ZetaQuest Rohr Damper Manual

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Introduction

ZetaQuest Technologies, LLC manufactures and sells vibration damping hardware for a variety of applications for the purpose of reducing vibration amplification due to natural frequencies. The products include Starr and Rohr product lines.

The Starr product is a viscous damping device in a cylindrical arrangement with connections on other end that can be adjusted to fit between the vibrating component and a rigid tie point. These products can provide significant vibration damping as well as some dynamic stiffness although having no static stiffness so that static pipe stress is not impacted due to application of the Starr damper product. These products are particularly effective at 30 Hz and lower frequencies.

The Rohr product is an optimally tuned dynamic vibration absorber. The product line includes devices with moving mass range from 1.5 lb to 50 lb. The Rohr product is used as an attachment to the vibrating structure using a variety of mounting hardware options. The design functions well with the damper mass being about 15% of the modal mass (moving mass) of the vibrating structure and with the device tuned for the natural frequency on the structure. These devices are very effective for about 20 Hz and higher with common applications in the 240 Hz or higher range.

Rohr Damper

ZetaQuest developed the Rohr damper (patent pending) to assist with vibration control on resonant mechanical systems when operating near resonance. The Rohr can easily be mounted onto a variety of structures with piping and tubing being one of the common uses. Although the devices can be used on any mechanical system that is resonant, the following documentation details the use for piping systems.

The Rohr product model numbers are as follows:

Rohr XX.X – YY.Y

- YY.Y: Target Frequency in Hz
- XX.X: Internal Damper Mass, Lb

The dampers are available in a wide range of target frequencies, with stock frequencies being from 21.2 Hz to 295 Hz. The damper sizes currently available include 1.5 Lb, 5 Lb, 20Lb, and 50 Lb damper masses. The 1.5 Lb damper part numbers are detailed in table 1. The 1.5 Lb line is available for the full frequency range. The 5 and 20 Lb is available up to 120 Hz with higher frequency devices in development. The 50.0 Lb line is currently built to order.

Table 1 - Rohr Damper Part Numbers

Target Frequency	1.5 Lb Part Number	5 Lb Part Number	20 Lb Part Number	50 Lb Part Number
21.2 Hz	Rohr 1.5-21.2	Rohr 5-21.2	Rohr 20-21.2	
30 Hz	Rohr 1.5-30	Rohr 5-30	Rohr 20-30	
42.4 Hz	Rohr 1.5-42.4	Rohr 5-42.4	Rohr 20-42.4	
50 Hz	Rohr 1.5-50	Rohr 5-50	Rohr 20-50	
60 Hz	Rohr 1.5-60	Rohr 5-60	Rohr 20-60	Rohr 50.-60
84.8 Hz	Rohr 1.5-84.8	Rohr 5-84.8	Rohr 20-84.8	
120 Hz	Rohr 1.5-120	Rohr 5-120	Rohr 20-120	
170 Hz	Rohr 1.5-170			
240 Hz	Rohr 1.5-240			
295 Hz	Rohr 1.5-295			

A variety of pipe and tube clamps are available for connecting the dampers to pipes or tubes. The standard clamps for the 1.5 Lb line are included in the Tables 2 and 3. Pipe clamps for the 5 Lb line are available from 1 ½" to 4" pipe sizes as detailed in table 4. The 20 Lb line has clamp sizes from 2" to 12" pipe sizes as shown in table 5.

Table 2 – 1.5 Lb Standard Pipe Sizes

Description	Outside Diameter	1.5 Lb Part Number
¼" Pipe	0.54"	CP-1.5-1/4"
3/8" Pipe	0.675"	CP-1.5-3/8"
½" Pipe	0.84"	CP-1.5-1/2"
¾" Pipe	1.05"	CP-1.5-3/4"
1" Pipe	1.315"	CP-1.5-1"
1 ¼" Pipe	1.66"	CP-1.5-1 1/4"
1 ½" Pipe	1.9"	CP-1.5-1 1/2"
2" Pipe	2.375"	CP-1.5-2"

