NEXT SHALE 2017

Organized by: dmg::events

Navigating the Future of Unconventional Resources

Shale Completions: Coiled Tubing Workstring Design for Extended Reach Shale Wells

Tenaris

Agenda

- Introduction and main Coiled Tubing challenges for Plug&Perf completions in longer laterals.
- Lateral Reach Challenges
  - String Design Objectives and Alternative Solutions
  - Operational Demands on Coiled Tubing String Designs
- Fatigue and New Product Technology in CT Metallurgy
- Coiled Tubing Field Usage and Top Performers
- Conclusions

Shale Wells: Longer Laterals´ Challenges

Coiled Tubing Milling Plugs

Completion Challenges

Plug & Perf

Lateral Reach

Weight on Bit

Fatigue

Longer Laterals (1500 – 3200 m), more than 25/30 frac stages (P&P)

Lateral Reach Challenges

As axial compression force increases

↓

Friction between CT and wellbore increase

↓

Helical buckling occurs when
Axial Force > HBL

↓

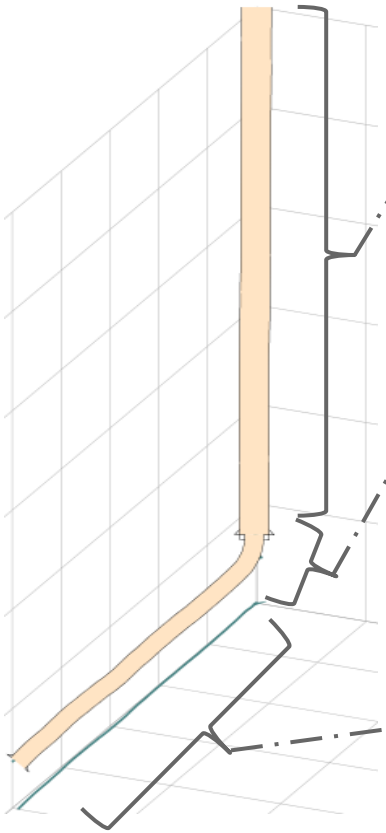
Wall contact force (WCF) increases

↓

Force transfer loss increase/WOB decrease

↓

Helical lockup is defined as 1% or less of force applied at surface is transferred to the CT

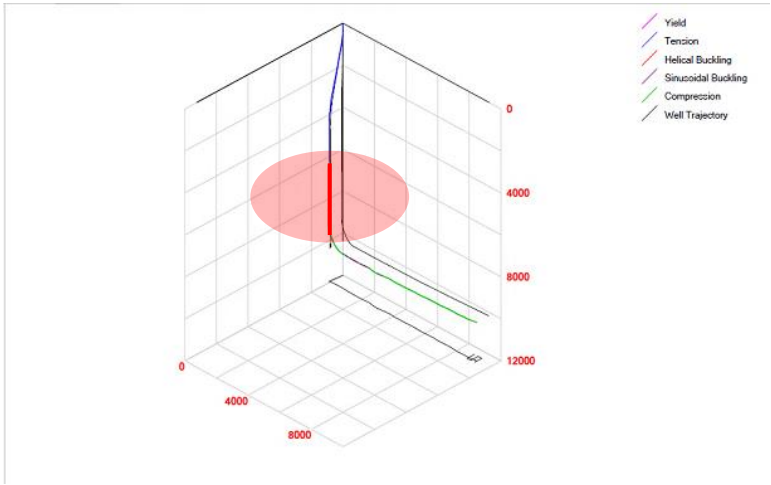


- **Vertical**
  - HBL is virtually zero (straight pipe)
  - High force transfer loss due to WCF once helical buckling occurs
- **Heel**
  - If CT is buckling as it enters heel; buckling will continue.
  - Reduction of lateral reach
  - If no buckling, the build rate has minimal effect on lateral reach
- **Lateral/Horizontal**
  - Most wall contact in the lateral is due to buoyant weight of tubing

