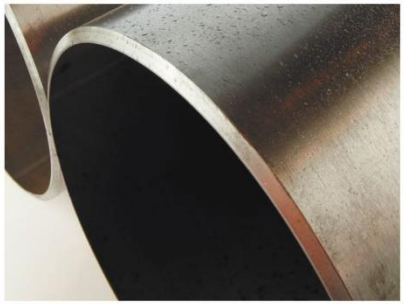
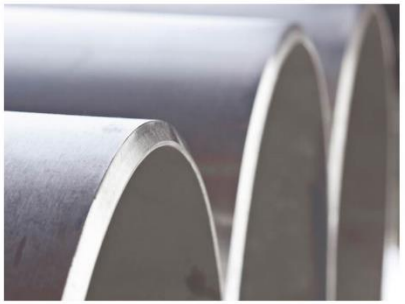
Well Casing Design Case Study: Slim Hole in Curve Build Section





2019

Well Casing Design Case Study: Slim Hole in Curve Build Section

Andrew Madyarov, PhD
Sr Development Engineer
TMK-IPSCO – Houston R&D
May 2019

Disclaimer

No representation or warranty (express or implied) is made as to, and no reliance should be placed on, the fairness, accuracy or completeness of the information contained herein and, accordingly, none of the Company, or any of its shareholders or subsidiaries or any of such person's officers or employees accepts any liability whatsoever arising directly or indirectly from the use of this presentation. This presentation contains certain forward-looking statements that involve known and unknown risks, uncertainties and other factors which may cause the Company's actual results, performance or achievements to be materially different from any future results, performance or achievements expressed or implied by such forward-looking statements. PAO TMK does not undertake any responsibility to update these forward-looking statements, whether as a result of new information, future events or otherwise.

This presentation contains statistics and other data on PAO TMK's industry, including market share information, that have been derived from both third party sources and from internal sources. Market statistics and industry data are subject to uncertainty and are not necessarily reflective of market conditions. Market statistics and industry data that are derived from third party sources have not been independently verified by PAO TMK. Market statistics and industry data that have been derived in whole or in part from internal sources have not been verified by third party sources and PAO TMK cannot guarantee that a third party would obtain or generate the same results.

