

Subject 2515

June 8, 2018

SUMMARY OF TOPICS

The following changes in requirements to the Standard for Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings, UL 2515, are being proposed:

Publish an Updated New Edition which Includes References to the Mexican Electrical Installation Code, Reference Publications and ANCE References

STP BALLOTS AND ALL COMMENTS DUE: July 23, 2018

If you are interested in applying for STP 651 membership or are aware of potential candidates for this STP, please contact the STP Project Manager, Joshua.Johnson@ul.com.

For your convenience in review, proposed additions to existing requirements are shown underlined and proposed deletions are shown ~~lined-out~~.

Publish an Updated New Edition which Includes References to the Mexican Electrical Installation Code, Reference Publications and ANCE References

RATIONALE

Include References to the Mexican Electrical Installation Code, Reference Publications and ANCE References

Proposal submitted by: CANENA THC 23A MT12

(See 1.1, 1.6, 2.5, 3.1, 4.6, 5.10.1.1, 5.11.2.1, 5.11.4.1, 5.13.1, 5.14.4, 5.14.5, 5.14.11, 5.14.13, 5.16.1, 6.2, 6.4, 6.8)

In the current round of proposals to amend this standard, it is transitioning from binational to trinational status. To accommodate the adoption of this standard in all of North America, the addition of normative references to the appropriate Mexican standard is necessary.

Like the US, Mexico permits the use of conduit bodies as outlet boxes for the splicing of conductors.

Given the proposed replacement of the reference to CAN/CSGB 3.1 in 5.11.8 with a more generic specification for the propane, it should be deleted here.

Delete the Year for all Normative References

Proposal submitted by: CANENA THC 23A MT12

In accordance with current standards practice, references are to the latest edition.

Improve Readability

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Proposal submitted by: CANENA THC 23A MT12

This proposal is to improve readability of 5.6.2 as this can be misunderstood.

Update the FT4 Procedure in Wire and Cable Test Methods

Proposal submitted by: CANENA THC 23A MT12

Since last edition of the standard, UL, CSA and ANCE updated the FT4 procedure in trinalational wire and cable test methods standard UL 2556/CSA C22.2 No. 2556/NMX-J-498-ANCE, to specify generically the propane gas used in the test.

Given the proposed replacement of the reference to CAN/CSGB 3.1 in 5.11.8 with a more generic specification for the propane, it should be deleted here.

Removal of Carbon Arc Testing

Proposal submitted by: CANENA THC 23A MT12

(See 5.14.1, 5.14.4, 5.14.5, 5.14.6, 5.14.7, 5.14.12, 5.14.13, 5.14.14)

Due to environmental and laboratory personnel safety concerns, UL and CSA no longer conduct carbon arc testing

Support for Type RTRC

Proposal submitted by: T. Guida, TJG Services Inc.

(See Section 5.22, 6.1, 6.9, Table 21, Table 22, Table 23)

The National Electrical Code (NEC) in 355.30 (B) states that Type RTRC shall be supported as required in Table 355.30. It also states that this conduit may be listed for support at spacing other than as shown in Table 355.30.

We are proposing an addition to UL 2515, complete with a new test method that produces repeatable results. Testing done on PVC conduit indicate that this new test would be appropriate for any conduit material. The proposed test is optional and is intended only for RTRC to be marked for extended support distances. The term “extended” refers to support distances beyond those listed in NEC Table 355.30, so there is no need to re-test any products already meeting UL 2515 criteria. The deflection requirement is independent of trade size. The point of the test is to determine if any given conduit trade size is suitable for use at a support distance greater than NEC Table 355.30 values, as permitted by the NEC.

The 2008 NEC separated RTRC and PVC into two Articles. Previously, there was a single Article with no definition of the conduit material other than “nonmetallic” and a single support distance table and a statement about extended support distances. This only continued the assumption that PVC and RTRC possess similar properties. They do not.

PVC conduit has significant thermal property deficiencies when compared to steel, aluminum and RTRC materials. Flexural modulus values will fall as conduit temperatures rise with resulting increased deflection. This is acute for PVC whereas aluminum, steel, and RTRC are in a separate, less affected

group. This is supported by the fact that the "Deflection Under Heat and Load" tests in UL 2515 and UL 651, which are used to evaluate the suitability of RTRC and PVC for elevated temperature performance, are identical except the test temperature in UL 2515 is 40°C (104°F) higher.

Inside diameters are different for all PVC Schedule 40 and RTRC trade sizes. Consequently, 40 percent wire fill values are also different. For example, a 1-1/2 RTRC conduit with 1.740 inch inside diameter has 16 percent greater wire fill than the same size 1-1/2 PVC conduit with 1.610 inch inside diameter. A new 40 percent RTRC wire fill load table was calculated using RTRC inside diameters. The maximum quantity and weight of THHN cables meeting 40 percent wire fill criteria was then determined for each RTRC trade size.

