



BlueCoil™ Technology

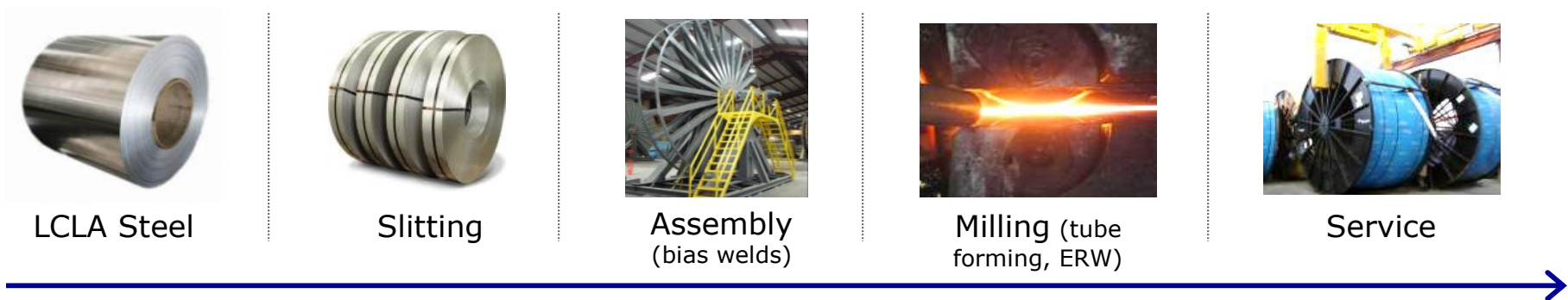
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# Outline



- Conventional Coiled Tubing Technology and Manufacturing
- BlueCoil™ Technology and CT Manufacturing
- Performance of BlueCoil™ Technology and CT Grades
- Validation of BlueCoil™ CT Grades for Field Applications
- Summary of Benefits

# Conventional Coiled Tubing Technology and Manufacturing

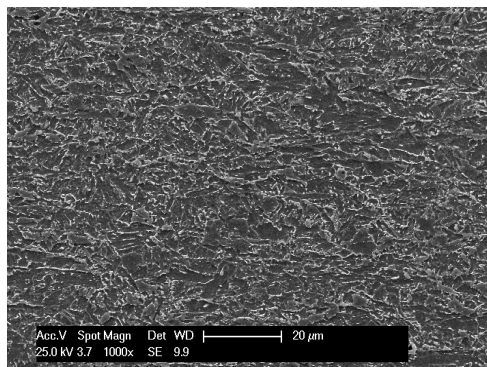


- Tube properties mostly defined by flat strip manufacturing
- Steel metallurgy limits making very high yield strength, reliable CT
- Welding degrades strip properties locally
- Final tube exhibits reduced performance in and around welds

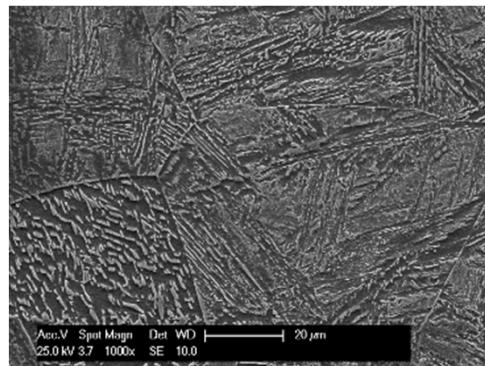
# Conventional Coiled Tubing Technology and Manufacturing