Lateral Reach Challenges

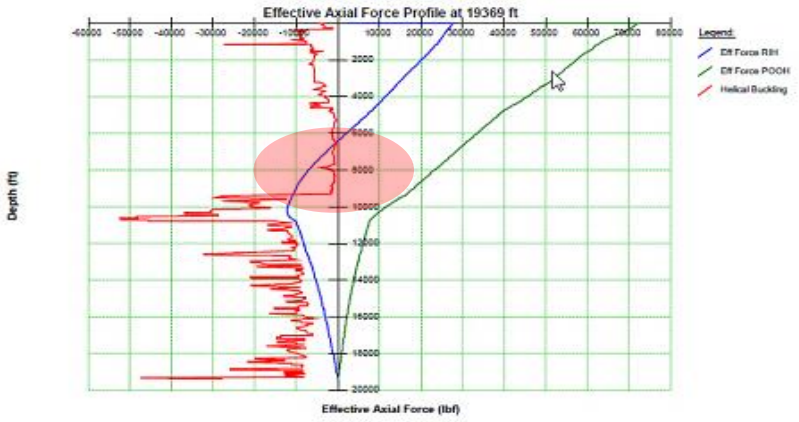
Objective

- Delay helical buckling of the CT as long as possible
- Minimize force transfer loss due wall contact force
- Maximize weight on bit



Potential Solutions

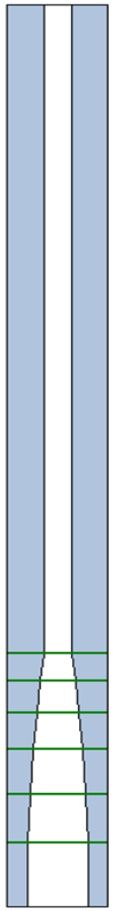
- Optimize wellbore design
  - Built rate, toe inclination, lateral tortuosity
  - Minimize annular clearance between casing and CT to reduce Helical Buckling
- Fluid selection (Reduce casing/CT friction)
- Tools (tractors, fluid hammer, etc)
- Optimized Coiled Tubing Design



Lateral Reach Challenges

Operational Demands on Coiled Tubing String Design

Tapered Design



Increase CT OD

- ↓ Wall Contact Force
- ↓ Force transfer loss
- ↑ Stiffness
- ↑ Pumping rate
- ↑ Annular velocity

