An electrical conduit is an electrical piping system used for protection and routing of electrical wiring. Electrical conduit may be made of metal, plastic, fiber, or fired clay. Flexible conduit is available for special purposes.

Conduit is generally installed by electricians at the site of installation of electrical equipment. Its use, form, and installation details are often specified by wiring regulations, such as the U.S. NEC or other national or local code. The term “conduit” is commonly used by electricians to describe any system that contains electrical conductors, but the term has a more restrictive definition when used in wiring regulations.

Early electric lighting installations made use of existing gas pipe to gas light fixtures (converted to electric lamps). Since this technique provided very good protection for interior wiring, it was extended to all types of interior wiring.

### Conduit Performance Selection Table

<table>
<thead>
<tr>
<th>Conduit Type</th>
<th>Metallic</th>
<th>Allow to be threaded</th>
<th>Flexible or Pliable</th>
<th>Liquid tight</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMC</td>
<td>![Coated](Coated, Heavy)</td>
<td>![Coated](Coated, Heavy)</td>
<td>![Coated](Coated, Heavy)</td>
<td>![Coated](Coated, Heavy)</td>
</tr>
<tr>
<td>RNC</td>
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<td>![Galvanized, Heavy](Galvanized, Heavy)</td>
<td>![Galvanized, Heavy](Galvanized, Heavy)</td>
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<tr>
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<td>![Galvanized, Middle](Galvanized, Middle)</td>
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<td>![Galvanized, Middle](Galvanized, Middle)</td>
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<tr>
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<tr>
<td>PVC conduit</td>
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<td>![Coated](Coated, Middle)</td>
<td>![Coated](Coated, Middle)</td>
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</tr>
</tbody>
</table>

### Comparison with other Wiring Methods

Electrical conduit provides very good protection to enclosed conductors from impact, moisture, and chemical vapors. Varying numbers, sizes, and types of conductors can be pulled into a conduit, which simplifies design and construction compared to multiple runs of cables or the expense of customized composite cable. Wiring systems in buildings are subject to frequent alterations. Frequent wiring changes are made simpler and safer through the use of electrical conduit, as existing conductors can be withdrawn and new conductors installed, with little disruption along the path of the conduit.

A conduit system can be made waterproof or submersible. Metal conduit can be used to shield sensitive circuits from electromagnetic interference, and also can prevent emission of such interference from enclosed power cables. When installed with proper sealing fittings, a conduit will not permit the flow of flammable gases and vapors, which provides protection from fire and explosion hazard in areas handling volatile substances. Some types of conduit are approved for direct encasement in concrete.

This is commonly used in commercial buildings to allow electrical and communication outlets to be installed in the middle of large open areas. For example, retail display cases and open-office areas use floor-mounted conduit boxes to connect power and communications cables.
Both metal and plastic conduit can be bent at the job site to allow a neat installation without ex-cessive numbers of manufactured fittings. This is particularly advantageous when following irregular or curved building profiles. The cost of conduit installation is higher than other wiring methods due to the cost of materials and labor. In applications such as residential construction, the high degree of physical damage protection is not required so the expense of conduit is not warranted. Conductors installed within conduit cannot dissipate heat as readily as those installed in open wiring, so the current capacity of each conductor must be reduced if many are installed in one conduit. It is impractical, and prohibited by wiring regulations, to have more than 360 degrees of total bends in a run of conduit, so special outlet fittings must be provided to allow conductors to be installed without damage in such runs. While metal conduit can be used as a grounding conductor, the circuit length is limited. A long run of conduit as grounding conductor will not allow proper operation of overcurrent devices on a fault.

**Types of Conduit**

Conduit systems are classified by the wall thickness, mechanical stiffness, and material used to make the tubing.

- **Rigid Metal Conduit (RMC)**
  Rigid Metal Conduit (RMC) is a thick threaded tubing, usually made of coated steel, stainless steel or aluminum.

- **Rigid Nonmetallic Conduit (RNC)**
  Rigid Metal Conduit (RNC) is a thick threaded tubing.