Motivation

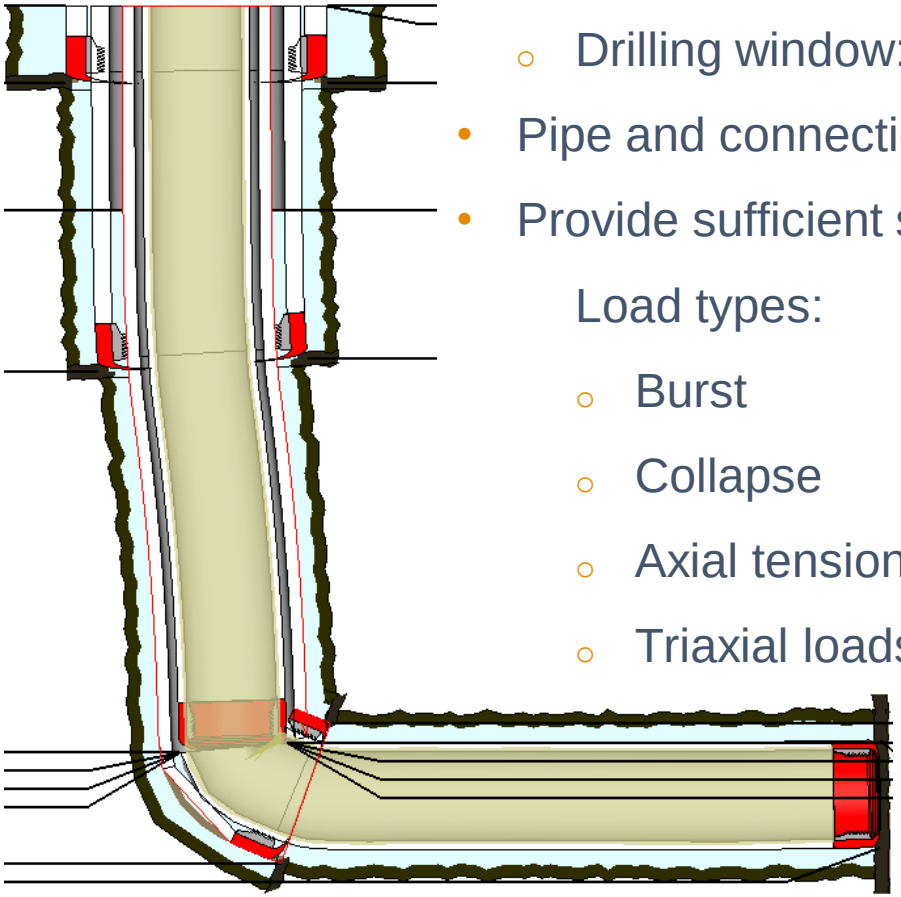
Provide support for well casing design

- Simulation with Halliburton | Landmark® StressCheck™
- Validate proposed well design
  - Design criteria
  - Loading conditions
- Compare design options
  - Pipe and connection selection
  - Advise changes
- IPSCO casing and connection database

Well Casing Design

Casing design for every well

- Casing point depth and mud weight selection
  - Regulations
  - Drilling window: pore pressure and fracture gradient
- Pipe and connection selection
- Provide sufficient strength



Load types:

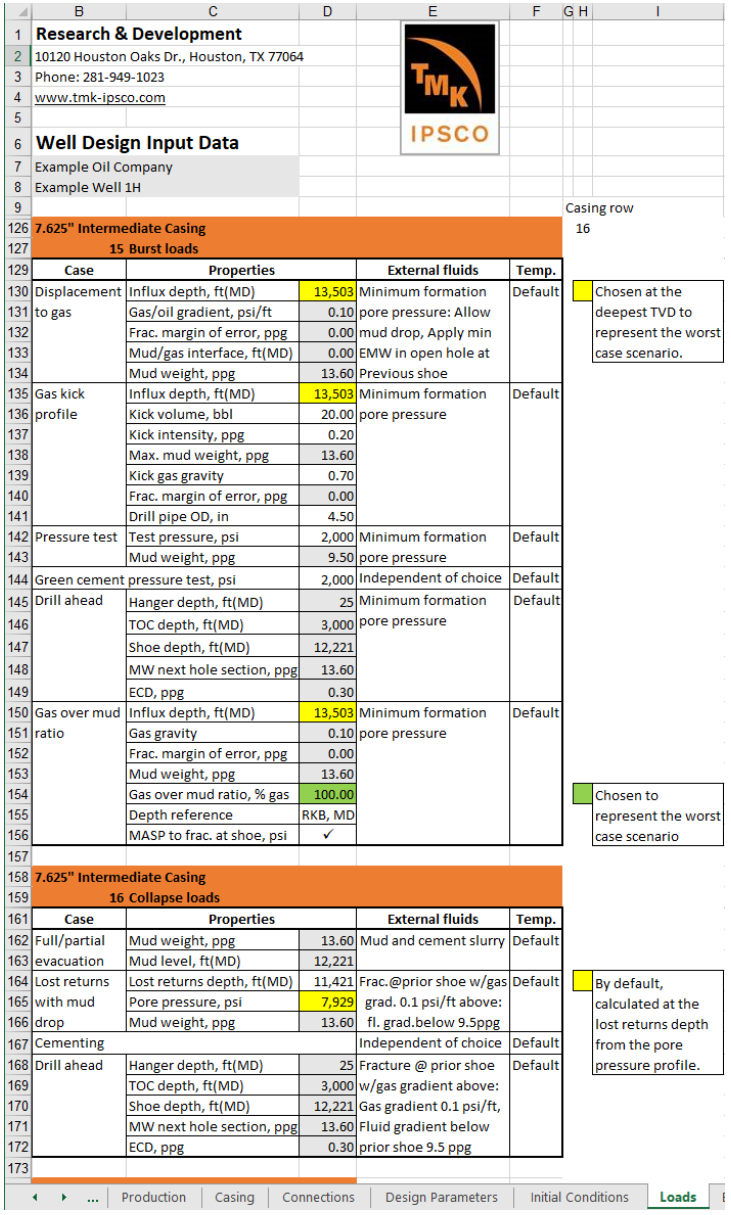
- Burst
- Collapse
- Axial tension and compression
- Triaxial loads

Operations phases:

- Installation
- Drilling
- Completion
- Production

Workflow for Casing Design Modeling

- Establish project scope and timeline
- Collect input data from Client
  - Well survey
  - Wellbore schematic
  - Excel template
    - Pore pressure and fracture gradient
    - Casing and connection selection
    - Initial conditions
    - Load scenarios
- Walk through inputs and model setup with Client
- Build and run StressCheck™ model
- Prepare presentation and report for Client; iterate as necessary



