DetaPipe™ – Reactive Metal Clad Pipe Filling a Void for the Reactive Metal Pipe

Introduction

NobelClad's DetaPipe™ product line addresses a gap regarding reactive metal pipe supply options. Launched in 2021, DetaPipe™ provides the first-ever technically and commercially viable clad pipe products using titanium, zirconium, tantalum, and related alloys. The DetaPipe manufacturing process is based upon unique reactive metal clad manufacturing technology developed by NobelClad's highly skilled technicians. DetaPipe is often the ideal lower-cost solution for managing high pressures and external mechanical loads compared to solid reactive metal piping components. Further, the unique supply chain of clad pipe is often more favorable to achieving tight delivery timelines than mill production, mainly when the alloy or pipe size and schedule are unusual.

Historical Background - Reactive Metal Clad

Certain alloys of the reactive metal family exhibit superior corrosion resistance for many highly corrosive chemical process applications. The technical advantage of these metals was recognized early in the 20th century. In the following years, emerging military and aerospace companies eventually advanced reactive metal applications to become a well-respected material of choice. A critical feature these industries relied upon was the significant benefit of corrosion resistance. When considering the broad range of reactive metal elements, titanium, zirconium, and tantalum were chosen to optimize corrosion performance, availability, fabricability, and cost.

The cost was a significant obstacle to developing many early industrial reactive metal applications. This showed an evident concern for pressure vessels and accompanying piping where heavy wall structures were necessary. Applications requiring significant reactive metal thickness for strength reasons were rarely found to be feasible when constructed of solid reactive metal components.

During the 1950s, process equipment fabricators and engineers recognized that clad products, consisting of a thin corrosion-resistant alloy layer bonded to a much heavier steel base metal, would be necessary for the cost-effective construction of heavy equipment. These clad products included the full spectrum of metals, ranging from simple stainless steels to nickel alloys to reactive metals. The development of joining technology was relatively straightforward for metals like stainless steel and nickel alloys. Roll bonding and weld overlay quickly gained broad acceptance for clad plates. On the other hand, these joining technologies proved to be highly

unsuitable for making composite metal clad plates from reactive metals. Brittle intermetallics formed at the interface, resulting in a deficient bond quality, unfit for forming, fabrication, and use. Dupont's 1959 discovery of explosion welding, a cold bonding technology, presented a reliable solution for manufacturing reactive metal clad plates and components.

By the end of the 1960s, explosion welding technology had been extensively codified, and the process was used broadly to manufacture clad plates with most industrial alloys, including reactive metals. Reliable design and fabrication methods for titanium, zirconium, and tantalum-clad vessels were developed, providing a proven platform for manufacturing reactive metal pressure vessels and similar equipment.

Nowadays, equipment constructed of reactive metal clad is used extensively worldwide. Production of titanium, zirconium, and tantalum-clad plates for pressure vessels and similar applications typically exceeds 100,000 metric tons annually. Vessel size and pressures and piping size/pressure requirements have grown significantly. Purified Terephthalic Acid (PTA) production and similar plants require a large tonnage of titanium clad in the chemical processing industry. The PTA oxidation reactors require as much as 1,000 metric tons, and wall thicknesses are often in the range of 3 to 4 inches (75 to 100 mm). Pressure-leaching autoclaves for the hydrometallurgy industry require around 1,000 metric tons of titanium clad each and operate at significantly higher pressures. Zirconium clad is used extensively in Acetic Acid plants and other processes. As with the PTA process vessels, size and pressure have grown considerably. Piping for this equipment ranges up to 30 in (750 mm) NPS, with wall thicknesses often in the 1 to 2 in (25 to 50 mm) range.

Background Reactive Metal Clad Pipe

The history of reactive metal clad pipe has been quite different from that of clad plate. The same explosion welding technology developed for a flat clad plate proved equally effective for producing clad concentric cylinders. By the late 1960s, NobelClad began the promotion of DetaClad reactive metal clad pipe and other cylindrical-clad components for the chemical process industry.

However, at this early stage in the growth of the reactive metal clad vessels, pressures were relatively low, and equipment and related piping were quite small by today's standards. Solid alloy pipe was generally available in smaller sizes and schedules for the basic grades of titanium (Gr 2) and zirconium (Gr 702). These piping sizes and thicknesses were rarely large enough to benefit from the potential cost savings of clad. Like many novel new products of the era, NobelClad's concentric reactive metal clad components were a proven product seeking a need in a nonexistent marketplace. Within a few years, efforts to promote reactive metal clad pipe were discontinued. Plans to install the unique equipment needed for handling pipes were scrapped. NobelClad diligently documented the technology and periodically produced small, unique, concentric-clad products primarily for Research and Development.

By the early 2000s, the size and pressure of reactive metal clad equipment had advanced considerably. The significant need and cost savings of reactive metal clad pipe had become real, but…there were no reactive metal clad pipe producers. Over the years, NobelClad has amassed significant propriety technology for managing the complexities of reactive metal clad products. This unique technical knowledge has positioned NobelClad with the proprietary technology necessary to develop further and modernize clad pipe production capabilities for the DetaPipe reactive metal clad pipe products.

DetaPipe™

NobelClad's DetaPipe is a unique and proven piping product line that combines the superior corrosion resistance of reactive metal alloy cladding with the strength, durability, and low cost of steel. For simplification of installation, straight pipe and related piping components are supplied as spools for mechanical assembly in the field. The bore and flange facing of the DetaPipe spools are integrally clad with the specified reactive metal cladding alloy. The steel pipe substrate can be almost any commercially available steel or stainless steel compliant with ASME/ANSI dimensional standards. NobelClad has optimized the clad bonding technology to provide unequaled gripping force and exceptional fatigue performance at high pressures and elevated temperatures. As with other NobelClad products, the DetaPipe cladding process does not alter the optimized corrosion properties of the cladding alloy or the mechanical properties of the steel base metal. DetaPipe pipe spools, Figure 1, are provided ready for installation in new construction or for replacement of aging components.

