Anti-vibration clamp design guide for pipe stress engineers

What is a pipe support?

Pipe supports are used to constrain the movement of piping and reduce stresses and loads in the piping system. Examples of pipe supports are:

- Resting supports
- Guides
- Line stops
- Spring hangers
- Trunnions
- Hold downs

This document will focus on Wood's **hold-down type** supports.

What causes piping to move?

Piping (or pipework) can experience both static and dynamic movement

Causes of **static movement**:

- Weight of the pipe, insulation and fluid
- Internal or external pressure
- Temperature changes
- External loads like wind, soil or snow

Causes of **dynamic movement** (also called vibration):

- Pressure pulsations
- Transients like water hammer and slug flow
- Mechanical excitation from nearby machinery

Both static and dynamic movement must be considered when designing a piping solution.

What factors affect pipe support selection?

The main goal of selecting pipe supports is to reduce **static** pipe stress, pipe deflection and equipment nozzle load. This is typically done by designing solutions for static pipe movement, and selecting supports like resting supports, hangers or guides.

However, piping systems with **dynamic forces** may require hold downs to reduce the dynamic pipe stress caused by dynamic pipe movement (vibrations). Friction forces on resting supports are usually not sufficient to resist dynamic forces.

Piping systems connected to reciprocating machinery are at risk of high vibrations, and standards like API 618 and 674 do **not** recommend resting supports, hangers and guides. Balancing the support design to control both static deflections and vibrations is a common challenge for piping designers.

What pipe support spacing is required?

The spacing between pipe supports is determined by pipe stress, pipe deflection and susceptibility to vibration. An example of pipe support spacing is shown in Table 1 (including spacing from ASME B31.1). For reciprocating compressors and pumps, the support spacing depends on the frequency of the dynamic forces created.

Table 1 – support spacing in different services

Nominal pipe size, NPS	Gas service (B31.1)		Water service (B31.1)		Recip, gas service (1200 RPM)		Recip, water service (300 RPM triplex)	
	ft	m	ft	m	ft	m	ft	m
2	13	4.0	10	3.0	5.6	1.7	9.0	2.7
4	17	5.2	14	4.3	7.9	2.4	12	3.7
6	21	6.4	17	5.2	10	2.9	15	4.4
8	24	7.3	19	5.8	11	3.4	16	5.0
12	30	9.1	23	7.0	14	4.3	19	5.9
16	35	10.7	27	8.2	16	4.8	21	6.4
20	39	11.9	30	9.1	18	5.4	23	6.9
24	42	12.8	32	9.8	19	5.9	24	7.4

What variables are required to model a support?

The three typical variables required to model a pipe support are support stiffness, contact surface friction and contact gap.

What is the stiffness of a pipe support?

The stiffness of a pipe support depends on two factors: the stiffness of the clamp (K_{clamp}) and the stiffness of the structure underneath the pipe ($K_{structure}$). Clamp stiffness for Wood's anti-vibration clampsare described in the next section. The structure stiffness can be calculated from the civil department's structural FEA model or with simple hand calculations using beam theory.

The support stiffness can then be estimated using the formula below. In many cases, especially for elevated piping supported in pipe racks or by vertical posts, the structure stiffness has a larger effect on the support stiffness than the clamp stiffness.

$$K_{support} = \frac{1}{\frac{1}{K_{clamp}} + \frac{1}{K_{structure}}}$$

What is the stiffness of Wood's hold-down clamps?

Wood's clamps have a stiffness of approximately **2E6 lb/in [3.5E6 N/cm]** in the vertical, axial, and lateral directions. For pipe sizes above NPS 12, the lateral stiffness will start to decrease in part due to the flexibility of the pipe (see Wood clamp stiffness in Table 2 below).

Many companies model the stiffness of supports as rigid (eg, 1E12 lb/in or 1.8E12 N/cm) either due to limited information or as a first step before the civil department designs the structure. This is incorrect (if not updated with the actual stiffness) and can lead to unnecessary recommendations or overlooked problems.

