# Permanent Non-Welded and Cold Bent Piping Solutions

An Alternative Solution to Welded Piping for the Oil and Gas Market

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# Experience a Faster, Safer Alternative to Welding.

Non-Welded Solutions Are Creating Efficiencies in the Oil and Gas Market.

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Since the invention of the first commercial oxyacetylene welding torch and the coated metal electrode in the early 20th century, welding has become the predominant method for joining metals and fabricated piping systems. Welded pipe systems can be found in nearly every industry that relies on the movement of process streams at elevated pressure or temperature, including oil and gas facilities and power generation plants.

However, for certain applications, there are viable alternatives to welded piping systems. Piping solutions using non-welded connections and cold bent piping offer significant value through reductions in welding fabrication labor, validation and inspection times, and piping system commissioning times – all without the introduction of the workplace hazards associated with welding.

## Conventional Welded Piping Systems

For pressure piping systems, butt and socket welds are utilized. Butt welding of pressure piping systems is especially common on piping systems larger than 2"/60.3mm. Small bore (2"/60.3mm NPS or smaller) pipe and fittings frequently use socket weld (SW) flanges and fittings.

Butt welds (BW) are commonly used in high-integrity or severe service applications where the weld joint must be able to withstand higher pressures and more demanding operating conditions. Butt welding is typically used for weld neck and lap joint flange connections and requires full penetration welds (**Figure 1**). For butt welded connections, the ends of pipes and fittings must be chamfered (beveled) in order to accommodate the fully penetrated weld bead and assure a strong joint.

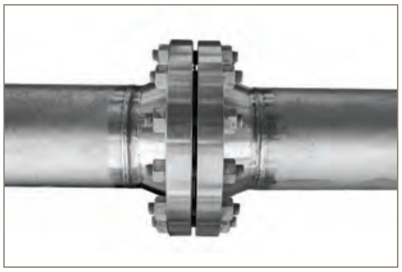


Figure 1 – Two butt weld flanges being aligned prior to final installation.

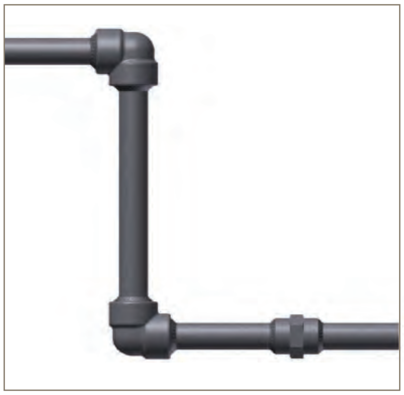
Socket weld (SW) costs are lower than those associated with butt welding because precise fit-ups and beveling are not required and typically fewer cumulative weld passes are needed (**Figure 2**). Where butt welding and socket welding are both commonly used (1/2" to 2" sizes), the man-hours per stainless steel pipe weld joint are roughly doubled for a butt weld compared to a socket weld. These typically require one fillet weld per joint (two joints per SW fitting). Socket welding, however, does not come without challenges. Compared to butt welding, socket welds have lower resistance to vibration and shock/water hammer effect. Further, for both socket and butt welds, qualified and proper welding is required to ensure welds do not fail prematurely due to shear stresses induced during the welding/cooling process.

Figure 2 – Piping system with socket weld elbows and tees.

# Challenges of Traditional Welded Piping Systems

To different extents, both butt welding and fillet socket welding require processes and costs that are unavoidable as described in **Table 1**. Pipe welding involves much more than the physical act of striking an arc and applying the weld bead; numerous pre- and post-weld tasks are required to produce a structurally sound joint. These tasks add time, labor and expenses that may be overlooked as part of the overall welded piping installation.

To help illustrate a conventional welded system, consider the example shown in **Figure 3**, which contains two socket weld elbows and one straight coupling.



| WELDED SYSTEM | |
|---|---|
| Welds | 6 |
| Elbow fittings | 2 |
| Welding fabrication time | High |
| System flushing Time | High |
| Flow characteristics | Abrupt |
| Turn-around time | High |
| Total installed cost | High |

Figure 3 – Double 90º piping arrangement with socket weld elbows and coupling.

