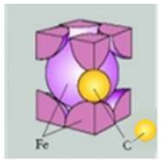
Field Performance of BlueCoil Including Performance of Mechanically Damaged CT

Radovan Rolovic & Bruce Reichert
Tenaris Coiled Tubes



ICoTA Roundtable, Calgary, Canada
October 25, 2017

Tenaris

Outline

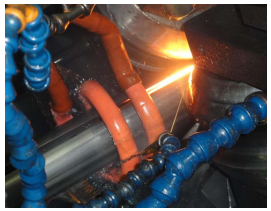
- Brief technology background
- Overall field performance of new technology CT
- Field performance of mechanically damaged new technology CT
- Laboratory testing of mechanically damaged CT
- Conclusions

New Technology & CT Manufacturing

New Steel Chemistry

Slitting

Assembly (bias welds)

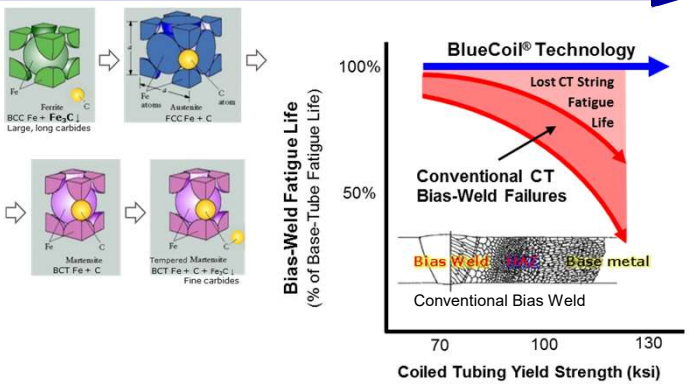


Milling (tube forming, ERW)

Full Microstructure Transformation Heat Treatment

QC & Shipping

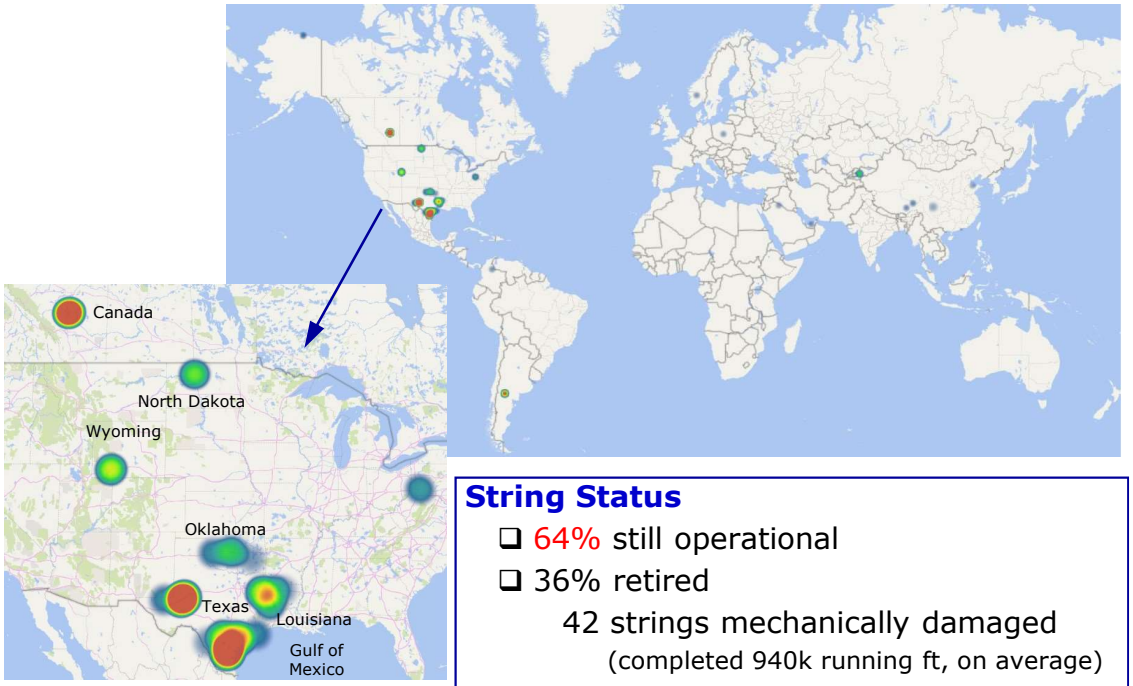
- Uniform and improved steel microstructure and properties across entire CT string, including all welds
- 95, 110, 125 and 140 ksi min. yield strength grades
- No bias weld de-rating