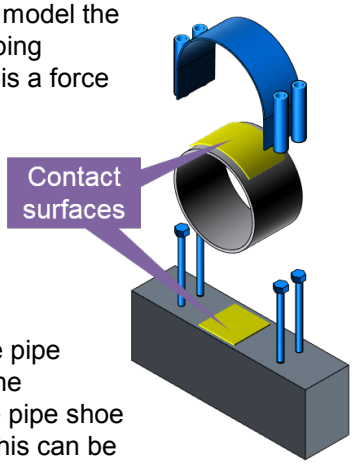
When using **DamperX™** clamps, with *Dampion™* Black HD or *Dampion™* Black HT damping material, the clamp stiffness is reduced by 90%. While at first this may look like a deficiency, the increase in vibration damping greatly decreases vibration response. Therefore, use **0.1 times** the value in Table 2 below when modeling **DamperX™** clamps.

Table 2 – Wood CL-1 style clamp stiffness

Nominal pipe size, NPS	Vertical/axial stiffness		Lateral stiffness	
	10^6 lb/in	10^6 N/cm	10^6 lb/in	10^6 N/cm
2 – 12	2.0	3.5	2.0	3.5
16			1.2	2.1
20			0.78	1.4
24			0.68	1.2
30			0.40	0.7

What is the friction of a support?

A friction value is required to model the friction force acting on the piping accurately. The friction force is a force that resists the motion of the piping and is equal to the coefficient of friction between the contact surfaces (*Mu*) times the normal force on the contact surfaces.



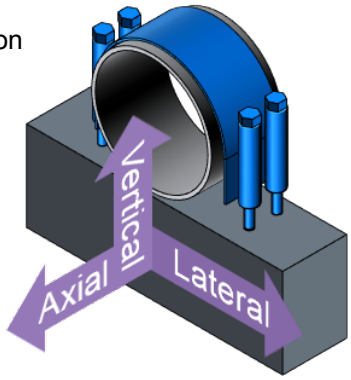
For resting-type supports like pipe shoes and guides, there is one contact surface (between the pipe shoe and the support structure). This can be modeled in piping stress analysis (PSA) software like Caesar II by simply entering *Mu* on the restraint definition. Some common values of *Mu* are shown in Table 3 below for reference, including damping liners and wear pads used in Wood's **DamperX™** anti-vibration clamps.

For Wood's anti-vibration clamp, there are two contact surfaces (between the pipe and clamp and between the pipe and support structure). To model this, enter the sum of the coefficient of friction from both contact surfaces ($Mu_{total} = Mu_{surface1} + Mu_{surface2}$).

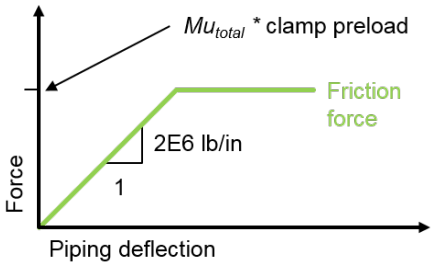
Table 3 – common values of Mu

Contact surface	Coefficient of friction (*Mu*)
Steel to steel	0.3
PTFE to steel	0.1
Dampion™ Black HD to steel	0.5
Dampion™ Black HT to steel	1.0

The complicating factor in modeling Wood's anti-vibration clamps is the clamp preload, which is created when the clamp bolts are tightened. The clamp preload increases the normal force on the contact surfaces. A simple modeling technique is to add an external load to the PSA model that is equal to the clamp preload. However, this can cause spurious stress and deflection if the stiffness in this direction is low. When modeling Wood's anti-vibration clamps (including **DamperX™** clamps), a more accurate method is to use a bilinear restraint in the direction of the friction force (using the clamp preload and Mu_{total}).



Bilinear restraints are restraints that have two stiffness values, as shown in the figure to the right. This method accurately models the case where the pipe force overcomes the contact friction force and the pipe moves axially through the clamp.



What is the clamp preload?

The preload on a hold-down clamp is the sum of the preloads in all the bolts. The bolt preloads depend on the torque applied to the bolt nuts.

Wood's anti-vibration clamps, including **DamperX™** clamps, have a specified torque which results in the clamp preloads shown in Table 4 below.

Table 4 – Wood anti-vibration clamp preload

Nominal pipe size, NPS	Clamp preload	
	lb	N
2 – 6	4,800	21,350
8	11,200	49,820
≥ 10	17,600	78,290

What is the contact gap in a pipe support?

The contact gap is the amount the pipe can move before the pipe support engages. For anti-vibration clamps, this is typically very small (≤1/16”,1.588 mm) due to fabrication tolerances.

What is the maximum allowable clamp load?