- **Galvanized Rigid Conduit (GRC)**
  Galvanized rigid conduit (GRC) is galvanized steel tubing, with a tubing wall that is thick enough to allow it to be threaded. Its common applications are in commercial and industrial construction.

- **Electrical Metallic Tubing (EMT)**
  Electrical metallic tubing (EMT), sometimes called thin-wall, is commonly used instead of galvanized rigid conduit (GRC), as it is less costly and lighter than GRC. EMT itself may not be threaded, but can be used with threaded fittings that clamp to it. Lengths of conduit are connected to each other and to equipment with clamp-type fittings. Like GRC, EMT is more common in commercial and industrial buildings than in residential applications. EMT is generally made of coated steel, though it may be aluminum.

- **Flexible Metallic Conduit (FMC)**
  Flexible Metallic Conduit (FMC) is made through the coiling of a self-interlocked ribbed strip of aluminum or steel, forming a hollow tube through which wires can be pulled. FMC is used primarily in dry areas where it would be impractical to install EMT or other non-flexible conduit, yet where metallic strength to protect conductors is still required. The flexible tubing does not maintain any permanent bend. Cutting FMC requires a specialized hand tool with a rotary abrasive disc to create a small incision into the ribbing so that a twisting motion separates the segments. The disc cuts deep enough to sever the armor coil but not so deep that it could damage the inside conductors. Short segments of FMC called “whips” are often used as circuit “pigtails” between fixtures and a [junction box], especially in [suspended ceiling]. Whip assemblies save a great deal of repetitive labor when installations require several pigtails for several fixtures. Flexible metal conduit coated with a UV-resistant polymer is liquid-tight when installed with appropriate [Gland (engineering)|glandular] fittings containing liquid-tight features such as [O-ring]s. Wiring regulations vary; in locales following the U.S. [National Electrical Code | National Electric Code] (NEC), flexible metallic conduit may serve as an equipment-grounding conductor. Other areas may require a bonding wire for equipment grounding. The bonding wire in direct contact with the interior of the conduit creates a lower resistance grounding conductor than the conduit alone.
Features

- **Liquid-tight Flexible Metal Conduit (LFMC)**
  Liquid-tight Flexible Metal Conduit (LFMC) is a metallic flexible conduit covered by a waterproof plastic coating. The interior is similar to FMC.

- **Flexible Metallic Tubing (FMT)**
  Flexible Metallic Tubing (FMT) is not the same as Flexible Metallic Conduit (FMC) aka “greenfield” or “flex” which is National Electrical Code (NEC) Art 348. FMT is a raceway, but not a conduit and is a separate NEC Article - 360. It only comes in 1/2” & 3/4” trade sizes whereas FMC is sized 1/2” ~ 4” trade sizes. NEC 360.2 describes it as: “A raceway that is circular in cross section, flexible, metallic and liquid-tight without a nonmetallic jacket.”

- **Liquid-tight Flexible Nonmetallic Conduit (LFNC)**
  Liquid-tight Flexible Nonmetallic Conduit (LFNC) refers to several types of flame-resistant non-metallic tubing. Interior surfaces may be smooth or corrugated. There may be integral reinforcement within the conduit wall. It is also known as FNMC.

- **Aluminum Conduit**
  Aluminum conduit, similar to galvanized steel conduit, is a rigid conduit, generally used in commercial and industrial applications, where a higher resistance to corrosion is needed. Such locations would include food processing plants, where large amounts of water and cleaning chemicals would make galvanized conduit unsuitable. Aluminum cannot be directly embedded in concrete, since the metal reacts with the alkalis in cement. The conduit may be coated to prevent corrosion by incidental contact with concrete. The extra cost of aluminum is somewhat offset by the lower labor cost to install, since a length of aluminum conduit will have about one-third the weight of an equally-sized rigid steel conduit.

- **Intermediate Metal Conduit (IMC)**
  Intermediate Metal Conduit (IMC) is a steel tubing heavier than EMT but lighter than RMC. It may be threaded.

