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DEEPWATER DEVELOPMENT

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GULF QUEST

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X80 Heavy Wall Pipe Solutions for Deep and Ultra-Deep Water-Field Developments in Mild Sour Environment

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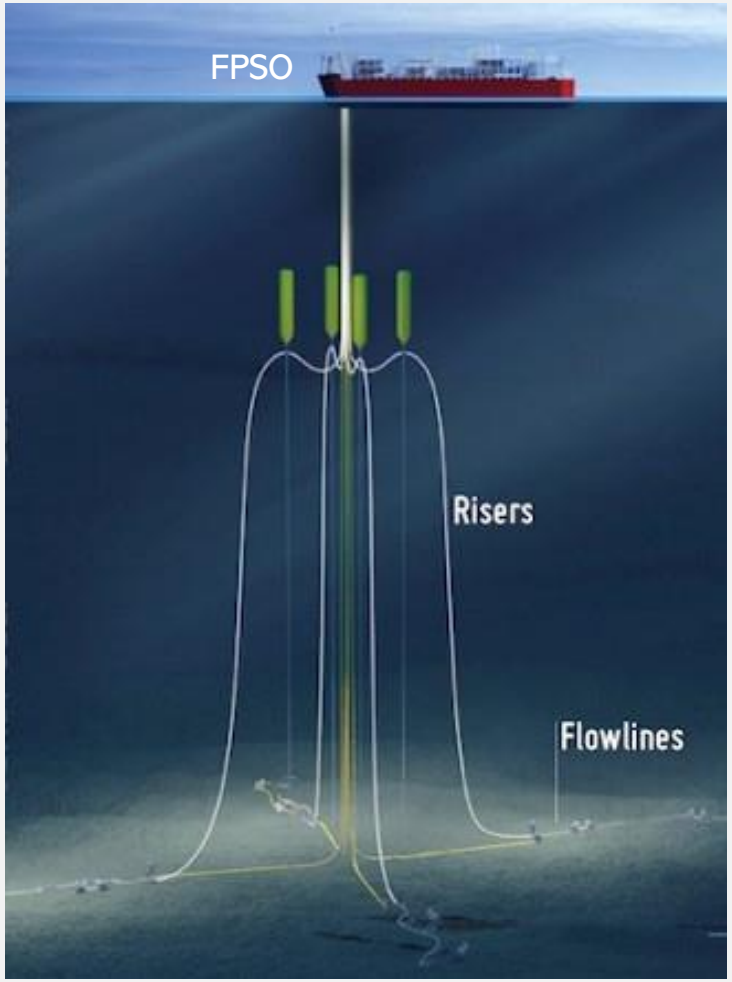
Outline

1. Benefits of X80 seamless pipes for projects in deep waters
2. Mechanical & corrosion results of X80 Heavy walled pipes
3. Weldability results

Deep-offshore O&G fields: technical challenges

- Heavy-walled pipes to withstand high hydrostatic pressure
- Deeper and longer risers leading to increase load on FPSO and line pipes
- Complex installation challenges for EPCIs



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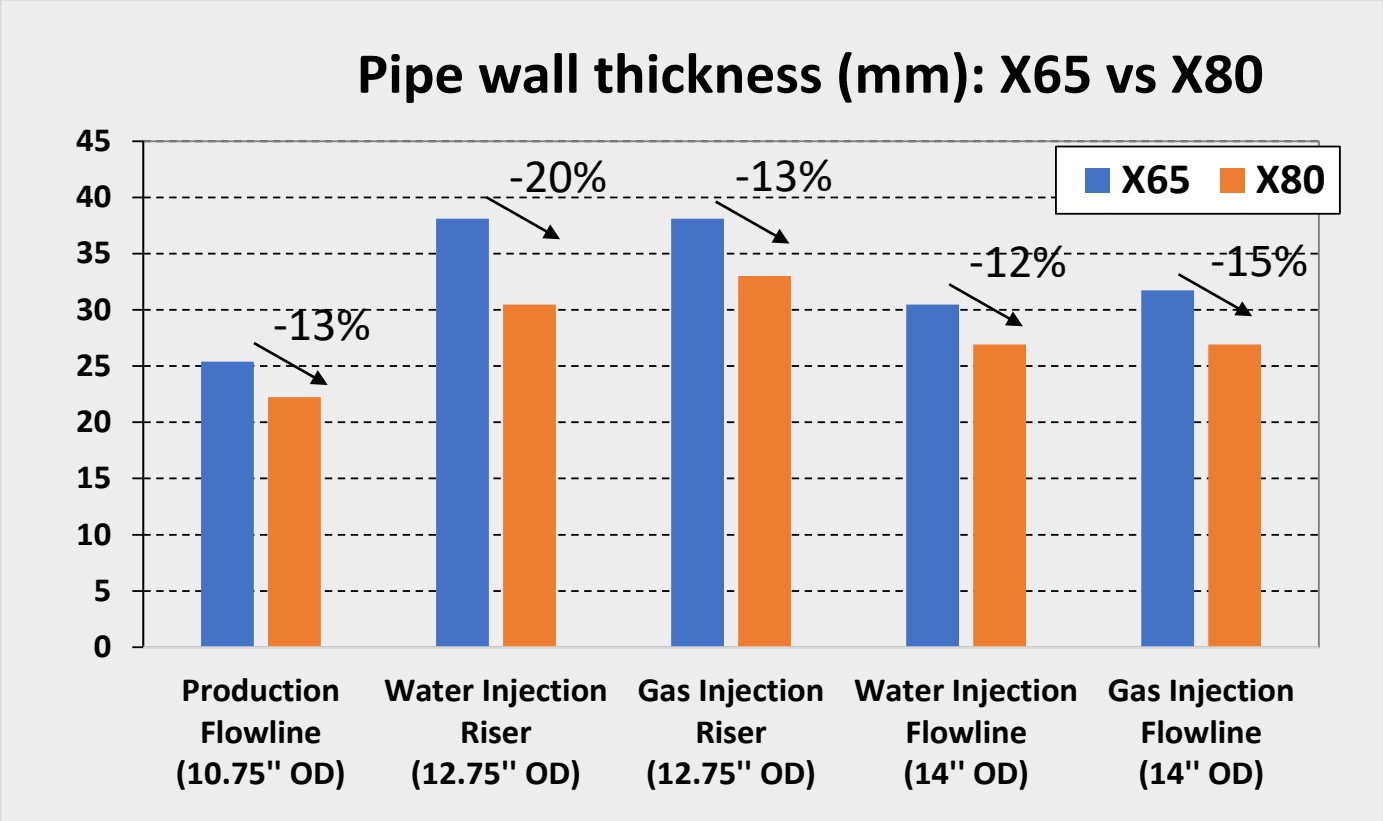
Benefits of X80 pipes: thickness reduction

