Pipeline Materials Selection -An Overview

Prasenjit Kayal

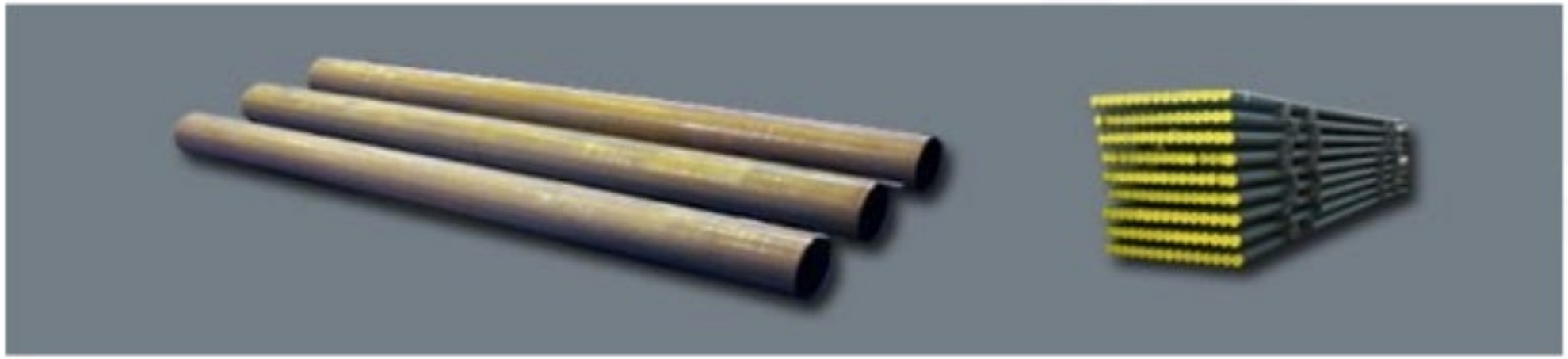
Index

Material Overview

Linepipe

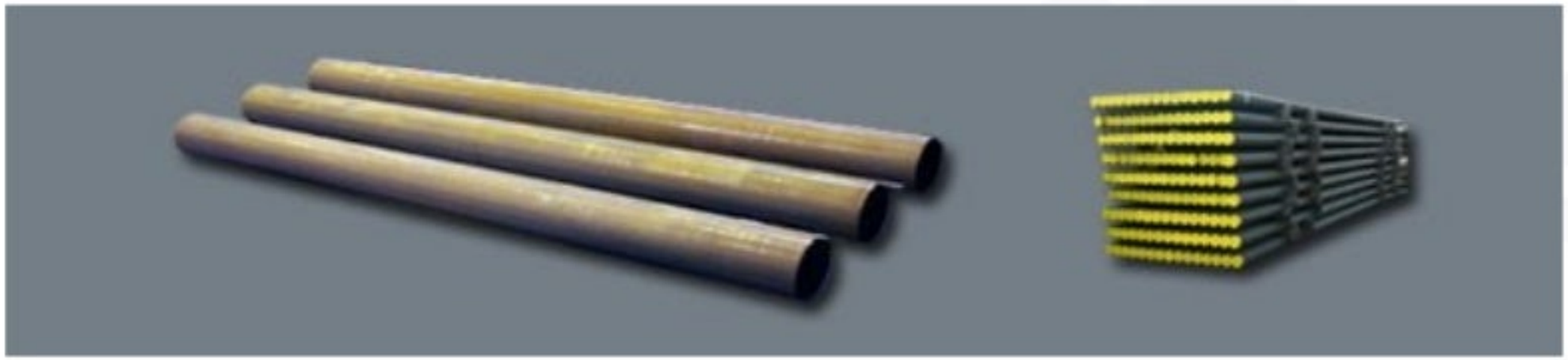
In the Oil & Gas Industry the pipe material selection depends on fluid conveyed (Sweet i.e. without H_2S or Sour service i.e. with H_2S). Typical pipe materials are:

- Low Carbon steel (Steel pipe)
- Corrosion Resistant Alloy-CRA (Duplex, Super duplex, Inconel 625, AISI 316L)
- CRA Cladded/Lined Carbon Steel (Clad pipe: Carbon steel layer + CRA layer)



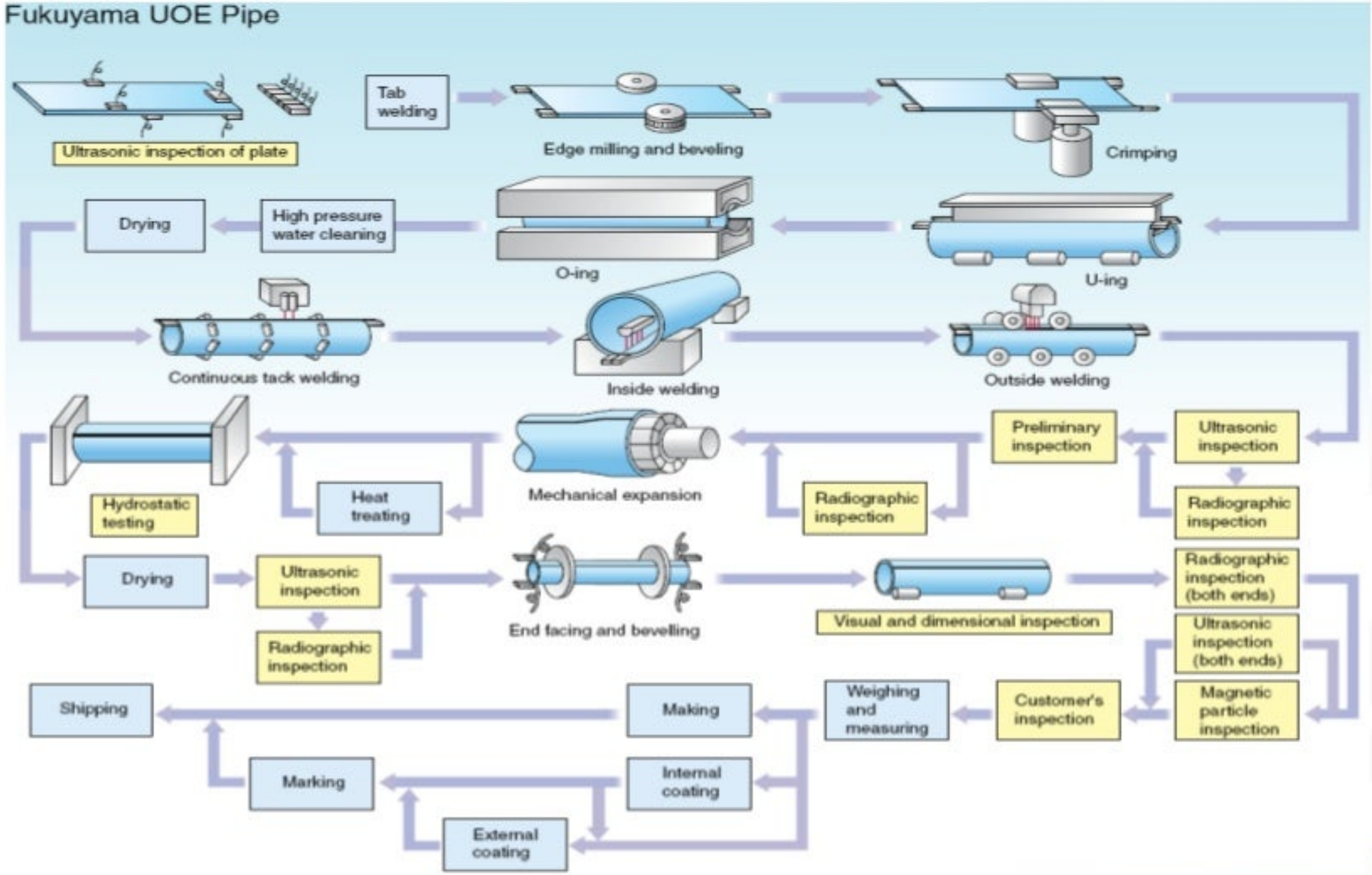
Linepipe - Fabrication Process

- Submerged Arc Welded (SAW)
- Electrical Resistance Welded (ERW)
- High Frequency Induction (HFI) welded or High Frequency Welded (HFW)
- Seamless (SMLS), i.e. without longitudinal (seam) weld



Material Overview

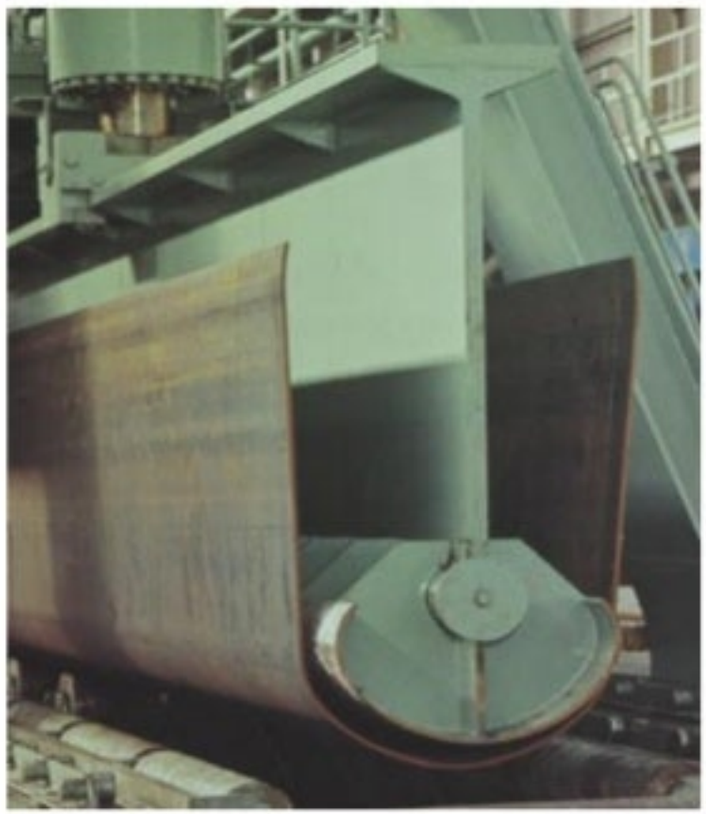
Submerged Arc Welded Pipe (SAW) - UOE



Material Overview

Submerged Arc Welded Pipe (SAW) - UOE

Edge Milling



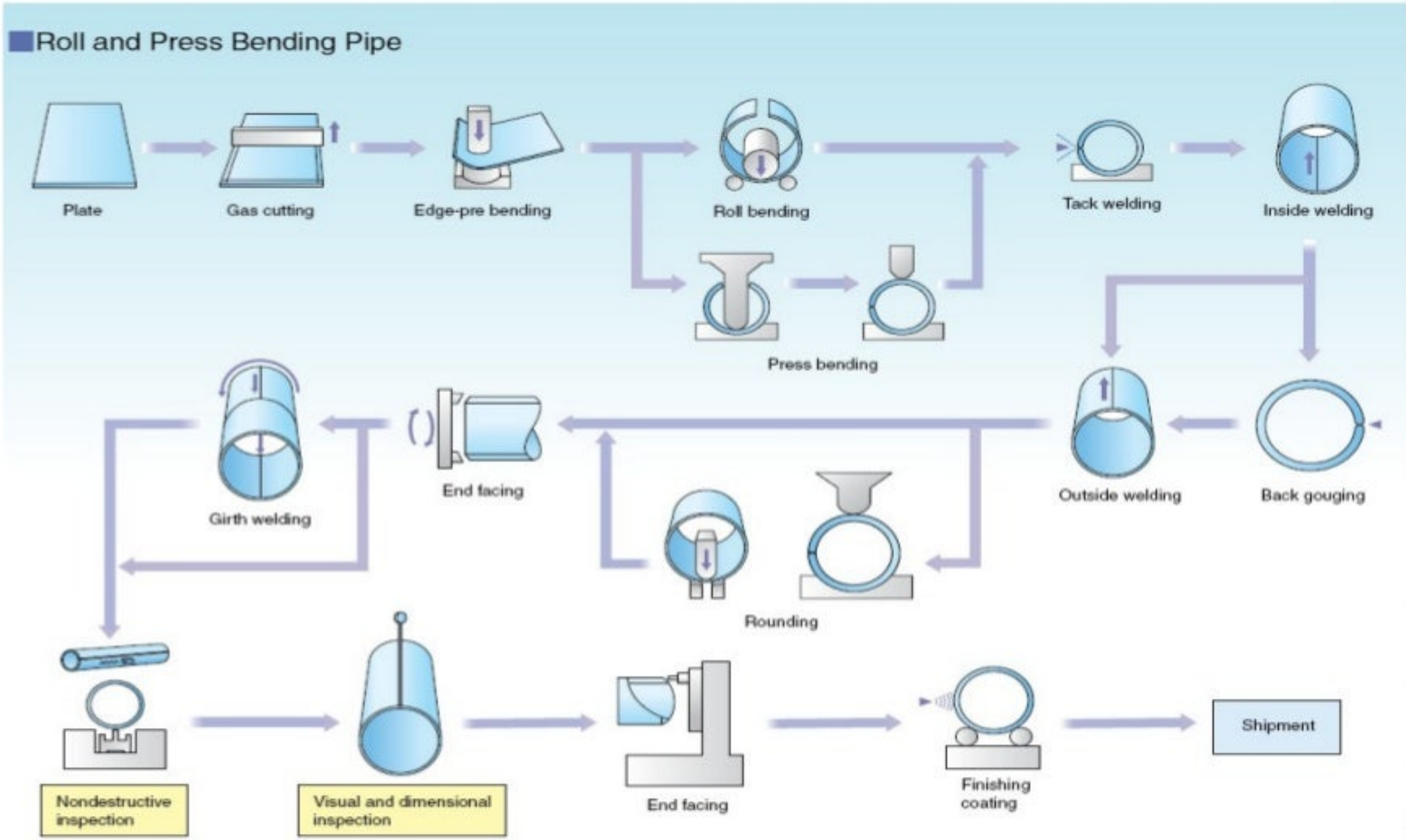
Tack Welding

Outside Milling

Inside Welding

Material Overview

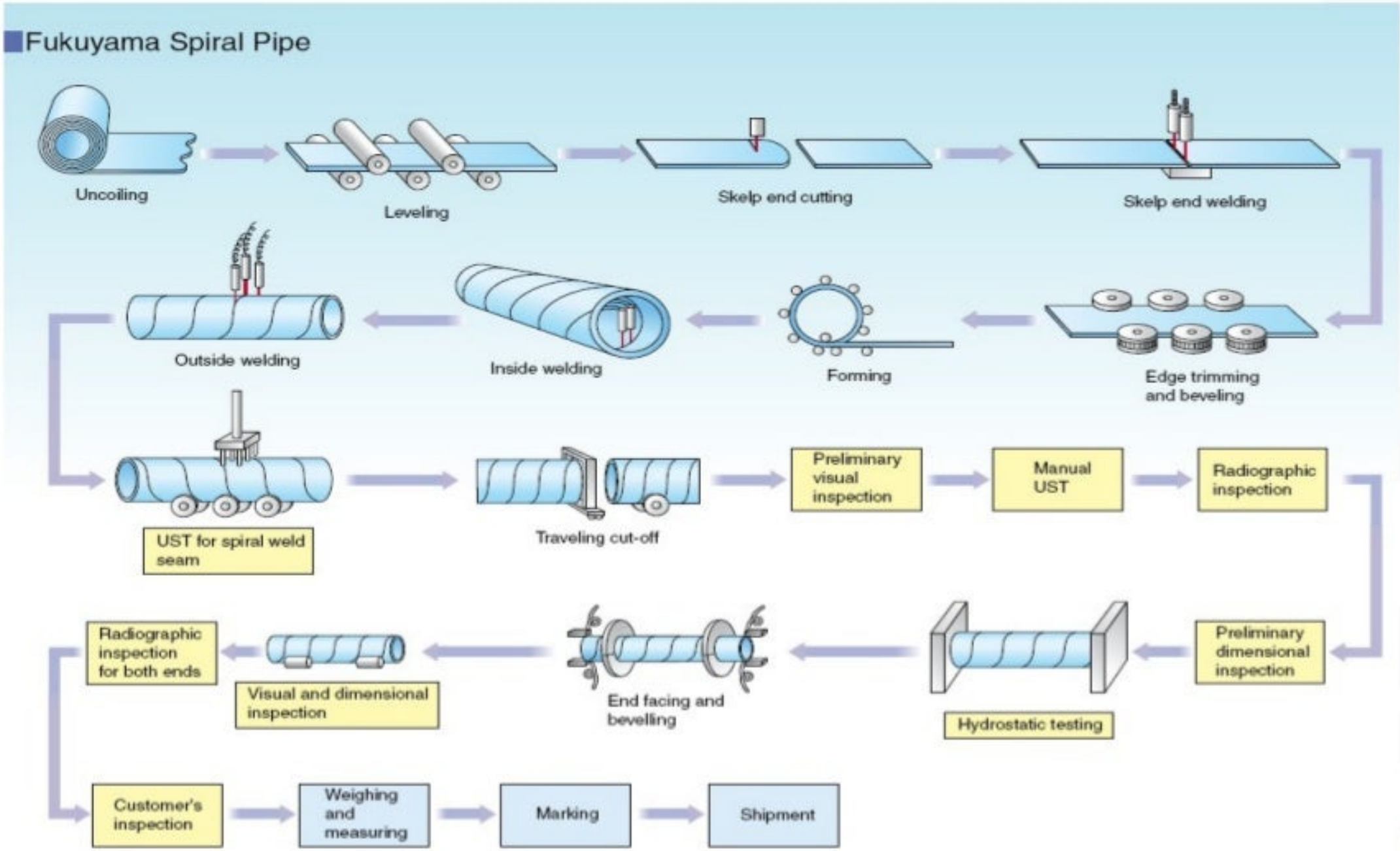
LSAW Pipe: Press Bending Method



LSAW Pipe: Press Bending Method

Material Overview

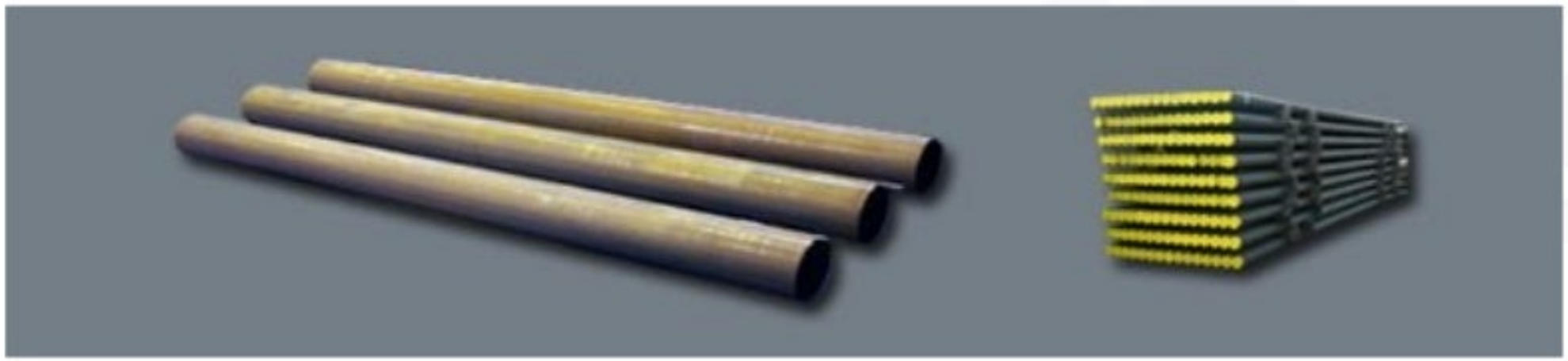
Spiral/Helical SAW Pipe



Spiral/Helical SAW Pipe

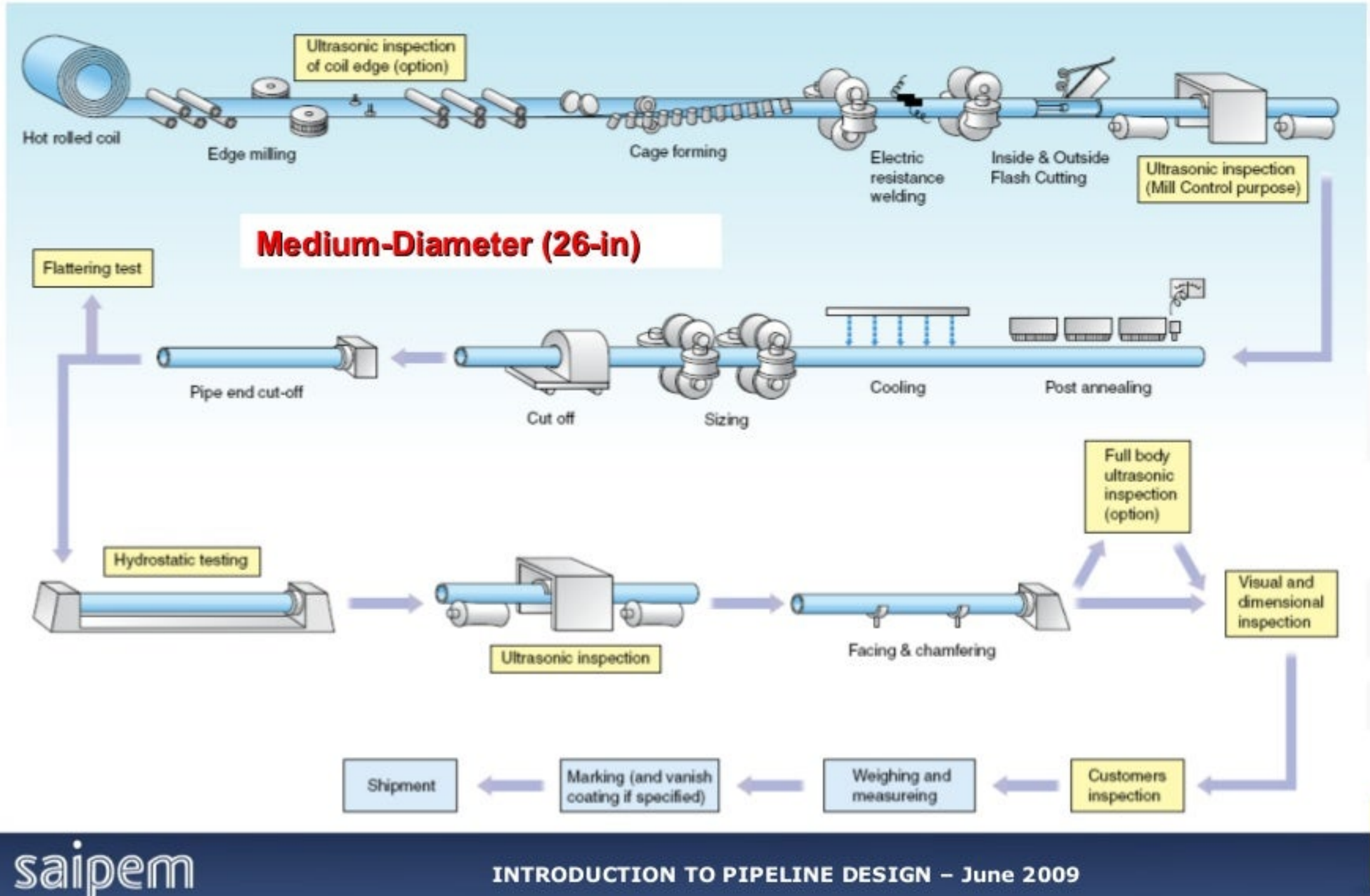
Linepipe - Fabrication Processes

- Submerged Arc Welded (SAW)
- Electrical Resistance Welded (ERW)
- High Frequency Induction (HFI) welded or High Frequency Welded (HFW)
- Seamless (SMLS), i.e. without longitudinal (seam) weld



