Hydropower & Dams

Increase safety, save time and save money
by eliminating onsite pipe welding

Parker

ENGINEERING YOUR SUCCESS.

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In the hydropower world, the mention of hydraulics or hydraulic piping may immediately conjure images of enormous pipes that you could stand in. However, from mini-hydro to mega-dams, there are many miles of much smaller hydraulic piping essential for connecting the hydraulic power unit (HPU), main inlet valve (MIV), accumulators, and actuators for water flow and turbine speed control systems.

Engin Cekic

Application Development Engineer at Parker Hannifin, explains how piping solutions utilizing non-welded piping technologies and cold bent piping offer reductions in fabrication and commissioning time while improving workplace safety.

Since the early 20th century, welding has become the predominant method for joining metals and is adopted when fabricating pipe systems. Welded pipe systems can be found in nearly every industry that relies on the movement of process streams at elevated pressure or temperature. However, there is an alternative that is steadily emerging as a more efficient and cost-effective approach: piping solutions using non-welded connections and cold bent piping. These advancements are proving themselves across multiple industries including hydropower, offering significant value through reductions in fabrication and commissioning time, while improving workplace safety.

Why Weld?

A typical hydraulic pipe run in a hydropower plant is from the hydraulic power unit to a main inlet valve actuating cylinder. This pipe run is typically made of 1.4571 stainless steel and, in modern installations, can often have dimensions of 75mm with a pressure rating over 150 bar. Older technology was often 60 bar, but today's higher performance and more compact designs are running at higher pressures.

Welding is a complicated process for producing pipe connections. Butt welds are commonly used in severe service applications where the weld joint must be able to withstand higher pressures. Slip-on flanges are more economical and suitable for less severe applications. They require less accuracy in cutting/beveling the pipe or fittings, however two circumferential fillet welds are required to attach the flange – one at the pipe outside diameter and one on the flange face, and this necessitates refacing after welding. In addition, welded joints between straight tubes and elbows often require the prevention or removal of heat "tint" around the weld. Tint removal is typically accomplished using mechanical or chemical methods or, for best corrosion resistance, acid pickling, introducing an extra processing step and additional handling concerns.

Welding is, therefore, a technical, time-intensive process that requires skilled tradesmen. Even the best welder does not produce perfect welds. Which is why comprehensive checks require much time. As an additional challenge, appropriately certified specialists are rare. Welding is also associated with special cleaning, degreasing agents, anti-corrosion resources and the use of a significant amount of energy. There is also the safety aspect to consider because fumes are emitted, creating risks of fire and explosion.

The welding process, therefore, involves much more than the physical act of striking an arc and applying the weld bead. There are many pre- and post-weld tasks that must be performed to produce a structurally sound joint (see table 1). Each of these can add time, labour and therefore cost.

Task	Description
Material prep	Blasting, removal of oils, etc.
Joint prep	For butt welding - beveling of pipe using beveling equipment
Preheat	Raising the temperature of the parent steel before welding slows the cooling rate of the weld and base material, providing greater resistance to fabrication hydrogen cracking
Actual welding and on-site costs	Welder labour, hot work permits, consumable materials (electrodes, shielding)
Post-weld treatments	Brushing, grinding, passivation and pickling to remove all imperfections, including slag/spatter
Pickling / passivation	Hydrofluoric / nitric acid / citric treatment
Nondestructive examination (NDE)	Radiography, magnetic particle, liquid dye penetrant

Table 1. Tasks associated with welding

Hydropower Applications

In a hydropower application, the complexities of welding are made even more difficult as these piping systems are generally located below ground level at the bottom of a deep shaft, which requires cranes to drop them into place. Challenges include long inside-building handling distances, limited lifting capacities and difficult manoeuvring of the pipes with the possibility of damage in so doing. As the work space is restricted, hot-work permits are required and welding is often not permitted at the installation. This means that only spot welding is viable in-situ at the bottom of the shaft, and that the piping system must then be removed by the crane so that the main weld operation can take place off-site, before eventually dropping the piping system back down the hole again. This adds significant time, handling and logistic considerations to the installation, which translates directly into cost implications.