Commercial Usage of New Technology CT

Over 240 CT Strings deployed since 2015

- >5 million feet of CT shipped
  - 1.75" - 2.625" OD, 0.125" - 0.250" WT
  - >70% tapered-wall CT strings (all with gradual/continuous wall thickness change)
  - HT-125, HT-110 & HT-95 grades
  - 26,500 ft max string length (2.375" OD)
- 47 customers (33 in North America)
- >90 million total CT running feet in field operations (>4,000 jobs)
- 6 strings with >1.5 million running feet
  - 17 strings > 1 million running feet
  - 49 strings > 800k running feet
- 92% maximum used fatigue life for a CT string (1,016k running feet)
- 1.9 million maximum running feet with a CT string (at 89% used life)



String Status

- 64% still operational
- 36% retired
  - 42 strings mechanically damaged (completed 940k running ft, on average)
  - 22 strings voluntarily retired (after 1,100k running ft, 2017 average)

Similar conventional CT strings have been used up to about 400k to 500k RF, on average, in same operations

Commercial Usage of New Technology CT

Most used HT CT strings (completed ~2-4 times more downhole work than conventional CT on similar jobs)

	Grade	OD (WT)	Length (ft)	Area	Jobs	Pressure	Used Life	Running ft	Still Operational ?
1	HT-125	**2.375** (0.204-0.175)	25,368	West Texas	**69**	HP, some LP	**89%**	**1.90 M**	No (mechanically damaged)
2	HT-125	**2.375** (0.204-0.175)	24,105	South & West Texas	64	HP, some LP	**77%**	**1.85 M**	No (mechanically damaged)
3	HT-125	**2.375** (0.224-0.175)	21,000	South Texas	**72**	HP, some LP	**92%**	**1.68 M**	No (voluntarily retired by client)
4	HT-125	**2.375** (0.204-0.175)	25,933	West Texas	55	HP, some LP	61%	**1.62 M**	Yes
5	HT-125	**2.375** (0.204-0.175)	22,800	Oklahoma	**77**	HP, MP, LP	45%	**1.61 M**	No (voluntarily retired by client)
6	HT-125	**2.375** (0.204-0.156)	22,500	West Texas	50	HP, some LP	**78%**	**1.55 M**	No (voluntarily retired by client)
7	HT-125	**2.375 (0.224-0.250-0.156)**	23,300	West Texas	**76**	HP, some LP	48%	**1.43 M**	No (mechanically damaged)
8	HT-110	**1.75** (0.156)	12,680	Canada	N/A	LP-MP	N/A	**1.25 M**	No (mechanically damaged)
9	HT-125	**2.375** (0.204)	22,410	Louisiana, East Texas	37	HP, some LP	46%	**1.17 M**	No (mechanically damaged)
10	HT-125	**2.375** (0.204-**0.250**-**0.134**)	23,500	North Dakota	57	HP, some LP	49%	**1.15 M**	No (voluntarily retired by client)
11	HT-125	**2.625 (0.224-0.250-0.156)**	23,648	South & West Texas	**58**	HP-LP	39%	**1.13 M**	No (voluntarily retired by client)

Similar conventional CT strings have been used up to about 425k RF, on average, in same operations