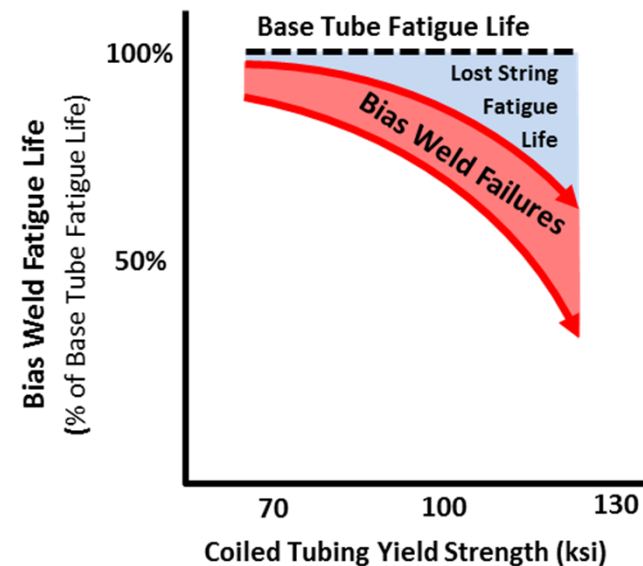
- Coarse, non-uniform microstructure in weld and heat-affected zone areas
- Bias weld fatigue and environmental performance degrade as CT yield strength is increased



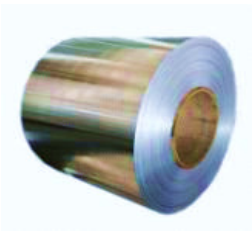
**Base Tube**



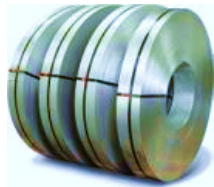
**Bias Weld**



# BlueCoil™ Technology & CT Manufacturing



New Steels



Slitting



Assembly  
(bias welds)



Milling (tube  
forming, ERW)



Full Heat  
Treatment



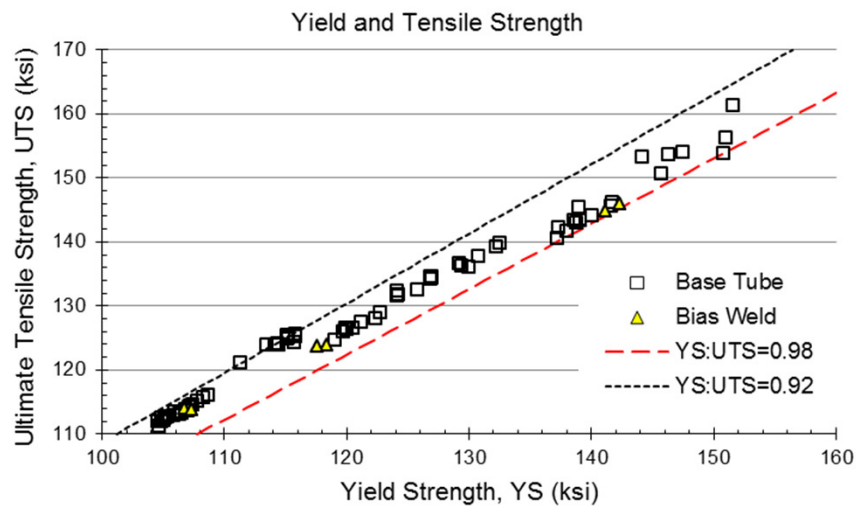
Service

- 
- New technology platform based on new steel chemistry and new manufacturing processes
  - Technology platform for extending CT capability and reliability for extreme ops. demands
  - New, superior microstructure & much higher strength
  - CT properties defined continuously at the last manufacturing stage
  - Uniform microstructure across entire CT string, including all welds
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# Metallurgical and Mechanical Properties of BlueCoil™ CT

