

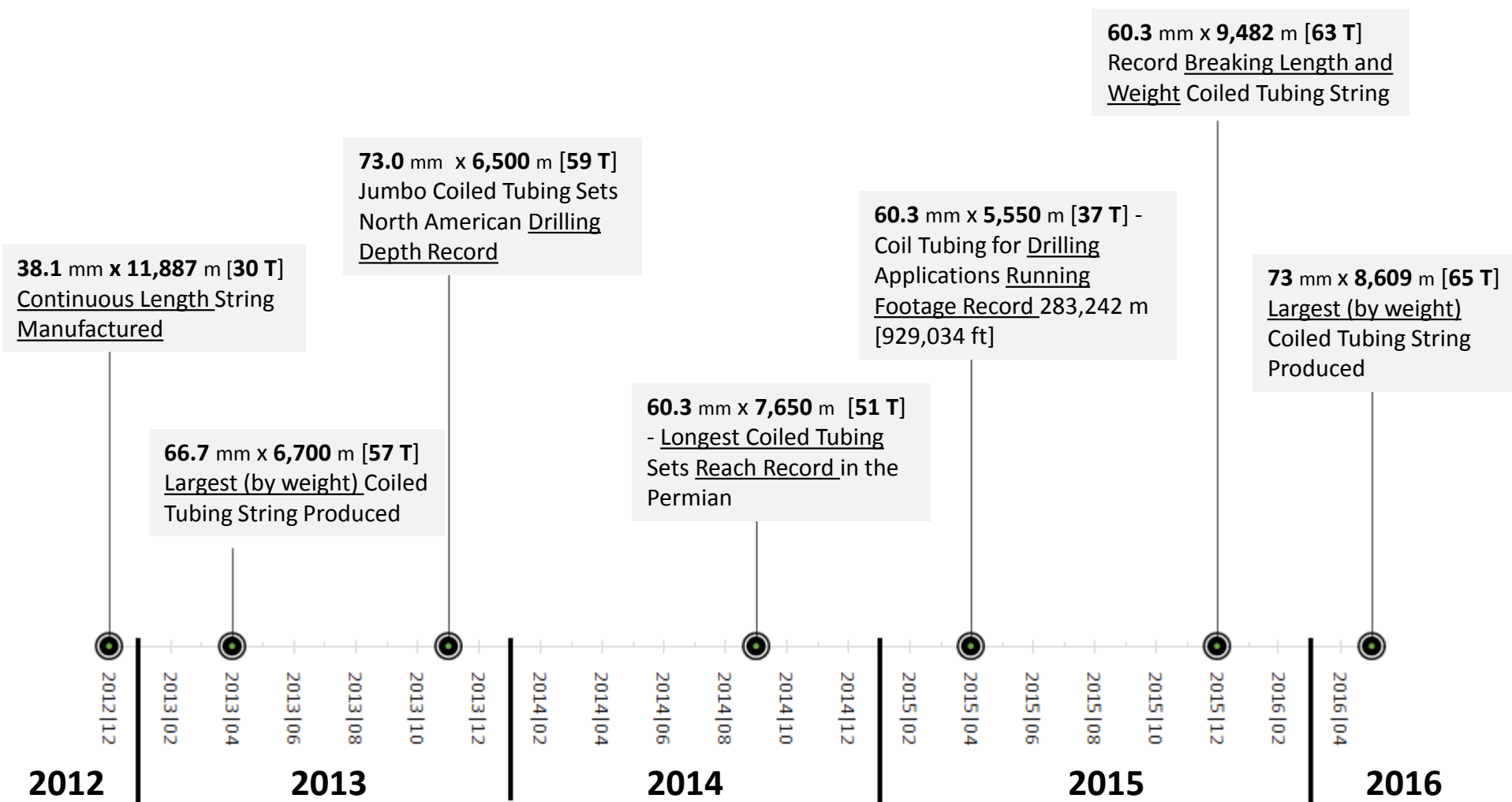


Challenges designing large diameter coiled tubing over 9,000m continuous length

Ramada Plaza Calgary Downtown— October 19th, 2016

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Global Tubing Record Milestones



Objective

This presentation will describe a coiled tubing design project of an ongoing extended reach well intervention plan to stimulate wells with MD|TVD ratios of up to 4:1 and total measured depths of over ~9,100 m [30,000 ft].