NEC Article 300.18 requires raceways to be completely installed prior to the installation of conductors. Conductors are then pulled into the conduit system. At that point all conductors are fully supported and are not exposed to abnormal stresses regardless of initial conduit deflection due to the weight of the installed conductors (wire fill). Connections will see no additional stress. Any additional stress on conductors, conductor connections and joints will come from thermal and other factors. From a wiring system standpoint, RTRC thermal properties are similar to aluminum and much better than PVC. The proposed test evaluates RTRC support distances at 15.9 mm (5/8 inch) deflection using fixed ends and an equivalent cable load. It should be noted that in addition to initial deflections due to wire fill, historically acceptable thermal deflections in excess of 100 mm (4 inches) can occur at support distances up to 6.1 m (20 feet).

Couplings can also be used in the proposed test method, which goes one step further by specifying connection location at 1/4 of the support distance. Installation instructions are supplied with couplings.

For test purposes, the long accepted setup using 5 support distances is often cited to evaluate conduit deflections, but that would necessitate an extraordinary test area up to 46 m (150 feet) long. In order to create a more practical test, the center span condition in a 5-span support distance setup is approximated to a fixed-ends beam scenario. After many witnessed tests using multiple test fixtures, results were consistent and repeatable. Test results consistently reach maximum deflection in 72-96 hours (3-4 days). The specified 168 hours (7 days) test duration is approximately double the time needed to ensure deflection stability.

PROPOSAL

1 Scope

1.1 This Standard specifies the requirements for low-halogen aboveground (Type AG) reinforced thermosetting resin conduit (RTRC) and fittings for installation and use in accordance with CSA C22.1, Canadian Electrical Code (CEC), Part I, and NFPA 70, National Electrical Code (NEC) and NOM-001-SEDE, Standard for Electrical Installations (Mexico), in non-hazardous locations.

1.2 The products specified in this Standard are intended for use at -40°C (-40°F) to 110 °C (230°F). The products are for use above ground in exposed and concealed locations. The products are also suitable for use below ground by direct burial or by encasement in concrete.

1.3 Type AG conduit has not been evaluated for directional boring applications.

1.4 This Standard covers ID (dimensions based on inside diameters) and IPS (dimensions based on outside diameters of iron pipe sizes) conduit and fittings. Trade sizes (metric designators) are 1/2 (16) to 6 (155).

Note: The values in parenthesis are metric size designations of conduits and fittings and do not necessarily reflect metric trade sizes.

1.5 ID and IPS conduit are designated as SW (Standard Wall) or HW (Heavy Wall), which refer to specific wall thicknesses.

1.6 Fittings specified in this Standard include, but are not limited to, straight couplings, 5° angle couplings, adapters, and elbows with plain ends or integral belled ends at one or both ends, expansion joints, and conduit bodies.

Note: In Canada, conduit bodies are not evaluated as outlet boxes – they are fittings. Requirements in this standard for conduit bodies intended for use as outlet boxes do not apply in Canada. In Mexico and the United States, a conduit body may be used as an outlet box for the splicing of conductors.

1.7 For products intended for use in Canada, general requirements are given in CSA-C22.2 No. 0.

2 Definitions

2.1 The following definitions apply in this Standard:

2.2 Conduit body – ~~a conduit body~~ is a separate portion of a conduit system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system.

2.3 Integral belled end – a belled end installed at the factory, either integrally wound or a permanently attached coupling.

2.4 Low-halogen – a material having not more than 0.2% by weight of total halogen content.

2.5 Type AG – conduit and associated fittings that have been evaluated for use in exposed or concealed locations and/or for direct burial with or without being encased in concrete.

Note: For other definitions, refer to the CE Code, Part 1, the NEC and/or GEG NOM-001-SEDE.

3.1 Reference publications

3.1.1 Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified. This Standard refers to the following publications; where such reference is made to CSA or UL Standards, it shall be considered to refer to the latest edition and all amendments published thereto; and where such reference is made to other publications, it shall be to the edition listed below:

Product Standardization and Certification Center (CNCP)

NMX-E-186-CNCP

Plastic industry – Conduit and fittings – IZOD impact resistance of rigid materials – Test method

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SCFI Standard****NMX-E-003-SCFI**

Plastic industry – Determination of thickness of plastic films and sheets by mechanical scanning – Test method

NMX-J-70-SCFI

Plastic industry – Pipes and fittings – Deflection temperature under load – Test method

SEDE* Standard****NOM-001-SEDE**

Standard for Electrical Installations

† American National Standards Institute/National Fire Protection Association.

‡ American Society for Testing and Materials.

§ Canadian General Standards Board.

* National Electrical Manufacturers Association.

