# Clad pipes: Growing market increasing requirements

## Metallurgically clad pipes

**The growing global demand for fuels confronts the oil and gas industry with the challenge of exploiting increasing inaccessible deposits. These include energy sources under deep water, with media containing corrosive elements at high temperatures and pressures. These conditions place severe demands on the corrosion resistance of the pipework materials in which oil and gas are to be transported. For both technical and economic reasons, pressurised pipes are not made entirely of stainless steels or nickel alloys. Butting has been working for many years to combine the corrosion resistance of high-alloy steels with the excellent strength and ductility properties of carbon-manganese steels by developing clad steels.**

### Key to Successful Projects

Clad pipes offer an optimum solution to the most demanding requirements of strength, corrosion resistance and cost-effectiveness. Here, the (generally) unalloyed carbon steel outer pipe handles the internal and external pressure, while the high-alloy cladding provides the corrosion protection.

Butting states that they are currently the only pipe manufacturer in the world producing clad pipes by two different processes. In addition to mechanically bonded pipes (so called BuBi®-pipes) the pipe manufacturer of Knesebeck (Germany) produces pipes from metallurgically clad steel plates in a discontinuous production process. In these bought-in sheets, the two metal layers are bonded firmly together by a diffusion bridge. Butting mainly handles roll-bonded raw material, but also uses explosive bonded plates in exceptional cases. According to the requirements specifications pipes are produced from single plates of various material grade combinations. The cladding can be applied on one side – externally or internally – or both sides.

### Individual Material Combinations

The main parent metals used for clad plates are structural steels, pipe steels (API grades) and fine-grained structural steels distinguished by a good weldabilty and working properties. The choice is made after checking the strength and ductility requirements for the specific operating conditions.

Typical cladding materials are austenitic stainless steels, nickel and copper nickel and titanium alloys, characterised by different levels of corrosion resistance.

More than fifty projects all over the world have been furnished with metallurgically clad pipes from Butting to date.

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Table 1: Selection of parent metal

| Material grade | $R_{p\,0,2}$ min (MPa) | $R_m$ min. (MPa) |
|---|---|---|
| API X52 | 358 | 455 |
| API X60 | 413 | 517 |
| API X65 | 448 | 530 |
| API X70 | 482 | 565 |
| S 460 N | 460 | 550 |

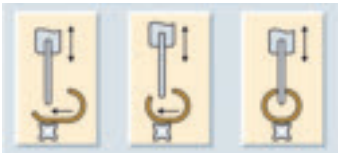


Diagram of the forming process.

Table 2: Chemical composition of a selection of typical cladding materials

| Cladding material | | Standard chemical composition (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Material number | Name | C ≤ | Si ≤ | Mn ≤ | Cr | Mo | Ni | Other elements |
| 1.4404 | 316L | 0.030 | 1.00 | 2.00 | 16.50<br>18.50 | 2.00<br>2.50 | 10.00<br>13.00 | N ≤ 0.11 |
| 1.4438 | 317L | 0.030 | 1.00 | 2.00 | 17.50<br>19.50 | 3.00<br>4.00 | 13.00<br>16.00 | N ≤ 0.11 |
| 1.4539 | 904L | 0.020 | 0.70 | 2.00 | 19.00<br>21.00 | 4.00<br>5.00 | 24.00<br>26.00 | N ≤ 0.15 Cu = 1.20<br>2.00 |
| 2.4858 | Alloy 825 | 0.025 | 0.50 | 1.00 | 19.50<br>23.50 | 2.50<br>3.50 | 38.00<br>46.00 | Al ≤ 0.20<br>Co ≤ 1.00<br>Cu = 1.50<br>3.00<br>Fe = rest<br>Ti = 0.60<br>1.20 |
| 2.4856 | Alloy 625 | 0.030<br>0.100 | 0.50 | 0.50 | 20.00<br>23.00 | 8.00<br>10.00 | ≥<br>58.00 | Fe ≤ 5.00<br>Al ≤ 0.40<br>Ti ≤ 0.40<br>Cu ≤ 0.50<br>Co ≤ 1.00<br>Nb + Tb = 3.15<br>4.15 |
| 2.4363 | Monel 400 | 0.150 | 0.50 | 2.00 | - | - | ≥ 63 | Al ≤ 0.50<br>Co ≤ 1.00<br>Cu = 28.00<br>34.00<br>Fe = 1.00<br>2.50<br>Ti ≤ 0.30 |

The tables show a selection of materials for the parent metal and the cladding, which may be combined according to the strength required.

## Highest Requirements: Riser Pipes

The pipes produced by Butting from clad materials are used all over the world for many different applications, mainly in the oil and gas industry. A key use of clad pipes in this industry is for riser pipes. Whereas pipelines are laid horizontally on the sea bed, the term riser covers those pipes that are responsible for transporting the medium vertically from the sea bed to the surface for further processing. Because of the way they are suspended from the 'floating production, storage and offloading' (FPSO) vessel, and the method of laying them to the extraction point on the sea bed, these pipes are exposed to very large dynamic stresses from the currents and the movement of the ship, both horizontally and vertically. The high internal and external pressure from ocean currents and wave movements, and highly corrosive media, mean that these pipes have to meet the highest quality standards. The resulting form tolerances and welding requirements constitute a constant challenge to Butting in the production of these pipes. In deep sea areas, special steel catenary riser (SCR) pipes are used, which are under substantial dynamic stress as well as high pressure and temperature, and so also need especially high resistance to fatigue. For this, the tightest tolerances and particular quality standards have to be met in the production of the welded joints and pipe ends.