The maximum allowable load on Wood’s anti-vibration clamps depends on many factors including clamp design (eg, thickness, width), bolt preload, load frequency, operating environment and clamp liners. The values below are provided for information only. Actual allowable loads need to be determined on a case by case basis.

Table 5 – Wood maximum allowable clamp loads

Nominal pipe size, NPS	Maximum allowable load			
	Vertical Direction		Axial/Lateral Direction	
	lb	N	lb	N
2 – 6	5,000	22,200	4,000	17,800
8 – 10	15,000	66,700	12,000	53,400
≥ 12	20,000	89,000	16,000	71,200

How do I model Wood’s anti-vibration clamps in PSA software?

Wood’s anti-vibration hold-down clamps can be modeled using the information provided in this document.

Figure 1 below is an example of a piping system (NPS 8 or DN 200 pipe) which has two different pipe clamps. On the left is a Wood CL-1 steel anti-vibration clamp, and on the right is a **DamperX™** clamp that is lined with PTFE to allow axial movement of the pipe (style DCL-1-HT-T). The values in Figure 1 are shown in Imperial units for typical PSA software.

The clamps are modeled using bilinear stiffness in the axial direction. It is assumed that the clamps are installed on a rigid concrete foundation. If the clamps were installed on a more flexible structure, like a pipe rack, the stiffness should be adjusted to reflect the combined clamp/rack stiffness using the formula on page 1.

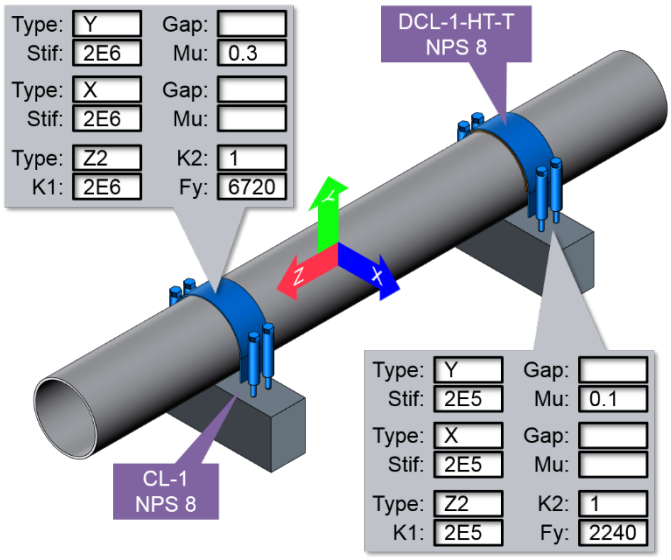


Figure 1 – Wood example of PSA input

Important note

This data is provided for information only. Although reasonable steps were taken when preparing this document, Wood does not warranty the accuracy of the data provided.

What pipe clamps does Wood offer for vibration control?

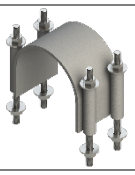
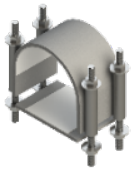
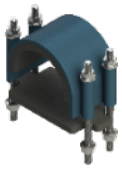
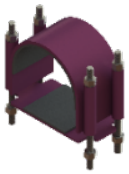
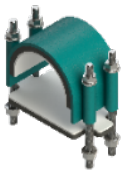
Wood offers a variety of anti-vibration hold-down type clamps in sizes from NPS 1 (DN 25) through NPS 40 (DN 1000). The unique design reduces vibration loosening, increases damping and allows for a more compact design than typical hold-down clamps (see Table 6).

Who can I contact for more information?

Contact **Wood‘s vibration, dynamics and noise team** to discuss the vibration integrity of your piping system or to inquire about **DamperX™** anti-vibration products:

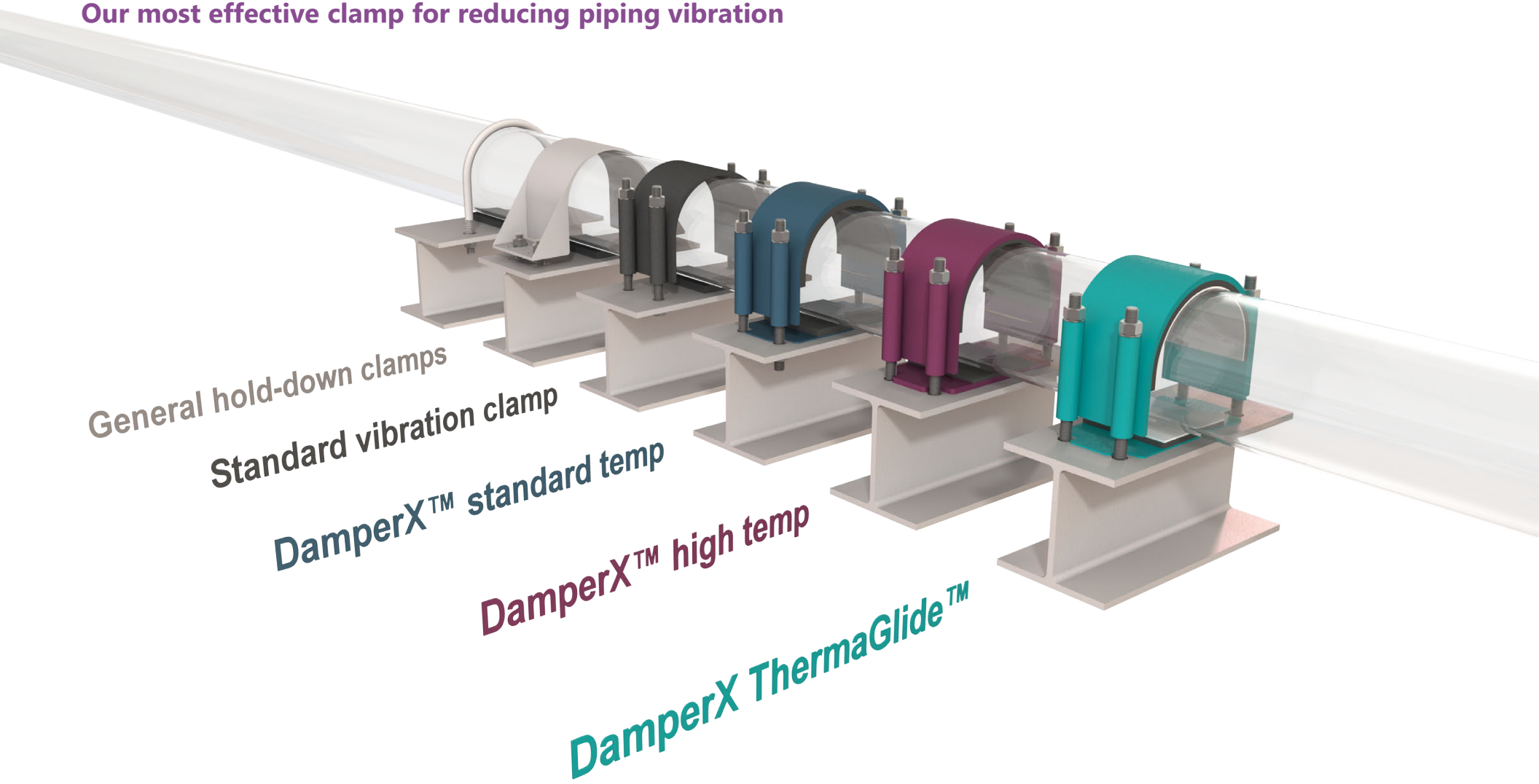
info.vdn@woodplc.com	www.woodplc.com/VDN
☎ +1 281 920 4441 (United States)	☎ +1 800-561-5666 (Toll free in North America)
☎ +1 403 245 5666 (Canada)	☎ +44 (0)23 80118806 (United Kingdom)
☎ +603 2770 2852 (Malaysia)	☎ +61 7 3010 9528 (Australia, Brisbane)
☎ +86 137 0107 8772 (China)	☎ +61 8 9489 2000 (Australia, Perth)

Table 6 – Wood anti-vibration pipe clamps

Clamp style	Illustration	Features
CL-1		► Carbon steel hold-down anti-vibration clamp ► Customized finishes for corrosive or offshore exposure
CL-1-T		► PTFE-lined clamp and wear pad allow axial movement of pipe ► 15°F to 400°F (-9°C to 204°C)
DamperX™ DCL-1-HD		► *Dampion*™ Black HD lined clamp and wear pad reduce piping vibration ► 1°F to 140°F (-17°C to 60°C)
DamperX™ DCL-1-HT		► *Dampion*™ Black HT lined clamp and wear pad reduce piping vibration in higher temperature applications ► 15°F to 400°F (-9°C to 204°C)
DamperX™ DCL-1-HT-T		► *Dampion*™ Black HT and PTFE-lined clamp and wear pad reduce piping vibration and allow axial pipe movement ► 15°F to 400°F (-9°C to 204°C)

DamperX™ anti-vibration clamps

Our most effective clamp for reducing piping vibration



For more information, visit our vibration, dynamics and noise website or contact our anti-vibration products team directly.