Table 3 – 1.5 Lb Copper Tube Options

Description	Outside Diameter	Part Number
5/8" Tube (1/2" nominal)	0.625"	CT-1.5-0.625"
¾" Tube (5/8" nominal)	0.75"	CT-1.5-0.75"
7/8" Tube (3/4" nominal)	0.875"	CT-1.5-0.875"
1 1/8" Tube (1" nominal)	1.125"	CT-1.5-1.125"
1 3/8" Tube (1 ¼" nominal)	1.375"	CT-1.5-1.375"
1 5/8" Tube (1 ½" nominal)	1.625"	CT-1.5-1.625"
2 1/8" Tube (2" nominal)	2.125"	CT-1.5-2.125"
2 5/8" Tube (2 ½" nominal)	2.625"	CT-1.5-2.625"

Table 4 – 5 Lb Standard Pipe Sizes

Description	Outside Diameter	5 Lb Part Number
1 ½" Pipe	1.9"	CP-5-1 1/2"
2" Pipe	2.375"	CP-5-2"
3" Pipe	3.5"	CP-5-3"
4" Pipe	4.5"	CP-5-4"
5" Pipe	5.563"	CP-5-5"
6" Pipe	6.625"	CP-5-6"
8" Pipe	8.625"	CP-6-8"

Table 5 – 20 Lb Standard Pipe Sizes

Description	Outside Diameter	20 Lb Part Number
3" Pipe	3.5"	CP-20-3"
4" Pipe	4.5"	CP-20-4"
5" Pipe	5.563"	CP-20-5"
6" Pipe	6.625"	CP-20-6"
8" Pipe	8.625"	CP-20-8"
10" Pipe	10.75"	CP-20-10"
12" Pipe	12.75"	CP-20-12"

Function of the Rohr Damper

Rohr dampers work to reduce resonant vibration amplitudes on mechanical systems by adding mechanical damping to the system. Common applications will be those where mechanical systems are being excited with excessive vibration due to dynamic forces interacting with the natural frequency on the system causing resonant response.

Rohr dampers are optimally tuned dynamic absorbers. A sample device mounted on refrigeration piping is shown to the right.

Figure 1 - Typical Mounting

The Rohr devices were designed to be optimized for 15% modal mass. That means that for all the moving mass, the damper should ideally have about 15% of the moving mass as damper mass. The Rohr 1.5-60 damper model has 1.5 lb mass and is set for a target frequency of 60 Hz. That damper would be optimal for a 10 lb moving mass (15% of 10 = 1.5 lb). For systems with higher moving mass, multiple dampers or a damper with larger mass could be employed. Two 1.5 lb dampers will function like one 3.0 lb damper.

Since the Rohr dampers are assembled with a specific target frequency, the device will provide the most damping benefit if the resonant system has the same frequency as the target frequency. Therefore, it is important to select the correct damper to best "target" the actual natural frequency.

Exciting forces can be transmitted vibration from rotating or reciprocating machinery, vibration transmitted through support structures, or dynamic forces in the piping network due to things like flow turbulence, pressure pulsations in the fluid inside the pipe, cavitation, or a variety of other sources.

The exciting forces can be separated into two main classes: harmonic frequencies or broadband sources. The harmonic frequencies would include orders of machinery speeds (1x, 2x, 3x…). Broadband sources will produce exciting energy over a wide frequency range.

The harmonic frequencies that can be excited will often include 1xRPM, 2x, 3x, 4x… caused by the rotating or reciprocating machinery that the piping is connected to (or adjacent to). For example, reciprocating compressors can easily generate vibrations up to 12xRPM and higher. Most design standards recommend avoiding resonance on connected piping for reciprocating machinery with consideration for "significant" orders. The actual compressor or pump layout (number of cylinders) will determine which orders to avoid although other harmonic frequencies can generate significant vibration on associated piping.

When these rotating machines are operated using variable speeds such as on an electric motor with a variable speed drive, the harmonics will vary continuously throughout the operating speed range, and when one of the harmonics lines up with the natural frequency, then the vibration will be amplified by as much as 50 times!!

One common application for Rohr dampers is small bore piping systems with piping resonances excited by adjacent rotating machinery.