Research & Development
10120 Houston Oaks Dr., Houston, TX 77064
Phone: 281-949-1023
www.tmk-ipsco.com

Well Design Input Data
Example Oil Company
Example Well 1H

Casing row: 16

7.625" Intermediate Casing
15 Burst loads

Case	Properties		External fluids	Temp.	
Displacement to gas	Influx depth, ft(MD)	13,503	Minimum formation pore pressure: Allow mud drop, Apply min EMW in open hole at Previous shoe	Default	Chosen at the deepest TVD to represent the worst case scenario.
	Gas/oil gradient, psi/ft	0.10			
	Frac. margin of error, ppg	0.00			
	Mud/gas interface, ft(MD)	0.00			
	Mud weight, ppg	13.60			
Gas kick profile	Influx depth, ft(MD)	13,503	Minimum formation pore pressure	Default	
	Kick volume, bbl	20.00			
	Kick intensity, ppg	0.20			
	Max. mud weight, ppg	13.60			
	Kick gas gravity	0.70			
	Frac. margin of error, ppg	0.00			
	Drill pipe OD, in	4.50			
Pressure test	Test pressure, psi	2,000	Minimum formation pore pressure	Default	
	Mud weight, ppg	9.50			
Green cement	pressure test, psi	2,000	Independent of choice	Default	
Drill ahead	Hanger depth, ft(MD)	25	Minimum formation pore pressure	Default	
	TOC depth, ft(MD)	3,000			
	Shoe depth, ft(MD)	12,221			
	MW next hole section, ppg	13.60			
	ECD, ppg	0.30			
Gas over mud ratio	Influx depth, ft(MD)	13,503	Minimum formation pore pressure	Default	
	Gas gravity	0.10			
	Frac. margin of error, ppg	0.00			
	Mud weight, ppg	13.60			
	Gas over mud ratio, % gas	100.00			Chosen to represent the worst case scenario
	Depth reference	RKB, MD			
	MASP to frac. at shoe, psi	✓			

7.625" Intermediate Casing
16 Collapse loads

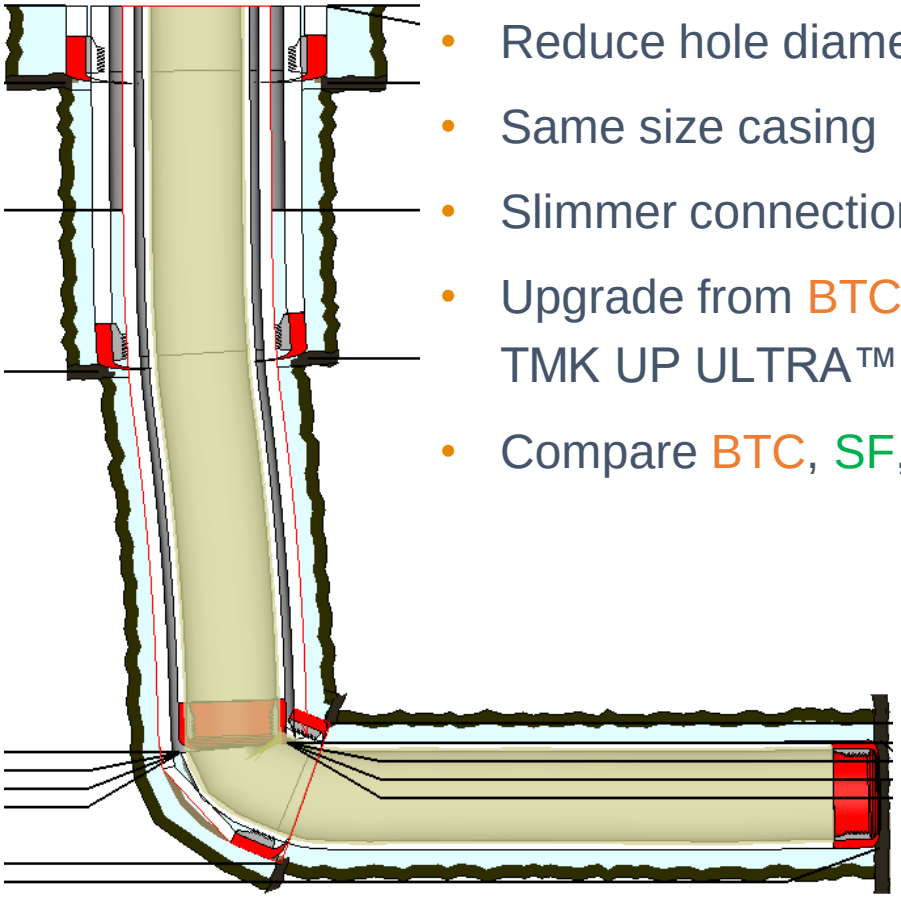
Case	Properties		External fluids	Temp.	
Full/partial evacuation	Mud weight, ppg	13.60	Mud and cement slurry	Default	
	Mud level, ft(MD)	12,221			
Lost returns with mud drop	Lost returns depth, ft(MD)	11,421	Frac.@prior shoe w/gas grad. 0.1 psi/ft above: fl. grad.below 9.5ppg	Default	By default, calculated at the lost returns depth from the pore pressure profile.
	Pore pressure, psi	7,929			
	Mud weight, ppg	13.60			
Cementing			Independent of choice	Default	
Drill ahead	Hanger depth, ft(MD)	25	Fracture @ prior shoe w/gas gradient above: Gas gradient 0.1 psi/ft, Fluid gradient below prior shoe 9.5 ppg	Default	
	TOC depth, ft(MD)	3,000			
	Shoe depth, ft(MD)	12,221			
	MW next hole section, ppg	13.60			
	ECD, ppg	0.30			

