



Power and Control **T Y P E**

BY RAVI GANATR



Tray Cable: TC

This article discusses how the requirements in both the installation code and the product standard are utilized to manufacture and install power and control tray cable, Type TC, products that are suitable for various applications. Where appropriate, alternate wiring methods are identified to provide some useful comparison. Also, some of the applicable requirements in Canada and Mexico¹ are identified and discussed to provide a North American perspective.

Installation and Applications Requirements

Table 1 (pages 32-34) provides a brief comparison of installation and applications requirements for Type TC tray cables in Canada and the US. Significant requirements for product recognition and application are identified. Since Type TC cables are typically used in cable trays, references related to cable trays are also identified. For complete details, references provided in the table should be consulted.

In the US, the *National Electrical Code (NEC)*, NFPA 70 standard, recognizes various types of wire and cable products and also defines requirements for their uses and installations for intended applications. Most, if not all, of these products are manufactured and listed in accordance with applicable product standards, generally developed by the Underwriters Laboratories (UL). Article 318 defines cable trays, in 318-2. Cable tray installations are used more commonly in industrial establishments to provide flexibility in wiring of process equipment. In accordance with 318-3, cable tray installations are not limited to industrial establishments. However, single conductor cables, provided they are identified for use in cable trays, are limited to industrial establishments only in accordance with 318-3(b)(1).

Article 340 of the *NEC* recognizes Type TC products and defines requirements for their uses and installations in cable trays, in raceways, or where supported by a messenger wire. UL Standard 1277, *Electrical Power and Control Tray Cables with Optional Optical-Fiber Members*, defines prescriptive and performance requirements for Type TC products. For their use in cable trays, the suitability of single conductor cables, which are recognized in Table

