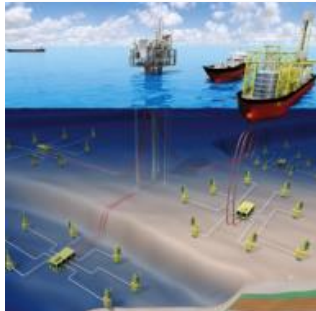


MANUFACTURING PROCESS OF WELDED TUBES SOLAR TOWER RECEIVER APPLICATION

Raiselife seminar

Dusseldorf, November 28th 2019

New generation of superduplex stainless steel premium tubes



Umbilicals market for Oil & Gas:

- Super Duplex 2507 tubes
- ID 1/2" to 1 1/2" → 2"
- WT 1.0 to 3.4 → 4.5 mm
- Laser seam welded tubes
- $A_{YS0.2} > 750\text{MPa}$, $UTS > 900\text{MPa}$
- One plant located at Venarey-les-Laumes
- Qualified by IOC and BV



▶ **High quality grade 2507** (UNS S32750 / EN 1.4410) strip

- PREN ≥ 42.5
- Suitable pitting and crevice corrosion resistance
- Excellent resistance to SSC and HISC tests

▶ **Control:**

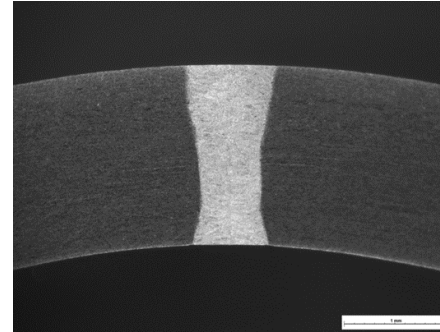
- NDT performed over the entire length of the finished tubes (100%).
- Hydrostatic test performed internal hydrostatic pressure

▶ **Tight dimensional tolerances**

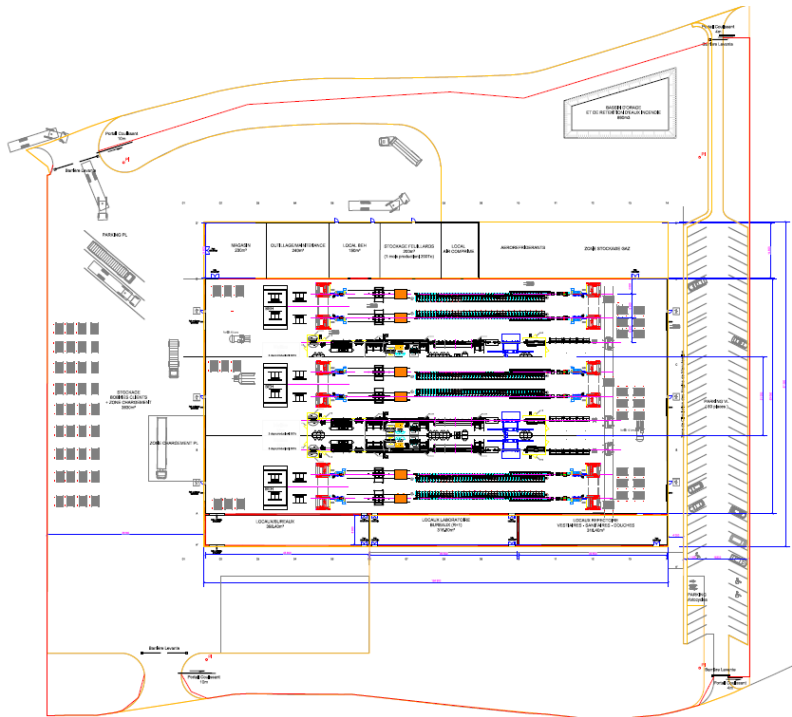
- No internal and external weld bead
- Wall Thickness (WT): $\pm 5\%$
- Outside Diameter (OD): $\pm 0.1\text{mm}$ (including ovalisation)

