

# Carlton® Expansion Fittings for PVC Rigid Nonmetallic Conduit

All construction materials expand and contract with fluctuations in temperature. These temperature changes affect polyvinyl chloride (PVC) more than traditional materials such as aluminum and steel. For example, the coefficient of thermal expansion for PVC ( $3.38 \times 10^{-5}$  in./in./°F) is almost three times as high as for aluminum and six times as high as for steel.

Thermal expansion and contraction have a significant effect on long straight runs of conduit. For this application, expansion fittings are used to accommodate changes in length. This prevents potentially harmful thermal stresses in the conduit itself or in any supporting structures.



## The National Electrical Code Requirements

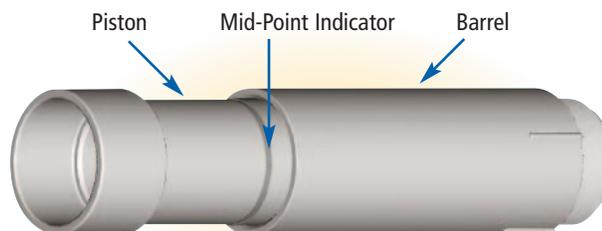
Section 352.44 of the National Electric Code® requires that expansion fittings be installed for rigid nonmetallic conduit to compensate for thermal expansion and contraction where the length change is anticipated to be 0.25 in. (6.36mm) or greater,

in accordance with Table 352.44 of the NEC, in a straight run between securely mounted items. Securely mounted items are boxes, cabinets, elbows, or other conduit terminations.

## When are expansion fittings used?

The importance of knowing when to use an expansion fitting is as important as knowing how to use an expansion fitting. Expansion fittings are used in aboveground installations where temperature changes are anticipated to exceed 25°F (14°C).

Expansion fittings are usually used where the straight run length is greater than 25 feet and expected temperature change is greater than 60°F. Rigid PVC conduit has a coefficient of expansion of  $3.38 \times 10^{-5}$  in./in./°F. A 10 foot length will change in length about 3/8" with a change in temperature of 100°F. This equates to more than 4 inches over a 100 foot run.



## When are expansion fittings used? *(continued)*

Changes in conduit temperature outdoors can exceed 140°F considering the heat of summer and cold of winter. This means a 100 foot run of conduit could change approximately 6 inches in length between summer and winter. If not compensated for with expansion fittings, this change in length can cause unsightly

conduit bowing, distorted boxes, or broken couplings or fittings. The anticipated expansion and contraction for various lengths of runs and temperature changes is given in Table 352.44 of the National Electric Code®. (See Table below)

### Expansion Characteristics of PVC Rigid Nonmetallic Conduit Coefficient of Thermal Expansion = $3.38 \times 10^{-5}$ in./in./°F

| Temperature Change in Degrees F | Length Change in Inches per 100 ft. of PVC Conduit | Temperature Change in Degrees F | Length Change in Inches per 100 ft. of PVC Conduit | Temperature Change in Degrees F | Length Change in Inches per 100 ft. of PVC Conduit | Temperature Change in Degrees F | Length Change in Inches per 100 ft. of PVC Conduit |
|---------------------------------|--|---------------------------------|--|---------------------------------|--|---------------------------------|--|
| 5                               | 0.2  | 55                              | 2.2  | 105                             | 4.2  | 155                             | 6.3  |
| 10                              | 0.4  | 60                              | 2.4  | 110                             | 4.5  | 160                             | 6.5  |
| 15                              | 0.6  | 65                              | 2.6  | 115                             | 4.7  | 165                             | 6.7  |
| 20                              | 0.8  | 70                              | 2.8  | 120                             | 4.9  | 170                             | 6.9  |
| 25                              | 1.0  | 75                              | 3.0  | 125                             | 5.1  | 175                             | 7.1  |
| 30                              | 1.2  | 80                              | 3.2  | 130                             | 5.3  | 180                             | 7.3  |
| 35                              | 1.4  | 85                              | 3.4  | 135                             | 5.5  | 185                             | 7.5  |
| 40                              | 1.6  | 90                              | 3.6  | 140                             | 5.7  | 190                             | 7.7  |
| 45                              | 1.8  | 95                              | 3.8  | 145                             | 5.9  | 195                             | 7.9  |
| 50                              | 1.8  | 100                             | 4.1  | 150                             | 6.1  | 200                             | 8.1  |

### For conduit installed outdoors,

the maximum and minimum air temperature expected can be used to calculate the range of expansion and contraction. Conduit installed outdoors in direct sunlight will be considerably hotter than air temperature during the day because of the absorption of the sun's heat.

