Pipe-joining Techniques Examined:

A Comparison of Mechanical Pipe Coupling and Flanging for Shipboard Applications

Didier Vassal, Vice President OEM and Maritime Services at Victaulic, compares the flanged and grooved pipe joining methodologies and explains the advantages that grooved pipe joints provide over flanges.

Efficient piping systems are essential for the range of services needed on board a vessel including secondary systems such as bilge and ballast systems, sea and fresh water cooling, lube oil, fire protection and deck wash.

For these systems, where piping class permits, an effective pipe-joining alternative to welding/flanging is the use of grooved mechanical joints which offer a range of technical, economic and practical benefits. These include enhanced performance; faster, simpler installation and maintenance and weight reduction on board.

Performance Issues

In a flanged pipe joint, two mating flanges are bolted together and compress a gasket to create a seal. As the bolts and nuts of a flanged joint absorb and compensate for system forces, over time the bolts and nuts can stretch and lose their original tightness due to pressure surges, system working pressure, vibration and thermal expansion and contraction. When these bolts experience torque relaxation, the gasket will lose its compressive seal, which can result in varying degrees of leakage.

Depending on the location and function of the piping system, leaks can be costly and hazardous, resulting in maintenance/repair downtime and exposure to risk. Gasket replacement will be required when the joint is taken apart, as the gasket will bond to the flange faces during the course of time. When the joint is disassembled, the gasket will need to be scraped from both flange faces and these surfaces will need to be cleaned before the gasket is replaced, again increasing maintenance downtime. Due to the bolting forces along with system expansion and contraction, flange gaskets can also develop compression "set" over time, presenting another cause of leakage.

The design of a grooved mechanical pipe joint overcomes these performance issues. A groove is first formed in the pipe end and the piping connection is secured by a coupling which houses a resilient, pressure-responsive elastomer gasket. The coupling housing fully encloses the gasket, reinforcing the seal and securing it in position as the coupling engages and forms a positive interlock into the pipe groove. The latest coupling technology enables pipes up to 24" (600mm) in diameter to be fully assembled with only two nuts and bolts in order to secure the self-restraining joint. The mechanical joint creates a triple seal due to the design relationship between the pipe, gasket and housings, which is enhanced when the system is pressurized.

Rigid and Flexible Couplings

Available in both rigid and flexible forms, grooved mechanical pipe couplings are Class Society Type Approved, and may be used in lieu of welded/flanged methods in 30 systems, subject to installation criteria established by each certifying agency.

Rigid couplings are used, for example, around areas such as manifolds and valves, where they offer easier access and replacement than flanges. By nature of their design, rigid couplings also provide axial and radial rigidity comparable to flanged or welded joints.

Flexible couplings have advantages in applications where relative movement between the pipe and supporting structure is
anticipated, in addition to pipe movement resulting from thermal expansion or vibration. Expansion and contraction can stress the flange and piping, which can compromise the gasket over time. When this occurs, the joint is at risk of leaking. Grooved flexible couplings can accommodate pipe displacement in the form of axial movement or angular deflection. For this reason they are ideal for installing long piping runs especially between blocks where high seas can cause flanges to loosen over time, resulting in leaks and the risk of pipe separation. Both rigid and flexible couplings also provide the benefit of noise and vibration attenuation, eliminating the need for specialised noise reduction components and perishable rubber bellows or similar items. Using a mechanical grooved piping system can speed up and simplify both installation and maintenance and improve the efficiency of onboard piping systems.

Ease of Installation
On initial installation, bolt holes of a flange must be precisely aligned and then tightened to hold the joint. The bolt-hole index on equipment inlets and outlets must also line up perfectly with the flange on the piping to be connected to the unit. With only one of a number of fixed positions determined by the number of holes in a flange, a fitting or valve can only be rotated to match the bolt holes. Additionally, the opposite end of the Diemed pipe must also line up with its mating flange, which further increases assembly difficulty and the risk of misalignment.

Grooved piping systems do not have this problem and allow much more convenient installation with a full 360-degree rotation available for the pipe and mating components. There is no bolt-hole pattern to line up, and a coupling can be oriented at any position around the joint. The coupling can be rotated around the pipe to provide easy access to the bolts and simplify access to the equipment.

In addition to eliminating misalignment during installation, a coupling’s 360-degree orientation capabilities, together with its smaller profile compared to a flange, make the installation of grooved systems ideal for confined spaces. Additionally, the installer can orient all of the assembly bolts on each joint in the same position to ease system inspection and maintenance.

Flanges are roughly twice the outside diameter of the pipe they are attached to. On average, grooved couplings are only half this size. The size advantage of the smaller design makes the grooved system ideal for jobs where space is limited, such as deck and wall penetrations - a fact recognised as far back as the 1930s when Victaulic couplings were originally used in U.K. shipyards.

Speed of Assembly
Because couplings have fewer bolts and no torque requirements up to 12” (300mm), grooved piping is much faster to install than flanging. Unlike flanges that must be welded to the pipe end, grooved valve assemblies do not require welding, which further cuts installation time and eliminates potential heat damage to the valve while also reducing safety risks by eliminating hot works.

