exclusively by the utility.

1.2 Purpose

The purpose of this standard is to describe the requirements for a comprehensive integrity system for pad-mounted enclosures providing long field life with minimum maintenance and positive safety features.

2. Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.[1]

ASTM D523, Standard Test Method for Specular Gloss.

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

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ASTM D660, Standard Test Method for Evaluating Degree of Checking of Exterior Paint.

ASTM D714, Standard Method of Evaluating Degree of Blistering of Paints.

ASTM D1654, Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.

ASTM D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).

ASTM D3170, Standard Test Method for Chipping Resistance of Coatings.

ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test.

ASTM D3363, Standard Test Method for Film Hardness by Pencil Test.

ASTM D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.

ASTM D4585, Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation.

ASTM D4587, Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings.

SAE J400, Test for Chip Resistance of Surface Coatings.[2]

3. Definitions

For the purposes of this document, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* [B9][3] should be referenced for terms not defined in this clause.

3.1. above grade: A term referring to an equipment use location above the high water line not intended for partial or total submersion.

3.2. axial force: A force applied along the axis of the pry bar from its handle to its pry tip.

3.3. carbon steel: A steel containing only residual quantities of elements other than carbon, except those added for deoxidation or to counter the deleterious effects of residual sulfur. Silicon is usually limited to about 0.60%, and manganese, to about 1.65% by weight. *Syn:* **ordinary steel, plain carbon steel, straight carbon steel.**

NOTE—See *The Metals Black Book: Ferrous Metals* [B18].[4]

3.4. conformance tests: Certain performance tests are 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 margins (capabilities) beyond the standard requirements is unnecessary.

[2]SAE publications are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, USA (http://www.sae.org/).

[3]The numbers in brackets correspond to those of the bibliography in Annex C.

[4]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

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

NOTE—Design tests, sometimes called *type 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 the modification 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.

3.6. dry film thickness: Thickness of any applied coating(s) measured after curing.

3.7. enclosure security: The completely assembled apparatus that will resist unauthorized entry when tested in accordance with the procedures of this standard, IEEE Std C57.12.28-2005.

3.8. padlock: A locking device specified by the user that will prevent the disengagement of the pentahead device (e.g., key or combination lock, one time or twist lock, single use lock, or similar device).

3.9. pad-mounted enclosure: An enclosure containing electrical apparatus, typically located outdoors at ground level where the general public has direct contact with the exterior surfaces of the equipment. The general construction of this equipment shall be such that authorized personnel may obtain access to the apparatus inside the equipment compartment(s).

3.10. prying leverage: A force at right angles to the handle times the distance from this force to the point of insertion of the pry tip into a joint, crevice, or similar opening in an enclosure.

3.11. 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.

NOTE 1—Certain quality assurance tests on identified critical parts of repetitive high-production devices may be tested on a planned statistical sampling basis.

NOTE 2—Routine tests are sometimes called *production tests.*

3.12. substrate: The material that provides structural integrity to the enclosure.

4. Enclosure security

4.1 Test requirements

In addition to passing the tests defined in this standard, the construction of pad-mounted enclosures shall comply with the requirements of 4.1.1 through 4.1.9.

4.1.1 Enclosure mounting

The bottom edge of the enclosure shall provide for flush mounting on a flat, rigid mounting surface.

4.1.2 Water resistance

The enclosure shall restrict the entry of water (other than flood water) into the enclosure so as not to impair the operation of the apparatus inside.

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4.1.3 Sharp corners

External sharp corners and projections shall be minimized.

4.1.4 Panel assembly

Panels shall be fastened or hinged to resist disassembly, breaking, or prying open from the outside with the doors in the closed and locked position. Normal entry shall be possible only with the use of proper access tools. There shall be no exposed screws, bolts, or other fastening devices that are externally removable (with the exception of pentahead bolts provided for extra security) that would provide access to energized parts in the enclosure.

4.1.5 Door hardware

Locking bolts and associated threaded receptacles, hinges, and hinge pins shall be AISI type 304 stainless steel or material of equivalent corrosion resistance.

4.1.6 Handhole covers

If handhole covers are exposed, they shall be secured from the inside of the enclosure.

4.1.7 Locking/latching devices

The latching device(s) shall be designed and constructed of such a material so as to resist breaking or bending. The provision for locking device(s) on the enclosure door(s) shall be designed and located as to comply with the defined tests.

4.1.8 Enclosure access

All access doors shall be fastened with a device that uses a pentahead tool to permit unlatching the door only after the padlock has been removed. This pentahead device or bolt shall be coordinated such that the padlock may not be inserted into the hasp until the access door is fully latched and the pentahead device is securely engaged.

Enclosures without latches shall have padlock and pentahead bolt provisions and shall be coordinated to prevent insertion of a padlock until the access door is fully closed and the pentahead device or bolt is securely engaged. The padlock shall be removed before the pentahead bolt can be disengaged.

A minimum of one pentahead device or bolt and padlocking means shall be provided. The pentahead device or bolt shall be surrounded by a nonrotating guard or shall be recessed such that the pentahead device or bolt can be engaged only by the proper tool. The dimensions of the pentahead bolt and nonrotating recess shall comply with Figure 1. The pentahead device or bolt shall not be readily removable until the padlock has been removed. More than one door may be fastened with a single padlock and pentahead device or bolt.