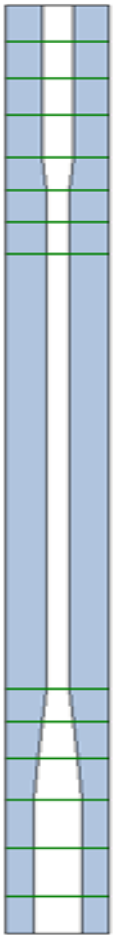
Increase Wall Thickness

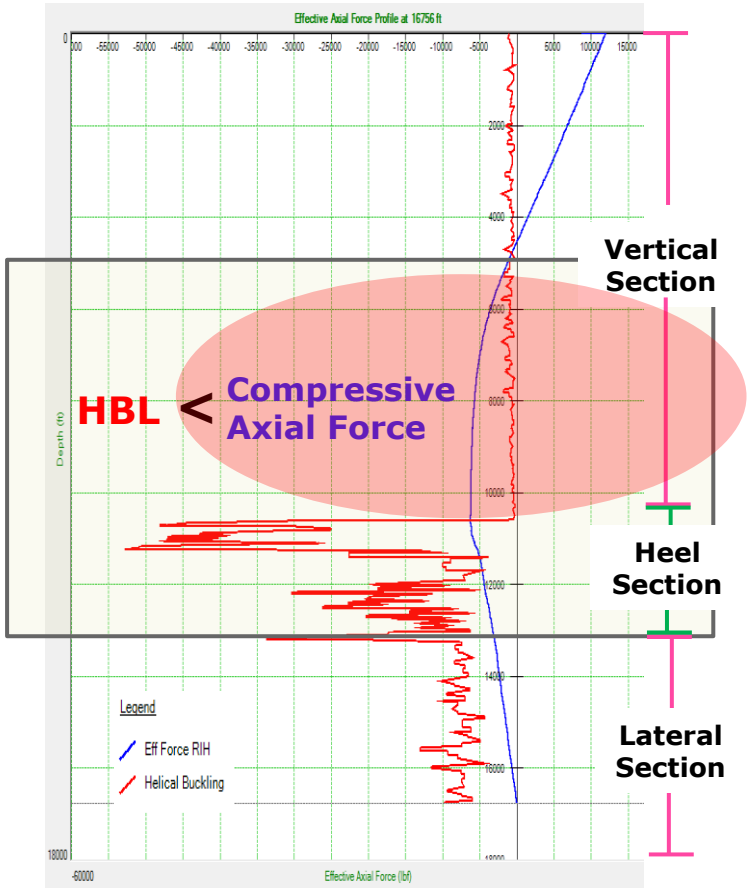
- ↑ Stiffness
- ↓ Wall Contact Force
- ↓ Force Transfer Loss