** *Secretary of Commerce and Industrial Development (Mexico)*

*** *Secretary of Energy (Mexico)*

ANCE Standards**NMX-J-451-ANCE**

Wires and cables - Thermoset insulated wires and cables – Specifications

NMX-J-511-ANCE

Cable tray - Metallic cable tray - Specifications and test methods

NMX-J-192-ANCE

Wires and cables - Flame test on electrical cables - Test methods

NMX-J-553-ANCE

Wires and Cables – Weather Resistance of Insulation or Jacket of Electrical Conductors – Test Method

CSA Group Standards**C22.1-09**

Canadian Electrical Code (CE_Code), Part I

CSA C22.2 No. 0

General Requirements - Canadian Electrical Code, Part 1

C22.2 No. 38-05

Thermoset Insulated Wires and Cables

GAN/CSA-C22.2 No. 126.1-02 (R2007)

Metal Cable Tray Systems

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UL Standard

UL 44

*Thermoset-Insulated Wires and Cables***ANSI/NFPA† Standard**

NFPA 70-2008

*National Electrical Code (NEC)***ASTM‡ Standards**

D 256-06a

Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D 638-08

Standard Test Method for Tensile Properties of Plastics

D 648-07

Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position

D 5025-05

Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials

D 5207-03

Standard Practice for Calibration of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials

G 151-06

Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G 153-04

Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

G 155-05a

*Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials***CAN/CGSB§ Standard**

3.14-2006

*Liquefied Petroleum Gas (Propane) for Fuel Purposes***National Research Council Canada Publication***National Building Code of Canada, 2005***NEMA* Standard**

VE-1 2002

Metal Cable Tray Systems

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3.2 Units of measurement

3.2.1 The values given in SI (metric) units ~~are mandatory~~ normative. Any other values given shall be ~~are~~ for information only.

4 Construction

4.1 General

4.1.1 Conduit shall be fiber impregnated with a cured thermosetting resin compound. The conduit shall have a uniform wall, a smooth interior, and shall not contain any features that can damage wiring installed in the conduit.

4.1.2 Conduit shall be straight, and both ends of each length of conduit shall be perpendicular to the longitudinal axis of the conduit.

4.1.3 Integral and non-integral connections shall provide a mechanically secure and watertight joint.

4.2 Conduit with an integral belled end

4.2.1 The dimensions of conduit with an integral coupling on one end shall be in accordance with Tables 1 to 4. They shall also meet the requirements of ~~Clauses~~ 5.7 and 5.8.

4.3 Couplings

4.3.1 Couplings shall be straight with belled ends, or 5° angle couplings. Dimensions of couplings shall be in accordance with Tables 5 to 8. Couplings shall also meet the requirements of ~~Clauses~~ 5.7 and 5.8.

4.4 Elbows

4.4.1 Elbows shall be provided with plain ends or have an integral belled end at one or both ends. Elbows shall also meet the requirements of ~~Clause~~ 5.7.

4.4.2 The radius and dimension of an elbow shall be as shown in Table 9 and Figure 1.

4.4.3 The straight-end portions (see dimension L_s on Figure 1) of an elbow shall be at least 13 mm (1/2 in) longer than the maximum socket depth.

4.5 Adapters

4.5.1 Threaded adapters and threaded box connectors

4.5.1.1 Adapters for joining conduit to other threaded systems shall be as specified in Table 10.

4.5.2 Other adapters

4.5.2.1 Other adapters shall meet the watertightness test specified in Clause 5.7 and the joint separation requirements specified in Clause 5.8.

4.5.3 Bore of conduit and elbows

4.5.3.1 The internal diameter of a finished elbow shall be such that a round ball or an equivalent mandrel will pass freely through the bore of the conduit and elbow. The diameter of the ball or equivalent mandrel shall be 90% of the original internal diameter for conduit and 85% of the original internal diameter for elbows.

Note: As an alternative to using a ball to check the bore of conduit and elbows, an inside micrometer gauge or a telescopic gauge and micrometer caliper may be used.

4.6 Conduit bodies

Note: In Canada, conduit bodies are not evaluated as outlet boxes – they are fittings. Requirements in this Standard for conduit bodies intended for use as outlet boxes do not apply in Canada. In Mexico and the United States, a conduit body may be used as an outlet box for the splicing of conductors.

4.6.1 General

4.6.1.1 Conduit bodies shall be of thermosetting resin material that provides flame and mechanical properties consistent with the conduit system.

4.6.1.2 A conduit body shall have a cross-sectional area not less than that specified in Table 11, based on the largest size raceway that is intended to be connected to it.

4.6.1.3 A conduit body having provision for the connection of conduit larger than the 1/2 (16) trade size:

- a) shall have a removable blank cover; and
- b) shall comply with Clauses 4.6.2.1 and 4.6.2.3.

4.6.1.4 The requirement in Clause 4.6.1.3 does not apply to a conduit body:

- a) marked for use only with No. 6 AWG (13.30 mm²) or smaller conductors;
- b) having an internal length (measured as shown in Figure 2) that is equal to or greater than the dimensions specified in Table 12.

