

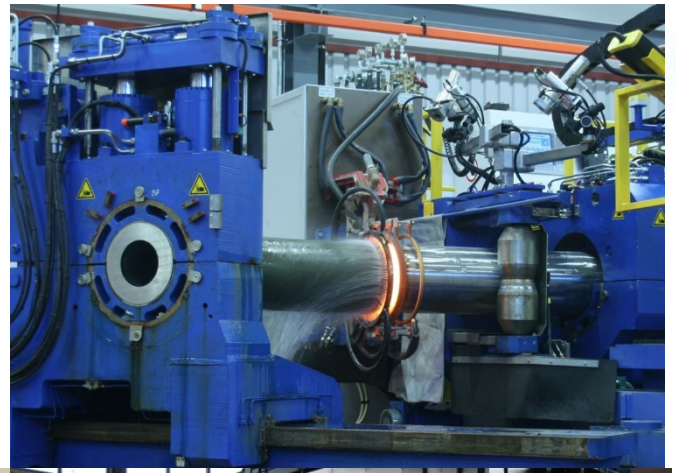

Induction bending

www.niras.no

INDUCTION BENDING

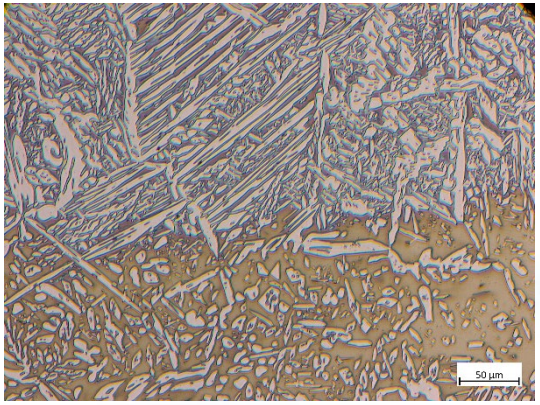
Induction bending provides a cost effective and more sustainable alternative to traditional pipe spool fabrication.

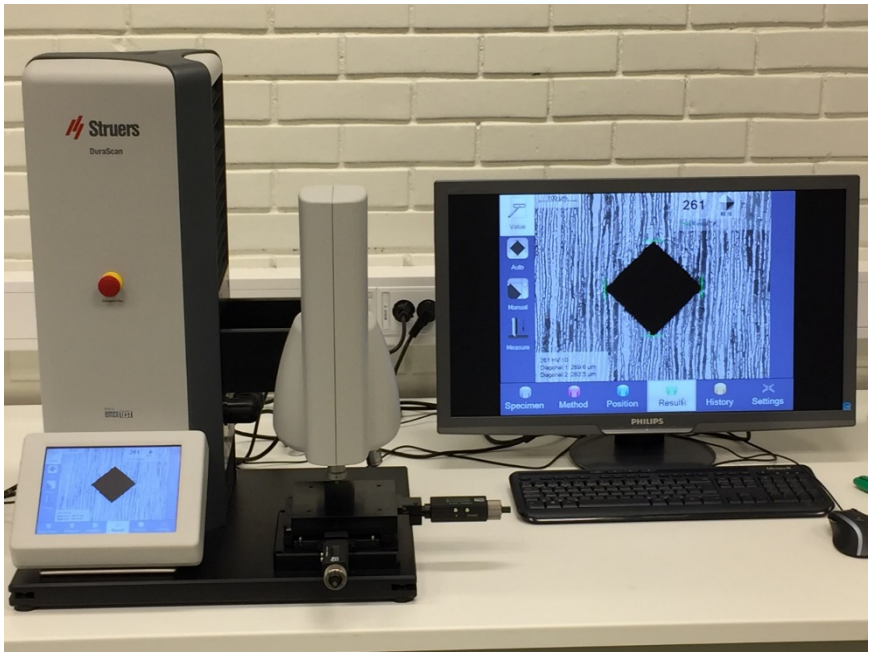
NIRAS handles bending of pipes in the outer diameter range: ½” to 20”



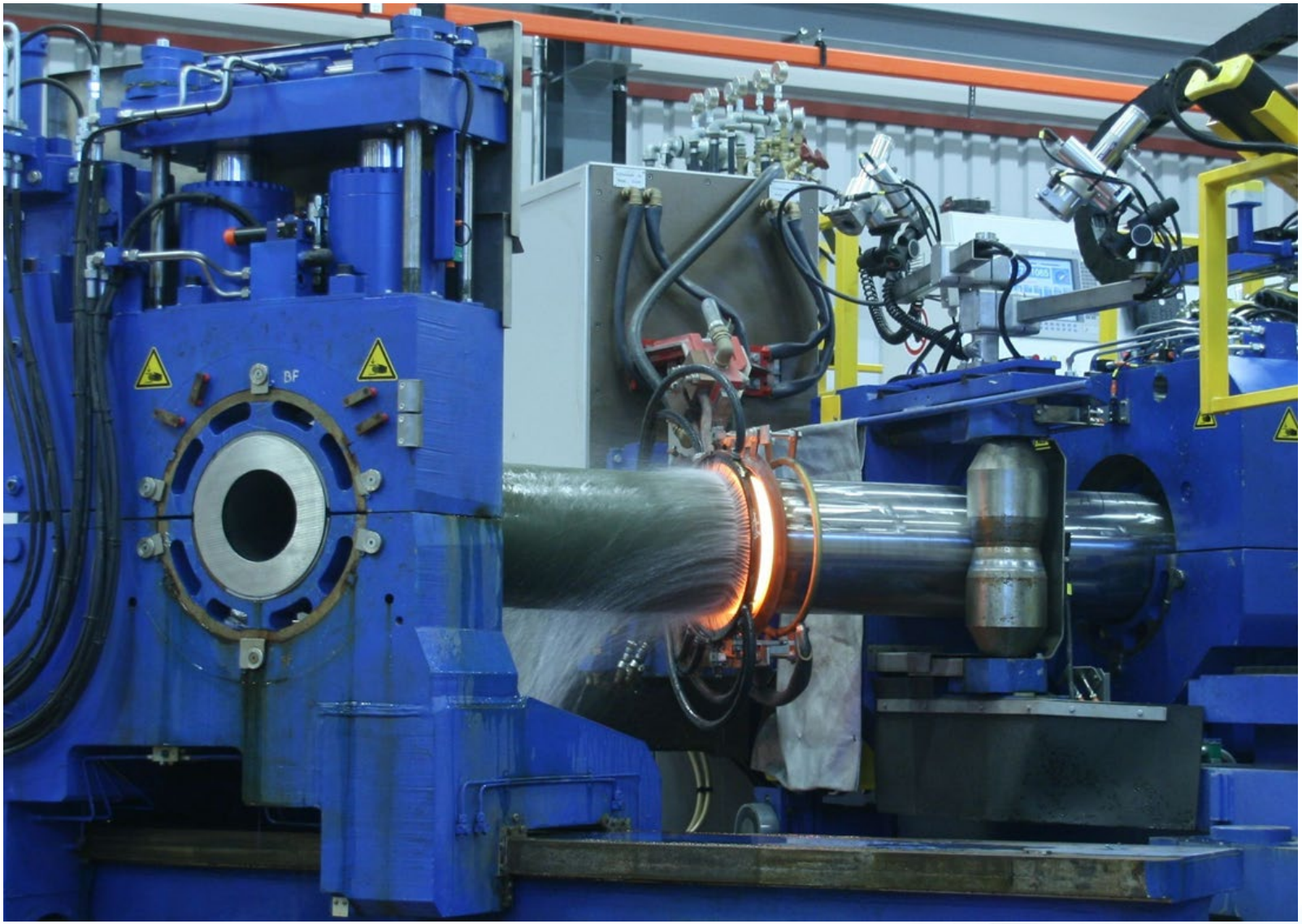
Laboratory:

- Microstructural analysis
- Hardness testing
- Corrosion testing





Duplex 70 mm wall



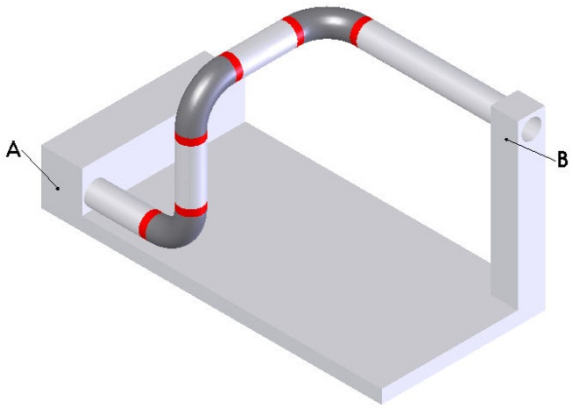
Some examples

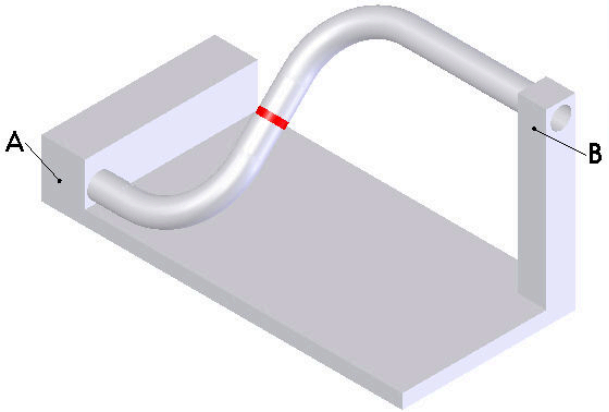
Benefits when using induction bending

Reduce number of welds

Cost saving designs

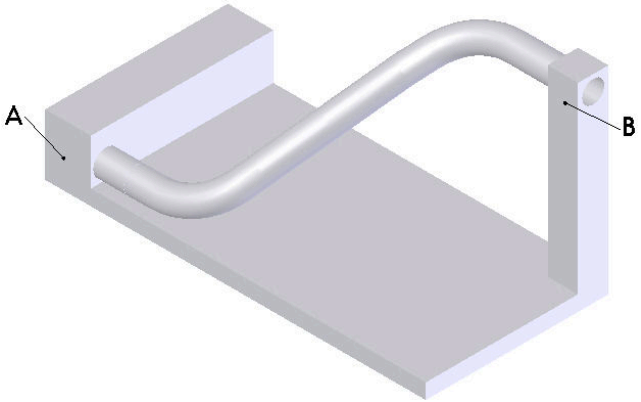
Traditional
6 welded joints

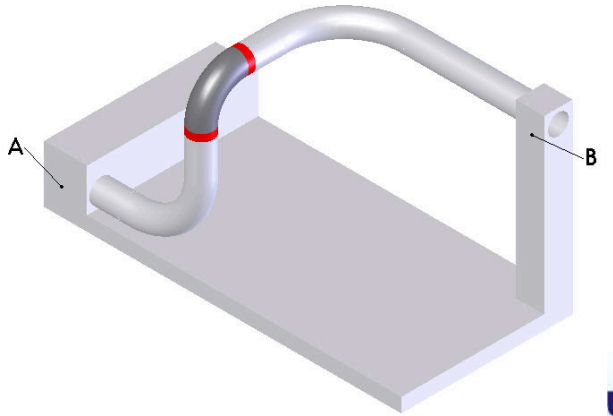




Induction bends
1 welded joint

Induction spool
0 welded joints





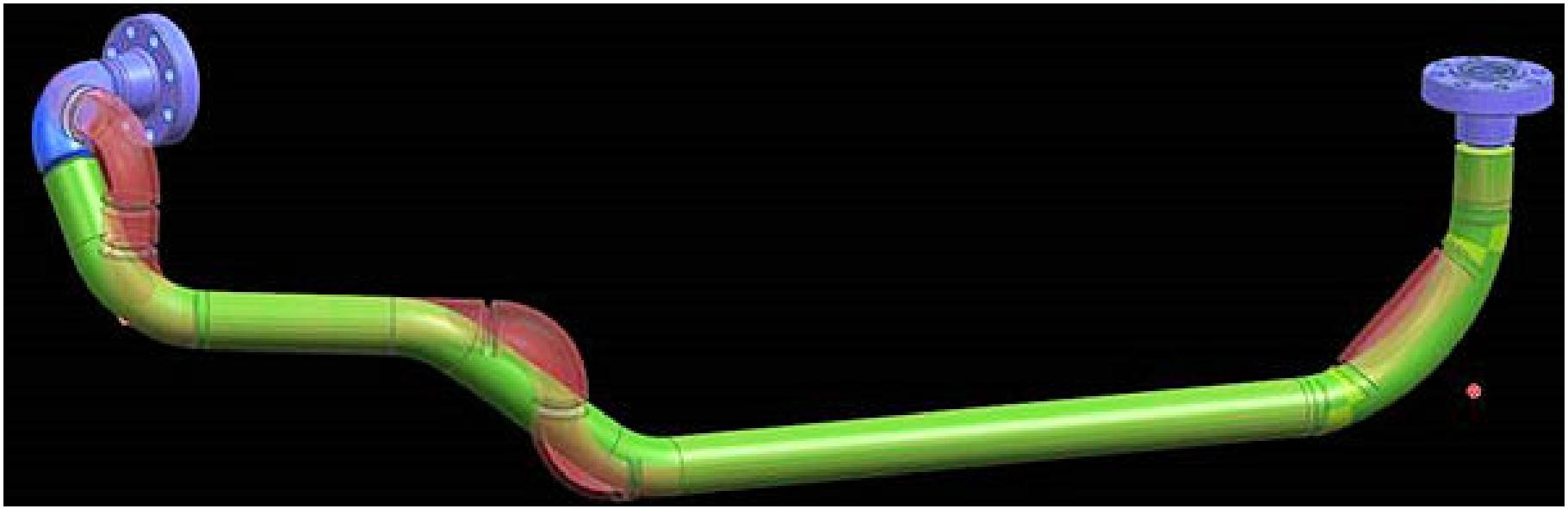
Induction bends
2 welded joints

