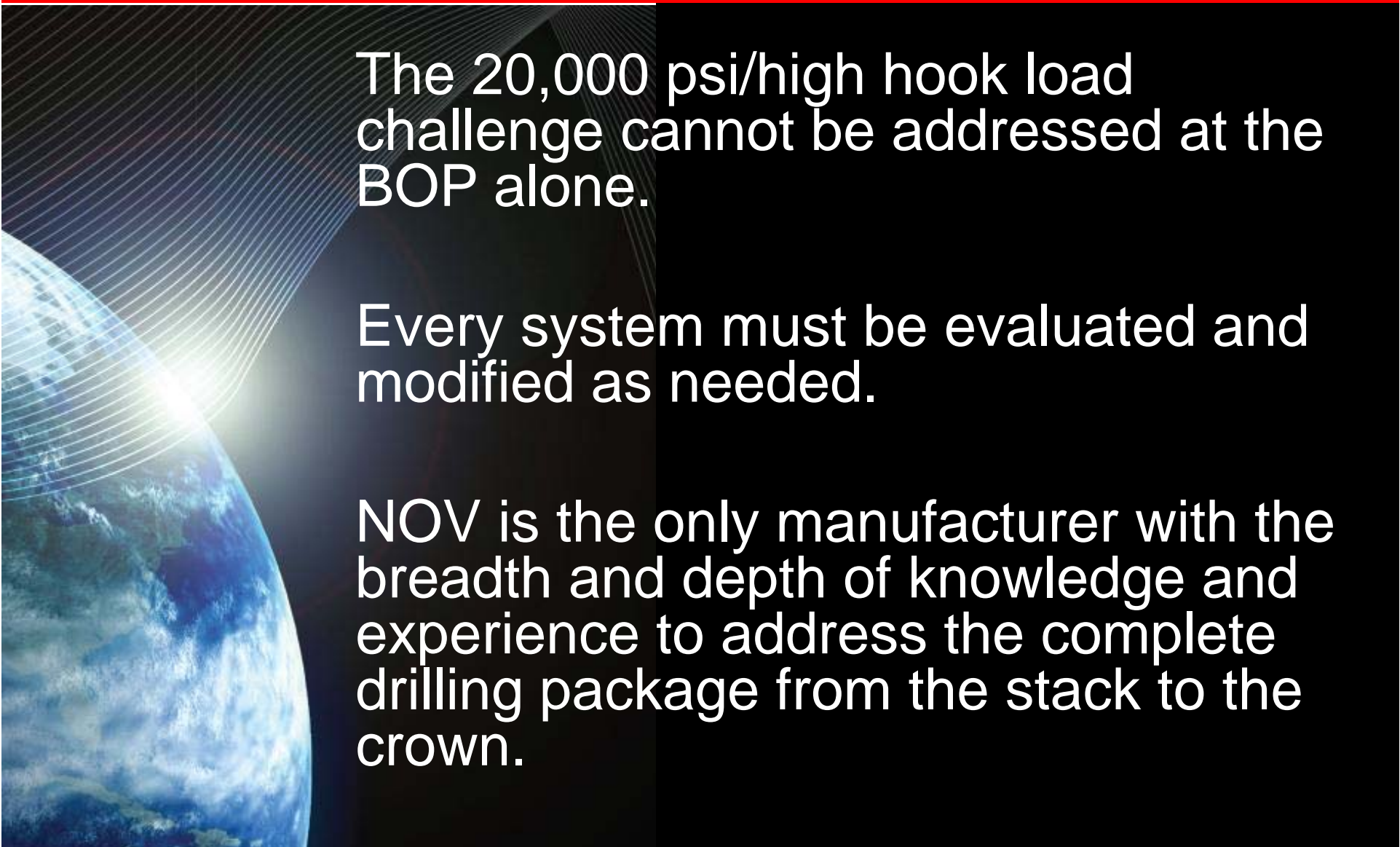


Drilling 20,000 PSI wells with High Hook Loads: The Solutions



Starting statements:

The background of the slide is a composite image. On the left side, there is a view of the Earth from space, showing the blue oceans and white clouds. Overlaid on this is a series of white, curved lines that resemble a signal or data stream, curving from the top left towards the center. The right side of the slide is a solid black background where the text is placed.