Six welds (two per fitting) are required for this configuration. Total installed costs and lead time would need to account for all the tasks listed in **Table 1**. Considering these many factors, a high-pressure installation requiring Schedule 160/XXS pipe with 6000# socket weld pressure pipe fittings, total welding time can easily exceed eight hours depending upon material, weld type, and size. This excludes the post-welding associated tasks and time. An unintended consequence of the overuse of 90° elbows can impart abrupt flow direction changes, typically manifesting in associated pressure losses.

| TABLE 1 – STANDARD WELDING TASKS | |
|---|---|
| **TASK** | **DESCRIPTION** |
| Material prep | Grinding, blasting, removal of oils, paint, etc. |
| Joint prep | Butt welding – beveling of pipe<br>Socket welding – square cut and light deburr |
| Preheat/tack-up | Dependent upon Welding Procedure Specification (WPS) and materials; raising the temperature of the parent steel before welding slows the cooling rate of the weld and base material providing greater resistance to hydrogen embrittlement |
| Welding and pipe fitting | Welder and pipe fitter labor, including time between weld passes such as cooling/wait time, slag removal, brushing, grinding, visual and/or Liquid Dye Penetrant (LDP) inspection, subsequent pass preparation, etc. |
| Pickling/passivation | Hydrofluoric/nitric acid/citric treatment |
| Nondestructive examination (NDE) and certification | Visual, radiography, magnetic particle, liquid dye penetrant; certification and documentation (validation against WPS) |
| Rework (as needed) | If visual inspection and/or NDE shows defects, joints require repair or remake and are sent back for post weld processing and follow-up NDE |
| Other on-site tasks and costs | Hot work permits, consumable materials (electrodes, gases), industrial hygienist, Weld-Specific Personal Protective Equipment (PPE), purge gases, disposal of hazardous chemicals |

# Non-Welded Piping Connections and Cold Bending

Today there are proven alternatives to weld fittings for the high-pressure fluid power requirements of the oil and gas industry. Mechanically Attached Fittings (MAF) are available that can replace both socket or butt weld fittings in applications exhibiting high pressure, high vibration, cyclic pressure, hydraulic shock, and high fluid acceleration. MAFs can be used for a variety of pipe sizes, schedules, and pressures. Typical configurations are available for stainless steel pipe in sizes 3/4" to 2", from standard schedule to extra heavy (160/XXS), and in pressure ranges up to 10,000 psi/ 700 bar.

MAFs typically do not require highly-skilled pipe welding labor and require none of the post-weld tasks described previously in **Table 1**. Compared to hours with welding, MAFs can be fabricated and installed in minutes. Applications for such MAFs include fluid power, lubrication, power generation high pressure grease distribution pressure pipe systems, land-based upstream energy extraction and exploration, marine, offshore oil and gas, and even critical fluid power/ hydraulic systems.

Referring back to the example double-90° piping run shown in **Figure 3**, a comparable non-welded MAF hydraulic piping system can be fabricated and ready to install in a fraction of the time – under 40 minutes – and is as equally reliable as a fully inspected welded system, but with the elimination of associated EHS requirements such as: firewatch, welder PPE and environmental monitoring.

In addition, compared to carbon steel, welded stainless steel piping systems require even more welding time and more EHS oversight to protect workers from hazardous fumes, particularly chromium.

MAFs can dramatically reduce welds in a fluid power piping system. For maximum weld reduction, MAF technologies should be paired with cold bending of pipe. For each cold bend, a minimum of two welds are removed from the system and, as compared to weld elbows, impart lower pressure drops and more laminar flow with direction changes. By combining the cold bends with a MAF, most, if not all, of the welds in the fluid power piping system can be removed.

Completed spools, after pig cleaning, are ready for immediate installation and use, unlike welded piping connections that require post-weld tasks that could take several days until welded piping spools can be installed. A visual reference of the time advantage can be seen in **Figure 4**.

Many of the benefits of non-welded piping technology are summarized in **Table 2**. These benefits range from reduced weld preparation and inspection time to a safer work environment.