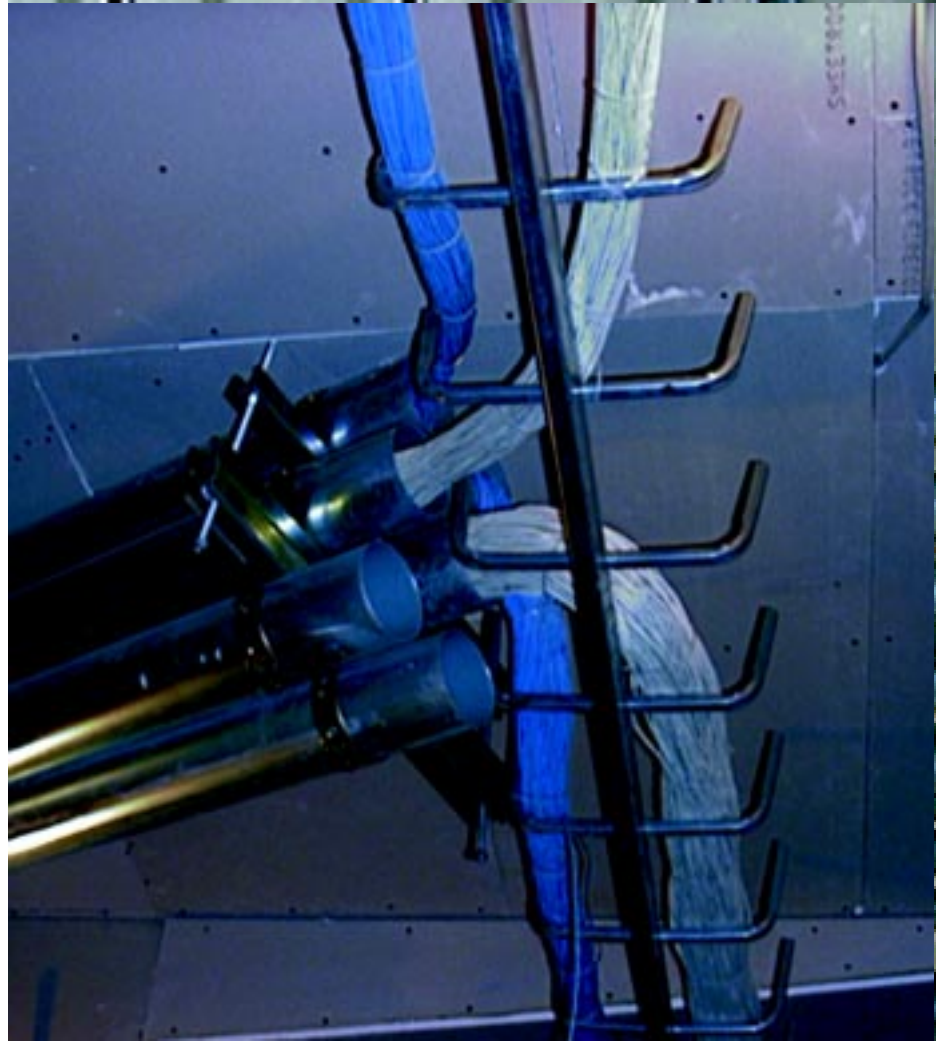
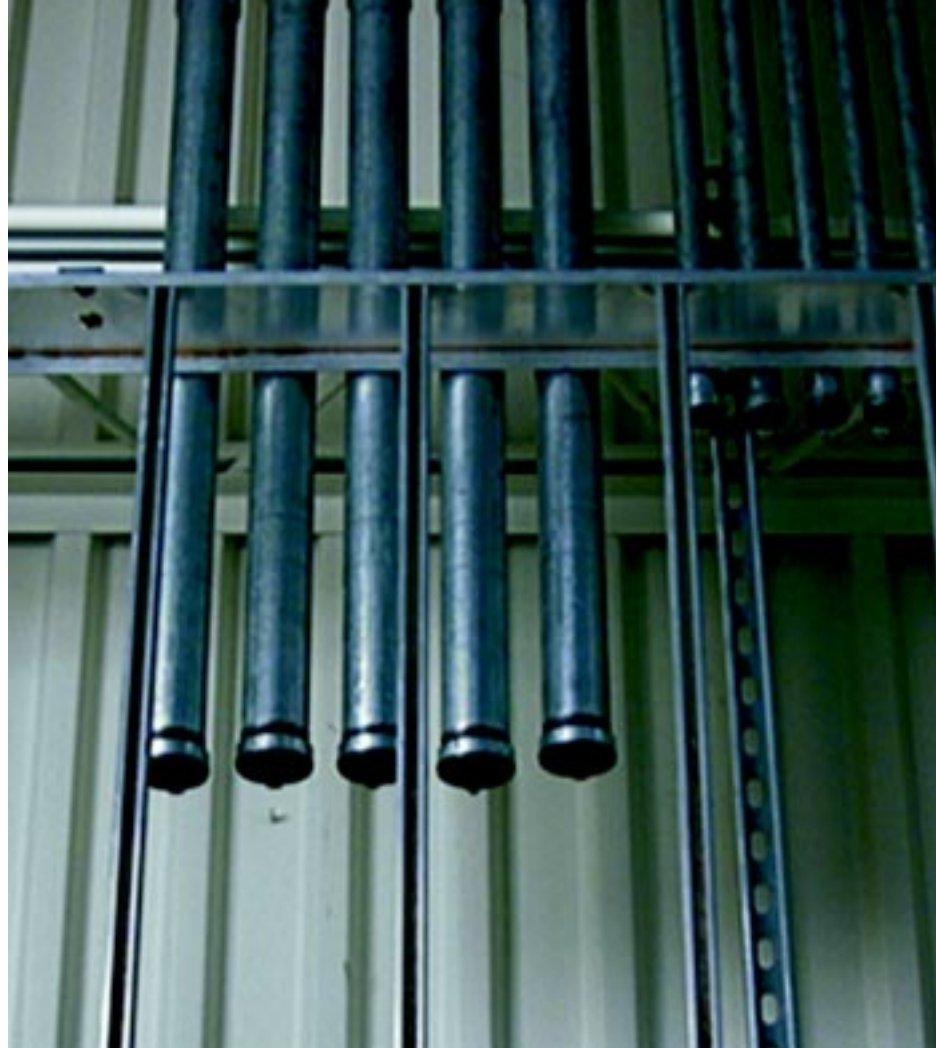