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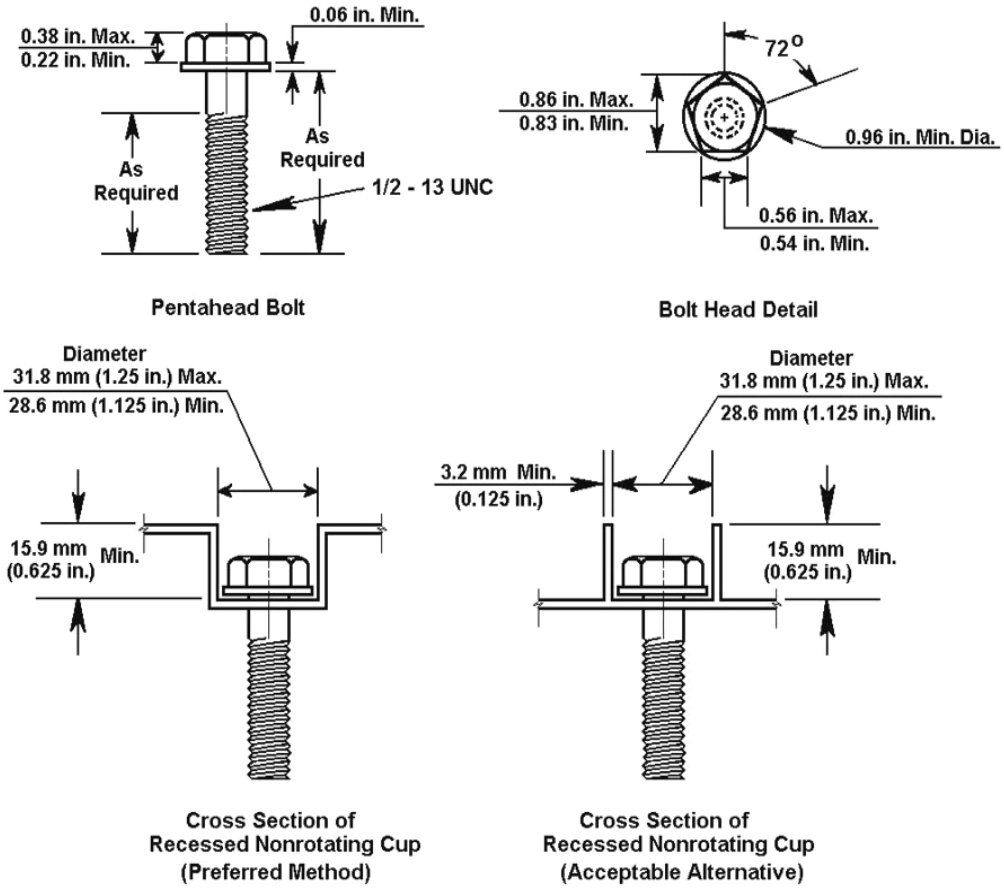


Figure 1—Captive and recessed pentahead bolts

NOTE—The captive method is not shown.

4.1.9 Fire resistance

The enclosure shall be constructed of fire-resistant material.

4.2 Test equipment

The tests for enclosure security shall be conducted with the following equipment or equivalent.

4.2.1 Pry bar

The pry bar shall be constructed with the pry tip shown in Figure 2. The pry bar shall be capable of accurately indicating the axial force and prying leverage specified in Table 1.

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Table 1—Test values

Test	Value
Inward axial force	222 N (50 lbf)
Prying leverage tests	102 N•m (900 lbf-in)
Pull test	667 N (150 lbf)
Deflection test	445 N (100 lbf)

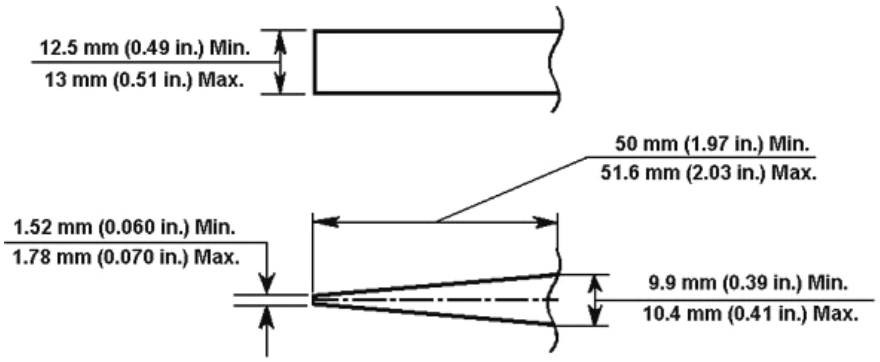


Figure 2—Pry bar tip

4.2.1.1 Tool

The axial force and prying leverage indication may be obtained from a variety of readily available or custom made tools. Annex B includes a complete set of detail drawings for one set of such tools. Other pry bar designs complying with 4.2.1 are acceptable.

4.2.1.2 Measurement

The prying leverage applied can be measured indirectly by measuring the deflection of the pry bar. The indicator is mounted on the pry bar and set to measure the 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 indicator.

4.2.2 Pull tool

The device shown in Figure 3 shall be used in the pull tests.