Benefits when using induction bending

Reducing the number of welds

Benefits when using induction bending

Reducing the number of welds



From 13 to 3 welds

Benefits when using induction bending

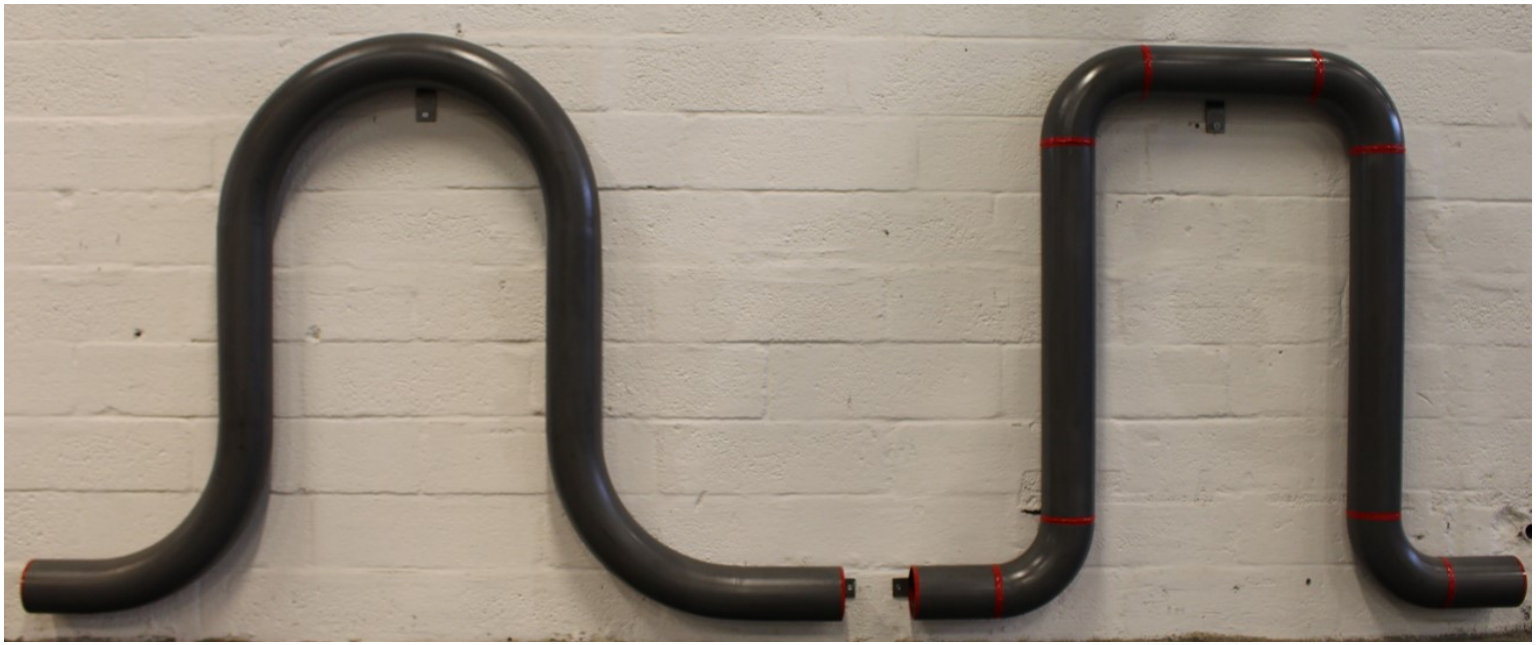
Geometry

Induction bending allow designers more freedom

Benefits when using induction bending

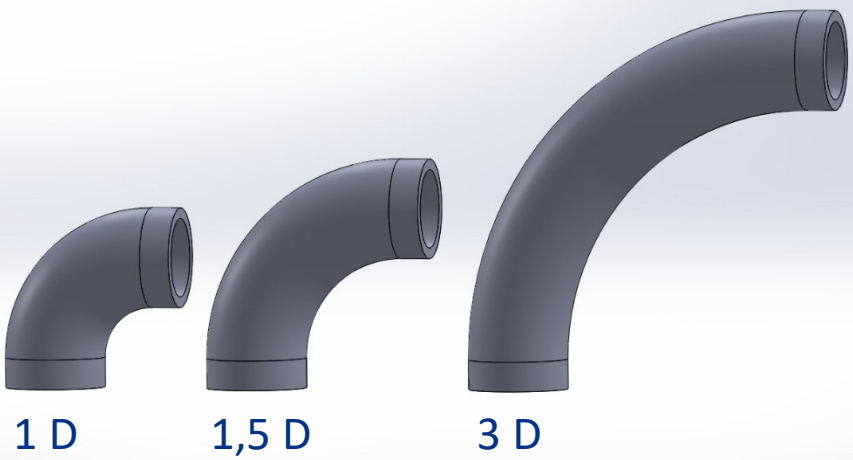
Flow

Designing piping systems with smooth arcs, no welds and larger radii, reduces turbulence and pressure drop and increase the effectivity of the system.