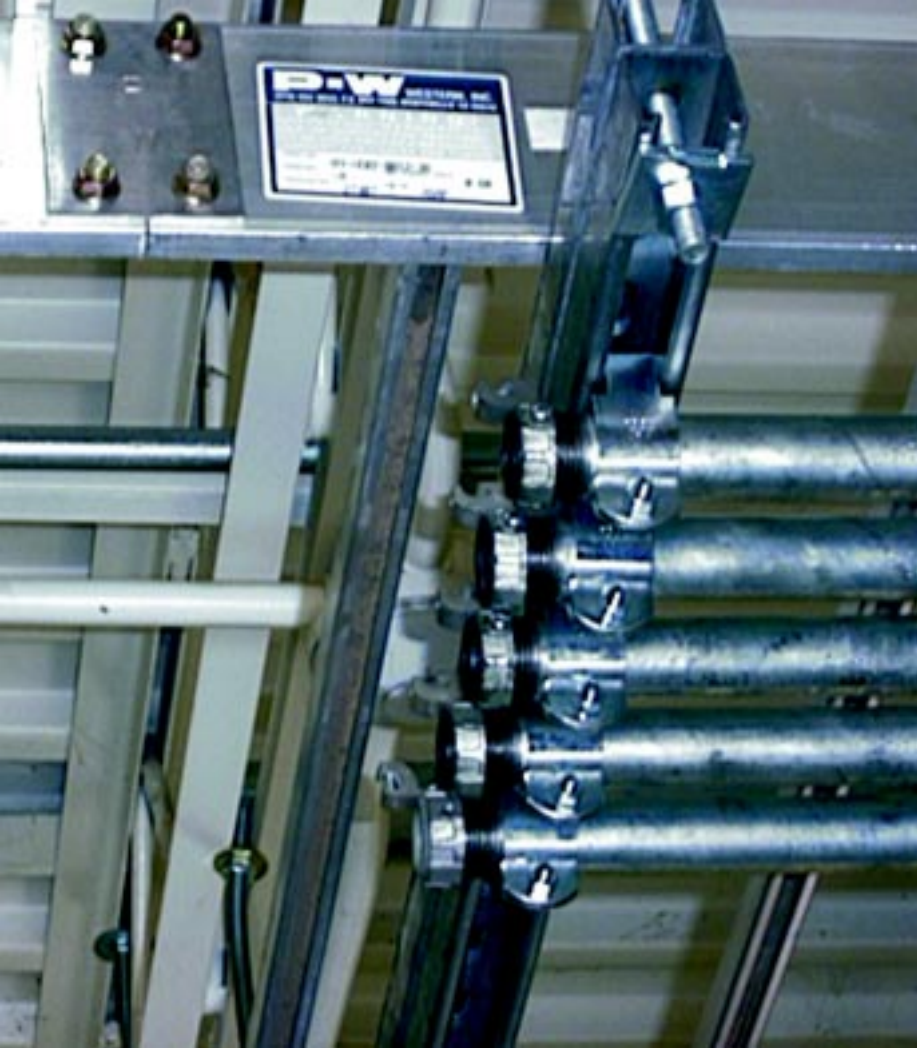