▶ **Excellent tube mechanical properties**

- Optimised strength
 - » $YS_{0,2} > 750\text{MPa}$
 - » $UTS > 900\text{MPa}$
- Elongation $\geq 25\%$
- Excellent fatigue properties



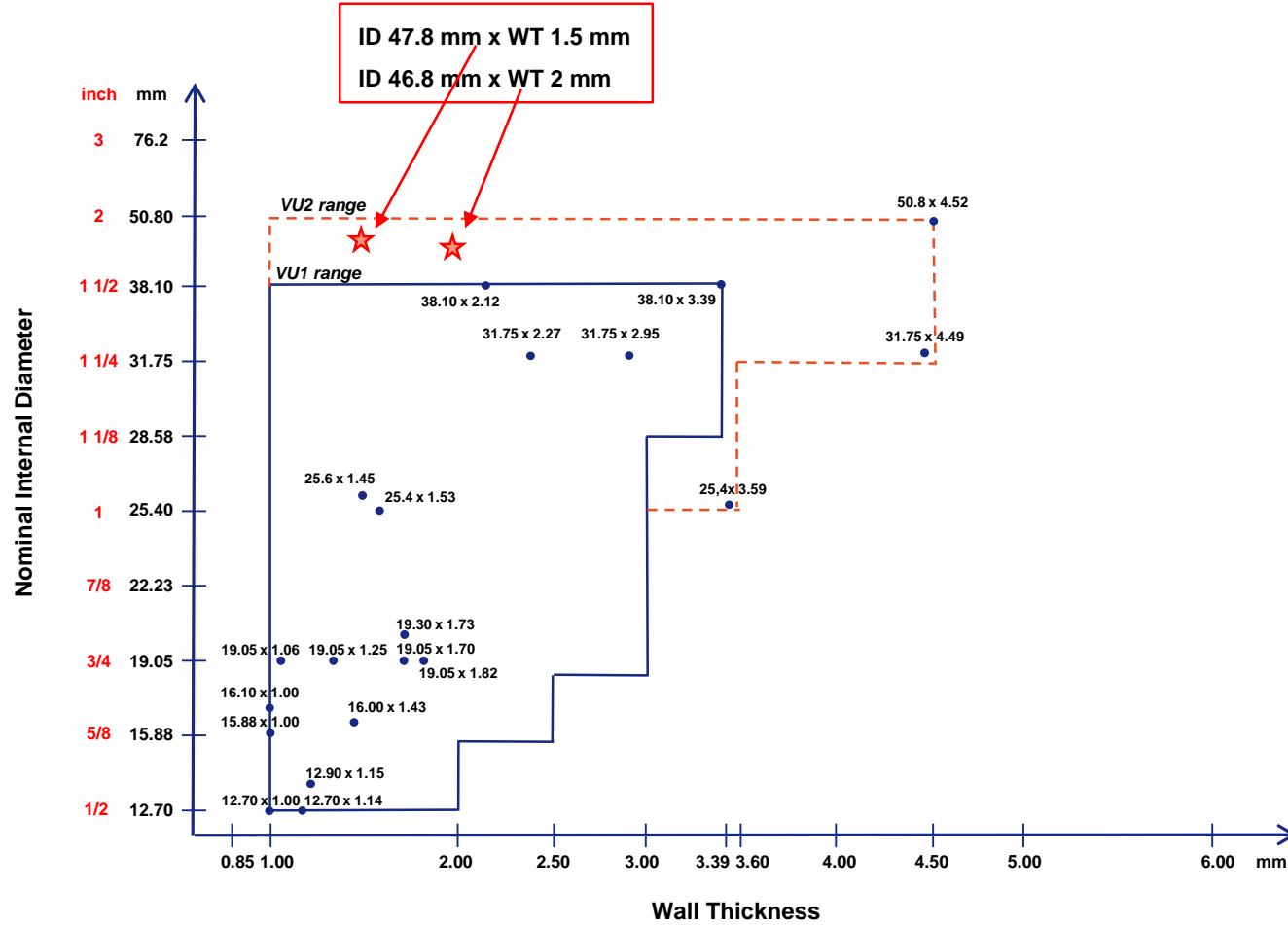
Capacity and capability increase



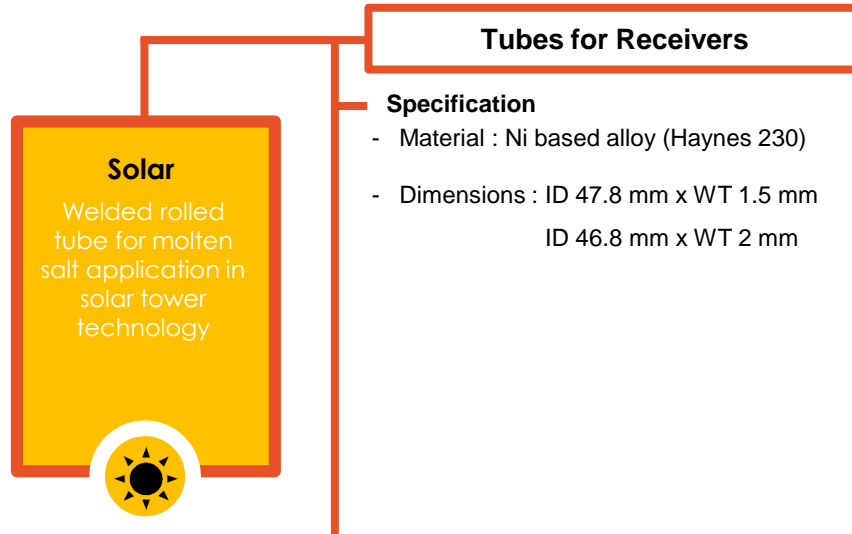
Renewable energies with first focus on tubes for CSP



TUBES FOR RECEIVERS



TUBES FOR RECEIVERS



Tubes for Receivers

Solar

Welded rolled tube for molten salt application in solar tower technology



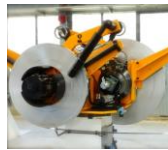
Specification

- Material : Ni based alloy (Haynes 230)
- Dimensions : ID 47.8 mm x WT 1.5 mm
ID 46.8 mm x WT 2 mm
- Cold worked

