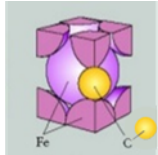


# New Coiled Tubing Grade for Improved General and Sour Service

Bruce Reichert and Radovan Rolovic  
Tenaris Coiled Tubes



ICoTA Roundtable, Calgary, Canada  
October 19, 2016



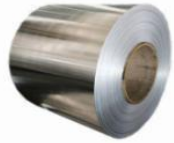


- BlueCoil® CT Technology Background
- New BlueCoil® CT Grade – HT-95
- General and Sour Performance of HT-95 CT
- Overview of BlueCoil® CT Field Experience
- Conclusions

# Conventional CT Technology and Manufacturing



**Hot-rolled LCLA steel**  
(at steel mill)



**Master coil slitting**



**Strip assembly (bias welds)**



**Milling (tube forming, ERW)**

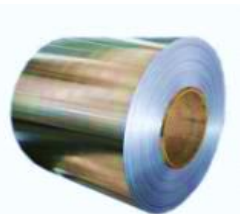


**QC & Service**



- Tube properties mostly defined by flat strip manufacturing
- Welding degrades strip properties locally
- Final tube exhibits reduced performance in and around welds

# BlueCoil<sup>®</sup> Technology & CT Manufacturing



**New Steels**



Slitting



Assembly  
(bias welds)



Milling (tube  
forming, ERW)



**Full Microstructure  
Transformation  
Heat Treatment**



QC & Service

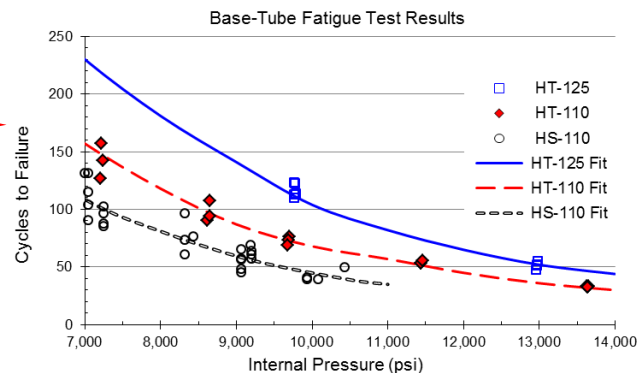
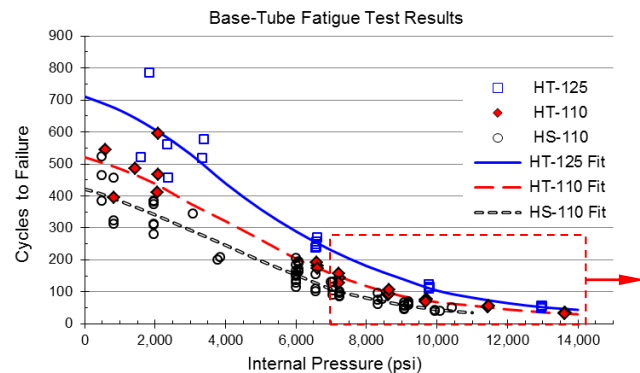
- 
- New technology platform based on new steel chemistry and new manufacturing processes
- 
- Technology platform for extending CT capability and reliability for extreme ops. demands
- 
- New, superior microstructure & much higher strength
- 
- CT properties defined continuously at the last manufacturing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