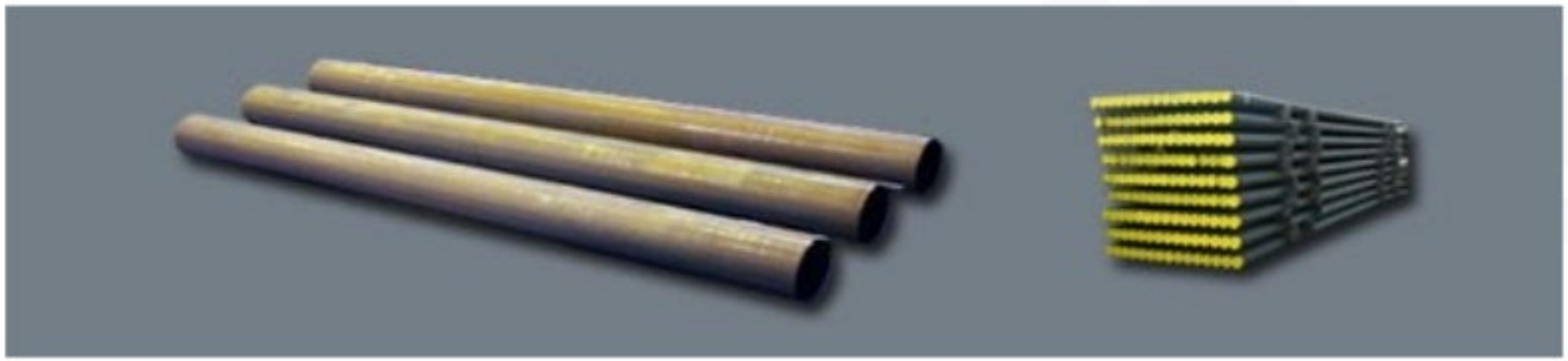
Material Overview

Electrical Resistance Welded Pipe (ERW)



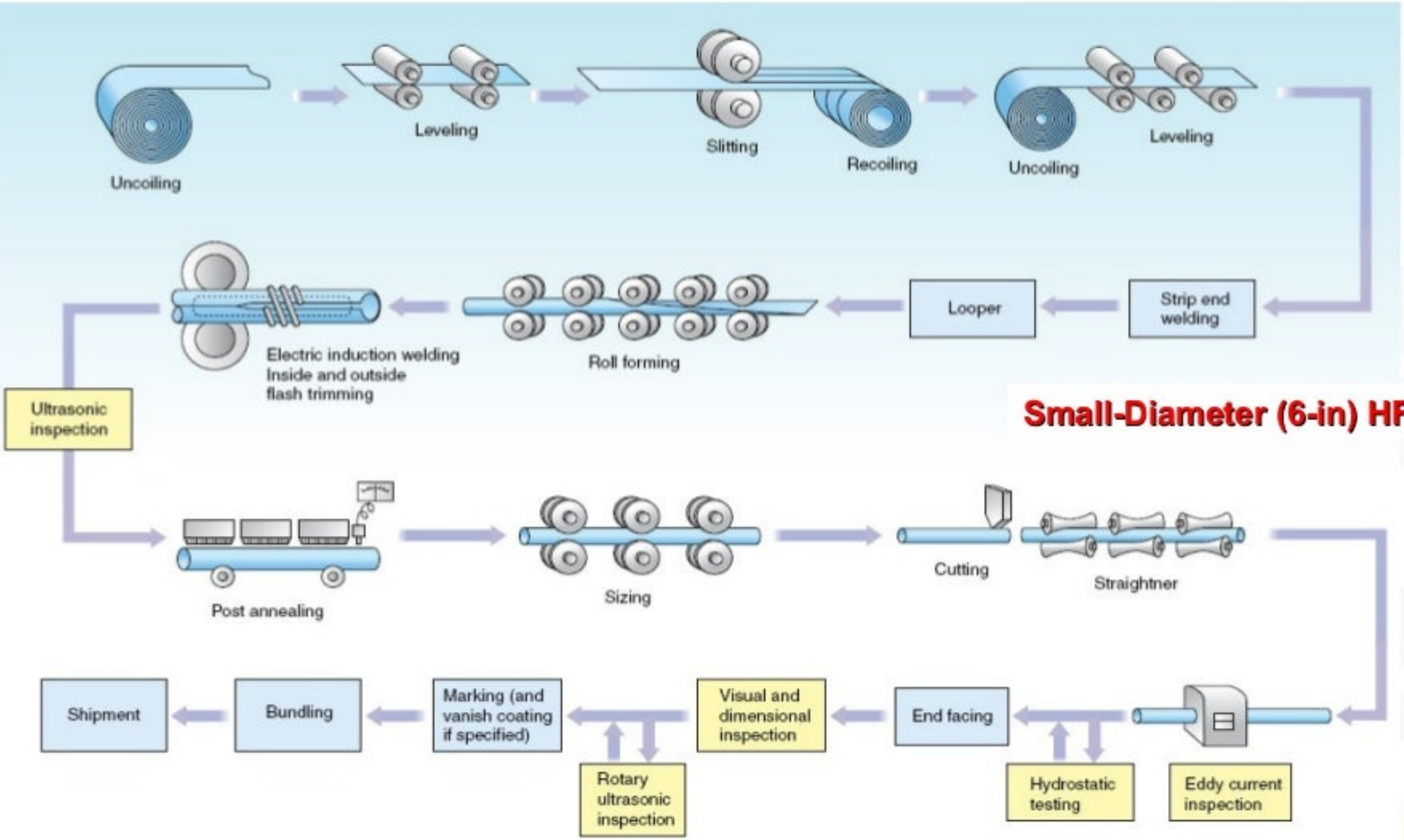
Linepipe - Fabrication Processes

- Submerged Arc Welded (SAW)
- Electrical Resistance Welded (ERW)
- High Frequency Induction (HFI) welded or High Frequency Welded (HFW)
- Seamless (SMLS), i.e. without longitudinal (seam) weld



Material Overview

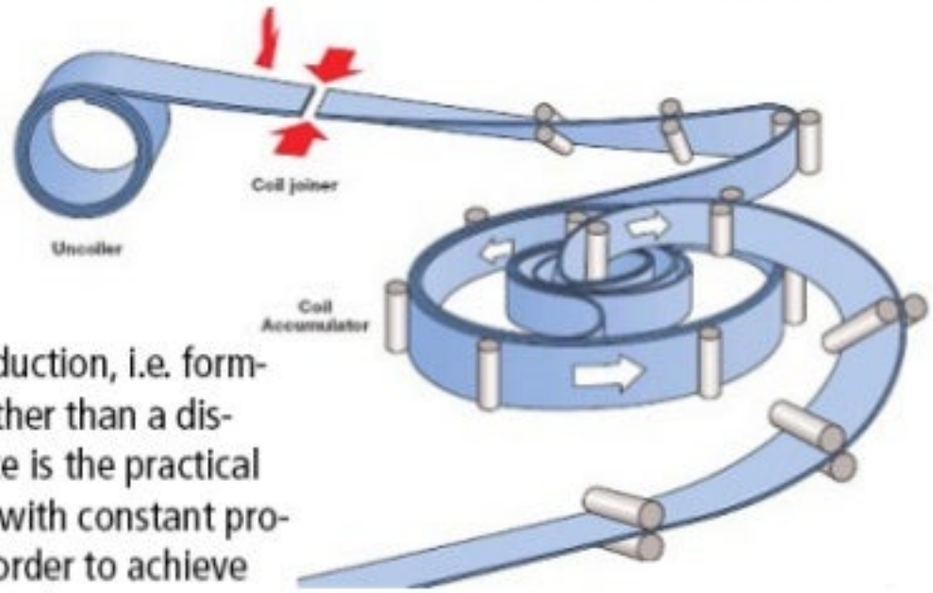
High Frequency Welded or Induction Welded Pipe (HFW/HFI)



Small-Diameter (6-in) HFI Pipe

Material Overview

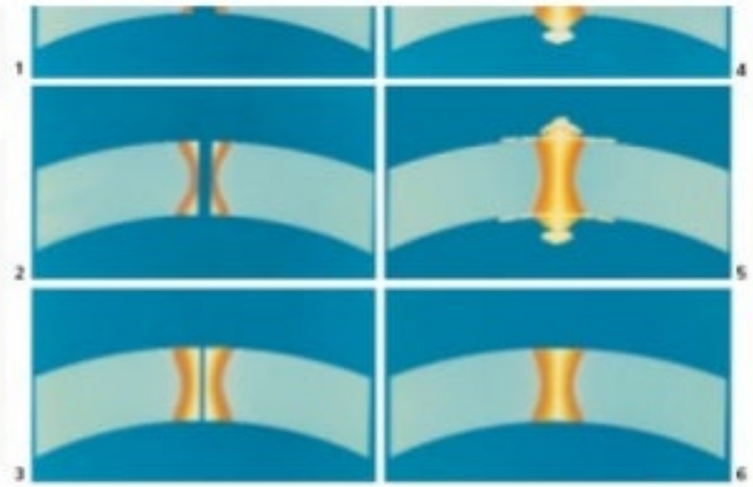
HFI PIPE – Coiler



The continuous production, i.e. forming and welding, rather than a discontinuous sequence is the practical solution to operate with constant process parameters in order to achieve a high quality standard.

The supercoiler is a strip storage unit with a capacity of about 200 m. The supercoiler works like a spiral spring. The strip is fed into the inside and removed from the outside of the spring.

HFI PIPE – Welding



The above figures show the welding operation sequence in a roughtime exposure and shows that this HFI welding is done without using additional welding metal, which enables us to get a uniform pipe after heat treatment.
At point (1) the first heat input is concentrated at the very edges. The initial contact of the heated edges takes place at point (4), where the molten material is squeezed out and forms the inner and outer flash which is removed by means of scarfing tools. The light ferrite line shows that melting temperature was reached and illustrates the liquid phase pressure welding system.
This pressure welding system is characterized by the only use of electric energy and pressure without using additional welding wire as it is done for submerged arc welding.

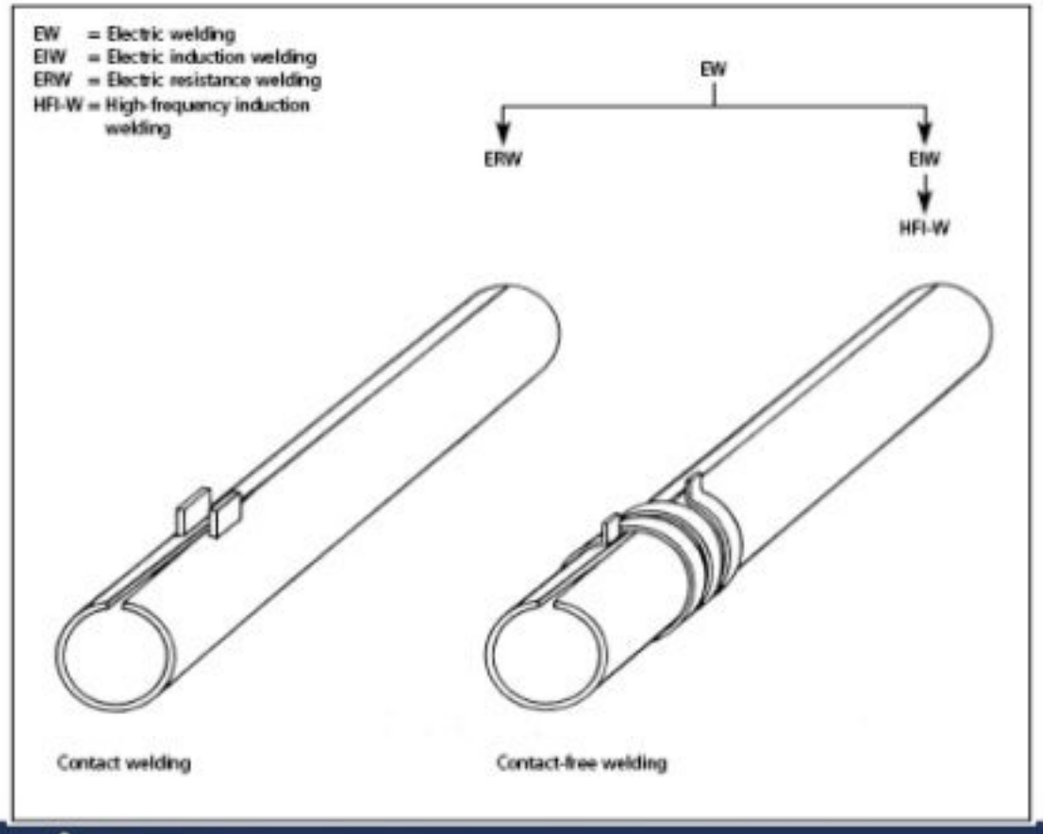
Material Overview

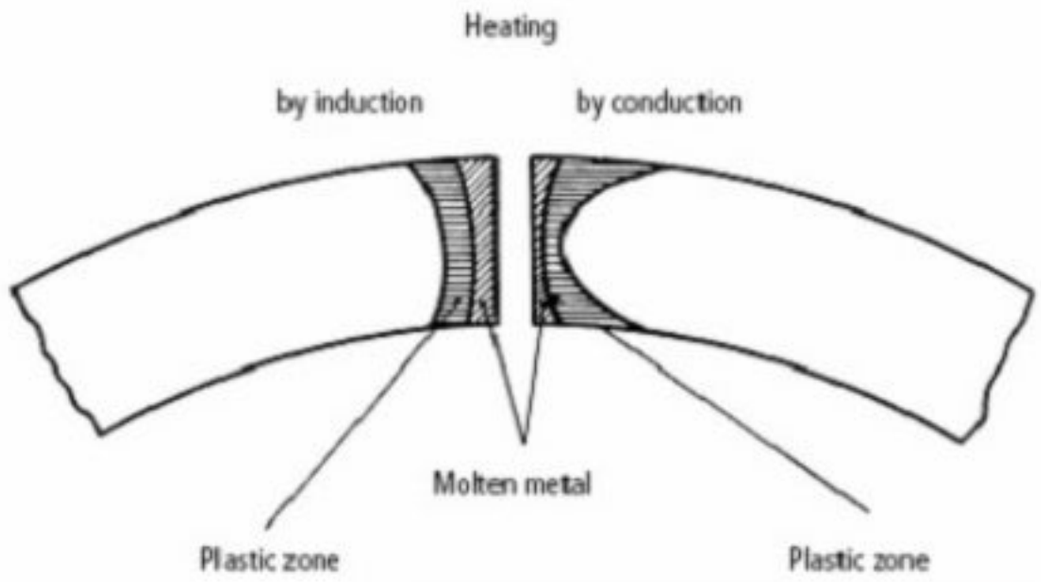
ERW Pipe vs. HFI Pipe

HFI welding belongs to the electric welding processes including electric resistance welding (ERW) and electric induction welding (EIW). HFI welding is a contact-free electric induction welding process, in which the induction current is transferred with a high frequency of ≥ 100 000 Hz via a ring inductor.

Comparing this HFI process with the ERW process (contact welding), we see the following advantages:

- uniform temperature distribution over the cross section of the pipe wall
- freedom from welding contact marks due to arcing





Material Overview

WELDED-PRODUCT RANGE

TENARIS

OUTSIDE DIAMETER in	WALL THICKNESS 0.125	0.157	0.172	0.188	0.203	0.219	0.237	0.250	0.281	0.312	0.344	0.375	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750	0.812	0.844	0.875	1.000	1.125	1.250	OUTSIDE DIAMETER mm
4 ½																											114
6 ⅝																											168
8 ⅝																											219
10 ¾																											273
12 ¾																											324
14																											356
16																											406
18																											457
20																											508
22																											559
24																											610
26																											660
28																											711
30																											762
32																											813
34																											864
36																											914
38																											965
40																											1016
42																											1067
44																											1118
46																											1168
48																											1219
	3.2	4.0	4.4	4.8	5.2	5.6	6.0	6.4	7.1	7.9	8.7	9.5	10.3	11.1	11.9	12.7	14.3	15.9	17.5	19.1	20.6	21.4	22.2	25.4	28.6	31.8	mm
	WALL THICKNESS																										

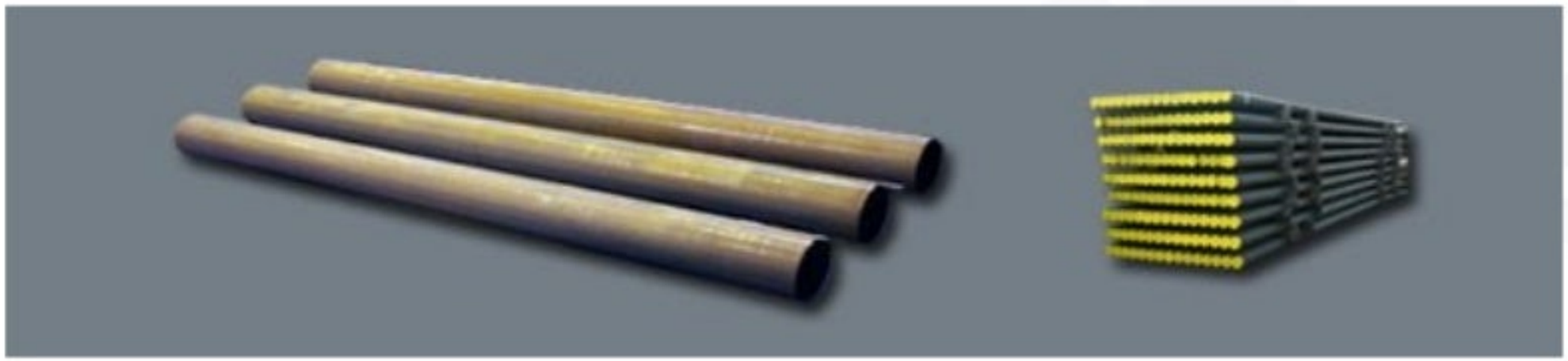
STANDARD PRODUCTS SUBJECT TO AVAILABILITY

ERW PROCESS FROM 4 ½" UP TO 24" O.D. SAW LONGITUDINAL PROCESS FROM 12 ¾" UP TO 48" O.D. SAW SPIRAL PROCESS FROM 20" UP TO 100" O.D.

Note: ERW pipes are available in maximum lengths of 18 meters from 8 ⅝" up to 20" O.D.
Intermedidate sizes (OD&WT) are available upon request.

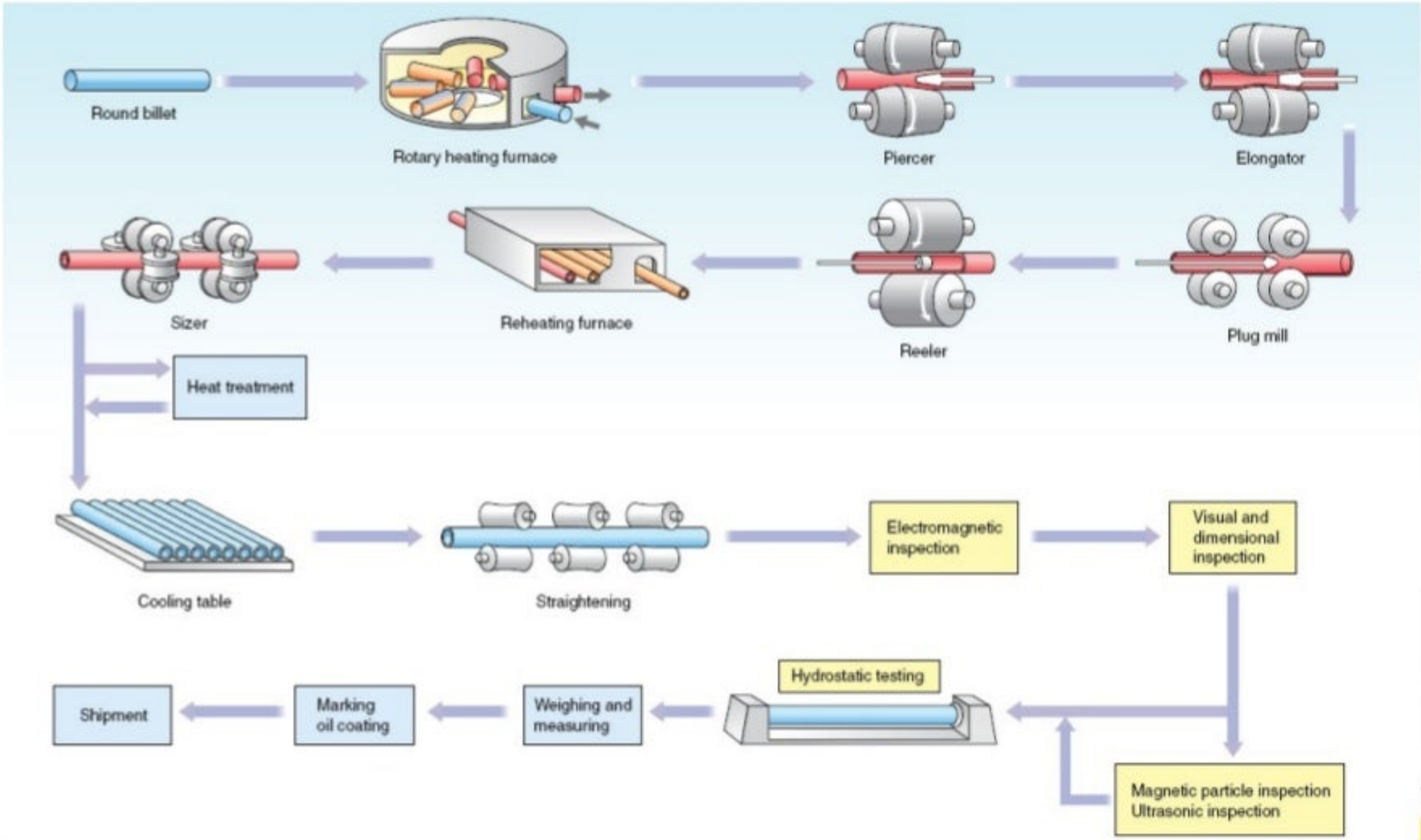
Linepipe - Fabrication Processes

- Submerged Arc Welded (SAW)
- Electrical Resistance Welded (ERW)
- High Frequency Induction (HFI) welded or High Frequency Welded (HFW)
- Seamless (SMLS), i.e. without longitudinal (seam) weld



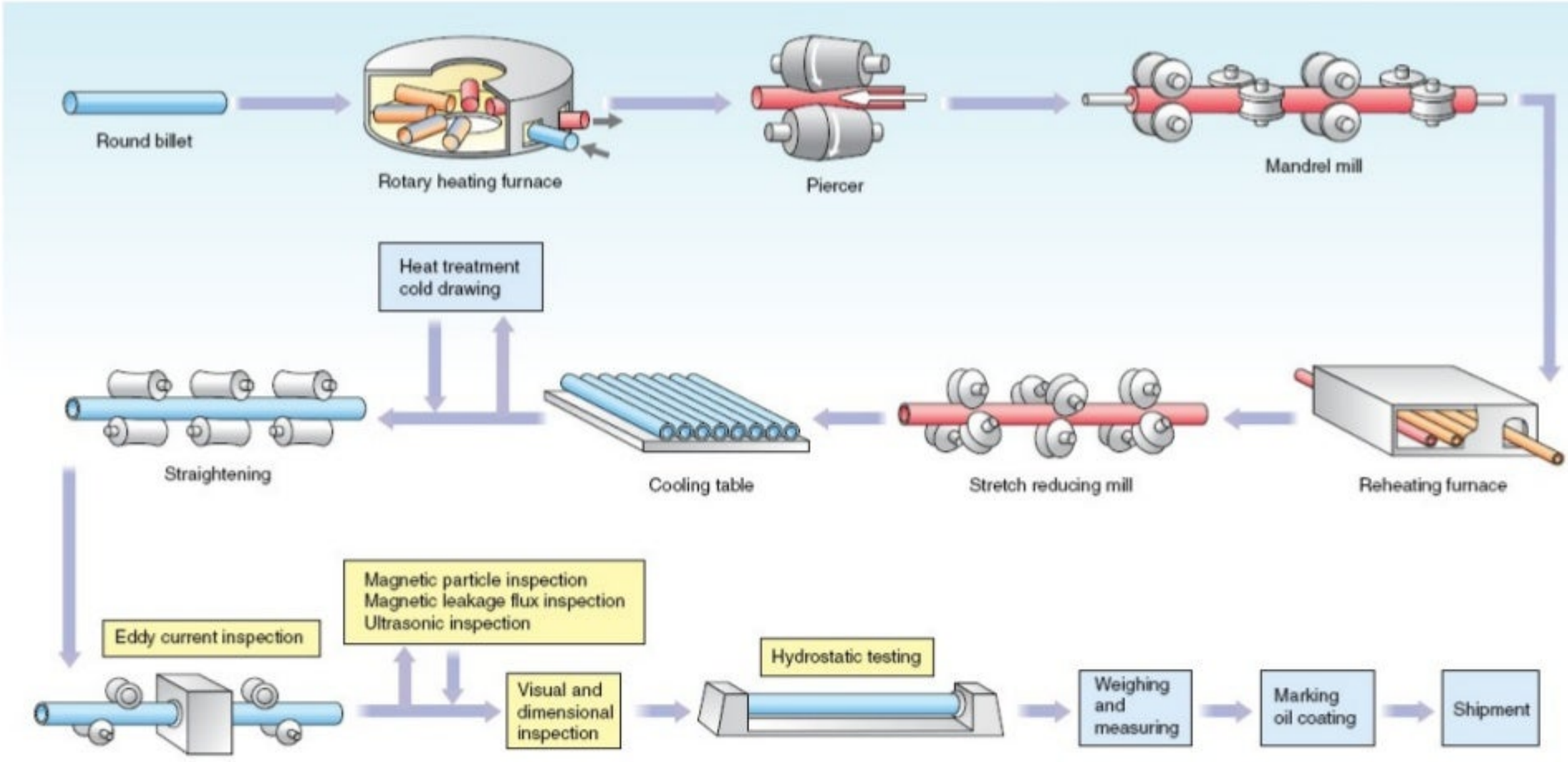
Material Overview

Plug Rolling Mill (Medium Diameter Seamless Pipe)