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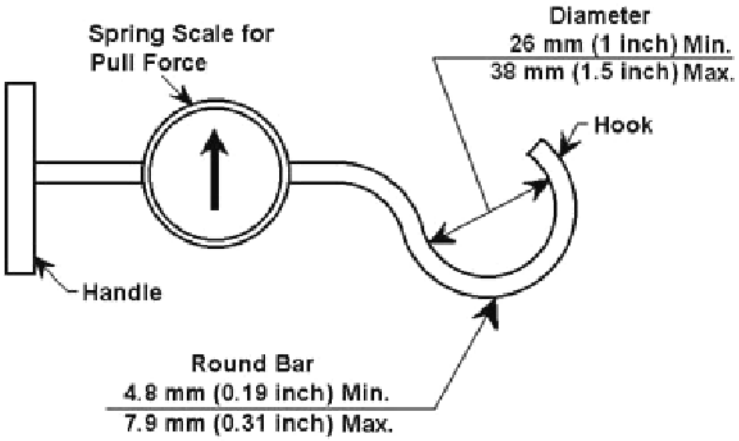


Figure 3—Pull hook

4.2.3 Push tool

A device that has a 12.7 mm × 12.7 mm (0.5 in × 0.5 in) square face as shown in Figure 4 with associated indicator to measure axial force shall be used to perform the deflection test.

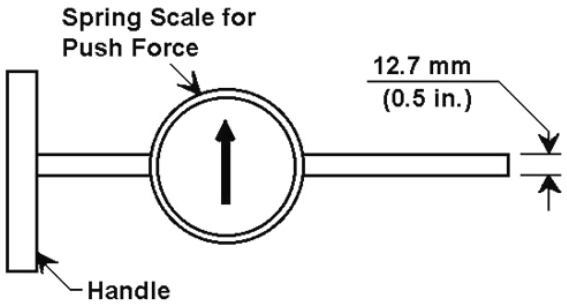


Figure 4—Pushing tool

4.2.4 Probe wire

The probing wire shall be bare number 14 AWG soft-drawn solid copper wire 3 m (10 ft) long.

4.3 Resistance to foreign objects

The following tests are to be performed on the enclosure. The enclosure shall resist the entry of foreign objects such as sticks, rods, or wires.

4.3.1 General

The pad-mounted enclosure shall be mounted on a flat surface according to the manufacturer's specification. With the access door(s) closed and locked using a padlock with an 8 mm (5/16 in) diameter shackle, the following sequence of tests shall be performed:

a) Pry tests
b) Wire probe tests
c) Pull tests
d) Repeat wire probe tests

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e) Deflection tests

f) Operation test

4.3.2 Pry tests

The pry bar shall be used on all joints, crevices, hinges, locking means, and other objects that exist between the enclosure components, including the enclosure/pad interface. The pry bar shall be permitted to 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 1. Then, with that axial force being maintained, the prying force specified in Table 1 applied alternatively first in one direction and then in the opposite direction (i.e., once in each direction). Application of either or both axial and prying force shall be maintained so long as relaxation is occurring. When relaxation ceases, or if no relaxation occurs, the pry bar shall be removed and pry test reapplied at the same location. When relaxation ceases or no relaxation occurs after the second test, the pry bar shall be removed and applied at an untested location.

4.3.3 Pull tests

A pulling force shall be applied to the critical points of all enclosure parts that can be engaged by the pulling hook. A pulling force indicated in Table 1 shall be exerted at any angle to the enclosure surface. This force is to be maintained during any relaxation. When relaxation ceases, or if no relaxation occurs, the pull test shall be terminated. The hook shall then be inserted into any other part in which it can engage, and the test shall be repeated at the new location. All parts that can be engaged by the pull hook shall be tested once.

4.3.4 Wire probe tests

Following the pry tests and pull tests described in 4.3.2 and 4.3.3, an attempt to penetrate the enclosure with the probe wire shall be made. This penetration shall be attempted at all crevices and joints. The wire shall be straight with no prebends and shall be gripped by the tester with his or her bare hands. If the wire enters the joint, the wire shall be continually pushed and bent until either it can no longer be pushed or it has entered the enclosure completely. This test is passed if an inspection determines the probing wire either has not entered the enclosure, or if visible, the probing wire is restricted by a barrier from intrusion into the interior.

4.3.5 Deflection tests

The deflection test shall be applied to all sides and walls of the enclosure. This test is passed if the specific force (see Table 1) applied perpendicularly to the surface of the enclosure does not impair the dielectric, mechanical, or corrosion performance of the equipment.

4.3.6 Operation test

Following all of the tests in 4.3.2 through 4.3.5, the enclosure shall be easily unlocked and opened and shall be easily closed and locked.

4.4 Test values

The minimum test values for which entry shall be prevented are provided in Table 1.

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5. Enclosure design and coating system requirements

5.1 Enclosure design requirements—Objective

The objective of this sublcause is to describe design and performance requirements for carbon steel pad-mounted enclosures not situated in coastal or other severe environments. Other performance requirements may be needed to provide long field life in other environments.

5.1.1 Accessibility

The enclosure shall be designed such that all exterior surfaces are accessible for proper surface preparation and the application of a uniform amount of the coating materials. Additionally, all exterior surfaces of the enclosure shall be accessible for the purposes of inspection and maintenance of the enclosure over the life of the equipment.

5.1.2 Contaminant accumulation

The enclosure shall be designed to shed water and minimize areas where corrosive elements can accumulate.