Expansion fittings should be installed to allow for the anticipated temperature change. For direct sunlight exposure, add 30°F to ambient air temperature change.

### Where installed inside buildings,

the conduit temperature is the ambient air temperature plus the heat contributed by the conductors inside the conduit. Generally, expansion fittings are not required inside unless conduit is located in an area of

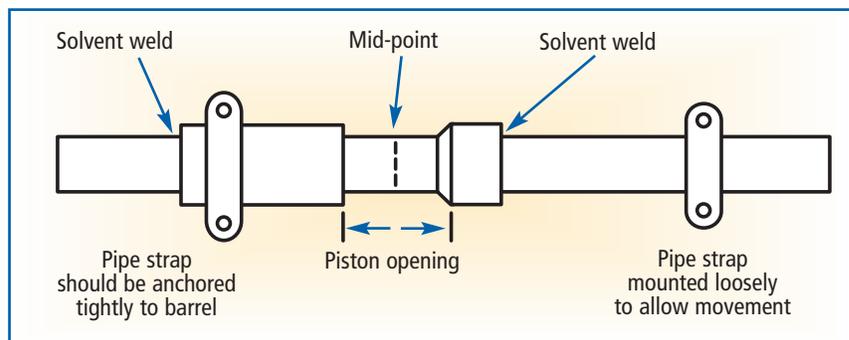
widely varying temperatures. Attics of buildings are areas where temperature swings exceeding 100°F are common and expansion fittings are required.

| Length of Run (Feet) | Inches of Expansion Allowance Needed for Temperature Changes of: |       |       |       |       |
|----------------------|--|-------|-------|-------|-------|
|                      | 60°F   | 80°F  | 100°F | 120°F | 140°F |
| 25                   | 5/8  | 3/4   | 1     | 1 1/4 | 1 3/8 |
| 50                   | 1 1/4  | 1 5/8 | 2     | 2 3/8 | 2 3/4 |
| 75                   | 1 3/4  | 2 3/8 | 3     | 3 1/2 | 4 1/8 |
| 100                  | 2 3/8  | 3 1/8 | 4     | 4 3/4 | 5 1/2 |
| 125                  | 3  | 4     | 5     | 6     | 7     |
| 150                  | 3 5/8  | 4 3/4 | 6     | 7 1/8 | 8 1/4 |

*Add 30°F to temperature change for direct sunlight exposure.*

## Proper Position

Expansion fittings are usually installed in a horizontal position. However, if they must be put in a vertical application, the open end should be securely fastened in the down position. The expansion fitting must be installed close to the top of the run with the barrel pointing down, so that rain water does not enter into the opening. The lower end of the conduit run should be secured at the bottom. This will result in an upward movement due to the length change caused by temperature variations.



## Setting Position of Piston

If an expansion fitting was installed completely closed with the piston bottomed on a cool day, there would be no travel available when the conduit warmed up and expanded. If it was installed in a maximum open position on a hot day, the expansion fitting would pull apart when cooled. Thus, "setting" the expansion fitting is very important.

In addition to the proper number and sizes of expansion fittings chosen, they must also be installed so they can accommodate the expected length change. This requires proper "setting" of the expansion fitting. Most will be installed at a temperature

halfway between maximum and minimum; for example, installation at 65°F with an anticipated maximum temperature of 125°F and a minimum of 5°F. In this case, the expansion fitting would be installed or set with the inner piston halfway out. Expansion fittings are marked with a mid-point. If it was a colder day, for example 35°F with the same expected temperature change range, the inner piston would be set with 1/4 of its maximum travel out. If the temperature was hot (95°F), it would be set with the inner piston only 3/4 way out.