X80 grade allowing between **12 % to 20 % Wall Thickness reduction vs X65**

Case study (*)

- Water depth: 2000 m
- Design pressure: 10 ksi
- Pipeline length: 88 km
- Steel lazy Wave Risers configuration



* Source: H. Evin - Pipeline & Gas Journal (producer) (2022) [webcast]
X80 Grades for Risers and Flowlines: Enabling Ultra-Deepwater Field Development (on24.com)

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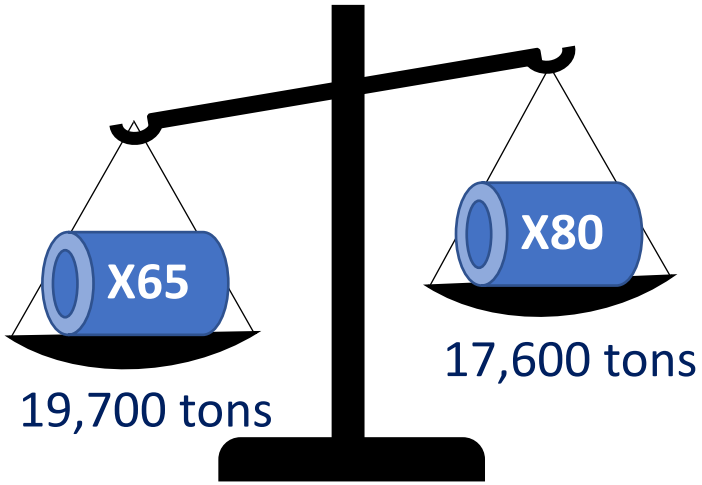
Weight savings with X80 & CO2 footprint

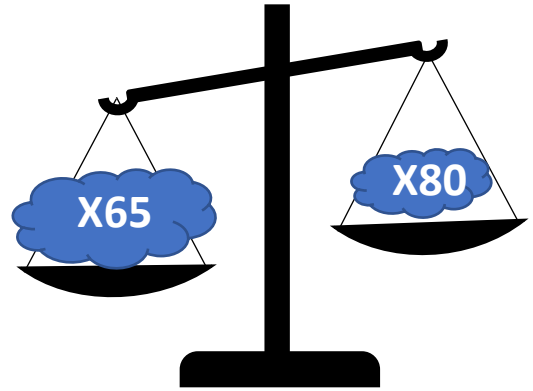
Steel pipe weight



Weight saving with X80: ca. 2000 tons

CO2 emissions

≈ 1.8 tons of CO2 emitted per ton of steel pipe (*)
from raw material to transport to final destination



CO2 emission saving with X80: ca. 3500 tons

(*) Cradle-to gate approach, evaluation according to EPD International PCR 2012:01 standard (2012)