**TABLE 2 – BENEFITS OF NON-WELDED PIPING TECHNOLOGY**

| BENEFIT | VALUE |
|---|---|
| Eliminate welding | Reduced preparation and fabrication time for joints; eliminates the need for weld inspections (NDE), pre-heating, purge gas, costs for welding electrodes and shielding; reduced welding PPE and environmental monitoring costs |
| No post-weld cleaning | No acid cleaning (pickling/passivation) costs and associated delays for such; minimized safety risk from open flame |
| No weld induced stresses | Longer pipe lifetime through reduced maintenance costs associated with weld fatigue, improper welding processes and corrosion |
| No “hot work” permits required | Installation permissible in areas with fire risk without interrupting production; reduced downtime costs; increased safety in controlled shop environment |
| System productivity | Shorter installation times, ready for immediate use |
| Labor productivity | No firewatch labor; connections fabricated by pipe fitters allowing for flexibility between pipe fitters/pipe welders |
| Piping system cleanliness | Reduced overall flushing and commissioning time/costs; reduced risk associated with component/system damage due to weld-induced particulate contamination |
| Health, safety and environmental | Reduced air monitoring and PPE requirements; reduced worker exposure to open flame and fugitive emissions; no chemical cleaning waste disposal cost |

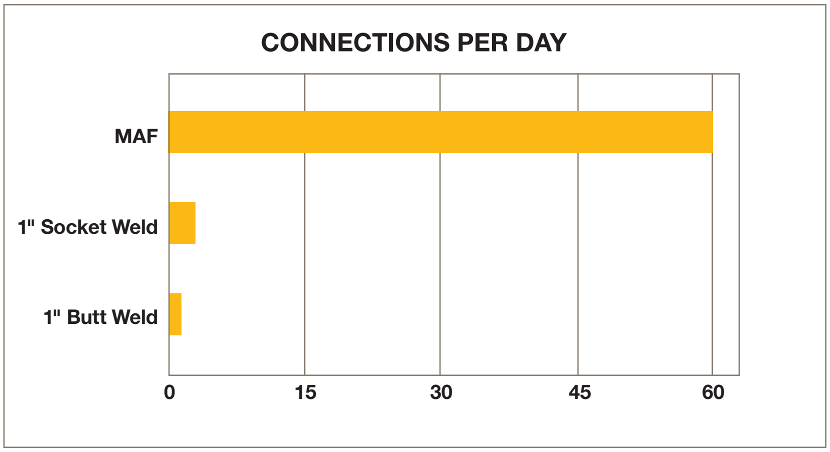



Figure 4 – Shows how many welded and non-welded connections can be made in a typical 12-hour work day. Compared to a welded connection, the time to assemble and MAF is not size dependent.

# Phastite – The Inside Story

Parker's Phastite® for Pipe is a patented permanent MAF technology that enables connections to off-the-shelf stainless steel schedule pipe. The Phastite system can withstand pressures up to 10,000 psi at subsea depths of 15,000 feet. These systems are tested in accordance with ASTM F1387 requirements and meet the requirements of ASME B31.1 and B31.3.

Phastite fittings create a permanent metal-to-metal swaged connection, replacing both socket and butt weld fittings in applications exhibiting high pressure, high vibration, cyclic pressure, hydraulic shock and high fluid acceleration. Phastite non-welded connections can be used for 3/4" to 2" ASTM A312 type 300 Series stainless steel pipe in schedules 40/STD, 80/XS, 160 and XXS.

Phastite has been tested in compliance with the design requirements of ASME B31.1, ASME B31.3 and has been exhaustively tested and qualified through DNV-GL for subsea and top-side offshore fluid power piping applications. While developed, qualified and tested for the most demanding subsea fluid power systems, Phastite can also be used on fluid process and fluid conveyance applications when specified properly and subject to appropriate code or classification body requirements.

Figure 5 – Phastite PMAF non-welded fittings.

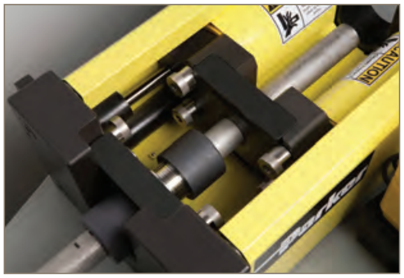


Figure 6 – Phastite swaging tool.

