



WELLHEAD FATIGUE MITIGATION SYSTEM

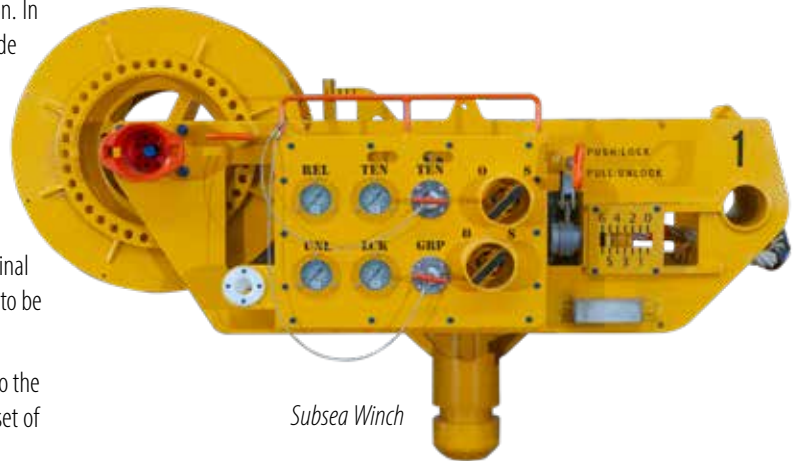
Two emerging technical challenges facing the drilling industry today are well fatigue and wellhead strength.

BOPs are increasing in size and weight, and drilling times are getting longer, causing wellhead fatigue issues to emerge as an industry challenge. New well designs must ensure that a high value well is engineered sufficiently to tolerate excessive fatigue caused by the newer and larger BOPs in use today. Legacy wells were mainly drilled with smaller BOPs and with a conductor design that was less robust. When attempting to interface with newer generation BOPs this exacerbates an already tenuous condition. In both cases, there are times when a wellhead fatigue mitigation device can provide substantial risk reduction.

The tethered BOP Wellhead Fatigue Mitigation System alleviates these effects by arresting the motion of the BOP stack above the wellhead, thereby substantially reducing wellhead cyclic stresses and enhancing fatigue life. Depending on the specific riser and wellhead configuration, the increased fatigue life is often seen to indicate, through analysis, an improvement of 25 to 1000 times the original unmitigated wellhead fatigue. No mitigations to the wellhead or casing string need to be performed. All modifications are performed to the BOP outer frame on deck.

An added benefit to the Wellhead Fatigue Mitigation System is the increased limits to the wellhead watch circle this system permits. Bending of the wellhead from lateral offset of

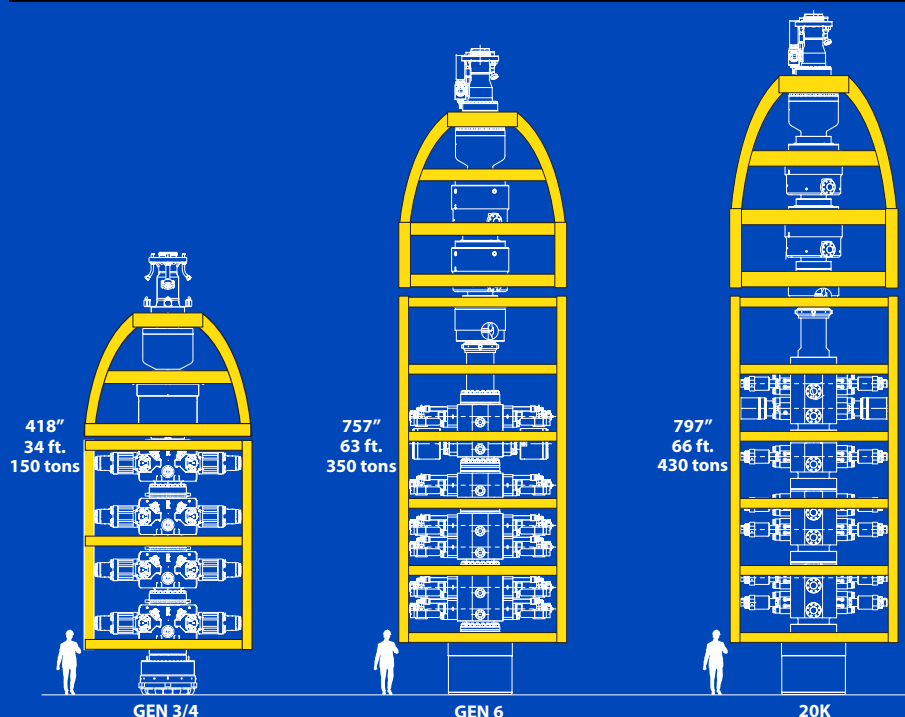
the MODU due to drive off/drift off loads are reduced by factors of 3 to 4, enabling safer operations and decreasing position criticality. In shallow water, where watch circles can be very restrictive and approaching the Dynamic Positioning station keeping limits, this allows for a larger watch circle and decreased reliance on the DP's station keeping performance.