- **PVC Conduit**
  PVC conduit is the lightest in weight compared to other conduit materials, and usually lower in cost than other forms of conduit. In North American electrical practice, it is available in three different wall thicknesses, with the thin-wall variety only suitable for embedded use in concrete, and heavier grades suitable for direct burial and exposed work. The various fittings made for metal conduit are also made for PVC. The plastic material resists moisture and many corrosive substances, but since the tubing is non-conductive an extra bonding (grounding) conductor must be pulled into each conduit. PVC conduit may be heated and bent in the field. Joints to fittings are made with slip-on solvent-welded connection, which set up rapidly after assembly and attain full strength in about one day. Since slip-fit sections do not need to be rotated during assembly, the special union fittings used with threaded conduit (Ericson) are not required. Since PVC conduit has a higher thermal coefficient of expansion than other types, it must be mounted so as to allow for expansion and contraction of each run. Care should be taken when installing PVC underground in multiple or parallel run configurations due to mutual heating effect of cable.

- **Other Metal Conduits**
  In extreme corrosion environments where plastic coating of the tubing is insufficient, conduits may be made from stainless steel, bronze or brass.

- **Underground Conduit**
  Large diameter (more than 2 inch/50 mm) conduit may be installed underground between buildings to allow installation of power and communication cables. An assembly of these conduits, often called a duct bank, may either be directly buried in earth or encased in concrete. A duct bank will allow replacement of damaged cables between buildings or additional power and communications circuits to be added, without the expense of ex-cavation of a trench. While metal conduit is occasionally used for burial, usually PVC, polyethylene or polystyrene plastics are now used due to lower cost. Formerly, compressed asbestos fiber mixed with cement was used for some underground installations. Telephone and communications circuits were installed in fired-clay conduit.
Comparison of Some Types of Conduit

Exact ratios of installation labor, weight and material cost vary depending on the size of conduit, but the values for 3/4 inch (21 metric) trade size are representative.

Relative to rigid galvanized steel conduit, 3/4 inch (21 metric) size

<table>
<thead>
<tr>
<th>Relative</th>
<th>RGS</th>
<th>Aluminum</th>
<th>IMC</th>
<th>EMT</th>
<th>PVC</th>
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</thead>
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<tr>
<td>Labor</td>
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<td>0.89</td>
<td>0.62</td>
<td>0.55</td>
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<tr>
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<tr>
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<td>0.99</td>
<td>0.84</td>
<td>0.35</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Other Wire-ways

- Surface Mounted Raceway (wire molding)
  This type of “decorative” conduit is designed to provide an aesthetically acceptable passageway for wiring without hiding it inside or behind a wall. This is used where additional wiring is required, but where going through a wall would be difficult or require remodeling. The conduit has an open face with removable cover, secured to the surface, and wire is placed inside. Plastic raceway is often used for telecommunication wiring, such as network cables in an older structure, where it is not practical to drill through concrete block.

Advantages
- It allows one to add new wiring to an existing building without removing or cutting holes into the drywall or lath and plaster.
- It allows circuits to be easily locatable and accessible for future changes thus enabling minimum effort upgrades.

Disadvantages
It’s appearance may not be acceptable to all observers.

Trunking
The term TRUNKING is used in the United Kingdom for electrical wire-ways, generally rectangular in cross section with removable lids. Mini TRUNKING is a term used in the UK for small form-factor (usually 6mm to 25mm square or rectangle sectioned) PVC wire ways. In North American practice “wire trough” or “lay-in wire-ways” are terms used to designate similar products, but these are never used enclosed in masonry or a wall.
Technical tip for Electrical Wiring

Electrical wiring in North America follows regulations and standards for installation of building wiring. Electrical wiring in the United States is generally in compliance with the National Electrical Code, a standard sponsored by the National Fire Protection Association which has been periodically revised since 1897. Local amendments or supplements to this model code are common in American cities or states. For electrical wiring in Canada, the Canadian Electrical Code is a very similar standard published in Canada by the Canadian Standards Association since 1927. Other countries neighboring the U.S. also usually use the same standards, including much of Mexico.

