Vibration Isolation and Seismic Control Manufacturer's Association
994 Old Eagle School Road -- Suite 1019
Wayne, PA 19087-1866
www.viscma.com

General Guidance on the Use of Rod Stiffeners when Seismically Restraining Pipe, Duct, or Electrical Distribution Systems

Introduction

In mechanical, electrical, and plumbing distribution systems, hanger rods are used to provide the vertical (dead) load support, making the primary force imposed on them a tension force. However, when cables or rigid brace members are used to provide restraint against seismic forces, the hanger rods at the brace locations can be loaded with a net compression force, which, if large enough, can cause the hanger rod to fail. This guide will discuss how the net compression load is developed because of the seismic bracing device, as well provide a simple table to help determine when rod stiffeners are necessary when seismic bracing is utilized.

Compression Load on Rod

The compression force that a hanger rod experiences comes from the vertical component of the tension load on the brace. During a seismic event, the floor above the braced system begins to move in response to the motion of the soil & foundation of the building. As it moves, everything attached to it must "hang on for the ride", and the acceleration produced by this movement develops a design force on the distributed system (Fp in the diagram below). This load is then resisted by the brace device, which is typically attached to the floor or roof system above. Because the brace device goes back up at an angle and is engaged in tension, the rod now must keep the system level to counter the vertical component of the brace. Depending on the weight & geometry of the distributed system as well as the strength of the earthquake, the rod may undergo a net compression force, which if strong enough, may cause the rod to buckle. Rods are slender (i.e. small cross section) and given the right length and a large enough axial compression force, the rod will fail by buckling (i.e. bowing outward).

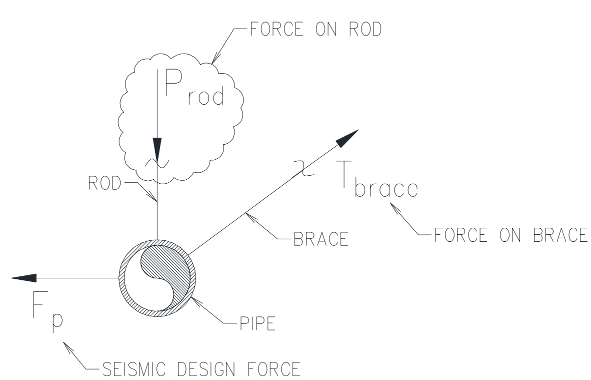

Figure 1

Why Rod Stiffeners Are Needed

Rod stiffeners are necessary to counter this buckling phenomenon. They succeed in doing this by stabilizing the rod over its length by effectively creating several shorter "rods" in series or reducing its "effective length". In other words, they reduce the ratio of the rod's cross-sectional diameter to its length, thus increasing its axial compression capacity. See **Figure 2** below for visual explanation of what rod stiffeners do to a rod.

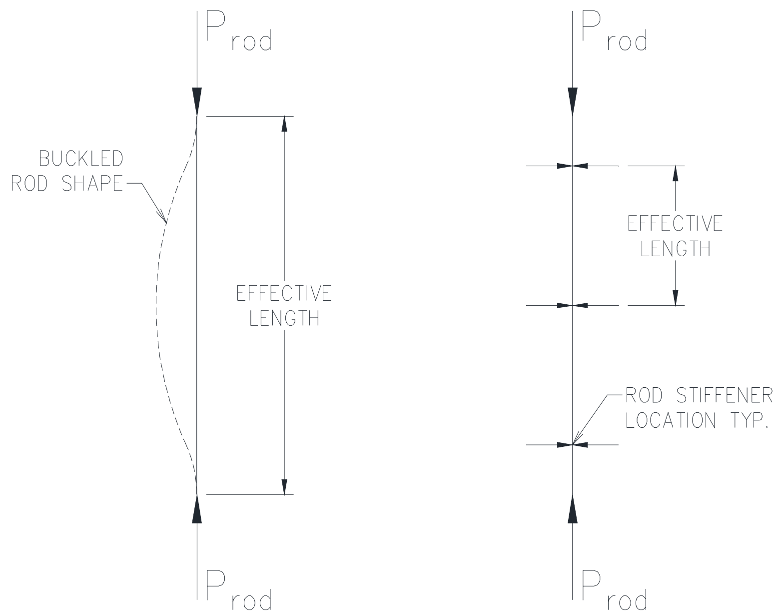

Figure 2

Rod Stiffener Guidelines

Building Codes (and their referenced design standards) have force development equations that account for a variety of factors to determine the seismic design force of a given distribution system. For this guide, the 2018 International Building Code in conjunction with the ASCE 7-16 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures) is used, along with the following basic assumptions that covers most distribution system conditions:

- The system or systems in question are braced with cable or rigid brace arms.
- Systems are supported with hanger rods directly attached to the structure above without a vibration isolation device. The hanger rods are assumed as being 36" long at maximum from the point it's attached to the structure to the point it's connected to the system.

