Rule 12-802 Special terminology

Bottom shield — a protective layer between the floor and the Type FCC cable to protect the cable from physical damage. Note that the bottom shield may or may not be incorporated as an integral part of the whole system. The top shield and the metal tape may be two separate components, or may be a single integral component of the Type FCC system.

Rule 12-808 Floor covering

The intent of this Rule is to allow easy access for repairs and servicing.

Rule 12-814 Enclosure and shield continuity

Metal shields, tapes, boxes, receptacle housings, and self-contained devices must be electrically continuous and bonded to ground to prevent a shock or arcing hazard. Tapes that have a conductive surface in intimate electrical contact with metal shields throughout the Type FCC system are considered to be bonded when they are approved for the purpose.

Rule 12-818 Anchoring

Using mechanical fasteners to secure the FCC cable creates bumps under the carpet that can result in a safety hazard.

Rule 12-824 System height

Rule 12-820 allows FCC cables to cross over one another. However, it is not acceptable to stack Type FCC cable.

Raceways

General

Rule 12-900 Raceway Rules

Raceways are channels designed for enclosing and loosely containing insulated and bare conductors, cables, or busbars. They may be metal or non-metallic. Conductors or cables can be pulled in or laid in, depending on the type of raceway. Some of the different types of raceways include conduit (rigid and flexible, metallic and non-metallic), electrical metallic and non-metallic tubing, underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters.

Rule 12-902 Types of insulated conductors and cables

When determining the minimum bending radius for the conduit and tubing from Rule 12-902 2) b) ii), note that the Rule is using the cable's voltage rating (1000 V or less, or over 1000 V) instead of low-voltage and high-voltage as used in Rule 12-614 3). The intent of using 1000 V instead of the low-voltage in Rule 12-902 2) b) ii) is to allow 1000 V rated armoured cable, typically used in a low-voltage system (750 V or less), to use the smaller bending radius.

When armoured cables are pulled into raceways, they are susceptible to damage caused by exceeding the maximum pulling tension is exceeded or the sidewall bearing pressure (the latter being the limiting factor in these types of installations).

As noted in Rule 12-614 3) c), specification data and calculation methods for determining the acceptable cable length to be pulled into a raceway are available from cable manufacturers. The minimum cable bending radius must also be considered. The minimum bending radii might have different values, depending on the type of cable. The cable manufacturer should be consulted for accurate minimum bending radii values of specific cables.

Rule 12-902 2) b) ii) describes examples of acceptable installations. They are based on a maximum cable size of 1000 kcmil and raceway with a 90° bend at each end. Bends with a 0.944 m radius are used for low-voltage cable and a 1.524 m radius is used for high-voltage cable. Installations beyond these parameters should have calculations completed to establish acceptability.

Rule 12-904 Conductors in raceways

The intent of Subrule 1) is to prevent inductive heating.

The intent of Subrule 2) is to prevent conductors connected to different power or distribution transformers, or different sources of voltage, from contacting the other and impressing a different voltage source on a circuit. This is achieved by prohibiting conductors of different voltage sources from being installed in the same raceway or compartment channel of a multiple-channel raceway.

Cable tray, is by definition, as raceway. However, Subrule 2) does not apply to conductors installed in cable tray. See the requirements of Rule 12-2202.

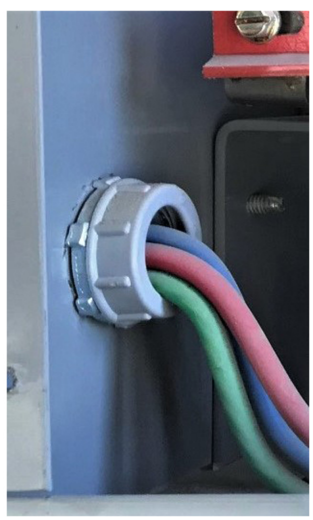
Regarding Rule 12-904 2) c), it should be noted that conductors that are connected to lower voltages are not permitted to be connected directly to lighting branch circuits when they are installed in a raceway that contains conductors that are connected to a higher voltage. The rationale is that problems with performance, safety, and the life expectancy of the lower voltage lighting systems may arise if conductors derived from the higher voltage source were to contact and impress that energy directly on conductors of the lower voltage [see also Subrule 4)].