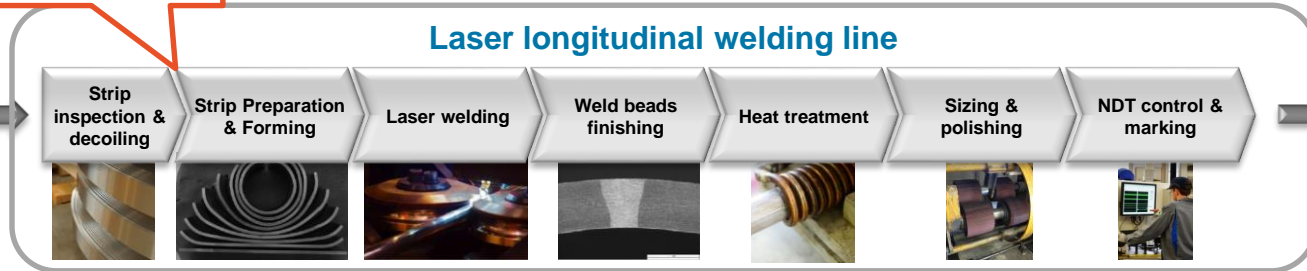


- Forming rollers give progressively a round shape to the strip

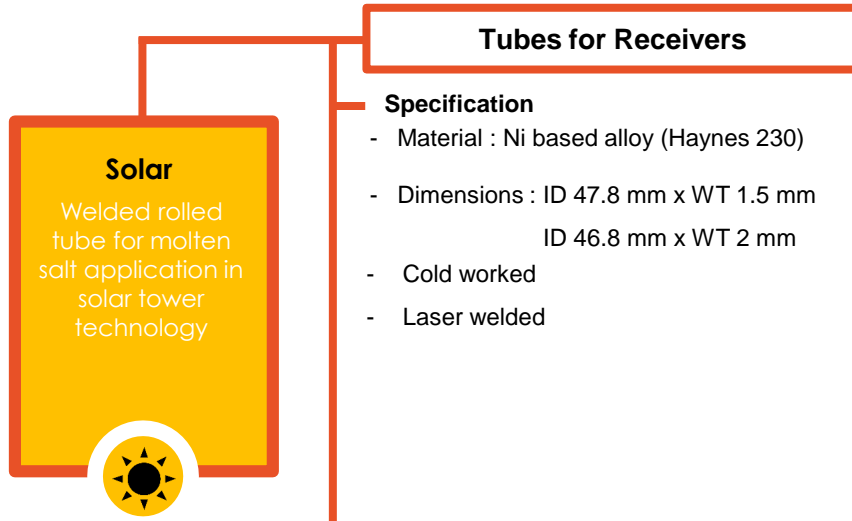
Laser longitudinal welding line



Coiled strip



Intermediate reel



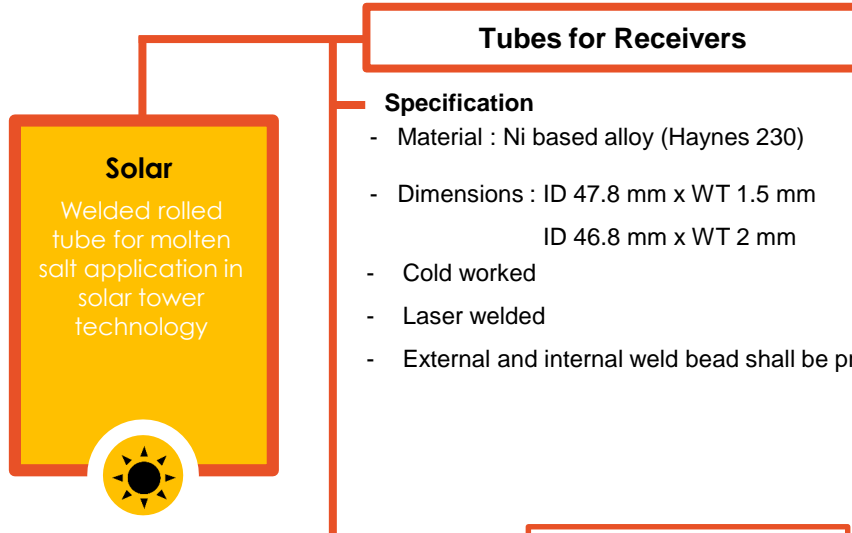
• CO₂ laser is used
• Energy can reach 8KW



Coiled strip



Intermediate reel



Specification

- Material : Ni based alloy (Haynes 230)
- Dimensions : ID 47.8 mm x WT 1.5 mm
ID 46.8 mm x WT 2 mm
- Cold worked
- Laser welded
- External and internal weld bead shall be properly removed