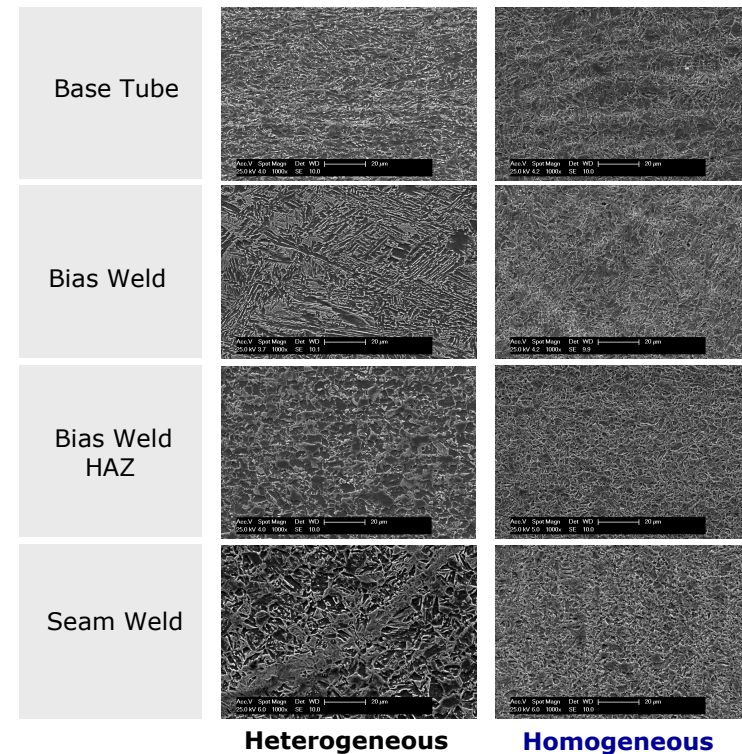


- Better and uniform microstructure across entire CT string
- Ultra high strength grades



Conventional CT

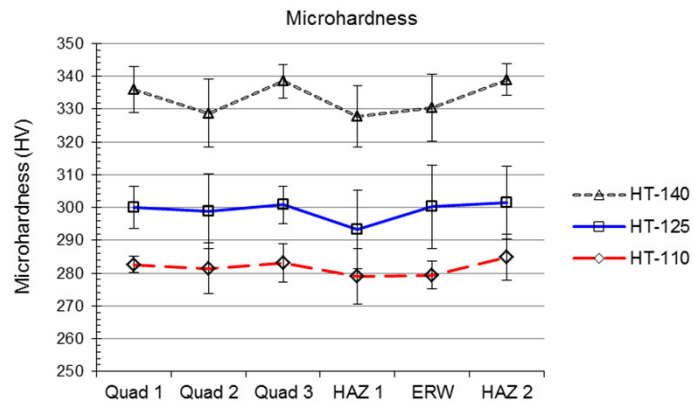
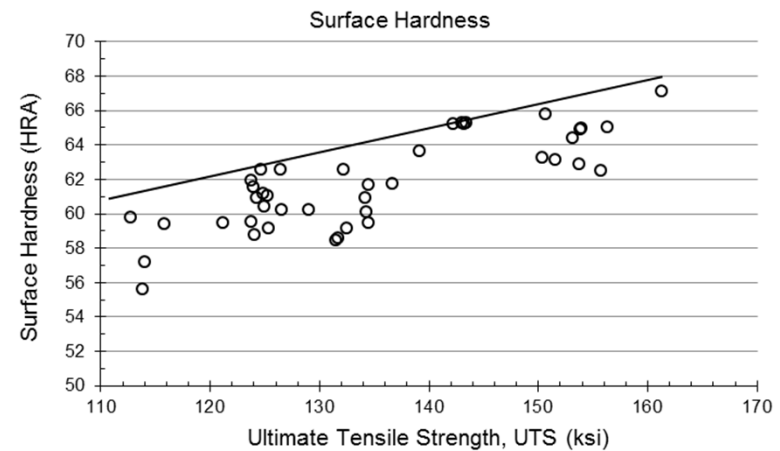
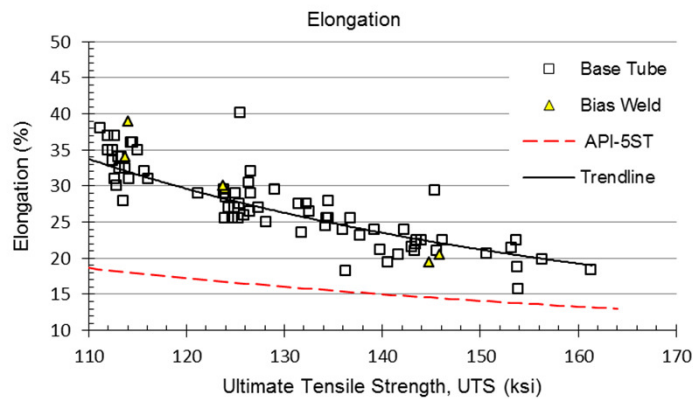
BlueCoil™ CT