Commercial Usage of New Technology CT

Most used **2.625" CT** strings

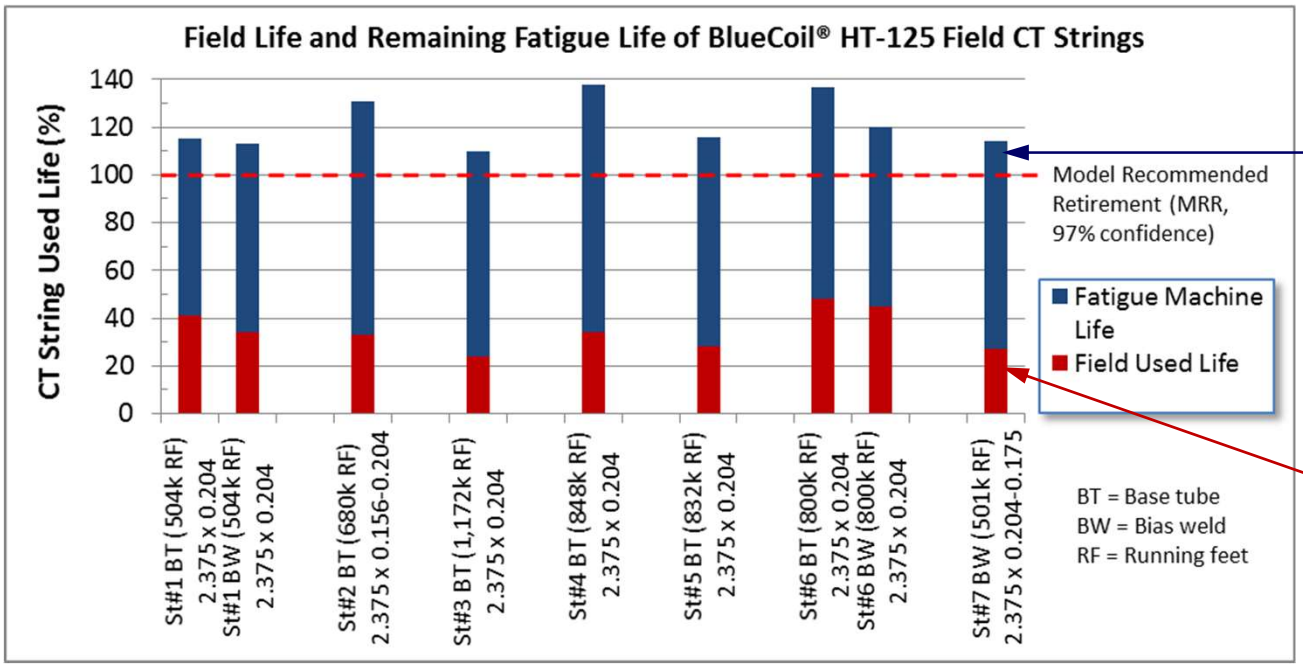
	Grade	OD (WT)	Length (ft)	Area	Jobs	Pressure	Used Life	Running ft	Still Operational ?
1	HT-125	**2.625** (0.224-0.250-0.156)	23,648	South & West Texas	**58**	HP-LP	39%	**1,126 k**	No (voluntarily retired by client)
2	HT-125	**2.625** (0.224-0.156)	21,500	South Texas	31	HP-LP	51%	**1,049 k**	Yes
3	HT-125	**2.625** (0.224-0.175)	22,947	South Texas	45	HP-LP	28%	**988 k**	Yes
4	HT-125	**2.625** (0.224-0.156)	23,563	South Texas		HP-LP	43%	**915 k**	Yes
5	HT-125	**2.625** (0.204)	23,019	West Texas	39	HP-LP	48%	**899 k**	Yes
6	HT-125	**2.625** (0.224-0.156)	22,000	West Texas	38	HP, some LP	68%	**894 k**	No (Corrosion damage)
7	HT-125	**2.625** (0.250-0.156)	21,204	West Texas		HP-LP	43%	**877 k**	No (mechanically damaged)
8	HT-125	**2.625** (0.204)	22,000	South Texas	29	HP-LP	53%	**852 k**	No (Mechanically damaged)
9	HT-125	**2.625** (0.224-0.250-0.156)	23,500	West Texas	33	HP, some LP	54%	**811 k**	No (voluntarily retired by client)
10	HT-125	**2.625** (0.224-0.175)	24,058	West Texas	30	HP-LP	35%	**758 k**	No (mechanically damaged)

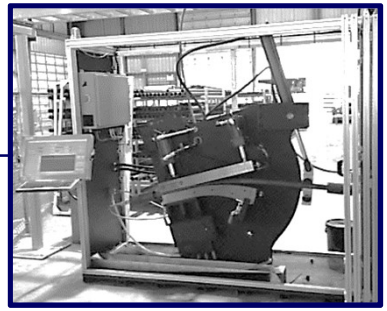
Similar conventional 2.625" CT strings have been used up to about 300k-400k RF, on average, in same operations