4.6.1.5 A conduit body having a raceway entry in the wall opposite the removable cover specified in Clause 4.6.1.3 (a) shall have a distance from the cover to the opposite wall not less than that specified in Table 13.

4.6.1.6 With reference to Clause 4.6.1.5, the distance shall be measured from points located at each of the raceway entries where the axis of the raceway passes through the plane of the end stop of the conduit hub to the inside surface of the cover. See Figure 2.

4.6.1.7 A conduit body shall also comply with Clauses 6.6 and 6.7.

4.6.2 Capacity

4.6.2.1 A conduit body that does not change the direction of wiring passing through it shall have a length not less than eight times the trade size of the connected largest conduit. The length shall be measured inside the conduit body from the end stop of the conduit hub, away from the center of the body, to an equivalent point on the conduit hub on the opposite wall, or for a conduit body having a single raceway entry, to the opposite wall. See Figure 2.

Note: Measurements expressed as multiples of trade sizes are to may be determined by converting the trade size of the raceway (not the metric designator) to a value expressed in millimeters. Example: $1/2$ trade size $\times 8 = 4 = 4$ inches = 101.6 mm.

4.6.2.2 A conduit body that is shorter than the requirement specified in Clause 4.6.1.5 complies when it is investigated for installation of a combination of conductors that are less than the specified maximum fill for the largest conduit size that the conduit body will accommodate. See Clause 6.7.

4.6.2.3 A conduit body constructed to enable a change in the direction of the axis of a conduit system (see Figure 2) shall have a distance inside the body between each conduit entry and the entry hub on the opposite wall of the body intended to enclose a common conductor not less than that specified in (a) or between each conduit entry and the opposite wall not less than the sum of (a) and (b) (see note to Clause 4.6.2.1):

- a) six times the trade size of the largest conduit for which the body is intended; and
- b) the sum of the diameters of all other conduit entries in the same wall of the body.

4.6.2.4 A conduit body having smaller dimensions than those specified in Clause 4.6.2.3 shall be investigated for installation of a combination of conductors, including 4 AWG (21.2 mm²) or larger, that is less than the specified maximum fill for the largest conduit size that the conduit body is intended to accommodate. See Clause 6.7.

4.6.3 Covers

4.6.3.1 Conduit bodies shall be furnished with a blank cover. Threaded inserts may be molded into or assembled on the body.

4.6.3.2 Mating surfaces of a cover and body shall provide a close fit. A gasket, where required to provide a tight fit, shall be provided with the cover. The gasket shall not be required to be cemented or otherwise secured in place on the cover.

4.6.3.3 A cover shall be attached to the body by No. 6 or larger machine screws not having more than 32 threads per 25.4 mm (1 in). The screws shall thread into metal having at least two full threads.

5 Qualification tests

5.1 Conditioning

5.1.1 Unless specified otherwise in the description of the test, all specimens shall be preconditioned for at least 24 h in still air at a temperature of $23 \pm 2^{\circ}\text{C}$ ($73 \pm 4^{\circ}\text{F}$).

5.2 Compression

5.2.1 General

5.2.1.1 The internal diameter of conduit shall not decrease by more than 25% during application of the force specified in Tables 14 and 15 when tested in accordance with Clauses 5.2.2 to 5.2.4. The conduit shall show no evidence of cracking or buckling after removal from the compression machine.

5.2.2 Apparatus

5.2.2.1 The apparatus for this test shall consist of:

- a) an inside micrometer or telescopic gauges and a micrometer caliper; and
- b) a compression machine having 2 steel platens at least 150 mm (6.0 in) long and 10 mm (0.4 in) thick, and capable of running at a speed within the range of 10 to 15 mm/min (0.4 to 0.6 in/min).

5.2.3 Specimens

5.2.3.1 The specimens shall consist of three 150 ± 3 mm (6.0 ± 0.125 in) lengths of conduit.

5.2.4 Procedure

5.2.4.1 The inside diameter of the specimen shall be measured and recorded. The specimen shall be placed between the plates of the compression machine such that the measured inside diameter is perpendicular to the platens. The machine shall be set in motion until the force specified in Tables 14 and 15 has been applied to the specimen. The machine shall be stopped and the inside diameter re-measured. The percent decrease in the internal diameter shall be calculated and recorded.

5.3 Beam strength

5.3.1 General

5.3.1.1 The ultimate beam strength of conduit shall not be less than that specified in Table 16 when tested in accordance with ~~Clauses~~ 5.3.2 and 5.3.3.

5.3.2 Apparatus

5.3.2.1 The apparatus for this test shall consist of

- a) two rigidly supported V-blocks carefully aligned on a free span (see Figure 3). The angle of the "V" shall be $120 \pm 3^\circ$;
- b) a suitable testing machine having a speed of 10 to 15 mm/min (0.4 to 0.6 in/min); and
- c) a flexible strap having a width of 50 ± 3 mm (2.0 ± 0.125 in).

