WHITE PAPER

Using Grooved Mechanical Joining Systems to Accommodate Thermal Piping Movement

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The key to effectively accommodating thermal expansion and contraction in a building is to allow the predictable, controlled movement of the piping itself. This can be done in a variety of ways, and the selection of a specific method is based upon the engineer, the type of piping system and the project parameters.

Thermal transients may impose stress on a piping system as the pipe grows when heated and contracts when cooled. All materials, including pipe, experience dimension changes as a result of changes in temperatures and their coefficient of expansion. This often occurs at directional changes or causes "bowing" at the mid points of long straight pipe runs, resulting in stress on the piping system and equipment.

When a system is subjected to temperature, it may experience horizontal movement, vertical movement and angular deflection simultaneously. Additional strains on the piping system vary based on whether the piping is vertical or horizontal. For horizontal piping, the major obstacle is typically the space constraints around the length and turns of the pipe. For vertical piping, considerations are different and should involve dynamic, static and elevation head calculations of the pressures and loads that are exerted on the bottom portion of the pipe.

Carbon steel pipe will experience thermal expansion or contraction at a rate of 0.75 inches for every 100° F change in temperature per every 100 feet of pipe. Piping subject to temperature changes is placed in a condition of stress, with potentially damaging reactive forces on components or equipment. The forces generated during this thermal dimension change are often significant and the movement must be accommodated and controlled, to prevent transmission of these stresses throughout the piping system.

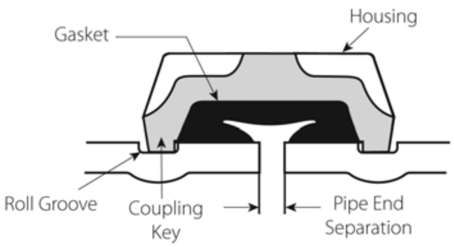
Inadequate accommodation of this movement can result in business risks caused by excess stress on the piping system, including increased incidence of ruptures and leaks, increased stress on boilers, chillers, valves and other equipment and components, and increased downtime and labor expenses. This can negatively impact the owners of the building by resulting in increased maintenance costs and potential business shutdowns.

When accommodating thermal expansion and contraction, the grooved pipe joining system conforms to industry practices while providing design flexibility, reducing stress on the piping system and providing a more compact, inspectable and productive method of installation over other pipe-joining methods such as welding or flanging. Additionally, the grooved method has all sealing elements combined within a metallic housing.

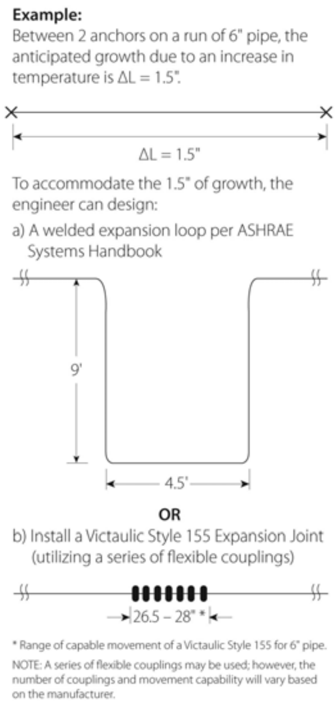
There are four common methods for accommodating thermal pipe movement with a grooved system:
1) providing an expansion joint utilizing grooved mechanical pipe components
2) allowing the system to “free-float”
3) utilizing the linear movement/deflection capabilities of flexible grooved couplings
4) providing an expansion loop utilizing grooved mechanical components

The selection of one of these methods is dependent on the system type, the scope of the project and the engineer's preference. Since it is impossible to predict all system designs, this article will call attention to the design benefits and mechanical advantages of the grooved piping method when used to accommodate thermal expansion and contraction.

The grooved mechanical pipe joint
Grooved mechanical couplings allow for movement in the pipe due to the design of the components. The dimensions of the coupling key are narrower than the groove in the pipe allowing room for that coupling key to move in the pipe groove. Additionally, the width of the coupling housing allows for pipe end separation leaving room for controlled linear and angular movement. The mechanical coupling remains a self-restrained joint, and the unique pressure responsive design provides sealing even under deflection and pipe movement.