It follows then, that a 115 V control circuit's conductors, which are interconnected or dependent upon equipment for proper operation and functionality, are allowed to be installed in the same raceway as conductors supplying a 440 V, three-phase motor, as long as every conductor within the raceway has insulation rated at 600 V. However, the conductors for 24 V extra-low-voltage lighting circuits cannot be installed in the same run of electrical metallic tubing as conductors for 120 V lighting circuits, even though the insulation's voltage rating on all conductors within the EMT is rated at 600 V, or for the highest voltage within in the raceway (in this case, 120 V). This is because the 24 V circuit is not interconnected or dependent upon anything in particular for proper operation and functionality. It is simply feeding another type of equipment and there is no metal armour or barrier provided to separate the two, as required by 12-904 2) a) and 2) b).

Rule 12-906 Protection of insulated conductors at ends of raceways

For more information about Subrule 2) a), see Figure 12-47.

Figure 12-47
Plastic bushings may be required



Notes:

1) *The insulated-type (plastic) bushing in Figure 12-47 complies with the requirement of Rule 12-906 2) a).*

2) *Photo courtesy of Ron Hiscock.*

Rule 12-908 Inserting insulated conductors in raceways

Regarding Subrule 2), lubricants (such as oils or greases) or cleaning agents containing minerals of a conductive nature are not to be used. Lubricant types that are electrically conductive could increase the potential for capacitive leakage, resulting in interference with instruments or other types of sensitive equipment.

Rule 12-910 Conductors and cables in conduit and tubing

Determining the sizes and numbers of conductors and cables that are permitted in conduit and tubing installations requires a detailed study of the circuit components, design layout, and material and installation costs of both conduit or tubing and the conductors.

Subrule 4) requires that the number of insulated conductors or multi-conductor cables in a single conduit or tubing is to meet the requirements for maximum conduit and tubing percentage fill, as specified by Table 8. For other types of raceways (e.g., surface raceways in the 12-1600 series of Rules), installers must obtain the maximum percentage fill from the appropriate Rules in Section 12. These percentages are based on:

- a reasonable limit on the lengths of conductors or cables pulled into conduit or tubing;
- the number of bends [not to be greater than the equivalent of four 90° bends (360°) in one run];
- ease of insertion and withdrawal (pulling tension); and
- heat dissipation, to prevent damage to the conductor's insulation.

Note: *Grounding and bonding conductors (whether insulated or bare) are to be included when computing conduit and tubing fill [as stipulated in Rule 4-004 6)]. However, they are not included when computing ampacities as required by Rule 4-004 1) and 2). Grounding and bonding conductors do take up space in raceways and, therefore, must be accounted for. However, they do not carry current under normal conditions and, for that reason, do not factor into the ampacity computation.*

Dimensions of bare bonding or grounding conductors, such as bonding conductors that are required for some raceway installations under applicable Code Rules, can be obtained from Table D5. They should be verified by measurement before installation.