Heterogeneous

Homogeneous

# Mechanical Properties of BlueCoil™ CT



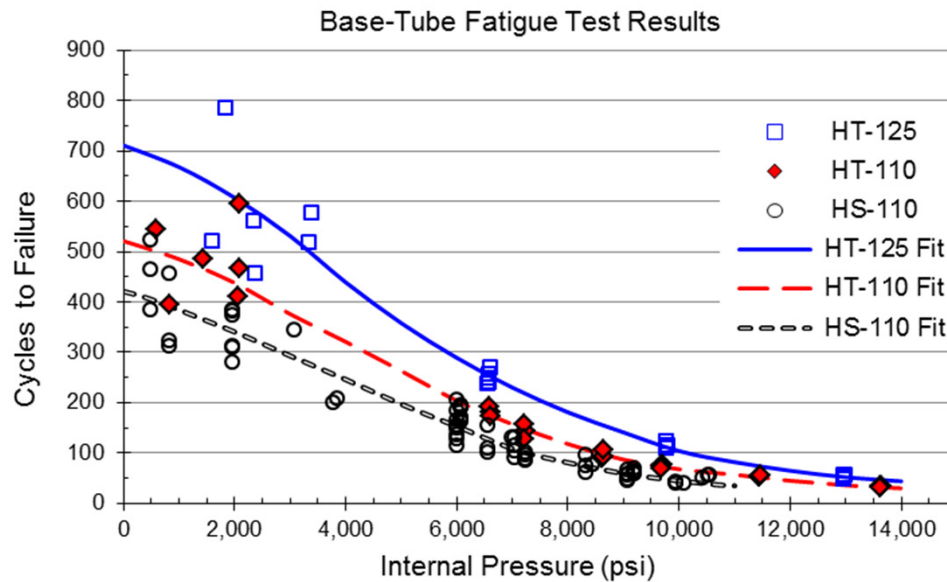
HT-110 < 30 HRc

HT-125 < 33 HRc

HT-140 < 36 HRc



# BlueCoil™ CT Base-Tube Fatigue Performance



## Average fatigue life comparisons:

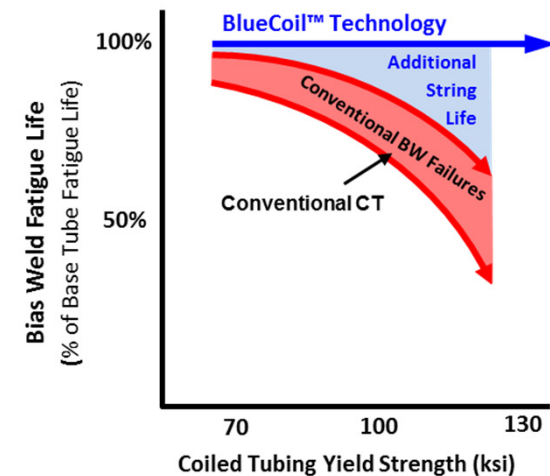
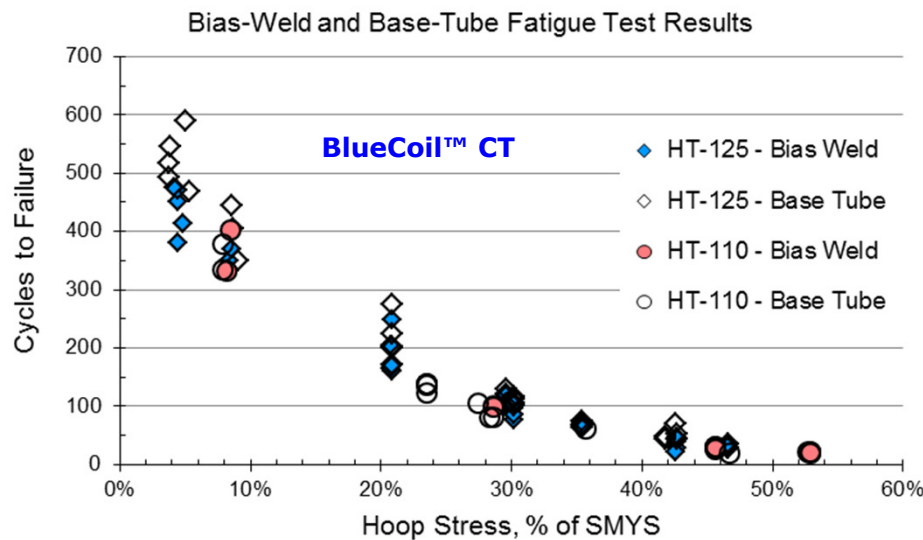
HT-110 / HS-110  $\cong$  1.2 (LowP) – 1.6 (HP)