Overview:

- Project Overview
- Extended Reach Well Details
- CT Design Requirements
- CT Design Challenges
- CT Design Methodology
- Final CT Designs
- Manufacturing Challenges
- Extended Reach CT Design Optimization
- Conclusions

Project Overview

Artificial Islands development in the Zakum Region of the Arabian Gulf

Strategic goal:

Increase crude oil production from 500,000 - 750,000 barrel/day by 2017

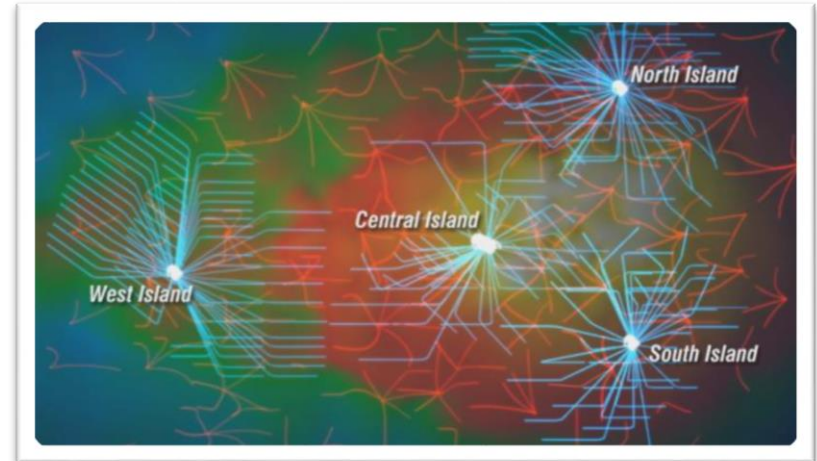
Location:

84 km offshore Abu Dhabi in the Arabian Gulf

Water depth:

between 5 to 15 meters

> 4 artificial islands in the UZ field



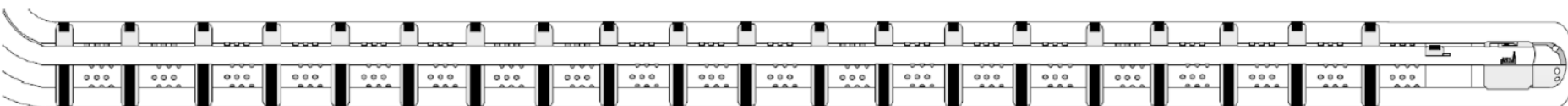
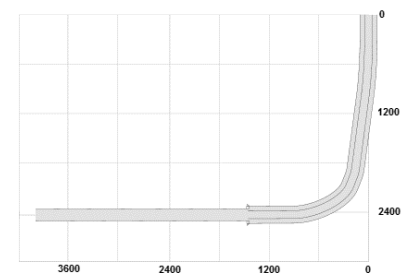
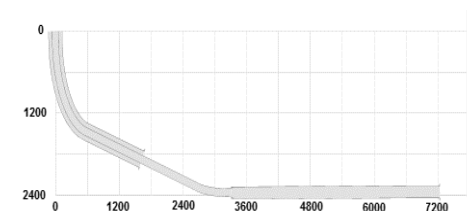
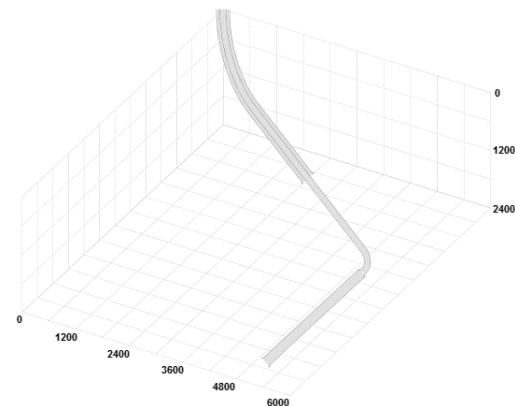
Source: OTC 2215