Grooved mechanical couplings are a great alternative to welded U-shaped expansion loops, welded offsets, expansion joints and rubber bellows. These couplings are easier and faster to install, accommodate movement within the design capability of the coupling, all the while doing this within the products "free range of motion.” This means that piping system movement caused by thermal expansion and contraction can be accommodated in smaller spaces, with low stress on the components.



Accommodating thermal movement utilizing expansion joints

Grooved mechanical couplings are available with two distinct performance features. One class is designed as "rigid" and the other as "flexible." Rigid grooved mechanical couplings are designed to "fix" the joint in its installed position, permitting neither linear, angular nor rotational movement at the joints. Flexible grooved mechanical couplings on the other hand are designed to allow controlled linear and angular movement at each joint that can accommodate pipeline deflection.

Expansion joints are devices that can be compressed or expanded axially and are generally the most costly alternative for accommodating thermal movement. A welded expansion joint is typically an expensive specialty joint, flanged into the system and requiring regular maintenance. More cost-effective expansion joints utilize grooved mechanical couplings and specially grooved, short pipe nipples with flexible couplings placed in long straight runs of pipe and pre-set to allow the desired amount of contraction and/or expansion. Axial movement can be adjusted by simply adding or removing couplings. When a series of flexible couplings are installed, the resulting grooved expansion joint will further protect equipment by reducing vibrations and stresses in the system.

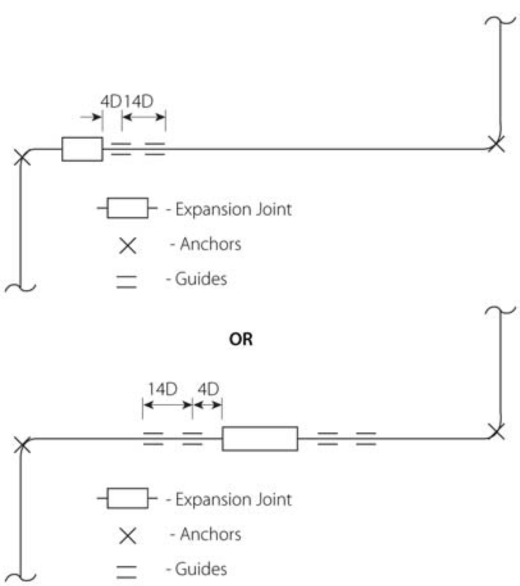
Whether using specialty expansion joints or a grooved expansion joint, the adjacent piping must be properly guided to ensure the movement is directed into the device and no lateral movement is experienced.

For proper operation of the expansion joint, the piping system should be divided into separate expansion and contraction sections with suitable supports, guides and anchors to direct axial pipe movement.

Anchors should be classified as main or intermediate for the purpose of force analysis. Main anchors are installed at terminal points, major branch connections, or changes of piping direction. The forces acting on a main anchor are due to pressure thrust, velocity flow and friction of alignment guides and weight support devices.

Intermediate anchors are installed in long runs to divide them into smaller expanding sections to facilitate using less complex expansion joints. The force acting on the intermediate anchor is due to friction at guides, weight of supports or hangers, and the activation force required to compress or expand an expansion joint.

Pipe alignment guides are essential to ensure axial movement of the expansion joint. If the situation allows, the expansion joint should be adjacent to an anchor within four pipe diameters. The first and second alignment guides on the opposite side of the expansion joint should be located a maximum distance of four and 14 pipe diameters, respectively. Additional intermediate guides may be required throughout the system for pipe alignment. If the expansion joint cannot be located adjacent to an anchor, install guides on both sides of the unit.