HT-125 / HS-110  $\cong$  1.5 (LowP) – 2.5 (HP)

HT-125 / HT-110  $\cong$  1.3 (LowP) – 1.6 (HP)



# BlueCoil™ CT Bias-Weld Fatigue Performance



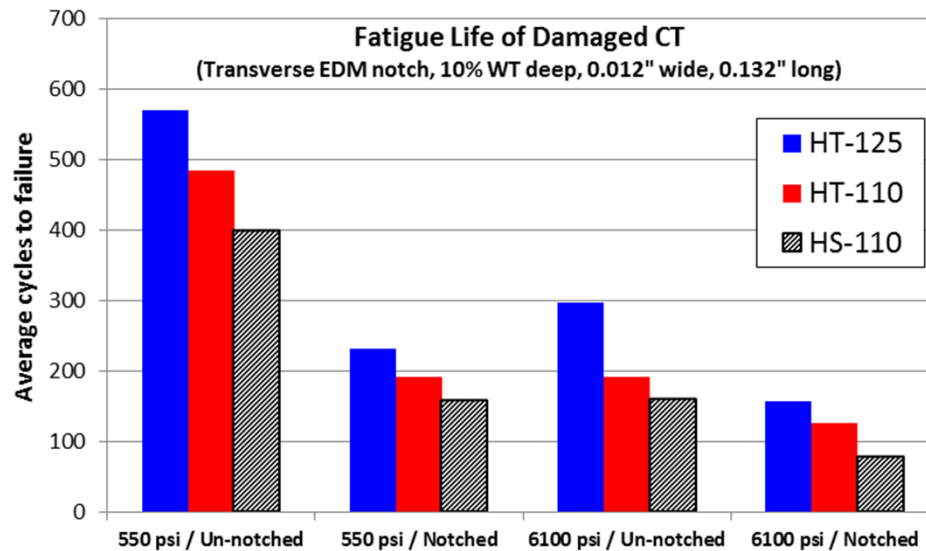
**Bias Weld (CT string) fatigue life comparisons:**

**HT-110** / HS-110  $\cong$  2.0 (LowP) – 2.7 (HP)

**HT-125** / HS-110  $\cong$  2.5 (LowP) – 4.0 (HP)

**Similar fatigue performance of BlueCoil™ CT bias weld and base tube**

# Base-Tube Fatigue Performance - Damaged CT



Fatigue de-rating, sharp transverse cut, 10% WT deep		
Grade	Low Pressure	Mid Pressure
HS-110	61%	51%
HT-110	60%	34%
HT-125	59%	47%