5.3.3 Procedure

5.3.3.1 The flexible strap shall be placed around the conduit specimen at the center of the span and attached to the testing machine.

5.3.3.2 The testing machine shall be set in motion. The conduit shall not buckle.

5.4 Impact resistance at low temperature

5.4.1 When tested in accordance with ~~Clauses~~ 5.4.2 to 5.4.4, there shall not be any fracture or break in the laminate surface of seven out of ten 200 mm (8.0 in) long specimens of the finished conduit. A fracture or break shall be considered to have occurred where a broken section of the laminate forms a protrusion within the inside diameter or extends beyond the outside diameter of the conduit. The portions of the conduit within 50 mm (2.0 in) from the cut ends of the specimen shall not be examined.

5.4.2 The specimens shall be cut from finished lengths of each trade size of conduit. The specimens, the test apparatus, and the surrounding air shall be in thermal equilibrium with one another at a temperature of $-40 \pm 1^{\circ}\text{C}$ ($-40 \pm 1^{\circ}\text{F}$) during the test. Each specimen shall be tested separately while resting on a solid, flat steel plate that is at least 13 mm (1/2 in) thick and shall be firmly anchored with its upper surface horizontal.

5.4.3 When it is necessary to remove the specimen from the low-temperature chamber due to handling difficulties, the impact test shall commence as soon as possible and shall be completed within 15 s of the time of removal.

5.4.4 The impact energy shall be provided by a weight of 9 kg (20 lbs) in the form of a 51 mm (2.0 in) solid, right-circular, steel cylinder with a flat impact face having rounded edges, as shown in Figure 4, falling freely through a vertical guide with the impact force as specified in Tables 17 and 18. The flat face of the weight shall strike the center of the specimen. Provision shall be made for keeping the weight from striking the specimen more than once.

5.5 Water absorption

5.5.1 Conduit shall not absorb water more than 0.25 percent of its weight while immersed for 24 h in distilled water when tested in accordance with ~~Clauses~~ 5.5.2 to 5.5.4.

5.5.2 The cut edges of a specimen shall be sealed with epoxy cement. The cement shall cure at room temperature for 24 h. Specimens shall be preconditioned by drying in a full-draft circulating-air oven at a temperature of $50 \pm 3^{\circ}\text{C}$ ($122 \pm 5^{\circ}\text{F}$) for 24 h, after which they shall remain in still air at a temperature of $23 \pm 2^{\circ}\text{C}$ ($73 \pm 4^{\circ}\text{F}$) for 24 h.

5.5.3 Following conditioning, the weight of the specimen, W_1 , shall be determined to within 5 mg of balance, and the specimen shall then be immersed in distilled water for 24 h at a temperature of $23 \pm 2^{\circ}\text{C}$ ($73 \pm 4^{\circ}\text{F}$). The specimen shall then be removed from the water, dried quickly inside and out with a clean piece of lint-free, absorbent material, and its weight, W_2 , shall immediately be determined within 5 mg of balance. W_2/W_1 shall not be larger than 1.0025.

5.5.4 When a specimen is known to contain or is suspected of containing an appreciable amount of water-soluble material, two specimens shall be preconditioned by drying in a full-draft circulating-air oven at a temperature of $50 \pm 1^{\circ}\text{C}$ ($122 \pm 2^{\circ}\text{F}$) for 24 h and cooling in a desiccator for 24 h; then their weight, W_1 , shall be immediately determined. The specimens shall then be immersed in distilled water for 24 h with the water at a temperature of $23 \pm 2^{\circ}\text{C}$ ($73 \pm 4^{\circ}\text{F}$). Immediately following this immersion, the specimens shall be reconditioned for 24 h in the oven at $50 \pm 3^{\circ}\text{C}$ ($122 \pm 5^{\circ}\text{F}$), cooled in a desiccator for 24 h, and their weight, W_2 , immediately determined.

5.6 Chemical resistance (optional)

5.6.1 Conduit and any adhesive system used to bond lengths of conduit shall be subjected to the tests described in ~~Clauses~~ 5.6.2 to 5.6.10 if marked in accordance with ~~Clause~~ 6.5. The results of the test on any trade size of conduit shall be considered representative of the performance of the whole size range.

5.6.2 After being exposed to the reagents indicated by the manufacturer at the intended concentration and temperature for 90 days, the crush strength of specimens of the finished conduit shall not be reduced by more than 15 percent, nor shall the specimens experience a change in weight of more than 2.5 percent. Where there is more than 1.0 percent change in weight after 90 days of exposure to the reagent, that change shall not be more than 1.65 times the change in weight measured after 30 days of exposure to the reagent. There shall not be any softening or disintegration of the specimens as a result of exposure to the reagents.

Note: ~~Usually, a A~~ reagent is commonly understood to be a substance used to produce a characteristic reaction in chemical analysis. For the purpose of this Standard, however, ~~it is convenient to consider the word term "reagent" is referred to in the less restrictive sense of as~~ any chemical, oil, or other substance that has a corrosive or degrading influence on conduit or conduit products.