Material Overview

Mandrel Mill (Small Diameter Seamless pipe)



Material Overview

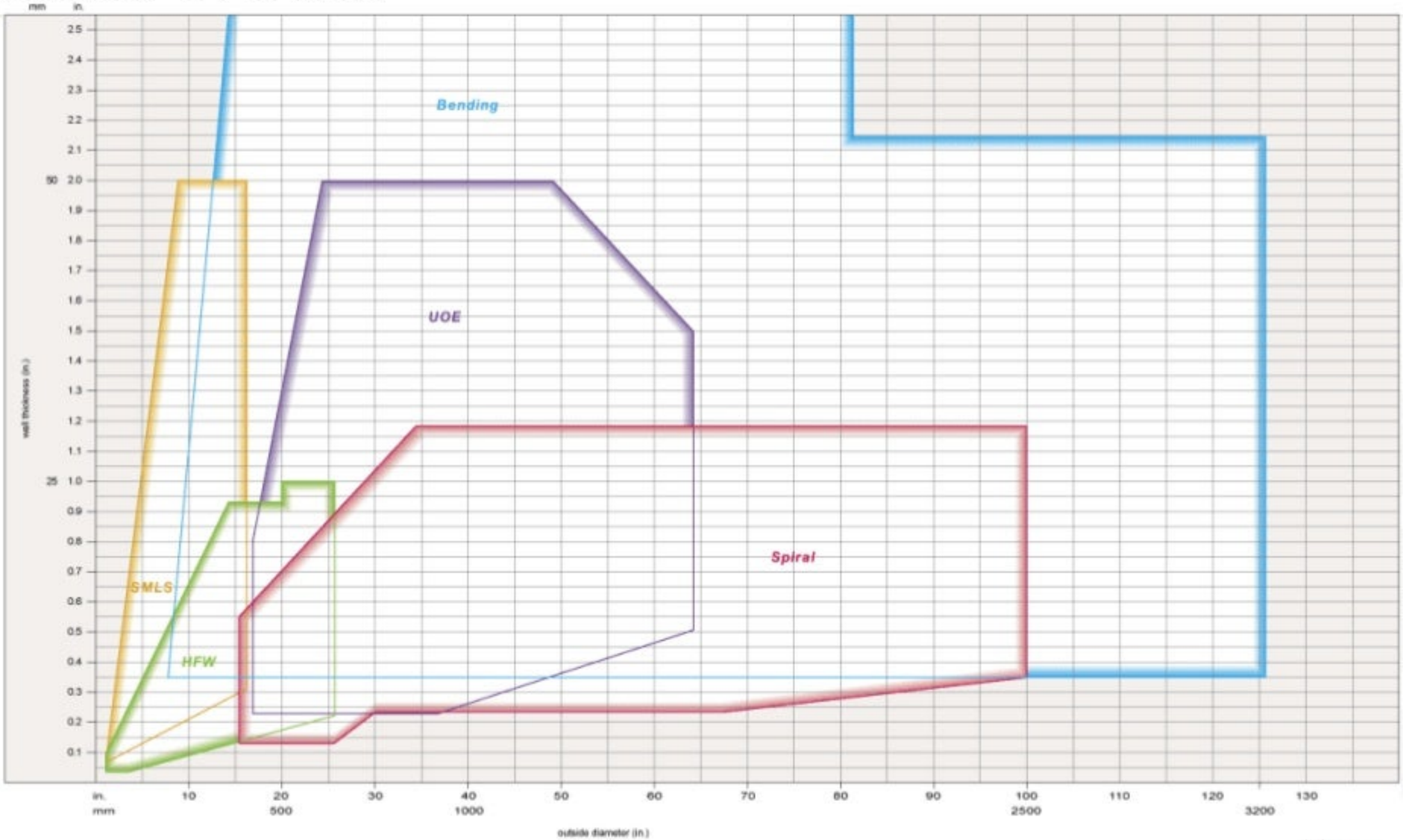
SEAMLESS-PRODUCT RANGE

OUTSIDE DIAMETER In	WALL THICKNESS 0.114	0.125	0.142	0.157	0.172	0.193	0.203	0.219	0.237	0.250	0.281	0.312	0.344	0.375	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750	0.812	0.844	0.875	1.000	1.125	1.189	1.250	1.375	1.437	1.500	1.575	
1.315																																		33.4
1.660																																		42.2
1.900																																		48.3
2.375																																		60.3
2.875																																		73.0
3.500																																		88.9
4.000																																		101.6
4.500																																		114.3
5.563																																		141.3
6.625																																		168.3
8.625																																		219.1
10.750																																		273.1
12.750																																		323.9
14.000																																		355.6
16.000																																		406.4
16.500																																		419.1
16.750																																		425.5
17.000																																		431.8
18.000																																		457.0
18.500																																		469.9
18.625																																		473.1
20.000																																		508.0
20.500																																		520.7
21.000																																		533.4
22.000																																		559.0
22.500																																		571.5
24.000																																		610.0
24.500																																		622.3
26.000																																		660.0
28.000																																		711.0
	2.9	3.2	3.6	4.0	4.4	4.9	5.2	5.6	6.0	6.4	7.1	7.9	8.7	9.5	10.3	11.1	11.9	12.7	14.3	15.9	17.5	19.1	20.6	21.4	22.2	25.4	28.6	30.2	31.8	34.9	36.5	38.1	40.0	mm
	WALL THICKNESS																																	OUTSIDE DIAMETER

TENARIS

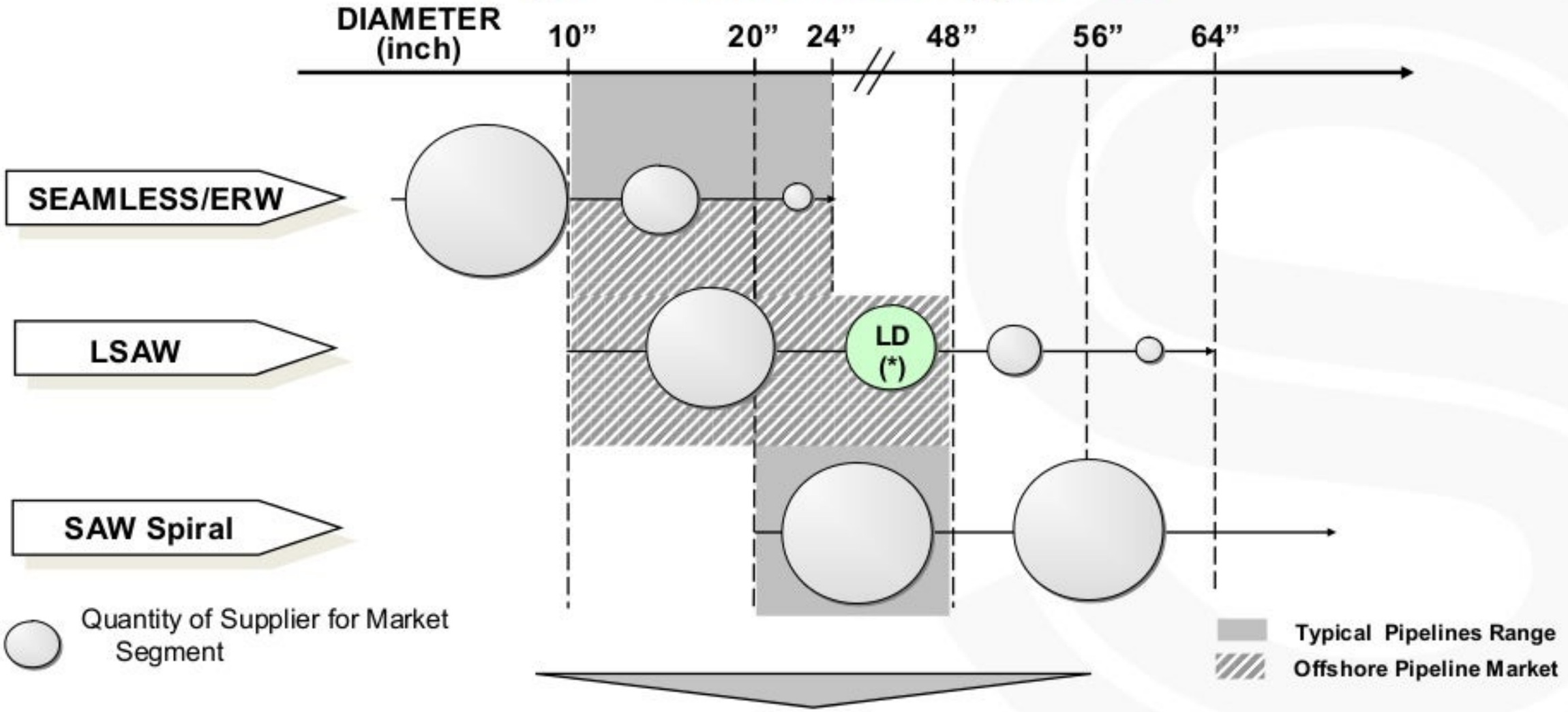
Note: Intermediate sizes (OD&WT) are available upon request.

Material Overview



Material Overview

Pipe – Market Segment



Pipelines usually have diameters within 10”and 48”. Large diameter linepipes (*) correspond to SAW longitudinal welded pipes that match more requirements for Oil & Gas applications. Generally speaking, ERW and SEAMLESS pipes are respectively less and more expensive than LSAW.

Index

Material Overview

CLAD Pipe

Offshore Pipeline for corrosive service (sour service i.e. with H2S) are fabricated in:

- Corrosion Resistant Alloy-CRA (Duplex, Super duplex, Inconel 625, AISI 316L)
- CRA Cladded/Lined Carbon Steel (Clad pipe: Carbon steel layer + CRA layer)

Clad pipelines are formed from a carbon manganese steel outer pipe (base material or back steel) lined internally with a thin layer (2-3 mm thick) of corrosion resistant material.

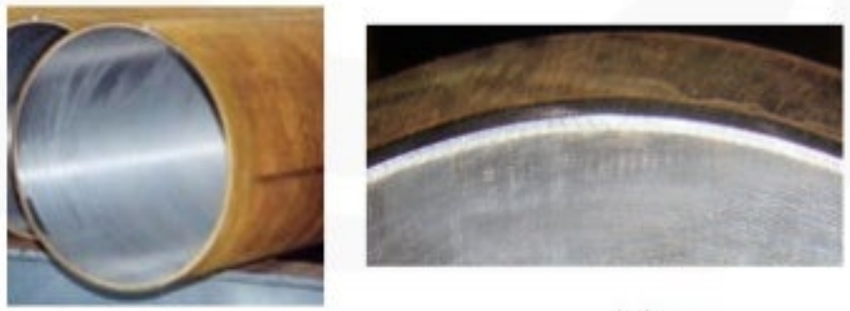
Definition:

- Linepipe is denoted “clad” if the bond between base and cladding material is metallurgical.
- Linepipe is denoted “lined” if the bond between base and cladding material is mechanical.

Lined Pipe

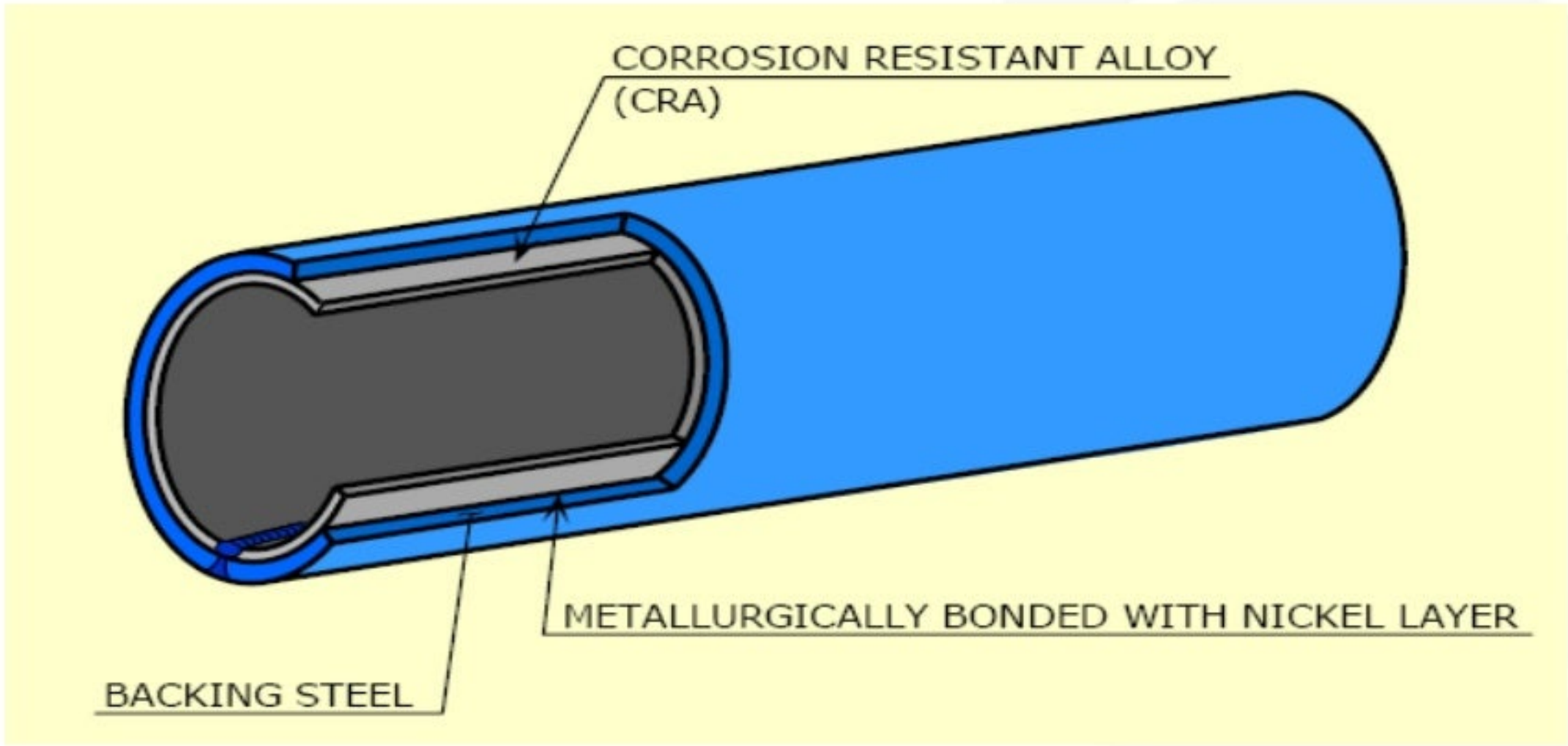
CRA Pipe

Clad Pipe



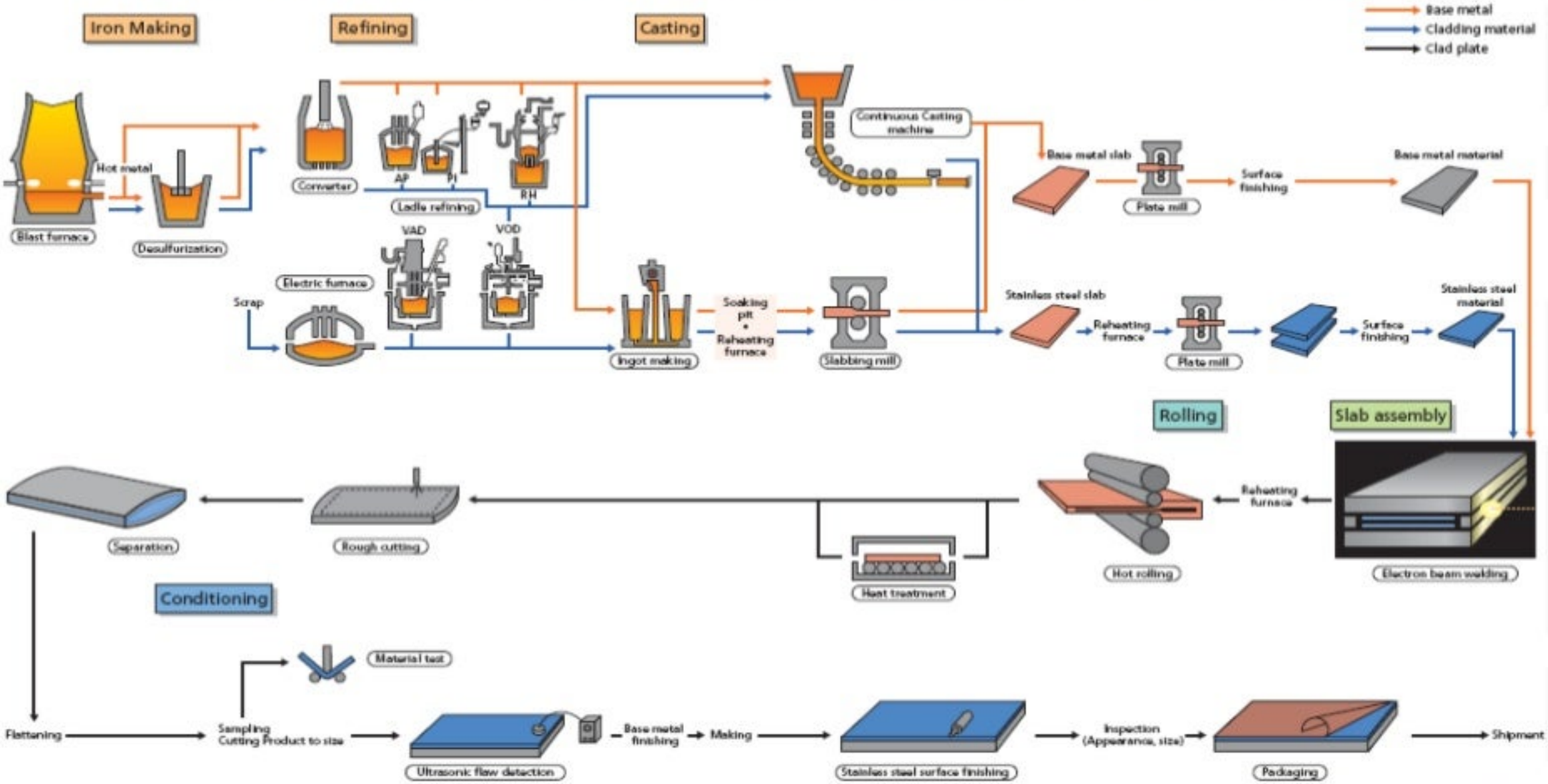
Material Overview

CLAD Pipe

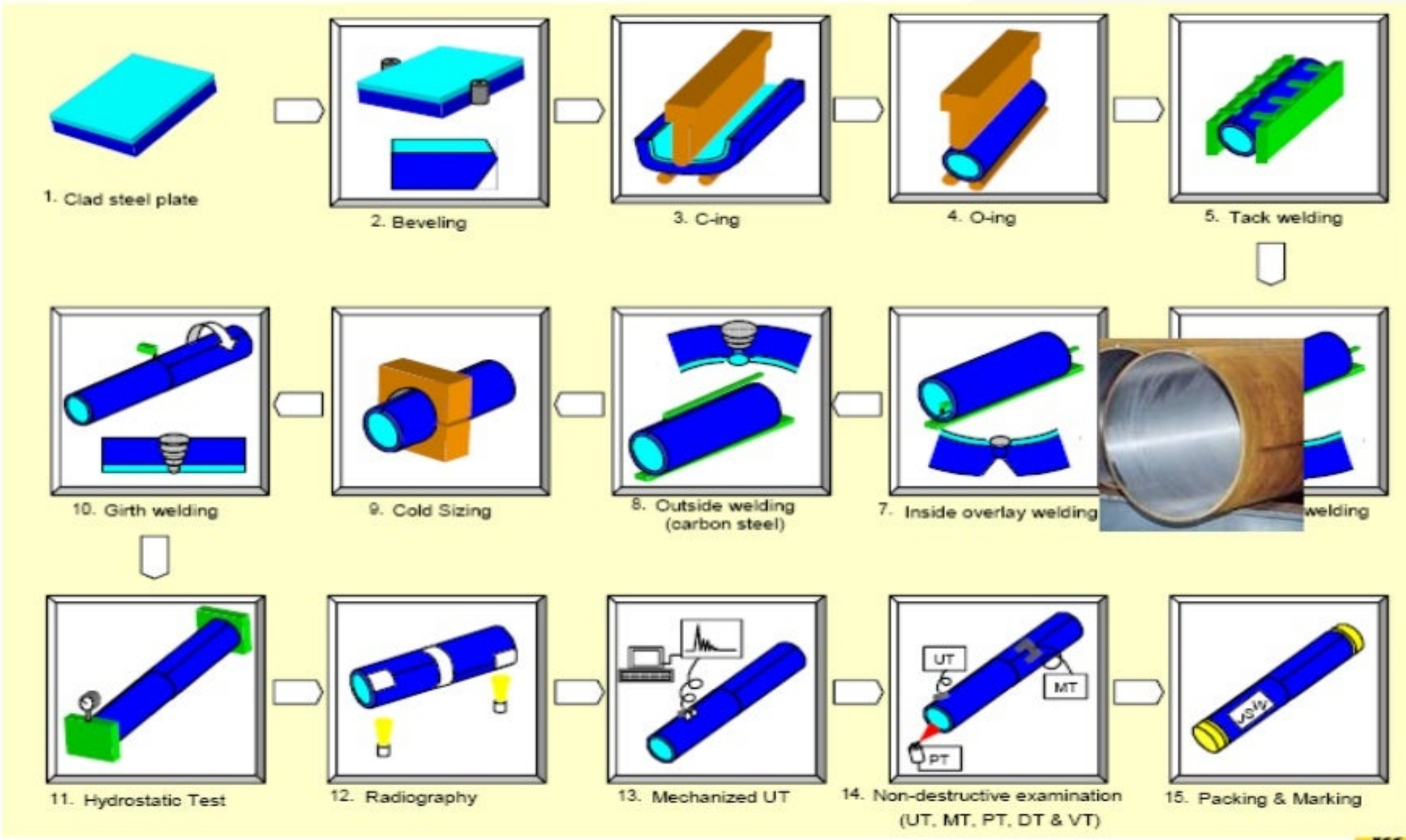


Material Overview

Clad Steel Plate Fabrication Process - Example



Welded Clad Steel Pipe - Fabrication Process Example



Material Overview

Lined Pipe

An example of Mechanically Bonded (Lined) pipe:

BUTTING BuBi®

In order to increase the advantages of a clad pipe, BUTTING developed a mechanically bonded **BU**TTING-**Bi**metal-pipe (BuBi®-pipe) at the beginning of the '90.

The BuBi®-pipe consists of a CRA pipe which is telescopically aligned inside a pipe in carbon-manganese material (seamless or welded pipe).

The tight bonding between the two pipes is achieved by hydraulic expansion.