Photo 1 (top): Ladder-type tray supporting conduit at transition.

Photo 2 (right): Transition from EMT to cable tray – communications circuits.



310-13, is evaluated in accordance with their respective product standards.

In Canada, the *Canadian Electrical Code* (CEC) Part I, CSA Standard C22.1, recognizes various types of wire and cable products and also defines requirements for their uses and installations for intended applications. All of these products are manufactured and listed in accordance with applicable product standards listed in Appendix A of the CEC Part II.² These standards are developed by the Canadian Standards Association (CSA). In Canada, a cable tray is considered a "raceway." Unlike US, Type TC tray cables can be either single or multi-conductor product in accordance with CEC. Also, tray cable in Canada also includes medium voltage power cables. Type TC tray cables shall be permitted in cable trays only in areas of industrial establishments that are inaccessible to the public, as an alternate to the main rule which requires that the conductors used in cable trays in all areas shall have a continuous metal sheath or interlocking armor. Similar to US, single conductor Type TC tray cables shall not be smaller than 1/0 AWG.

Cable trays provide the needed flexibility in circuit layouts in various industrial establishments, such as those found in petro-chemical, pulp and paper, textile, mining, etc. Wire and cable products used in various non-raceway applications in these industries require superior mechanical, flame test, and cold temperature handling properties.

Armored cables, such as Type MC Cables in US and Types AC90, ACWU90 and TECK90 in Canada, have been the primary choice for these applications. This is because these products can be installed by themselves or in cable trays. Type TC cables require a protection when outside of the cable trays while armored cables may not require such protection in most cases.

Inherent construction design of armored cables provides a better

Photo 3 (top) and Photo 4: Ladder-type cable tray and conduit supports at transition points.



Ladder-type cable tray with external equipment grounding conductor connected.

opportunity to attain higher levels of mechanical performance, flame test performance for the overall cable construction, a higher level of insulating properties for the conductor insulation, and a higher level of cold temperature properties for the cable. Similar level of achievement is difficult with Type TC products, especially when the jacket alone cannot provide the needed performance for all different needs.

Additional applications, such as for control and signal circuits, of Type TC cables are identified in Table 1. The installation requirements for various wire and cable products in cable trays are provided in the code references for cable trays in Table 1. In particular, these references should be consulted for clearances between the cable trays, spacing of conductors and cables within a cable tray, securing of conductors and cables within a cable tray, etc. These installation requirements for cable trays determine permitted ampacity for conductors and cables installed in a given cable tray.

Mechanical loading of trays is also a critical factor for proper installation of cable trays. In general, Type TC tray cables provide an advantage over heavier armored cables. Generally, the weight of these products would decrease in the following order: armored cables with copper conductors, tray cables with copper conductors, armored cables with electrically equivalent size aluminum conductors, and tray cables with electrically equivalent size aluminum conductors.

Construction and Performance Requirements

Table 1 also provides a comparison of the construc-

tion and performance requirements for Type TC tray cables in two countries. With few exceptions, the requirements are very similar. Typical constructions of Type TC with three and four conductors with an equipment grounding conductor for power applications are shown in Figures 1 and 2 (page 31).

Insulated conductors recognized in Table 310-13 of the *NEC* are cabled together with or without the equipment grounding conductor and fillers. Conductor types used most commonly for 600 V rated Type TC products include THHN/THWN, XHHW, and RHH/RHW. For 2000 V rated Type TC products, conductor types used include RHH/RHW recognized in Table 310-62 of the *NEC*. A separator tape is used to wrap the assembly of conductors. An overall jacket is then applied over the assembly.

Materials for conductor insulation, fillers, tapes, and jacketing play an important role in delivering the required performance in accordance with the listing requirements, optional requirements, customer specifications and industry practices for Type TC products. A balance between the electrical, mechanical and flame test properties of the insulation type; mechanical and flame test properties of the overall construction; and required optional performance capabilities is arrived at by the users in various industrial establishments for their specific needs. Construction capable of meeting the requirements for a higher level of low temperature handling, a higher level of vertical flame test, for a lower level of acid gases, etc., is different than the construction capable of meeting the normal requirements for the same properties.