5.6.3 Twelve 50 mm (2 in) long specimens shall be used for each reagent. Each specimen shall be cut from clean lengths of the finished conduit and cleaned of loose particles and ragged edges. The edges of all specimens shall be coated with the same resin used to fabricate the conduit. The weight of each specimen, W_1 , shall be determined prior to immersing the specimen in the test solution. Six additional specimens shall be prepared and set aside for comparison purposes during the crush test.

5.6.4 The weighed specimens shall each be immersed in the reagents in separate, covered containers that do not react with the reagent. Each container shall be filled with the reagent at the intended concentration and temperature to the depth necessary to completely cover the specimens that are placed in it. When the liquid comes to rest in each container, the containers shall be closed and kept at the intended temperature for 30 days without agitation of the reagent.

5.6.5 After 30 days, half of the specimens shall be removed from the reagent, rinsed with clean cold water, and carefully wiped dry inside and out with a clean piece of lint-free, absorbent material. The weight of each of the six dried specimens, W_2 , shall be determined to within 10 mg of balance and compared to the original weight, W_1 , of the specimen. W_2 shall not be greater than 1.025 times W_1 .

5.6.6 The six specimens immersed for 30 days and the specimens set aside for testing unaged shall be in thermal equilibrium with one another, the testing machine, and the surrounding air at a temperature of $23 \pm 2^\circ\text{C}$ ($73 \pm 3^\circ\text{F}$) throughout the test. The inside diameter of each specimen shall be measured and recorded. The specimens shall then be tested separately between a pair of rigid, flat steel plates that are at least 150 mm (6 in) long and that are horizontal and parallel to one another. The measured inside diameter shall be perpendicular to the platens. One plate shall be moved toward the other at the rate of $12.7 \pm 3.2 \text{ mm/min}$ ($0.5 \pm 0.125 \text{ in/min}$):

- a) until the surface of the specimen pulls away from contact with either plate, that is, until the specimen buckles; or
- b) until the minor axis measured inside the flattening specimen is 60 percent of the inside diameter measured before the test.

5.6.7 The crushing loads at the buckling and 60 percent points shall be noted on the dial on the machine and recorded for each specimen. The loads at each of these points for the aged specimens shall each be divided by the average loads at each of these points for the unaged specimens. The resulting ratios shall not be less than 0.85, and no conditioned specimen shall crack or collapse before buckling or the 60 percent point is reached.

5.6.8 The six remaining specimens shall remain immersed for an additional 60 days at the intended temperature. After the full 90 days, the specimens shall be removed from the reagent, rinsed, and dried as specified in Clause 5.6.6 before being re-weighed. The weight of each of the dried specimens, W_3 , shall be determined to within 10 mg of balance. The following requirements apply:

- a) W_3 shall not be greater than 1.025 times W_1 .
- b) If W_3 is greater than 1.01 times W_1 , the ratio of $(W_3 - W_1)$ to $(W_2 - W_1)$ shall not be greater than 1.65.

5.6.9 The specimens immersed for 90 days shall be in thermal equilibrium with the testing machine and the surrounding air at a temperature of $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$). The inside diameter of each specimen shall be measured and recorded. The specimens shall be tested separately between a pair of rigid, flat steel plates that are at least 150 mm (6 in) long and that are horizontal and parallel to one another. The measured inside diameter shall be perpendicular to the platens. One plate shall be moved toward the other at the rate of 12.7 ± 3.2 mm/min (0.5 ± 0.125 in/min):

- a) until the surface of the specimen pulls away from contact with either plate, that is, until the specimen buckles; or
- b) until the minor axis measured inside the flattening specimen is 60 percent of the inside diameter measured before the test.

5.6.10 The crushing loads at the buckling and the 60 percent points shall be noted from the dial on the machine and recorded for each specimen. The loads at each of these points shall be averaged for the set of six specimens. The average loads at each of these points for the immersed specimens shall be divided by the average loads at each of these points for the unaged specimens. The resulting ratios shall not be less than 0.85, and no conditioned specimen shall crack or collapse before buckling or the 60 percent point is reached.

5.7 Watertightness

5.7.1 Coupled conduit and fittings shall not leak when tested in accordance with Clause 5.7.2. Expansion joints marked in accordance with Clause 6.3 do not require this test.

5.7.2 A 300 ± 3 mm (12.0 ± 0.125 in) length of conduit shall be inserted into the integral coupling of another length of conduit having a total length of 300 ± 3 mm (12.0 ± 0.125 in), according to the manufacturer's installation instructions.

5.7.3 In the case of an elbow or fitting, one or two 300 ± 3 mm (12.0 ± 0.125 in) lengths of conduit, as appropriate, shall be inserted into the coupling according to the manufacturer's instructions. One end of the assembly shall be capped with a suitable enclosure. The assembly shall be placed in the vertical position, with the sealed end at the bottom, and filled with tap water. After a minimum of 4 h, the specimen shall be visually examined to determine any evidence of leakage.