A typical hydropower piping system installation using welded pipes includes each of the following stages:

1) Engineering and material planning
2) Check and fulfil HSE weld requirements (consider shielded area, work permit, trained personnel, etc.)
3) Transportation of the pipe to the MIV
4) Tube end preparation (cut, chamfer, clean)
5) Tack welding of the pipe
6) Disassemble the tube at the MIV
7) Carefully transport tube to workshop for final welding
8) Final welding of the pipe
9) NDE (non-destructive examination) and documentation – may need to be taken off site to achieve this
10) Acid clean of the welded tube
11) Treat the tube with corrosion protection
12) Transport the tube back to the MIV
13) Installation

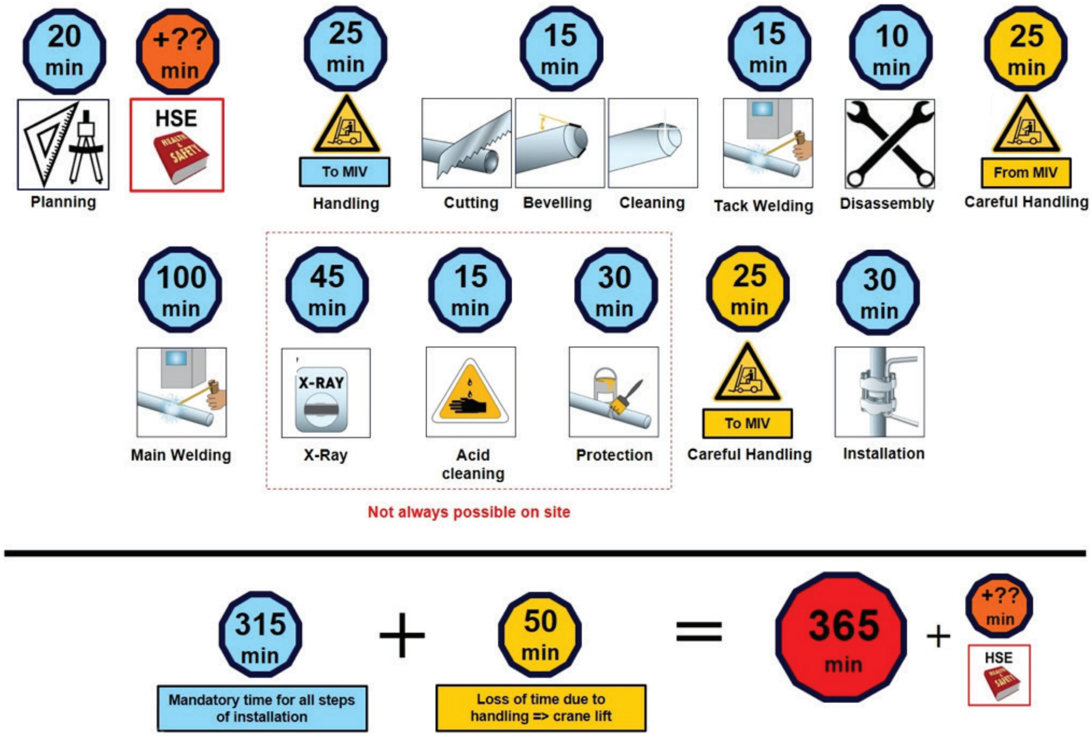

Figure 1: Based on multiple case studies, Parker has created average times per pipe and weld associated with piping system installation using welded pipes in a typical hydropower setting

Although welding may currently represent the status quo for joining metals and fabricating pipe systems, it comes with multiple associated challenges. Not only is it time consuming, logistically challenging and requiring the skills of trained welders, it is also potentially dangerous and in some hydropower locations may necessitate an evacuation of the area and potentially even firefighting personnel on standby.