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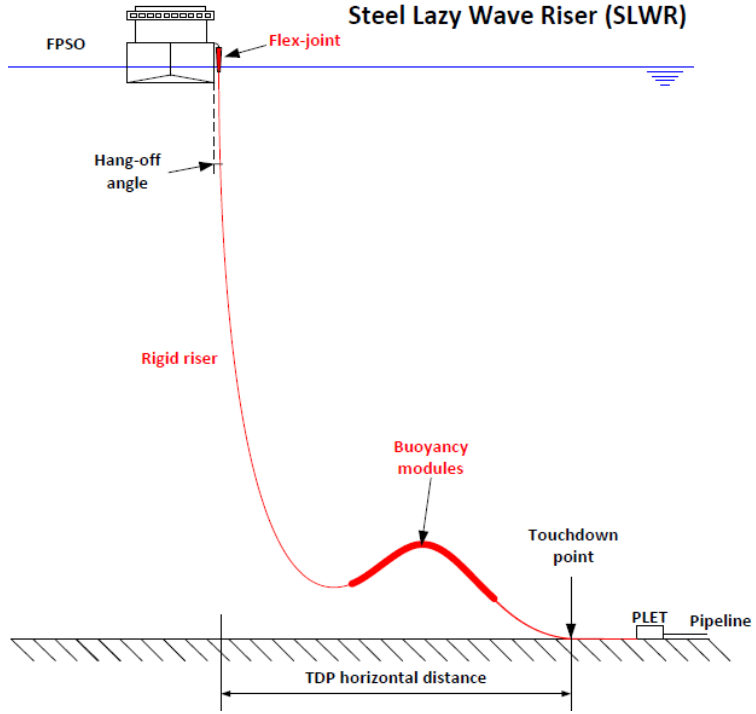
Other benefits of X80

- Easier design
  - Improved floater and hangoff design
  - Reduced floater payload
- Cost and time saving in installation
  - Lower vessel top tension requirements
  - More flexibility in the vessel for the pipelaying
  - Less buoyancies required for Steel Lazy Wave Risers



Material used in the study

- Tests performed on X80 seamless pipes in 273.1 x 40 mm
- Steel composition

Content	C	Si	Mn	P	S	V+Ti+Nb	Others	Fe	Carbon equivalents	
									CE_{IIW}	pcm
Wt %	0.07 %	0.25 %	1.5 %	0.01 %	0.001 %	0.08 %	Mo, Cu, Cr, Ni, Al, N	Bal.	0.42 %	0.19 %

- Industrialized solution from Vallourec Brazil

Mechanical tests / X80 pipes in 273.1 x 40 mm

Tensile tests / longitudinal / round specimen

YS (MPa)	TS (MPa)	YS / TS
586	664	0.88

Hardness quadrant (HV10)

	OD	Mid wall	ID
Av. Hardness (HV10)	243	216	232

Max ≤ 275 HV10

Charpy V-notched @ -30 °C

	Mid wall	ID +2 mm
Av. Energy (J)	319	287

SENB tests @ -10 °C

Geometry	T°	Notch direction	Av. CTOD (mm)
Bx2B	-10°C	X-Z	1.40

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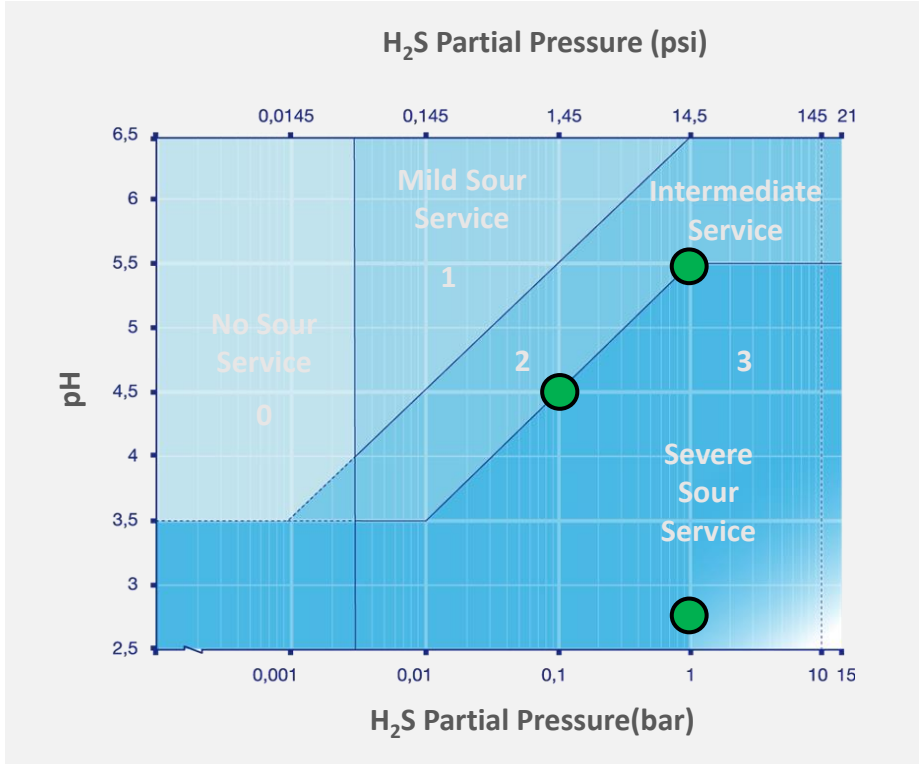
Corrosion testing on parent pipes

- Four-point bending tests on X80 pipes as per NACE TM 0316

pH	Partial pressure H_2S	Solution	T °C	Applied stress	Test results (MPI / cross sections)
4.5	0.1 bar H_2S (bal. CO_2)	NACE sol. B (+ sodium bicarbonate)	24	90 % AYS	No SSC cracks
5.0	1 bar H_2S	NACE sol. B (+ sodium bicarbonate)	24	80 % AYS	No SSC cracks
2.7	1 bar H_2S	NACE Sol. A	24	90 % AYS	No SSC cracks