5.8 Joint separation

5.8.1 A joint (conduit and socket) shall not separate when tested in accordance with Clause 5.8.2.

5.8.2 Two joints in each trade size shall be assembled as intended. A gasketed joint shall be subjected to an axial pull of 444 N (100 lbf), applied to the assembly for 5 min, intending to pull the conduit out of the socket. A mechanical or threaded joint shall be subjected to an axial pull of 4448 N (1000 lbf), applied to the assembly for 1 min, and tending to pull the conduit out of the socket. An adhesively secured joint shall be subjected to an axial pull of 6670 N (1500 lbf), applied to the assembly for 1 min, and tending to pull the conduit out of the socket.

5.9 Flattening resistance

5.9.1 The vertical inside diameter of conduit shall not decrease by more than the value indicated in Table 19 when tested in accordance with Clause 5.9.2.

5.9.2 Two specimens shall be tested. Each specimen shall be 75 ± 3 mm (3 ± 0.125 in) long. The vertical inside diameter of each specimen shall be measured and the value recorded. The specimens shall be placed horizontally side by side between the 2 steel platens of a static load test as shown in Figure 5. The specimens shall be placed such that the measured vertical inside diameter is in the vertical position. No part of the specimen shall extend beyond either platen. A test mass of 45 kg (100 lb), including the mass of the upper platen, shall be symmetrically applied. This assembly shall be maintained at a temperature of $110 \pm 1^\circ\text{C}$ ($230 \pm 2^\circ\text{F}$) for a period of 24 h. The specimens shall be allowed to cool, with the test mass removed, at $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$) for a minimum of 1 h. The vertical inside diameter shall be re-measured, recorded, and the actual decrease calculated and recorded.

5.10 Flame retardant properties

5.10.1 Apparatus

5.10.1.1 The apparatus for this test shall consist of the following:

- a) a test shield of sheet metal approximately 300 mm (12 in) wide, 350 mm (14 in) deep, and 600 mm (24 in) high, open at the top and front, and 2 rigid support clamps for supporting the test specimen in a vertical position;
- b) a burner conforming to ASTM D 5025 or NMX-J-192-ANCE having a bore of 9.5 ± 0.3 mm (0.37 ± 0.01 in) and a length of 100 ± 10 mm (4 ± 0.4 in) from the top of the air-inlet openings to the top of the mixing tube, or an equivalent which meets the calibration requirements of ASTM D 5207 or NMX-J-192-ANCE;
- c) a supply of bottled, technical grade methane or natural gas of approximately 37 MJ/m³ (1000 Btu/cu ft) at normal pressure with a suitable regulator and meter for uniform gas flow;
- d) a stopwatch or other suitable timing device; and
- e) surgical cotton.

5.10.2 Specimens

5.10.2.1 Test specimens shall be the actual conduit, or a plaque having a minimum size of 100 x 150 mm (4.0 x 6.0 in) and a wall thickness not greater than the minimum wall thickness of the conduit.

5.10.2.2 When the material is furnished in a range of colors, melt flows, or reinforcements, specimens representing these ranges shall also be provided. When the burning characteristics are not essentially the same for all specimens representing the range, evaluation shall be limited only to the material in the colors, melt flows, and reinforcement contents tested; or additional specimens in intermediate colors, melt flows, and reinforcement contents shall be provided for testing.

5.10.2.3 Three specimens of each type shall be available for testing.

5.10.3 Procedure

5.10.3.1 The test shall be made in a still-air test chamber.

5.10.3.2 A specimen of the material shall be supported in a vertical position in the test chamber, by 2 rigid support clamps at both vertical edges of the specimen (see Figure 6).

5.10.3.3 The height of the flame, with the burner vertical, shall be adjusted to approximately 127 mm (5.0 in) with an inner blue cone approximately 38 mm (1.5 in) high, producing a temperature of $816 \pm 50^{\circ}\text{C}$ ($1500 \pm 90^{\circ}\text{F}$) at the tip of the inner blue cone at a gas pressure equivalent to the one exerted by a 76 mm (3.0 in) water column.

5.10.3.4 The burner shall be tilted to an angle of 20° from the vertical and the flame applied to the material under test so that the tip of the inner blue cone of the flame touches the specimen at a point approximately 70 mm (2.75 in) above its lower end. A stop shall be fixed in position as shown in Figure 6 to permit the burner to be returned to the same position, thereby maintaining the initial fixed distance between the forward edge of the barrel of the burner and the initial position of the test specimen.

5.10.3.5 The flame shall be brought up to the material so that the vertical plane containing the major axis of the burner barrel is at right angles to the line of approach.