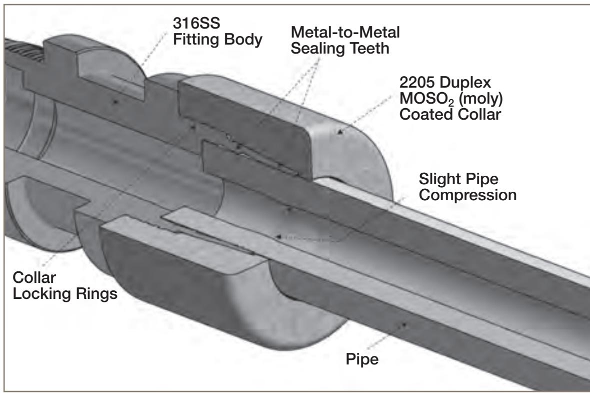



Figure 7 – Phastite MAF connection detail.

Phastite fittings (**Figure 5**) are axially swaged to the pipe using a bench-mounted attachment tool (**Figure 6**).

During pipe attachment, the Phastite collar is axially engaged to the fitting body as radial fitting teeth are locked to the pipe (**Figure 7**). A precise amount of pipe compression is achieved through the radial force and axial load, providing a permanent connection in a matter of minutes. Phastite connections are highly resistant to pressure cycling, vibration and external loading that occur in high-pressure fluid power/hydraulic systems.

# Extreme Testing for Extreme Environments

To meet the specialized industry concerns for subsea fluid power/hydraulic piping, the qualification and testing of Phastite for Pipe was carried out in accordance to DNV-GL RP-A203 and ASTM F1387. A Threat Assessment was conducted to identify all relevant failure modes of concern for the elements defined. A Technology Qualification Plan (TQP) was developed to identify and document the specific qualification parameters and tests that would be undertaken in order to qualify Phastite for Pipe for the intended subsea service, as well as the acceptance criteria for each qualification test. All qualification activities were third party witnessed.

Many tests and analyses were executed during the qualification of the Phastite, including, but not limited to:

- **Vibration testing**
- **SCC corrosion**
- **Crevice & pitting corrosion**
- **HISC corrosion**
- **Bending**
- **Tension/pull-out resistance**
- **Torsion**
- **Burst**
- **Impulse/cyclic loading**
- **Hyperbaric chamber**
- **Fire**

In addition, extensive Finite Element Modeling was performed to support the qualification activities.

Phastite has been designed and tested specifically to meet the demanding and unique requirements of subsea hydraulic systems. Parker is continually working closely with customers, classification bodies, and independent experts, to meet the challenging demands of the market as a replacement technology for welded fittings on subsea oil and gas hydraulic piping.

# Phastite – Case Study – BOP Hydraulic Piping Upgrade

When considering the total cost of piping technologies and installations for high pressure fluid power applications, Phastite emerges as a proven time, safety and application improvement to welded systems.

A recent example of an offshore subsea Blowout Preventer (BOP) rebuild (**Figure 8**), included 15 pipe spools utilizing Phastite for Pipe and cold bending. This piping scheme would traditionally be fabricated from 1" and 1 1/2"/Sch 160/XXS stainless steel pipe and 6000# forged socket weld fittings. A minimum of 30 welds were eliminated from this relatively simple piping arrangement by replacing socket weld SAE/ISO 4-bolt hydraulic flange weld flanges with Phastite and all 90/45 SW elbows with cold bends. Even in this simplified example, nearly 75 hours of weld labor was removed from the construction or refurbishment project window.

When looking at the total production throughput improvement, a typical hydraulic piping upgrade lead time as illustrated could be completed in 5-7 days as opposed to 25-30 days for a comparable welded system.

Figure 8 – Typical BOP with Phastite for pipe and field fabricated cold bent pipes.

For additional information on non-welded connections and cold bent piping systems, please contact Parker Tube Fittings Division at **614-279-7070** or visit **www.parker.com/tfd**.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