The Alternative to Welding Pipe

Cold bending is steadily emerging as a viable alternative to welding, providing a cleaner solution to addressing directional flow changes in piping systems without limiting the design to the use of 'off the shelf' 90°, 45°, and 22 ½° degree fittings. Modern computer numerical controlled (CNC) controlled pipe and tube benders are now being used to provide more accurate and repeatable pipe fabrication in the safe and controlled shop environment for pre-fabrication.

CNC controlled pipe and tube benders in a shop environment for pre-fabrication

The elimination of weld fittings, however, only addresses part of the challenge in fabricating a viable piping layout. Piping systems must also account for service breaks and equipment connectivity – typically accomplished through a weld flange. Mechanical flange alternatives to welded connections and flanges are available, with the use of an orbital flaring process. Figure 2 shows a complete non-welded piping system comprising two 90° cold bends combined with a Parker Parflange F37 non-welded connection. This non-welded connection can be used for 1/2-inch / DN 15 to 10-inch / DN 250 pipe sizes at pressures up to 6000 psi/ 420 bar.

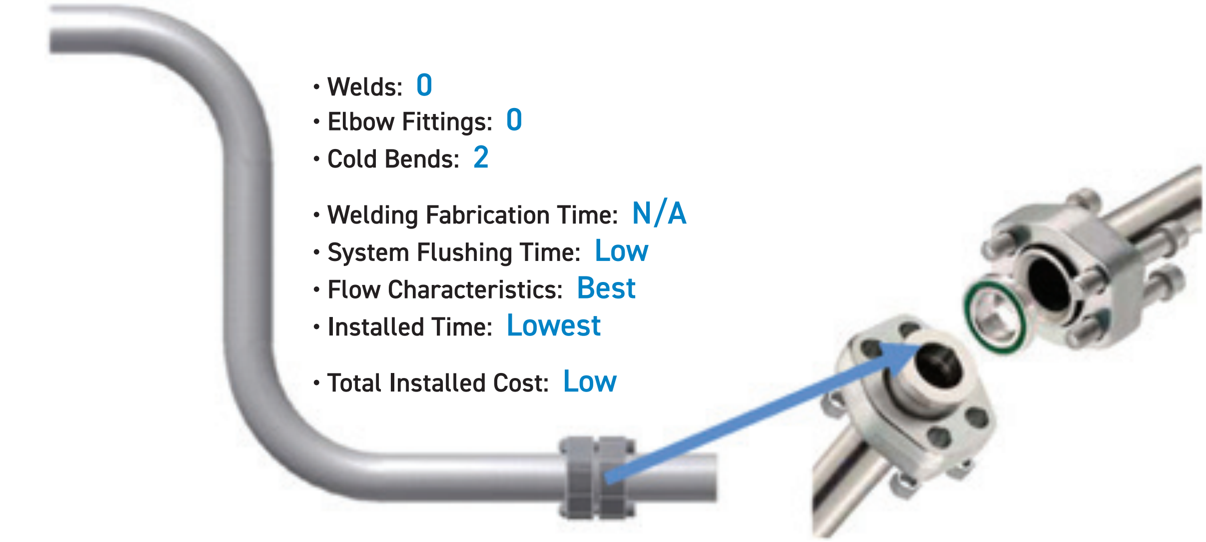

Figure 2: Cold bent non-welded piping system with Parflange F37 connection

The Parflange F37 technology plus the cold bending of pipe and tubing are becoming widely used and have gained acceptance from piping engineers dealing with hydraulic systems, providing interconnected piping between hydraulic power units, actuators, manifolds, accumulator banks, motors and grease/lubrication points. It can be field-fabricated, pre-fabricated, or a combination of both. For streamlined piping installations that minimise weld assembly, piping kits can be pre-fabricated and delivered to the project site ready for installation, reducing onsite installation time compared to field-welded systems.