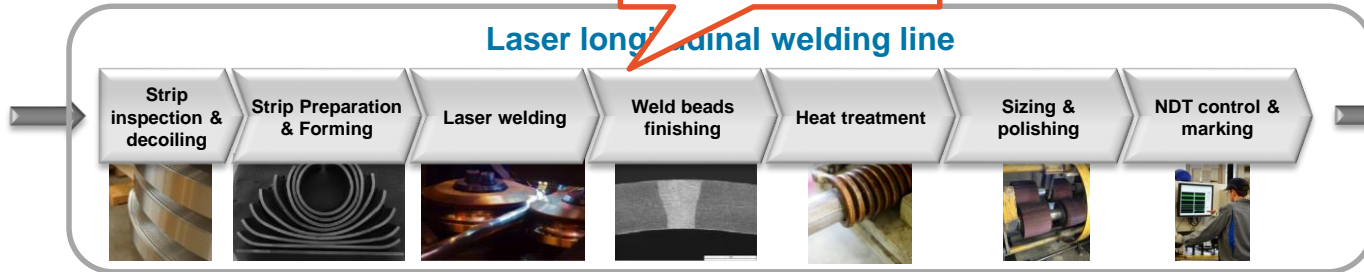


- Bead are internally and externally rolled
- External surface is brushed

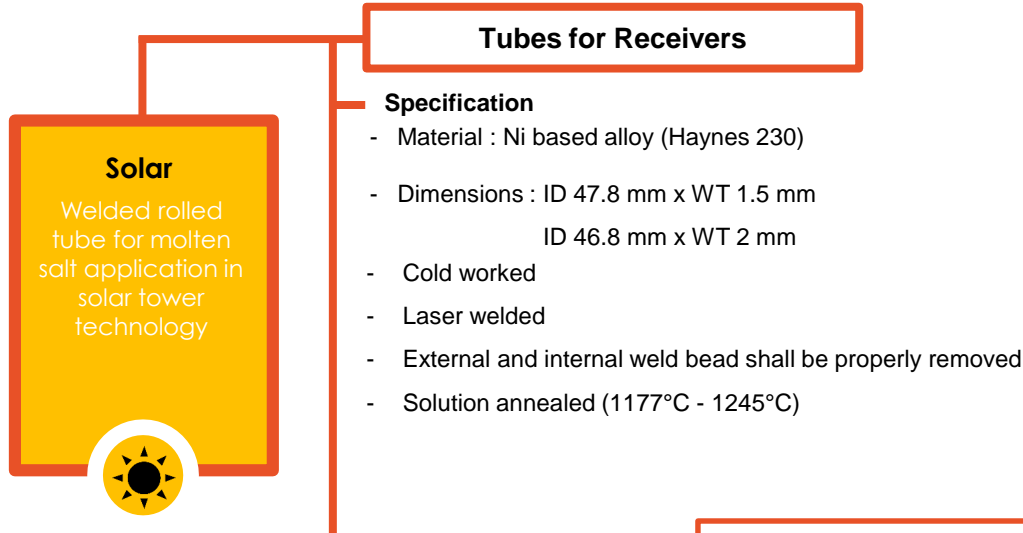
Laser longitudinal welding line



Coiled strip



Intermediate reel



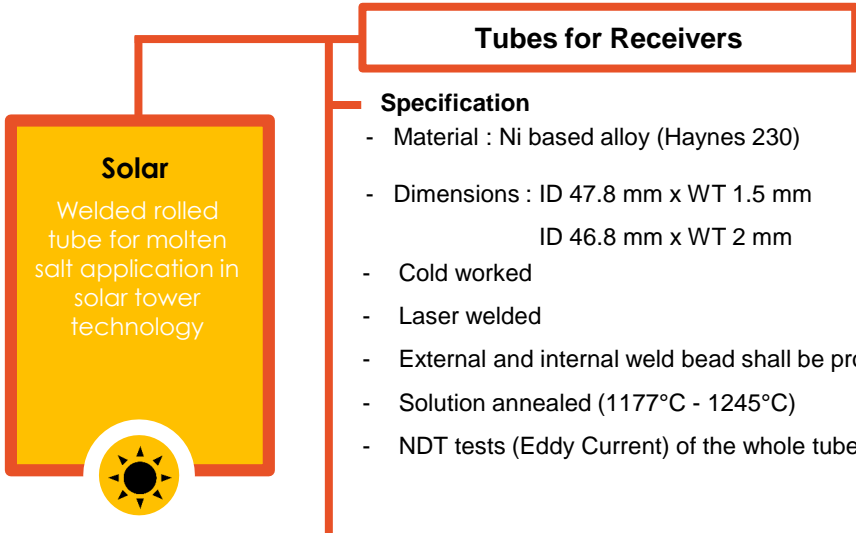
• Heating then cooling inside 10 m long tunnel in a controlled atmosphere