# BlueCoil® CT Base-Tube Fatigue Performance

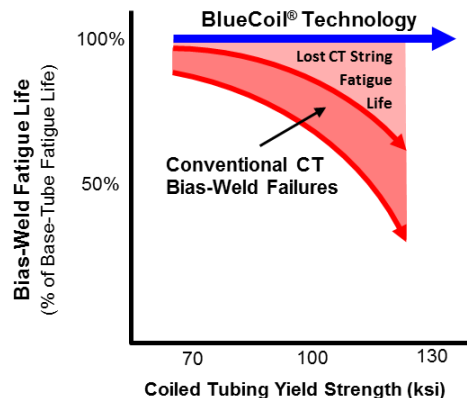
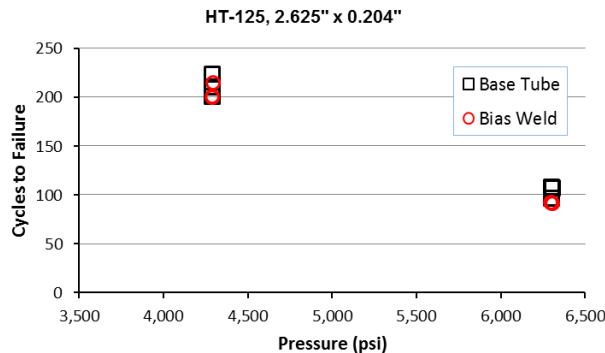
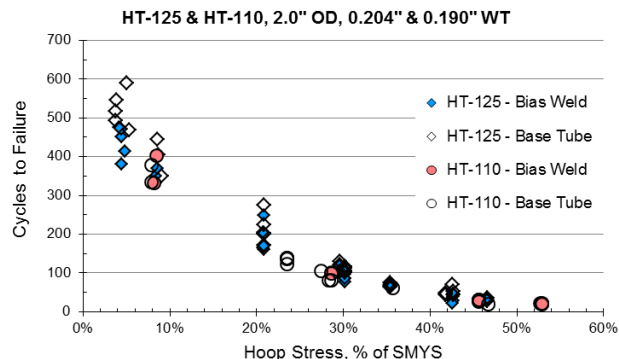


HT → BlueCoil® CT

HS → Conventional CT



# BlueCoil® CT Bias-Weld Fatigue Performance



Similar fatigue performance of BlueCoil® CT bias weld and base tube

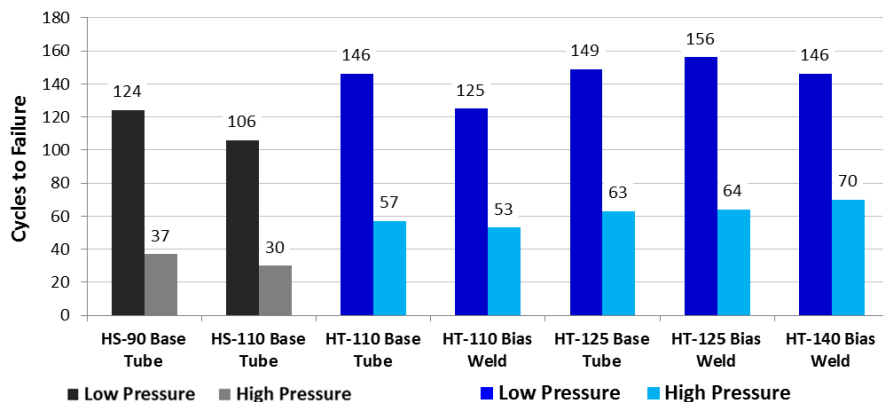
**2 to 4 times longer BlueCoil® HT-125 bias-weld life and overall CT string life than HS-110**

# BlueCoil® CT Sour Fatigue Performance



**Moderate H<sub>2</sub>S levels** ( $\leq 1.0$  psi H<sub>2</sub>S pp,  $\leq 7\%$  H<sub>2</sub>S at room p & T)  
no H<sub>2</sub>S inhibition used

Sour Fatigue Test Results

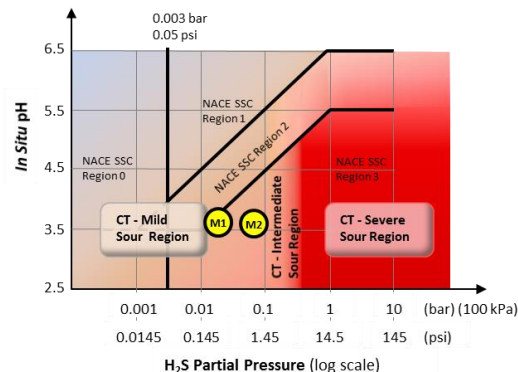


7 days H<sub>2</sub>S exposure  
(up to 1.0 psi H<sub>2</sub>S pp)