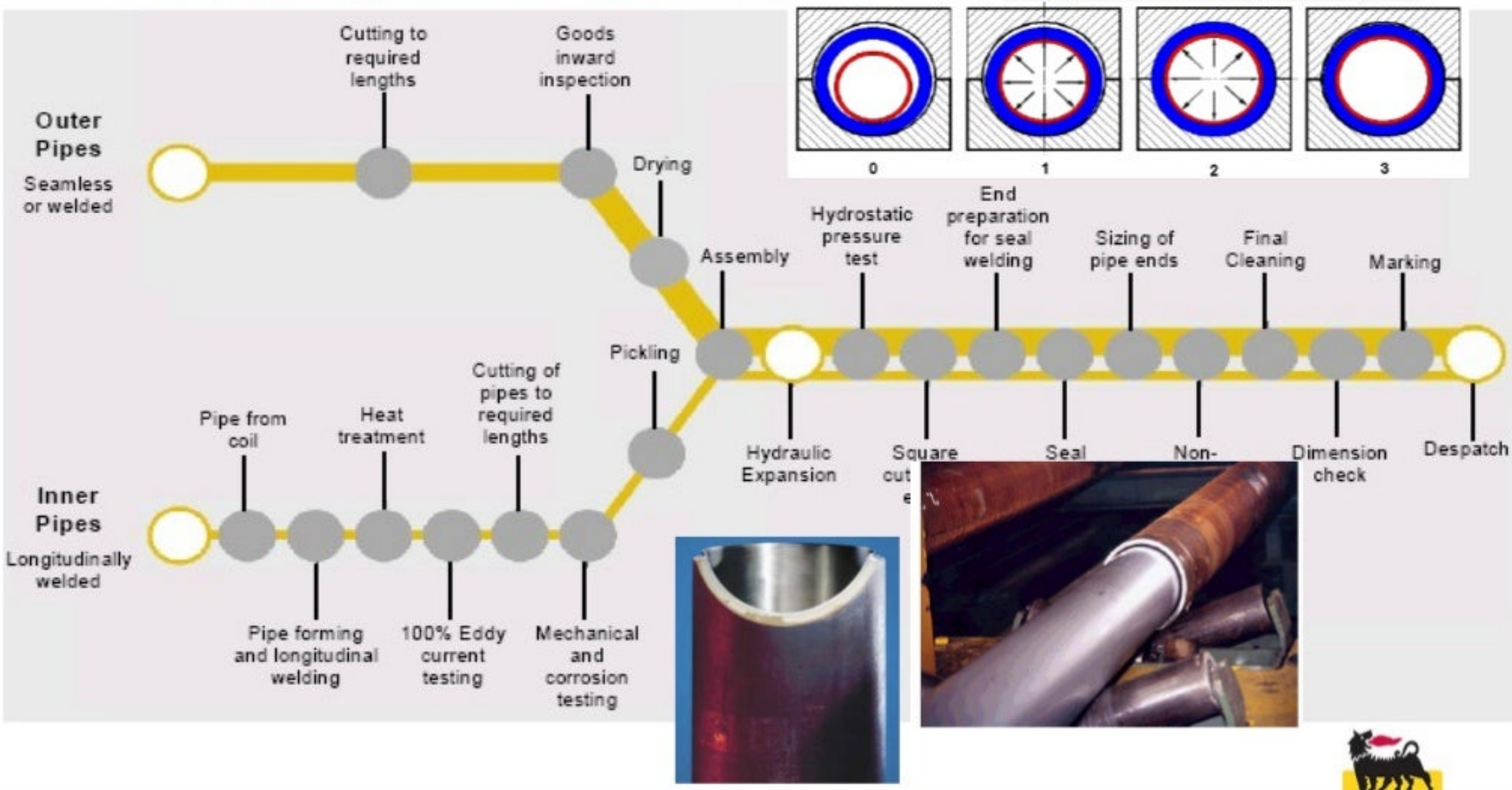
The producible size range comprises pipes in OD's from 114.3 mm (4") up to 660 mm (26") and lengths up to 12 m without circumferential weld.

Compared with the metallurgically clad pipe, BuBi®-pipe offers a wide range of material combinations - for both the inner and outer pipe - and price advantages.

Price advantage is due to the use of low cost carbon steels in conjunction with corrosion resisting steels and an economic production process.

Material Overview

Lined Pipe: BUTTING-Bimetal-pipe (BuBi®-pipe)



Index

Material Overview

Large Radius Bends

Offshore Application:

- Expansion loop (Spool) construction (e.g. goose neck, bend part).
- Riser construction (e.g. bend part).
- Top side Piping

Main Characteristics:

- Bend Radius ≥ 5 x OD Pipeline (i.e. piggable)
- Straight length (e.g. 0.5 -1.0 m)
- Same Chemical composition of mother pipe of linepipe (e.g. Carbon Equivalent)

Main Fabrication Processes:

- Hot bending of the original pipe (R≈5-10OD)
- Cold Bending of the original pipe (R≈0-40OD)

Bends – Hot Bend Production

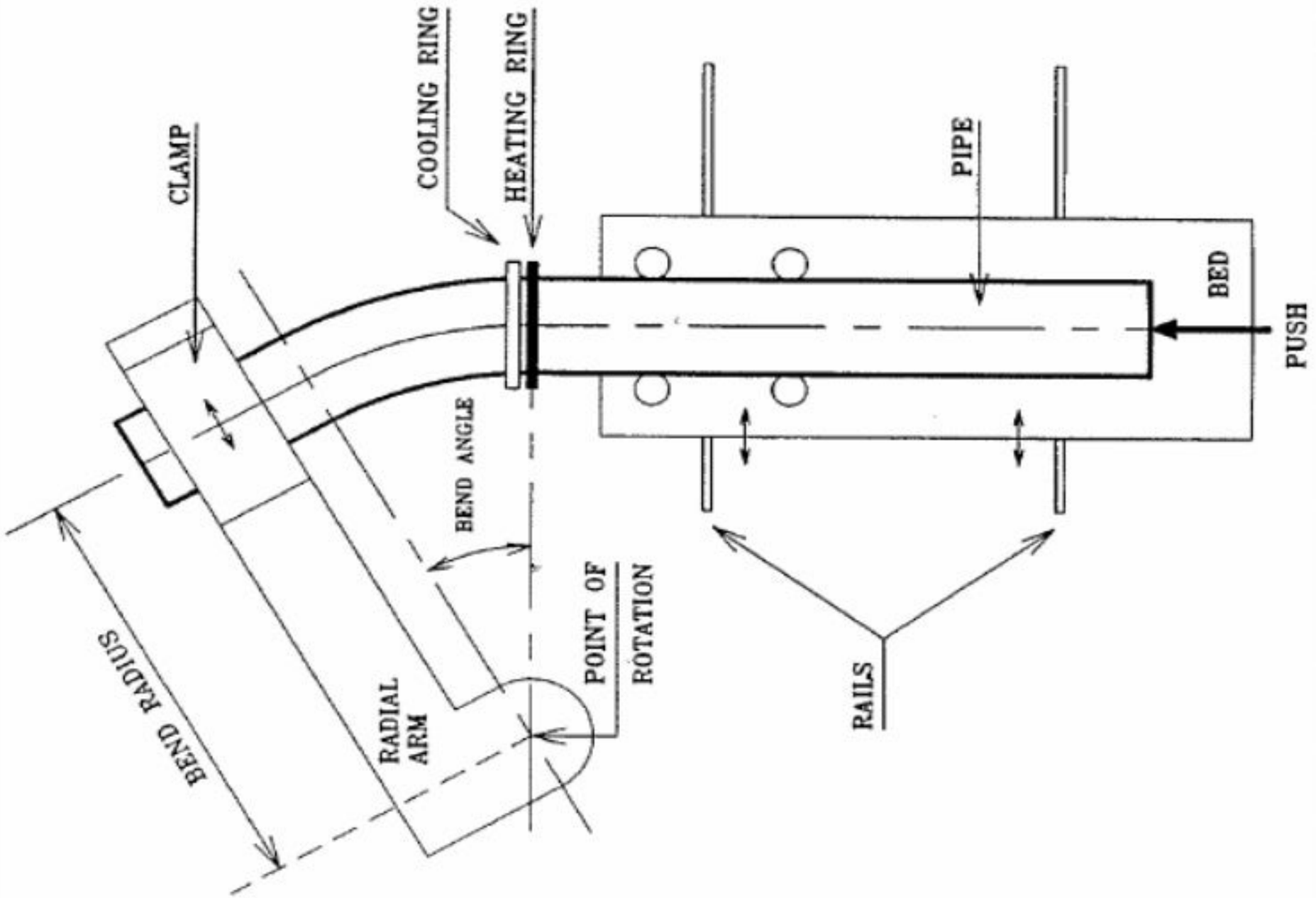
Hot Bend Production

Induction bending is a largely automated process. The "transformation" of straight pipe to pipe bend takes place only in the heated narrow annular zone which moves continuously along the length of the bend as the bending process advances (Figure 8 and 9). The heating of this zone is effected by means of an induction ring. An alternating current passes through the inductor and induces a potential which causes an eddy current in the material to be bent.

Figure 8: Hot induction bending of 48" line pipe at Mannesmann Bending Plant

Figure 9: Detailed view on induction coil and heated zone during bending

Bends – Hot induction Bending - Example

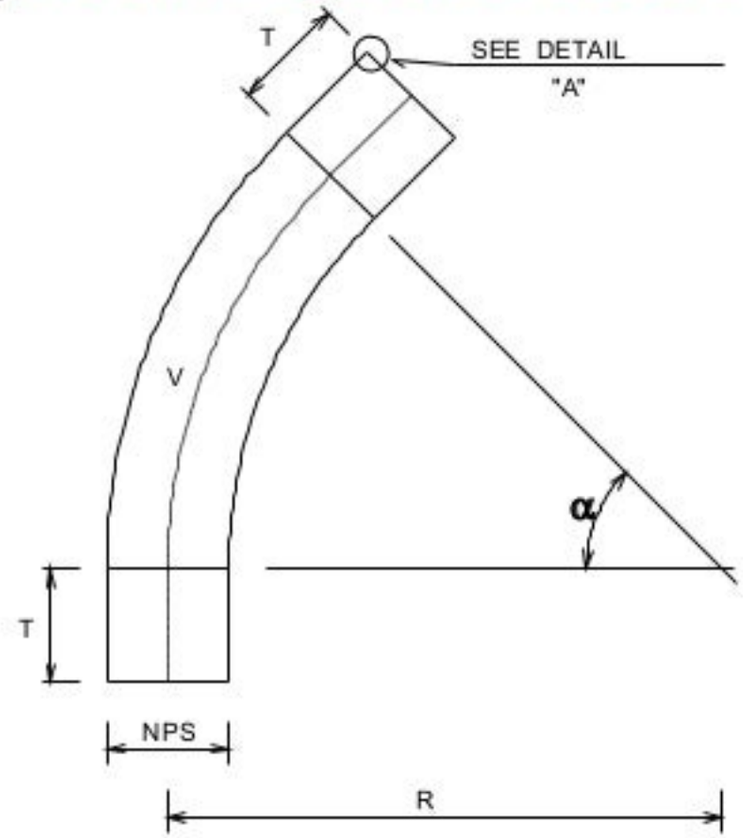


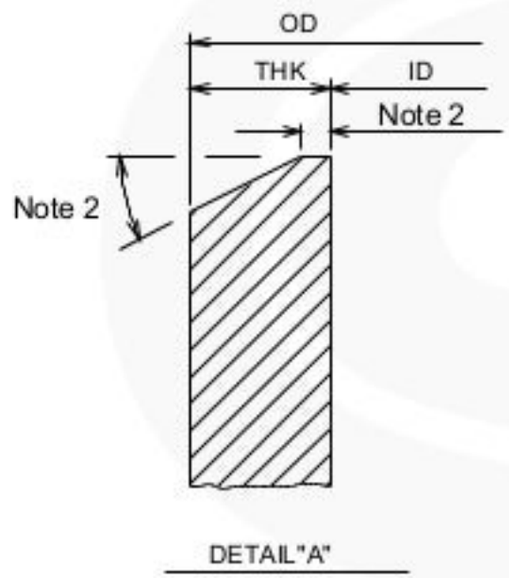
Bends – Hot induction Bending - Example

Bending Machine

Heating and Cooling Ring

Typical Bend Dimensions - Example





ITEM NAME	PIPE SIZE (inch)	Wall Thickness [mm]	Mother Pipe W.T [mm]	Material Grade Pipe Type	alpha (°)	R (mm)	V (mm)	T (mm)	V+2T (mm)
Expansion Loops 90° Bends	10	20,6	23,8	L415 QC SEAMLESS	90	1365,5	2145	500	3145
Goose Neck 20° Bends	10	20,6	23,8	L415 QC SEAMLESS	20	1365,5	477	500	1477

Index

Anticorrosion Coatings

Coating:

- The liquid, liquefiable, mastic, powder or any composition and material that after application to a substrate (e.g. pipes), is converted into a solid anticorrosion protective adherent films.

Offshore Application:

- Pipeline and Components (Bends, flange, fittings, etc.) External Anticorrosion Protection System.
- Riser External Anticorrosion and mechanical Protection System.

Coating System Selection Criteria is based on:

- Project Requirements
- Environmental service exposure (seawater, soil, other)
- Service temperature (depends on max. conveyed fluid temperature)

Material Overview

Anticorrosion Coatings

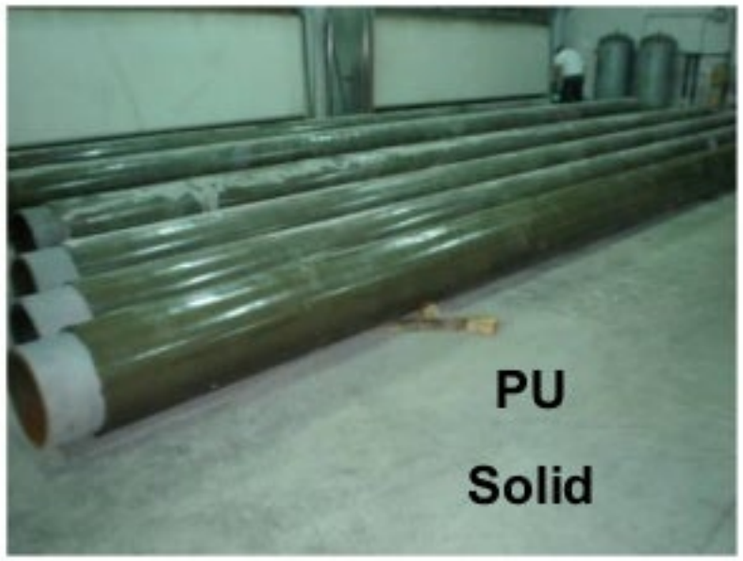
Anticorrosion coatings main type:

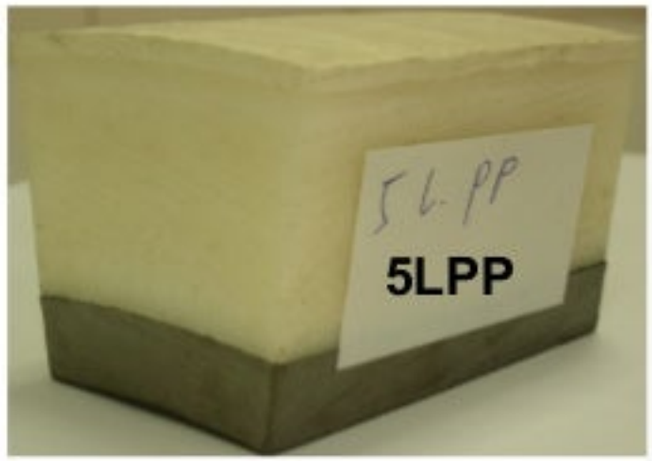
- Polyethylene (PE) (e.g. 3.5mm @ 950 kg/m^3 – linepipe)
- Coal tar Enamel (CTE) (e.g. pipeline)
- Polypropylene (PP) (e.g. 3mm @ 900 kg/m^3 linepipe, 3.5mm Flame Spray PP – Riser and Bends)
- Fusion Bonded Epoxy (FBE) (e.g. field joint)
- Polyurethane (PU) (e.g. 15mm@1500kg/m^3-Solid PU Risers, 1.5mm @ 1600 kg/m^3 PU tar free-Bends)
- Polychloroprene (PCP) (e.g. 15mm @ 1450 kg/m^3 – Risers)
- High solid Epoxy (e.g. Bends, 1.5mm @ 1600 kg/m^3 Flanges)

Main Characteristics to be required:

- Minimum Thickness; Minimum Density. and Min. and Max. Service Temperature.
- Cut back length (Depends on Welding System used)

Anticorrosion Coatings - Examples



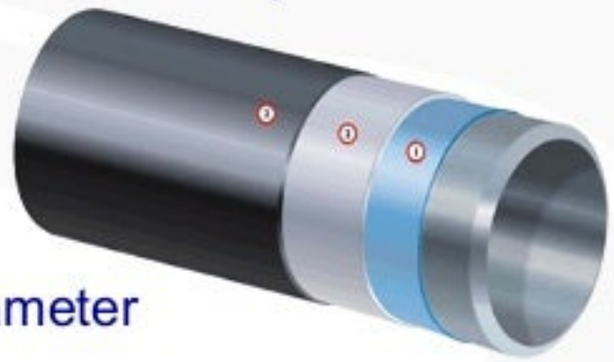


Material Overview

3-Layer Polyethylene (3LPE)

The three-layer's Polyethylene coating (3LPE) is a multilayer coating composed of three functional components:

- First layer: primer (liquid or powdered fusion bonded epoxy (FBE)). Continuous thin layer resistant to the corrosive agents. Guarantee a suitable adhesion of the coating to the steel.
- Second layer: co-polymer or modified polyethylene adhesive. Guarantee a suitable adhesion between the upper polyethylene layer and the primer.
- Third layer: polyethylene. It provides good mechanical strength, mechanical protection and electric insulation.



3LPE Systems provide excellent pipeline protection for small and large diameter pipelines with service temperatures varying from -60° C to +85 °C.

According to the maximum service temperatures the polyethylene may be:

- Low Density Polyethylene (LDPE) (918 - 935 Kg/m3)
- Medium/High Density Polyethylene (MDPE/HDPE) (940 - 950 kg/m3)

Minimum PE Coating Thickness: 3.5 mm

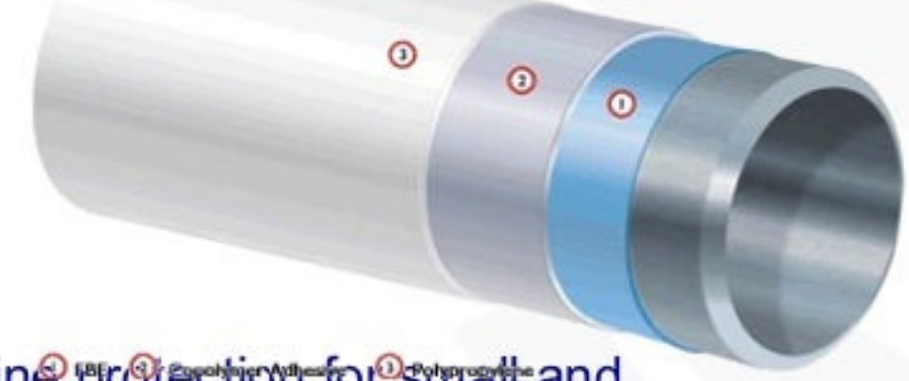
Cut back length required for pipeline installation: 150 mm +20/-0 mm;

Material Overview

3-Layer Polypropylene (3LPP)

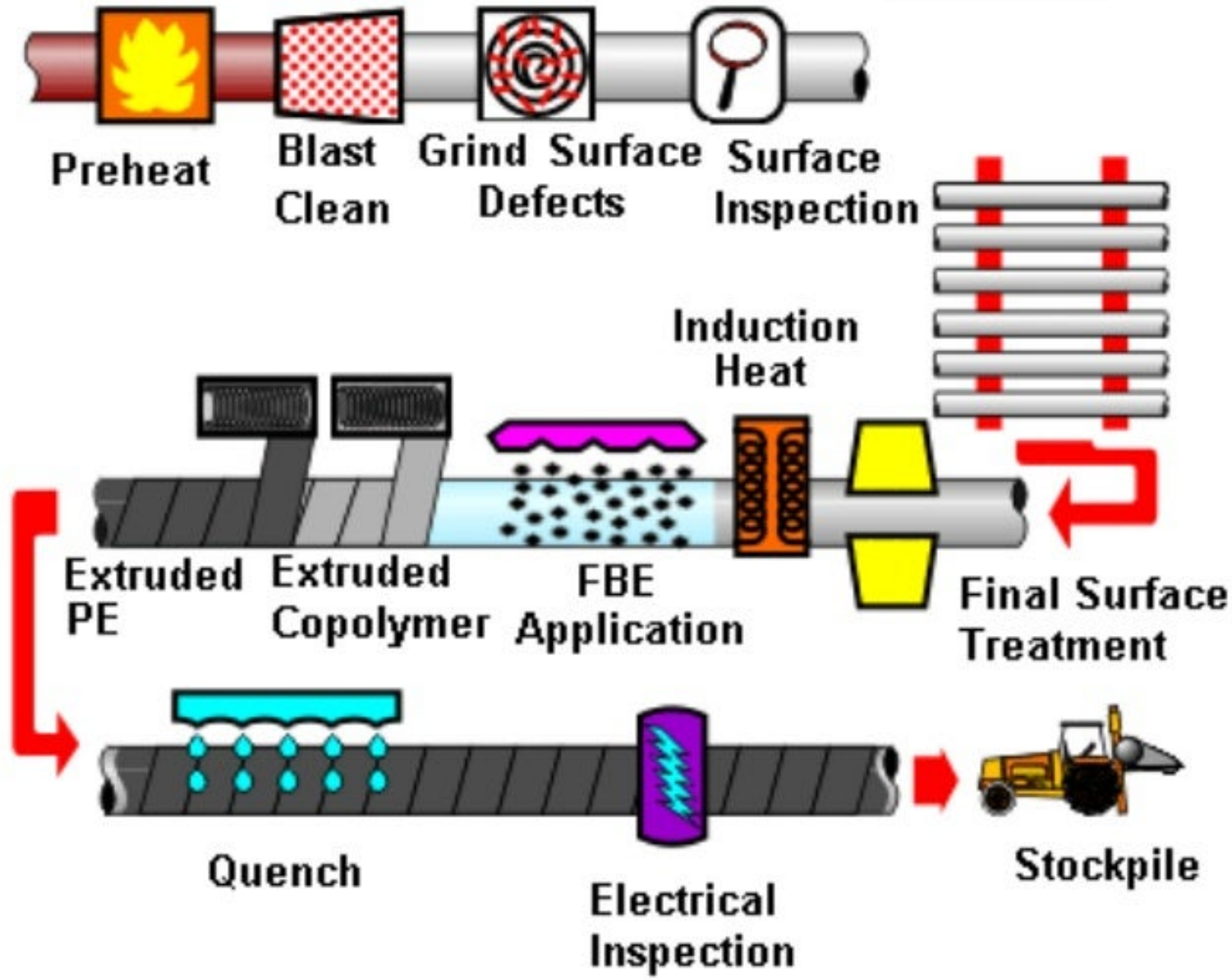
The three-layer's Polyethylene coating (3LPP) is a multilayer coating composed of three functional components:

- First layer: primer (liquid or powdered fusion bonded epoxy (FBE)). Continuous thin layer resistant to the corrosive agents. Guarantee a suitable adhesion of the coating to the steel.
- Second layer: co-polymer adhesive. Guarantee a suitable adhesion between the upper polypropylene layer and the primer.
- Third layer: polypropylene. It provides very good mechanical strength, mechanical protection and electric insulation.

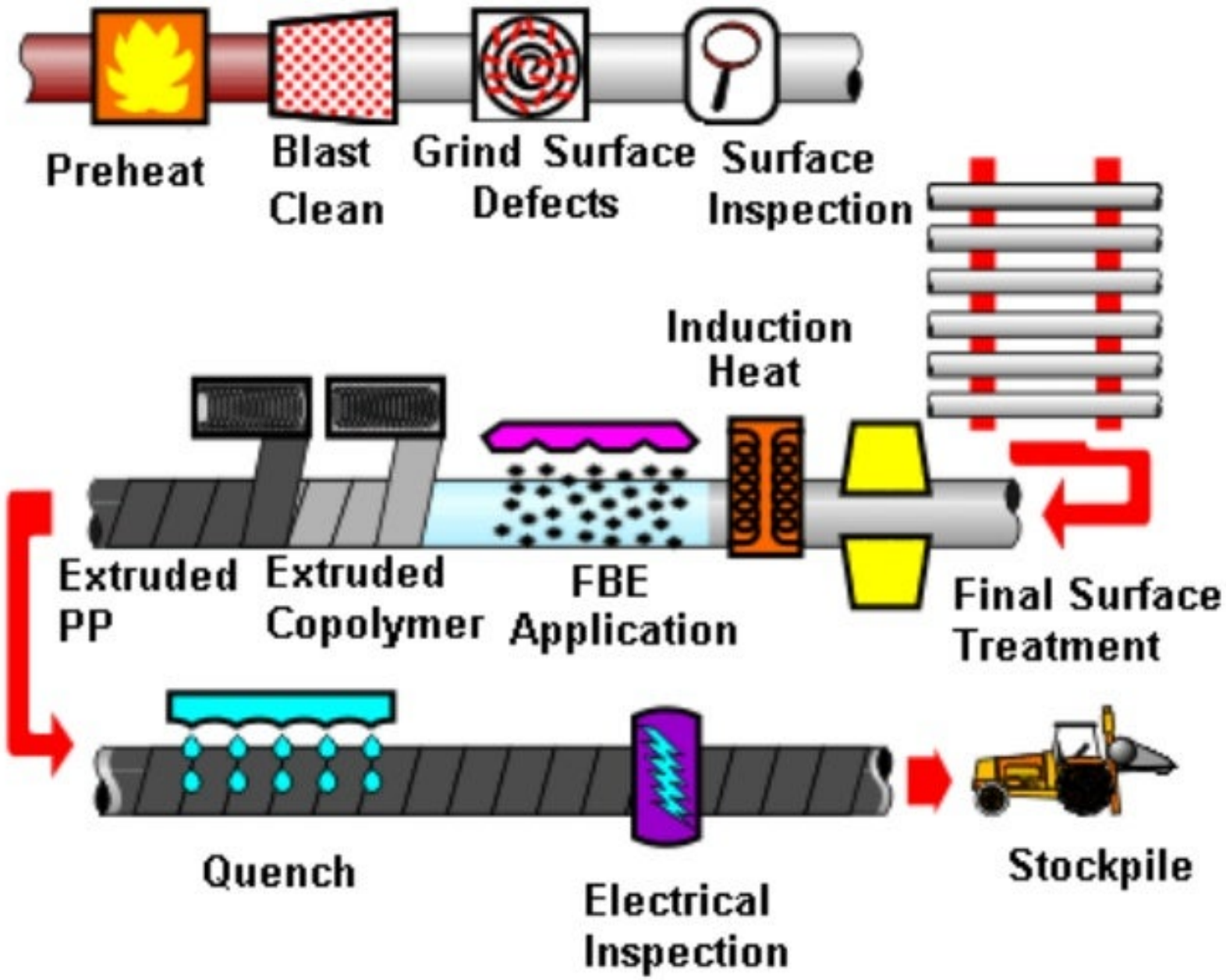


3LPP Systems provide excellent pipeline protection for small and Large diameter pipelines with service temperatures varying from -20° C to +140 °C.
Minimum Polypropylene Density 900 kg/m3
Minimum PE Coating Thickness: 3.5 mm
Cut back length required for pipeline installation: 150 mm +20/-0 mm.

