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Technical Resources Bulletin

To: SMACNA Members
SMACNA Chapter Executives

From: Technical Resources Department

Subject: **Tie Rods for Internal Reinforcement**

Introduction

A tie rod is an internal reinforcement typically used in rectangular duct or flat oval duct at joints and midpanels. Tie rods can be used with external reinforcement or as a standalone internal reinforcement. Smaller reinforcements than would otherwise be required can be used when a tie rod is placed in the duct so as to lock reinforcements on opposite sides together. Where external intermediate reinforcement is typically done with angles, channels, zees, or hat sections (see Table 2-29 of the *SMACNA HVAC Duct Construction Standards – Metal and Flexible, Fourth Edition* [HVAC-DCS]) or using any number of transverse reinforcement joints (Table 2-31 of the HVAC-DCS), tie rods are internal reinforcements that can be used to supplement external joint reinforcement or be used as midpanel/intermediate reinforcements.

Many designers have questions about the use of tie rods, such as:

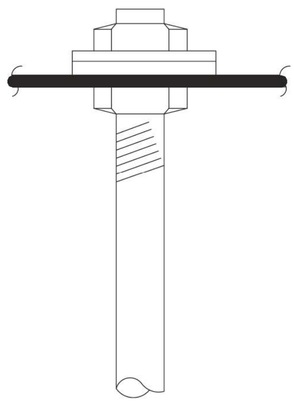
- What types of tie rods are acceptable?
- When can I use tie rods?
- How many tie rods are required?
- How are tie rods attached?
- Can I use them for positive and negative pressures?
- How are the tie rod loads determined and what are the tie rod capacities?
- Can the duct gage be smaller if I use tie rods?
- How are tie rods used at joints?
- How are tie rods used for midpanel reinforcement?
- Are there TDF/TDC tables that include tie rod internal reinforcements?
- How are tie rods used with fittings?
- How are tie rods used in double-wall duct?
- What tables are available to help select tie rods?
- How are tie rod pressure losses calculated?
- Do tie rods generate noise?

This paper answers those questions, but for additional information, see the HVAC-DCS.

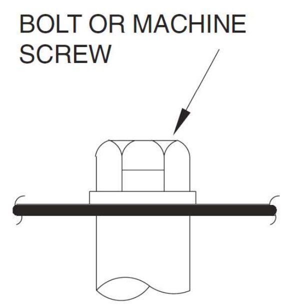
<u>What Types of Tie Rods Are Acceptable?</u>

Figures 2-5 and 2-6 of the HVAC-DCS show the type of tie rods that are acceptable and how they can be attached to the inner walls of the duct. One common tie rod is a rod that is partially threaded or fully threaded (all-thread) with internal and external nuts. Another common tie rod is made from EMT conduit with a threaded insert that is secured with a bolt or machine screw. See the figures below. Both of these can be used for positive or negative pressures.

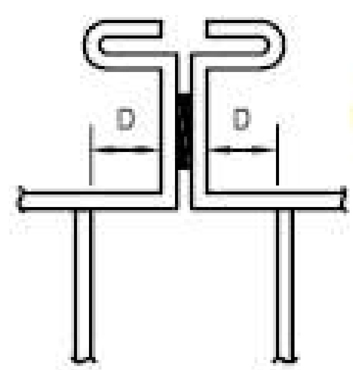
There are several other alternative types of tie rods as well. For positive pressure, the options include ½" rigid conduit (RC) and 1 in. x ¼ in. strap. For negative pressure, the alternatives also include rigid conduit, tubing, pipe or angles. Tie rods can be attached by welding, bolting, riveting, or screwing within one inch of each side of the joint. Tie rods should be galvanized steel or made of a material having the same nature and corrosion resistance as the duct wall material. There are other limitations. See Section 2.5 Tie Rod Installations, in the HVAC-DCS for additional information.