2 environments, ambient T & p

No inhibitors used

Fatigued to failure after H<sub>2</sub>S exposure



**BlueCoil® CT grades have longer sour fatigue life for tested conditions, even as the CT strength is increased**

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

# Latest Developments – Sour Performance

BlueCoil® CT - quenched and tempered martensite steels which NACE MR0175 deems acceptable for downhole casing and tubing in severe sour environments if the hardness does not exceed 26 HRC (30 HRC if  $T > 65^{\circ}\text{C}/150^{\circ}\text{F}$ ); { < 22 HRC for ferrite-pearlite microstructure of conventional CT }

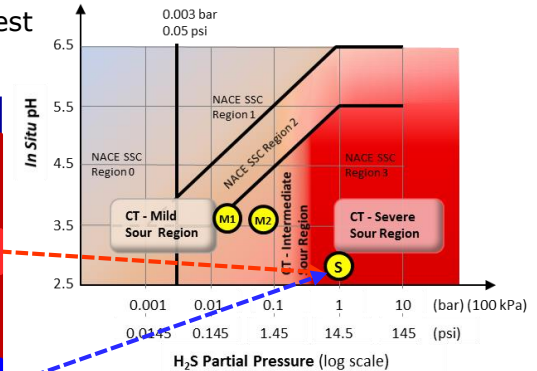
HT-95 hardness < 26 HRC

Standard NACE C-ring Test  
No Inhibitors used

Sulfide stress cracking (SSC) performance

Coiled Tubing		Stress Level		Test Environment		
Type	Grade	(% SMYS)	Absolute	Mild	Intermediate	Severe
Convent. CT	HS-80	90 %	72 ksi	Passed (5/5)	Inconclusive (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

\* Prototype-only grades



↑  
ERW

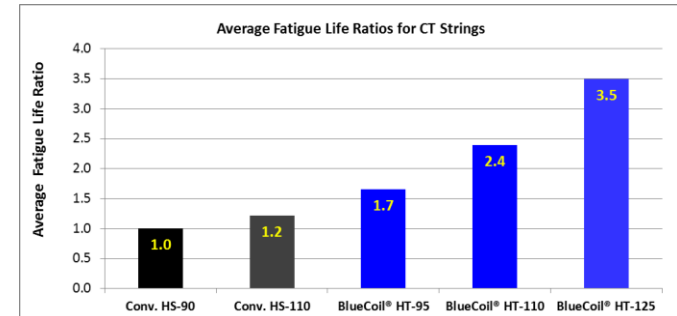
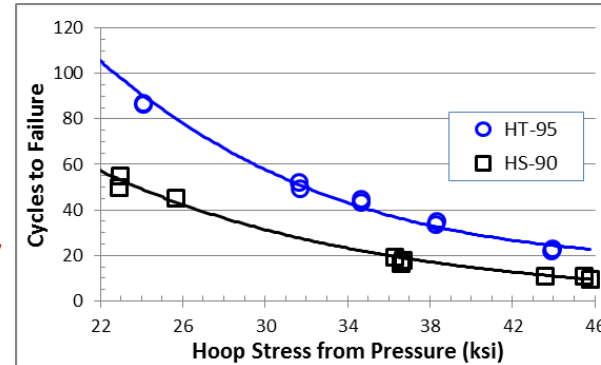
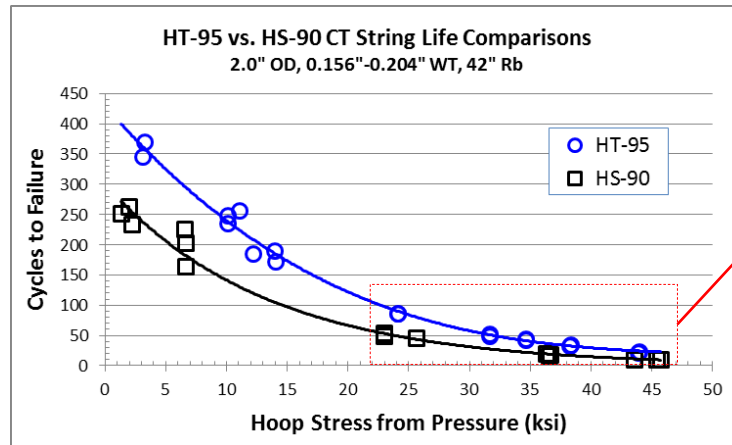
**HT-95 has good SSC performance (as good or better than higher strength HT-100) and better than any conventional CT grade**