Example

Determine the minimum size of EMT for four No. 6 T90 NYLON to be used for a 347/600 V, three-phase, 4-wire feeder in a commercial office building:

Method	Using Rule 12-910 4)	Using Rule 12-910 5)
Cross-sectional area for No. 6 T90 NYLON	32.71 mm^2 – Table 10A	N/A
Total cross-sectional area of conductors	32.71 × 4 = 130.8 mm^2	N/A
% tubing fill	40% – Table 8	N/A
Minimum size of EMT	21 trade size – Table 9G	21 trade size – Table 6K

Note: *When determining the size of conduit or tubing for an installation, the size determined according to Rule 12-910 is the minimum size allowed by the Code. The conduit or tubing size might need to be increased due to any of the following conditions:*

- *length of run;*
- *number of bends;*
- *required pulling tension;*
- *location (for example, concealed, encased, underground, or exposed);*
- *environment (for example, dry or wet, high or low temperature, Category 1 or 2, or a hazardous location);*
- *purpose of the conduit or tubing run (e.g., feeder, branch circuit, control, signal, or data);*
- *type of insulation on conductor;*

- *type of conductor or cable; or*
- *allowance for future expansion (i.e., to make room for cables to be added in the future).*

Table 12-7
Method to determine the minimum size of conduit or tubing containing conductors of various sizes and types when Tables 6A to 6K cannot be used

Step	Method
1	Using field measurements, determine the cross-sectional area of each single bare and insulated conductor and multi-conductor cable to be installed in the conduit or tubing. **Note:** *Tables 10A to 10D and D5 can be used to determine the cross-sectional area for the types of single insulated conductors listed in the Table using the conductor's size, its structure (i.e., stranded or solid), and insulation designation.*
2	Calculate the total area in mm^2 required by the number and size of each of the conductors or cables that are to be installed in the conduit, tubing, or raceway.
3	Calculate the total area in mm^2 required by all the conductors or cables that are to be installed in the conduit, tubing, or raceway.
4	Determine from Table 8 the maximum percentage conduit or tubing fill. For other types of raceways, obtain the maximum percentage fill from the appropriate Rule in Section 12.
5	Determine from Tables 9A to 9H the minimum size of conduit or tubing by using: • the type of conduit or tubing; • the maximum percentage conduit fill obtained from Table 8 (see Step 4); and • the maximum area in mm^2 of all the conductors or cables (see Step 3). When using a raceway with other than a circular cross-sectional area, determine the maximum area of the raceway that can be filled with conductors or cables by multiplying the total cross-sectional area of the raceway by the percentage fill obtained from Step 4. The area of the conductors or cables in mm^2 (see Step 3) is not to exceed the required conduit/ raceway fill in mm^2.

Table 12-8
Method to determine the minimum size of conduit containing conductors of the same size (other than lead-sheathed conductors) using Tables 6A to 6K

Step	Method
1	Find the conductor's voltage rating, insulation designation, and its status as jacketed or not jacketed (this is at the top of Tables 6A to 6K). If the conductor's insulation designation is not listed in this column, use the method given in Table 12-7 and Rule 12-910 4).
2	In the left-hand column of the appropriate Table (in Tables 6A to 6K), locate the conductor's size in AWG or kcmil.
3	In the row opposite the conductor's size, select the first column that has the number of installed conductors (or where the exact number of conductors is not listed, choose the column having the next highest number of conductors).
4	Record the area required in mm^2, then refer to Tables 9A to 9H to correctly determine the allowable fill for the chosen type of conduit or tubing based on the percentage fill limitations prescribed in Table 8.

Note: *To use this method:*
- *the conductors are to be the same size (AWG or kcmil);*

(Continued)

Table 12-8 (Concluded)

- *the CSA insulation letter designation is to be listed in Tables 6A to 6K; and*
- *the conductors are to be installed in a raceway type that allows the use of Tables 6A to 6K to determine conductor fill in accordance with Rule 12-910 5).*

Rule 12-914 Stranding of conductors
Stranded construction affords greater flexibility and prevents damage to the insulation when the conductors are installed in long raceway runs, or when they contain bends that the conductors or cables must be pulled around.

Rule 12-916 Electrical continuity of raceways
The intent of this Rule is to form a continuous electrical conductive path. A securely attached metal raceway system forms a continuous low-impedance path to ground that is intended to carry the amount of fault current required to trip the overcurrent protective device if fault to ground occurs on the system.