Production | Casing | Connections | Design Parameters | Initial Conditions | Loads

Case Study: Slim Hole in Curve Build Section

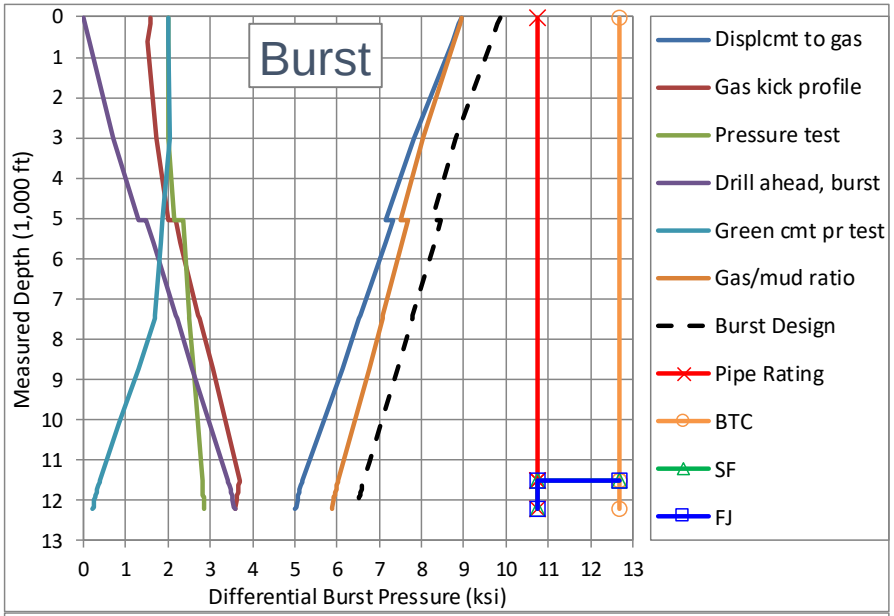
Motivation:

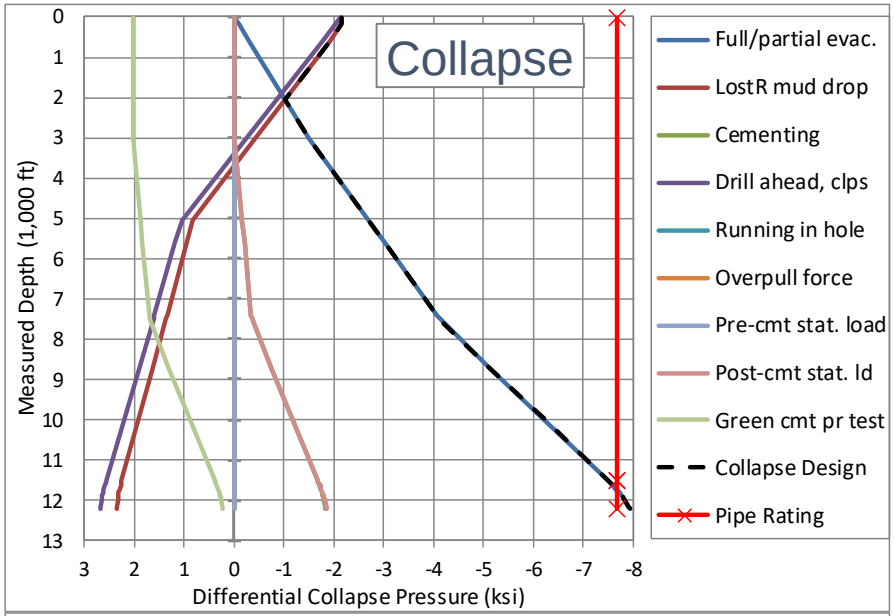
- 2nd intermediate casing (7-5/8”), from the Kick Off Point down through the curve build section (bottom 700 ft)