Performance of New Technology CT

Several CT strings have been tested after field use between 0.5M and 1.2M RF

- Total used life longer than the model recommended retirement (MRR) limit, including bias welds



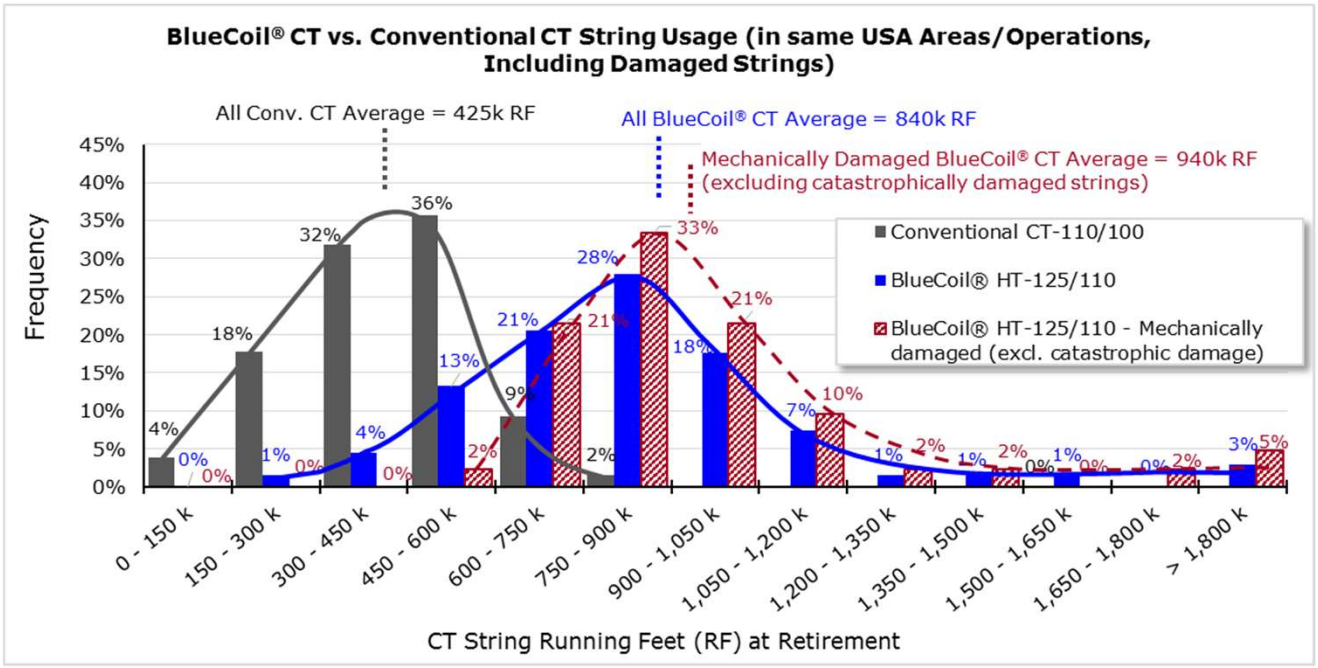


Similar conventional CT strings have been used up to about 400k to 500k RF, on average, in same operations

CT Damage – Main CT Retirement Cause

Field Usage & Performance Comparisons

Actual field usage of Conventional CT-110/100 and HT-125/110 CT strings in the same USA areas/operations, including damaged strings



CT Field Retirement Statistics for:

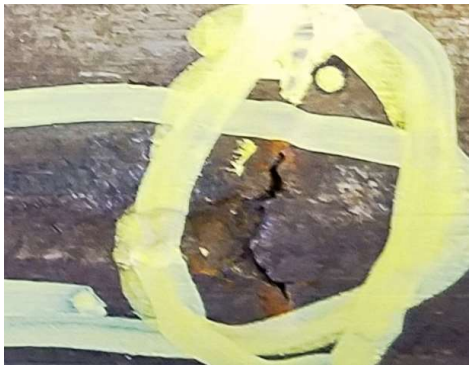
- All 100+ Conv. CT-110/100 strings retired since 2013
- All 68 HT-125/110 retired strings
- All 42 mechanically damaged retired HT-125/110 strings (out of above 68 strings, excluding catastrophically damaged & stuck/cut strings)

New technology CT strings, including damaged strings, on average completed 2 times more field work than conventional CT strings