When the raceway system is constructed of non-metallic materials, or the metal raceway system cannot be relied on to carry the fault current, a bonding conductor is to be installed according to the requirements set out in Section 10. See also Rules 10-604, 10-606, and 10-608 for the required bonding methods for raceways.

Rule 12-918 Mechanical continuity of raceways
Mechanically securing raceways to the electrical equipment (e.g., using couplings, locknuts, or threaded connections) will provide proper mechanical continuity of the system. See Figure 12-48.

Note: *To “mechanically secure” is to fasten the raceway system’s components to each other, to the electrical equipment, and/or to the building structure so that they do not slacken or come apart when subjected to normal conditions of use, including vibration.*

Figure 12-48
Mechanically-secure installation

Notes:
1) *Figure 12-48 shows the equipment is securely fastened to the building structure and metal raceways are securely mounted and continuous.*
2) *Photo courtesy of Ron Hiscock.*

Rule 12-920 Support of raceways
Supporting raceways with suspended ceiling (T-bar or drop-ceiling) supporting wire or tie wires is not considered an acceptable means of fastening a raceway.

Rule 12-922 Removal of fins and burrs of raceways

Removing sharp fins and burrs from the ends of raceways will prevent damage from occurring to the conductor's insulation when inserting or pulling conductors. There are a variety of tools available for the efficient removal of sharp and jagged edges from the cutting of raceways.

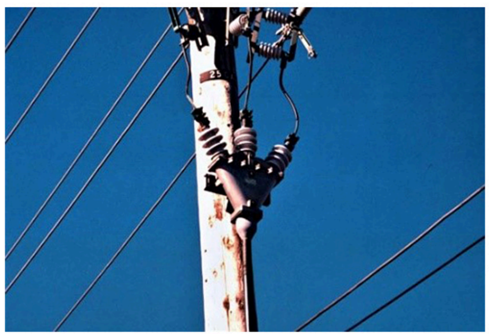
Rule 12-928 Entry of underground conduits into buildings

Moisture and gases that can enter electrical equipment can be the cause of corrosion and can lead to surface tracking, resulting in equipment failure. Health concerns are also a possibility. In order to prevent moisture and gases from an underground distribution system from entering the building through a conduit, installers are required to seal the conduit with an appropriate compound.
Rule 6-300 3) and 4) require sealing methods equivalent to the requirements of Rule 12-928.
Rule 6-300 3) stipulates that raceways entering a building (that form part of an underground service) be sealed, and that they should enter the building above ground where practicable. These raceways must also be suitably drained or be installed in such a way that moisture and gas will not enter the building.

Rule 12-930 Raceways installed underground or where moisture may accumulate

Regarding Subrule 2), see Figure 12-49.

Figure 12-49
Lead-sheathed cable terminating in a pothead



Note: *Photo courtesy of Steve Douglas.*

Rule 12-936 Raceways installed in concrete, cinder concrete, and cinder fill

Concrete can be considered a wet or damp location. When reinforcing steel and chloride additives are present in a concrete mixture, a galvanic action takes place, resulting in corrosion to aluminum.

Notes:

1) *The requirements in this Rule are similar in nature to Rule 12-602 3) and 4) regarding metal-armoured cables installed in similar environments.*

2) *Regarding the installation of raceways in concrete construction, designers and installers should be aware that, where raceways pass across structural expansion or control joints, it is possible to have relative movement that could damage the raceway. This should be accounted for in the design.*

Rule 12-938 Raceway completely installed before insulated conductors or cables are installed

The intent of Subrule 1) is to prevent damage to conductors and cables.

Regarding Subrule 2), in buildings that are under construction, conductors and cables are allowed to be installed in areas where construction operations will not damage the raceway, cables, or conductors and where they are physically protected from the weather.

Rule 12-940 Capping of unused raceways

Capping spare or unused raceways that terminate in enclosures helps prevent the possibility of a shock or short that could result from personnel pushing a steel fishtape into a panelboard or other equipment (such as a MCC containing live parts).