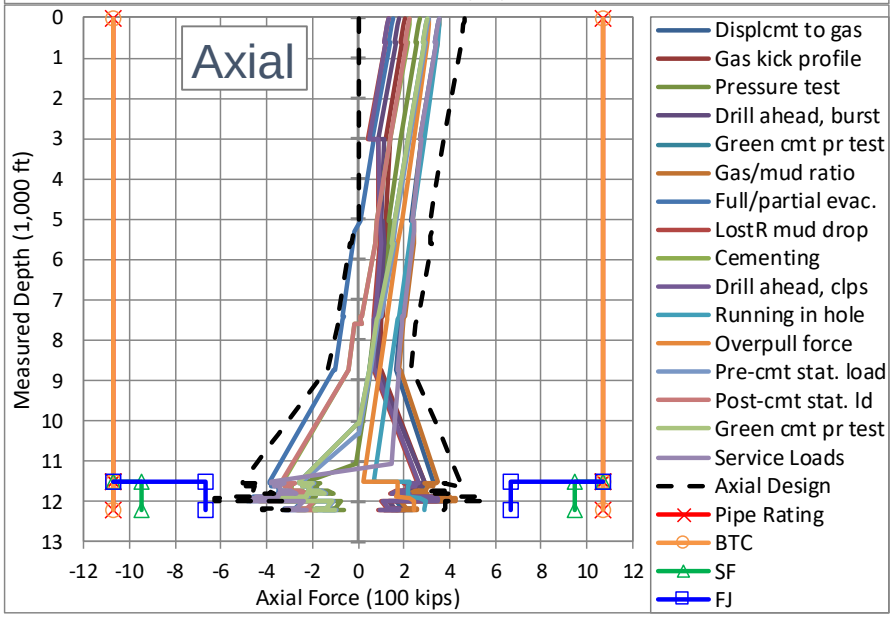


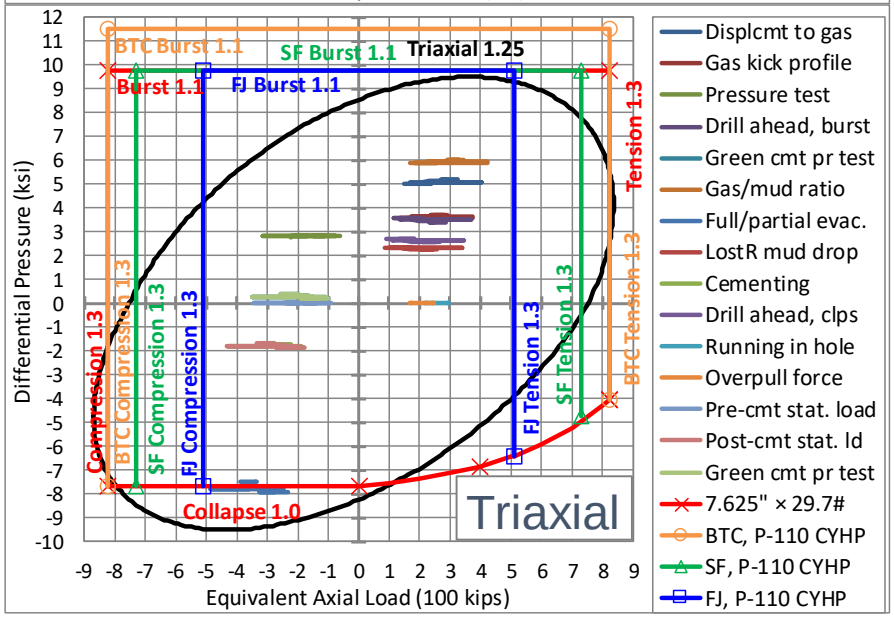
- Reduce hole diameter from 9-7/8” to 8-3/4” – save costs!
- Same size casing
- Slimmer connection profile required
- Upgrade from BTC to premium connection TMK UP ULTRA™ SF or TMK UP ULTRA™ FJ
- Compare BTC, SF, and FJ options in StressCheck™

