PRACTICAL GUIDANCE FOR SEISMICALLY RESTRAINING PIPING AND DUCTWORK

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1. INTRODUCTION

While seemingly simple, the wide range of factors that comes into play when adding restraints to hanging pipe and ductwork makes this the most difficult and misunderstood seismic task that mechanical contractors have to face. The requirements vary significantly with size, application, location in the structure, mounting arrangement and building use.

In practice, piping and ductwork is commonly re-routed from the initial design path. Other components compete for space, significant structure to which to attach it is unavailable and access is difficult. The net result is that the individual doing the installation does not have a clear "road map" to apply. He needs to understand fully what he is trying to accomplish so as to be able to devise workable solutions to each problem that comes up.

The focus here is on problem issues most frequently encountered in the field. Offered are suggestions as to how to address them as well as strategies to avoid the need for restraint, selecting, sizing and placing them as well as dealing with tight spaces.

2. WHERE ARE RESTRAINTS REQUIRED?

The 1995 NBC is currently the master code driving seismic issues in Canada. Although it is due to be replaced in 2005 with an "Objective" based code, this has not yet been finalized and for the purpose of this discussion, the 1995 code will be referenced.

Within the Code, Chapter 4 addresses Structural issues and section 4.1.9 offers guidance with respect to seismic design. In addition, the current addendum to the 95 NBC references NFPA 13 1999 as the appropriate standard for Fire Piping. To the best of my knowledge, there are no exclusions listed in the NBC code for small pieces if equipment, pipes, ducts or special conditions. The SMACNA design standard has however, been historically accepted in both the United States and Canada as a sufficient design standard. It does carry with it some exceptions that have been universally applied. Drawing from SMACNA, the following piping and ductwork does not require restraint as long as the likely swinging motion of these components will not damage the components themselves or through impact, will not result in damage to other components.

SMACNA Exemptions

Piping: All non-hazardous piping under 2-1/2 in. dia
All non-hazardous piping in mech rooms 1 in. dia and smaller.
All piping runs suspended on hanger rods 12 in. or less in length

Ducts: All ducts under 6 sq ft in. area
All duct runs suspended on hanger rods 12 in. or less in length

(Note: Multiple trapeze mounted pipes or ducts where the summed weight equals the above are also exempted.)

NFPA Piping Exemptions

Lateral Braces for all branch lines under 2-1/2 in. dia
Lateral Braces for all piping runs suspended on hanger rods 6 in. or less in length

3. ADHERENCE TO THE 12 IN. OR 6 IN. RULES

If installing a system tight to the ceiling to take advantage of the 6 or 12 in. hanger exclusion rule, the dimension is measured from the top of the pipe or duct if it is individually supported on a hanger. If supported by a trapeze bar or at its centerline, the dimension to the support point is used. The top of the hanger rod is at its connection to the structure. All supports for a given run of pipe or duct must comply to use the 12 in. rule.

An additional requirement of the 6 or 12 in. rule is that the hanger rod must include a non-moment generating (free-swinging) connection to the structure. This is to allow the pipe or duct to swing without stressing the hanger rod. A swivel, a cable or an isolation hanger can accomplish this function. If using an isolation hanger, a vertical limit stop must be positioned on the hanger rod just below the isolator housing so that when subjected to an uplift load, the limit stop will come into contact with the isolator housing and prevent significant upward motion of the rod. For a strap-supported duct, a half twist in the strap will usually allow the duct to swing freely in all directions.

4. PROS AND CONS OF STRUTS VS CABLES

In general, piping restrained by struts will require only 1 strut per restraint location while piping restrained with cables requires that 2 cables be fitted forming an "X" or a "V". As a trade-off, the number of restraint points needed on a run of piping or duct will typically be considerably higher for a strut-restrained system than for the cable-restrained system. As a rule, strut-restrained systems will be more costly to install.

The obvious advantage to struts is that, when space is at a premium, cables angling up to the ceiling on each side of a run may take more space than is available. Struts can be fitted to one side only, allowing a more narrow packaging arrangement. As struts can be loaded in compression however, they impact the tensile forces in hanger rods. This often requires the hanger rod size and its anchorage to be upsized.