MONITORING SYSTEM & FUNCTION OVERVIEW

- Monitor tension in tether lines
- Store the recorded real-time data for later recovery subsea (on retrieval – up to 1 year)
- Pre-process the data (power spectral density and low-pass filtering)
- Acoustically transfer the data to the rig topside (regularly and on demand)
- Possible integration into existing topside receiver system for wellhead fatigue monitoring provided by 3rd party
- Remote access to change operations mode (turn off / turn on / enter standby mode etc.)
- Display line tension status through existing wellhead fatigue topside system

Different Generations BOP and Size Comparison

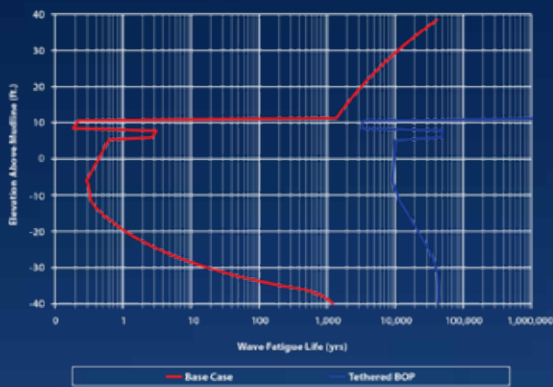


FATIGUE LIFE ANALYSIS

FE Beam Model to assess fatigue damage in time domain includes:

- Riser stack-up
- Wellhead and casing information
- Rig specific motions (RAO or similar)
- Soil information
- Site specific environmental design parameters

Site specific analysis results show improvements of wellhead fatigue life factors ranging from 200 to 1,000.