Benefits when using induction bending

Effect of radius on pressure drop in bend



Calculated reduction in pressure drop:

1D ➔ 3D **48 %**

1,5D ➔ 3D **22 %**

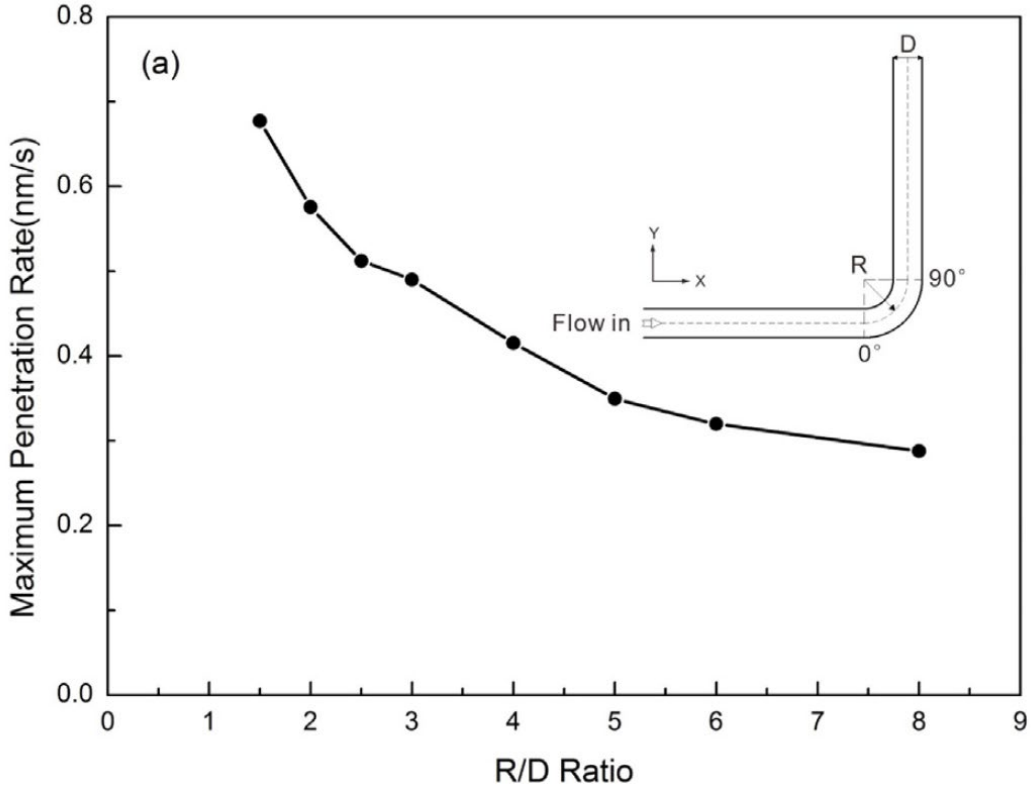
$$\Delta p = f \frac{L}{D} \frac{\rho V^2}{2}$$

Example: V = 5m/s, D = 0.100m, f = 0.018, r = 1000kg/m3

L = equivalent length, V = velocity, D = inner diameter,
f = frictions factor (Moody's diagram), ro = density

Reduced erosion rates

Effect of radius on erosion rates



*Ref.: W. Peng, X. Cao / Powder Technology 294 (2016) 266–279

Reduction of erosion rates*:

1,5D ➔ 3D **25 %**

1,5D ➔ 5D **45 %**

Derived from CFD analysis
-particles in water

Niras Spool vs. Standard Spool

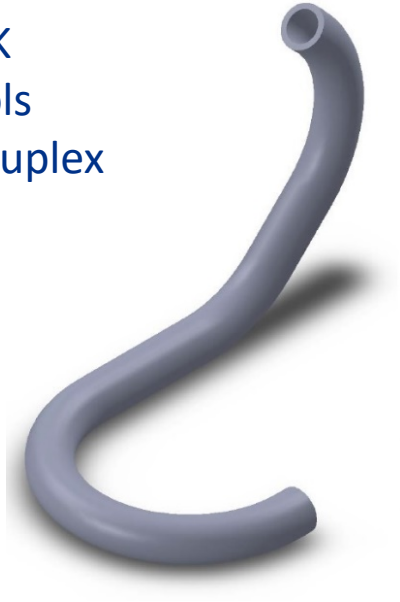
Radius: 3D
Bend angle: 180°- 45°- 90°

Radius: 1,5D
Bend angle: 90°- 90°- 45°- 90°

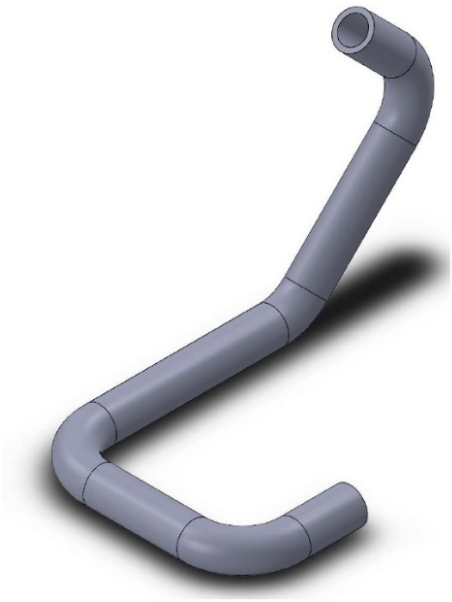
Specification: NORSOK
Quantity: 10 Spools
Material Grade: Super Duplex

All costs included:

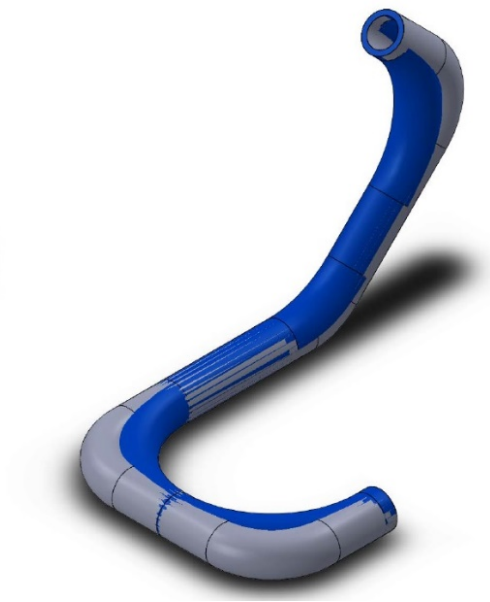
- Pipes
- Bends
- Welds
- NDT
- Dimensional control
- Documentation



Niras Spool



Standard Spool



Route comparison

Real Cost Comparison

Niras Spools vs. Standard Spools

6 Inch Sch XXS:
66 % cost saving

2 Inch Sch 160:
61 % cost saving

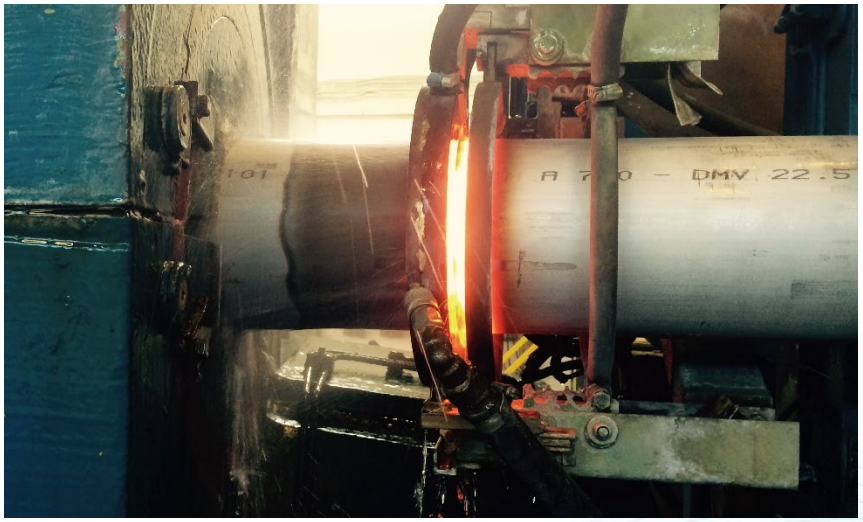
Induction bending

Basic principle

The principle behind induction bending is to heat up a small cross section of a pipe or profile
to such an extent that plastic deformation can be performed by applying relatively small forces.

The work piece is forced forward through the induction coil while guided by a rotating arm.

Only applying heat to a small section allow high level of control and prevents the pipe or profile
from collapsing.



Intrados/extrados

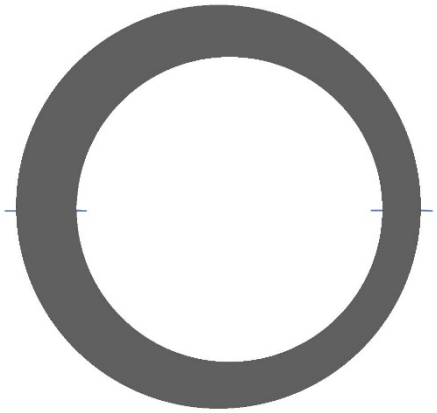
As the pipe moves forward it experiences compression in the intrados of the bend causing material build up and thickening of the pipe.
At the same time the extrados of the pipe experience tension. The tension causes the material to stretch and results in wall thinning.

Full scale pressure testing has shown that in spite of the thinner wall in extrados the pipe will fail in the unaffected portion of the pipe and not in the bent area.