- Pipe is constructed of high deformability materials (steel or copper) and assembled with welding/brazing, threaded or bolted connections, or with grooved couplings and is in accordance with ASME B31 Standard.
- Duct is constructed of high deformability materials (cold formed steel i.e. sheet metal) and is assembled with welding, fasteners, or other industry standard method of construction.

Since seismic criteria varies widely from jobsite to jobsite, this guide utilizes the Short Period Design Spectral Acceleration (S_{DS}) as the value to use to determine if rod stiffeners are required or not. For each following table, the threshold value of S_{DS} is listed for a given distribution size and/or weight. If the project S_{DS} value is equal to or exceeds the threshold values shown and the system meets the aforementioned general assumptions, rod stiffeners should be used. Typically, the S_{DS} value is listed explicitly in the first few sheets of the Structural Plans under "Design Criteria" or "Seismic Design Criteria". If it is not possible to determine the S_{DS} value, or the system does not fit the general assumptions, contact the EOR who designed the bracing system for the pipe/duct/conduit.

Pipe Systems

Minimum Value of S_{DS} to Use Rod Stiffeners									
	ATR	Seismic Brace Spacing in Feet							
Pipe Size	Dia.[2]	5'	10'	15'	20'	25'	30'	35'	40'
1-1/4" to 2"	3/8"	3.00	2.94	2.26	1.83	1.54	1.33	1.17	1.05
2-1/2" & 3"	1/2"	3.00	3.00	3.00	2.57	2.16	1.87	1.64	1.47
4" & 5"	5/8"	3.00	3.00	3.00	2.97	2.50	2.16	1.90	1.69
6"	3/4"	3.00	3.00	3.00	3.00	3.00	3.00	2.80	2.50
8" to 12"	7/8"	3.00	3.00	3.00	2.79	2.35	2.03	1.79	1.60

1. Pipe is single hung (i.e. 1 pipe per rod hanger support).
2. All threaded rod (ATR) used is minimum A36 carbon steel (Fy = 36,000 psi).

Electrical Conduit

Minimum Value of S_{DS} to Use Rod Stiffeners							
Conduit Size	ATR Dia.[2]	Seismic Brace Spacing in Feet					
		5'	10'	15'	20'	25'	30'
1-1/4" to 2"	3/8"	3.00	3.00	2.98	2.42	2.04	1.76
2-1/2" to 3-1/2"	1/2"	3.00	3.00	3.00	2.75	2.32	2.00
4" & 5"	5/8"	3.00	3.00	3.00	2.97	2.50	2.16
6"	3/4"	3.00	3.00	3.00	3.00	3.00	3.00

1. Conduit is single hung (i.e. 1 conduit per rod hanger support).
2. All threaded rod (ATR) used is minimum A36 carbon steel (Fy = 36,000 psi).

Rectangular Duct

Minimum Value of S_{DS} to Use Rod Stiffeners								
Duct Linear Weight (lb/ft)	ATR Dia.[2]	Height to Width Ratio (H/D)	Seismic Brace Spacing in Feet					
			5'	10'	15'	20'	25'	30'
30	3/8"	0.5	2.26	1.49	1.11	0.88	0.74	0.63
		1.0	2.86	2.06	1.61	1.32	1.12	0.97
		1.5	3.00	3.00	2.92	2.59	2.33	2.12
60	1/2"	0.5	2.82	1.86	1.39	1.10	0.92	0.79
		1.0	3.00	2.57	2.01	1.65	1.40	1.21
		1.5	3.00	3.00	3.00	3.00	2.91	2.64
100	5/8"	0.5	3.00	2.34	1.75	1.39	1.16	0.99
		1.0	3.00	3.00	2.53	2.07	1.76	1.53
		1.5	3.00	3.00	3.00	3.00	3.00	3.00

1. Duct is trapeze hung (2 rods per support point) and braced at the top.
2. All threaded rod (ATR) used is minimum A36 carbon steel (Fy = 36,000 psi).

Round Duct

Minimum Value of S_{DS} to Use Rod Stiffeners							
Duct Linear Weight (lb/ft)	ATR Dia.[2]	Seismic Brace Spacing in Feet					
		5'	10'	15'	20'	25'	30'
30	3/8"	1.87	1.17	0.85	0.67	0.55	0.47
60	1/2"	2.33	1.46	1.06	0.83	0.68	0.58
100	5/8"	2.94	1.83	1.33	1.05	0.86	0.73

1. Duct is hung with 2 rods at each support point and braced at its center of gravity.
2. All threaded rod (ATR) used is minimum A36 carbon steel (Fy = 36,000 psi).

VISCMA is a non-profit association representing the manufacturers of seismic restraint, vibration isolation and noise control equipment. The primary objectives of the organization are to educate the construction industry on the proper use and application of vibration isolation and seismic restraint and to develop standards to continually improve the industry.

In partnership with FEMA and ASCE, VISCMA also publishes three Seismic Installation and Inspection Manuals designed to assist field personnel.

The association office is located at 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087-1866 and can be reached at 610-971-4850 or info@viscma.com.