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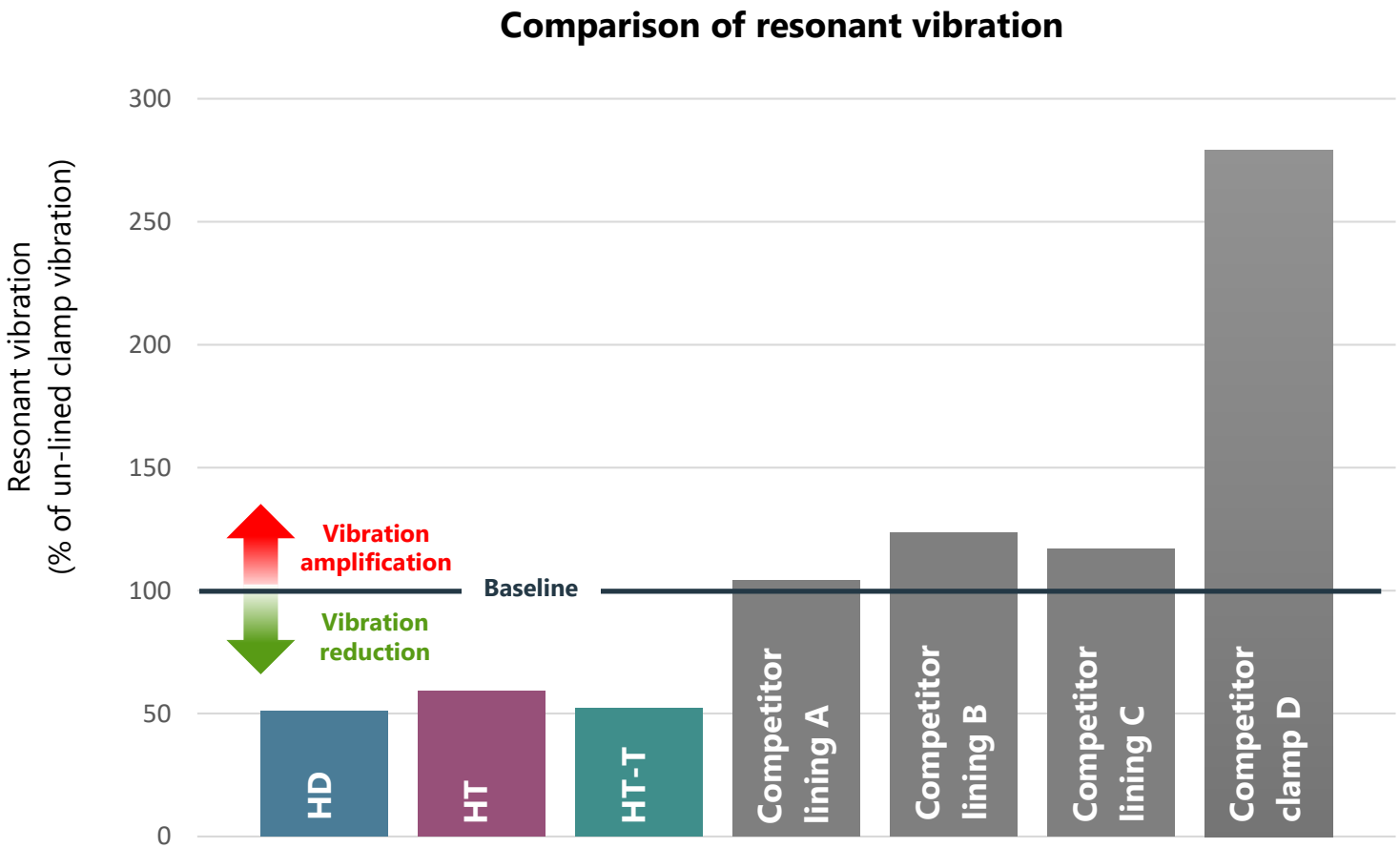
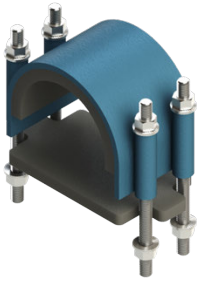
DamperX™ vs competitor linings