The advantages of cables are numerous. First, they can usually be spaced less frequently along a pipe than can struts. Second, they cannot increase the tensile forces in the hanger rod, so rod and rod anchorage capacities are not impacted. Third, they are easily set to the proper length. And fourth, they are well suited to isolated piping applications.

5. MIXING CABLE AND STRUTS

Within a run, cables and struts cannot be mixed. This is because the relative stiffness of the two restraint methods are significantly different and in mixed systems, the stiffer strut components will absorb an excessive amount of the load and fail prematurely.

6. RESTRAINT SPACING AND COMPONENTRY SELECTION

There are many factors that can impact the restraint spacing. The primary factor is the buckling capacity of the pipe or duct and this varies with the relationship between its weight and its stiffness. The spacing also varies with the magnitude of the force applied. For added safety, this spacing must be cut in half for hazardous or life safety systems.

The spacing is also controlled by the capacity of the restraint device or anchorage. In many cases, especially those involving struts, practical limits for the restraint system components reduce the allowable spacing between restraints.

Tables are available from SMACNA or from the various providers of these types of systems that list the allowed axial and lateral restraint spacing by pipe or duct size, components used and ground acceleration. Because of the inter-relationship between the tabulations and the components, extreme caution must be used to ensure that components and tabulations are not mismatched.

7. DEALING WITH TIGHT SPACES

Most projects involve areas where space is at a premium and access is poor. An awareness that there are many equivalents to the classic "_/" cable or "_/" strut arrangement can often offer a solution to these issues. While there are far too many to include here, below are illustrated several equivalent restraint arrangements for ducts.

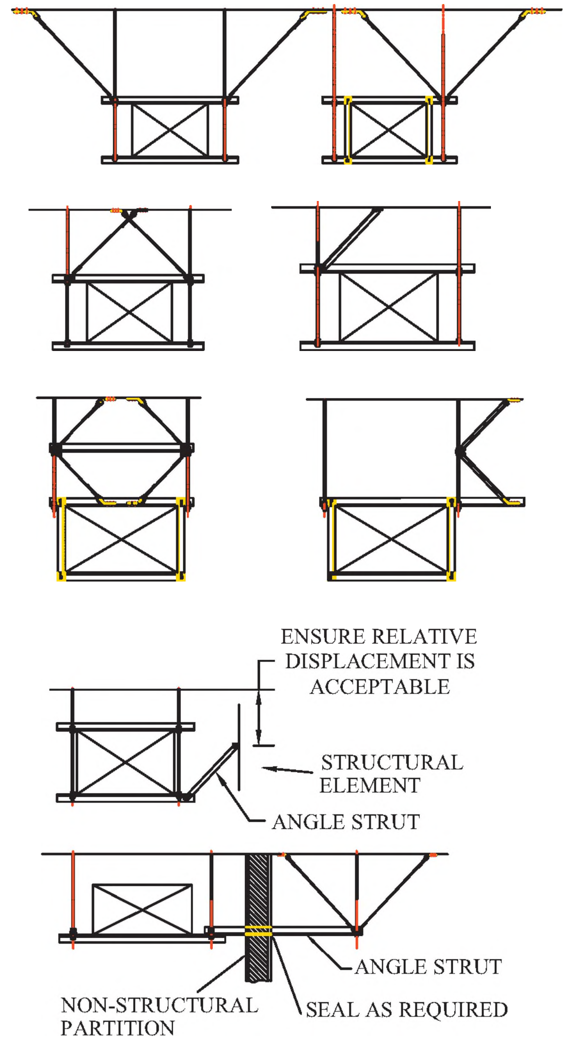

Figure 1

REFERENCES

Kinetics Noise Control Seismic Design Manual (2004)

NFPA*(National Fire Protection Association)* Standard 13 Installation of Sprinkler Systems (1999 Edition)

NRC-CNRC National Building Code (1995 + Addenda)

SMACNA*(Sheet Metal and Air Conditioning Contractors National Association)* Seismic Restraint Manual (1998)