Rule 12-942 Maximum number of bends in raceways
This Rule means that the entire run cannot exceed 360° of bends. This includes the offset bends located at an outlet or fitting. No single bend is to exceed 90°.

Rule 12-944 Metal raceways
Salts and other corrosive chemicals may be added to road surfaces to reduce hazards caused by ice formation. These additives can adhere to vehicles and then drip on the floors of parking areas, pavement and road beds, permeating the base material and corroding embedded metals, including metallic raceways. Protection is to be provided by using the proper wiring method or by providing a protective screen or coating around or over the wiring method. Rule 2-116 1) sets out a general technical requirement for the protection of metals that are intended to be used in wiring:

"Metals used in wiring, such as raceways, cable sheaths and armour, boxes, and fittings, shall be suitably protected against corrosion for the environment in which they are to be used or shall be made of suitable corrosion-resistant material."

The Appendix B Note to Rule 12-944 advises that CSA S413 restricts the use of metal raceways and boxes embedded in concrete slabs in parkades and similar structures where they are subject to corrosion, because the permeation of salt presents a corrosion hazard.

Rigid and flexible metal conduit

Rule 12-1000 Rigid and flexible metal conduit Rules
Rigid and flexible metal conduits are raceways of circular cross-section into which conductors are drawn and may also be withdrawn. Used extensively in general installations, rigid metal conduit is suitable for threading with standard tapered pipe threads. Flexible metal conduit is frequently used for shorter runs like motor connections, and is easily installed as compared to non-flexing types of conduit.

Rule 12-1002 Use
Under some conditions, Section 10 requires that a separate bonding conductor be placed in rigid metal conduit. For example, Rule 10-608 states:

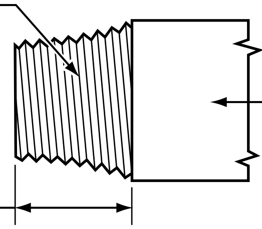
"Where a metal raceway serves as the bonding conductor, and expansion joints and telescoping sections are installed, the electrical continuity of the raceways shall be assured with a bonding conductor."

Rule 12-1006 Conduit threads
Regarding Subrule 1), a strong mechanical, as well as an effective electrical, connection relies on rigid conduit threads being cut in a tapered fashion. Straight tapped couplings are allowed to be used with tapered threads on rigid metal conduit. This will not compromise the strength of the joint, its ability as a ground fault return path, or its performance in hazardous locations (see Figure 12-50).

Regarding Subrule 3), running threads are field-cut tapered threads that are cut longer than the maximum dimension provided for in Table 40. When running threads are used to join lengths of rigid conduit together, the connection is weakened considerably and the impedance of the ground fault return path increases.

Regarding Subrule 4), when the conduit thread protrudes through an enclosure wall, and there is not sufficient thread length to apply a conduit bushing, Subrule 4) allows additional thread length, cut on the conduit as a continuation of the tapered thread dimensions given in Table 40, to accommodate the conduit bushing required by Rule 12-906. This does not weaken the connection at the enclosure because the enclosure does not use the rigid conduit as a support.

Figure 12-50
Tapered threads



Note: *When field threading rigid metal conduit, see ANSI/ASME B1.20.1.*

Rule 12-1010 Maximum spacing of conduit supports

The intent of Subrule 1) is to properly support the conduit weight, which will help to prevent strain at its terminations. Therefore, all rigid metal conduit is to be firmly fastened in place to a solid surface by conduit straps or by hangers. The maximum support spacing should be as shown in Table 12-9.

When mixing sizes of rigid conduits that are supported by a common rack or conduit gallery, support must be arranged so that the maximum support spacing is for the smallest conduit on the rack. For example, the support spacing for a 63 trade size conduit and a 16 trade size conduit mounted on the same hanger is 1.5 m, aligning with the maximum for the 16 mm conduit.