Reserves estimated at 50 billion barrels of oil

Extended Reach Wells

Well Name	MD	TVD	Completion	Lateral Length	MD/TVD
Well V	9,173 m 30,095 ft	2,321 m 7,615 ft	139.7 mm 29.8 kg/m - 168.3 mm 35.7 kg/m 5½" 20ppf - 6⅝" 24ppf	2,770 m 9,085 ft	4.0
Well W	9,139 m 29,983 ft	2,237 m 7,340 ft	114.3 mm 18.8 kg/m - 168.3 mm 35.7 kg/m 4½" 12.6ppf - 6⅝" 24ppf	2,415 m 7,922 ft	4.1
Well X	8,521 m 27,955 ft	2,374 m 7,788 ft	114.3 mm 18.8 kg/m - 168.3 mm 35.7 kg/m 4½" 12.6ppf - 6⅝" 24ppf	3,800 m 12,467 ft	3.6
Well Y	8,471 m 27,784 ft	2,381 m 7,810 ft	114.3 mm 18.8 kg/m - 168.3 mm 35.7 kg/m 4½" 12.6ppf - 6⅝" 24ppf	5,430 m 17,810 ft	3.6
Well Z	6,534 m 21,437 ft	2,477 m 8,125 ft	114.3 mm 18.8 kg/m - 168.3 mm 35.7 kg/m 4½" 12.6ppf - 6⅝" 24ppf	3,000 m 9,846 ft	2.6

The majority of the wells are in the range of 20kft – 27kft
[6,100m – 8,250m] MD



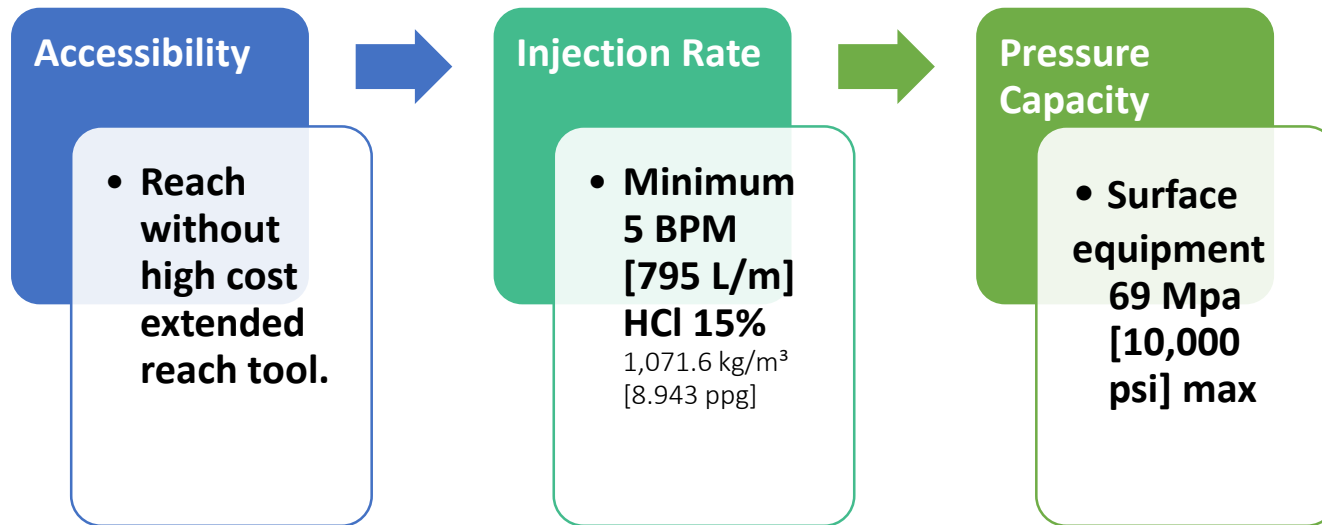
CT Design Requirements

CT size & Length:

60.3mm 2³/₈in x ~9,200m x GT-80 | GT-90

Main application:

Acid Stimulation ~ 2,400 – 5,400 m of 168.3 mm PPL
~ [8,000 – 17,810 ft of 168mm PPL]



CT Design Challenges

Well Characteristics

- Well Max MD's & Lateral Lengths
- CT Reach with conservative friction factors and minimum traction force



Frictional Pressure Losses

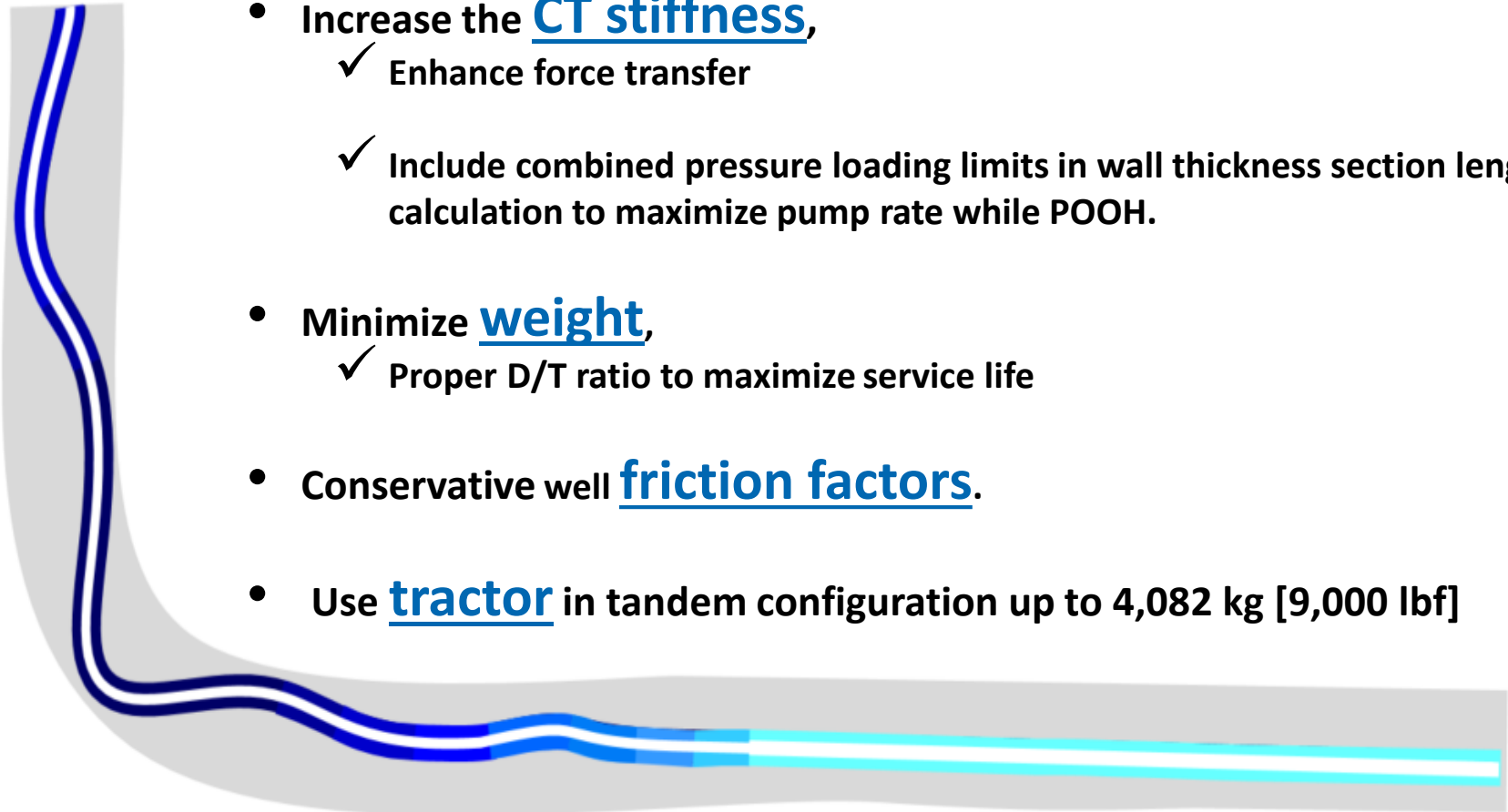
- CT length
- CT wall restriction
- Fluid density
- Min Flow Rate