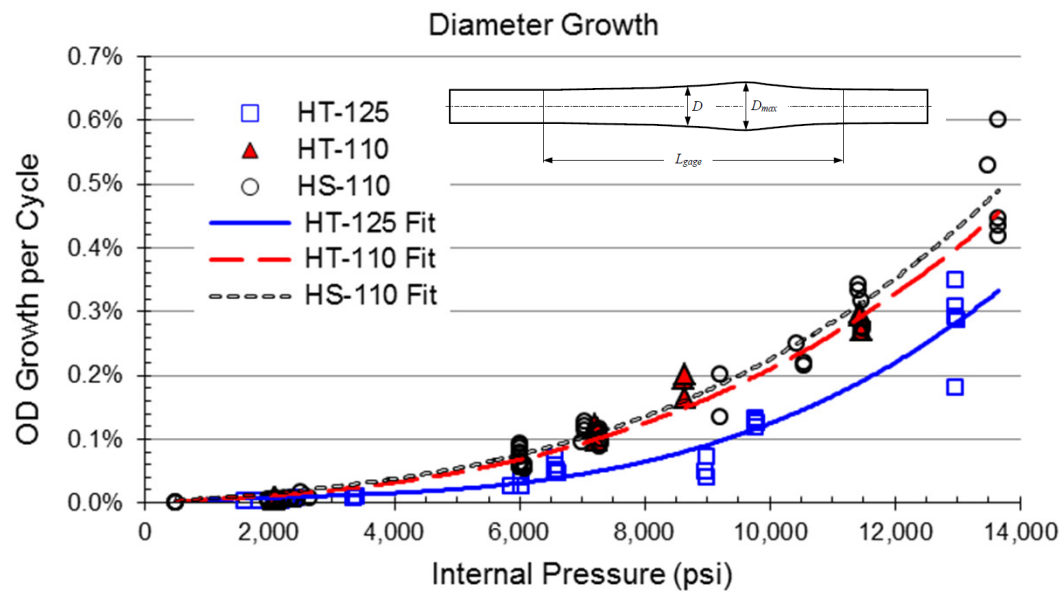
## Average fatigue life comparisons – notched CT:

HT-110 / HS-110  $\cong$  1.2 (Low P) – 1.6 (Mid P)

HT-125 / HS-110  $\cong$  1.5 (Low P) – 2.0 (Mid P)