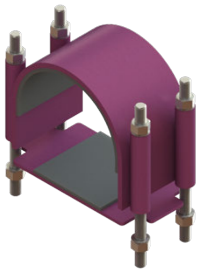
Lab test results





DCL-1-**HD**

Standard temperature DamperX lining



DCL-1-**HT**

High temperature DamperX lining

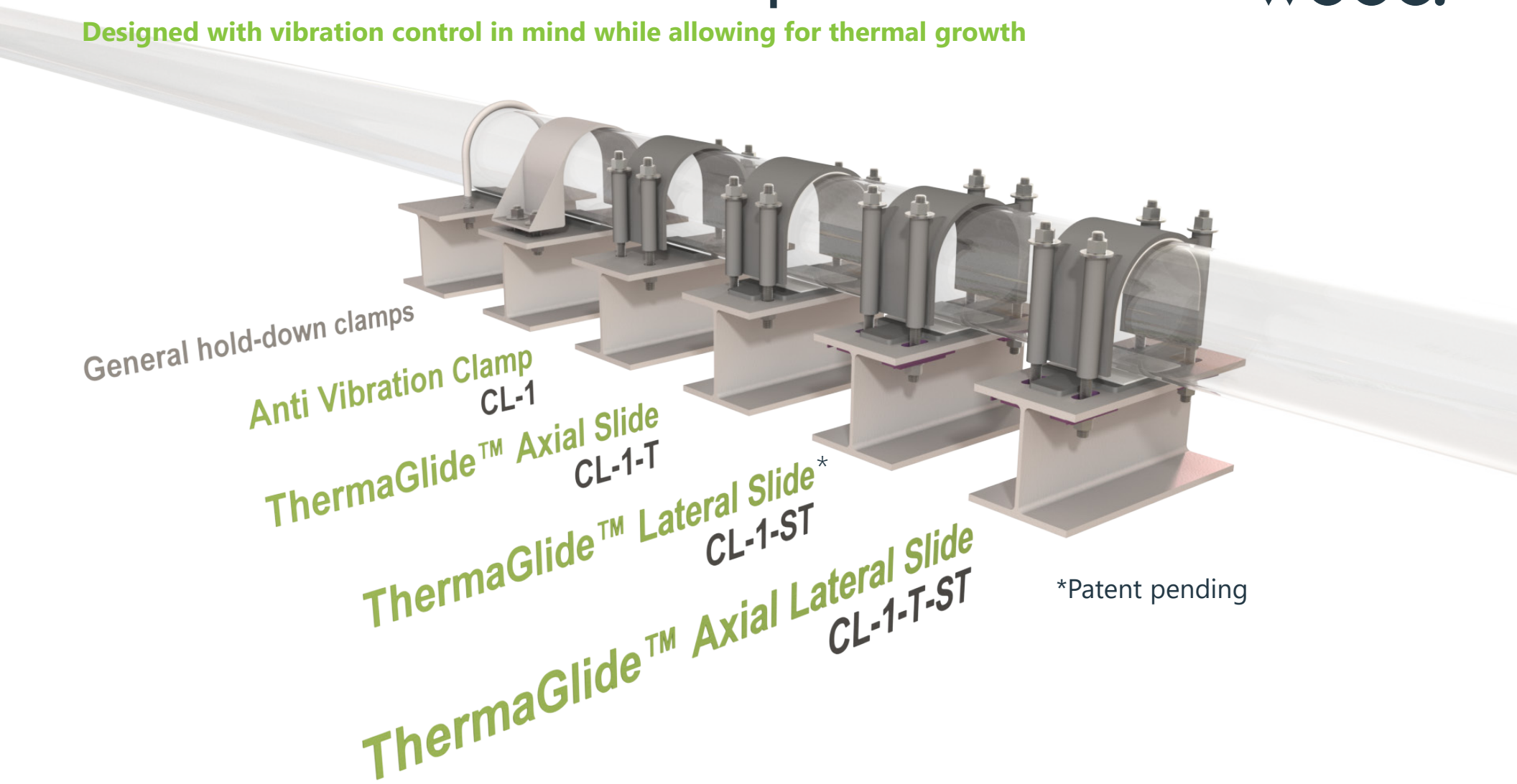


DCL-1-**HT-T**

High temperature DamperX lining + PTFE

ThermaGlide™ anti-vibration clamps

