IBC Onshore Pipeline Engineering
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Clad and lined pipe

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Why do we use corrosion resistant linepipe?

Corrosion resistant alloys (CRAs) are used in pipelines which see highly corrosive process fluids. This is due to a combination of the following reasons:

- The process fluids are wet
- The carbon dioxide content is high
- Corrosion inhibitor will not be used
- The hydrogen sulphide content is high
- The product is seawater with entrained oxygen
- The chloride content of the brines are significant
- Operating temperatures and pressures are high

The choice of the alloy depends upon the specific values of each of the parameters above.

What is the difference between clad pipe and lined pipe?

- Clad pipe is pipe composed of an internal corrosion resistant alloy (CRA) layer, metallurgically bonded to the base carbon steel material
- Lined pipe has an alloy liner which is mechanically bonded to the outer pipe

The CRA layer is full length within the carbon steel pipe and affixed by expanding the liner or shrinking the pipe

API specification for CRA clad or lined steel pipe

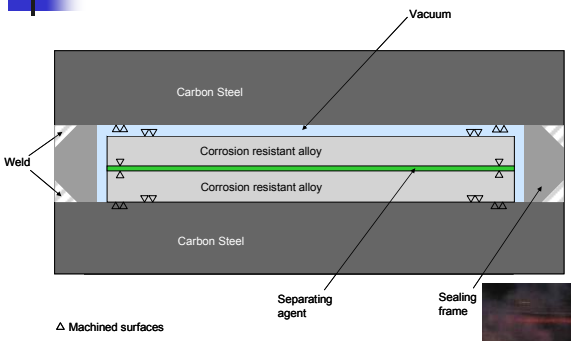
API specification 5LD - specification for CRA clad or lined steel pipe. 4th edition. March 2015.

- Grades of the CRA layer are the following:

Grade	Alloy Layer Type	UNS No
LC1812	316 Austenitic stainless steel	S31603 or S31653
LC2205	22 Cr duplex stainless steel	S31803
LC2506	25 Cr duplex stainless steel	S31260
LC2242	Nickel alloy 825	N08825
LC2262	Nickel alloy 625	N06625

- Base (carbon steel) grades from X42 to X80.

Manufacture of clad plate for linepipe



Base and cladding material plates are produced and surface ground

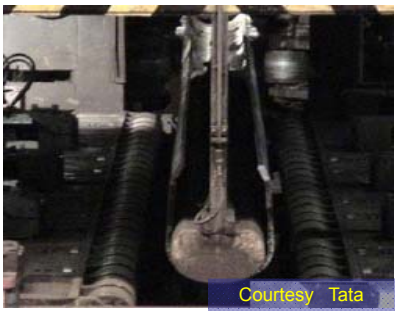
"Sandwiches" are made up

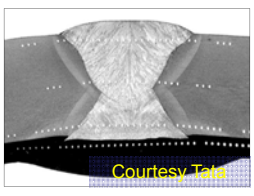
- The package is sealed airtight by welding and then evacuated
- The package is reheated to a uniform temperature and is then subject to rolling at a temperature to give fine grain in carbon steel and avoid sensitisation of the alloy layer
- The Package is opened, plates trimmed and ultrasonic tested.

Clad linepipe – pipe forming

Clad pipe is commonly made by press brake forming followed by longitudinal welding

There is a UOE production route





Use of clad pipe

BP Rhum consisted of

- 43 km of 16” diameter pipe
- 14.3mm thick c.s. plus 3mm 316 s.s.
- Pipe in pipe assembly

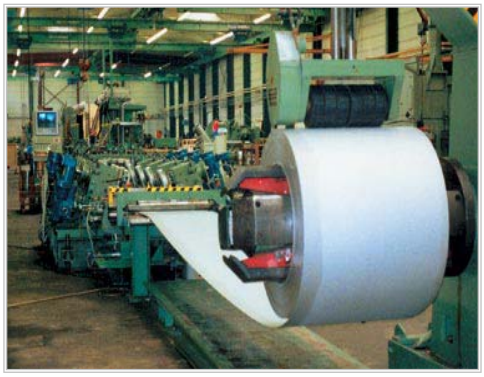
Welding of BP Rhum (laybarge welding)

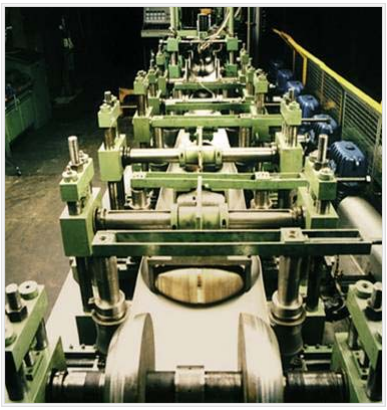
Manufacture of lined pipe

The process consists of expanding a CRA liner pipe inside a carbon steel outer pipe.