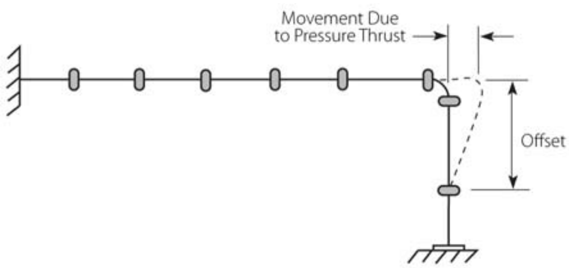


Grooved expansion joints may be used as flexible connectors; however, they will not simultaneously provide full expansion and full deflection. Expansion joints installed horizontally require independent support to prevent deflection, which will reduce the available expansion.

Accommodating thermal movement utilizing a Free-Floating System

Free-floating piping systems allow thermal expansion and contraction without the use of expansion joints. As long as this movement does not cause bending moment stresses at branch connections, it is not harmful to joints and changes in direction or to parts of structures and other equipment. A free-floating system can be achieved by installing additional grooved mechanicals joints or by installing guides to control the direction of movement. Engineers must take the effects of pressure thrusts into account when utilizing flexible grooved couplings, as the pipe will be moved to the full extent of the available pipe end gaps when allowed to float.

Ensure that branch connections and offsets are sufficiently long so that the maximum angular deflection of the coupling is never exceeded and that it can accommodate the anticipated total movement of the pipes. Otherwise, it is advised to anchor the system and to direct movements.



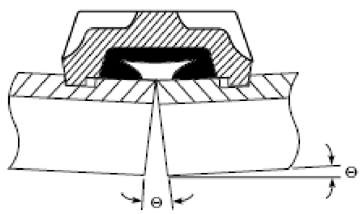
Flexible Grooved Couplings For Linear Movement and Deflection

Grooved mechanical couplings are an alternative to welded U-shaped expansion loops, welded offsets, expansion joints and rubber bellows. Associated with a free floating system, flexible couplings are used in piping systems to accommodate piping thermal growth— without any additional components or piping configuration required. Certain characteristics distinguish flexible groove type couplings from other types and methods of pipe joining. When they are understood, the designer can utilize the many advantages that these couplings provide.

By using flexible couplings at changes of direction and directing the movement toward the directional change with properly placed anchors and guides, movement is accommodated by the joining method itself. This method also produces little or no additional stresses in the system, unlike a welded expansion loop.

Flexible couplings also can be used strictly for their axial movement capabilities. In this case, straight runs are anchored on each end and the piping is guided at every other length. Each flexible joint is pre-gapped (either fully gapped or fully closed/butted) at installation to ensure that there are enough couplings to accommodate the expected expansion and/or contraction.

The flexible grooved coupling allows for controlled angular flexibility and rotational movement to take place at joints.



ANGULAR MOVEMENT TOLERANCE

Flexible grooved type couplings allow angular flexibility and rotational movement to take place at joints. In order to determine the appropriate number of couplings to use, compute the change in the linear length of the piping system by taking into account the length and size of the piping system and maximum and minimum operating temperatures.

Where full linear movement is required, a grooved expansion joint can be used. Note, joints which are fully deflected can no longer provide linear movement. Partially deflected joints will provide some portion of linear movement. It is also important to consider that standard cut-grooved pipe will provide double the expansion and contraction or deflection capabilities of the same size standard roll-grooved pipe.

When considering offsets utilizing grooved mechanical joints, the offsets must be capable of deflecting sufficiently to prevent harmful bending moments at the joints. If the pipes were to expand due to thermal changes, then further growth of the pipes would also take place at the ends.

Flexible couplings do not automatically provide for expansion or contraction of piping. Always consider best setting for pipe end gaps. In anchored systems, gaps must be set to handle combinations of expansion and contraction. In free floating systems, offsets of sufficient length must be used to accommodate movement without over-deflecting joints.

Ensure anchorage and support is adequate. Use anchors to direct movement away from or to protect critical changes in direction, branch connections and structure. Spacing and types of supports should be considered in accommodating anticipated pipe movements.