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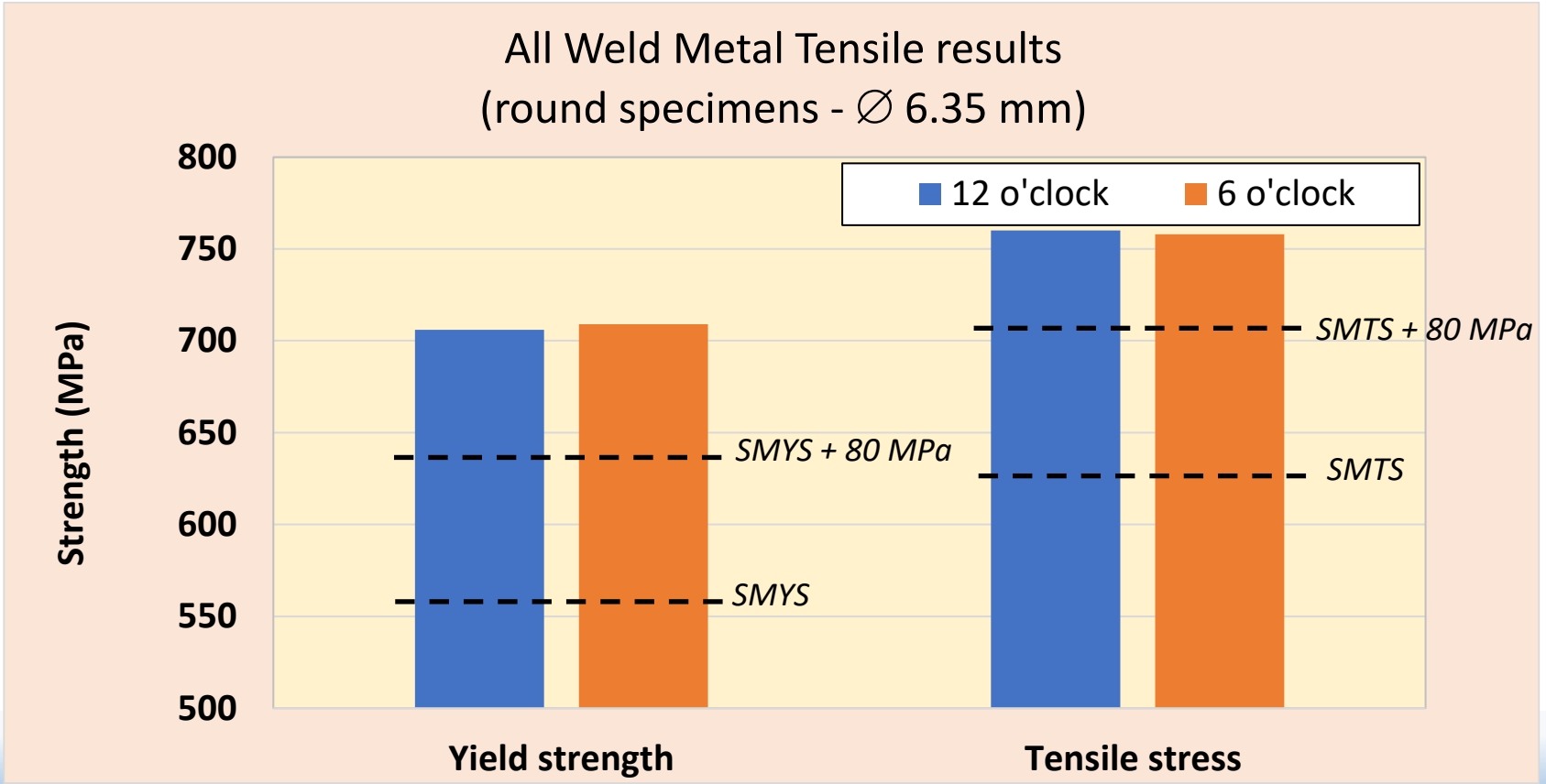
Welding procedure – X80 in 273.1 x 40mm

- Position: 2G (vertical welding)
- Process:
  - Root: GMAW-STT (Surface Tension Transfer)
  - Other passes: GMAW-Pulsed
  - Preheating temperature: 150 °C
  - Heat input: 3 - 12 kJ/cm
- Narrow J-Bevel
- Welding consumable:
  - Root: ER70S6 / Filling & cap: ER80S-G