ROD WITH INTERNAL AND EXTERNAL NUTS



TUBING OR CONDUIT WITH MALE OR FEMALE THREADED INSERTS



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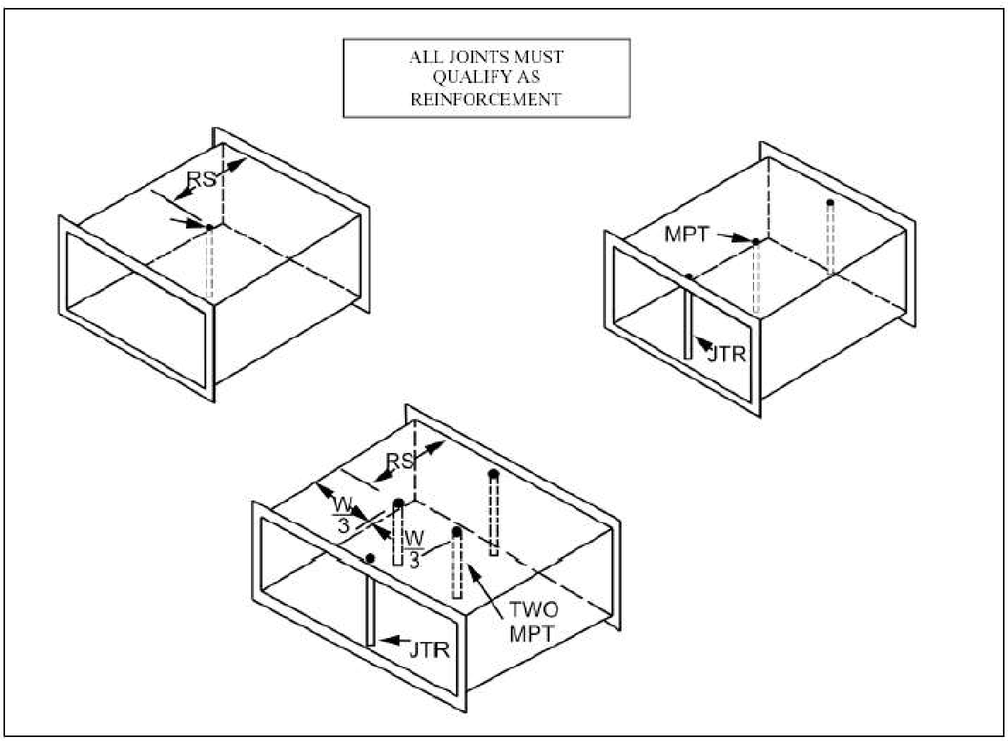
When Can I Use Tie Rods for Rectangular Duct?

Tie rods can be used to reinforce T-3, T-6a, T-8a, T-14, T-16, T-21, T-4 and T-25 joints. The T-25 joints are the TDC and TDF that have become very common in the industry. TDC/TDF gage/reinforcement tables were developed and are included in Table 2-8 through Table 2-28 for 4 ft, 5ft and 6 ft joint spacing. These tables include tie rod options at the joint (JTR) and at midpanel (MPT) spacing. They also have external reinforcement at the joint and midspan options. The tie rods (JTR) and connection at the joint must be able to withstand 75% of the pressure class load that is based on the reinforcement spacing. Table 2-34 of the HVAC-DCS gives you the pressure class loads in lbs. based on widths of 48 in. to 120 in., reinforcement spacings of 2, 2.5, 3, 4, and 6 ft, and for pressures from ½ in. wg to 10 in. wg.

The midpanel tie rods (MPT) that do not include external reinforcement at the midspan must be able to withstand the full load. If there are more than one MPT in the cross section, the load can be distributed proportionally. MPT should not be used for widths greater than 96 in. Table 2-41 is the midpanel tie rod (MPT) reinforcement schedule, good for +/- 6 in. wg and can be used for 26 ga though 16 ga metal thickness. It tells you how many MPTs are required in a cross-section, which is either none, 1 or 2. Up to 96-inch widths you should never need more than two MPTs. Table 2-46 gives the full design load in lbs. based on widths up to 96 in. and reinforcement spacings of 20 in. to 36 in. Remember, if there are two MPTs each of them only needs to withstand half the load but they should be spaced evenly in the cross section (halfway for one tie rod and one third from each side for two tie rods).