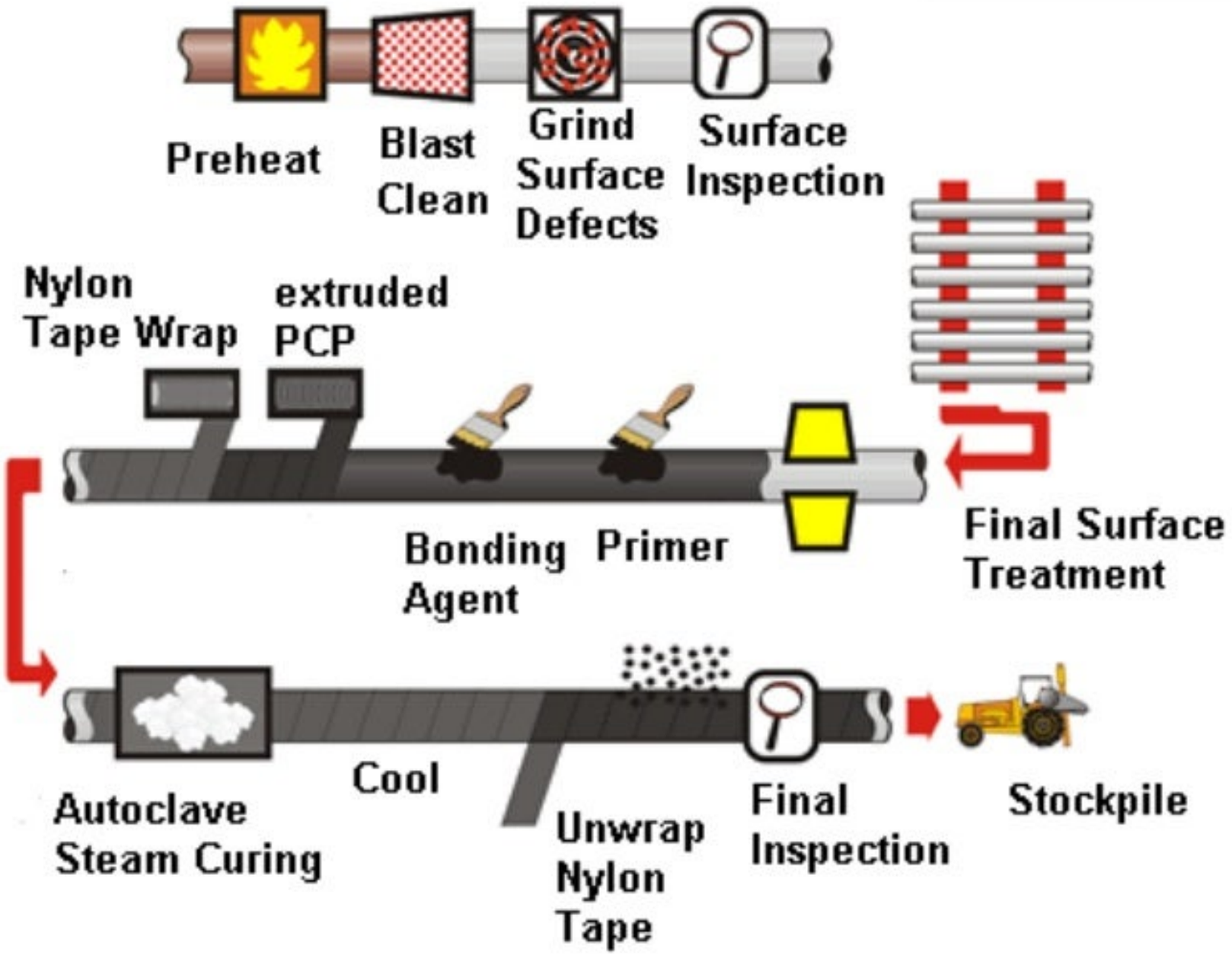
3LPE – Fabrication Process - Example



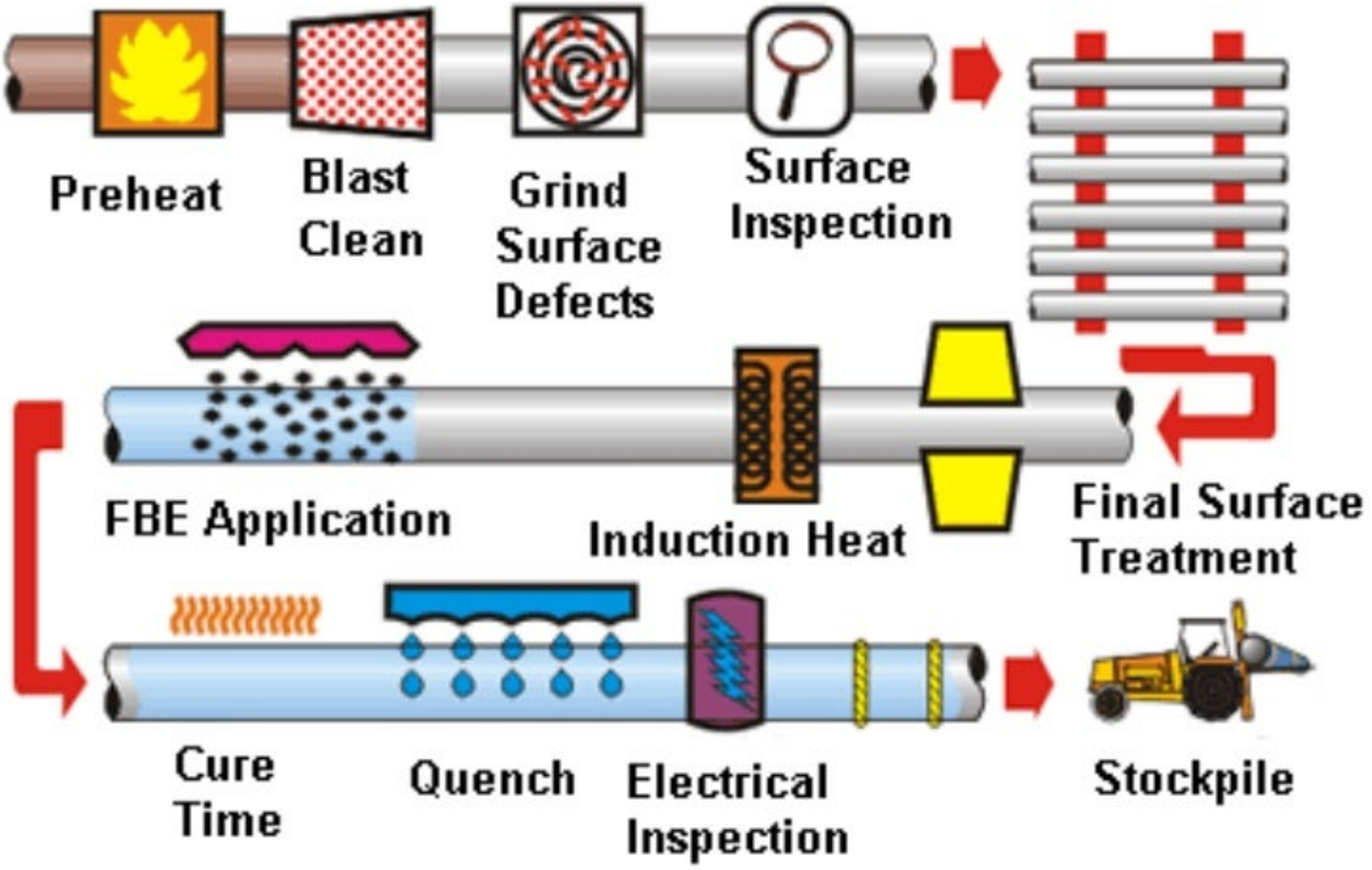
3LPP – Fabrication Process - Example



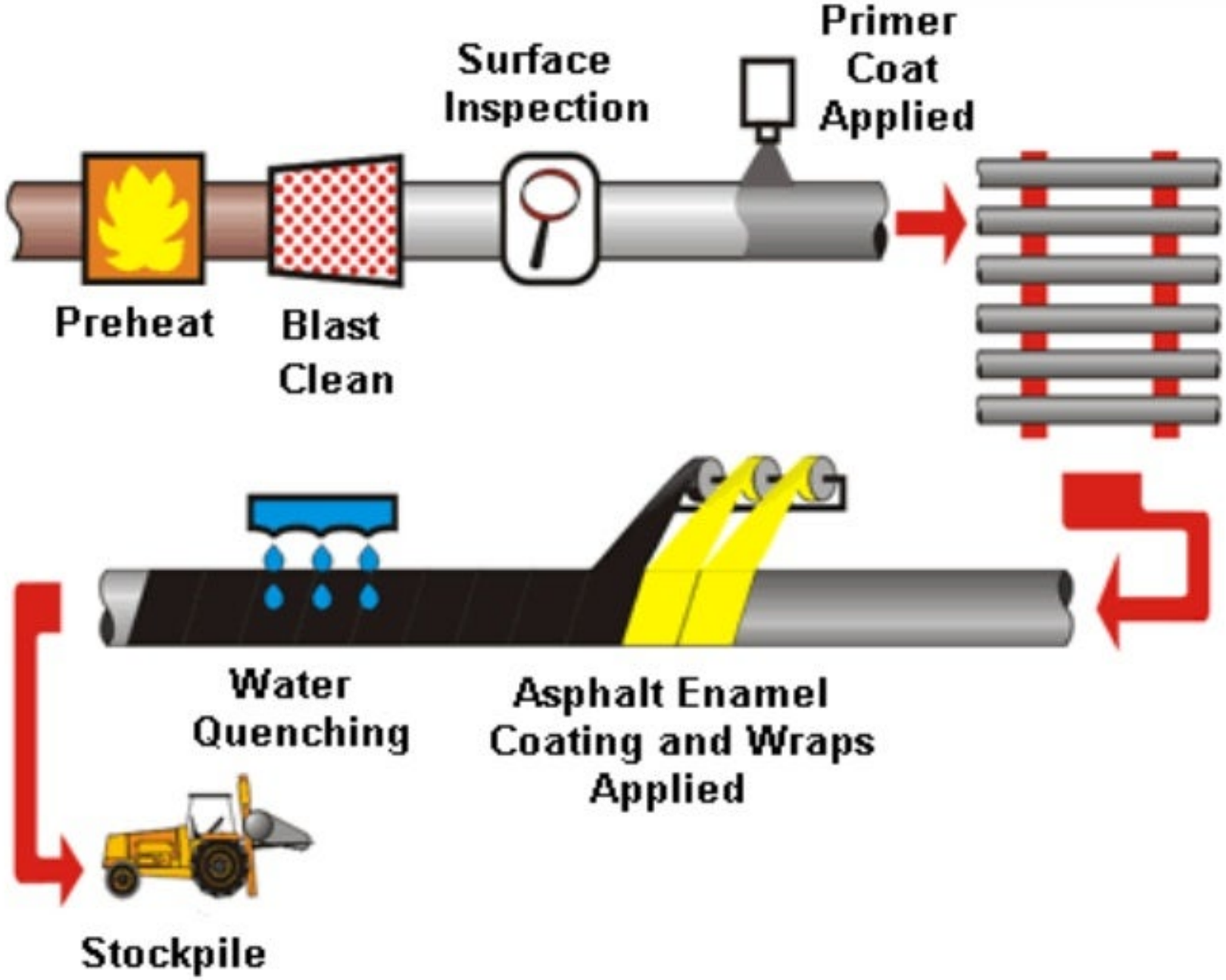
PCP – Fabrication Process - Example



FBE – Fabrication Process - Example



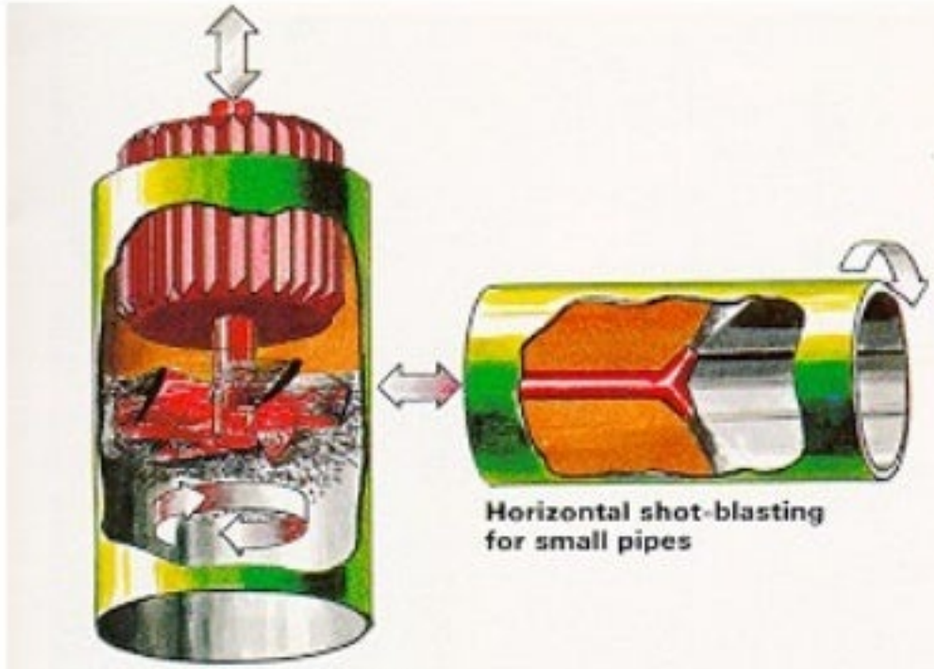
Coal Tar Enamel (CTE) – Fabrication Process - Example

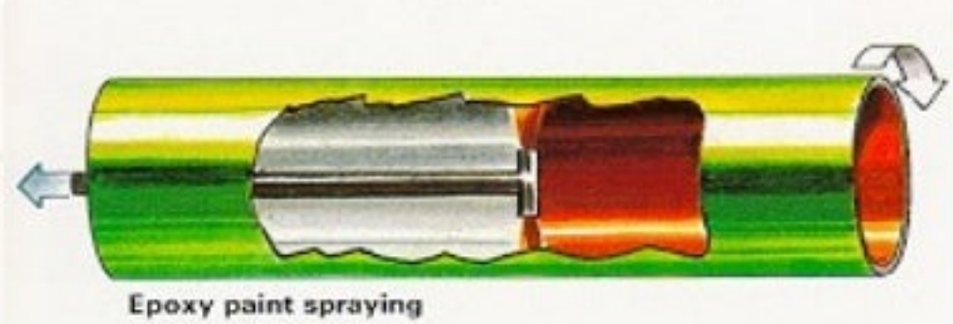


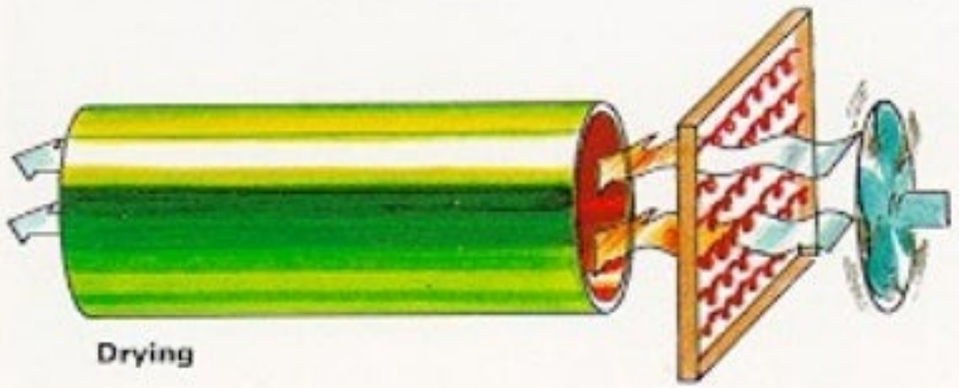
Epoxy Resin Lining – Application Example

This lining is applied by layering one or several coats of paint or by spraying epoxy powder.

1. The pipe is preheated to eliminate humidity
2. The interior surface is shot-blasted to remove mill scale and rust, obtaining a metal surface which facilitates the adhesion
3. When epoxy powder is fused, the pipe is preheated to 238°C, in order to quickly cure the epoxy.
4. The pipe is rotated and the lining is sprayed from a set of nozzles which moves inside the pipe.
5. When paint is used, it is dried by blowing hot air through the pipe.







Index

Concrete Coating

Reinforced Concrete Coating is made by a right mixture of cement, aggregates and water reinforced with steel cage or steel welded fabric .

Offshore Application:

- Pipeline Weighting (stabilization of offshore pipeline subjected to Hydrodynamic forces)

Main Characteristics to be required:

- Min. Compressive Strength at 7 and 28 day Core/Cube
- Minimum Applicable Thickness
- Minimum and Maximum Density
- Water Absorption
- Cut back length (Depends on Welding System used)

Typical Concrete Data - Example

Minimum Recommended Applicable Concrete Thickness: 40 mm;
Maximum Standard Applicable Concrete Thickness: 150 mm;
Maximum Standard concrete coating density (dry): 3.040 t/m^3;
Minimum Standard concrete coating density (dry): 2.240 t/m^3;
Concrete weight increase in order to take into account water absorption:

- on bottom stability analysis (minimum) 2% by weight;
- laying analysis (maximum) 5% by weight.

Cut back length required for pipeline installation:

- 370 mm +20/-0 mm (Presto & Passo Welding System);
- 390 mm +20/-0 mm (Wermaat Welding System).

Index

Material Overview

Sacrificial Anodes

Sacrificial Anode (Offshore Pipeline) is made by Indium activated aluminium alloy or Zinc alloy.

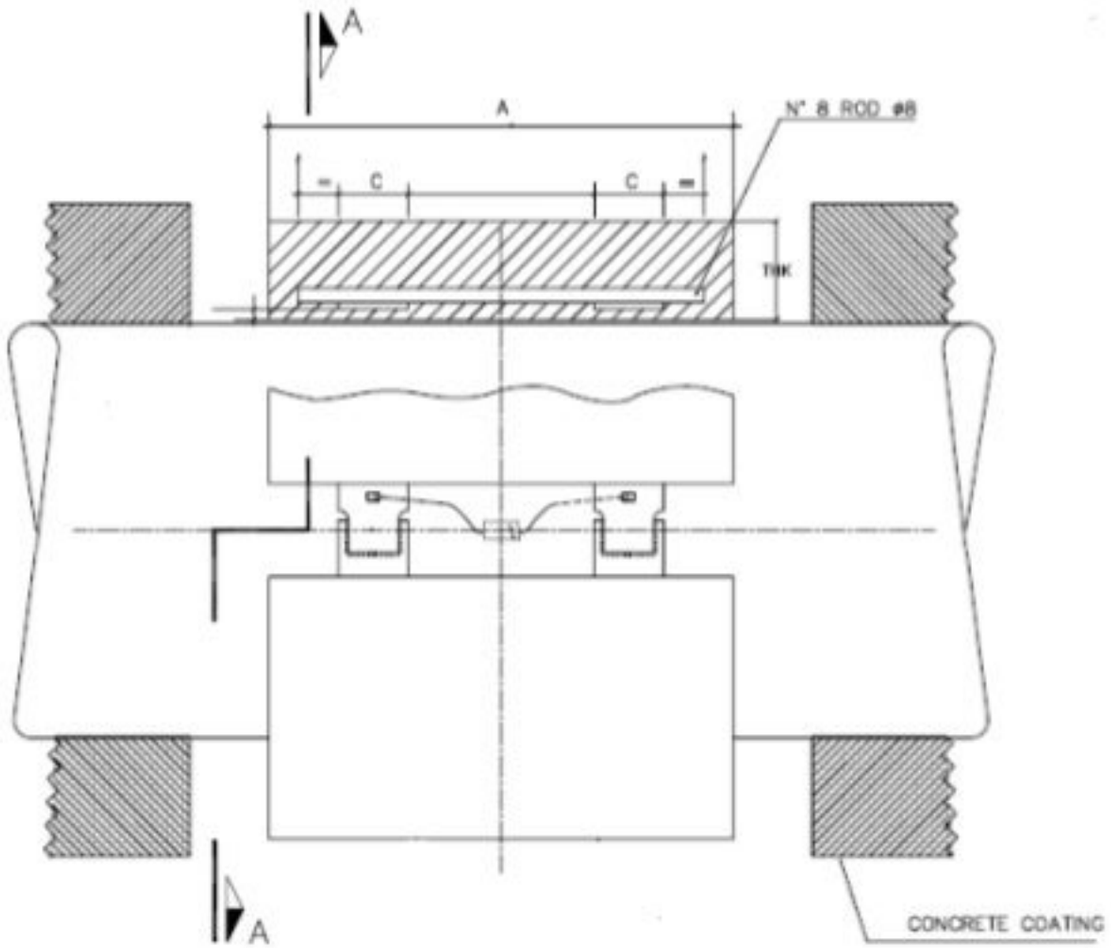
Offshore Application:

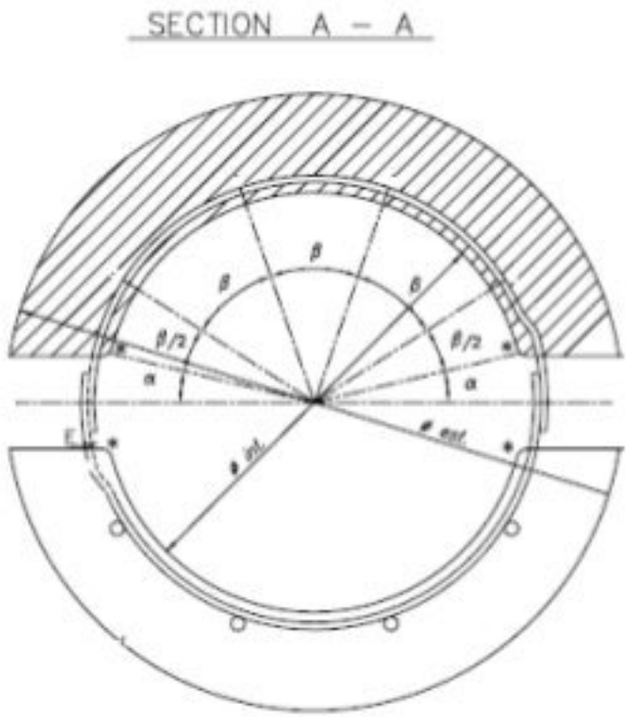
- Pipeline Cathodic Protection (External Anticorrosion System)

Anode Type:

- Bracelet, half-shell (squared and Tapered)
- Long Slender Stand-off (e.g. Platform Leg, Subsea Structure, etc.)
- Flush-mounted (e.g. Platform Leg, Subsea Structure, etc.)