Piping/Tubing Application

The 1.5 Lb Rohr damper design was originally developed for use on piping and tubing with consideration for small bore piping (pipe that is 2" nominal size and smaller). Typical examples for use include vents and drains (relatively short cantilever small bore branches), bypass lines around larger valves, and other locations with relatively small piping.

In other cases, the entire piping system can benefit from the same technology, with the larger Rohr devices (up to 50 lb size) being very effective to control larger piping runs as well.

Selecting the correct damper size will depend on the pipe layout. The details below provide general guidance for estimating the moving mass of the piping you are wanting to control.

Cantilever Pipe

This layout would be common for a vent connection, thermowell, drain line, pressure gage connection, etc. These are normally connected to the main pipe using a branch connection (Weld-O-Let, fabricated Tee, or other branch options) and extend from the main pipe and have a valve or other device near the end of the pipe.

When the cantilever layout is used, the moving (modal) mass can be estimated by adding the following:

- Use 30% of the weight of the pipe to the end of the run
- The weight of the valve, flanges, plugs, etc.

Using this modal mass estimate, select a damper mass to be 15% of the modal mass. Identify the natural frequency (typically by "bump" test with a vibration meter) and select the damper with the target frequency closest to the natural frequency. Mount the damper near the end of the branch run, with the ideal location being on the end of the run. This can often be done by using a "bull plug" as the last device to plug the line and connect the damper to the bull plug.

Piping Between Supports

This would normally be referred to as a simply supported setup. This is a very common layout for all piping with vibration normally highest at the middle of the span between the two supports.

When the between supports layout is used, the moving (modal) mass can be estimated by adding the following:

- Use 50% of the weight of the pipe between the supports
- The weight of the valves, flanges, plugs, etc. between the supports
    - If heavy components are located near supports they will have less modal mass and can have the modal mass reduced

The same approach applies for selecting the damper by using the "bump" test method and selecting the damper with the target frequency nearest the natural frequency.

Application Details

Since there will generally be variations between the actual modal mass, natural frequencies relative to target frequencies, limitations on where to mount the dampers, etc., it is imperative to conduct vibration measurements before and after mounting the dampers to confirm acceptable performance. If the vibration is generated by variable speed machinery or other operating conditions where elevated vibration can occur, it is important to review maximum vibration under those conditions after mounting the dampers to confirm acceptable function. In many cases, a properly done impact test ("bump" test) can be used to confirm damping function and elimination/reduction of resonant response.

Natural frequencies on piping systems can change due to variations in the function of supports. If the pipe thermally moves and supports lift (or start touching), the natural frequencies can change on the piping network. In other cases, supports can fail due to corrosion, excessive movement, damage, hardware coming loose, etc. System changes will influence the performance of the dampers.

Since it is possible for the natural frequencies, dynamic forces, and other items in the user's system to change, it is imperative that the user frequently evaluate the acceptable performance of the piping system with the dampers installed. The Rohr dampers have no wear parts and should have a long functional life. However, changes in the piping network will likely occur over time and warrant ongoing vibration reviews. A mis-applied damper may not provide acceptable vibration damping and may need to be replaced with a different model, relocated, or additional dampers may be required.

Vibration Limits

The purpose of using the dampers is to reduce resonant vibration and to ultimately reduce the risk of fatigue failures in piping systems. Reducing vibration to acceptably low vibration levels can significantly reduce the risk of fatigue failures. But how low is low enough??

Vibration limits are not necessarily stated in ANSI B31 piping codes or other standards since there is not a solid connection between vibration and fatigue risk for all situations. Alternatively, the codes dictate that dynamic stress be limited to acceptable levels to prevent fatigue failures. The acceptable levels of dynamic stress are detailed in ASME Section VIII, Division 2, Appendix 5 as well as other standards.

Unfortunately, achieving acceptable dynamic stress in piping is not necessarily related to a specific vibration displacement, velocity, or acceleration value. It is generally accepted that useful limits of vibration for the frequency range covered by Rohr dampers for piping are expressed in velocity units, either in/sec pk or mm/sec rms. Lower frequency vibration (<10 Hz) would more commonly be limited to displacement limits instead of velocity.

As a reference, API 618 "Reciprocating Compressor for Petroleum, Chemical, and Gas Industry Services" recommends a design limit of 20 mils pk-pk below 10 Hz and 0.63 in/sec pk above 10 Hz.