IF tie rods are required in both directions, they either need to be fixed if they touch or not touch each other, so that they do not rattle while air is flowing by them.

Fittings are reinforced like sections of straight duct.

Allowable Loads for Tie Rods

For positive pressure tie rods where the tie rods are in tension, the allowable tie rod loads are based on for the respective tie rod type:

- For rods (partially or fully threaded) use Table 2-35
- Use ½ in RC conduit
- For EMT conduit, ½ in. diameter is good up to 900 lbs., ¾ in. diameter is good up to 1340 lbs., and 1 in. diameter is good up to 1980 lbs.

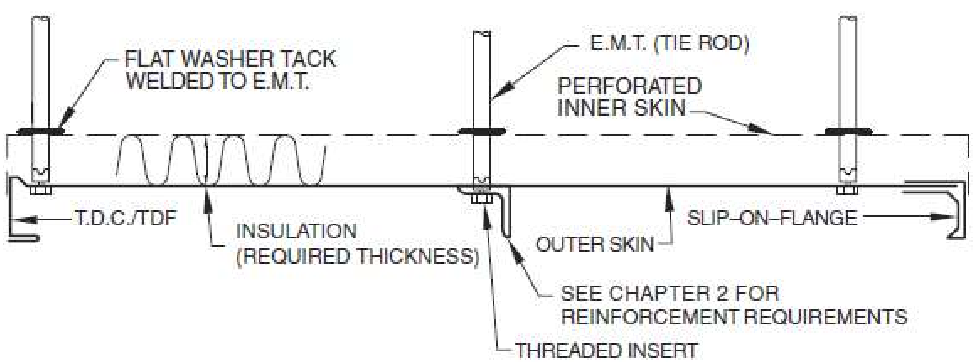
For negative pressure where the tie rods are under compression, the selection is based on both the tie rod length and the tie rod load. These are more limited than tie rods under tension. For:

- Rods, use Table 2-36 (limited to 42 in. lengths)
- RC Conduit, use Table 2-37
- EMT Conduit, use Table 2-38
- Steel Pipe, use Table 2-39
- Angles as Columns, use Table 2-40

All of these tables are in the HVAC-DCS. Make sure that you read the notes to the tables for correct usage, limitations, and other information.

Using Tie Rods for Double-Wall Rectangular Duct

Double-wall rectangular duct construction is discussed in Chapter 8 of the HVAC-DCS. It is important to remember that for double-wall duct, the outer shell is the structural (pressure) shell. The inner shell is typically perforated metal, which allows sound to be attenuated. So, the outer shell dimensions and pressure class are used to determine the gage/reinforcements. Figure 8-14 details how EMT conduit is attached, as shown below:



DUCTS REQUIRING TIE RODS

When Can I Use Tie Rods for Flat Oval Duct?

Flat Oval Gage/Reinforcement is covered in Section 3.3 and 3.4 of the HVAC-DCS. For longitudinal flat oval duct, the minimum gage for positive pressure to 10 in. wg is found in Table 3-15 based on the major dimension. The reinforcement options are the same as what is in the standard rectangular tables, Table 2-1 through Table 2-7, based on the reinforcement spacing.

SMACNA does not have designs for longitudinal flat oval duct under negative pressure. The tables for flat oval spiral duct, Table 3-16 through Table 3-22, include gage/reinforcement options for both positive and negative pressures. In Table 3-16 (½ in. w.g. +/-) through Table 3-21 (6 in. w.g. +/-) there are options for tie rods as well as external reinforcement. Note that these tables are for up to 30 in. minor dimensions. Like rectangular, the option may be for none, 1 or 2 tie rods and the loading is calculated the same way as rectangular, with the major dimension used in Table 2-36 for full loads.

When Should I *Not* Use Tie Rods?

In general, tie rods should not be used under the following conditions, although there could be exceptions. See Section 2.7 of the HVAC-DCS.

- Duct outside of buildings if the ducts do not have waterproof external insulation or waterproof and corrosion resistant wall penetrations
- Where condensation of grease could collect
- Underground in slab or under slab
- In fittings on non-parallel duct side
- When the air velocity exceeds 2500 fpm

If tie rods are used for ducts outside of buildings, they should be sealed so that weather cannot penetrate into the duct where they are attached. They should not be used for grease duct where there would be penetration into the duct walls and it is a good idea not to use them in grease ducts at all where grease can accumulate.