Stabiloy Type TC – 3 Conductor with Ground

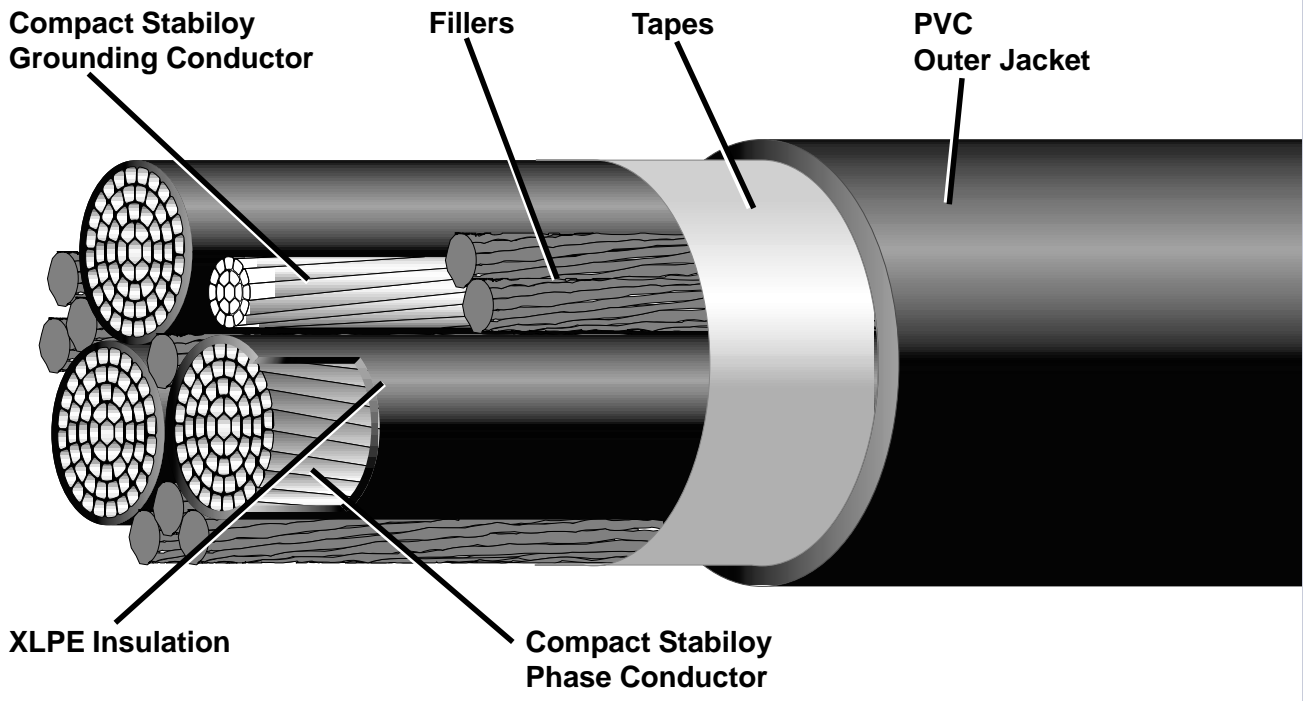


Figure 1.