All Weld Metal Tensile tests

Good strength overmatching of the weld metal



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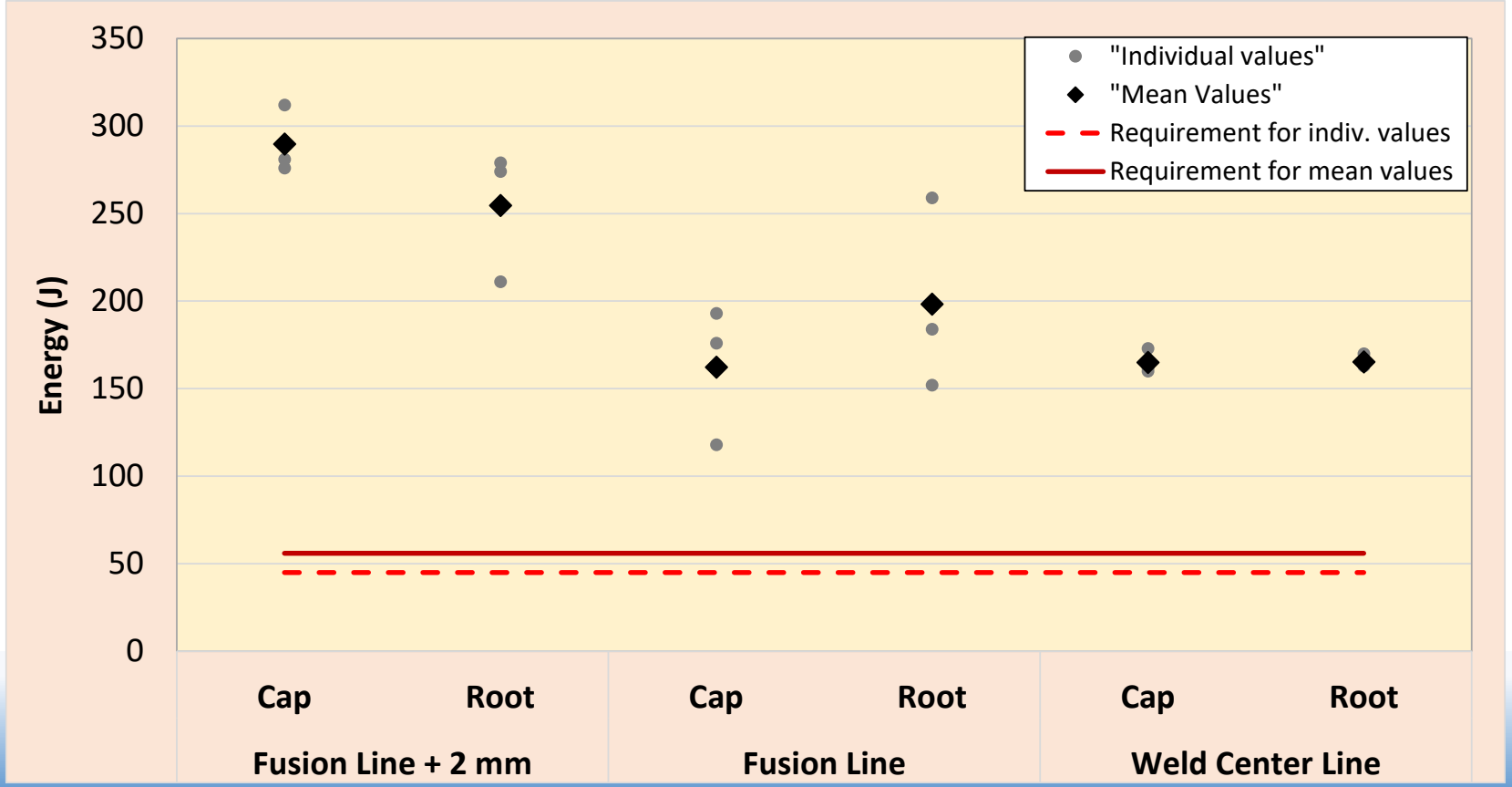
Charpy tests on weld joint at -30 °C

Results in HAZ and weld metal compliant with the requirements of DNV-ST-F101 (2021)