The benefits of non-welded piping technology are summarized in Table 2, ranging from lowered installation costs and safer installation, on-site time savings, increased on-site flexibility, and easy installation with standard installation workers.

Benefit	Value
Eliminate welding	Reduced preparation and fabrication time for joints; no costly weld inspections (NDE); no costs for welding electrodes and shielding
No post-weld cleaning	No acid cleaning (pickling/passivation) costs; minimized safety risk from open flame
No weld induced stresses	Longer pipe lifetime; 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
Shop pre-fabrication vs. field welding	Shorter installation time and reduced downtime
Cleanliness	Less contamination potential reduces need for repairs and replacement of hydraulic system components such as pumps, valves and cylinders; reduced overall flushing time and associated costs
Modular	Easy to dismantle, re-assemble and modify the piping system
Health, Safety & Environmental	Reduced air monitoring and personal protective equipment requirements; reduced worker exposure to open flame and fugitive emissions; no chemical cleaning waste disposal cost

Table 2: Benefits of non-welded piping technology

Shifting the emphasis from installation to engineering and purchasing

This entire process shifts the emphasis from installation to the engineering and purchasing phase.

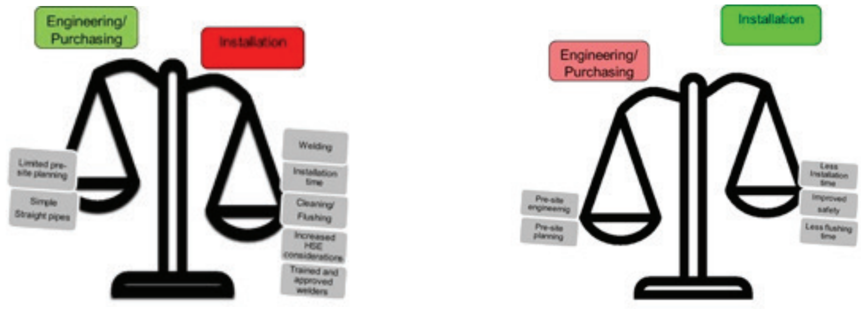

Figure 3: Shift in emphasis from installation to engineering and purchasing.

With its complete Piping Solutions (CPS) program, Parker Hannifin's Global Services offers a modular constructed system which comprises consultation on the design, manufacturing and installation of hydraulic tubing systems. Large-format tubes and flanges are designed, produced, connected to a complete system, and delivered directly to the installation location and assembled.

Firstly, system engineers will collaborate with the hydropower engineers in a CAD environment to determine the specific project requirements before developing a tubing layout between the power unit and accumulator.

On agreement from the customer, the pipes are prefabricated offsite, with outside tube diameters up to 273mm cold-formed on state-of-the-art CNC bending machines, achieving small bend radii. The finished and cleaned tubes are then assembled and dispatched to the building site and put into onsite containers. When ready, these systems are easy to install by standard installation workers, which means that when the tubing system arrives onsite, the customer can take charge of installation. However, if preferred, Parker Hannifin's experts can also assemble, rinse and give a final inspection of the system.

Increased Safety, Time Savings and Cost Reductions

Parker Hannifin has supplied piping systems to hydro plant installations including Akkatsin Sweden, Budarhals in Iceland, Foyers in Scotland, and Ingula in South Africa amongst others.

Compared to Figure 1, which illustrates average times associated with a typical hydropower piping system installation using welded pipes, Figure 4 offers a comparison for the installation of the pre-formed and flared pipe, which greatly simplifies the process significantly reduces the safety risks and the investment of effort and time on-site.

