RIGID POLYVINYL CHLORIDE (PVC) CONDUIT AND ELECTRICAL NONMETALLIC TUBING

INTRODUCTION

The use of plastic piping and other plastic construction materials in homes, institutions, public buildings, utilities and industry continues to grow. Plastic conduits carry water, air, furnace exhaust gases, sewage and electric wiring. Contractors install plastic conduit underground and aboveground in a variety of applications including electrical system raceways.

NFPA 70, the *National Electrical Code*® (NEC), recognizes rigid polyvinyl chloride conduit (PVC) as an electrical raceway. Its trade size must be at least ½ in. (13 mm) diameter. PVC is commonly available in sizes up to 6 in. (150 mm) diameter. In underground use, the types with suitable physical characteristics include rigid polyvinyl chloride (PVC), reinforced thermosetting resin (RTRC) such as fiberglass reinforced epoxy and high density polyethylene (HDPE). Aboveground, rigid PVC and fiberglass reinforced epoxy conduit can be used. PVC is available in USA "Schedule 40," which is a heavy-wall conduit, and "Schedule 80," which is an extra-heavy-wall conduit suitable for use where exposed to physical damage.

Electrical Nonmetallic Tubing (ENT) is a pliable, corrugated, electrical raceway ½ in. – 2 in. (13 mm – 51 mm) diameter, commonly of PVC construction. The NEC does not permit direct earth burial of ENT. Indoors, for buildings not exceeding three floors high, ENT is usually concealed within walls, floors or ceilings, or alternately, may be exposed if the tubing is not subject to mechanical damage. In buildings exceeding three stories, ENT must be concealed. Further, this concealment must provide a 15-minute finish rating.

Unlike the NEC's use of the term finish rating, Underwriters Laboratories (UL) in its *Fire Resistance Directory* defines the term only for combustible walls. For an example of barrier construction, see Design No. U317. The UL rating refers to the time available before the back side of the barrier (and typically, the face of a combustible joist) reaches specification temperature. The finish rating of any thermal barrier identified in the UL *Fire Resistance Directory* may be suitable for NEC purposes whether or not a combustible joist component exists. Generally, the finish rating of a barrier applies whether or not a combustible wall member exists behind the finished, rated surface.

The scope of this guideline is restricted to the use of:

- PVC, and HDPE constructed to UL 651 and UL 651A standards and installed in accordance with NEC Article 352 - "Rigid Polyvinyl Chloride Conduit," Article 353 - "High Density Polyethylene Conduit," or Article 710 - "Over 600 Volts, Nominal General."

- Listed ENT installed in accordance with NEC Article 362 - “Electrical Nonmetallic Tubing.” No national consensus standard exists for ENT testing and specifications. UL lists ENT based on test procedures that follow an outline identified in their report “Investigation of Electrical Nonmetallic Tubing - Subject 1653.” This outline of investigation serves as an interim product test standard.

POSITION

The NEC and testing lab listing requirements regulate the use of PVC and ENT. Additionally, observe the following precautions:

- Where PVC or ENT pass through a fire-rated barrier, maintain the integrity of the fire rating by protecting openings in and around the raceway. Provide an effective firestop similar to that obtained with a UL listed Through-Penetration Firestop System. During firestop design, perform an electrical engineering analysis of the thermal gradient in the cable and the firestop’s effects on cable ampacity.
- PVC and ENT are normally acceptable in sprinklered locations. However, avoid their use if an overheated or burning raceway would produce smoke or corrosive products of combustion that subject the occupancy to major damage. Examples of highly susceptible occupancies include large computer complexes, computer manufacturing facilities, electronic component manufacturers and electrical control rooms.
- PVC and ENT are normally acceptable in nonsprinklered locations not requiring sprinklers if the occupancy is not unusually susceptible to the breakdown products resulting from overheating or burning the raceway, and if individual runs are separated from each other by 36 in. (910 mm) except at 90° crossover or junction points.
- The use of concealed ENT in accordance with the NEC is acceptable provided:
  - The occupancies of the rooms adjacent to the concealed tubing system are not unusually susceptible to damage from overheating or burning of the tubing.
  - Individual runs in wall, floor or ceiling cavities are separated from each other so that fire involving one unit would not be likely to spread to another unit.
  - The concealed space is firestopped to prevent transmitting smoke to highly susceptible exposures.
- Provide automatic sprinklers to protect shafts (chases) containing PVC or ENT. Shafts should be of fire resistive construction, and should be firestopped as described earlier.
- Do not install PVC raceways inside air handling plenums. Use only metal raceways in such spaces.
- Use only metal raceways for fire pump service.
- Avoid concentrations of PVC raceways in nonsprinklered electrical distribution centers, switchgear rooms and motor control centers. Designers are usually reluctant to sprinkler such areas, and the potential for contamination is great.
- Provide seals on PVC and ENT raceways installed for underground distribution at all building entrance points to prevent passage of gases and vapors.
- Install seals inside PVC and ENT raceway systems to prevent the passage of gases, vapors and moisture between separate portions of the electrical installations.