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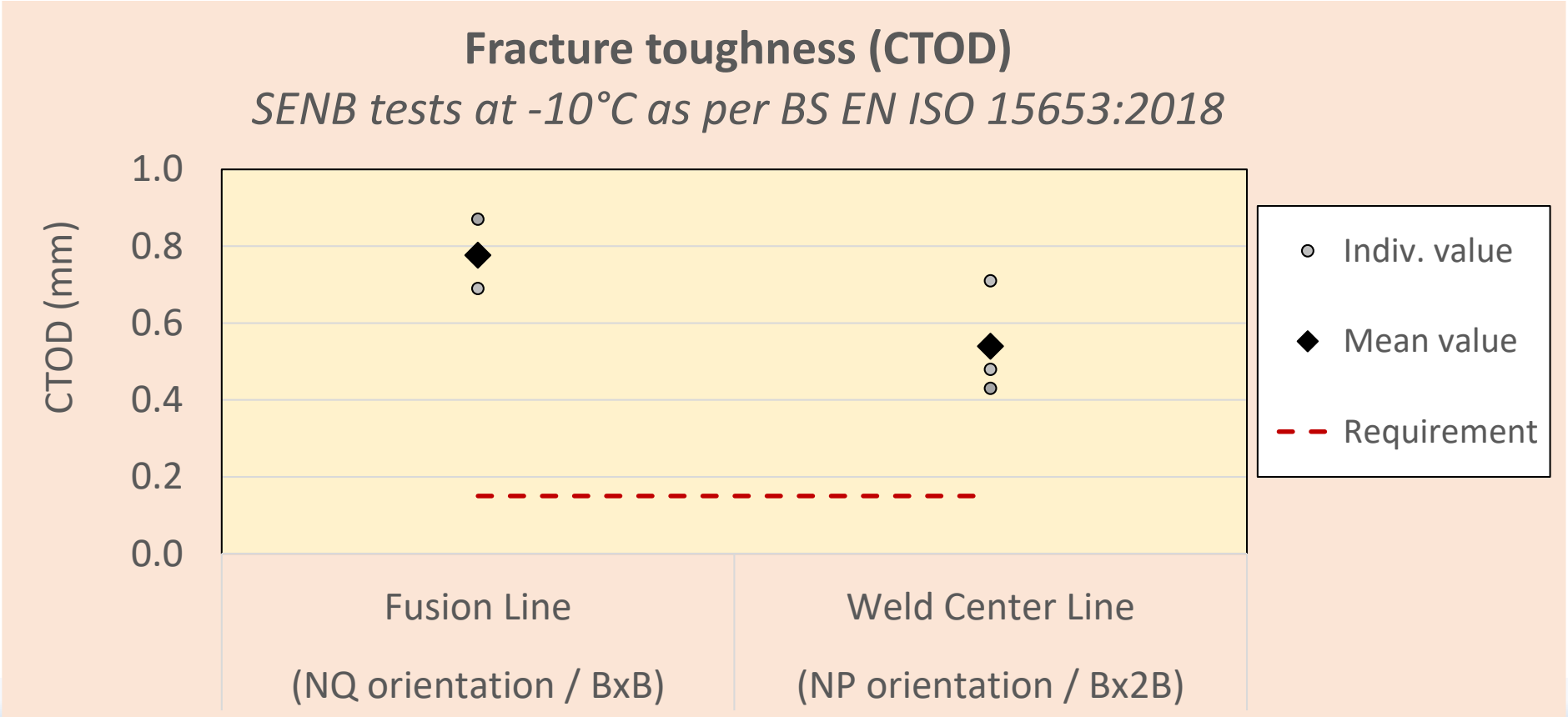
Fracture toughness of weld joint at -10 °C

Good CTOD values ≥ 0.7 mm in the HAZ and ≥ 0.4 mm in the weld metal



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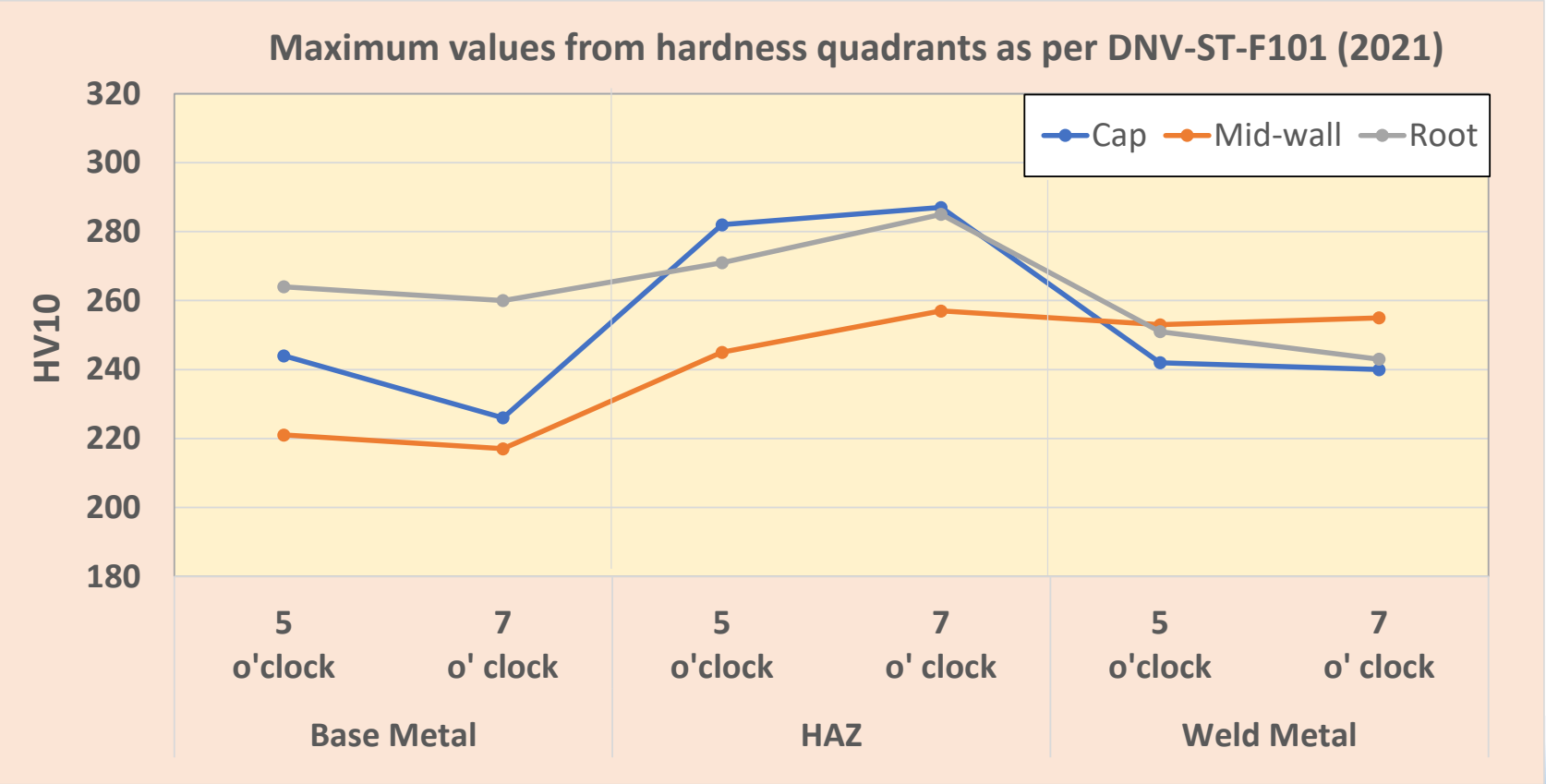
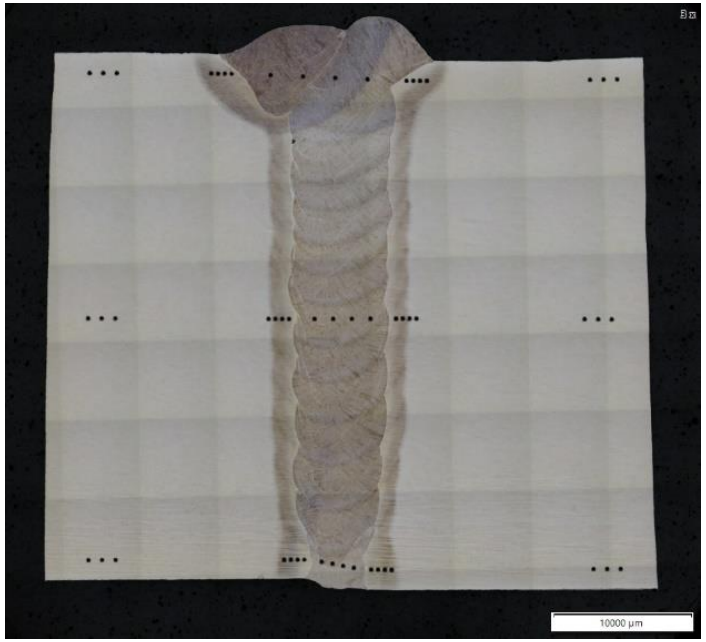
Macro-hardness – X80 girth weld