- **Terminology**
  Although much of the electrician’s field terminology matches that of the electrical codes, usages can vary.
  - A neutral wire is the return leg of a circuit; in building wiring systems the neutral wire is connected to earth ground at least at one point. North American standards state that the neutral is neither switched nor fused. The neutral is connected to the center tap of the power company transformer of a split-phase system, or the center of the wye connection of a poly-phase power system. American electrical codes require that the neutral be connected to earth at the “service panel” only and at no other point within the building wiring system. Formally the neutral is called the “grounded conductor”; as of the 2008 defined in the Code to record what had been common usage.
  - Hot is any conductor (wire or otherwise) connected with an electrical system that has electric potential to electrical ground or neutral.
  - Grounded is a conductor with continuity to earth.
  - Leg as in ‘hot leg’ refers to one of multiple hot conductors in an electrical system. The most common service in the U.S., single split-phase, 240 V, features a neutral and two hot legs, 240 V to each other, and 120 V each to the neutral. A three-phase system will have three “hot” legs.
  - An outlet is called a receptacle in the NEC. In the NEC an outlet is a device for easily connecting a utilization device by inserting a mating plug.

### Electrical Codes and Standards

The National Electrical Code (NEC) specifies acceptable wiring methods and materials. Local jurisdictions usually adopt the NEC or another published code and then distribute documents describing how local codes vary from the published codes. They cannot distribute the NEC itself for copyright reasons. The purpose of the NEC is to protect persons and property from hazards arising from the use of electricity. The NEC is not any jurisdiction’s electrical code per se; rather, it is an influential work of standards that local legislators (e.g., city council members, state legislators, etc. as appropriate) tend to use as a guide when enacting local electrical codes. The NFPA states that excerpts quoted from the National Electrical Code must have a disclaimer indicating that the excerpt is not the complete and authoritative position of the NFPA and that the original NEC document must be consulted as the definitive reference. New construction, additions or major modifications must follow the relevant code for that jurisdiction, which is not necessarily the latest version of the NEC. Regulations in each jurisdiction will indicate when a change to an existing installation is so great that it must then be rebuilt to comply with the current electrical code. Generally existing installations are not required to be changed to meet new codes. Enforcement of code requirements varies by jurisdiction in the United States. In many areas, a homeowner, for example, can perform household wiring for a building which the owner occupies; this may even be complete wiring of a home. A few cities have more restrictive rules and require electrical installations to be done by licensed electricians. The work will be inspected by a designated authority at several stages before permission is obtained to energize the wiring from the local electric utility; the inspector may be an employee of the state or city, or an employee of an electrical supply utility.

- **Design and Installation Conventions**
  - Phase wire in a circuit may be black, red, orange (high leg delta) insulated wire, sometimes other colors, but never green, gray, or white (whether these are solid colors or stripes). Specific exceptions apply, such as a cable running to a switch and back (known as a traveler) where the white wire will be the hot wire feeding that switch. Another is for a cable used to feed an outlet for 250VAC 15 or 20 amp appliances that do not need a neutral, there the white is hot (but should be identified as being hot, usually with black tape inside junction boxes).
- The neutral wire is identified by gray or white insulated wire, perhaps with stripes.
- Grounding wire of circuit may be bare or identified insulated wire of green or having green stripes. Note that all metallic systems in a building are to be bonded to the building grounding system, such as water, natural gas, HVAC piping, and others.
- Larger wires are furnished only in black; these may be properly identified with suitable paint or tape.
- All wiring in a circuit except for the leads that are part of a device or fixture must be the same gauge. Note that different size wires may be used in the same raceway so long as they are all insulated for the maximum voltage of any of these circuits.
- The Code gives rules for calculating circuit loading.
- Ground-fault circuit interrupter (GFCI) protection is required on receptacles in wet locations. This includes all small appliance circuits in a kitchen, receptacles in a crawl space, basements, bathrooms and a receptacle for the laundry room, as well as outdoor circuits within easy reach of the ground. However, they are not required for refrigerators because unattended disconnection could cause spoilage of food, nor for garbage disposals. Instead, for refrigerators and other semi-permanent appliances in basements and wet areas, use a one-outlet non-GFCI dedicated receptacle. Two-wire outlets having no grounding conductor may be protected by an upstream GFCI and must be labeled “no grounding”. Most GFCI receptacles allow the connection and have GFCI protection for down-stream connected receptacles. Receptacles protected in this manner should be labeled “GFCI protected”.
- Most circuits have the metallic components interconnected with a grounding wire connected to the third, round prong of a plug, and to metal boxes and appliance chassis.
- Furnaces, water heaters, heat pumps, central air conditioning units and stoves must be on dedicated circuits.
- The code provides rules for sizing electrical boxes for the number of wires and wiring devices in the box.
- The foregoing is just a brief overview and must not be used as a substitute for the actual National Electrical Code.