# Latest Developments – BlueCoil® HT-95



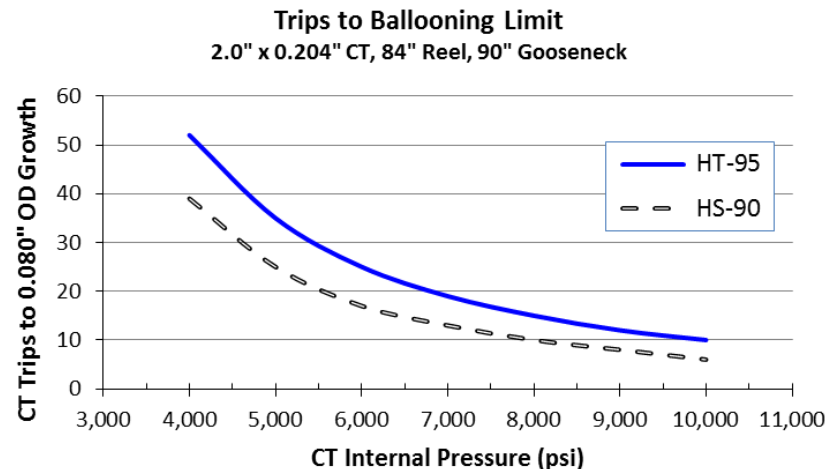
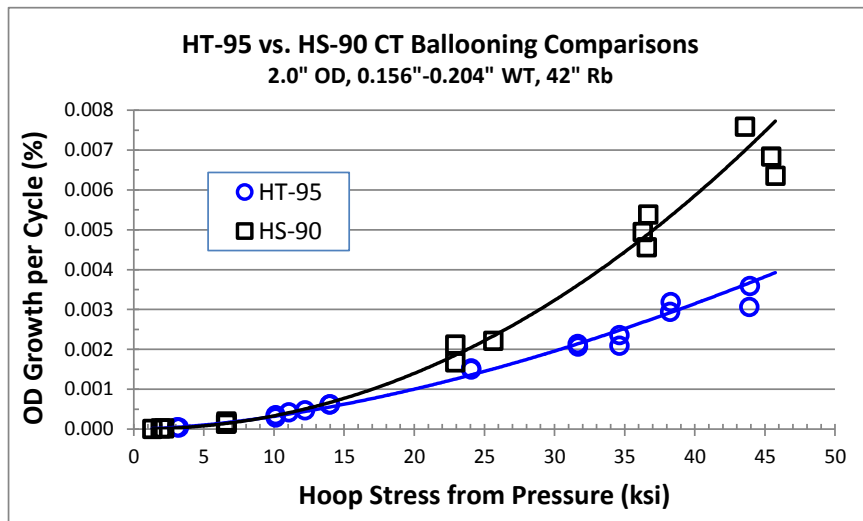
- **95 ksi minimum yield strength, hardness  $\leq$  26 HRC**
- **Much longer fatigue life than conventional HS-90 grade**