- **Large radii- small effect**
- **Small radii- bigger effect**

Calculator:
http://www.niras.no/downloads.html

Intrados- compression
Material build up

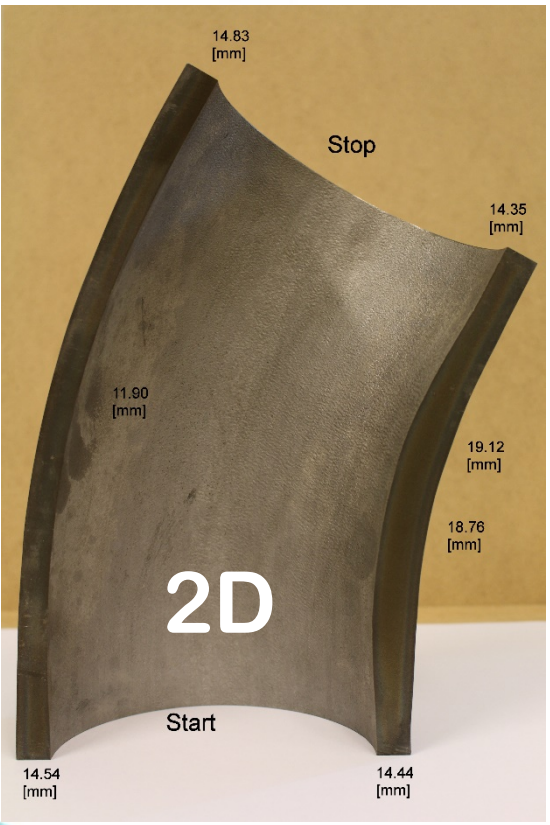


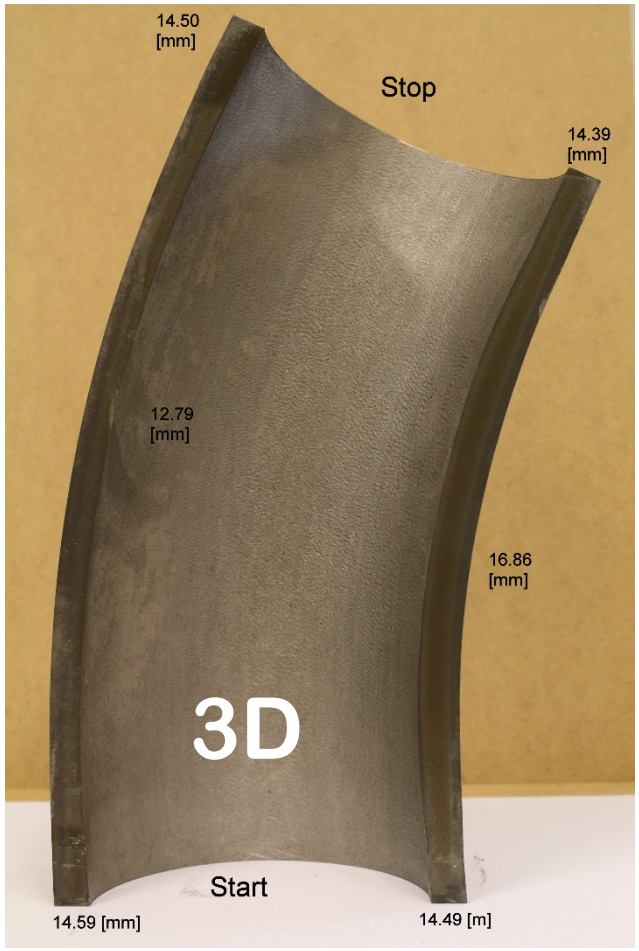
Extrados- tension
Wall thinning

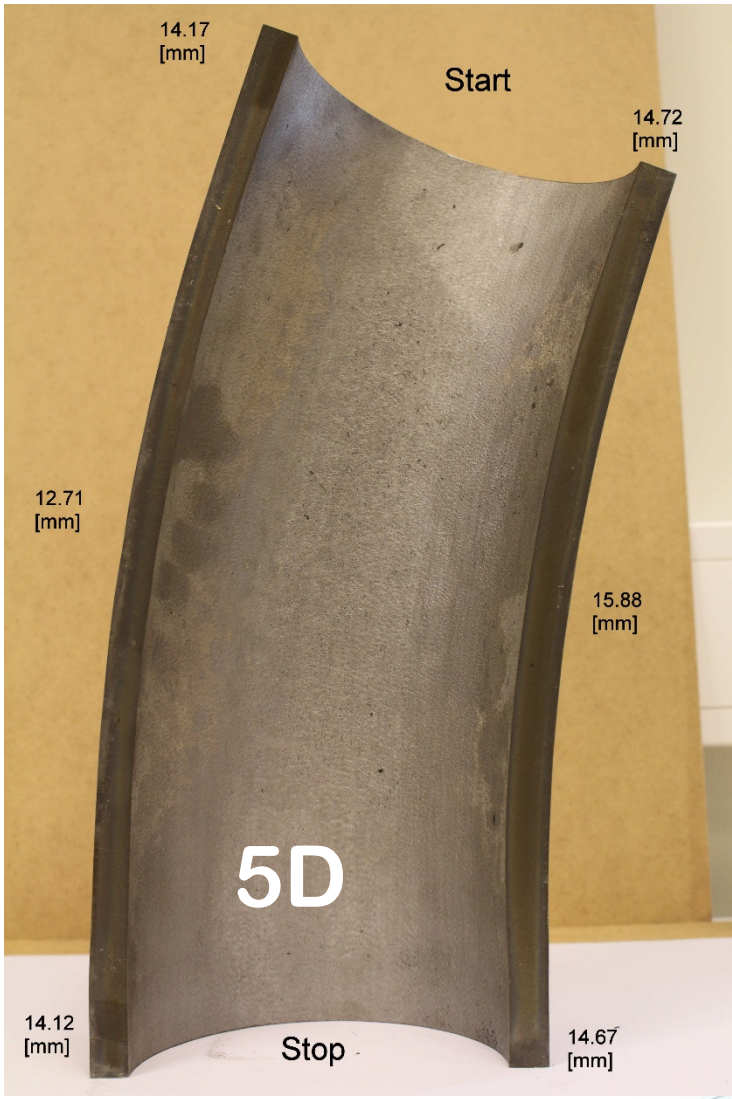
Geometry effects

Intrados/extrados:

Material distribution in bended area







Example of thinning/thickening on 6” sch120 pipe

Pressure distribution

Intrados/extrados:

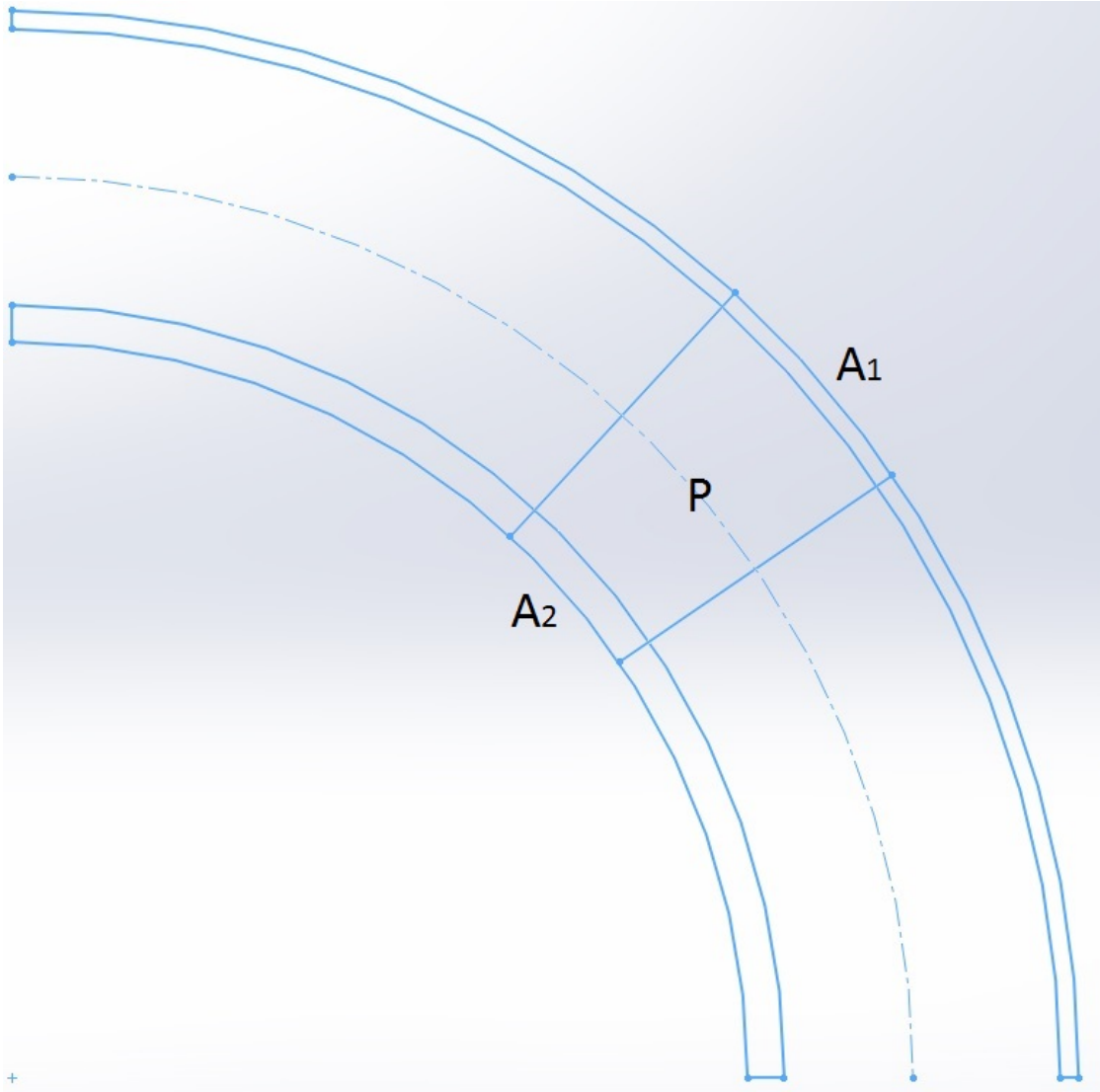
Centre line approach

The pressure is distributed on a larger area in extrados.
➔ Local forces acting on the wall becomes less.

The pressure is distributed on a smaller area in intrados.
➔ Local forces acting on the wall becomes greater.

FE-Analysis and destructive pressure testing confirms this approach.

Result: The bend can withstand higher pressure than the straight pipe!



R&D

Burst testing:

In collaboration with Telemark University Collage, Niras investigated the effect of induction bending on fracture location in burst testing.

Material grades investigated were Duplex (UNS S31803) and Grade 316 (UNS S31600).

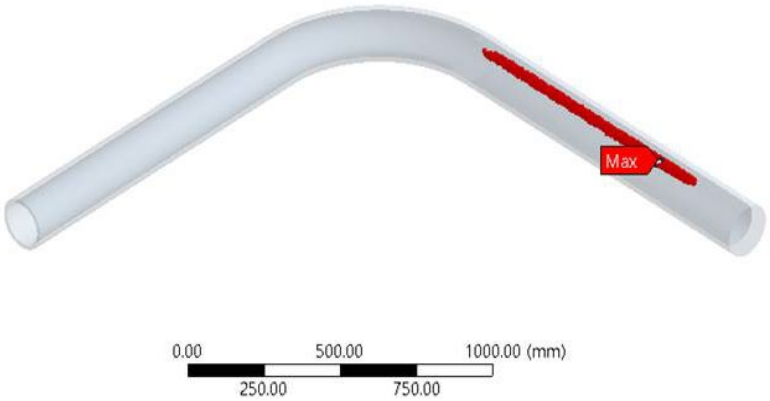
All tests performed showed fracture in the tangent.

R&D

Burst testing:

Burst pressure was 1297 bar, 1.5% above the burst pressure for equivalent standard bends according to ASME B16.9.

Selected geometry: 90° 3D bend



Plot from calculation model showing plastic deformation over 5%

Induction bend after burst testing

Duplex Steels

Bending without PBHT

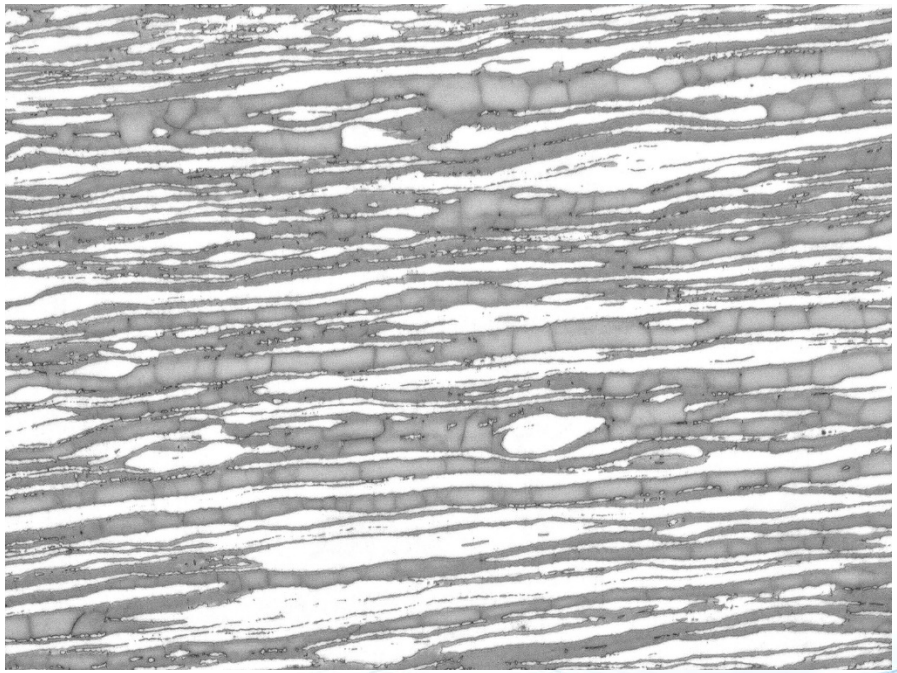
Duplex	up to 26 mm wall thickness
Super Duplex	up to 22 mm wall thickness

(dependent of mother pipe and other dimensions)

Limitation:
Sufficient heating
Sufficient cooling

Critical temperature range:
550 °C – 1050 °C
➔ Sigma formation

Above 1120 °C
➔ Nitride precipitation



Post Bend Heat Treatment (PBHT)

When necessary to maintain the material properties NIRAS will perform PBHT on the induction bended pipes.