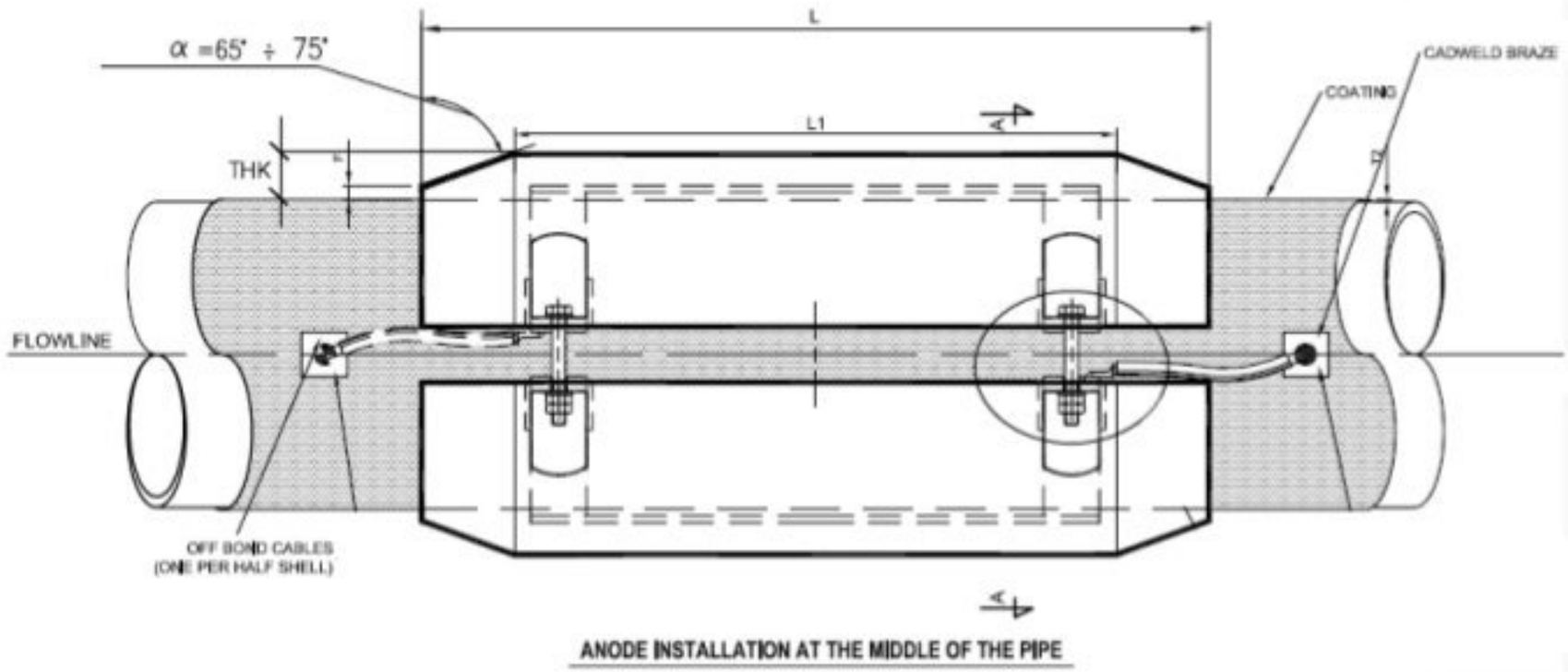
Anode Typical Drawing- Concrete Coated Pipe



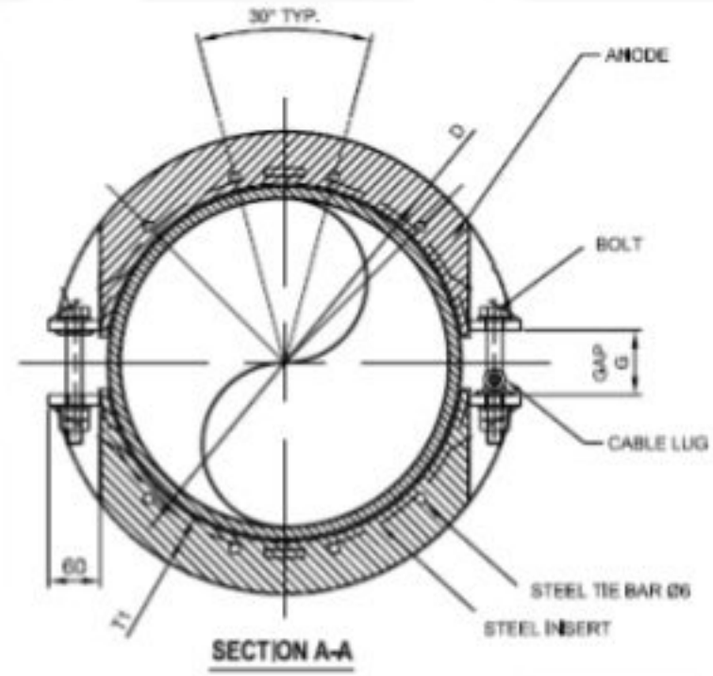


Material Overview

Anode Typical Drawing - Anticorrosion Coated Pipe



ANODE INSTALLATION AT THE MIDDLE OF THE PIPE



SECTION A-A

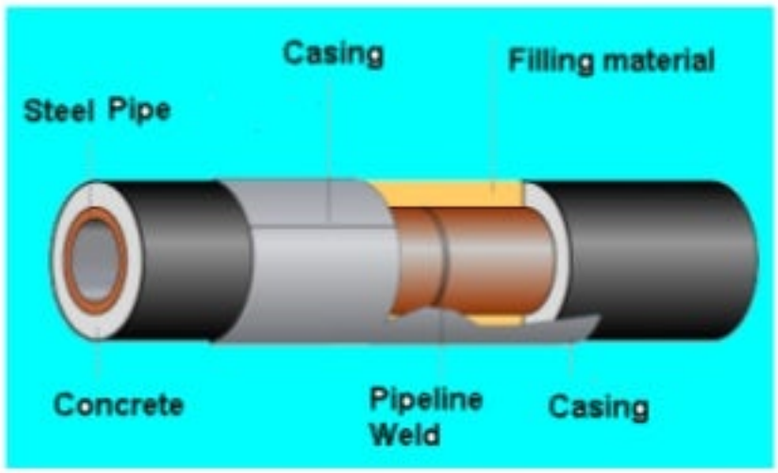
Index

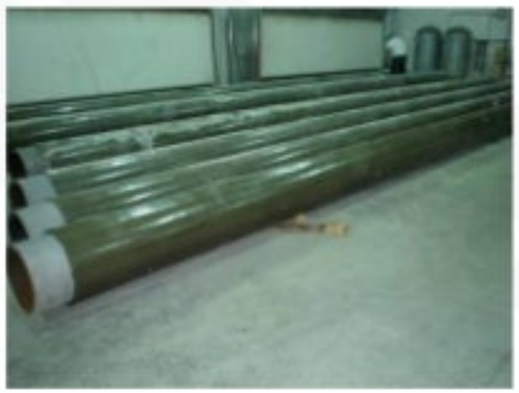
Field Joints Coatings

FJC is the protective coating applied on field weld joints (circumferential weld).
The FJC ensure the suitable corrosion protection and coating continuity to the steel pipes surface left bare (uncoated) during coating application on shop.

Field Joint coating System Selection Criteria is based on:

- Project Requirements
- Environmental service exposure (seawater, soil, other)
- Service temperature (depends on max. Fluid conveyed temperature)
- Compatibility with the pipeline External Anticorrosion Coating



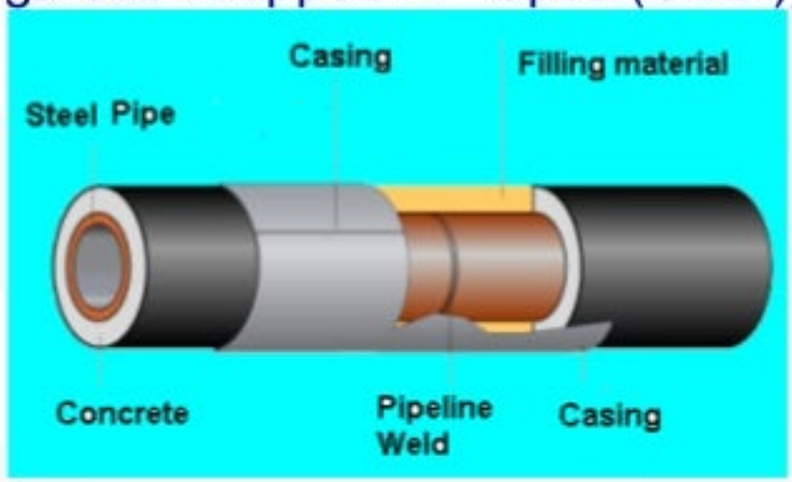


Field Joints Coatings

Field Joint coatings main type:

Anticorrosion Coated Pipe

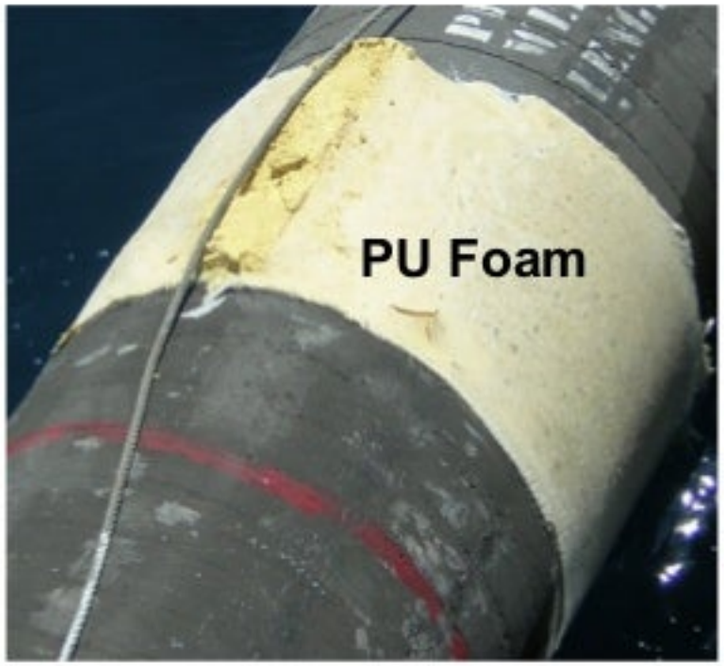
- Heat Shrinkable Sleeve (HSS)
- Polymer plastic tapes (e.g. Spirally wrapped PP tapes (PIH) & Cigarette wrapped PP tapes (CCSI))
- Fusion Bonded Epoxy Powder (FBE)
- Liquid Epoxy resin (Tar free)
- Liquid Polyurethane (Tar free) (e.g. Marinblock trademark)
- Injection Moulded Polypropylene (PP) and Polyurethane (PU)

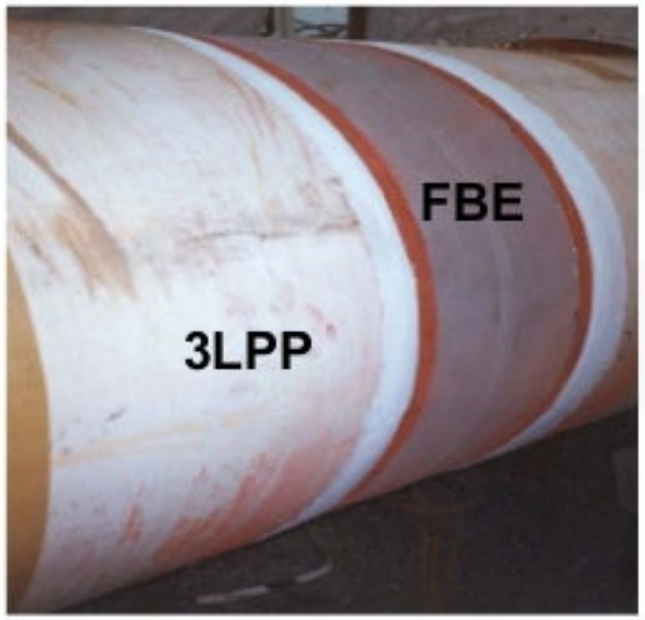


Concrete Coated Pipe

- Polyurethane mixture with anticorrosion properties (PU) (e.g. 1500kg/m^3) with or w/o Gravel
- Polyurethane Foam with anticorrosion properties (PU) (e.g. 125kg/m^3) with or w/o Gravel
- Heat Shrinkable Sleeve (HSS) + Polyurethane (PU) mixture Infill material (e.g. 1100 -1150kg/m^3)
- Flame Spray Polypropylene + Polyurethane (PU) mixture Infill material (e.g. 900Kg/m^3 PP+1400-1600kg/m^3 PU)

Field Joints Coatings - Examples





Application Of Heat Shrinkable Sleeve (HSS)

1. 2. 3. 7. 8. 9.

4. 5. 6. 10. 11.

1. and **2.** All weld areas shall be grit or sand blasted to remove all frayed or loosened coating at edges of the mill cutback and slightly abrade the coating sections to be covered by the heat shrinkable sleeve (HSS).

3. and **4.** Heating the weld joint up to the specified heating application temperature.

5. Before sleeve application, the primer, when required, shall be applied to bare steel and adjacent abraided mill coating using supplied applicator (i.e. spatula).
Then wrapping the sleeve centrally around the weld joint. Sleeve overlap onto itself should be not less than 150 mm.

6. Installation of the closure patch and pressing in position centering over the exsposed sheet end.

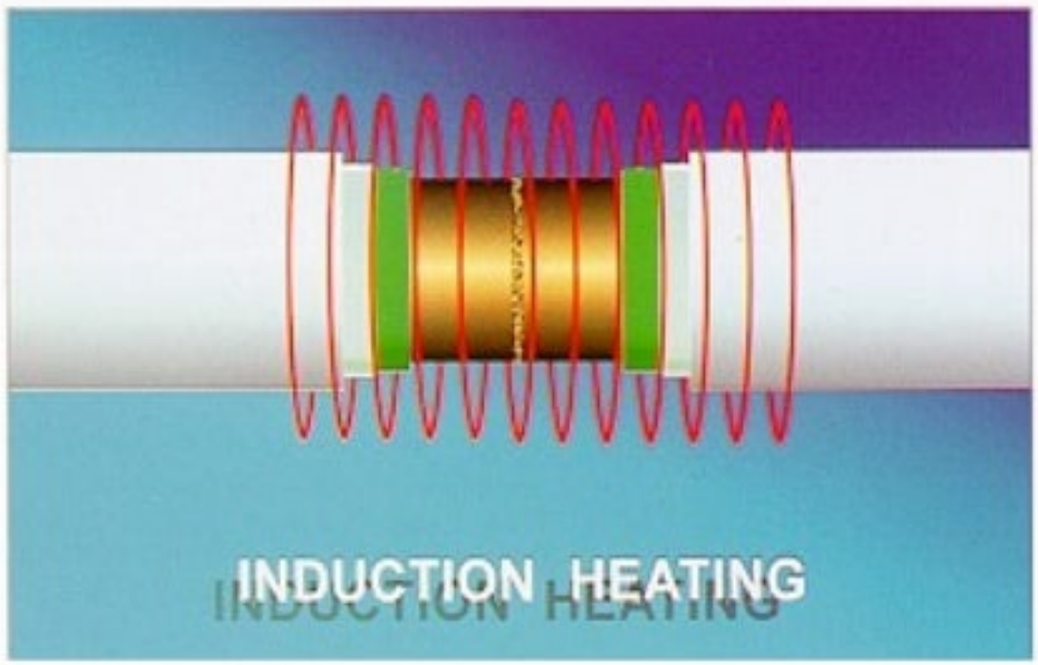
7. and **8.** Heating the closure patch evenly until the temperature sensitive paint converts color and with a gloved hand, smooth the closure patch to eliminate possible entrapped air and ensure good bonding.

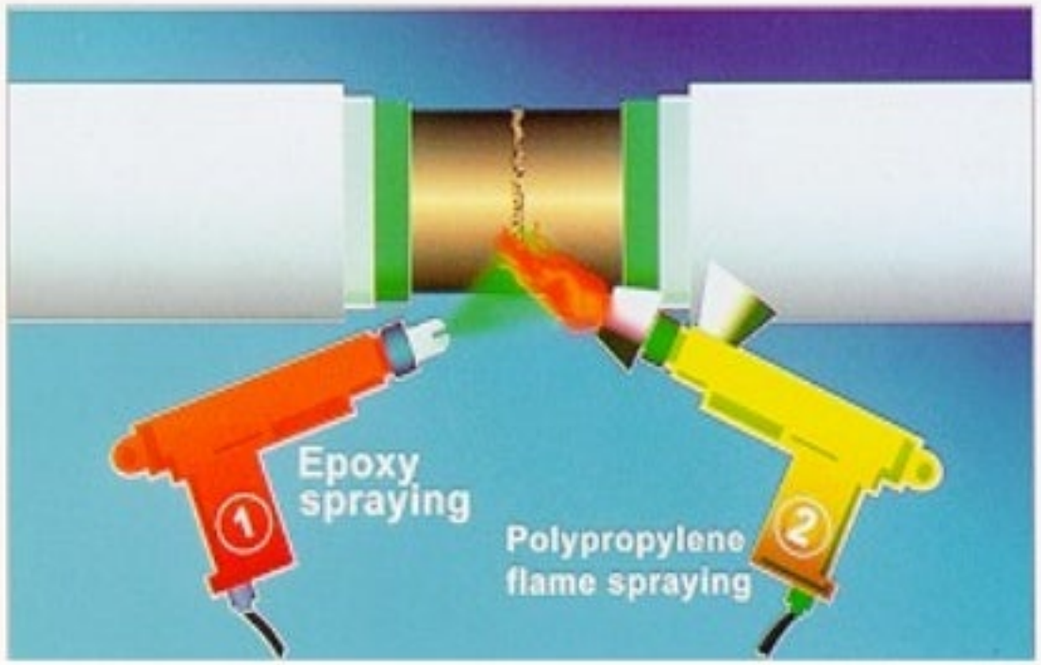
9. Using two torches (for pipe diam. above above 400 mm, two people are recommended) adjust flame length to approx. 50-60 cm. While continuously moving the torch in a paint brush motion, being heating circumferentially from one end until the band is completely recovered. Finish installation by shrinking circumferentially towards the other end.

10. During and after shrinking use rollers/gloved hand to remove air enclosures.

11. As installed.

PP Flame Spray – Application Process Example





Index

Material Overview

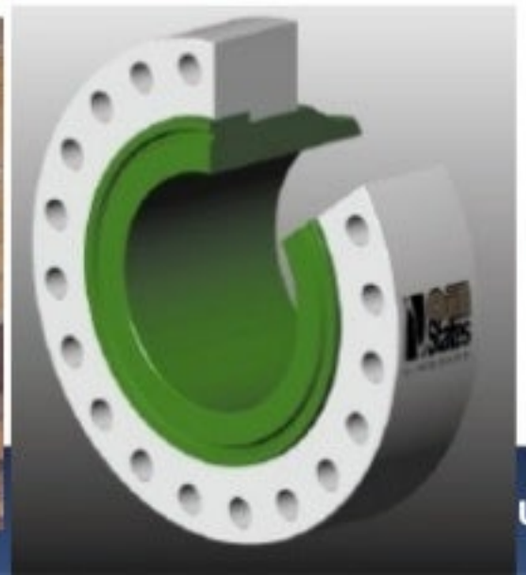
Flanges

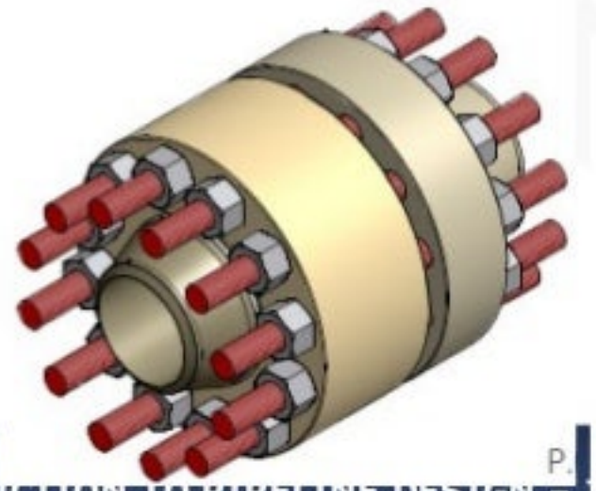
Flanges are hot or cold forged fittings
Required Flange Rating depends on the pipeline design and hydrostatic test pressures

Offshore Application:
Coupling flanged (e.g. Pipeline-Spool, Riser-Spool, Valve-piping, etc.)

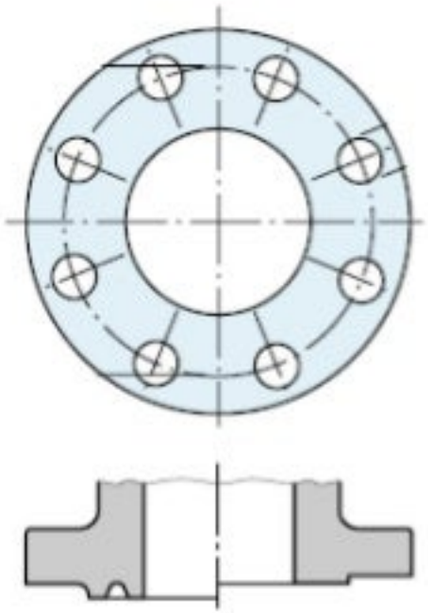
Typical Flanges Materials:
Carbon Steel, Low Alloyed Steel, Stainless Steel.

Flange Type:
Welding Neck (WN) - Swivel Neck (SW) - Blind (BL) - Flat Face (FF) - Raise Face (RF)

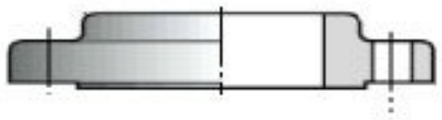




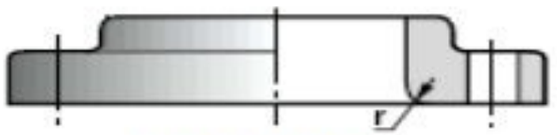
Flanges Types



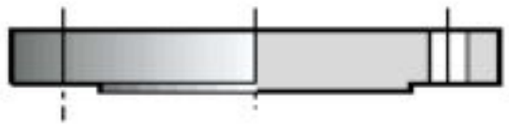
RTJ RF



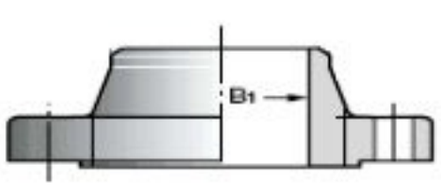
SLIP ON



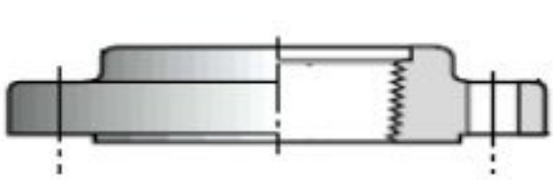
LAPPED



BLIND



WELDING NECK



THREADED

SOCKET WELDING

Carbon Steel Flanges Rating (ASME B16.5)

Table 2-1.1 Pressure–Temperature Ratings for Group 1.1 Materials

Nominal Designation	Forgings	Castings	Plates
C–Si	A 105 (1)	A 216 Gr. WCB (1)	A 515 Gr. 70 (1)
C–Mn–Si	A 350 Gr. LF2 (1)		A 516 Gr. 70 (1), (2)
C–Mn–Si–V	A 350 Gr. LF6 CL (4)		
3½ Ni	A 350 Gr. LF3		A 537 Cl. 1 (3)

	Working Pressure by Classes, bar						
Class Temp., °C	150	300	400	600	900	1500	2500
−29 to 38	19.6	51.1	68.1	102.1	153.2	255.3	425.5
50	19.2	50.1	66.8	100.2	150.4	250.6	417.7
100	17.7	46.6	62.1	93.2	139.8	233.0	388.3
150	15.8	45.1	60.1	90.2	135.2	225.4	375.6
200	13.8	43.8	58.4	87.6	131.4	219.0	365.0
250	12.1	41.9	55.9	83.9	125.8	209.7	349.5
300	10.2	39.8	53.1	79.6	119.5	199.1	331.8
325	9.3	38.7	51.6	77.4	116.1	193.6	322.6
350	8.4	37.6	50.1	75.1	112.7	187.8	313.0
375	7.4	36.4	48.5	72.7	109.1	181.8	303.1
400	6.5	34.7	46.3	69.4	104.2	173.6	289.3
425	5.5	28.8	38.4	57.5	86.3	143.8	239.7
450	4.6	23.0	30.7	46.0	69.0	115.0	191.7
475	3.7	17.4	23.2	34.9	52.3	87.2	145.3
500	2.8	11.8	15.7	23.5	35.3	58.8	97.9
538	1.4	5.9	7.9	11.8	17.7	29.5	49.2

NOTES:
(1) Upon prolonged exposure to temperatures above 425°C, the carbide phase of steel may be converted to graphite. Permissible but not recommended for prolonged use above 425°C.
(2) Not to be used over 455°C.
(3) Not to be used over 370°C.
(4) Not to be used over 260°C.