# Latest Developments – BlueCoil® HT-95

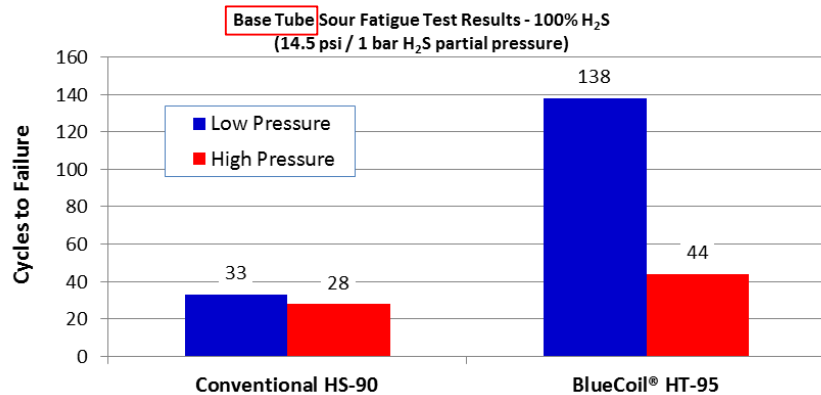


**About 40% less ballooning than HS-90  $\Rightarrow$  about 67% more CT trips before reaching max OD limit**



# Latest Developments – HT-95 Sour Performance

- **Sour fatigue performance – Severe H<sub>2</sub>S levels** ( $\geq 14.5$  psi / 1.0 bar H<sub>2</sub>S pp, 100% H<sub>2</sub>S at room p & T)
  - **No inhibition**

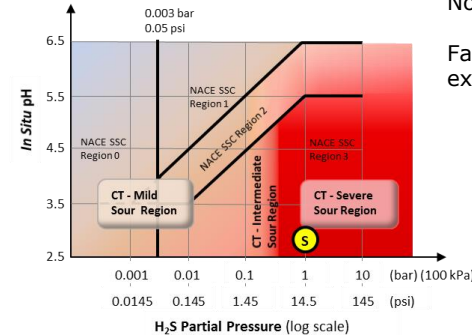


4 days H<sub>2</sub>S exposure, 100% H<sub>2</sub>S  
(1 bar/14.5 psi H<sub>2</sub>S partial pressure)

Ambient Temp & Pressure

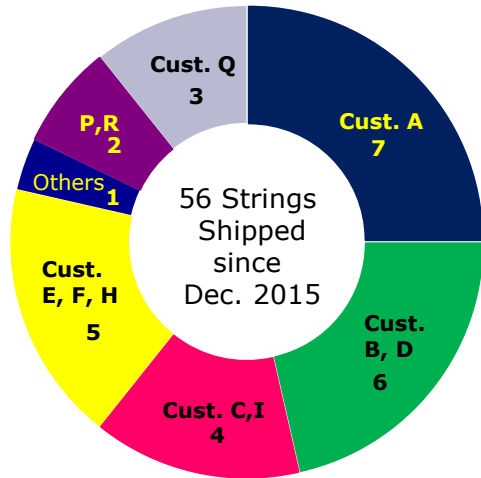
No inhibitors used

Fatigued to failure after H<sub>2</sub>S exposure



- **HT-95 showed much better sour fatigue performance than HS-90 and any other CT grade in severe H<sub>2</sub>S environments**
- **Conventional HS-90 bias-weld sour fatigue life is additionally reduced by 30-40% (SPE 130279)**
- HS-90 has been used successfully (with H<sub>2</sub>S inhibition) in wells with severe H<sub>2</sub>S levels
- No H<sub>2</sub>S inhibition was used in these sour fatigue tests for a more direct comparisons between materials/grades
- **Effective H<sub>2</sub>S inhibition should be used in CT field applications within NACE Region 3**