DISCUSSION

The main advantage of PVC and ENT over their metal counterparts is a built-in resistance to damage from water and corrosion. However, aboveground PVC and ENT installations can present fire and

smoke loss potentials that do not exist with metal conduit and tubing. Generally, PVC and ENT installed to meet the guidelines stated in the Position are not expected to significantly increase fire and smoke loss potentials.

UL Listings

The UL *Electrical Construction Materials Directory* lists PVC in three classifications, and ENT in one classification, as follows:

- DZKT - Rigid Nonmetallic Fiberglass Conduit
- DZYR - Rigid Nonmetallic Schedule 40 and Schedule 80 PVC Conduit
- EAZX - Plastic Rigid Nonmetallic Underground Conduit
- FKHU - Electrical Nonmetallic Tubing

Generally, PVC begins to degrade at the relatively low temperature of 212°F (100°C). When used aboveground, PVC raceways are generally limited to use in an ambient temperature of 122°F (50°C) or less with wires rated 167°F (75°C) or less. Extra-heavy-wall conduit is identified by the marking "Schedule 80 PVC" on each straight length of conduit, at least every 10 ft (3 m). Currently, over 20 manufacturers of PVC conduit have products listed. PVC sizes range from ½ in. – 6 in. (13 mm – 150 mm).

Generally, fiberglass conduit may be used with wires rated 194°F (90°C) or less. Only a few manufacturers list fiberglass conduit at this time.

NEC Uses

The NEC® describes the "permitted" and "not permitted" uses of PVC and ENT. Generally, nonmetallic raceways are suitable for locations subject to severe corrosion. They can also be installed in a wet location, like a dairy. Two perils to their use are exposures to physical damage and exposures to extreme cold. The NEC and the UL listings provide further guidance.

ENT is limited to systems rated at or below 600 volts. PVC can be used with higher voltages.

Where grounding is required by NEC Article 250, equipment-grounding conductors must be run through nonmetallic raceways. The grounding conductors provide electrical continuity of these raceway systems and provide means for grounding noncurrent-carrying metal parts.

Flame Retardant Properties of Nonmetallic Raceways

UL subjects PVC specimens to three 60 second applications of flame, with a 30 second period between applications. An 18 in. (457 mm) specimen is tested vertically in an enclosure and subjected to the flame of a Tirrill gas burner tilted 20° from the vertical. To be considered "flame retardant" and pass the test, the conduit must not flame longer than 5 seconds following any of the three applications, and not emit flaming or glowing particles that ignite the cotton padding below.

This small-scale test method does not fully reflect the flammability characteristics of plastic conduit. Real-life ignition sources, large-scale flame tests or both may produce greater flame propagation.

Similarly, the small-scale flammability test applied to ENT does not reflect real-life ignition and fire conditions. Further, neither PVC nor ENT listing requires performing smoke corrosivity tests as part of product investigations.

The smoke generated when plastics burn is a significant factor in loss control. Firefighting efforts are often hampered by the volume of smoke emitted and the liberation of irritating and potentially lethal gases. These factors, when combined with limited access to tunnels, concealed spaces and shafts, pose exceptionally difficult problems to firefighters.

Firestops, Barriers, and Seals

Firestops can block the spread of fire, smoke and water when properly installed at PVC and ENT raceway penetrations of fire rated walls, floors and floor-ceiling assemblies. Effective firestops provide a fire rating equivalent to the fire rating of original construction. The firestop's design considers the

hollow nature of raceway (where conductors are installed) and internal voids (typically 50% or more of the raceway's cross-sectional area.)

An effective firestop interrupts the spread of fire and contaminants both inside and around the conduit wall. UL listed Through-Penetration Firestop Systems meet the intent of this function. Conduit seals are not designed to stop fire, but can block the spread of gas, vapor and water through a raceway. Both firestops and seals are useful tools in loss control efforts.