Weight

- Transportation & Logistics
- CT Service Equipment Constraints

CT String Design Methodology



- Increase the CT stiffness,
 - ✓ Enhance force transfer
 - ✓ Include combined pressure loading limits in wall thickness section lengths calculation to maximize pump rate while POOH.
- Minimize weight,
 - ✓ Proper D/T ratio to maximize service life
- Conservative well friction factors.
- Use tractor in tandem configuration up to 4,082 kg [9,000 lbf]

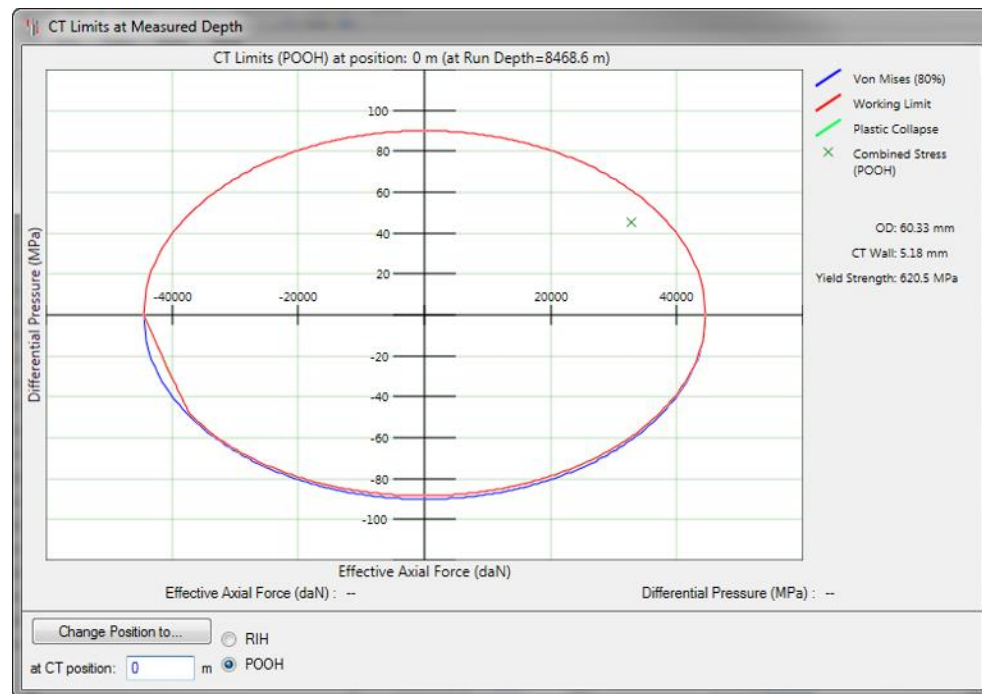
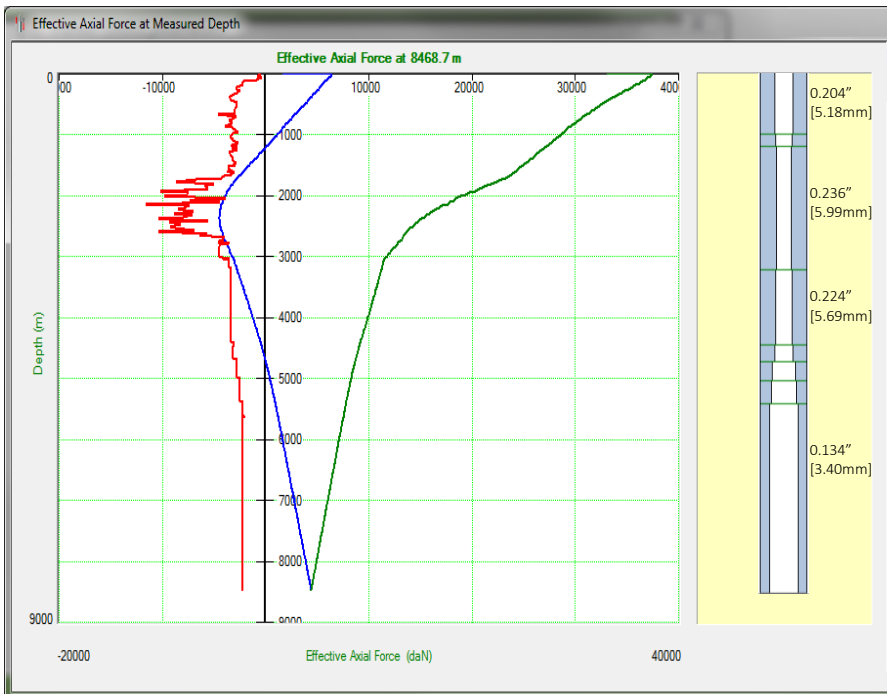
CT String Design Methodology