Table 12-9
Maximum support spacing — Rigid metal conduit

Trade size	Rigid metal conduit maximum support spacing, m
16	1.5
21	1.5
27	2
35	2
41	3
53	3
63	3
78	3
91	3
103	3
116	3
129	3
155	3

Rule 12-1012 Expansion and contraction of conduits

The lengths of the various rigid conduit types will fluctuate due to expansion and contraction of the metal caused by extreme temperature changes.

Examples

To determine the change in length of a 60 m run of 78 trade size aluminum conduit in a temperature range of –43 °C to 34 °C:

Length change (mm) = length of run (m) × temperature change (°C) × coefficient of expansion*
= 60 × (43 + 34) × 0.022 = 60 × 77 × 0.022 = 101.64 mm

To determine the change in length of a 50 m run of 53 trade size rigid steel conduit in a temperature range of –35 °C to 31 °C:

Length change (mm) = length of run (m) × temperature change (°C) × coefficient of expansion*
50 × (35 + 31) × 0.0114 = 50 × 66 × 0.0114 = 37.62 mm

For a 20 m run of rigid PVC conduit when the minimum expected temperature is –40 °C and the maximum expected temperature is 30 °C, the change in length is 20 × (40 + 30) × 0.0520 = 73 mm

* *See the Appendix B Note to Rule 12-1012 for coefficients of expansion for various materials.*

Rigid PVC conduit

Rule 12-1100 Use

Rigid polyvinyl chloride (PVC) conduit is a non-metallic, circular cross-section raceway into which conductors are pulled or withdrawn. Rigid PVC conduit is manufactured from unplasticized PVC and is intended for use at a maximum working temperature of 75 °C, and each piece is so marked.

Regarding Subrule 1), when installed in buildings, rigid PVC conduit is to conform to the flame spread requirements (FT rating) of the *NBCC*. See Rule 2-132.

Rule 12-1102 Restrictions on use

This Rule states that rigid PVC conduit is not to be used in locations where it will be enclosed in thermal insulation. It is acceptable, however, for the conduit to be in contact with thermal insulation, provided it is not completely enclosed within it.

Rule 12-1104 Temperature limitations

Regarding Subrule 1), tests show that 90 °C insulated conductors, continuously loaded, under conditions of 50% fill and 30 °C ambient, do not result in a temperature exceeding 75 °C. Insulated conductors with insulation ratings more than 90 °C may be used in PVC conduit, provided that the ampacity is derated to 90 °C. It is, therefore, imperative that rigid PVC conduit not be installed where any part of the conduit could be subjected to a temperature over 75 °C in normal conditions.

Regarding Subrule 2), using insulated conductors with temperature ratings over 75 °C in rigid PVC conduit is permitted, provided that the ampacities are corrected to those of 90 °C insulated conductors.

Rule 12-1106 Mechanical protection

Mechanical protection can be provided by using rigid metal pipe or a metal shield, or by relocating the conduit to a better suited location.

Rule 12-1108 Field bends

Field bending of rigid PVC conduit is acceptable if the bending equipment is specifically intended for the purpose. Flame-producing devices are not acceptable, as excessive heat damages the conduit. Thermostatically controlled heat guns uniformly apply heat without damaging the conduit for trade sizes up to 53. For trade sizes 27 to 53, springs or equivalent devices are to be used in conjunction with the heat gun to prevent reduction of the internal diameter. For trade sizes larger than 53, special jigs, moulds, springs, and heating arrangements are required.