Applicable PBHT's:

- Solution annealing
- Normalizing
- Quenching
- Tempering

Capacity: 3.75 MT
Temp. range: 580 – 1150 °C
Working zone: 5800 X 2300 X 1000
Qualification: NORSOK M-650/API 5L

Materials

Alloys for bending

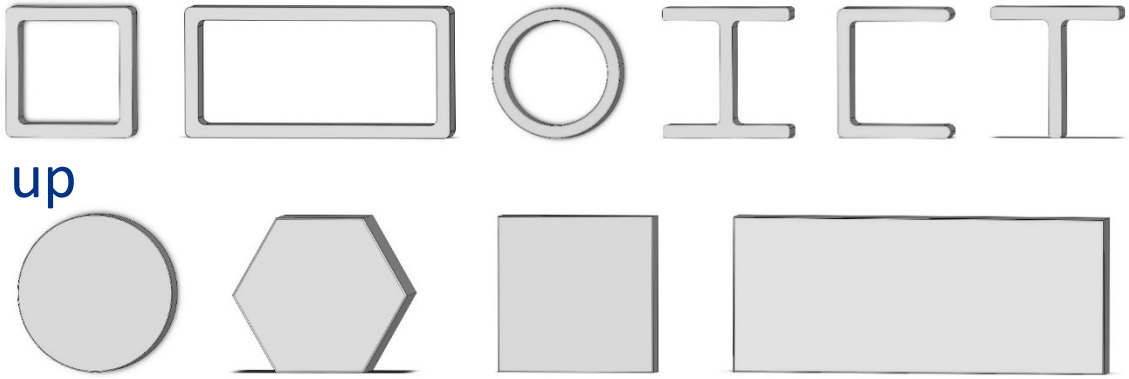
All electrically conductive materials can be induction bent.

Suitable for induction bending:

- All types of steel
- Aluminium
- Copper
- Nickle alloys
- Etc.

If properties can be maintained or enhanced after bending depends on the original condition of the material.

Pipe and Profiles



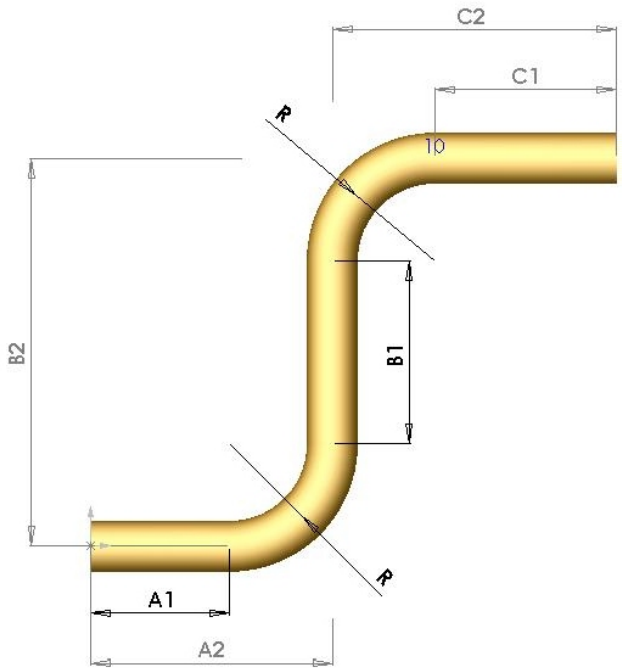
Pipe Dimensions: 16 mm and up
(Niras max. OD is 18inches)

Profile dimensions:
Maximum 300 x 600 mm
Radii up to 22 000 mm
Angle: 0° - 300°

Design

Niras design criteria

http://www.niras.no/downloads.html
If in doubt please contact us



DESIGN CRITERIA for Induction bending										
Pipe		Radius		Wall	"A1"	"A2"	"B1"	"B2"	"C1"	"C2"
OD nominal	OD mm	OD	(mm)	WT (mm)	Front Clamp (mm)	(mm)	(mm)	(mm)	(mm)	(mm)
½"	21,3	3	65	> 2	140	205	150	280	600	665
¾"	26,7	2,4	65	> 2	140	205	150	280	600	665
1"	33,4	2	67	> 2,5	140	205	150	284	600	667
1 1/4"	42,4	2	85	> 3	140	225	150	320	600	685
1 ½"	48,3	2	96	> 3	140	236	150	342	600	696
2"	60,3	2	121	> 3,5	140	261	150	392	600	721
3"	88,9	2	178	> 5	260	438	300	656	600	778
4"	114,3	2	229	> 6	260	489	300	758	600	829
5"	141,3	2	282	7 to 22	260	542	300	864	600	882
5"	141,3	2	282	> 22	460	742	460	1024	1150	1432
6"	168,3	2	337	8 to 22	260	597	300	974	600	937
6"	168,3	2	337	> 22	460	797	460	1134	1150	1487
8"	219,1	2	438	11 to 80	460	900	460	1340	1150	1590
8»	219,1	3	657	11 to 100	460	1120	460	1770	1150	1810
10"	273,1	2,5	680	15 to 75	460	1140	460	1820	1150	1830
10»	273,1	3	819	11 to 100	460	1280	460	2100	1150	1970
12"	323,8	2,5	810	11 to 70	460	1270	460	2080	1150	1960
12»	323,8	3	970	11 to 100	460	1430	460	2400	1150	2120
14»	355,6	2,5	890	17 to 60	460	1350	460	2240	1150	2040
14"	355,6	3	1067	13 to 100	460	1527	460	2594	1150	2220
16"	406,4	3	1219	15 to 39	460	1679	460	2898	1150	2370
16"	406,4	3	1219	40 to 100	460	1680	460	2900	1150	2370
18»	457,2	3	1372	15 to 50	460	1830	460	3200	1150	2520
18"	457,2	5	2286	50 to 70	460	2750	460	5030	1150	3440
	Values in grey areas are meant for pipes with extra thick wall.									

Doing it smart

Produce spools were possible

Save cost of welding and procurement of standard bends.
Reduces lead time due to fewer welding operations.

Send drafts and get valuable feedback

We have long experience with routing to optimise for induction bending.
Less bending – lower cost and lead time.

We do workshops with engineering companies on EPC projects from FEED and through-out to give input on how to best exploit the possibilities of the process.




Induction bending