5.1.3 Welds—Surface preparation

All welds shall be treated to prepare the weld area and the heat affected zones for coating. Weld splatter shall be removed. All welds shall be made in accordance with appropriate industrial welding standards.

5.2 Substrate requirements

The substrate shall be a material that when coated or otherwise processed will maintain the structural integrity of the enclosure over the life of the apparatus.

5.3 Coating system requirements

5.3.1 General

All coated surfaces on the exterior or interior of the enclosure that may be exposed to the atmosphere shall be capable of meeting the performance tests required by this standard.

5.3.2 Specification of coating characteristics

If more than one coating system is used for different areas of the enclosure, the areas in which each is used shall be identified. The laboratory test performance data of each coating system shall be identified. The laboratory test performance data of each coating system shall be submitted for approval upon request. This data shall be resubmitted whenever there are changes in the method and/or materials.

5.3.3 Coating touch-up prior to shipment

Touch-up, when required, shall be done at final inspection before any equipment is shipped. In areas where the integrity of the coating system is violated, the touch-up shall blend smoothly and meet all performance criteria of this standard.

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5.3.4 Enclosure color

Unless otherwise specified, the topcoat color shall be Munsell Number 7GY 3.29/1.5 pad-mount green. The color variation of the coated product shall not exceed the Munsell Color Standard by more than a ΔE (Hunter) value of four. See *Munsell Color Standards* [B16].

5.4 Coating system test specimens

Test specimens shall consist of panels of the same material composition used in production. Test specimens shall be in accordance with Figure 5, Figure 6, Figure 7, and Figure 8 as to size and type. Quantity and type of panels in each test are identified under the specific test. All panels shall be cleaned, coated, and cured using the production coating system. Coated test panels shall be conditioned at room temperature and humidity for a minimum of 7 days prior to any testing.

5.5 Coating system performance requirements

5.5.1 Crosshatch adhesion test

One coated test panel, per Figure 6, shall be scribed to bare metal in accordance with ASTM D3359.[5] Method A shall be used for films thicker than 0.13 mm (5 mils or 0.005 in) and method B shall be used for films less than or equal to 0.13 mm (5 mils or 0.005 in). There shall be 100% adhesion to the substrate and between layers. A rating of 5A for method A and 5B for method B per ASTM D3359 is required.

5.5.2 Humidity test

Two coated panels, per Figure 5, shall be tested for 1000 h in accordance with ASTM D4585 except that the test shall be conducted at 45 °C ± 1 °C (113 °F ± 2 °F). Upon completion of the test, panels shall be evaluated for:

a) Blistering—There shall be no blistering observed on the surface of the panels when inspected within 15 min after removal from the cabinet.

b) Softening—After removal from the cabinet, allow the panels to air dry for 24 ± 1 h. There shall be no more than one pencil hardness change when tested per ASTM D3363.

Any color change shall be noted.

5.5.3 Impact test

One coated panel, prepared per Figure 6, shall be impacted at room temperature on a concrete floor using procedures described in ASTM D2794 at 9 N•m (80 in-lb force). The impacted test panels shall be exposed to 24 h of salt spray per ASTM B117. There shall be no red rust visible in the impact (intrusion) area of the panel.

5.5.4 Insulating fluid resistance tests (for liquid-filled equipment only)

Partially immerse one coated panel, per Figure 6, in the insulating liquid for 72 h at 100 °C to 105 °C (212 °F to 221 °F). On the immersed portion of the panel, there shall be no loss of adhesion per ASTM D3359, no blisters, no streaking, and no more than one pencil hardness change per ASTM D3363, using either method. Any color shift shall be noted.

[5]Information on references can be found in Clause 2.

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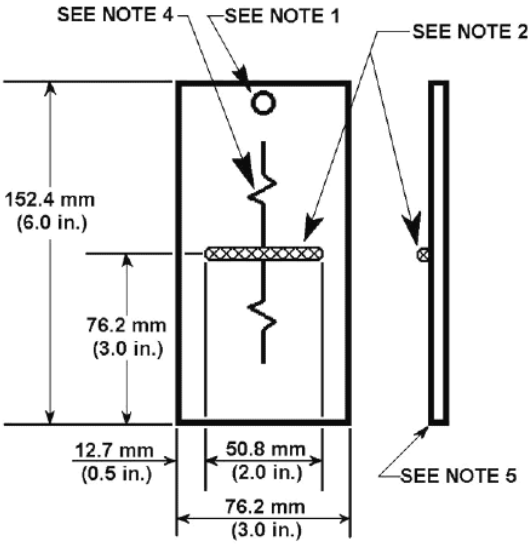