Designed with vibration control in mind while allowing for thermal growth



*Patent pending

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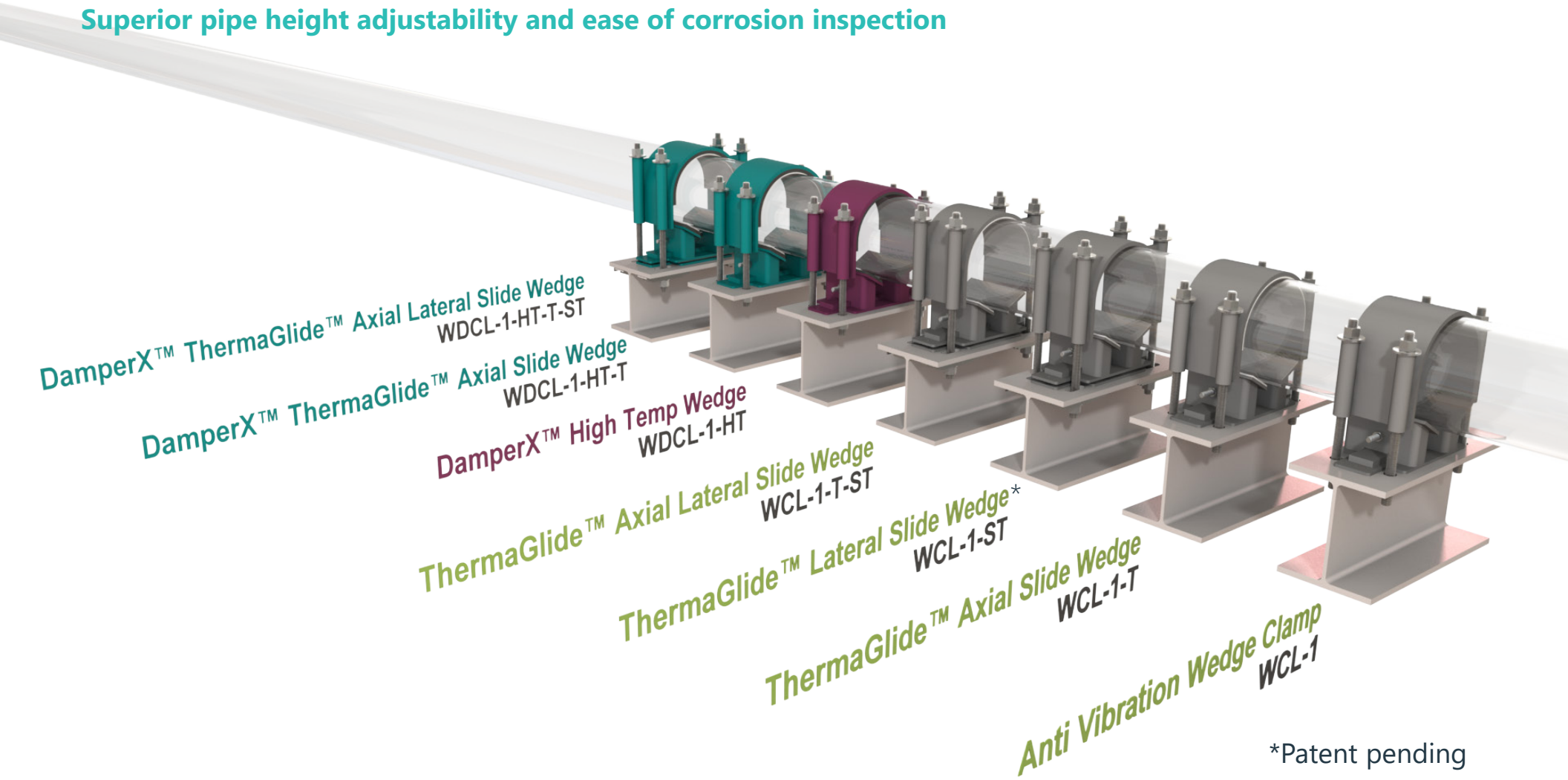
Anti-vibration *wedge* clamps

Superior pipe height adjustability and ease of corrosion inspection



*Patent pending

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