Figure 1:
Typical DetaPipe spool. Zirconium cladding on steel pipe and flange body.

Figure 2:
DetaPipe 10 D elbow spool. Zirconium Clad.

Considerable product testing, both analytical and physical, has been performed during the ANSI B31.3 qualification of DetaPipe. FEA testing validated by an independent 3rd party witness confirms DetaPipe's suitability to withstand applicable mechanical loads during service. Extensive fatigue cycle testing has been performed at elevated temperatures and pressures. This work has been predominantly performed on zirconium-steel piping, broadly considered the most challenging metal combination. Field testing is ongoing on several projects globally as well.

In general, piping installations require fitting components in addition to straight-run piping. The most common are elbows, tees, reducers, and valves. DetaPipe elbows, tees, and reducers are provided as clad spools in many alloys and sizes. At the time of this article, elbow spools were produced in 3D, 5D, and 10D sizing, Figure 2. Tees are made with a single leg diameter limited to 70% of the straight-through legs. For valving in DetaPipe systems, solid alloy valve spools are preferred. NobelClad technical support is highly recommended when designing DetaPipe piping systems.

Delivery time for DetaPipe spools primarily depends upon the availability of the reactive metal sheet needed for the cladding component of the assembly. Typically, the sheets are an in-stock item. NobelClad will provide a more precise delivery time for the sourced items upon request. Technical details are addressed in Data Sheet, Table 1.

How DetaPipe Fills the "Void" in Reactive Metal Piping Options

In general, pipe accompanying reactive metal pressure vessels and similar equipment should be of the same alloy and grade as the pressure vessel components to provide equivalent corrosion performance. For some reactive metal applications, pressures are low; vessel sizes are relatively small; piping is scheduled to be 10 or 40 at the most; and alloy requirements are commercial pure grades, commonly Titanium Grade 2. For these installations solid alloy piping is often available in the global marketplace with reasonable delivery times.

When the piping needs are outside these criteria, supply chain issues can become significant with minimal supply options for pipe diameters, schedules, alloy grades, and fittings. Frequently, the project team has few options other than mill production of the solid piping components. This typically includes excessive minimum order requirements and prolonged delivery. Alternatively, selecting an alloy with inferior performance may be the only option. Alloys other than the basic chemically pure grades can add considerable complexity to the supply problems. Rarely is there more than a single supplier option for the solid alloy; price and delivery often reflect this situation. This has been the traditional commercial "void" in the reactive metal supply chain.

The production approach of DetaPipe circumvents these issues. DetaPipe manufacture relies upon a much simpler supply chain. The steel (or stainless steel) substrate pipe and flanges are readily available, with considerable options for alloy and grade. The cladding component is typically purchased as a plate or sheet, which is subsequently welded into a cylinder adequately sized for the internal cladding. Facilities for performing the cladding operations are in place at the NobelClad factory. The result is high-quality clad piping components at a shorter delivery and lower price.

The cost benefits of clad pipe vs. solid alloy are similar to what the buyer faces for the adjacent reactive metal equipment. Clad can save considerable money for large, heavy piping spools and related fittings. As discussed earlier, the increase in the size of pressure vessel equipment over recent decades has been tremendous. The cost benefits of DetaPipe vs. solid alloy pipe can be enormous.

Table 1 - Technical Data Sheet

- **Cladding Alloys:** The DetaPipe cladding technology is designed specifically for the reactive metals group. Titanium, zirconium, and tantalum are the bases for the most produced reactive metal corrosion-resistant alloys. DetaPipe is predominantly applicable for the following cladding alloys:
    - Titanium: ASTM B265- Grades 1, 2, 5, 7, 9, 11, 12, 16, 17
    - Zirconium: ASTM B551- Grade 702, 700
    - Tantalum: ASTM B708- Unalloyed tantalum and Ta-2.5W
- **Base Metal Type:** DetaPipe base metal construction is provided in most ASME (or equivalent) steel and stainless-steel pipe alloys and grades, subject to commercial availability.
- **Dimensions:** DetaPipe spools are produced in standard ASME/ANSI nominal pipe sizes and schedules in lengths customized to the customer's needs, up to 20 ft (6 m). Typical pipe diameter sizes range from 6 in (150 mm) NPS to 30 in (750 mm) NPS for titanium and zirconium; tantalum is a maximum of 24 in (300 mm) NPS. Smaller sizes are available with engineering review. The interface diameter is the specified I.D. dimension for the external steel pipe component. The inside diameter of the clad products is smaller by the thickness of the cladding.
- **Spool End Flanges:** Standard pipe spool ends are completed with ASME B31.3 raised face weld neck flanges. Most other proprietary end flange designs, such as Grayloc, are available.
- **Cladding thickness:** Standard cladding thickness is 0.157 to 0.188 in (4 to 4.8 mm) for titanium and zirconium alloys and 0.040 in (1.0 mm) for tantalum. Other cladding thicknesses can be provided, subject to the customer's and NobelClad's agreement.
- **Maximum Allowed Working Pressure:** The MAWP for DetaPipe and pipe components is the ASME (or equal) specified MAWP for the steel components of the spool. Following ASME Sec VIII, paragraph UCL-11d, the strength of the cladding metal cannot be included in the design strength calculations.
- **Product Specification:** DetaPipe products are manufactured following NobelClad Specification DETA-221.