# Setting Expansion Fitting for Temperature

|   |  |
|---|--|
| <p><b>A.</b> For medium temperature (65° - 75° F) set piston 1/2 way in barrel.</p> |  |
| <p><b>B.</b> For cold temperature (20° - 30° F) set piston 1/4 way in barrel.</p>   |  |
| <p><b>C.</b> For hot temperature (95° - 105° F) set piston 3/4 way in barrel.</p>   |  |

## When a more precise calculation for expansion is needed, it can be calculated as follows:

### Example 1:

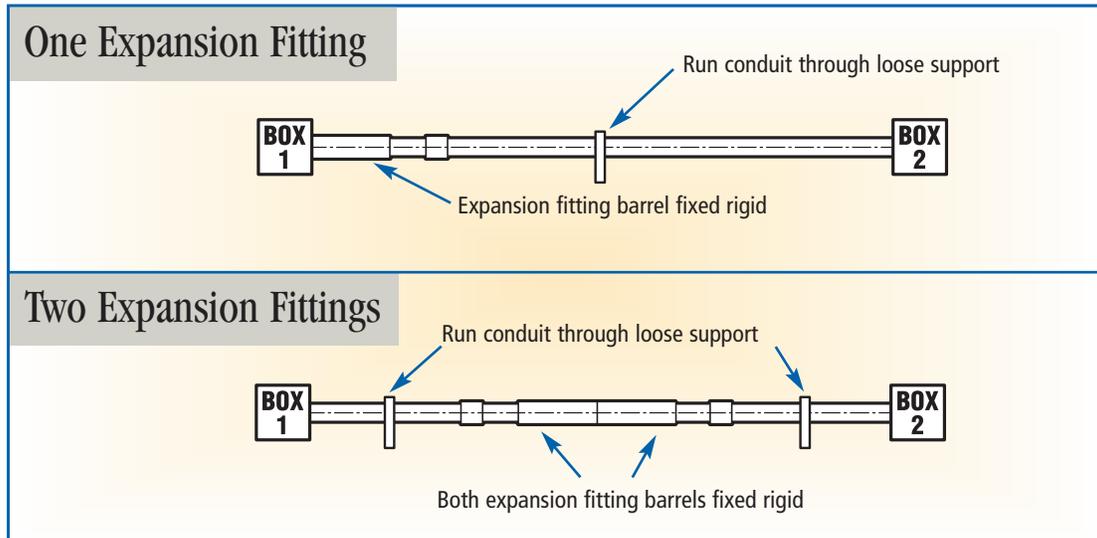
- You must determine the maximum temperature range. This is done by subtracting the lowest temperature you anticipate from the highest temperature you anticipate. Example: Let's say in winter, we expect the temperature to get down to -10°F and in the summer, we expect the temperature to get as high as 110°F. The maximum temperature range is  $110 - (-10) = 120^\circ\text{F}$ .
- The length of run between fixed points must be determined. Let's assume 90 feet for this example.
- The total expansion change can be calculated as follows:  
Total expansion change in inches = (coefficient of thermal expansion) x (maximum temperature range) x (length of run in inches).  
Example: Total expansion change =  $(3.38 \times 10^{-5} \text{ in./in./}^\circ\text{F}) \times (120^\circ\text{F}) \times (90\text{ft} \times 12\text{in./ft}) = 4.38 \text{ in.}$   
Thus, travel can be covered with one expansion fitting in Carlon trade sizes 2" through 6", which have an 8" travel, or two expansion fittings in Carlon trade sizes 1/2" through 1-1/2", which have a travel of 4".
- The "set position" can be determined from the following example.  
Example: If the temperature at installation was 65°F, the difference from maximum is  $110^\circ\text{F} - 65^\circ\text{F} = 45^\circ\text{F}$ . Use ratio:  $(\text{difference from maximum}) / (\text{Total expected range}) = 45/120 = .375 \text{ in.}$   
 $(.375) \times 8 \text{ inch travel} = 3 \text{ in.}$   
The piston at 65°F would retract 3 inches.