Expansion Loops Utilizing Flexible Couplings and Fittings

In vertical straight runs of pipe, expansion loops utilizing a U-shaped pipe configuration can also be designed into the piping system to accommodate expansion and contraction. Expansion loops can be designed as welded or grooved. Welded expansion loops require eight welded joints and fittings to assemble. In a welded expansion loop, the piping bends or flexes to accommodate the straight run movement. Although this method works, the forces to bend and flex the pipe are much greater than in a grooved loop, and the forces generate a larger magnitude of stress which requires larger anchors and guides to direct the movement and protect components and structures.

The flexible mechanical joint can be use in expansion loops without inducing stresses in the pipes, elbows or joints. Also, it is important to note that expansion loops utilizing rigid couplings are not designed to accommodate angular deflection, however an expansion loop utilizing rigid grooved copper couplings is designed to conform to industry standards.

The deflection capability of flexible couplings allows for thermal growth/contraction to be absorbed within the couplings at the elbows as the thermal forces induce deflection. A total of eight flexible grooved mechanical couplings, four grooved end 90-degree elbows and three pipe spools are required to complete each expansion loop. As system temperatures lower and the pipe run contracts, the loop expands and the deflection capability of the couplings accommodates this movement. As system temperatures increase the opposite effect occurs as the pipe run expands and the loop contracts with the couplings accommodating the deflection in the opposite direction (See Figures A through C).

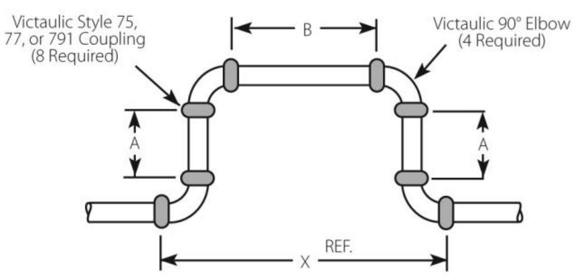


FIGURE A
Expansion Loop

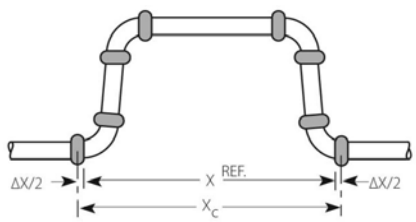


FIGURE B
Thermal Contraction
Pipeline Shrinks –
Loop Expands

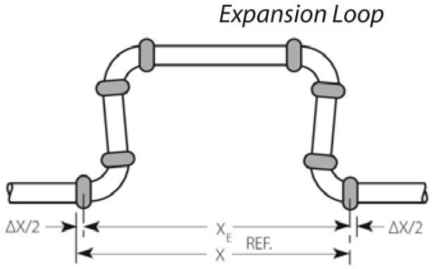


FIGURE C
Thermal Expansion
Pipeline Grows into Loop –
Loop Contracts

Using flexible couplings in an expansion loop configuration reduces the amount of force needed to flex the loop, and the loop itself is much smaller. A loop constructed in this manner will be 1/2 to 1/3 the size of a welded loop with the same capacity.

The space constraints of today's buildings also make this a more attractive option in HVAC piping, though welded expansion loops are still required in some system applications.

Making the Best Choice

Grooved mechanical systems offer four different methods to provide flexible, controlled movement of a piping system. The selection of expansion joints, free-floating systems, flexible couplings or expansion loops will be based on the type of piping system, the amount of anticipated movement and the mechanical engineer's preference.

In addition to effectively accommodating thermal expansion and contraction, engineers should consider the additional benefits of using the grooved method during construction, including a simplified assembly process that is readily inspectable relative to welded systems. Also, mechanical couplings reduce the need for welding and reduce man hours and material handling on the site, making for safer job sites and reduced risk of injury on-site. During operation, the simple disassembly of a coupling reduces chances of deferred maintenance and lengthy downtime for routine or unscheduled maintenance.

Overall, choosing the grooved mechanical method is an efficient way to accommodate excess stress on any piping system, eliminate incidents of ruptures and leaks due to thermal expansion, decrease maintenance needs of equipment, and simplifies the commissioning process.

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