



*Plant room equipment with grooved inlets and outlets*

# Grooved Mechanical Pipe Joining

## - an Introduction

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### Introduction

Mechanical grooved pipe joining has been subjected to research, testing and extensive evaluation during its 85-year history. It has been used in several famous engineering structures including the Hoover Dam in the United States, the Grand Arche de la Defence in France, the Alexandria Library in Egypt, and the Burj Khalifa in the Middle East. Recent work in India includes The Park Hotel Hyderabad, the Delhi Airport Metro Express, Mumbai Airport and the ICC Marriott in Pune.

For engineers, the benefits of the grooved system are many: the design versatility of the joint allows rigidity and flexibility throughout the system; a mechanical joint provides noise and vibration attenuation, seismic relief, and accommodates thermal expansion and contraction. The system also provides a union at every joint for ease of system maintenance and expansion.

### Roll Grooving

The most common preparation method used today in mechanical piping

systems is cold forming a roll groove onto the end of the pipe.

Roll grooving was invented in the 1950s and is used on 90 percent of grooving applications. Fast and clean, it is used on a wide variety of pipe sizes and standard wall thicknesses.

Roll grooving can be used on carbon steel, stainless steel, copper and aluminium pipe or tubing. Most coupling manufacturers provide roll-grooving equipment based on customer requirements.

The latest development in grooving technology is the Advanced Groove

System (AGS) for medium to large diameter pipes between 350mm and 1525mm (14" – 60"). AGS offers enhanced strength and reliability through a more robust coupling housing and a patented wedge-shaped roll groove, which results in a 40 percent increase in end-load carrying capabilities compared with previous joining methods.

### Grooving a pipe in the field

To groove a pipe, the pipe fitter places the pipe end between a roll set. As this roll set is rotated and compressed, a groove is formed around the pipe's diameter, protruding on the inside and recessed on the outside. This grooving method can be used for carbon steel, stainless steel, copper and aluminium pipe or tubing.

Most coupling manufacturers will provide the proper roll grooving



*Figure 1: Section of a grooved mechanical pipe joint*

### About the Author

**Pankaj Soni** is the country manager for India at Victaulic, a pioneer and global player in mechanical pipe joining systems. He has worked for a number of international engineering firms, and has more than 18 years of professional experience. He is a mechanical engineer and also holds an MBA.



Photo 1: VE270 field roll grooving tool

equipment based on customer requirements and there are a number of pipe grooving machines available for both working in the field and in workshops. For the groove to fit perfectly a purpose built machine should be used.

One example is the VE 270 Field Roll Grooving Tool (see Photo 1) – a self-contained unit for use onsite with integral gear motor, safety guards, safety foot switch and power cord with plug. On the other end of the spectrum is the fully-motorized, semi-automatic, electro-hydraulic VE 268 tool that is suitable for workshop fabrication, and comes complete with safety guards and safety foot switch (see Photo 2). These tools are manufactured by Victaulic in North America, and are available in India.

#### Does grooving weaken the pipe end?



Photo 2: VE 268 tool

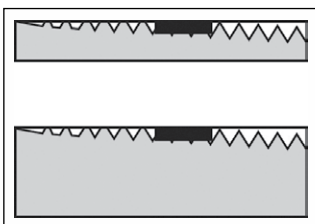


Figure 2: Rolling vs. threading

A question that is often asked regarding a grooved joint has to do with the reliability of the groove under stress.

When examining the stress on pipes created by internal pressure and the typical overstress failure mode, the cut groove has proved not to be the weakest link. When under pressure, two basic stresses occur: longitudinal and hoop. Longitudinal stress is often described as tensile stress in material, the force pushing pipe apart in the axial direction. A failure due to longitudinal stress would cause a circumferential fracture around a pipe. Hoop stress can be described as ballooning or expansion of a pipe diameter in a radial manner. A failure due to hoop stress would cause the pipe to split lengthwise along its axis.

Mathematically, the formulae for longitudinal and hoop stresses are:

$$\text{Hoop Stress} = \frac{(\text{Pressure} \times \text{Outside Diameter})}{(2 \times \text{Wall Thickness})}$$

$$\text{Longitudinal Stress} = \frac{(\text{Pressure} \times \text{Outside Diameter})}{(4 \times \text{Wall Thickness})}$$

With pipe that is roll grooved, any potential increase in pipe hardness, reduction in tensile strength or reduction in elongation has no effect on the integrity of the joint. Pipe material changes are comparable to any other cold-forming manufacturing operations.

The total installed cost of grooved joints is significantly lower than flanged, threaded or welded systems whilst system behaviour is very similar, with all piping remaining in strict alignment and not subject to deflections during operation.