Coiled strip



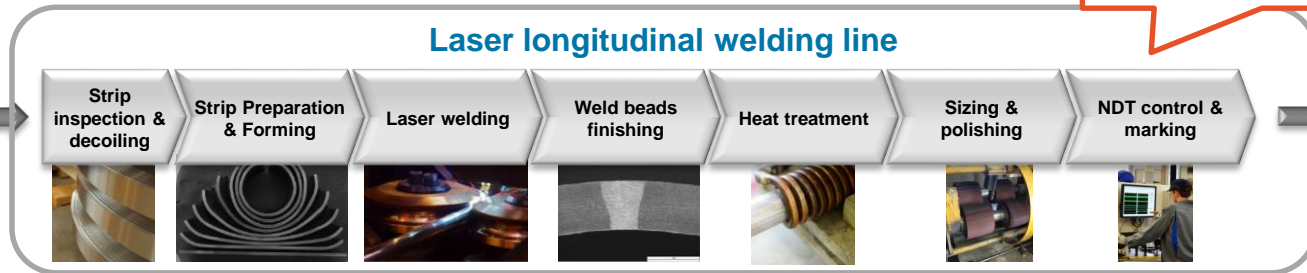
Intermediate reel



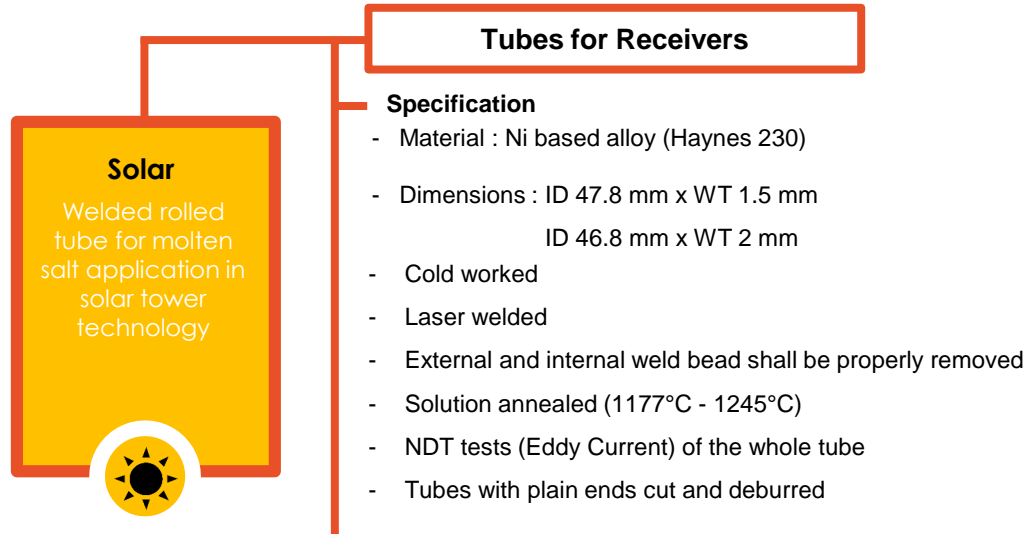
- US: 100% of the tube is controlled
- EC: 100% of the tube is controlled
- OD and WT control