Detailed review of dynamic stress using ASME B31 methods will result in vibration limits that will depend heavily on fabrication methods, layout, and in particular the location of and weight of added components like valves, flanges, etc. To reduce the risk of fatigue failures, heavier components should be located near supports when practical. Typical layouts can result in dynamic stress at code limits with about 1 in/sec pk vibration velocity. Operating experience suggested by a variety of sources indicates that vibration levels up to 1 in/sec pk are generally free from fatigue failures. Vibration in excess of 2 in/sec pk will result in fatigue failures being more common. Vibration below 0.5 in/sec pk has been generally accepted in the nuclear power industry as an acceptable screening level for elevated vibration on piping and can normally be used as a comfortable screening criteria for general piping.

Applications with vibration exceeding 1 in/sec pk should be limited to straight runs of pipe/tube with no stress concentrations (socket welds, brazed joints, etc.) in locations of higher bending stress and little or no lumped weights in the span (valves, etc.). For these layouts with good routing and fabrication methods, limits of 2 in/sec pk or higher may be acceptable with additional review.

Fatigue Risk

The purpose of controlling piping vibration using damping technology is to reduce the risk of fatigue failures on the piping. A piping system will include process piping for moving various liquids and gases as well as many smaller branch lines. These smaller lines are often referred to “small bore pipe” (SBP) and will often be limited to 2” and smaller pipe. The main pipe will vibrate due to transmitted vibrations from machinery or other sources as well as from internal forces transmitted to the pipe caused by pressure pulsations in the fluid or general flow turbulence.

The vibration amplitude on the main pipe will depend on the natural frequencies of the main pipe which may need dampers to control the main lines. In addition, the SBP may have natural frequencies as well that are then excited by the transmitted vibration from the main pipe. Therefore, it is important to control the main pipe first followed by the secondary pipe (SBP).

Controlling the main pipe will usually be done with proper designed supports to push natural frequencies above significant excitation frequencies from machinery and other sources. Acceptable vibration levels for the main process piping is identical to what was described above, with the 1 in/sec pk velocity amplitude being a common limit for general piping.

The secondary SBP will also need to be controlled to achieve similar vibration levels. It should be noted that the actual vibration limit will be relative vibration between the main pipe where the SBP is connected and the SBP. Resonances on the SBP will generally be the cause of elevated SBP vibration and are then well controlled with properly applied dampers. Since SBP is usually excited by vibration on the main pipe, the lowest vibration achievable on the SBP will be the vibration level on the main pipe.

Since the SBP is driven by transmitted vibration from the main process piping, achieving 1 in/sec pk on SBP will usually require a lower limit on the main pipe. A value of 0.5 in/sec pk is a reasonable goal for main process piping. Vibration on SBP with properly applied dampers will be limited to about 3.8x higher than the transmitted vibration from the main process piping. So in cases where the main process piping has higher vibration, it may be necessary to reduce vibration on that with modifications to the dynamic forces, main pipe layout, or additional vibration control (supports or dampers).

Mounting the Dampers

The dampers perform the best in the directions normal to the flat side. If the device is mounted as shown in figure 1, the radial vibration on the pipe in two directions will be impacted. Vibration in the axial direction (the flow direction of the pipe) will be affected to a lesser degree.

If it is necessary to mount the damper to be effective in the axial direction, damper rotation plates can be used as shown in figure 2 to allow the device to be rotated 90°.