CT Life after Field Mechanical Damage

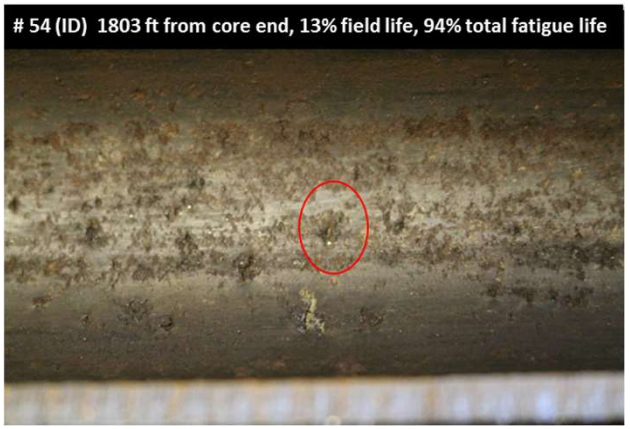
- Field damaged CT section - plough mark (no pinhole leak)
- HT-125, 2.375” x 0.190”
- Field used fatigue life was 25%
- Fatigue tested to failure at 7,100 psi on 48” bending radius
- Deep end of plough mark was on intrados in fatigue machine gage section at typical failure distance along the gage section
- Additional fatigue machine life was 45% (failed at the deep end of plough mark)
- Total life = 70%

Photo after sample failure in fatigue machine



CT Life after Field Corrosion Damage

- Field damaged CT section – Internal corrosion pitting (no field failure)
- HT-125, 2.375” x 0.204”, used on 26 South Texas jobs, 504k running feet
- Field used fatigue life was 13% at corrosion damage (41% for CT string)
- Fatigue tested to failure at 6,700 psi
- Additional fatigue machine life was 81% (failed at a corrosion pit)
- Total life = 94%

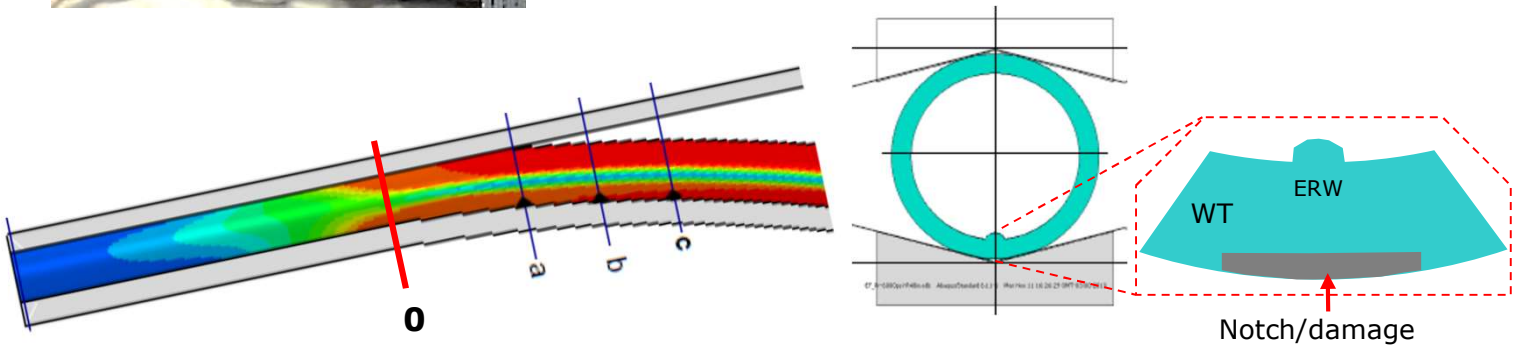


Pitting depth up to 15% of wall thickness (up to ~0.030”)