Stabiloy Type TC – 4 Conductor with Ground

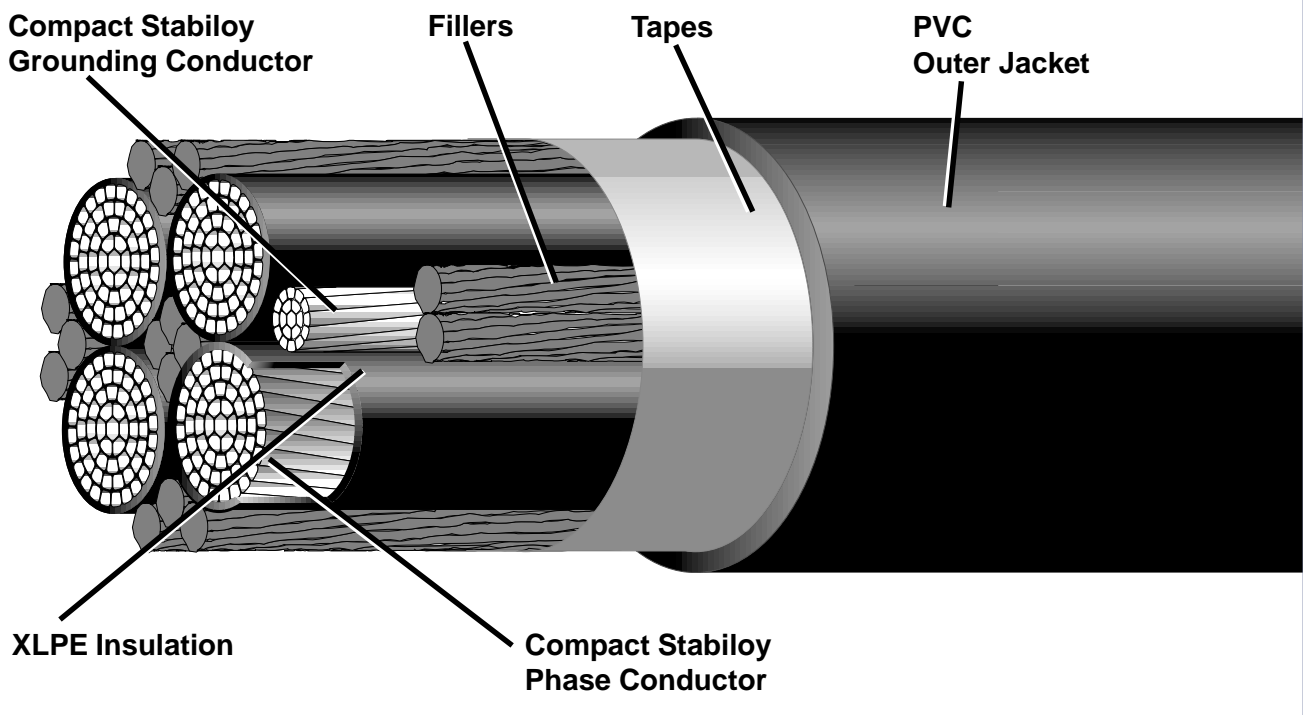


Figure 2.

Requirements for Type TC cables in accordance with the <i>NEC</i> and the <i>CEC</i>					
<i>NEC</i>			<i>CEC</i>		
General Requirements					
Description	Reference	Requirement	Description	Reference	Requirement
Cable Tray System	318-2. Definition. A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways.		Cable Tray	Section 0, Object, Scope And Definitions Cable tray means a raceway consisting of troughing, and fittings therefore, so formed and constructed that insulated conductors and cables may be readily installed or removed after the cable tray has been completely installed, without injury either to conductors or their coverings.	
Recognized Wiring Methods for Cable Tray Systems	318-3 (a) and (b) Multi-conductor Type TC cables are recognized in 318-3(a) as one of many permitted wiring methods for Cable Tray Systems. For industrial establishments, 318-3(b) permits single conductor cables No. 1/0 or larger (and, No. 4 or larger for grounding) that are marked "For CT Use".		Conductors in Cable Trays	12-2204 (2) Type TC tray cables shall be permitted (as an alternate to requirement in 12-2204 (1)) in cable trays in areas of industrial establishments that are inaccessible to the public. Single conductor Type TC tray cables shall not be smaller than 1/0 AWG.	
Type TC	Article 340 Power and Control Tray Cable: Type TC		Type TC	Table 19, Section 12 and other specific rules. No specific article for Type TC.	
Definition	340-1. Definition. Type TC power and control tray cable is a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a nonmetallic sheath, for installation in cable trays, in raceways, or where supported by a messenger wire.		Definition	No specific definition. Per CEC and CSA Standard C22.2 No. 230 – Tray Cables, it can be a single conductor (1/0 AWG and larger) or a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a non-metallic sheath, for installation in cable trays.	
Listing	In accordance with UL Standard 1277, Electrical Power and Control Tray Cables with Optional Optical-Fiber Members. Single conductor cables, which are recognized in Table 310-13, are evaluated in accordance with their respective product standards for their use in cable trays and marked "For CT Use".		Listing	In accordance with CSA Standard C22.2 No. 230 – Tray Cables.	

Table 1.