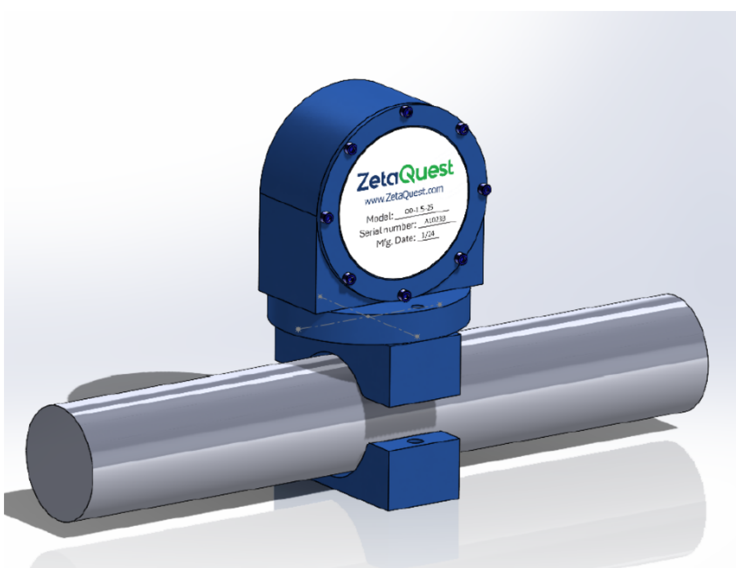


Figure 2 - Damper with Orientation Change

When the orientation change plate is use, the damper would then be effective both vertically and axially on the pipe shown.

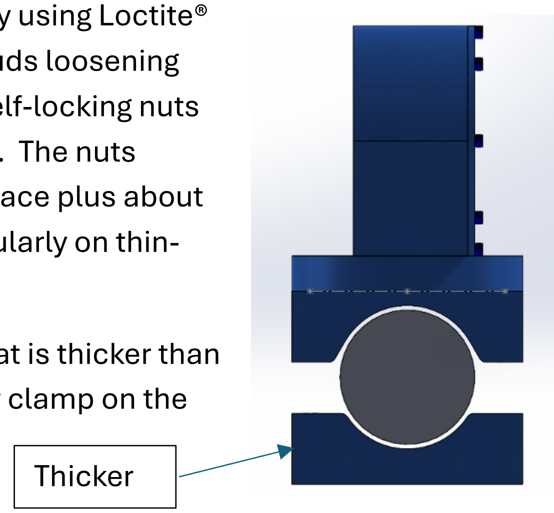
When the dampers are mounted, they should be located on straight pipe or tube away from welds and or brazing joints. The recommended gap from an adjacent weld, threads on pipe, brazing joints, or other discontinuities in the pipe or tube is 1”.

The damper clamps are provided with a 1/64” thick Aramid Fiber/Buna-N Rubber Blend gasket material so that the clamp bore is not contacting the pipe/tube wall directly. The 1/64” thick gasket material is effective at providing a good connection between the clamp and the pipe while remaining rigid for good dynamic connection between the pipe and damper.

Dampers are provided with either bolts or all thread for connection to the piping. Bolts are provided where required. Most clamps are provided with the all thread for additional flexibility in mounting.

All thread should be screwed into the damper body using Loctite® Red thread locker or similar to help prevent the studs loosening during service. The hardware provided includes self-locking nuts and lock washers for securing the damper clamps. The nuts should be tightened until the damper is firmly in place plus about ½ - 1 turn more. Do not overtighten clamps particularly on thin-wall tubing.

Some clamp assemblies have one clamp piece that is thicker than the other. When this is the case, install the thicker clamp on the side away from the damper as shown here.



Maintenance

The dampers should not require long term maintenance since they are sealed devices. Atmospheric exposure may result in external damage which would be an indicator of end of life. Extreme corrosion conditions can result in leakage of the internal damping fluid that would result in the device losing effectiveness.

For high corrosion environments, alternative construction materials can be used including stainless steel and others on request. Use of 304 and 316 stainless steel is common although the anodized aluminum are the standard stocked devices.

Vibration should be measured periodically to confirm continued success.

ZetaQuest
Your search for damping stops here

Documentation

Each application should be documented so that the effectiveness of the device can be documented for future reference as detailed below.

Site		Associated Equipment	
Description of Pipe/tube			
Pipe Size (OD)		Length Between Supports or Support to End	
Sketch of Layout (show damper locations and orientation)			
Frequency of Maximum Velocity (from FFT) before using dampers		Measured Natural Frequency (if available)	
Weight of pipe		Weight of valves, flanges, etc.	
Estimated modal mass (Lb)		Damper mass needed (10-15%)	
Dampers used:	Document the damper model and clamp size below		
Model:		Location:	
Model:		Location:	
Model:		Location:	
Model:		Location:	
Original Vibration		Final Vibration	