Slim Hole in Curve Build Section: Result Plots



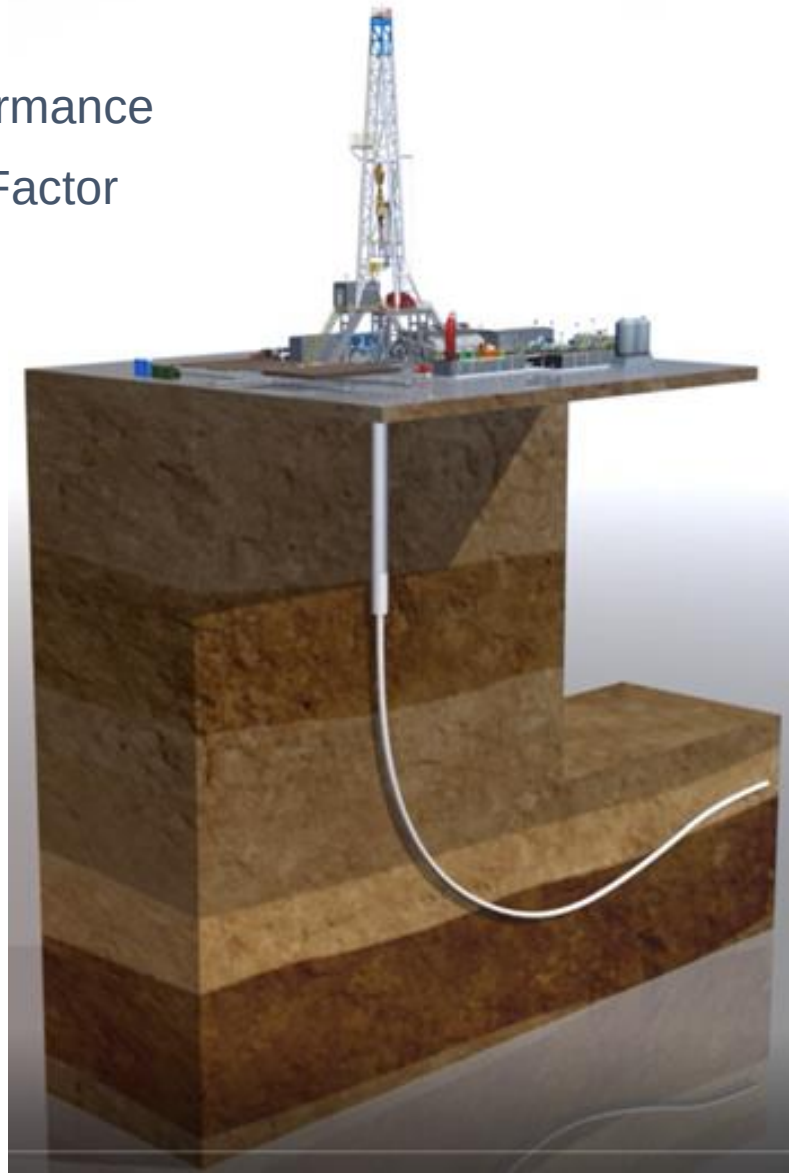




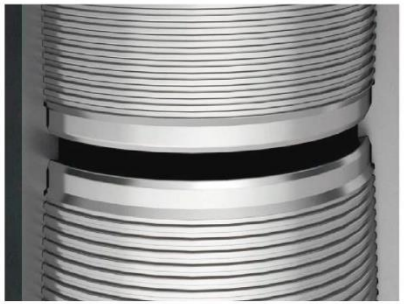


Slim Hole in Curve Build Section: Results

- Both SF and FJ provide sufficient performance
  - SF recommended for higher Safety Factor
- Concerns from the analysis communicated to the Client
  - Collapse potential at the bottom of the 7-5/8” casing, regardless the connection
  - Mud weight outside drilling window
  - Additional pick-up load required to prevent buckling
- Cost savings realized
  - Smaller size hole
  - Upgrade to premium SF connection



Thank you for your attention



WWW.TMK-GROUP.COM