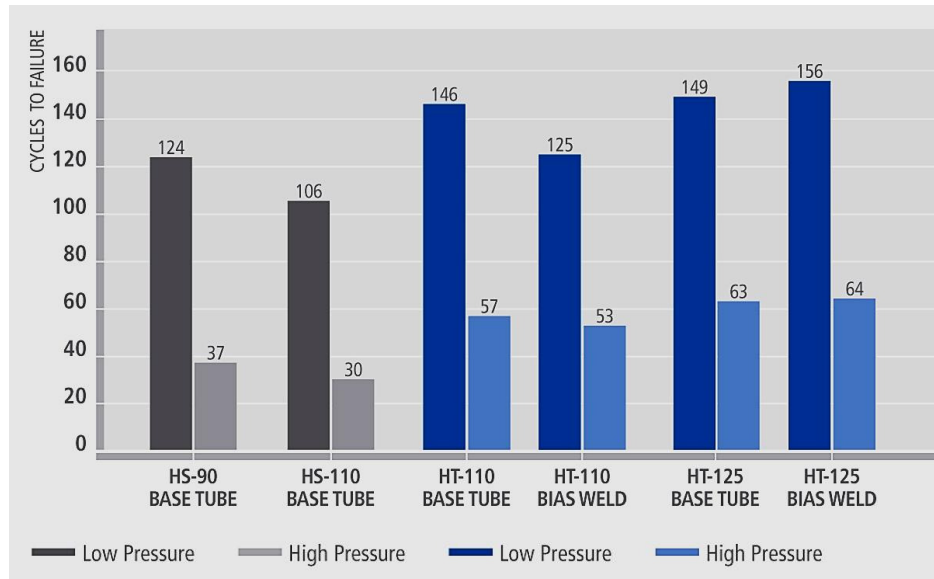
**More residual life after CT damage**

# BlueCoil™ CT Ballooning Performance



**Less ballooning than conventional CT**

# BlueCoil™ CT Sour Fatigue Performance

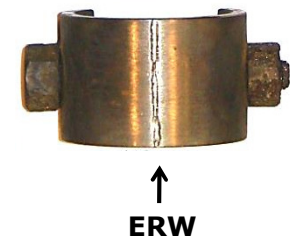
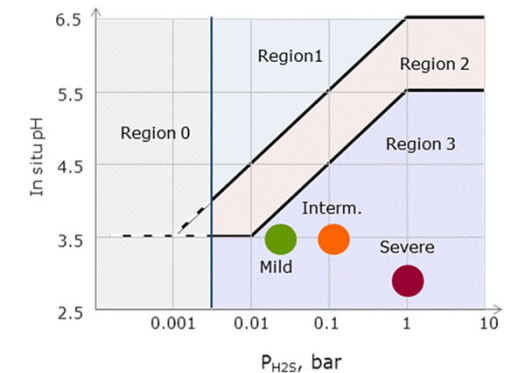


**BlueCoil™ CT grades have longer sour fatigue life even as the CT strength is increased**

**Bias-weld sour fatigue performance of BlueCoil™ CT is similar to base-tube performance**

# BlueCoil™ CT Sour Performance – Sulfide Stress Cracking (SSC)

Coiled Tubing		Stress Level		Test Environment		
Type	Grade	(% SMYS)	Absolute	Mild	Interm.	Severe
Convent. CT	HS-80	90 %	72 ksi	Passed (5/5)	Inconcl. (4/4)	Failed (6/6)
	HS-90	90 %	81 ksi	Failed (2/2)	N/T	Failed (2/2)
	HS-110	90 %	99 ksi	Failed (2/2)	N/T	Failed (2/2)
BlueCoil™ CT	HT-80	90 %	72 ksi	N/T	N/T	Passed (3/3)
	HT-100	90 %	90 ksi	N/T	N/T	Passed (6/6)
	HT-110	90 %	99 ksi	Passed (4/4)	Failed (2/2)	Failed (2/2)
	HT-125	90 %	112.5 ksi	Failed (2/3)	N/T	N/T

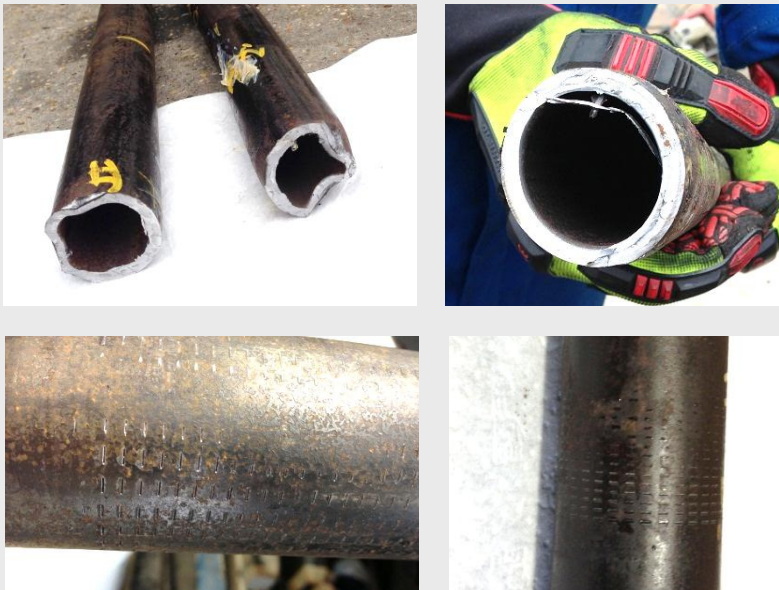


**Improved SSC resistance of BlueCoil™ CT allows 20ksi to 30ksi higher strength grades than conventional CT**

# BlueCoil™ CT Handling and Equipment Compatibility



## BOP shear and slip tests



- 4-1/16" & 5-1/8" 15K BOPs
  - HT-110 & HT-125 CT
  - 2.0" & 2-3/8" x 0.204" CT
  - All straight/clean cuts achieved
- 
- No slip at 50,000 lb pull & push

# BlueCoil™ CT Handling and Equipment Compatibility



## Injector and BHA connector tests



- HT-125, 2.0" x 0.204" CT
  - HR 680 Injector
  - No slippage at 80k lb pull
- 
- Dimple, slip & set screw connectors
  - No movement under 20k lb pull