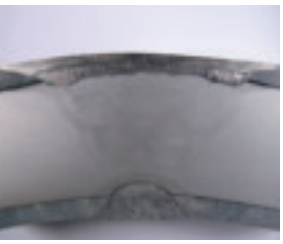
## SCR pipes in 24 m lengths

Butting employees and production facilities faced a particular challenge in January 2004 with an order for the Erha project. The year before, Butting had produced the world's first clad SCR (steel catenary riser) pipe for the Bonga project. The requirements for the Erha project in terms of the tolerances for the pipe ends were still more demanding, and standard lengths of 24 m were also required. The end-customer, ExxonMobil in Houston, was responsible for the detailed specifications. Because of the way the SCR pipes are suspended between the floating production, storage and offloading (FPSO) vessel and the extraction point, these pipes are exposed to very large dynamic stresses from the currents and the movement of the ship. For this reason, great emphasis was placed on the tolerances for the pipe ends and the execution of the circumferential welds.
The contract was for a total of 1,428 m of pipe measuring 168.3 x (15.9 x 3) mm and 273 x (20.6 + 3) mm. These metallurgically clad pipes were in a combination of the high-strength carbon-manganese steel X65 as the exterior material, with a guaranteed yield strength of 448 MPa, and a cladding of corrosion-resistant nickel-based alloy 2.4548.

Metallurgically clad pipes.

## Tightest tolerances

Another major challenge was to calibrate the 6 m long pipes. In order to achieve the required internal diameter tolerance of ±0.4 mm compared to a specified diameter, the Butting experts developed a special calibration method for this project. After the individual lengths of pipe had been produced successfully came the second challenge posed by the project. Sets of four pipes and a so-called J-Lay collar had to be welded into 24 m lengths. To do this, Butting set up a separate production line specifically for this project. Before this, the welding process for the high-quality circumferential seams had to be qualified at great expense, with Butting opting for TIG orbital welding.



Metallurgically double-sided clad pipe - here: grinding pattern of a longitudinal weld

When two pipe ends were joined, a maximum misalignment of 0.5 mm (so-called high-low) was permitted on the inside of the pipe, which meant that every joint had to be precisely measured and carefully documented. Initial test welds were subjected to a dynamic vibration test at the Welding Institute in Cambridge, to test their resistance to fatigue. The results were excellent. During production, all the welding parameters were recorded and checked by inspectors from the customer right round the clock. The circumferential welds were tested with a specially developed ultrasound testing method.

## Top-Quality Circumferential Welds

The project ended with the third great challenge: to produce six circumferential welds on so-called flex joints. Each of these components weighs 13.6 tonnes and is worth a lot of money. The qualified welders displayed professionalism and met this challenge with

**Table 3: Use of metallurgically clad Butting pipes in the oil and gas industry (examples):**

| Description | Material | Diameter | Wall thickness | Project |
|---|---|---|---|---|
| Riser pipes | X65 / Alloy 825 | 16“ – 18“ | 3.8 – 14.96 mm + 3.00 mm cladding | Bintang Field Development |
| Steel catenary riser pipes | API 5L-X65 / Alloy 825 | 168.3 / 273.1 mm | 15.9 / 20.6 mm + 3.0 mm cladding | Erha |
| Anoden pipes | SAWL 450 I SDL / Alloy 825 | ID 228.6 mm | 19.0 mm + 3.0 mm cladding | ASGARD, Statoil |
| Topside | API 5L-X65 / Alloy 625 | 4″ – 24″ | – | South Pars |
| Subsea jumper | API 5L-X65 / 316L (min. 2.5% Mo) | 219.1 mm | 12.7 mm + 3.0 mm cladding | M4 Project |
| Manifolds | API 5L-X60 / Alloy 825 | 12″ – 30″ | 7.14 – 15.88 mm + 3.0 mm cladding | Haradh Gas |
| Spool pipes | ASTM A516 Grade 70 / 317L | 8″ / 10″ | | Flint Hills |
| Tie-in spools | SML 450 I / 316L (min. 2.5% Mo) | 406.4 mm | 21.0 mm + 3.0 mm cladding | Perseus over Goodwyn |
| Splash zone riser pipes | Alloy 825 / DNV 415 ID / Monel 400 | 406.4 mm | 3.0 mm cladding 17.48 mm + 3.0 mm cladding | OSO Restoration A |

flying colours also.
To guarantee corrosion resistance, the inside surfaces of the metallurgically clad pipes was pickled using the pickling pig patented by Butting. The result was 24 m long precision riser pipes with tight dimensional tolerances in terms of shape and position.
The year after, the family-owned company received the largest orders to date for metallurgically clad pipes. As well as supplying over 530 tonnes of pipes to the Greater Plutonio project, was commissioned by Total to produce more than 650 tonnes of SCR pipes.