Reduce Wall Thickness

- ↓ Friction in Lateral
- ↓ Overall Weight

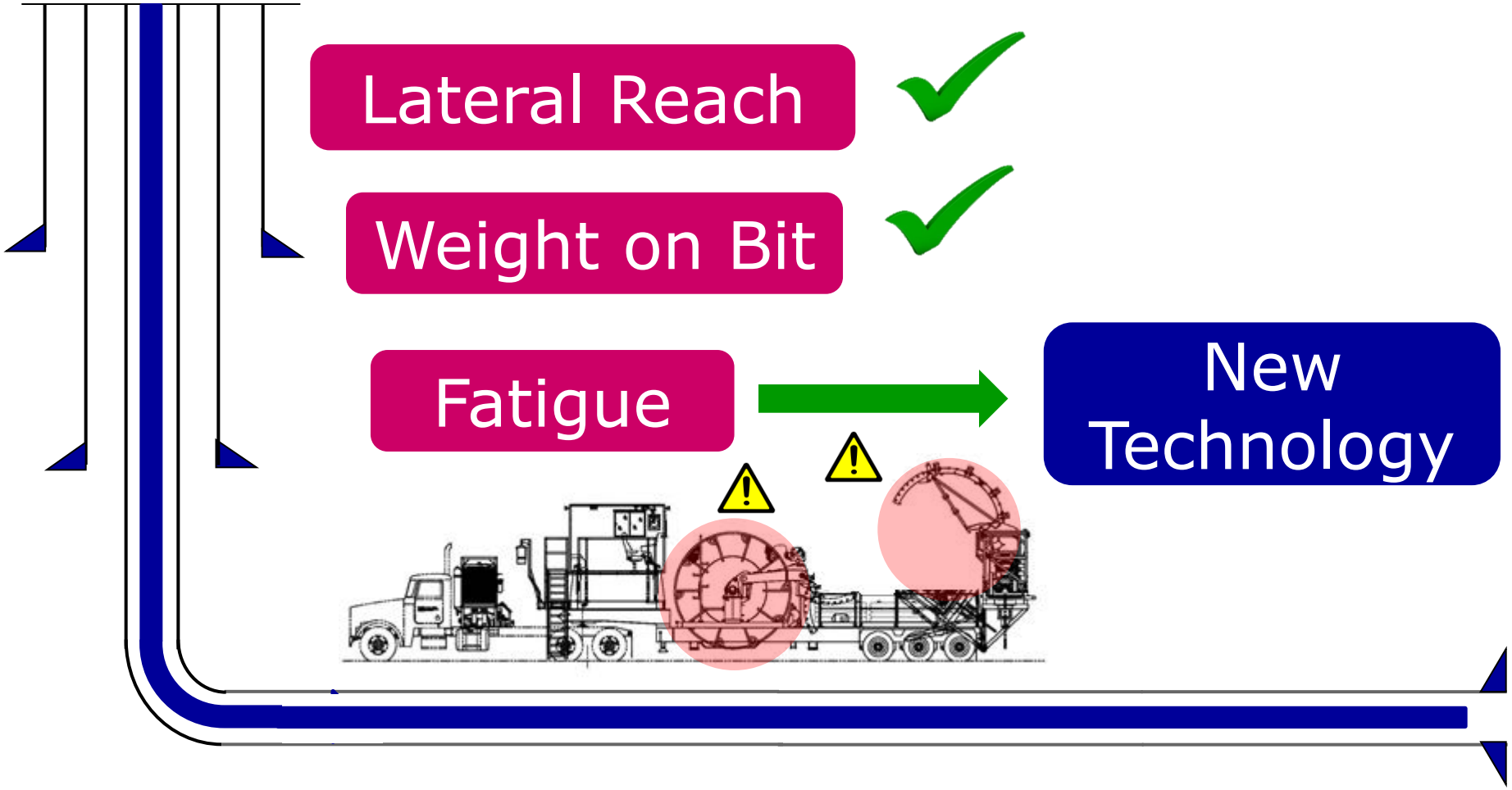
Hourglass Design





Shale Wells: Longer Laterals´ Challenges

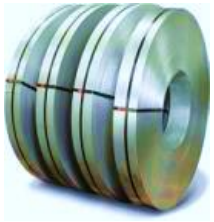
Coiled Tubing Milling Plugs



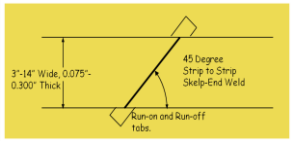
Fatigue and New Product Technology

New Coiled Tubing Technology and Manufacturing

New Steel Chemistry



Slitting



Assembly (bias welds)

Milling (tube forming, ERW)