Figure 5—Corrosion coating test panel

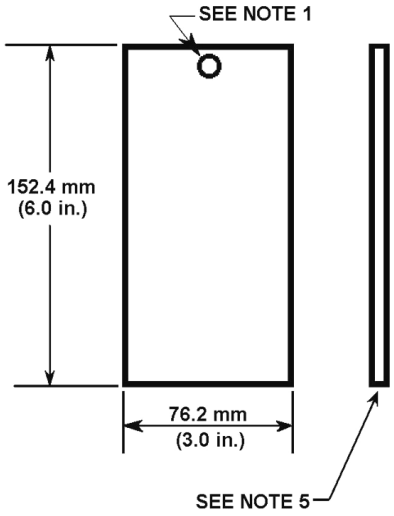


Figure 6—Plain coating test panel

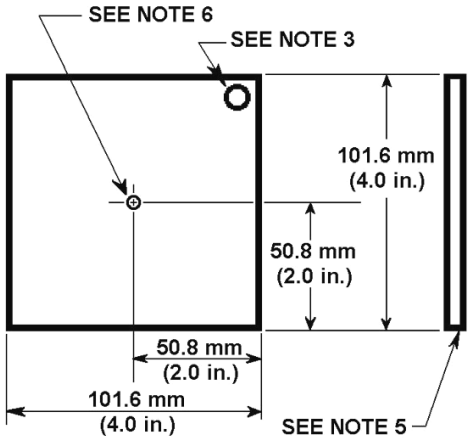


Figure 7—Taber Abraser coating test panel

NOTE 1—Hole can be placed in panel for hanging for coating operations if required. Locate centered on short dimension and 3.2 mm (1/8 in) to edge of hole on long dimension. Recommended maximum hole size 14.3 mm (9/16 in) in diameter.

NOTE 2—Weld bead to be the same type metal composition as the panel. Weld bead to be 6.4 mm (1/4 in) wide and 3.2 mm (1/8 in) high.

NOTE 3—Hole can be placed in panel for hanging. To be located in one corner. Recommended maximum hole size 14.3 mm (9/16 in) in diameter.

NOTE 4—Scribe per ASTM D1654 across weld approximately 100 mm (4 in) scribe length.

NOTE 5—Test panels shall be made from typical production stock of the same material type and thickness used in the construction of the device for which the specified test is intended

NOTE 6—6.4 mm (1/4 in) diameter hole may require reaming to fit Taber Abraser post.

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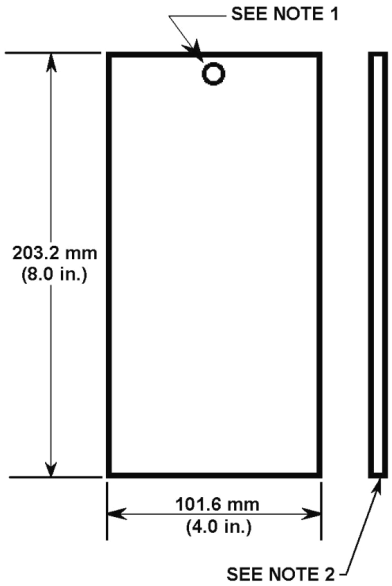


Figure 8—Gravelometer coating test panel

NOTE 1—Hole can be placed in panel for hanging for coating operations if required. Locate centered on short dimension and 3.2 mm (1/8 in) to edge of hole on long dimension. Recommended maximum hole size is 14.3 mm (9/16 in) in diameter.

NOTE 2—Panel thickness to be of typical production stock used in the manufacture of devices for which the test is intended.

5.5.5 Ultraviolet accelerated weathering test (QUV)

The following test is required for all coated surfaces on the exterior of the enclosure. Expose two test panels, per Figure 6, for 500 h per ASTM D4587, utilizing the FS-40 bulb with a cycle of 4 h ultraviolet at 60 °C (140 °F) followed by 4 h condensation at 50 °C (122 °F). Loss of gloss shall not exceed 50% of original gloss per ASTM D523. The coating shall not exhibit cracking or crazing under unaided visual inspection.

5.5.6 Simulated corrosive atmospheric breakdown (SCAB)

This test requirement shall apply to the coating systems applied to both the exterior and interior cabinet/front-plate surfaces of the pad-mounted enclosure. Three coated panels, per Figure 5, shall be prepared and tested in accordance with the procedure described in Annex A. The scribe shall be prepared for evaluation using ASTM D1654, procedure A, method 2. Upon completion of 15 cycles of SCAB, the scribe line shall be divided into 6.4 mm (0.25 in) zones and the worst spot in each zone will be evaluated by measuring the amount of creepage along the scribe line [except the first 6.4 mm (0.25 in)] of the scribe at each end of the scribe line). The average of the 14 readings shall be rated per ASTM D1654, Table 1. After a rating has been set for each of the three panels, the average rating of the three shall not be less than a 6 rating. The area away from the scribe shall have no blisters.

5.5.7 Abrasion resistance Taber Abraser

The following test is required only for coated surfaces on the exterior of the enclosure. One coated panel, per Figure 7, having the minimum dry film thickness of the total coating system shall be tested using a CS-10 wheel, 1000 g weight, in accordance with ASTM D4060. A total number of 3000 cycles shall be run with the wheels resurfaced before testing and after each 500 cycle run. The abraded panel shall be exposed to 24 h of salt spray per ASTM B117. There shall be no visible red rust.

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5.5.8 Gravelometer

The following test is required only for coated surfaces on the exterior of the enclosure. Two coated panels, per Figure 8, are to be tested per ASTM D3170 at room temperature using 414 kPa (60 psig) gauge air pressure. Expose the test panels for 24 h in salt spray per ASTM B117. Remove from salt spray, rinse and dry panels. Evaluate panels per SAE J400 for quantity and size of rusted chipped areas. Minimum rating shall be 4B per SAE J400.

6. Labels

6.1 Purpose

Labeling can be an important aspect of pad-mounted enclosure integrity. Labeling can alert or inform an individual of potential hazard. Pad-mounted enclosures should be designed to achieve a high degree of integrity. When labels are attached to pad-mounted enclosures, they should be located as near the hazard as practicable. Labels should be concise and simple to understand, and should accurately communicate the type and degree of hazard.