#### Comparison with Flanged Joints

There are also advantages of using grooved systems over flanging and weld – including speed of installation, safety and environmental benefits. There are maintenance advantages also, as a grooved joint can be easily removed, allowing systems to be easily repaired or rerouted for maximum efficiency, with the coupling reused.

Flanges are difficult to work with and are time consuming to connect. A 144" flange has 52 bolts and nuts that require star-pattern tightening three times to complete the joint. They require enough clearance around the pipe to be able to secure each bolt, making use of flanges in confined spaces difficult. Flanges can also result in maintenance challenges, because after a valve or other piece of equipment has been removed, it is difficult to squeeze back in between the flanges.

In addition, the use of flexible mechanical joints can provide a natural solution to noise and vibration attenuation, removing the need for additional flexible connections around pump sets and expensive specialized equipment.

The use of a combination of flexible and rigid grooved couplings is also highly suited to accommodating seismic events, as well as sway in tall buildings – offering substantial advantages over traditional joining methods in these circumstances. Also, rigid couplings offer strength whilst flexible couplings can bear deflection and move with pipes, which reduces damage from vibration.



Photo 3: Grooved pipe joint installation in The Park Hotel Hyderabad

### Flow Dynamics

The inside protrusion of a roll groove is small and smooth at its entry and exit and has negligible effect on both flow and or line pressure. Published ratings take into account the groove and, through testing on the performance of a joint, pressure ratings with a three to one safety factor are evaluated.

Recent flow testing was conducted on joints grooved with roll grooving tools, and these tests confirmed good flow characteristics, with an insignificant contribution to system pressure loss. In fact, the amount was negligible in comparison with more common points of flow loss, such as pipe friction, valves, bends and branches.

In-house testing on grooved and plain end pipe using 104.8mm Type "K" copper tubing and 50mm and 200mm Schedule 10 and Schedule 40 carbon steel pipe saw pressure drops measured with velocities between 4-20 metres per second at ambient water temperature.

The results showed that pressure loss was negligible. These findings are also supported through rigorous independent testing by Factory Mutual Research Corporation, further attesting to

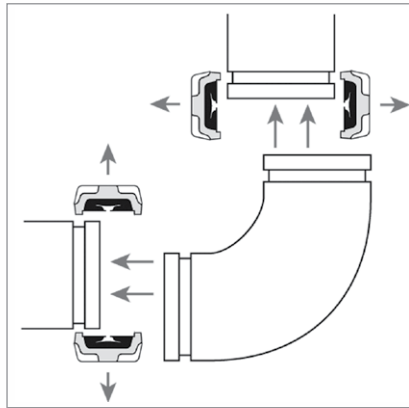


Figure 3: Union elbow with grooved ends

makes grooved joints suitable for HVAC applications.

### Reliability

When it comes to specifying systems, reliability is a top priority for engineers.

Mechanical grooved pipe joining has been a reliable and rugged component of a wide range of mission-critical applications, including data centres and flammable chemical cleaning. It has also met the rigorous system demands required for high pressure performance in power applications and in hydraulic elevators.

The mechanical joint in a grooved coupling comprises of four elements: grooved pipe, the coupling housings, a pair of nuts and bolts and the rubber gasket ring. This gasket is pressure responsive and is encased by the coupling housing when it engages in the groove around the circumference of the pipe. The gasket then creates a seal unified joint that is enhanced when the system is pressurized.

The gasket should not need replacing during normal use as it has no contact with the outside environment. In HVAC operation, only under exceptional circumstances would the gasket need replacing, and the joint can be quickly and easily opened to make the exchange.

The method has been used in some innovative engineering projects in recent years. Among them is the retractable roof over the centre court at the All England Lawn Tennis Club, Wimbledon, where grooved technology was selected for the heating and chilled water piping systems in the first project of its type in the world.

Grooved systems are verified by independent approval agencies including Factory Mutual Approvals (FM), Lloyd's Register of Shipping, Loss Prevention Certification Board Ltd. (LPCB), Underwriters Laboratories Inc. (UL), and American Society of Mechanical Engineers (ASME). These are the agencies that recognise welded, flanged and threaded systems.

### Conclusion

Properly used and installed, grooved mechanical joints are safe and effective. Details about the grooving process, the strength of grooved pipe, and flow characteristics are explained in published reports from independent agencies as well as by manufacturers.

Pioneered during World War I, mechanical pipe joining was invented by the company now known as Victaulic. Since being made commercially available in 1925, it has become a preferred joining method on many piping applications. ❖

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