Full Microstructure Transformation Heat Treatment

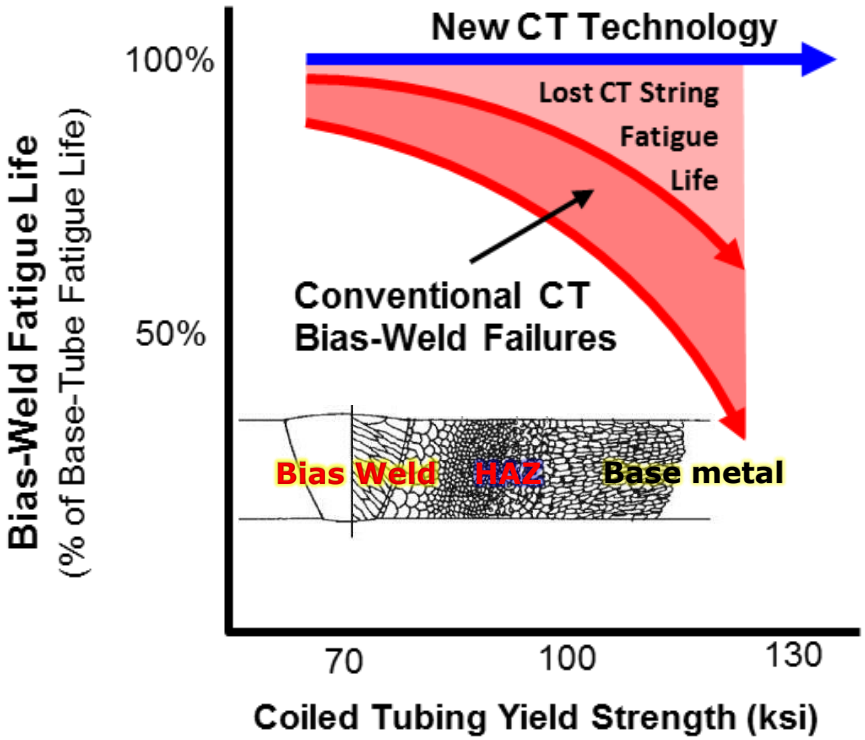
QC & Service

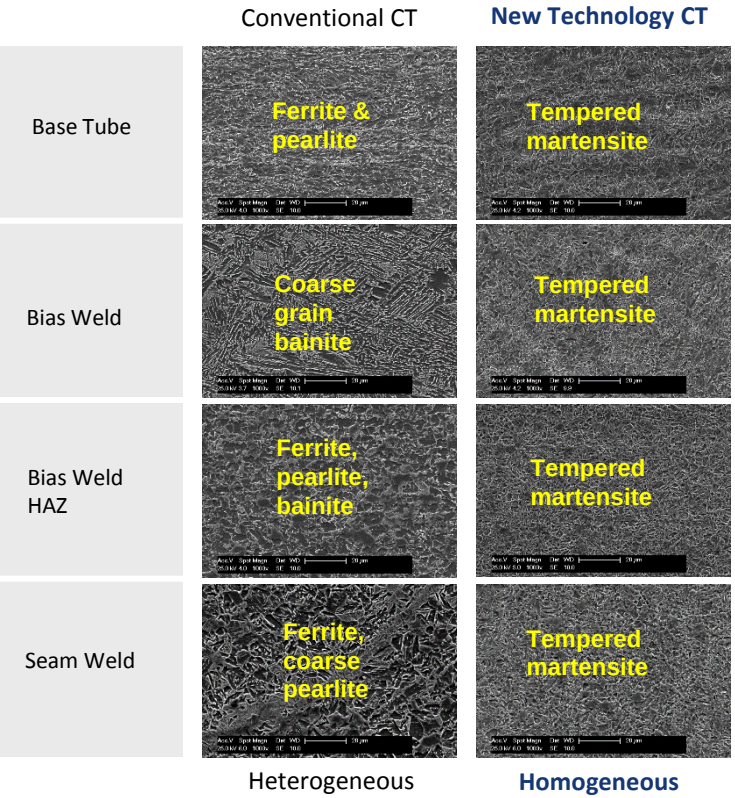
- New technology platform based on new steel chemistry and new manufacturing processes
- Technology platform for extending CT capability and reliability for extreme operational demands
- New, superior microstructure & much higher strength
- CT microstructure & properties defined continuously after all string forming and welding is done
- Uniform microstructure and properties along entire CT string, including all welds