Minimum Wall: **3.40mm & 3.68mm**
[0.134" & 0.145"]

Grade: **620 Mpa [90 ksi Ys]**

Friction Factor: **0.3 RIH 0.25 POOH**

Traction Force: Starting with
2,267 kg [5,000 lbf]



Final CT String Designs

Extended Reach

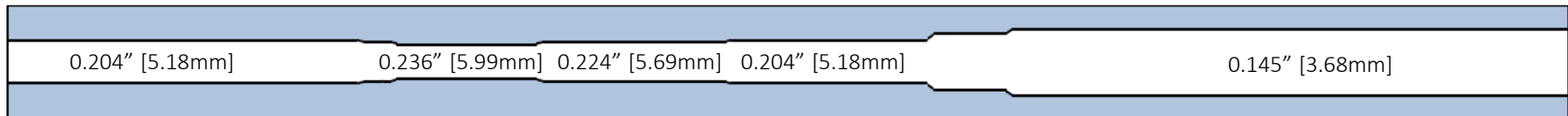
Heavy wall is strategically placed to maximize reach and durability



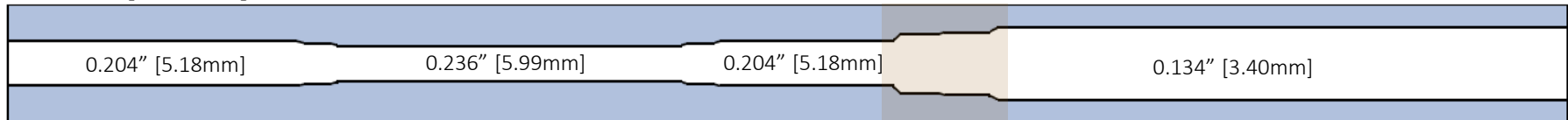
9,300 m [30,500 ft]

Proper Min WT Section Length

The thinnest wall thickness would never be over the gooseneck while high rate pumping operations to avoid wear and fatigue accumulation on this area of the string.



9,450 m [31,000 ft]



Weight Management

Hourglass Configuration - Trend in CT strings where transportation logistics also have a great influence on the design.