A comparison of a DIN 150 ballast line installed using Victaulic grooved products versus traditional joining methods showed a 66% reduction in total installation time required (150.47 man hours vs. 443.16 man hours). The time needed to install 52 slip-on flanges and weld elbows and tees compared with 60 rigid couplings showed the largest time differences.

Couplings require just two bolts up to 24” (600mm) pipe size. For comparison, at the higher size range a flange would require a minimum of 20 sets of nuts and bolts.

In addition, flanges require time-consuming star pattern tightening with specialised wrenches to measure and measure that correct torque specifications are achieved.

Grooved pipe technology allows couplings to be assembled using standard hand tools and the joint is properly installed once the mating bolt pads of the coupling housings meet metal-to-metal. A simple visual inspection confirms correct assembly. Flanges, on the other hand, do not provide visual confirmation: the only measure to ensure proper assembly is to fill and pressurize the system, check for leaks and retighten the joints as needed.

Maintainability
The same characteristics of grooved piping systems that accelerate installation—fewer bolts and no torque requirements—also make system maintenance or alteration a quick and simple task. To gain access to a pump or valve, for example, the two bolts of the coupling are loosened, and the housings and gasket are removed from the joint. In a flanged system, multiple bolts need to be removed. The same time-consuming bolt-tightening sequence required upon initial installation is also required upon reassembly of the flange.

Because they do not require retightening, couplings eliminate much of the routine maintenance associated with flanges. Unlike a flange that puts variable stress on the gasket, nuts and bolts, a coupling holds the gasket in precise compression from the outside of the pipe joint. Additionally, since coupling gaskets are not subjected to high compressive forces, they do not need to be replaced on a regular maintenance schedule, while flange gaskets need to be replaced when the system is disassembled for maintenance.

To attenuate system noise and vibration, flanged systems require rubber bellows or braided flexible hoses. These items can fail due to overextension and, with normal wear, need to be replaced every 10 years on average, incurring cost and system downtime. Mechanical grooved pipe couplings, however, last the life of the system. Their ability to accommodate system vibration reduces the risk of joint failure, without the need for
speciality products that require periodic repair or replacement. The resilient elastomeric gasket contained within both flexible and rigid couplings is very durable and can handle significant operating pressures and cyclical loading. A system can be pressurized and depressurized repeatedly without fatiguing the elastomer gasket.

**Weight reduction**

Valve assemblies are typically constructed with flanged components. However, this joining method can add unnecessary weight to a piping system. A 6” (150mm) flanged valve assembly constructed with a lug butterfly valve, connected with weld-neck flanges and eight bolts and nuts on each side of the valve, weighs approximately 85 lbs. A 6” (150mm) valve assembly that utilizes a grooved-end butterfly valve, grooved-end pipe and two rigid couplings to connect the components weighs approximately 35 lbs, representing a 58% weight reduction over the flanged assembly. A grooved valve assembly is therefore, an ideal alternative for the shipbuilding industry.

The above mentioned comparison of a DIN 150 ballast line installed showed a weight reduction of 30 percent (2,164 lbs vs. 3,115 lbs) when Victaulic grooved products were used instead of traditional joining methods. The 52 slip-on flanges, bolt sets and gaskets, versus 60 rigid couplings accounted for major weight increases in the welded/flanged system.

Weight reductions by using grooved pipe couplings instead of flanges are achievable across a range of pipe sizes. The magnitude of the reduction depends on the pipe diameter and type of coupling used. In tests where piping was connected using one Victaulic Style 77 coupling — the heaviest coupling in the range — compared with two light-weight PN10 slip-on flanges the total installed weight of the grooved assemblies was significantly lower. Weight reductions were recorded as follows: 4” (100mm) – 67 percent; 12” (300mm) - 54 percent; 20” (500mm) – 60.5 percent.

With the lighter-weight flexible Style 75 or rigid Style 07 couplings and/or a heavier type of flange, weight reductions of 70% are easily achievable. As an example, a 24” (600mm) flanged set for a TG2 system would weigh 507 lbs but a comparable assembly using Victaulic couplings would weigh only 88 lbs. Shipyards that have used grooved couplings in preference to flanges on selected systems have recorded weight savings of 12 tons on offshore support vessels and 44 tons on cruise ships.

The economic benefits of grooved technology to ship owners are clear: less weight means more cargo or passengers and less fuel consumption. It makes the handling of piping systems on board easier as well.

**Growing Trend**

Grooved piping systems can offer significant advantages over their flanged equivalents because of their speed of installation, maintainability and reduced weight. These characteristics, coupled with additional benefits such as reliability, ease of alignment and lower safety risks, are leading owners, engineers and shipyards to choose grooved mechanical systems instead of flanges.

This growing trend towards the use of grooved technology is supported by suppliers of equipment such as heat exchangers, box coolers and chillers, along with valve and compressor manufacturers, many of whom are now providing their products with grooved end connections. The range of services where grooved pipe couplings may be used is steadily increasing. Building on successful applications in water systems, Victaulic is continuing its long history of innovation to develop fire-resistant gaskets and gain Type Approval for their use on maritime fuel services.

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