Rule 12-1110 Support of luminaires

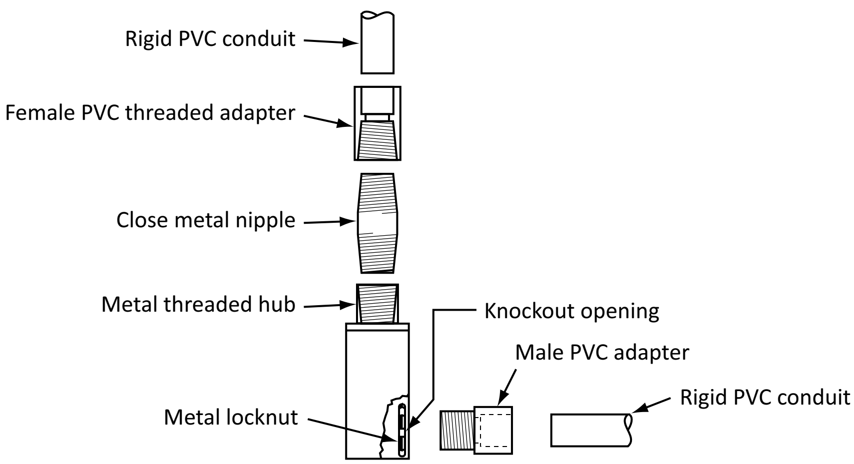
Luminaires can produce high temperatures. This could cause the PVC material to soften, resulting in the posts or inserts holding the screws to loosen and fall out, and causing the luminaire to fall.

Rule 12-1112 Fittings

Subrule 1) exists because rigid PVC conduit elbows, fittings, and bends are not threaded, therefore joining them together by adapters and couplings using a solvent cement is required. Using the incorrect type of solvent or contact cement (e.g., ABS solvent cement rather than PVC cement) can prevent the conduit connections from bonding together properly. This could result in connections that might come apart.

Regarding Subrule 2), because PVC conduit and rigid metal conduit have different coefficients of expansion, Subrule 2) requires that female PVC adapters (FA) be used with metal conduit nipples for terminations in threaded metal hubs or bosses (see Figure 12-51). PVC has just 0.4% of the thermal conductivity of steel. It follows then that, when using a metal female hub or boss with a PVC nipple, the higher expansion of the PVC inside the metal hub can damage the PVC nipple or crack or bend the metal hub. See Figure 12-51.

Figure 12-51
Fittings for rigid PVC conduit



Rule 12-1114 Maximum spacing of conduit supports

Rigid PVC conduit must be supported at intervals, as indicated in Table 12-10. The required support intervals for rigid PVC conduit are closer than those specified for rigid metal conduit. This is because the PVC conduit has a lower tensile strength and is prone to buckling or bowing at increased ambient temperatures. Where conduits of mixed sizes are installed as a group, the conduit supports are to be arranged so that the smallest conduit has the maximum support interval, as provided for in Subrule 1).

To allow for the expansion coefficient, except where rigid PVC is encased or embedded in at least 50 mm of masonry or poured concrete, the conduit is not to be clamped tightly—it is to be supported in a manner that permits adequate lineal movement which allows for expansion and contraction due to temperature change.

Table 12-10
Maximum support spacing — Rigid PVC conduit

Trade size	Rigid PVC conduit maximum support spacing
16	750 mm
21	750 mm
27	750 mm
35	1.2 m
41	1.2 m
53	1.5 m
63	1.8 m
78	1.8 m
91	2.1 m
103	2.1 m
116	2.1 m
129	2.1 m
155	2.5 m

Rule 12-1116 Support of equipment

Rule 12-3012 2) permits boxes and fittings with a volume of less than 1640 mL to be attached to a firmly secured exposed raceway by threading or other similar means.

Rule 12-1118 Expansion joints

The Code requires that expansion joints (a minimum of one) be installed in a conduit where the maximum temperature changes can cause expansion that will, likely, exceed 45 mm. If rigid PVC conduit is embedded in concrete, expansion and contraction do not need to be considered. The number of expansion joints required depend on the maximum range that a particular expansion joint is capable of telescoping.

The Appendix B Note to Rule 12-1118 refers to the method of calculating the expansion in a run of rigid PVC conduit.