The pressure loss of tie rods can potentially generate undesirable noise when velocities are above 2500 fpm. However, if the noise levels are already loud due to the surrounding environment and the generated noise of the tie rod will not increase the surrounding noise (that is, the surrounding noise is 10 dBs louder than the generated noise of the tie rods) then use of tie rods could be considered. See the section of Pressure Drops and Generated Noise, below. Do not use more tie rods than necessary. They can cause additional pressure losses and generated noise.

Pressure Drops Caused by Tie Rods

Research and existing information on tie rods indicate the loss coefficient will be about 0.02 to less than 0.07. The determination of the loss coefficient of less than 0.07 comes from the *SMACNA HVAC Systems Duct Design* manual, Table A-15H Obstruction, Smooth Cylinder in Round and Rectangular Ducts. The loss coefficient would likely be less than 0.07 even for a 2-inch diameter tie rod. This is based on a blockage factor of 0.05 or less.

If the loss coefficient is 0.07, the pressure drops would be:

- 1000 fpm, 0.004 in. wg
- 1500 fpm, 0.010 in. wg
- 2000 fpm, 0.017 in. wg
- 2500 fpm, 0.027 in. wg

So even at 2500 fpm, there is less than 0.03 in. wg pressure loss. Now of course these are additive in the design leg so they should be accounted for, but they only add a minimal amount of pressure drop to the system, especially for ½" tie rods, where research shows the loss coefficient may be less than 0.02.

<u>Generated Noise Caused by Tie Rods</u>

In general, pressure losses can create noise. The pressure loss is a function of the fitting or obstruction's loss coefficient and velocity pressure. Some fittings or obstructions may have large loss coefficients and are more prone to generate noise. The *SMACNA HVAC Sound and Vibration Manual* has data and equations to estimate generated noise in transitions, branches, tees, dampers and other components. Usually, it is not a problem if velocities do not exceed 2500 fpm.

We will continue to research on additional criteria as it applies to noise generated by tie rods, but we know the loss coefficients are relatively small compared to other duct components. Research by United McGill Corporation shows the generated noise level (GNL) as compared to bare duct:

	63 Hz	**125 Hz**	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**
Bare Duct	38	35	34	37	34	28	(20)	(20)
With One Tie Rod	48	42	40	41	38	31	35	36

From United McGill Corporation for 24 in. x 24 in., 18 ga, Rectangular Duct at 1500 fpm.
Engineering Report No. 157 Internal Tie-Rod Reinforcement for Rectangular Duct, 6/94

The bare duct is about an NC Level of 35 while the duct with one tie rod is about NC 39. Usually though the fan noise dominates and has to be attenuated, which is much higher than the noise that the tie rod generates.

<u>Summary</u>

Tie rods can be an economical alternative to external reinforcement when used properly. The HVAC-DCS explains in detail when and how to use them, as discussed in this paper. Using the right amount of tie rods at velocities of 2500 fpm or less, will produce high quality ductwork gage/reinforcement.

Although the pressure drop and generated noise levels should not be a problem, more research may help us understand their proper utilization. Data researched to date has been on a single tie rod in a section. We need to study what happens when the midspan has one or two tie rods, along with the joint having a tie rod or none, and how the tie rod diameters affect the loss coefficient and the pressure loss. The research should also measure and compare the generated noise levels of tie rods based on the pressure losses.

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References

HVAC Duct Construction Standards – Metal and Flexible, Fourth Edition, 2020, Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA

HVAC Systems Duct Design, Fourth Edition, 2006, Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA

HVAC Sound and Vibration Manual, First Edition, 2004, Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA

Engineering Report No. 156 Internal Tie-Rod Reinforcement for Flat Oval Duct 5/94, United McGill Corporation, Groveport, OH

Engineering Report No. 157 Internal Tie-Rod Reinforcement for Rectangular Duct 6/94, United McGill Corporation, Groveport, OH

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