# BlueCoil® CT Commercial Usage – as of Sep. 2016

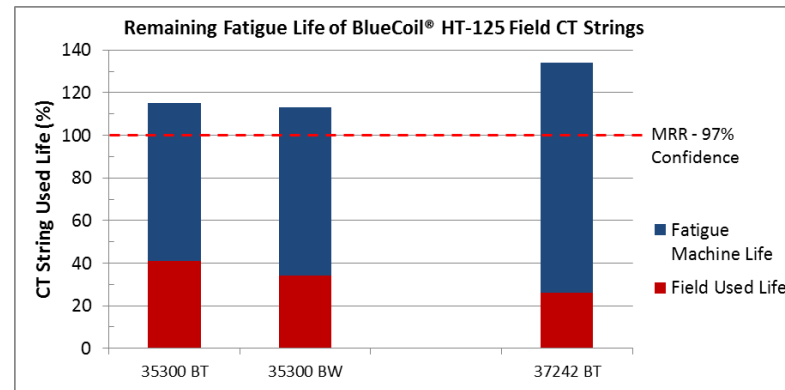


- ❑ **1.1 million** feet of BlueCoil® CT shipped
  - 1.75" - 2.625" OD, 0.125" - 0.250" WT
  - > 20 tapered CT strings
- ❑ **18** customers
- ❑ **12 million** total CT running feet in field operations
- ❑ Multiple strings with over 800K running feet
- ❑ **55%** maximum used fatigue life for a CT string so far (2.375" OD, >800K running feet in mostly high pressure operations)

# BlueCoil® CT Commercial Usage



- **56** CT strings shipped
  - **30** operational
  - **10** retired
    - **4** stuck and cut
    - **2** mechanically damaged
    - **4** voluntarily retired – Eagle Ford
      - Customer E - 800K running feet – Case study coming soon
      - Customer A - 500K running feet – Field test - Eagle Ford SPE 179048
      - Customer B - 716K running feet – May continue usage
      - Customer B - 690K running feet
- 16** in transit or waiting for jobs



# Summary of BlueCoil® CT Benefits



## ❑ Better fatigue performance vs. conventional CT

- Base-tube life longer for the same grade (better steel microstructure)
- 2 to 4 times longer bias-weld and CT string fatigue life
- Better fatigue resistance of damaged CT

## ❑ Less pipe ballooning than conventional CT

- Enables higher pressures and flow rates, with improved CT service life

## ❑ Longer sour fatigue life with higher strength CT grades

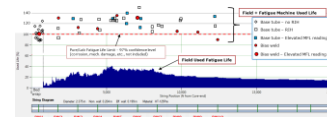
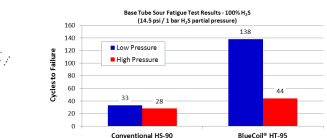
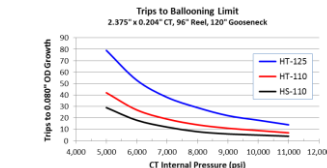
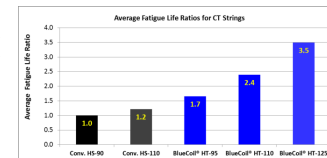
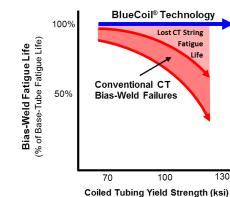
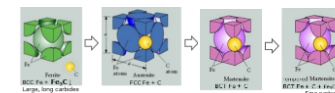
- Allows higher overpull and pressure capacity, & longer life in sour applications

## ❑ Improved sulfide stress cracking (SSC) resistance

- Allows 20 ksi-30 ksi higher strength CT grades for similar SSC resistance

## ❑ Much higher yield-strength grades are possible without degrading CT performance

- Enables work at higher pressures, in deeper wells, with more safety margin
- Enables larger CT ODs for longer extended reach, with improved service life





Thank you for your attention.

Questions?