Max hardness values ≤ 290 HV10





5 o’clock

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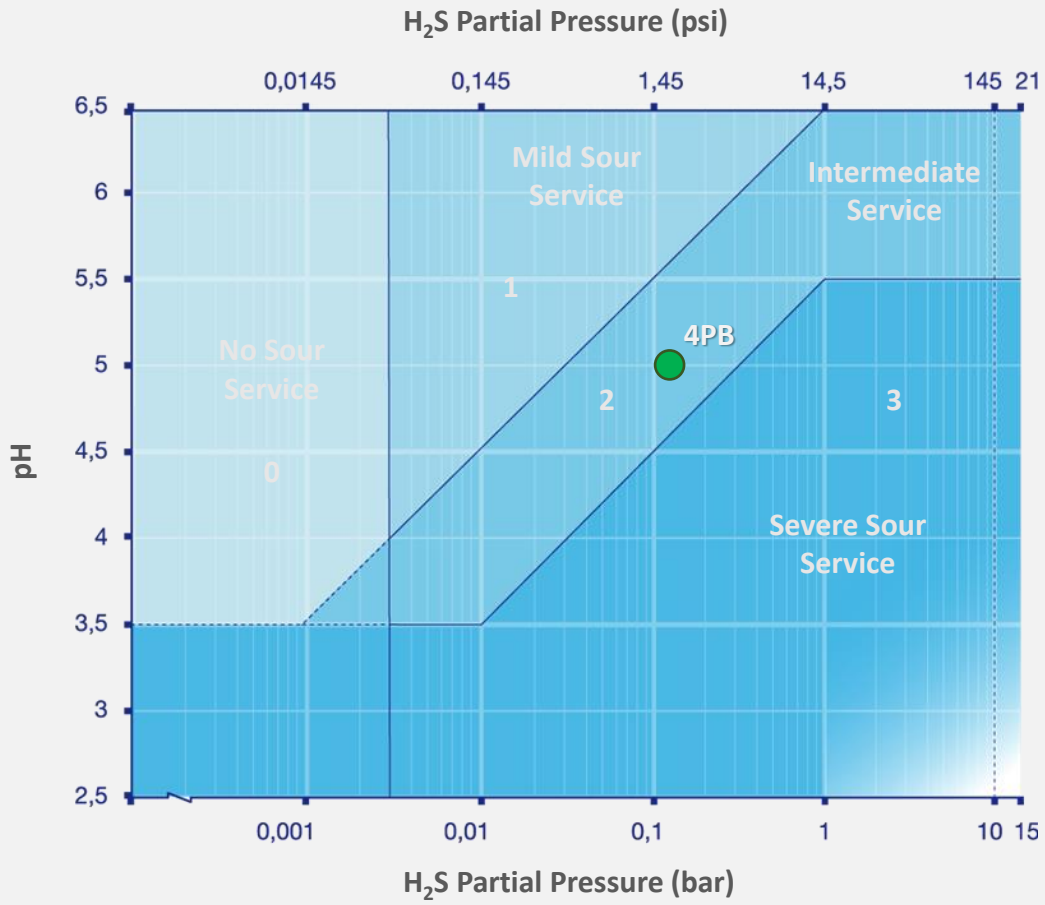
SSC testing on X80 girth weld: conditions