Quick Transitions

~245m [~800 ft] sections are used to transition up to 2 wall thicknesses. 6 wall thickness change total in ~730 m [~2,400 ft]



Manufacturing Capabilities



Accumulator Reel



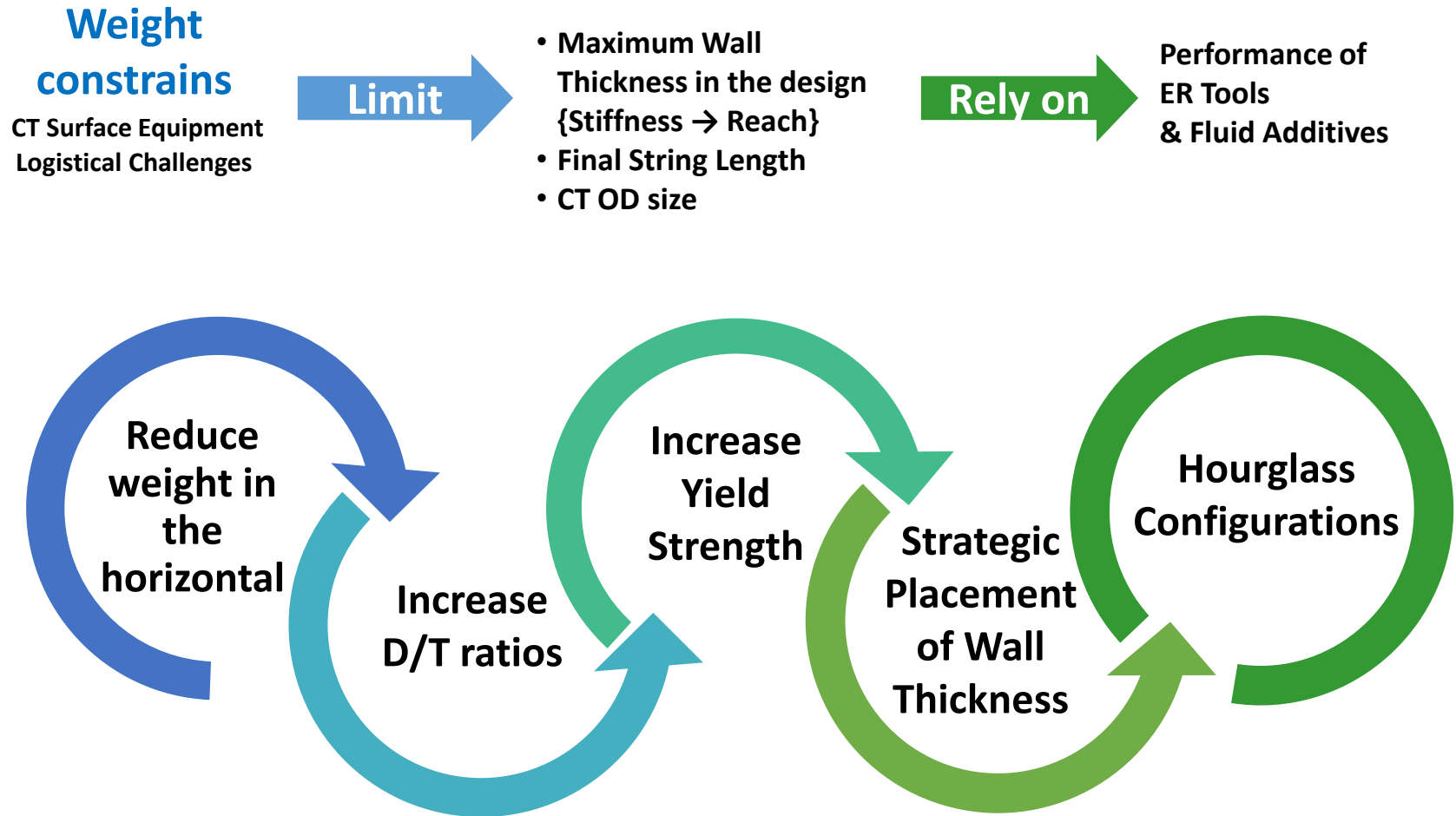
Spool Stand



Transportation & Logistics



Extended Reach Optimization



Conclusions

Extended Reach string designs are an **Iterative optimization based on:**

- I. CT Surface Equipment/mobilization weight constrains.
- II. Extended Reach tools and Fluid additives performance
- III. Accurate pre-job modeling
- IV. Selection of the optimal wall thickness and transition points
- V. CT manufacturer capabilities
- VI. The interrelation of the CT use limitations

Questions ?

Thank you

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