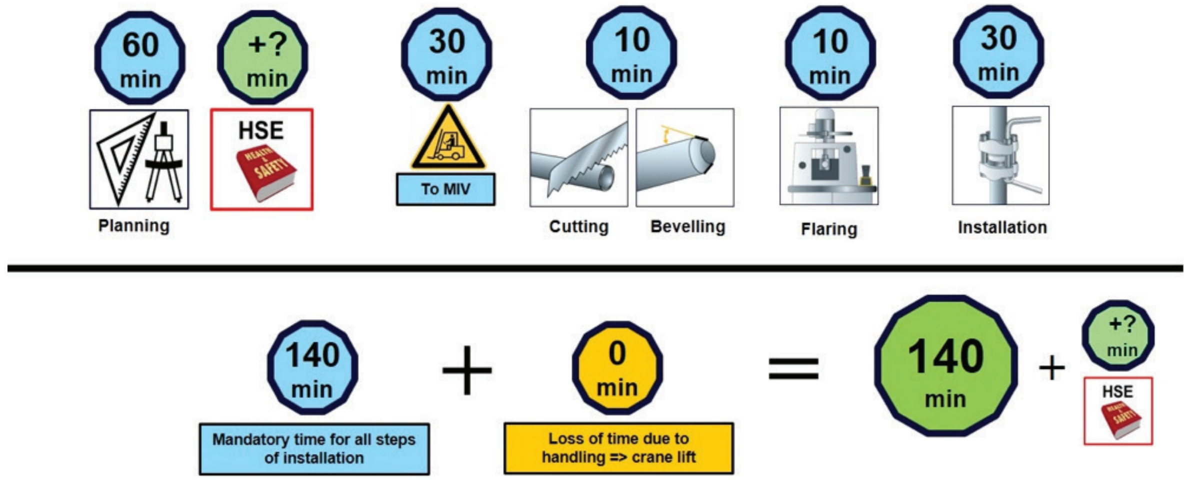

Figure 4: Based on multiple case studies, Parker has created average times per pipe and weld associated with installation of pre-formed and flared pipe in a typical hydropower setting

A typical hydropower piping system installation using pre-formed and flared pipe reduces the process to the following stages

1) Engineering and material planning
2) Check and fulfil general HSE requirements
3) Transportation of the tube to the MIV
4) Tube end preparation
5) Form tube end
6) Installation

As there is no welding required, this reduces the preparation time per joint and eliminates the costly, required inspections of each weld. In addition, there are many harder-to-measure benefits. For example, with no post-weld cleaning required, this removes acid cleaning and waste disposal costs, and as a hot work permit isn't needed, the operation can take place in areas with fire risk without interruption of production, reducing downtime costs. Cleanliness is increased and overall flushing time and costs reduced. And thanks to the workshop prefabrication, the need for onsite work and product handling is minimized, leading to shorter installation time, shorter maintenance and downtime, and a shorter overall project time. Workshop conditions also deliver higher quality joints with better accuracy, and safety is another key area, with risks significantly reduced.

Time savings can be as important as financial savings, especially for well-established dams that have been online for a long time. For those hydropower installations that are producing power for the grid, scheduled outages are extremely time sensitive and strict timelines govern the acceptable offline period. In these scenarios, the time factor is critical, as any unforeseen delays across the breadth of the project can cause a considerable headache. The ability to complete the pipe work in an estimated quarter of the usual time provides an invaluable safety net, reducing the risk of delay across the total project.

The benefits of the prefabricated system may not all be directly measurable in dollars, however they are tangible and estimable. This requires different thinking when it comes to project costs, which need to be distributed differently. Although the burden on engineering and product purchasing might be slightly increased, when taking the project as a whole, this is more than balanced out by the greatly reduced burden on installation costs, time and safety risks.

Today, welded systems may no longer represent the most effective or economic choice. Although the material costs of standard weldable pipes and bends are cheaper than pre-fabricated plug and play pipe runs, piping solutions using non-welded connections and cold bent piping offer significant value through reductions in fabrication and commissioning time, while improving workplace safety.

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