### Example 2:

- You must determine the maximum temperature range. This is done by subtracting the lowest temperature you anticipate from the highest temperature you anticipate. Example: Let's say in winter, we expect the temperature to get down to 20°F and in the summer, we expect the temperature to get as high as 100°F. The maximum temperature range is  $100 - 20 = 80^\circ\text{F}$ .
- The length of run between fixed points must be determined. Let's assume 90 feet for this example.
- The total expansion change can be calculated as follows:  
Total expansion change in inches = (coefficient of thermal expansion) x (maximum temperature range) x (length of run in inches).  
Example: Total expansion change =  $(3.38 \times 10^{-5} \text{ in./in./}^\circ\text{F}) \times (80^\circ\text{F}) \times (90\text{ft} \times 12\text{in./ft}) = 2.92 \text{ in.}$   
Thus, travel can be covered with one expansion fitting.
- The "set position" can be determined from the following example.  
Example: If the temperature at installation was 65°F, the difference from maximum is  $100^\circ\text{F} - 65^\circ\text{F} = 35^\circ\text{F}$ .  
Use ratio:  $(\text{difference from maximum}) / (\text{Total expected range}) = 35/80 = .4375 \text{ in.}$   
 $(.4375) \times 4 \text{ inch travel} = 1.75 \text{ in.}$  or  $(.4375 \times 8 \text{ inch travel}) = 3.5 \text{ inches}$   
The piston at 65°F would retract 1.75 inches for Carlon trade sizes 1/2" through 1-1/2" or 3.5 inches for Carlon trade sizes 2" through 6.

# Installation

1. The expansion fitting should be mounted so that the piston can travel in a straight line within the barrel. If alignment is not straight, the piston will bind and prevent the fitting from working properly.
2. The expansion fitting barrel must be clamped securely whereas the conduit is mounted loosely so that it can slide freely during expansion and contraction.
3. Nonmetallic conduit straps suitable for this purpose, must be used to allow the conduit to move freely during expansion and contraction while properly securing it.



## Location

Proper placement and installation of expansion fittings and conduit allow for correct functioning of the expansion fittings. For example, if one expansion fitting is needed between two boxes, the barrel of the fitting must be securely fastened close to one box. The conduit must be fastened loosely so as to allow for movement during expansion and contraction.

If there is more than one expansion fitting used, then fittings are installed at the boxes with the center of the conduit run rigidly fixed. With two expansion fittings utilized, the center of

the conduit must be fixed so as to properly proportion expansion or contraction between the two fittings. Otherwise, the expansion or contraction would only occur at the free fitting, while the tighter fitting would not move.

In a very long run, two or more fittings should be placed in series with one another. The barrels of each expansion fitting must be anchored so as to allow each length of conduit to expand or contract freely. Each section acts independently.

## Use of Expansion Fittings Where Concrete Encased or Direct Buried

In normal circumstances, expansion fittings are not needed with concrete encased nonmetallic conduit since the movement of the conduit will coincide with the expansion and contraction of the concrete. The only place where an expansion fitting would be utilized is where the concrete itself has an expansion joint.

In direct burial situations, expansion fittings are not needed because the ground has relatively constant temperatures. In cold areas, buried lines must be below the frost line to prevent buckling during freezing and thawing cycles. In warmer areas, the depth of cover protects against temperature extremes.

## Most Common Mistake

The most common error is not using enough expansion fittings. When in doubt, use an additional expansion fitting. It is much more difficult and costly to insert an expansion fitting once wiring has been set up and in service.

## Wire Inside the Conduit

The coefficient of expansion for the wire inside the conduit is much lower than the nonmetallic conduit, therefore its length change due to expansion and contraction is very little. If the expansion fittings are mounted correctly, there should be little concern as to its effect on the wires inside.

# Carlon Expansion Fittings



| Coupling End Part No. | Male Terminal Adapter End Part No. | Size  | Std. Ctn. Qty. | Travel Length (in.) |
|-----------------------|------------------------------------|-------|----------------|---------------------|
| E945D                 | E945DX                             | 1/2   | 20             | 4"                  |
| E945E                 | E945EX                             | 3/4   | 15             | 4"                  |
| E945F                 | E945FX                             | 1     | 10             | 4"                  |
| E945G                 | E945GX                             | 1 1/4 | 5              | 4"                  |
| E945H                 | E945HX                             | 1 1/2 | 5              | 4"                  |
| E945J                 | E945JX                             | 2     | 15             | 8"                  |
| E945K                 | E945KX                             | 2 1/2 | 10             | 8"                  |
| E945L                 | E945LX                             | 3     | 10             | 8"                  |
| E945M                 | E945MX                             | 3 1/2 | 5              | 8"                  |
| E945N                 | E945NX                             | 4     | 5              | 8"                  |
| E945P                 | E945PX                             | 5     | 1              | 8"                  |
| E945R                 | E945RX                             | 6     | 1              | 8"                  |

**Carlon Exclusive**



**Male Terminal Adapter End**



**Coupling End**

**Carlon**<sup>®</sup>  
LAMSON & SESSIONS