The outer pipe is a pre-manufactured (seamless) carbon steel pipe.

The CRA liner pipe is manufactured by longitudinal welding.





Courtesy of H. Butting

Manufacture of lined pipe

The CRA liner pipe is aligned inside the outer pipe. It is smaller diameter to avoid pipe contact during assembly.

The assembly is placed inside a die tool consisting of two half shells.

Courtesy of H. Butting

Manufacture of lined pipe 2

Hydraulic expansion

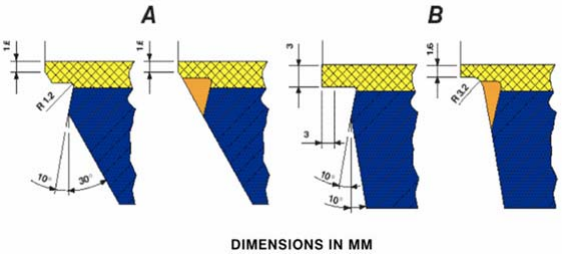
Completion of the expansion process

- The pipes are simultaneously hydraulically expanded radially at up to 2,500 bars and axially compressed by a force of up to 2,500kN
- The CRA liner expands by 2-5% until in contact with the outer pipe
- Both inner and outer pipes are the expanded by approximately 0.5-1.0% until the outer pipe is flush with the die
- The pipe wall thickness remains the same but the length is reduced.

Courtesy of H. Butting

Pipe ends

The ends (which are damaged by the process) are cut off, seal welded and re-bevelled.



Pipe bevelled ready for site welding

Onshore applications of lined pipe

Year	Project	Country	Length (km)	Diameter and wall thickness	Outer pipe	Liner
1997	LL&E Bighorn	USA	1.52	168.3 x (7.11 +2.5)	X65	alloy 825
1998	Mobil Visselhövede	D	1.7	168.3 x (12.5 +3)	StE 360.7	904L
1998	NAM Anjum Phase II	NL	6.708 0l.612	406.4 x (11.2 + 2.5) 406.4 x (13.5 + 2.5)	X65	316L
1999	Burlington resources Big Horn 5-6	USA	3.965	219.1 x (9.53 + 2.5)	X65	alloy 825
2000	RWE-DEA Bleckmar Z 1 - Wardböhmen Z1	D	1.178	168.3 x (16 +3)	L450QB	904L
2000	Mobil Söhlingen Z10 – Z14	D	1.1	168.3 x (17.2 +3)	L450QB	904L
2000	Gulf Resources Gelam	Indonesia	2	168.3 x (7.11 +2.0)	X52	alloy 825
2000	Burlington resources Big Horn 6-7	USA	6.031 9.151	219.1 x (9.53 + 2.0) 168.3 x (7.11 +2.5)	X65	alloy 825
2001	Mobil Siedenburg Z 25 – Z 27	D	0.574	114.3 x (11.0 + 3.0)	L 360 QB	alloy 825
2002	Burlington resources Big Horn 9-4	USA	1.067	168.3 x (7.11 + 2.5)	X65	alloy 825
2002	Mobil Söhlingen Z15 – Z11	D	1.2	168.3 x (17.2 +3.0)	L450QB	904L
2003	Burlington resources Big Horn wells	USA	3.658	168.3 x (7.11 + 2.5)	X65	alloy 825

Limitations on mechanically bonded pipe

- Manufacturing limitations on the combination of diameter and wall thickness. For X65 pipe: 29” diameter and 25mm wall thickness
- A 12 metre starting pipe may end up 11.5 metres long (or less)
- The process to date has used seamless pipe as its feed stock which is currently limited to 26”
- Bends and fittings have not been manufactured from mechanically bonded linepipe since rippling of the liner may occur if bent to a tight radius.

Suitable alloys for the lining include

- *13% Cr,*
- *316L stainless steel,*
- *alloy 825*
- *alloy 625*

The end