6.2 Application

The application of any labels, whether intended for interior or exterior use, shall be subject to an agreement between the purchaser and the manufacturer.

7. General

7.1 Shipment

The manufacturer shall provide a method of shipment that will allow the enclosure to be received by the purchaser such that it still meets the performance tests required by this standard.

7.2 Coating repair procedure

A coating system repair procedure shall be recommended by the manufacturer.

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Annex A

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SCAB procedure

1) The three panels prepared per 5.4 and evaluated per 5.5.6 are to be tested per ASTM D4587 for 504 h. Test equipment with FS-40 bulbs and the cycle set for 4 h ultraviolet at 60 °C ± 2 °C (140 °F ± 4 °F), followed by 4 h condensation at 50 °C ± 2 °C (122 °F ± 4 °F) is to be used. No evaluation is necessary after test as this is a conditioning step. The ultraviolet exposure part of this test method does not apply to interior cabinet/front-plate coating systems. SCAB Corrosion exposure testing of interior surface coating systems shall begin at step 2.

2) Scribe the panels in accordance with ASTM D1654 and as shown in Figure 5.

3) Place the test panel (scribed side facing up) in a plastic or wood rack with the scribe line in a vertical position. The rack shall hold the panels at a 15 degree (± 5 degree) angle from the vertical. Multiple panels in the test rack should not touch one another.

4) Expose the panels for the specified number of cycles. (One weekday equals one cycle).

   a) Mondays only

      1) 1 h in oven at 60 °C ± 2 °C (140 °F ± 4 °F)

      2) 15 min in freezer at –23 °C ± 2 °C (–10 °F ± 4 °F). Panel should be transferred into freezer within 1 min after removal from the oven.

      3) Remove the panels from the freezer and immerse in a 5% NaCl solution by weight for 15 min. The NaCl solution should be at room temperature. The panel transfer time from freezer to the NaCl immersion should be less than 1 min.

      4) Remove from NaCl bath and let hang in room temperature and humidity atmosphere for 1 h 15 min.

      5) Place panel in 60 °C ± 2 °C (140 °F ± 4 °F) and 85% ± 3% relative humidity cabinet for 21 h.

   b) Tuesday through Friday

      1) Test panels to be immersed in a 5% NaCl solution by weight for 15 min. The NaCl solution should be at room temperature.

      2) Allow the test panels to age at room temperature and humidity for 1 h 15 min.

      3) Place the test panels in 60 °C ± 2 °C (140 °F ± 4 °F) and 85% ± 3% relative humidity cabinet for 22 h 30 min.

   c) Saturdays and Sundays: Leave the test panel in the humidity cabinet at 60 °C ± 2 °C (140 °F ± 4 °F) and 85% relative humidity.

   d) Monday (last day): Remove the test panels from the humidity cabinet and evaluate per 5.5.6.

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Annex B

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Pry bar

B.1 General

The pry bar depicted in this annex (see Figure B.1) is just one design intended to meet the functional requirements of 4.2.1. Other pry bar designs complying with 4.2.1 are acceptable.

The pry bar consists of three parts: pry tip, torque wrench, and axial force plunger. The pry tip (see Figure B.2) is designed for installation on a half-inch drive of a torque wrench. The plunger is designed to be inserted into the handle of a torque wrench with a hollow handle that has an interior stop for the plunger to fit into and press against.[6]

The addition of a pry tip to the torque wrench increases the moment arm of the tool. Consequently, the tool must be recalibrated to account for the longer moment arm. Calibration is accomplished as follows:

a) Clamp approximately 1 in of the pry tip to a workbench or other rigid surface.
b) Select a point on the torque tool handle to apply force.
c) Measure the distance (in inches) from this point to the end of the pry tip.
d) Divide 900 in-lb by this distance to determine the force (inch pounds) to be applied during calibration.
e) Using a calibrated force measurement tool, apply the calculated force to the handle and record the torque indicated on the torque wrench dial.
f) This value becomes the target prying leverage force to be used during the pry test.

The plunger is a simple spring-force measurement tool made from machined steel parts (see Figure B.7). The plunger must be calibrated and marked to indicate when the desired force has been reached. The plunger fits into the hollow pipe handle of the torque wrench and must be installed into the torque wrench prior to calibration. Calibration is accomplished as follows:

1) Apply force to the plunger using a calibrated force measurement tool.
2) As force is applied, the plunger body moves into the torque wrench handle. When the desired force is obtained (50 lb) mark the plunger body at the torque wrench handle rim.
3) During the pry test, depress the plunger until the mark aligns with the wrench handle rim.

B.2 Drawings

All dimensions are in inches. All tolerances are ± 0.03 in unless otherwise stated.

Assembly instructions:

1) Insert plunger tip (Figure B.5) from threaded end of plunger sleeve (Figure B.6).
2) Insert plunger spring (Figure B.3) from threaded end of plunger sleeve.
3) Screw plunger handle (Figure B.4) into plunger sleeve.

[6]At the time of publication of this standard, the Snap-On® model TE100 torque wrench was the only known example of this technology. This information is given for the convenience of users of this standard and does not constitute an endorsement by the IEEE of this product. Equivalent technology may be used if it can be shown to lead to the same results.