Summary

Examination of code and standards requirement in North America suggests that the interactive system of *Code-Product Standards-Verification* provide a set of choices for wiring methods in demanding environments in the industrial establishments. Power and Control Tray Cable – Type TC products can be used successfully in many applications in these environments. It is also clear that there is no single construction of Type TC that is suitable for all possible applications. Selection of a specific design depends upon the installation conditions and the required product performance characteristics for a particular application. Also, versatility, availability, and costs of alternate wiring methods, such armored cables and conductors in raceways, are compared against the similar features of Type TC cables and associated cable tray installation.



RAVINDRA H. GANATRA

Ravindra H. Ganatra is a senior engineer for distributor products at Alcan Cable's head office in Atlanta, Georgia. Ravi has been involved in several areas of wire and cable manufacturing, including: product, process and materials development; product applications; and codes and standards development activities in ASTM, CANENA, NEMA, NFPA, and UL. He is a principal member of CMP-6 and an alternate member of CMP-7 of the *NEC*.

¹ The installation code (NOM-001-SEMP-1994) recognizes Type TC products in Article 340. However, it is being revised and at present time there is no known product standard in place for Type TC products in Mexico, limited information from Mexico is presented here. Since the installation code in Mexico is likely to remain similar to the *NEC*, it also likely that the product standard, when developed, for Type TC products will be similar to UL 1277.

² In Canada, Appendix A in CEC Part II is an integral part of the *Code*.

Applications and Installation Requirements

<p>Uses Permitted</p>	<p>340-4</p> <ol style="list-style-type: none"> 1. For power, lighting, control, and signal circuits. 2. In cable trays, or in raceways, or where supported in outdoor locations by a messenger wire. 3. In cable trays in hazardous (classified) locations as permitted in Articles 318, 501, 502, 504, and 505 in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons will service the installation. 4. For Class 1 circuits as permitted in Article 725. 5. For nonpower-limited fire alarm circuits if conductors comply with the requirements of Section 760-27. 6. In industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons will service the installation, and where the cable is not subject to physical damage, Type TC tray cable that complies with the crush and impact requirements of Type MC cable and is identified for such use shall be permitted as open wiring in lengths not to exceed a total of 50 ft (15.24 m) between a cable tray and the utilization equipment or device. The cable shall be supported and secured at intervals not exceeding 6 ft (1.83 m). Equipment grounding for the utilization equipment shall be provided by an equipment grounding conductor within the cable. 	<p>Uses Permitted</p>	<p>Table 19</p> <p>Tray cables are recognized for use in raceways including ventilated, non-ventilated, and ladder type cable trays in wet locations and where exposed to weather.</p> <p>12-2204</p> <p>(2) Type TC tray cables shall be permitted in cable trays in areas of industrial establishments that are inaccessible to the public provided the cable is:</p> <ol style="list-style-type: none"> (a) Installed in conduit, other suitable raceway, or direct buried, where not in cable tray; and (b) Provided with mechanical protection where subject to damage either during or after installation; and (c) No smaller than 1/0 AWG if a single conductor is used; and (d) Installed only where qualified persons service the installation. <p>Table 19 and (18-068, 18-156, and 18-252)</p> <p>For use in cable trays in Class I Division 2 and Class II Division 2 hazardous locations.</p> <p>Table 19</p> <p>Type TC cable directly buried in the earth shall be marked as suitable for the purpose.</p>
<p>Uses Not Permitted</p>	<p>340-5</p> <ol style="list-style-type: none"> 1. Installed where it will be exposed to physical damage 2. Installed as open cable on brackets or cleats 3. Used where exposed to direct rays of the sun, unless identified as sunlight resistant 4. Direct buried, unless identified for such use. 		<p>Uses permitted rules include (or preclude) conditions for uses not permitted.</p>
<p>Bends</p>	<p>340-8</p> <p>Bends in Type TC cable shall be made so as not to damage the cable.</p>		<p>No specific reference for Type TC.</p>
<p>Bending Radius</p>	<p>None specified.</p>		<p>None specified.</p>
<p>Ampacity</p>	<p>340-7</p> <p>The ampacities of the conductors of Type TC tray cable shall be determined from Section 402-5 for conductors smaller than No. 14 and from Section 318-11.</p>		<p>12-2212</p> <p>Similar to the requirements in 318-11, the ampacities of the conductors of Type TC tray cable is determined in accordance with various provisions for installation of Type TC cable in cable trays.</p>