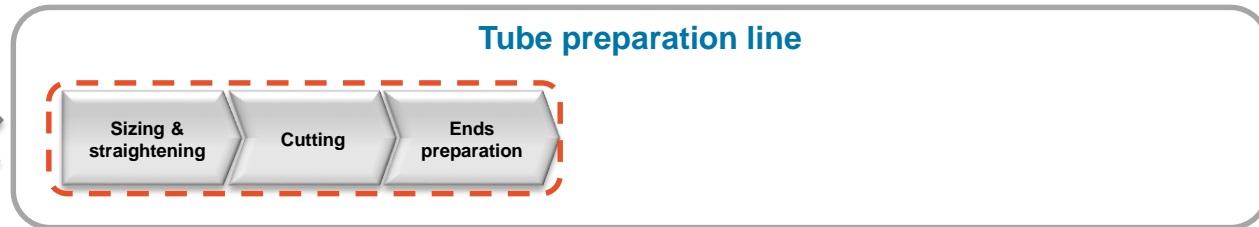
Coiled strip



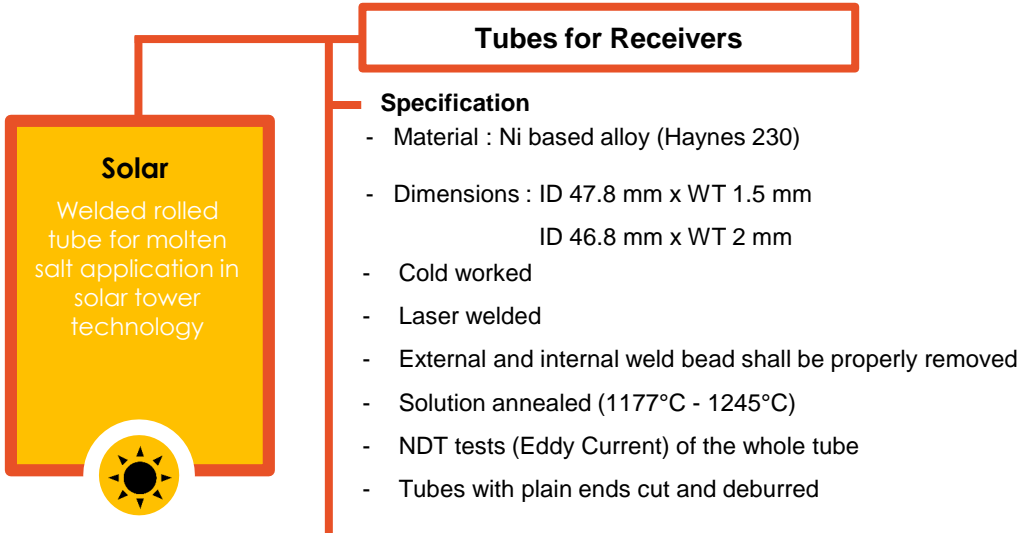
Intermediate reel



Intermediate reel



Laboratory

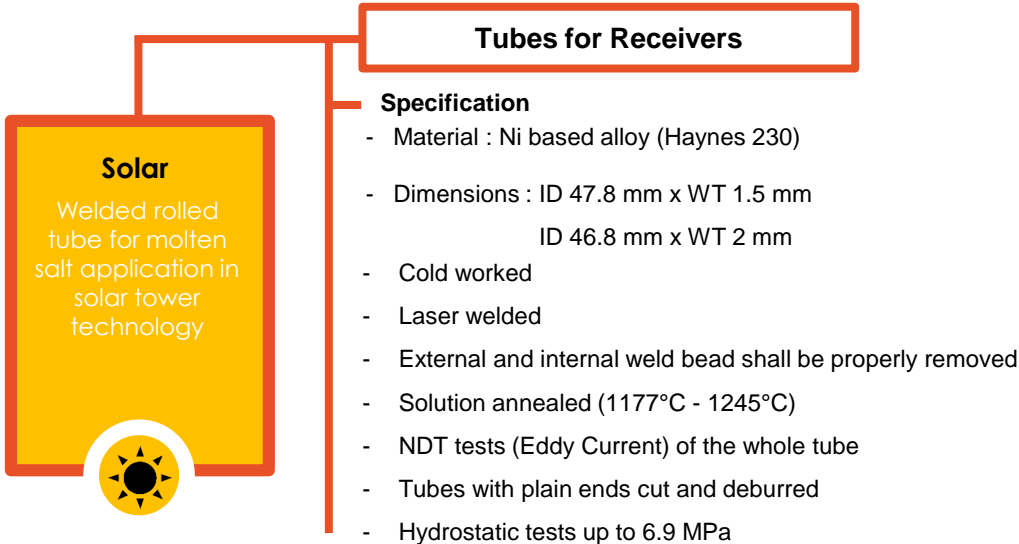


• Straight tube preparation



Intermediate reel

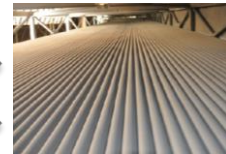
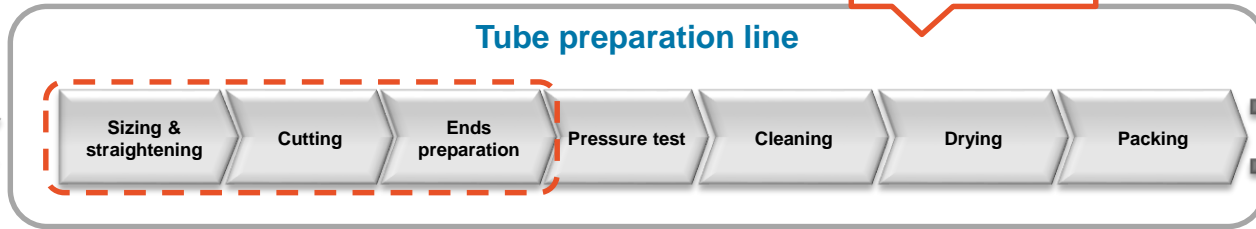
Laboratory



• Hydrostatic test



Intermediate reel



Customer tubes



Laboratory

TUBES FOR RECEIVERS

- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:



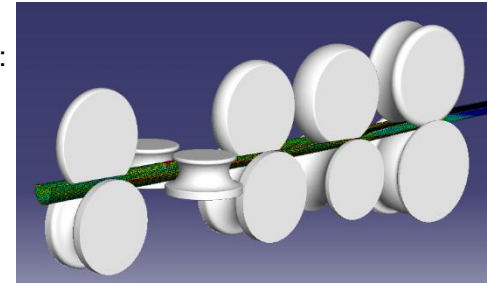
- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:
 - Forming



Finite Element Modelling

Numerical simulation of strip forming using :

- Roller shape
- Mechanical properties of strips
- Strips dimensions



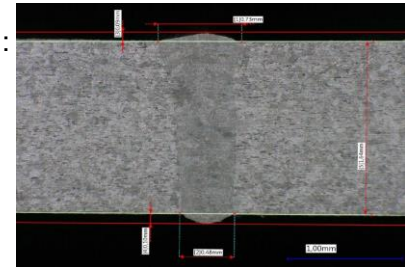
- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:
 - Forming
 - Laser welding



Laser Welding tests

Laser welding tests on Haynes 230 strip using :

- CO₂ laser
- Welding energy, focal distance..