5.10.3.6 The flame shall be applied for 15 s, and then removed for 15 s, until five such applications have been made. The flame shall not be reapplied while the material is still burning. If the material burns for more than 15 s but less than 30 s, the flame shall be immediately reapplied upon cessation of flaming.

5.10.3.7 The material shall not support combustion for more than 30 s after any of the first four flame applications or 60 s after the fifth application of the test flame.

5.10.4 Results

5.10.4.1 The following shall be observed and recorded for each specimen:

- a) whether or not there is flaming for more than 30 s after the first, second, third, or fourth flame application; and
- b) whether or not there is flaming for more than 60 s after the fifth flame application;

5.11 Vertical flame test (FT4) – conduit on cable tray (optional)

5.11.1 General

5.11.1.1 This test shall apply to nonmetallic conduit containing wire and cable, intended for installation inside buildings, and exposed, where permitted. The flame spread of conduit shall be determined in the same manner as any cable with combustible jacket used inside a building.

Note: ~~The flame spread of conduit shall be determined in the same manner as any cable with combustible jacket used inside a building.~~ The FT4 flame test is a National Building Code of Canada requirement in designated noncombustible construction buildings.

5.11.2 Type of Insulated Conductors and Conduit Fill

5.11.2.1 The conduit shall contain insulated conductors that do not meet the FT1/VW1 flame rating, such as Type RW90 unfilled cross-linked polyethylene meeting the requirements of CSA C22.2 No. 38 or Type RHH in accordance with UL 44 or NMX-J-451-ANCE. The conduit fill shall be 40%.

5.11.3 Enclosure

5.11.3.1 An enclosure shall be provided to eliminate any external influence on the normal upward draft of the burner flame.

5.11.3.2 The enclosure shall contain a window to permit observation of the fire test.

5.11.3.3 No point of the enclosure, above grade, shall be closer than 1 m (3.3 ft) to the in situ cable tray.

5.11.3.4 The intake fresh airflow shall be sufficient to maintain the oxygen content within the test enclosure, as evidenced by the clear visibility of the test flame through the observation window (see Annex A).

5.11.3.5 The maximum air movement within the enclosure, with only the intake and exhaust openings open, the exhaust fan on, where applicable, and the burner off, shall not exceed 1 m/s (3.3 ft/s), as measured by a vane-type anemometer in the following areas:

- a) at the floor level where the burner will be positioned during the test; and
- b) 1.5 m (5 ft) above the enclosure floor where the cable tray will be positioned during the test.

5.11.3.6 The temperature of the enclosure and the incoming air shall be at least 5°C (41°F) throughout the test.

5.11.4 Trays

5.11.4.1 A steel, ladder cable tray, conforming to GAN/CSA C22.2 No. 126.1; NEMA VE 1 or NMX-J-511-ANCE, approximately 0.46 m (18 in) wide, 75 mm (2.5 in) deep, and 3 m (10 ft) long, and with longitudinal openings of 0.2 m (8.0 in), shall be used. The rungs shall be arranged such that the burner flame will impinge on the conduit midway between rungs. (See Annex A.)

5.11.5 Burner

5.11.5.1 The burner shall be a 250 mm (100 in) ribbon-type propane gas burner, with an air/gas Venturi mixer.

Note: Carlisle Machine Works, Inc. (412 S. Wade Blvd, Millville, NJ 08332) manufactures the following equipment that complies with the test specifications: ribbon-type burner, catalog no. 55AGF001-0098, venturi mixer, catalog no. 55AGF001-0113, and a kit including both the burner and mixer, catalog no. 55AGF001-0091.

5.11.5.2 The burner shall be mounted on a stand and placed 20° from the horizontal, burner ports up, with the major axis of the burner ports 300 ±30 mm (12 ±1.2 in) above the enclosure floor during the fire test.

5.11.5.3 A guide shall be attached to the burner or stand to permit the leading edge of the burner face to be located quickly and accurately 75 ±5 mm (2.5 ±0.2 in) horizontally away from the nearest surface of the conduit during the burn period of the test.

5.11.6 Flowmeters

5.11.6.1 A flowmeter shall be inserted in each of the propane and air lines feeding the burner to measure the flow rates of these gases during the test.

5.11.6.2 The propane flowmeter shall be capable of measuring a flow rate of $2.3 \times 10^{-4} \text{ m}^3/\text{s}$ ($3 \times 10^{-4} \text{ yds}^3/\text{s}$) and the air flowmeter a rate of $13.3 \times 10^{-4} \text{ m}^3/\text{s}$ ($17.4 \times 10^{-4} \text{ yds}^3/\text{s}$). Measurements shall be accurate to within 3%.

5.11.7 Air

5.11.7.1 The air supplied to the burner shall be compressed air, either bottled or supplied through a compressed air system.

5.11.7.2 The dew point of the air shall not be higher than 0°C (32°F) as measured by a dew point measuring device such as Alnor Model 7000U, No. 1999, or its equivalent.