DRIVE OFF/DRIFT OFF

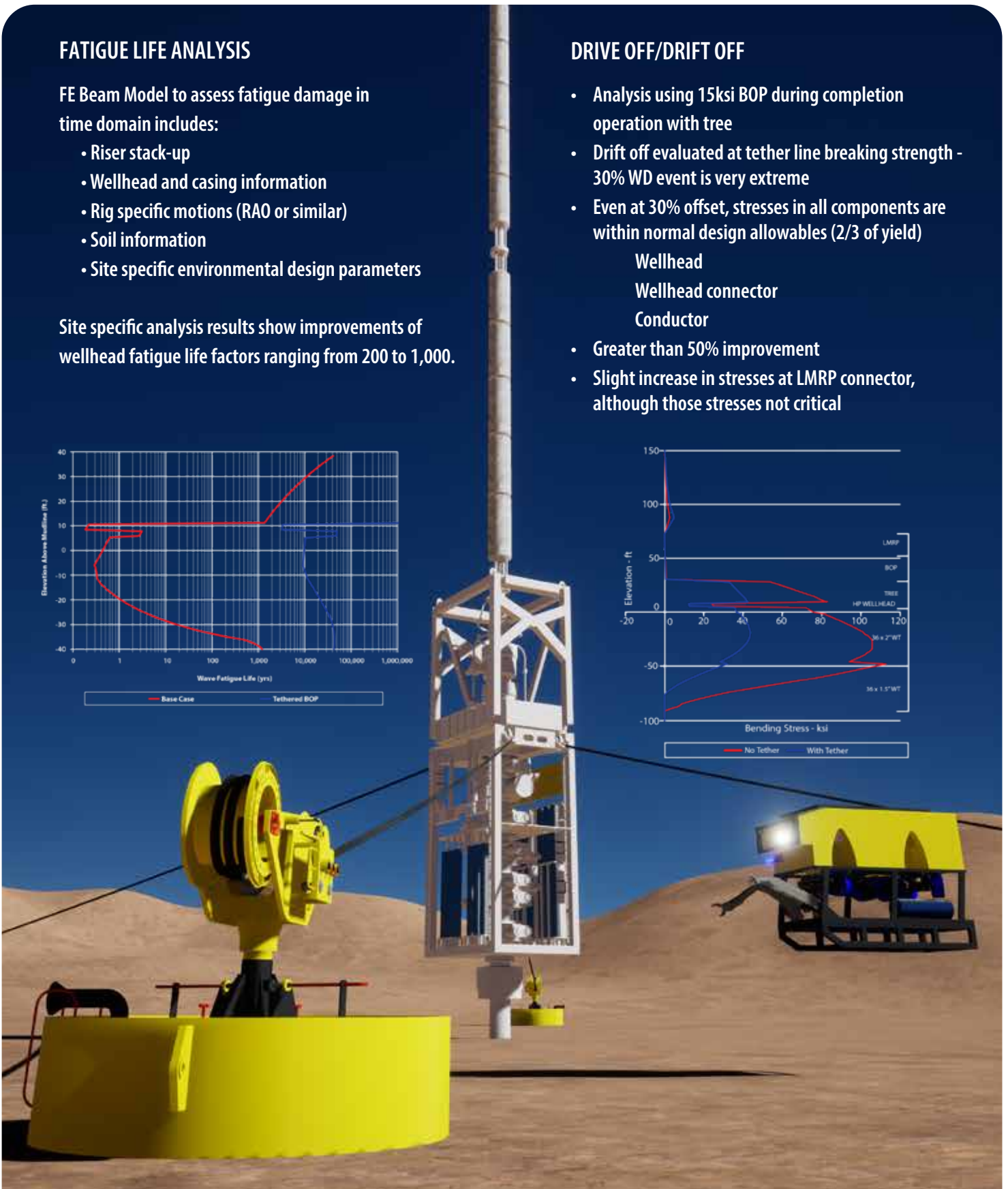
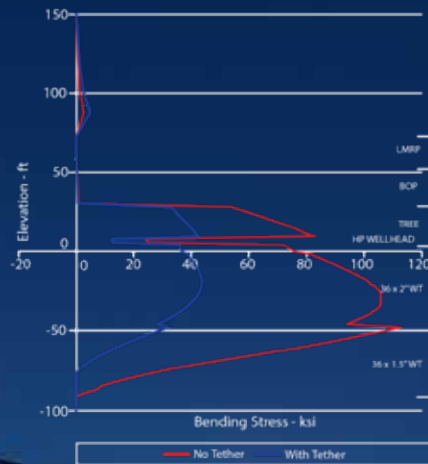
- Analysis using 15ksi BOP during completion operation with tree
- Drift off evaluated at tether line breaking strength - 30% WD event is very extreme
- Even at 30% offset, stresses in all components are within normal design allowables (2/3 of yield)

Wellhead

Wellhead connector

Conductor

- Greater than 50% improvement
- Slight increase in stresses at LMRP connector, although those stresses not critical



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