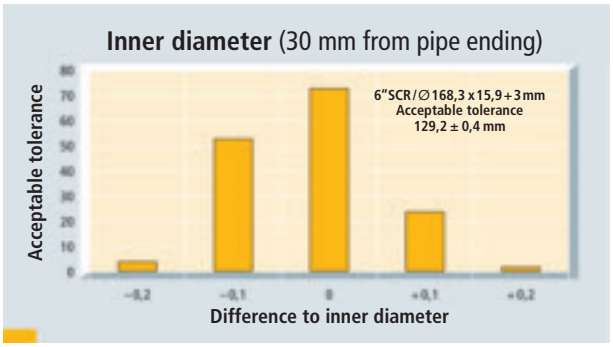
## New Fields of Application

As early as 1993, the pipe manufacturer received an order from Malaysia to produce and supply clad pipes for the DUA NLG Phase II project. For the splash zone, pipes of 998.6 x (35.75 + 3.0) mm were needed. This project was the first time that Butting processed clad plates, clad on the outside in Monel 400 grade material.
A particularly important job for Butting was the production of metallurgically clad pipes for the OSO Restoration A and B project in 2007. For the splash zone, the plan was to lay pipes in a combination of Alloy 825/DNV 415 ID/Monel 400 materials. The 406.4 x (3.0 + 17.48 + 3.0) mm pipes were manufactured by the discontinuous production process and delivered in time.

## Efficient Prefabrication: Spools

In 2007, Butting received another interesting order from the oil industry, via Butting Canada. Butting produced and supplied metallurgically clad pipes and semi-finished products for the Pine Bend refinery operated by Flint Hills Resources. In connection with this project, completed in the autumn of 2007, Butting Canada received an order for metallurgically clad pipes measuring 219.1 x (9.27 + 3.18) mm (8“) and 273.0 x (9.27 + 3.18) mm (10“). The pipes made from the base material ASTM A516 Grade 70 with the cladding material TP 317L were produced by the main Butting plant in Knesebeck from roll-bonded plates.
In this project, Butting was also responsible for processing the pipes into ready-to-install spools. Apart from the pipes themselves, semi-finished products were used for this, including weld-clad flanges, elbows, tees, branches and reducers. These were mostly produced by a partner company from pipes delivered by Butting. Based on isometrics provided by the customer, 40 ready-to-install spools were then produced in the cost-saving prefabrication facility.

**High quality prefabrication of metallurgically clad spools for a refinery.**




**Ehra project: achieved inside diameter tolerances at pipe end.**

A special requirement was the prefabrication of the branches called “full couplings”. Here, the Butting know-how and experience in production and welding methods were in demand as the branches required a special mechanical preparation of the weld edge before being welded.
Last but not least, Butting also produced the so-called weld-on shoes. These were used as pipe supports, on which the spools were laid in the finished system.
All spools were pickled and passivated in the clad inner areas through spray pickling before embarking on their long journey from Knesebeck across the Atlantic.

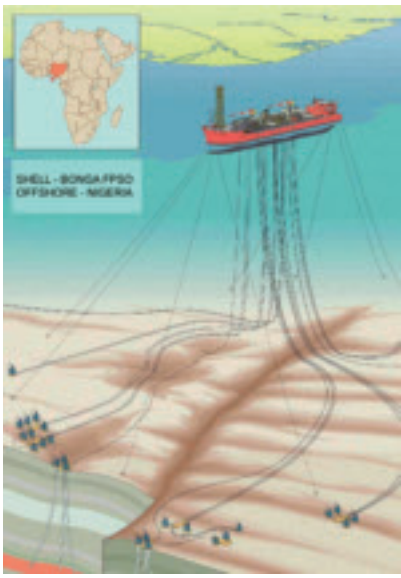



**Diagram of deep sea exploration by means of a FPSO-vessel (Floating, Production, Storage and Offloading Vessel).**

## Expanded Production Processes and Facilities

At its Knesebeck works, Butting has further expanded its expertise in forming and joining clad pipes, and has invested in the latest manufacturing equipment. For example, the innovative 12 m brake press and optimised discontinuous production process offer you many new possibilities. Very tight tolerances can be realised as well and standard lengths of 24 m and the production of clad spools. Because of manufacturing constraints, single random lengths of up to 12 m can be produced without circumferential welds. For greater lengths (e. g. 24 m), individual pipes are welded together with circumferential welds. The range of sizes covers outside diameters from 114.3 mm (4“) to 1,219 mm (48“) in various combinations of materials. The tolerances can be agreed in accordance with the relevant standards, e. g. API or DNV-OS-F101, or according to individual customer specifications, as e. g. for the Erha project.

## Worldwide Deliveries

The Butting company has been producing metallurgically clad pipes since the mid-1980s. These Butting pipes can be found in various material combinations from Norway and the American continent to Australia and Malaysia. Since 1987, a total of over fifty projects with pipes in bonded materials of the highest technical quality have been delivered. Butting assumes that in the future clad pipes from Knesebeck will also come into operation worldwide.