Low Alloyed Steel Flanges Rating (ASME B16.5)

Table 2-1.9 Pressure–Temperature Ratings for Group 1.9 Materials

Nominal Designation	Forgings	Castings	Plates
1¼Cr–½Mo		A 217 Gr. WC6 (1), (3)	
1¼Cr–½Mo–Si	A 182 Gr. F11 Cl. 2 (1), (2)		A 387 Gr. 11 Cl. 2 (2)

	Working Pressures by Classes, bar						
Class Temp., °C	150	300	400	600	900	1500	2500
−29 to 38	19.8	51.7	68.9	103.4	155.1	258.6	430.9
50	19.5	51.7	68.9	103.4	155.1	258.6	430.9
100	17.7	51.5	68.6	103.0	154.4	257.4	429.0
150	15.8	49.7	66.3	99.5	149.2	248.7	414.5
200	13.8	48.0	63.9	95.9	143.9	239.8	399.6
250	12.1	46.3	61.7	92.7	139.0	231.8	386.2
300	10.2	42.9	57.0	85.7	128.6	214.4	357.1
325	9.3	41.4	55.0	82.6	124.0	206.6	344.3
350	8.4	40.3	53.6	80.4	120.7	201.1	335.3
375	7.4	38.9	51.6	77.6	116.5	194.1	323.2
400	6.5	36.5	48.9	73.3	109.8	183.1	304.9
425	5.5	35.2	46.5	70.0	105.1	175.1	291.6
450	4.6	33.7	45.1	67.7	101.4	169.0	281.8
475	3.7	31.7	42.3	63.4	95.1	158.2	263.9
500	2.8	25.7	34.3	51.5	77.2	128.6	214.4
538	1.4	14.9	19.9	29.8	44.7	74.5	124.1
550	...	12.7	16.9	25.4	38.1	63.5	105.9
575	...	8.8	11.7	17.6	26.4	44.0	73.4
600	...	6.1	8.1	12.2	18.3	30.5	50.9
625	...	4.3	5.7	8.5	12.8	21.3	35.5
650	...	2.8	3.8	5.7	8.5	14.2	23.6

NOTES:
(1) Use normalized and tempered material only.
(2) Permissible, but not recommended for prolonged use above 590°C.
(3) Not to be used over 590°C.

Stainless Steel Flanges Rating (ASME B16.5)

Table 2-2.3 Pressure–Temperature Ratings for Group 2.3 Materials

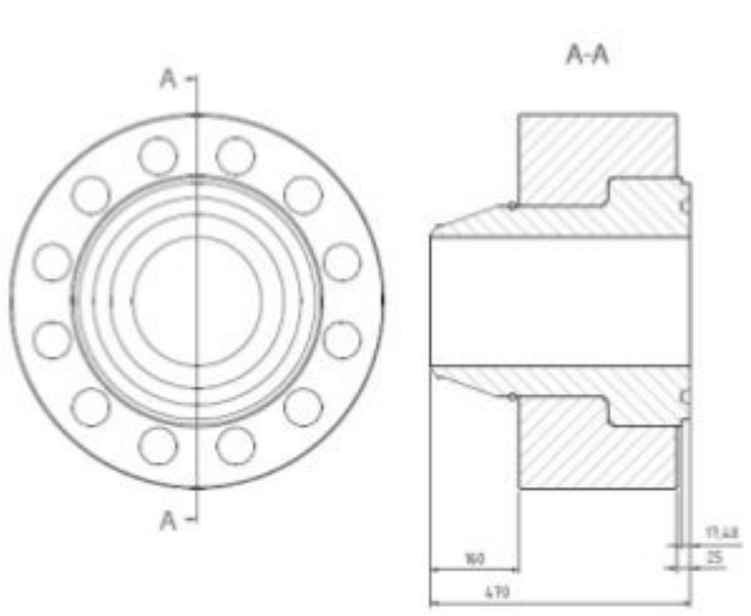
Nominal Designation	Forgings	Castings	Plates
16Cr–12Ni–2Mo	A 182 Gr. F316L		A 240 Gr. 316L
18Cr–8Ni	A 182 Gr. F304L (1)		A 240 Gr. 304L (1)

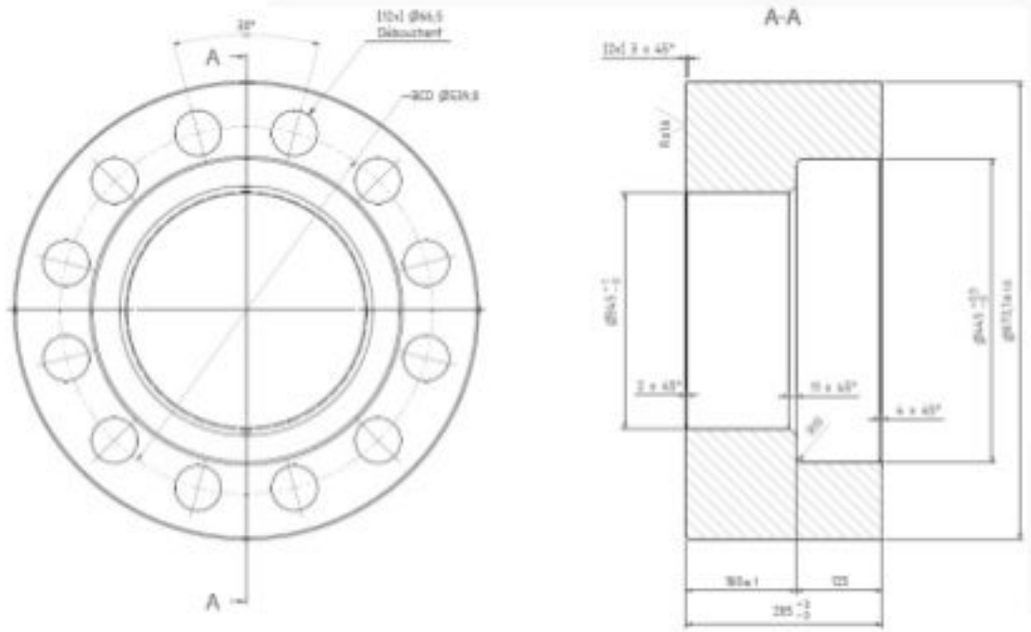
Working Pressures by Classes, bar							
Class Temp., °C	150	300	400	600	900	1500	2500
–29 to 38	15.9	41.4	55.2	82.7	124.1	206.8	344.7
50	15.3	40.0	53.4	80.0	120.1	200.1	333.5
100	13.3	34.8	46.4	69.6	104.4	173.9	289.9
150	12.0	31.4	41.9	62.8	94.2	157.0	261.6
200	11.2	29.2	38.9	58.3	87.5	145.8	243.0
250	10.5	27.5	36.6	54.9	82.4	137.3	228.9
300	10.0	26.1	34.8	52.1	78.2	130.3	217.2
325	9.3	25.5	34.0	51.0	76.4	127.4	212.3
350	8.4	25.1	33.4	50.1	75.2	125.4	208.9
375	7.4	24.8	33.0	49.5	74.3	123.8	206.3
400	6.5	24.3	32.4	48.6	72.9	121.5	202.5
425	5.5	23.9	31.8	47.7	71.6	119.3	198.8
450	4.6	23.4	31.2	46.8	70.2	117.1	195.1

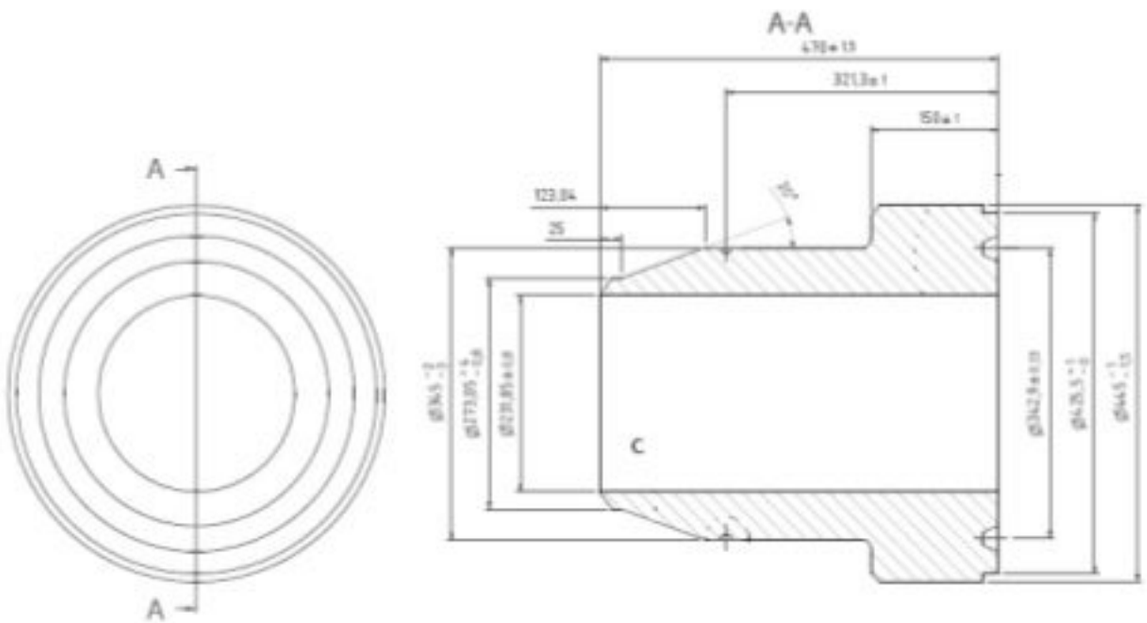
NOTE:
(1) Not to be used over 425°C.

Material Overview

Swivel Flange Typical Drawing- 10” SW RTJ Example

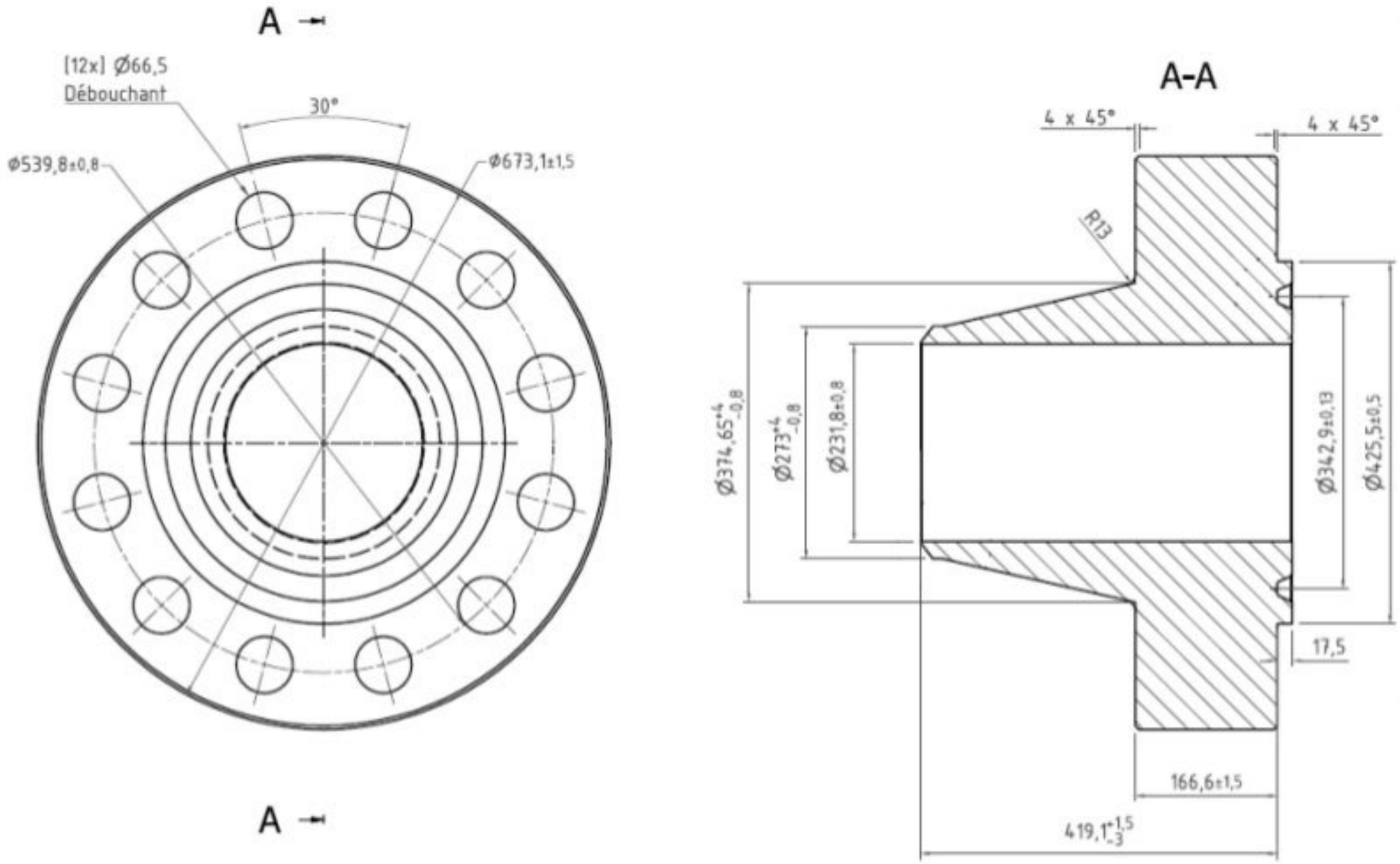






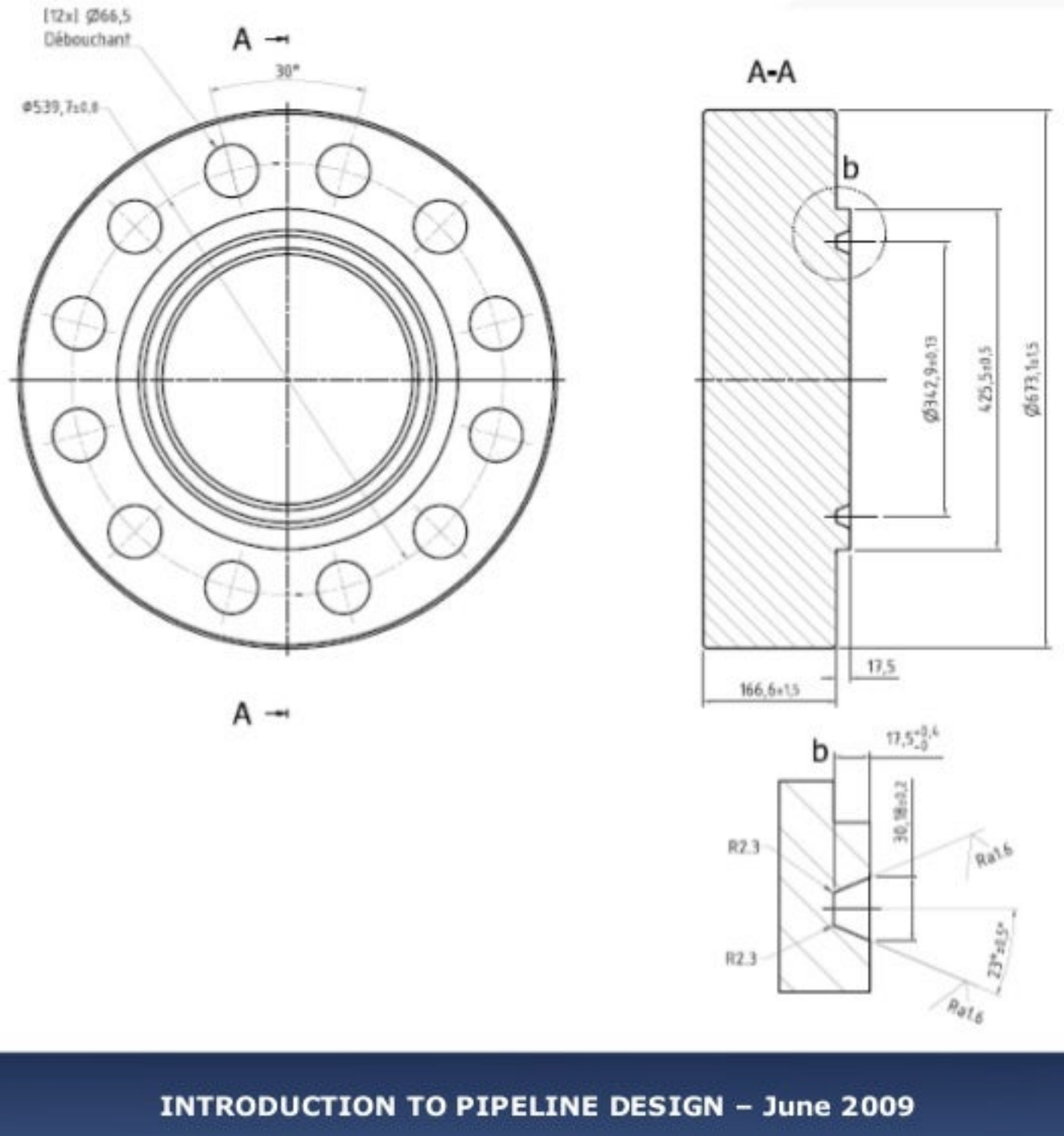
Material Overview

Weld Neck Flange Typical Drawing- 10” WN RTJ



Material Overview

Blind Neck Flange Typical Drawing- 10” BL RTJ



Gaskets (Offshore Application)

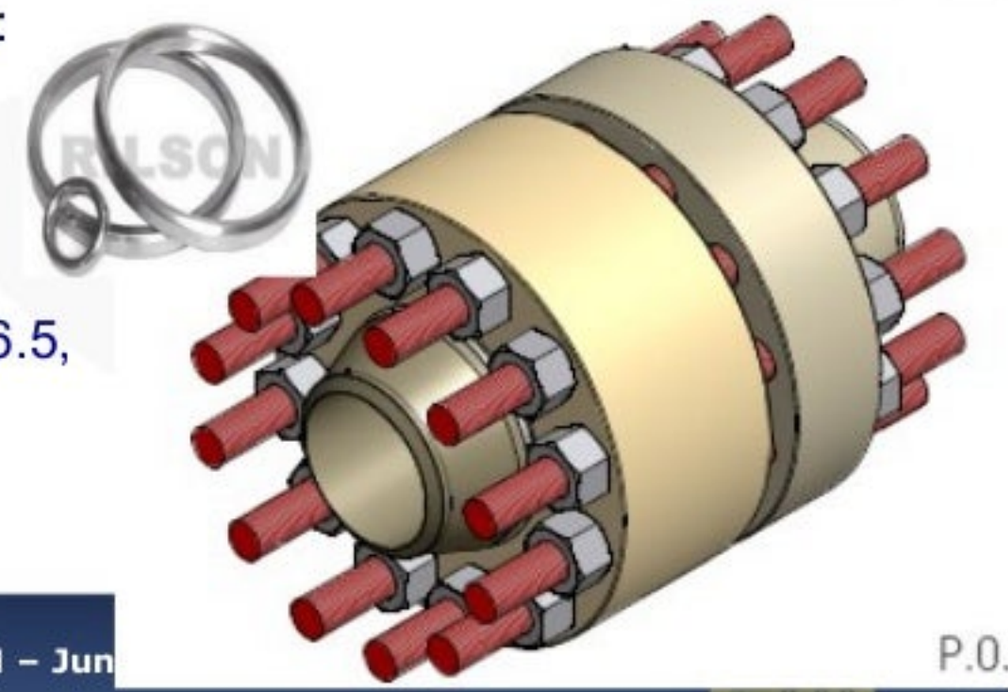
Ring Type Joint (RTJ) Gaskets are metallic sealing rings suitable for high pressure and high temperature applications (e.g. coupling flanged).
RTJ gaskets are designed to seal by "initial line contact" or wedging action between the mating flange and the gasket.
By applying pressure on the seal interface through bolt force, the softer metal of the gasket flows into the micro-fine structure of the harder flange material, creating
very tight and efficient seal.

Typical Gaskets Material: Soft iron, SS 316 (and Plastic, Metallic-Plastic)
The rings shall have hardness lower than that of the flange in order to assure tight joint.

Ring Gasket Profiles used in offshore pipeline application are:

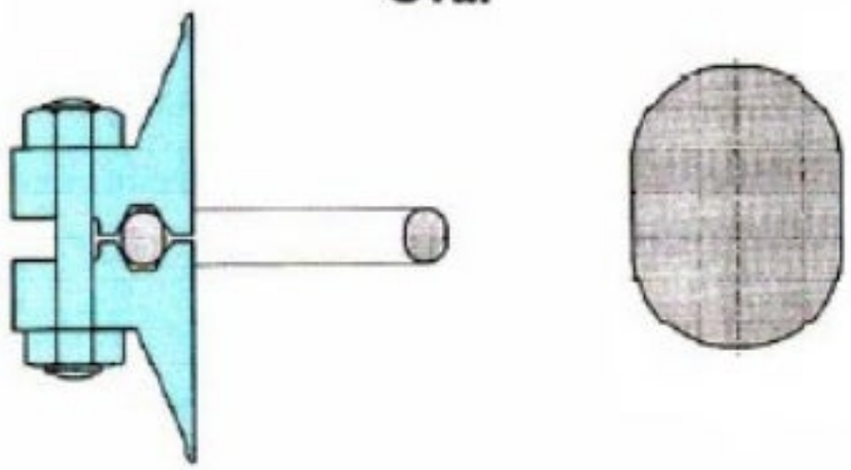
- Oval
- Flat
- Octagonal.

RTJ gaskets are manufactured in accordance with ASME B16.5, ASME B16.47, ASME B16.20 and MS SP 44 specifications.

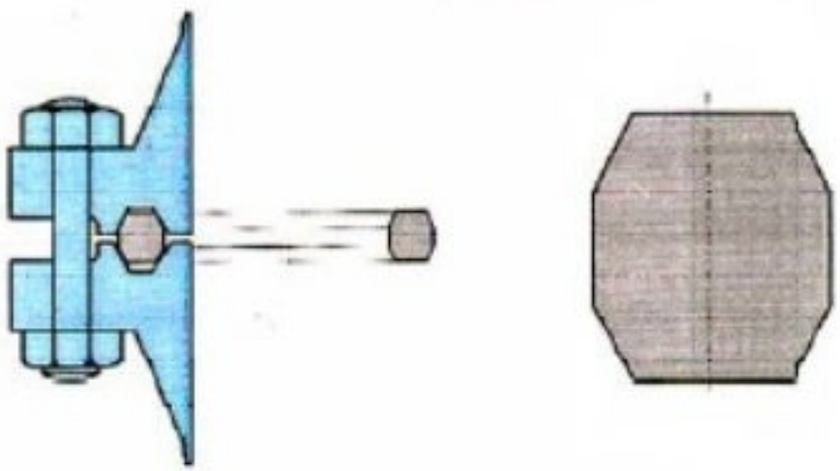


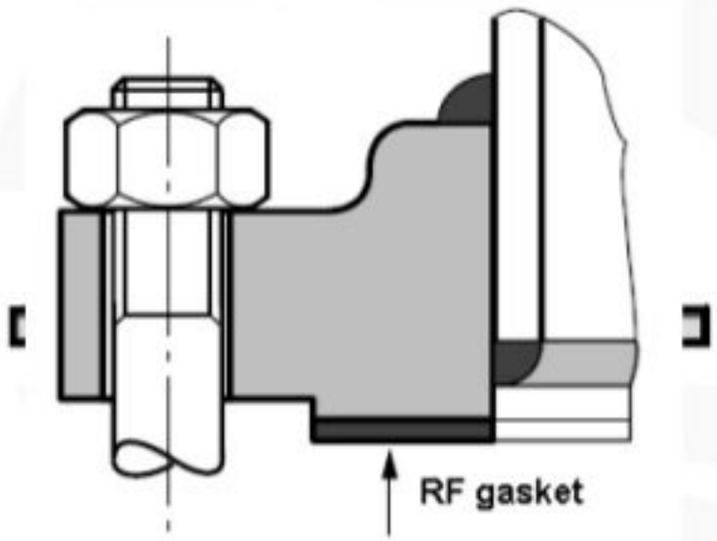
Ring Type Joint (RJT) & FLAT (RF) Gaskets-Examples

Oval



Octagonal



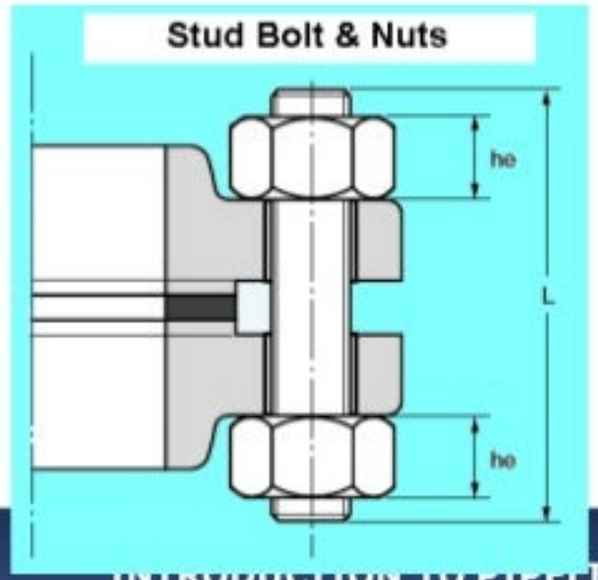


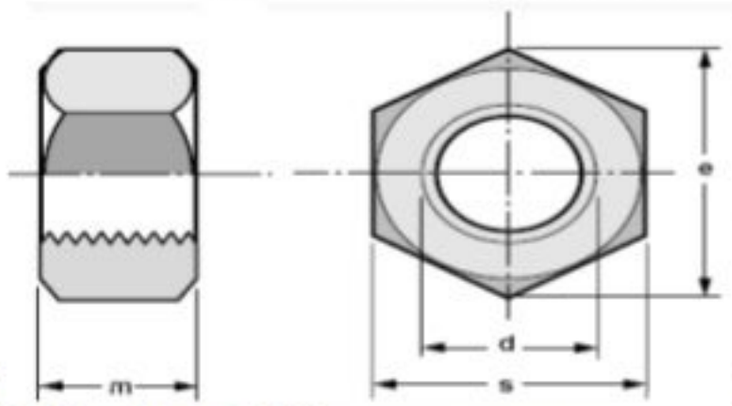
Stud Bolts and Nuts

Stud Bolts are made by alloy steel according to ASTM A 193 Grade B7.
The length “L” of stud bolts is measured from first thread to first major diameter thread.
The Bolt length has to be suitable for the WN/SW coupling flanged included the extra length for automatic bolt tensioner (hydra tight Type)
Both ends of stud-bolt shall have a tip.
The threading shall be carried according ANSI code B1.1.