Fatigue and New Product Technology

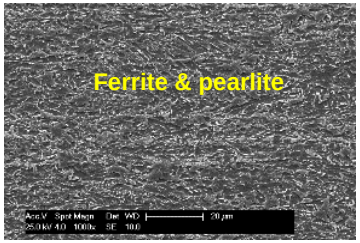
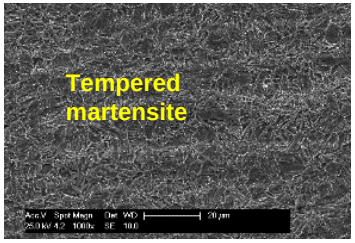
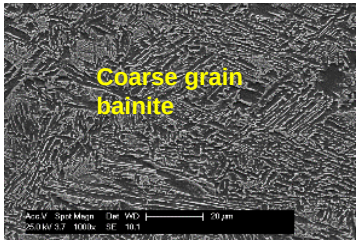
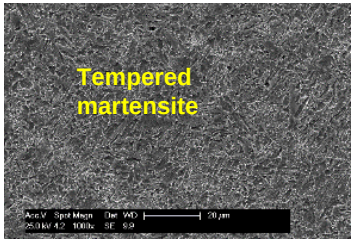
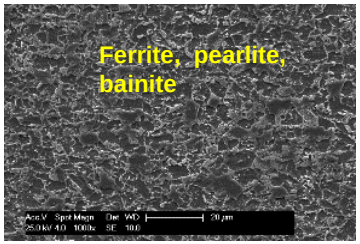
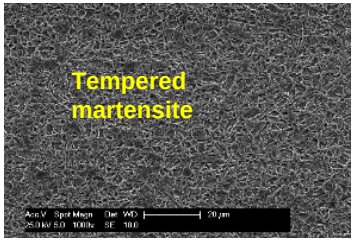
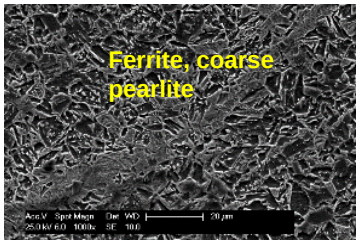
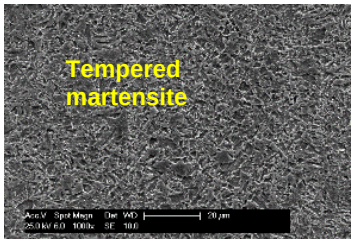
Full Metalurgical Transformation of CT String

- Prior base tube, weld & HAZ microstructures "erased"
- New technology bias welds same as base tube





Fatigue and New Product Technology

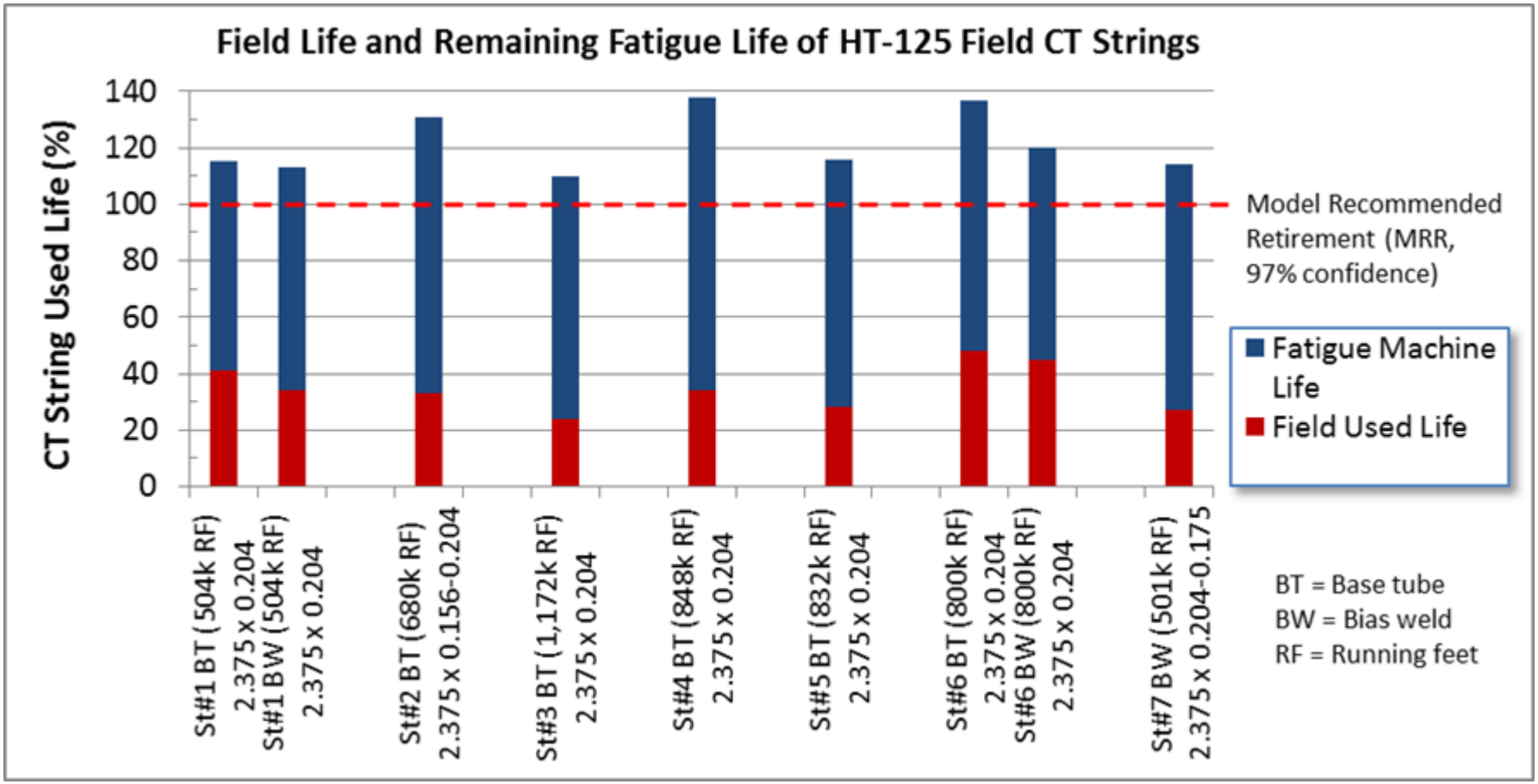
	Conventional CT	**New Technology CT**
Base Tube		
Bias Weld		
Bias Weld HAZ		
Seam Weld		
	Heterogeneous	**Homogeneous**