### Comparison of US Practices with Other Countries

Electrical wiring practices developed in parallel in many countries in the late 19th and early 20th centuries. As a result, national and regional variations developed and remain in effect. (see National Electrical Code, electrical wiring, electrical wiring in the United Kingdom). Some of these are retained for technical reasons, since the safety of wiring systems depends not only on the wiring code but also on the technical standards for wiring devices, materials, and equipment. Grounding (earthing) of distribution circuits is a notable difference in practice between United States wiring systems and those elsewhere in the world. Since the early 1960s, wiring in new construction has required a separate grounding conductor used to bond (electrically connect) all normally non-current carrying parts of an electrical installation. Portable appliances with metal cases also have a bonding conductor in the flexible cable and plug connecting them to the distribution system. The circuit return conductor (neutral) is also connected to ground at the service entrance panel only; no other connections from neutral to ground are allowed, unlike regulations in other parts of the world. Lighting and power receptacle circuits in North American systems are typically radial from a distribution panel containing circuit breakers to protect each branch circuit. The smallest branch circuit rating is 15 amperes, used for general purpose receptacles and lighting. In residential construction, branch circuits for higher ratings are usually dedicated to one appliance, for example, fixed cooking appliances, electric clothes dryers, and air conditioners. Lighting and general purpose receptacles are at 120 volts AC, with larger devices fed by three wire single-phase circuits at 240 volts. In commercial construction, three-phase circuits are used. Generally, receptacles are fed by 120 V or 208 V (in place of 240 V in a house), and can include special amperage rated outlets for industrial equipment. Lighting is usually fed by 277 V (with exception for special-use lights that use 120 V). Equipment can be hard-wired into the building using either 120/208 V or 277/480 V. Countries such as Mexico may adopt the NFPA standard as their national electrical code, with local amendments similar to those in United States jurisdictions. The Canadian Electrical Code, while developed independently from the NFPA code, is similar in scope and intent to the US NEC, with only minor variations in technical requirement details; harmonization of the CSA and NEC codes is intended to facilitate free trade between the two countries.
Technical tip for Electrical Wiring

- **Wiring Methods**
  - **Conduit.**
    In Class I, Division 1, locations, all conduit must be rigid metal or steel IMC with at least five full tapered threads tightly engaged in the enclosure. (An exception to 500.8(E) allows 4-1/2 for factory threaded NPT entries.) All factory-drilled and tapped SAMWHA enclosures satisfy this requirement. When field drilling and tapping is performed it may be required to drill and tap deeper than standard NPT to insure engagement of five full threads. For further information contact your SAMWHA field representative. A common method of wiring employs thick-walled conduit with a corrosion-resistant finish. In addition to the protective finish on the conduit, various types of paints or special finishes are used extensively to give extra protection from corrosive atmospheres. Alternate changes in temperature and barometric pressure cause “breathing” — the entry and circulation of air throughout the conduit. As joints in a conduit system and its components are seldom tight enough to prevent this breathing, moisture in the air condenses and collects at the base of vertical conduit runs and equipment enclosures. This could cause equipment shorts or grounds. To eliminate this condition, inspection fittings should be installed and equipped with Explosion-proof drains to automatically drain off the water.