Nuts are machined, hot or cold forged, in Carbon Steel according to ASTM A 194 Grade 2 (teflon coated).

Stud bolt with nuts





Index

Material Overview

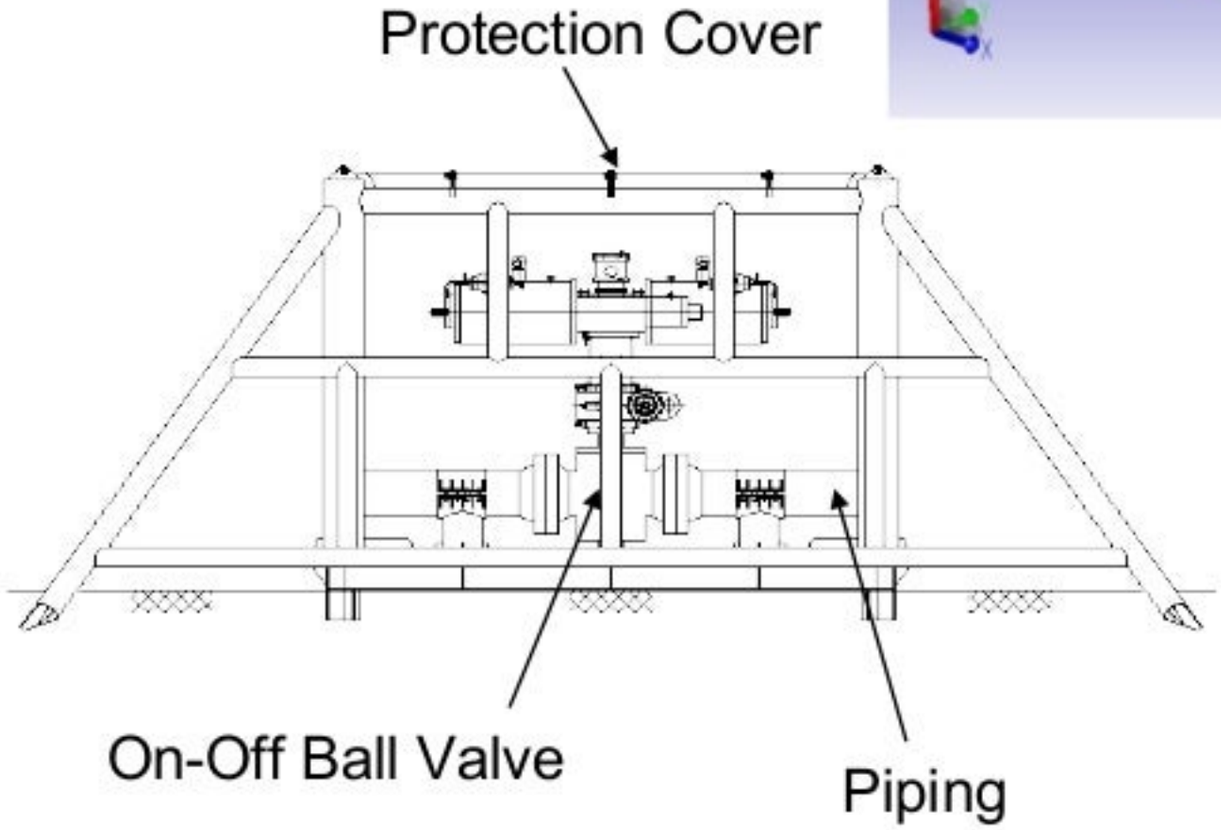
SSIV (Subsea Safety Isolation Valve)

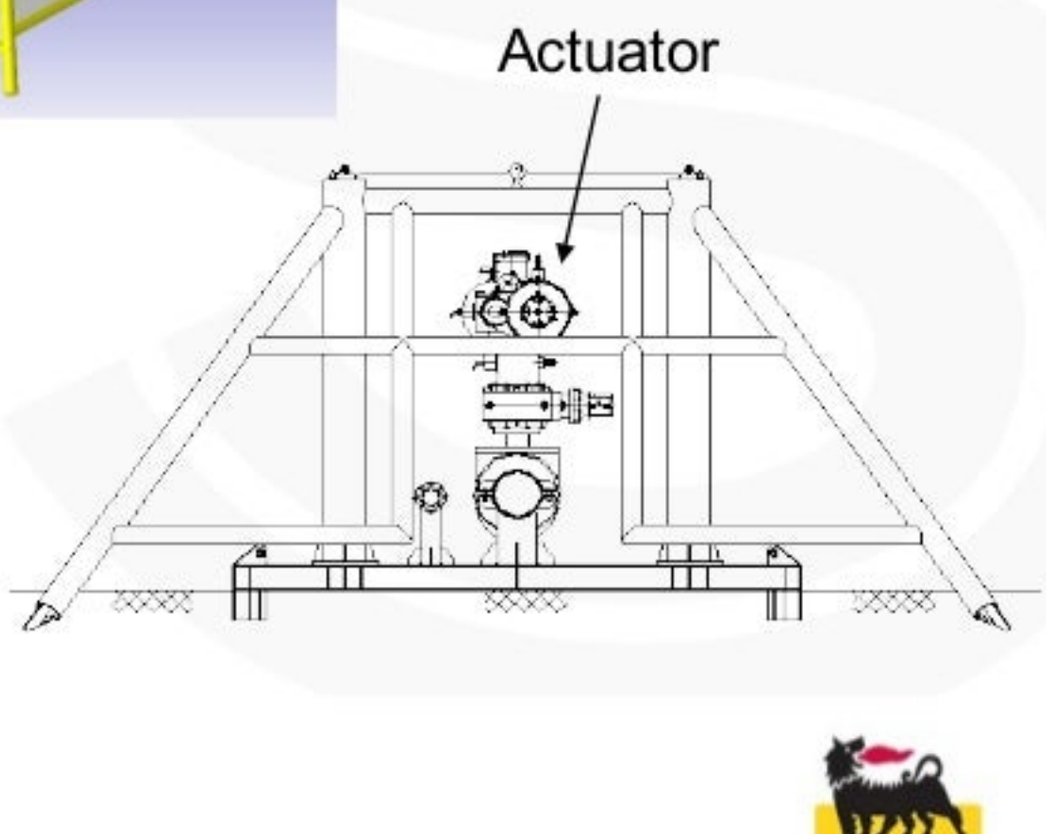
A **Subsea Safety Isolation Valve (SSIV)** is required in proximity (distance to be defined by dedicated study) of a selected platform to provide the isolation, in case of accident (e.g. fire), of the surface facilities and the riser from the fluid (e.g. Methane) contained inside the sealine coming from another Platform or from onshore Facilities.

SSIV Station Main Components:

- On-Off Ball Valve
- Actuator
- Base support + Protection Cover
- Piping (flanges included)
- Control Umbilical
- Control system
- J-tube and its top flange for the umbilical hang-off

SSIV Genaral Arrangement - Example

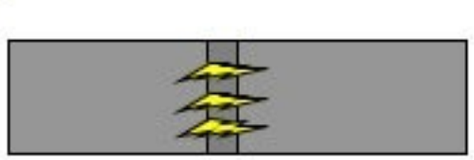




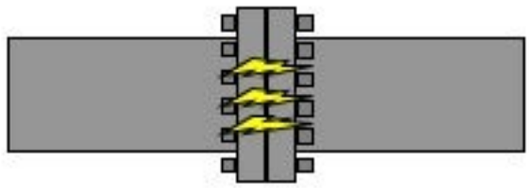
Index

Insulation Joint

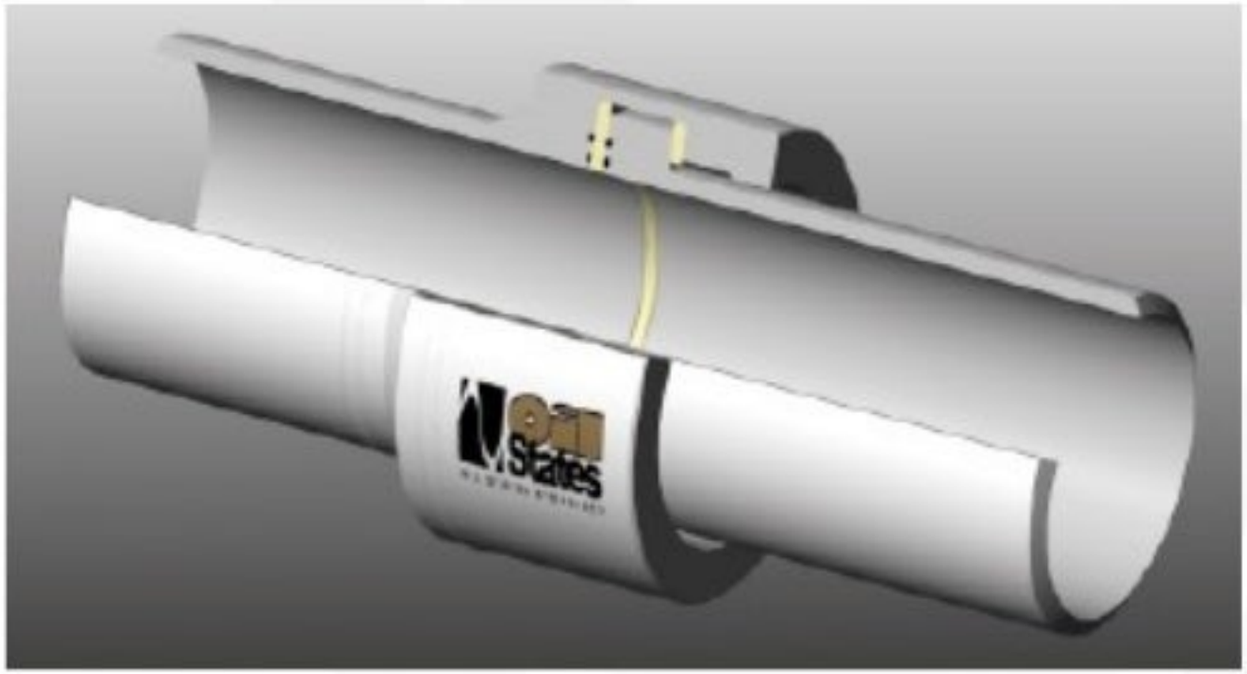
An Isolating Joint (IJ) is a high-resistance fitting used to electrically isolate sections of a pipeline in order to avoid any electrical current to cross from one side of the joint to the other one and consequently to improve the effectiveness of the cathodic protection system.



Welded connection

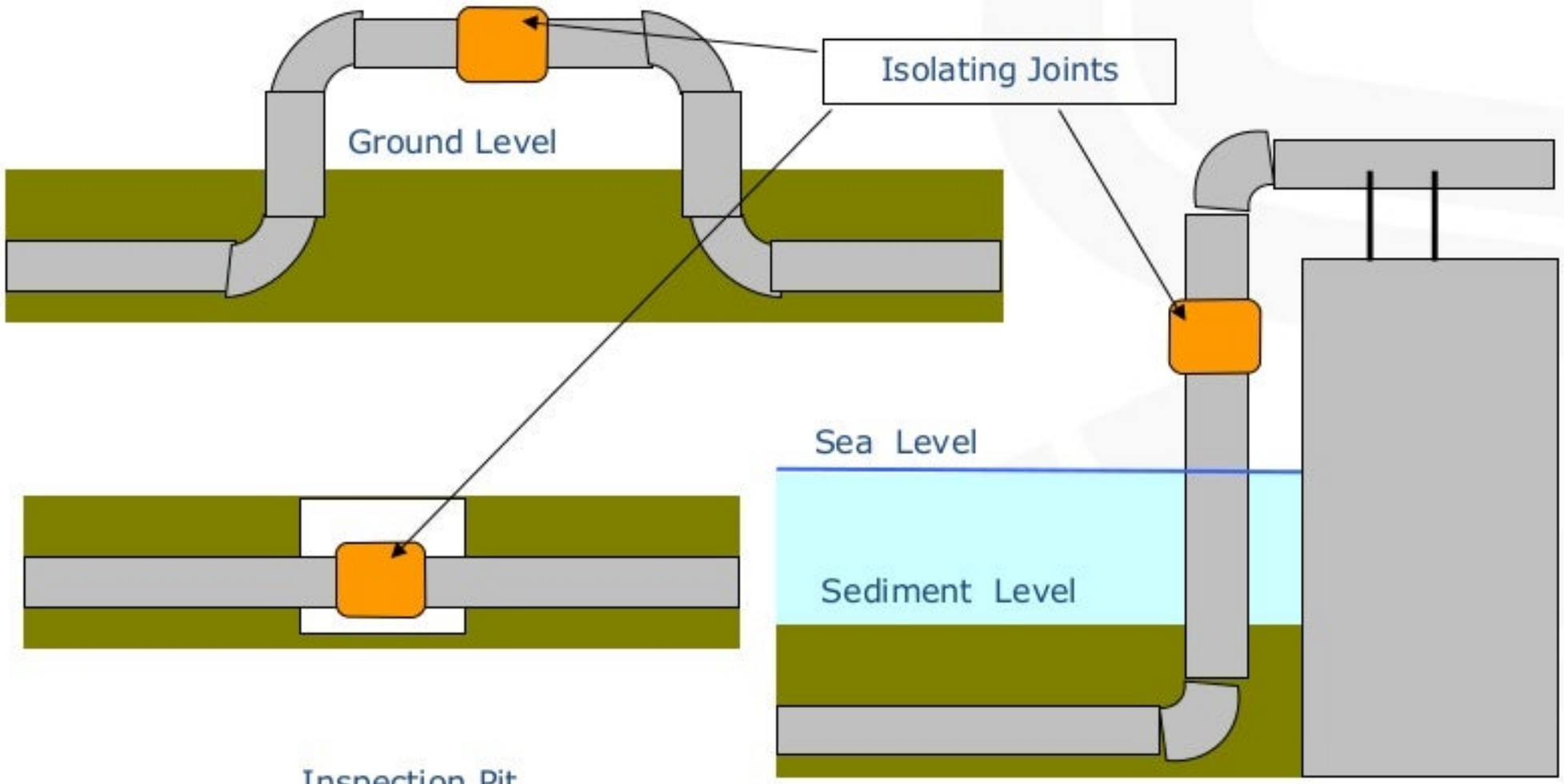


Flanged connection



Insulation Joint

Good insulation level between two sections of a pipeline is granted when the isolating joint is installed above ground or above sea level or in inspection pits.



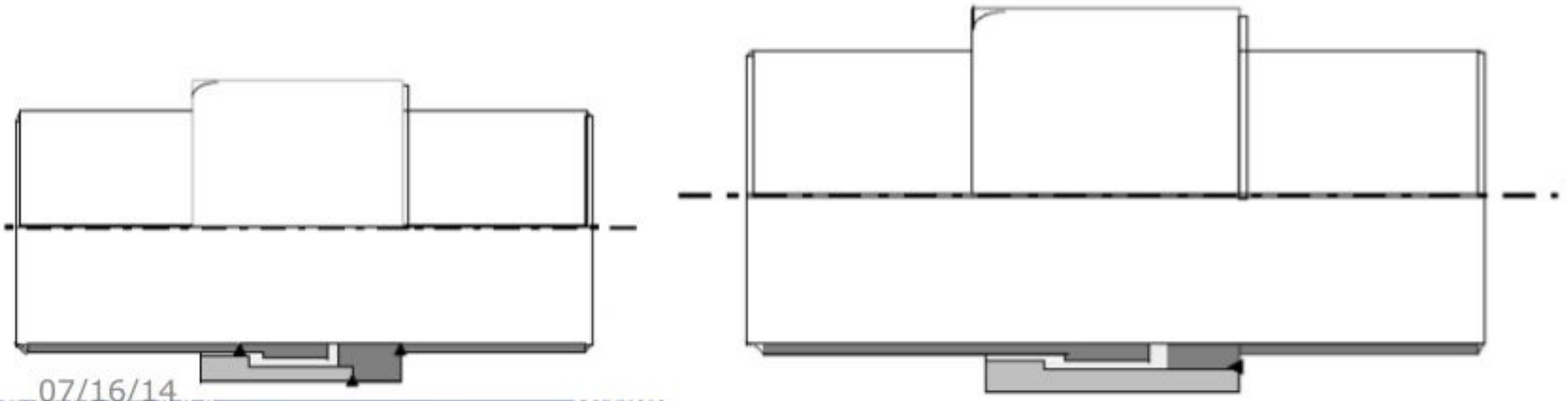
Material Overview

Insulation Joint

Insulation Joints are typically made in one piece (Monolithic) or flanged and can be designed and manufactured for any pipeline size and pressure rating.

A Monolithic dielectric Joint (MIJ) are composed of two pieces of metallic pipe, assembled by welding along with interposition of insulating material and sealing gaskets so that the two piece at the same time come out each other mechanically connected and electrically insulated.

MIJ is provided with extension nipples (pup piece) that must match the pipeline wall and grade and are long enough to eliminate any possibility of thermal damage to the MIJ during field welding.



Index

Buttwelded Fittings

Material Overview

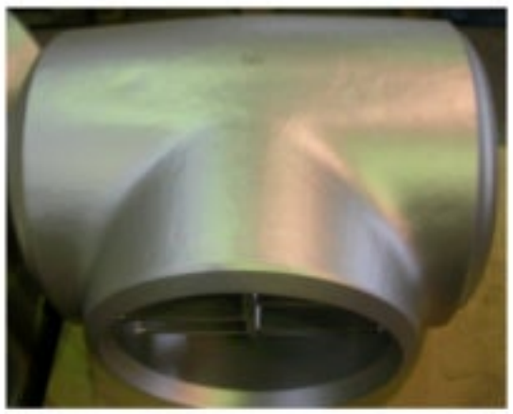
"T" and "Y" Tee

Tee piece is a special buttwelded fitting used to realize the connection between two pipelines with different headings and same (Straight tee) or different (Reducing Tee) Outsider diameters.

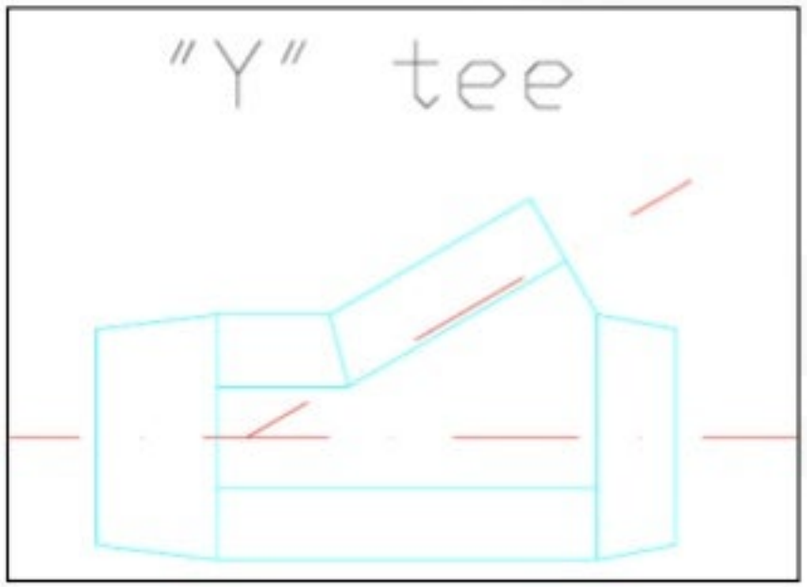
Y-way piece is a special buttwelded fitting used to realize the connection between two pipelines with different headings and same or different Outsider diameters.

Each Tee and y-way can be designed and manufactured for any pipeline size and Pressure rating.

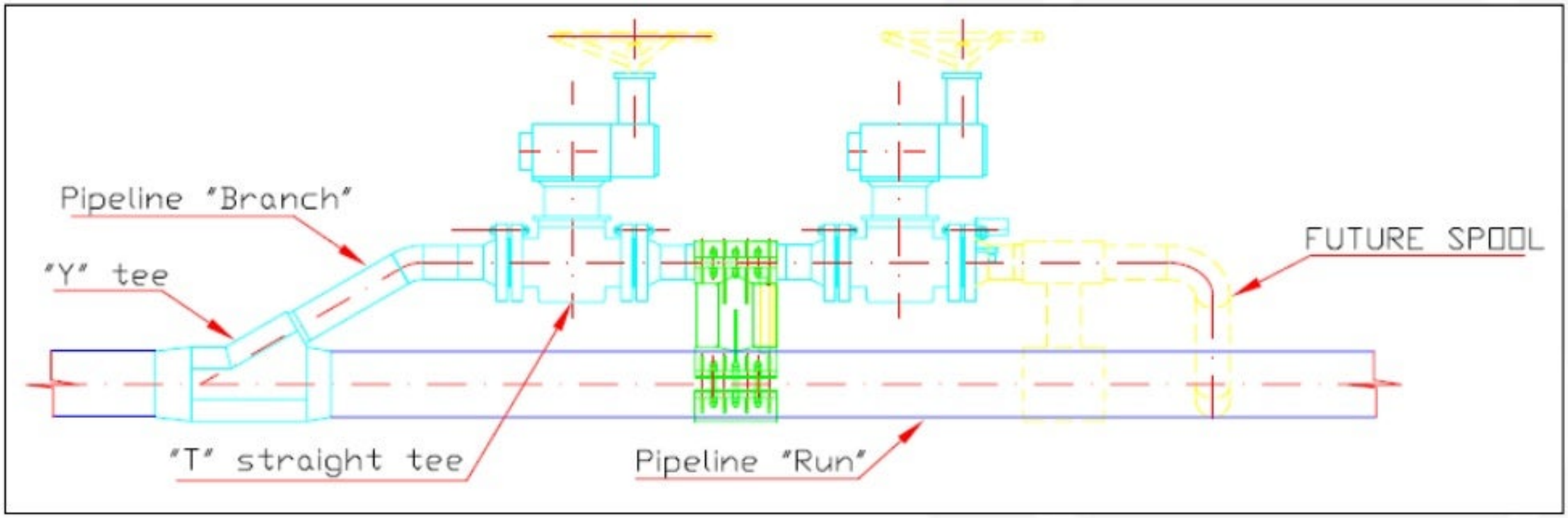
Straight Tee



Reducing Tee



"T" and "Y" Tee – Application Example: Laying In Line



"T" and "Y" Tee Welded on Spool - Example

Conical Reducer

A conical reducer is a buttwelded fitting used to connect two pipelines with different Outsider diameter (e.g. 36” OD offshore Pipeline with 34” OD existing onshore pipeline).

Conical Reducer can be made from steel plates and/or pipes and may be manufactured by forging, pressing, rolling, welding or by a combination of these processes.

Conical reducers can be designed and manufactured for any pipeline size and Pressure rating.