Construction and Performance Requirements

UL 1277		CSA Standard C22.2 No. 230 – Tray Cables	
Construction	Consists of two or more current carrying circuit conductors with or without either or both of the following, all under an overall jacket: a) One bare or one or more insulated grounding conductor(s), and b) One or more individually jacketed optical-fiber members.	Construction	Details of construction are not published in this Standard because the test and marking requirements of this Standard are in addition to the basic requirements for the cable construction that appear in other published CSA Standards. Except for single conductor products being marked Type TC, construction is similar to Type TC in the US.
Conductors	Copper (Sizes # 14 AWG and larger depending upon other specific requirements). Aluminum or copper clad aluminum (Sizes # 12 AWG and larger depending upon other specific requirements). Copper (Sizes # 16 - # 18) for control conductors.	Conductors	Copper (Sizes # 14 AWG and larger depending upon other specific requirements). Aluminum (Sizes # 12 AWG and larger depending upon other specific requirements). Copper (Sizes # 16 - # 18) for control conductors.
Equipment Grounding	Typically included. Same voltage rating as the circuit conductors.	Equipment Grounding	Typically included. Same voltage rating as the circuit conductors.
Insulation	Typically: Thermoplastic: Per UL 83 (600 V) wet and or dry ratings. (Ex: THW or THHN/THWN) Thermoset: Per UL 44 (600 V or 2000 V) wet and dry ratings. (Ex: XHHW (600 V) or RHH/RHW (2000 V)) Other: Control conductors per UL 62 Standard and or optical fiber member(s) in 600 V Tray Cables.	Insulation	Typically: Thermoplastic: Per CSA C 22.2 No. 75 (600 V) wet and or dry ratings. (Ex: TW or T90 (dry only)) Thermoset: Per CSA C 22.2 No. 38 (600 V or 1000 V) wet and dry ratings. (RW90 (600 V) or RW90 (1000 V)) Tray cable in Canada also includes medium voltage power cables. Other: Where permitted, control conductors and or other assemblies per other CSA Standards.
Temperature Rating	Temperature rating of conductor insulation.	Temperature Rating	Temperature rating of conductor insulation.
Sheath	Thermoplastic or thermoset. Properties of sheath and conductor insulation along with the assembly contribute towards the capability of the construction to meet the required flame test and other physical performance requirements.	Sheath	Thermoplastic or thermoset. Properties of sheath and conductor insulation along with the assembly contribute towards the capability of the construction to meet the required flame test and other physical performance requirements.
Vertical-Tray Flame Test	Per UL 1277 (UL 1581). Protocol is also known as IEEE 383.	FT 4 Vertical-Tray Flame Test	Per C22.2 No. 0.3. Protocol is also known as IEEE 1202 and considered more severe than IEEE 383.
Other required tests include	Cold Bend Test (-25° C), Deformation Test of Jacket, Heat Shock Test of Thermoplastic Jacket, etc.	Other required tests include	Cold Bend (-25° C), Impact Test, Crushing Test, Cold Impact Test, Weather Resistance Test, etc.
Marking	Type TC, conductor size, conductor material (where required), voltage rating, identification for ungrounded and grounded conductors, color of insulated grounding conductor, temperature rating (where required), etc.	Marking	Type TC, conductor size, conductor material (where required), voltage rating, identification for ungrounded and grounded conductors, color of insulated grounding conductor, temperature rating (where required), etc.
Optional Markings	FT 4 Vertical Tray Flame Test Cold Impact (-40° C) Open Wiring: Type TC shall meet crush and impact requirements for Type MC Sunlight-Resistance Direct Burial VW-1, oil-resistant, gasoline-resistant, reagent-resistant, or other individual conductor use may itself be identified on the tag, reel, or carton.		Cold Impact (-40° C) (Typically preferred) Low Acid Gas (LAG) (Not a requirement in the CEC or Standards but, complied commercially in most cases.)