  - **Seals for Conduit System.**
    NEC 501.15 requires that sealing fittings filled with approved compound be installed in conduits entering explosion-proof enclosures. Seals are necessary to limit volume, to prevent an explosion from traveling throughout the conduit system, to block gases or vapors from moving from a hazardous to a nonhazardous area through connecting raceways or from enclosure to enclosure, and to stop pressure piling - the buildup of pressure inside conduit lines caused by pre-compression as the explosion travels through the conduit. (See Appendix III - Selection of Seals and Drains.) The standard type seals are not intended to prevent the passage of liquids, gases or vapors at pressures continuously above atmospheric. Temperature extremes and highly corrosive liquids and vapors may affect the ability of seals to perform their intended function. In hazardous locations, seals are needed in the following instances:
    - Where the conduit enters an enclosure that houses arcing or high-temperature equipment. (A seal must be within 18 inches or closer if the manufacturer’s instructions so specify of the enclosure it isolates.)
    - Where the conduit enters enclosures that house terminals, splices or taps, if the conduit is 2-inch trade size or larger.
    - Where the conduit leaves a Division I area or passes from a Division 2 hazardous area to a nonhazardous location.

  - **Mineral Insulated Cable.**
    Another type of wiring system suitable for Division 1 is mineral insulated (MI) cable. Mineral-insulated wiring consists of copper conductors properly spaced and encased in tightly compressed magnesium oxide, clad in an overall copper sheath. Below the melting temperature of the copper sheath, MI cable is impervious to fire. Because of limitations on end connections, its operating range is generally considered to be -40 to 80°C with standard terminals, and up to 250°C with special terminals. When properly installed, MI cable is suitable for all Class I and Class II locations. MI cable is available with one to 17 conductors, making it most suitable for wiring of control boards, control components and instrumentation circuits where crowded conditions make conduit installations difficult and expensive. MI cable is hygroscopic; therefore, moisture can be a problem when the ends are left exposed. Care must be taken to install and seal the end fittings as soon as possible to prevent moisture accumulation. If moisture enters, the end must be cut off or dried out with a torch.
- **Metal-Clad Cable.**
  Metal-clad cable (Type MC) is permitted by the National Electrical Code for application in Class I, Division 2 locations.

  Use of this type of cable is not limited to any voltage class. The armor itself is available in various metals. When further protection from chemical attack is needed, a supplemental protective jacket may be used.

  The NEC also permits, under certain restrictions, a particular kind of metal-clad cable (MC-HL) to be used in Class I, Division 1 locations. This is detailed in 501.10(A)[1][cl]. Similarly, 501.10(A)[1][d] permits a certain type of Instrumentation Tray Cable (ITC-HL).

- **Tray Cable.**
  Power and control tray cable (Type TC) is permitted in Class I, Division 2 locations. It is a factory assembly of two or more insulated conductors with or without the grounding conductor under a nonmetallic sheath.

- **Other Permitted Cables.**
  In Class I, Division 2 locations, the NEC also recognizes the use of Type PLTC, similar to TC except the conductors are limited to No. 22 through No. 16; also Type MV, a single or multi-conductor solid dielectric insulated cable rated 2001 volts or higher. The NEC also permits Type ITC cable, as covered by Article 727, Instrumentation Tray Cable, which details its construction and use.

- **G. Cable Sealing.**
  In Class I, Division 1 locations the use of cable, except types MI, MC-HL and ITC-HL, is limited to installation in conduit.

  Multi-conductor cables that cannot transmit gases through the cores are sealed as single conductors; this type of cable, however, is not readily available. If a cable can transmit gases through its core, the outer jacket must be removed so that the sealing compound surrounds each individual insulated conductor and the jacket, or it can be sealed as a single conductor if the cable end in the enclosure is sealed by an approved means. SAMWHA epoxy is such a means.

  In Class I, Division 2 locations cables must be sealed where they enter enclosures required to be explosion-proof.

  In the case of extra-hard-usage flexible cord, SHF or SVF seals with appropriate cable terminators are recommended. If the cable core can transmit gases, the outer jacket must be removed so that the sealing compound surrounds each conductor to prevent the passage of gases.

  Cables without a gas-tight continuous sheath must be sealed at the boundary of the Division 2 and unclassified locations.

  If attached to equipment that may cause a pressure at a cable end, a sheathed cable that can transmit gases through its core must be sealed to prevent migration of gases into an unclassified area.

- **Nonmetallic Conduit**
  Under certain restrictions, in Class I, Division 2 locations, reinforced thermosetting resin conduit (RTRC) and Schedule 80 PVC conduit and associated fittings may be used.