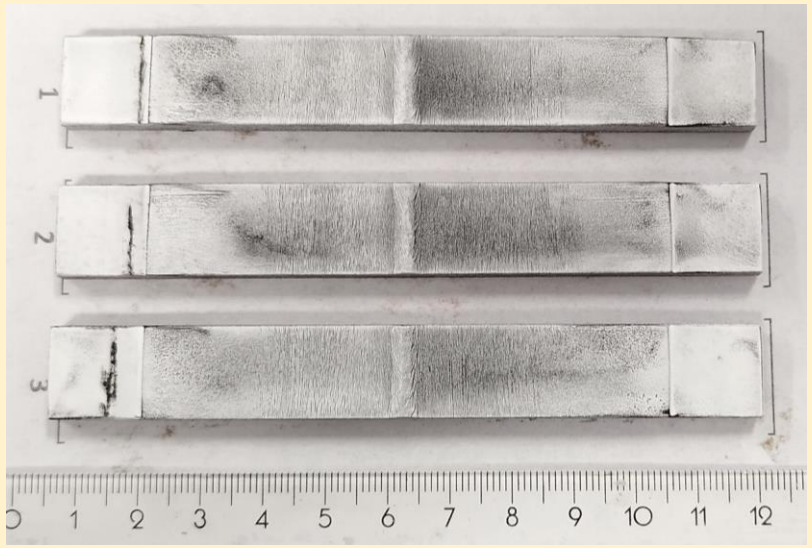
- Four-point bend tests according to NACE TM 0316
  - Fit-for-purpose condition – Region 2
    - NACE solution B + Sodium bicarbonate
    - pH 5.0
    - 0.14 bar H_2S / Balance CO_2
    - Applied stress: 80 % SMYS
  - Weld root left intact

No evidence of SSC cracking

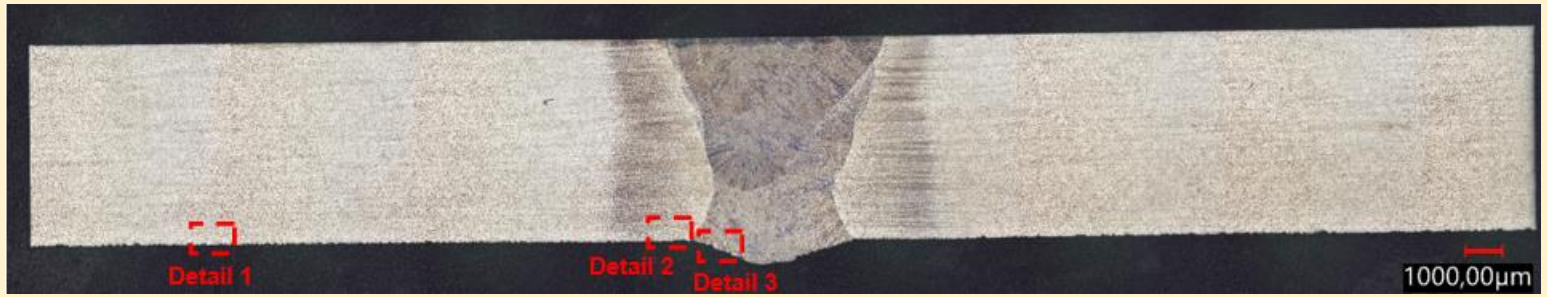


SSC testing on X80 weld: MPI & cross sections

No evidence of SSC cracking

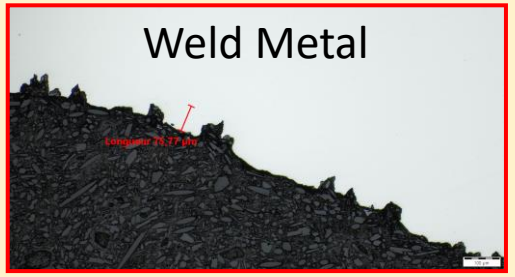


MPI of SSC coupons (5 x 15 x 115 mm)



Max depth: 85 µm

Max depth: 53 µm



Max depth: 76 µm

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Summary

- Benefits of switching from conventional X65 to X80:
  - Reduction of wall thickness typically between 12 and 20 %
  - Pipe weight saving with positive impact on CO2 emissions
  - Cost and time saving in installation thanks to the reduced payload

- Suitable solution for J-lay in mild sour conditions
  - Correct toughness results in HAZ and weld metal
  - No SSC cracks in NACE Region 2 at pH 5.0 / 0.14 bar H_2S (bal. CO_2) / 80% SMYS
  - Way forward: evaluation the performance in strained and aged conditions to assess the possibility of reel-lay installation

Thank you

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