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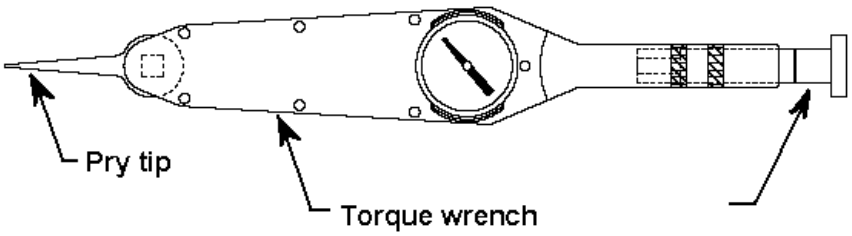


Figure B.1—Assembled pry bar

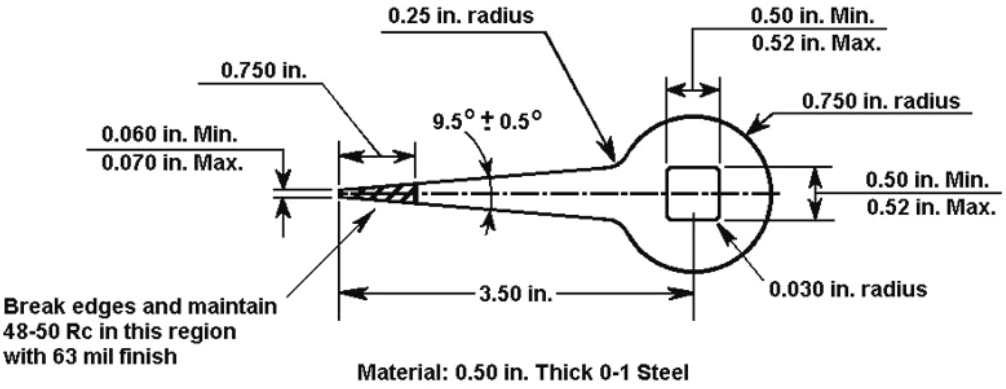


Figure B.2—Pry tip

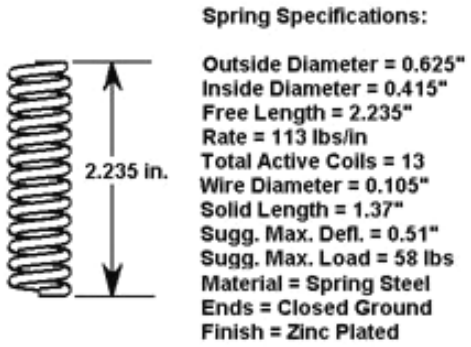
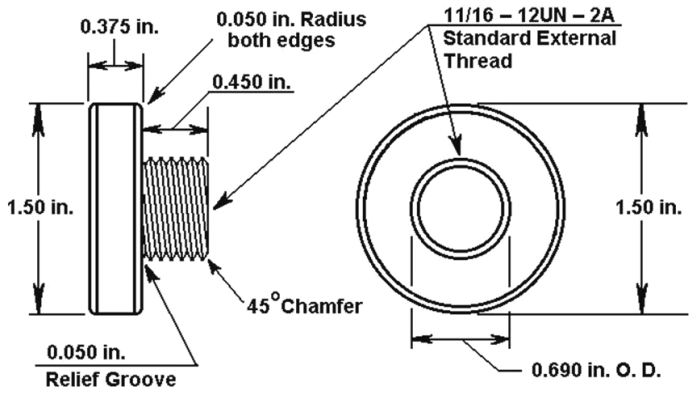


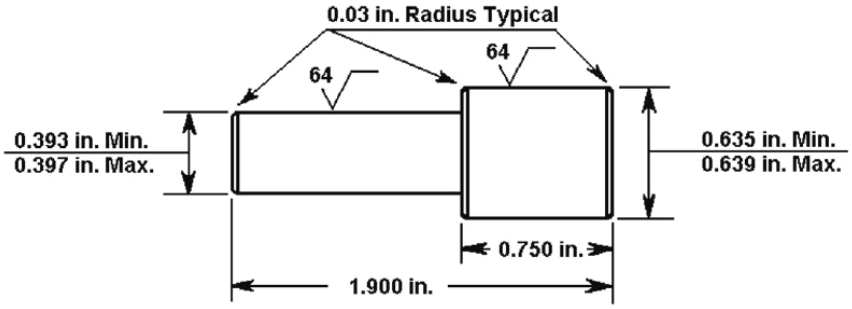
Figure B.3—Plunger spring

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Material: 1.50 in. Diameter AISI 304
Stainless steel Rod, Annealed
0.825 in. Long

Figure B.4—Plunger handle



Material: 11/16 in. Dia. AISI 304 Stainless Steel Rod
Annealed and Ground — 1.900 in. long