New Tech Coiled Tubing Field Usage

Fatigue and New Tech CT Performance

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



Field Usage – Top Performers

String	CT Grade	OD (WT)	Length (ft)	Area	No. of Jobs	CT Press.	Used Life (MRR)	Running feet	Still Operational ?
T1	HT-125	2.375 (0.204-0.175)	24,105	South & West Texas	64	HP-LP	**77%**	**1,850 k**	No
T2	HT-125	**2.375 (0.204-0.156)**	22,500	West Texas	50	HP-MP	**78%**	**1,547 k**	No (voluntarily retired by client)
T3	HT-125	2.375 **(0.224-0.250-0.156)**	23,300	West Texas	**76**	HP-MP	48%	**1,432 k**	No (mechanically damaged)
S1	HT-110	**1.75** (0.156)	12,680	Canada	N/A	LP-MP	N/A	**1,249 k**	No (mechanically damaged)
T4	HT-125	2.375 (0.204-0.175)	22,800	Oklahoma	56	HP-MP	34%	**1,219 k**	Yes
S2	HT-125	2.375 (0.204)	22,410	Louisiana, East Texas	37	HP-LP	46%	**1,172 k**	No (mechanically damaged)
T5	HT-125	**2.0** (0.204-0.175)	21,950	East Texas	24	HP-MP	54%	**1,110 k**	No (voluntarily retired by client)
T6	HT-125	2.0 (0.175–0.156)	16,580	Wyoming	48	HP-LP	**92%**	**1,016 k**	No (voluntarily retired by client)
...	...	...	...	...	...	...	...	...	...
T7	HT-125	**2.625** (0.224-0.156)	22,000	West Texas	N/A	HP-LP	83% eq.	**877 k**	No (mechanically damaged)

Most used CT strings (completed 2-3 times more jobs than conventional CT on similar jobs)

Conclusions

- ✓ Achieving sufficient weight on bit to mill out all plugs is one of the key issues in lateral reach
  - Specially engineered designs with geometrical combinations of OD´s and wall thickness increases WOB by reducing force transfer losses
- ✓ New technology for CT allow specialized engineering string to reach target depth while optimizing fatigue life
- ✓ Field data has validated the success of the new technology strings performance in longer lateral wells