- Dimensional check (tolerances)



- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:
 - Forming
 - Laser welding
 - Heat treatment



Heat treatment tests

Heat treatment tests on Haynes 230 strip using :

- Dilatometer control
- Chemical etching
- SEM observations



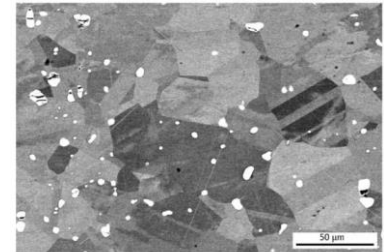
- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:
 - Forming
 - Laser welding
 - Heat treatment
 - Microstructure



Metallurgical investigation

Microstructure investigation on Haynes 230 strip :

- Carbides
- Intermetallic phases
- Grain growth
- Precipitation γ'/γ''



(b)

- Receiver (straight) tubes: Grades 625 or Haynes 230
- In accordance to VU dimension range
- Industrialization study on Haynes 230 in Vallourec Umbilicals:
 - Forming
 - Laser welding
 - Heat treatment
 - Microstructure
 - Mechanical properties



Tensile tests

Tensile tests on Haynes 230 strip :

- Mechanical properties at room temperature
- Tensile specimens (1.6 mm and 2 mm)



THANKS FOR YOUR ATTENTION