Figure B.5—Plunger tip

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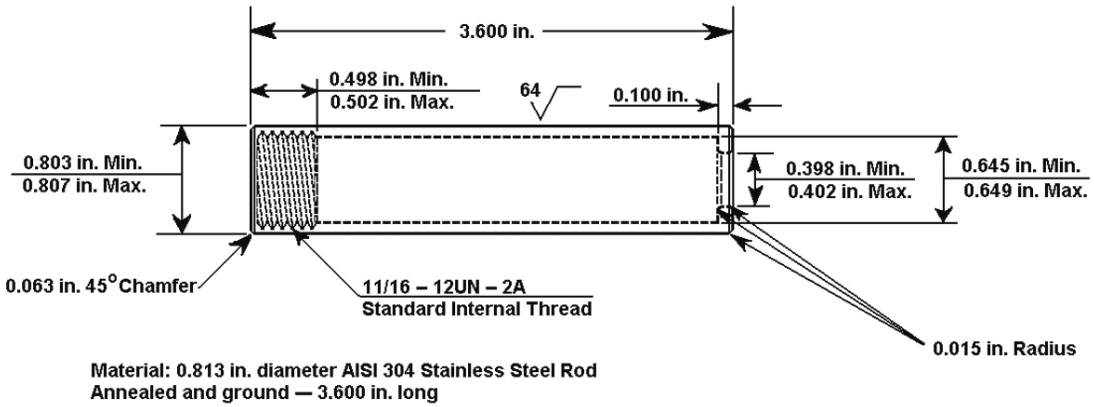


Figure B.6—Plunger sleeve

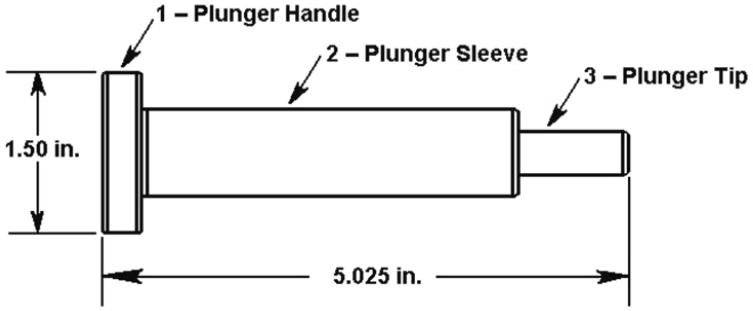


Figure B.7—Plunger assembly

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Annex C

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Bibliography

The following standards are listed here for information only and are not essential for the completion of the requirements of this standard. When the following standards are superseded by an approved revision, the revision shall apply.

[B1] ANSI C57.12.10-1997, Transformers—230 kV and below 833/958 through 8333/10 417 kVA, Single-Phase, and 750/862 through 60 000/80 000/100 000 kVA, Three-Phase without Load Tap Changing; and 3750/4687 through 60 000/80 000/100 000 kVA with Load Tap Changing—Safety Requirements.[7]

[B2] ANSI/IEEE C57.12.20™-1997, American National Standard for Overhead Distribution Transformers, 500 kV and Smaller; High Voltage, 34 500 V and Below; Low Voltage 7970/3 800 Y V and Below—Requirements.[8]

[B3] ANSI/IEEE C57.12.21™-1992, American National Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; High Voltage, 34500 GrdY/19 920 V and Below; Low Voltage, 240/120 V; 167 kVA and Smaller.

[B4] ANSI/IEEE C57.12.22™-1993, American National Standard for Transformers—Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA and Smaller: High Voltage, 34 500 GrdY/19 920 V and Below; Low Voltage, 480 V and Below—Requirements.

[B5] ANSI/IEEE C57.12.24™-2000, American National Standard for Transformers—Underground-Type, Three-Phase Distribution Transformers, 2500 kVA and Smaller; High Voltage, 34 5000 GrdY/19 920 V and Below; Low Voltage, 480 V and Below—Requirements.

[B6] ANSI/IEEE C57.12.25™-1990, American National Standard for Transformers—Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors; High Voltage, 34 500 GrdY/19 920 V and Below; Low Voltage, 240/120 V; 167 kVA and Smaller—Requirements.

[B7] ANSI/IEEE C57.12.28™-1999, American National Standard for Pad-Mounted Equipment—Enclosure Integrity.

[B8] ANSI/IEEE C57.12.29™-1991, American National Standard Pad-Mounted Equipment—Enclosure Integrity for Coastal Environments.

[B9] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition.

[B10] IEEE Std C57.12.23™-2002, IEEE Standard for Underground-Type, Self-Cooled, Single-Phase, Distribution Transformers with Separable Insulated High-Voltage Connectors; High Voltage 25 000 V and Below; Low Voltage 600 V and Below; 167 kVA and Smaller.[9]

[7]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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[B11] IEEE Std C57.12.26™-1992, IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors (34 500 GrdY/19 920 V and Below, 2500 kVA and Smaller).

[B12] IEEE Std C57.12.31™-2002, IEEE Standard for Pole-Mounted Equipment—Enclosure Integrity.

[B13] IEEE Std C57.12.32™-2002, IEEE Standard for Submersible Equipment—Enclosure Integrity.

[B14] IEEE Std C57.12.34™-2004, IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 2500 kVA and Smaller—High Voltage: 34 500 GrdY/ 19 920 V and Below; Low Voltage: 480 V and Below.

[B15] IEEE Std C57.12.35™-1996, IEEE Standard for Bar Coding for Distribution Transformers.

[B16] *Munsell Color Standards,* GretagMacbeth LLC, 617 Little Britain Road, New Windsor, NY.

[B17] Accredited Standards Committee C-2, National Electrical Safety Code® (NESC®).[10]

[B18] *The Metals Black Book: Ferrous Metals,* Third Edition, John E. Bringas and Michael L. Wayman. Edmonton, Alta., Canada: CASTI Publishing Inc., 1998.

[10]This publication is available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

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