# BlueCoil™ CT Field Operations



## **Commercial operations**

- **March-April 2015, Eagle Ford field**
- **2.375" x 0.204" HT-125; 20,500ft**
- **26 runs**
- **Depths up to 19,600ft**
- **Plug milling**
- **Cleanouts**
- **Fishing jobs**
- **Complete success**

# Process Video



# BlueCoil™ Technology Summary



## □ New CT technology platform

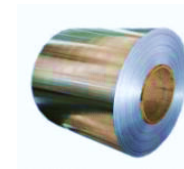
- New steel chemistries
- New heat-treatments
- Platform for meeting extreme demands

## □ Fundamentally better microstructure

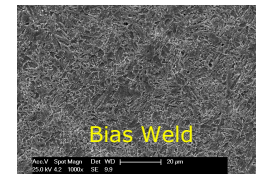
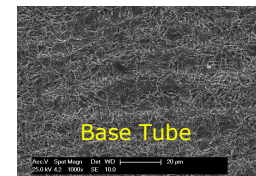
- Tempered martensite vs. ferrite, pearlite, and bainite

## □ Uniform microstructure along CT string

- Implemented continuously and at the last manufacturing stage
- Same in base tube, bias weld & seam weld

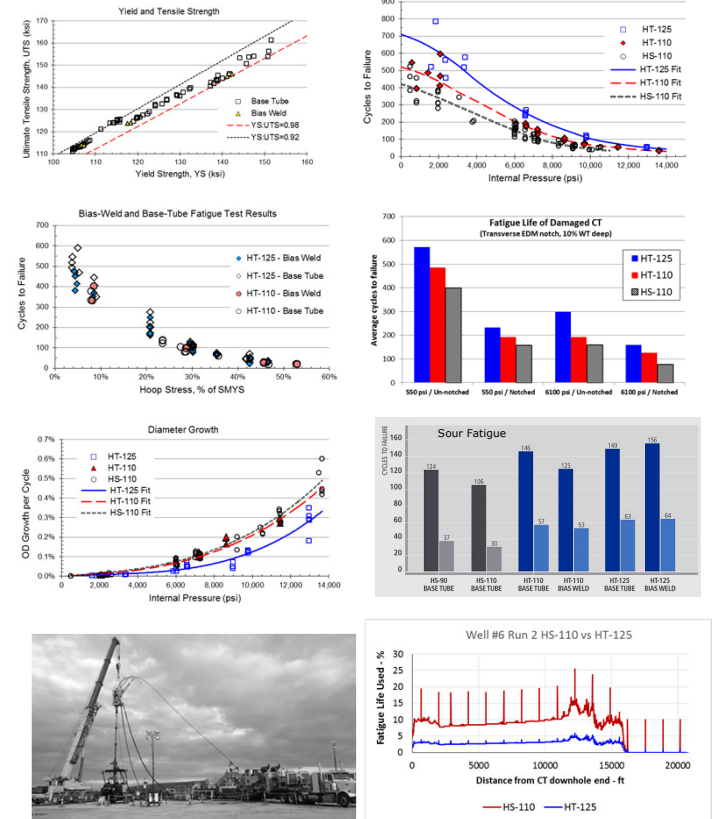


New Steels



# Summary of Benefits

- ❑ **Much higher yield-strength grades are possible without degrading performance**
  - Higher pressures, deeper wells, more safety margin
- ❑ **Better fatigue performance vs. conv. CT**
  - Base-tube life longer for the same grade
  - 2 to 4 times longer bias-weld fatigue life
  - Better fatigue resistance of damaged CT
  - Better CT utilization and more reliability
- ❑ **Less pipe ballooning than conv. CT**
  - Enables higher pressures and flow rates
- ❑ **Longer sour fatigue life for entire string**
  - Even for ultra-high strength CT grades
  - Bias-weld sour fatigue life similar to base tube
  - Lower likelihood for CT failures
- **Improved SSC resistance**
  - Allows 20ksi-30ksi higher strength grades
  - More safety and reliability margin





Thank you for your attention.

Questions?