Fatigue Performance - Damaged CT Testing

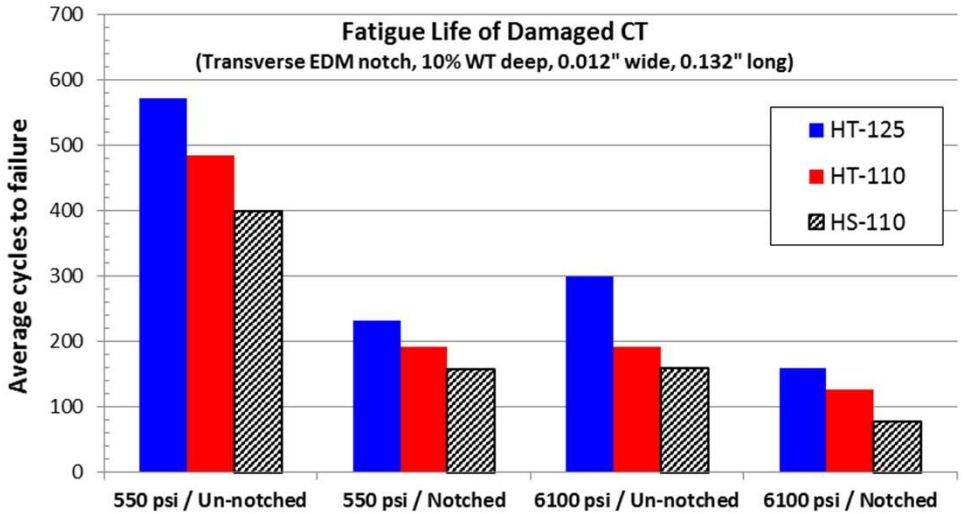
Test conditions:

- ❑ 3 same transverse EDM notches on OD intrados along ERW at ~ 2.3” apart, starting at 4” into the gage section (this is where undamaged CT normally fails)
- ❑ New 2.0” x 0.204” CT
- ❑ 5%, 10%, an 15% WT notch depth, 0.012” wide (longitudinally), 7x transverse length to depth ratio, sharp corners
- ❑ HT-125, HT-110, HS-110
- ❑ 500 psi and 6100 psi fatigue tests
- ❑ 3 repeated fatigue tests for each grade and condition



Fatigue Performance - Damaged CT Testing

Test results for 10% deep transverse notches in HT-125, HT-110 and Conventional HS-110 base tube (averages of 3 tests)



Undamaged CT

Fatigue Life Ratio, undamaged CT		
Grade/Grade	Low Pressure	Mid Pressure
HT-110/HS-110	121%	120%
HT-125/HS-110	143%	187%

Damaged CT

Remaining Life Ratio, sharp transverse cut, 10% WT deep		
Grade/Grade	Low Pressure	Mid Pressure
HT-110/HS-110	123%	163%
HT-125/HS-110	148%	204%

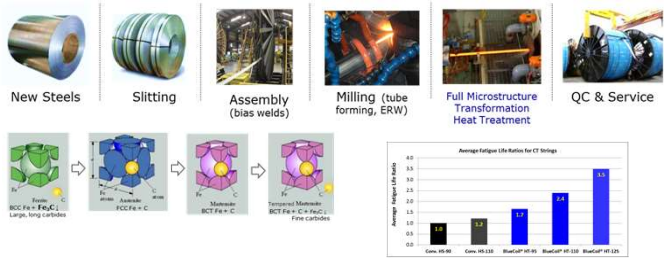
HT CT advantage increased after CT damage

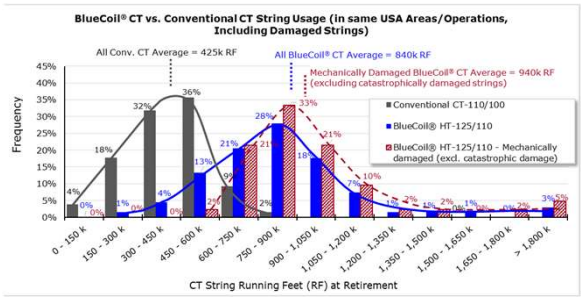
Much more HT CT residual life after CT damage, with even bigger advantage at bias weld

Removing/grinding out these notches (up to ~15% deep) to a smooth surface restores the fatigue life close to 100%

Summary of New Technology CT Performance

- **Proven field performance**
  - > 240 field strings (1.75” – 2.625” OD, majority 2.375”)
  - > 2 years in field operations
  - > 4000 CT jobs, majority high pressure
  - > 90 million running feet
- **Much longer field life vs. conventional CT**
  - 2 to 4 times more downhole work with a CT string
- **Much longer CT string life even when damaged**
  - Twice longer field use after CT string gets damaged, on average
- **Lower operational risk and cost**





Thank you for your attention.

Questions?