The 20,000 psi/high hook load challenge cannot be addressed at the BOP alone.

Every system must be evaluated and modified as needed.

NOV is the only manufacturer with the breadth and depth of knowledge and experience to address the complete drilling package from the stack to the crown.

The Challenges



1) 20,000 PSI Wells

2) High Hook Load Requirements

May be related, but not always

The Challenges

1) 20,000 PSI Wells

- Pressure Containment
- High Temperature
- Increased Weight
- Reliability Demands



The Challenges

2) High Hook Load Requirements

- What is the real load?
- Hoisting
- Rotating
- Motion Compensation

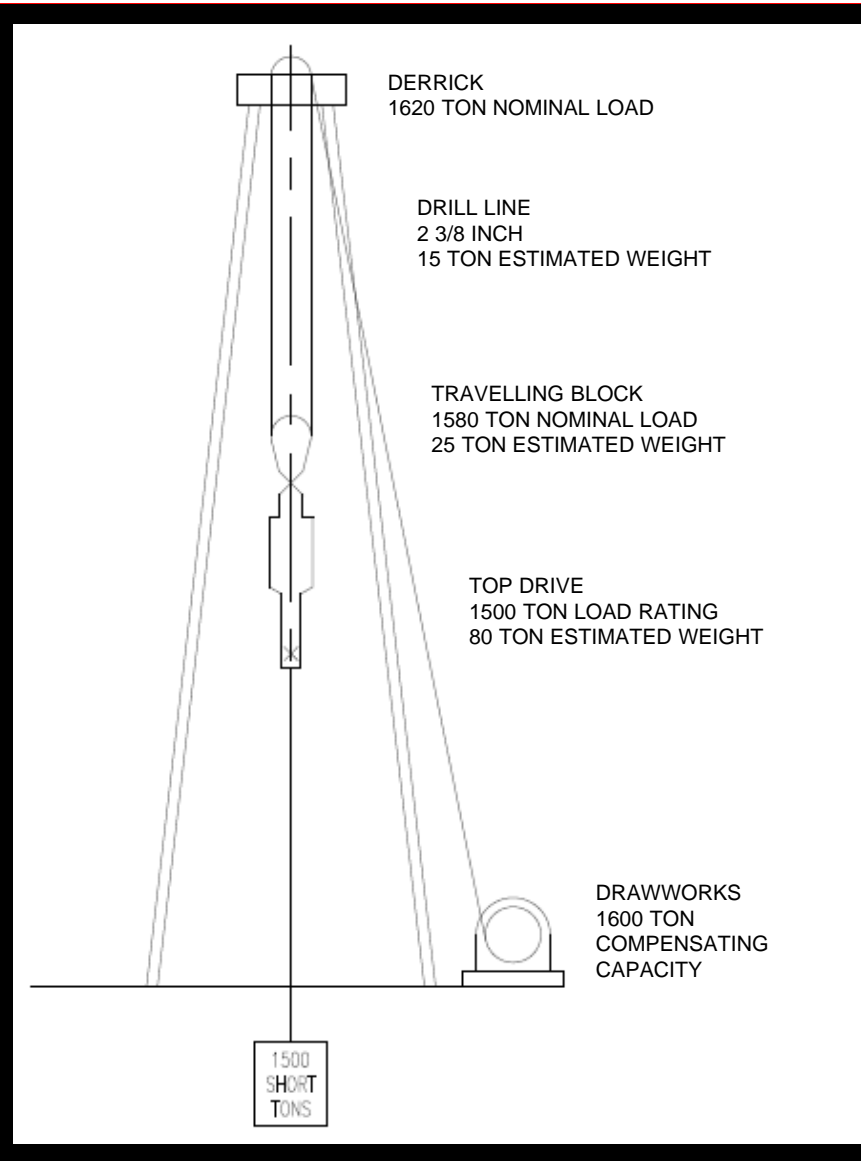
The Unknowns

The background of the slide is a composite image. On the left side, there is a curved view of the Earth from space, showing blue oceans, white clouds, and green landmasses. Overlaid on this and extending across the top and right are numerous thin, white, curved lines that represent orbital paths or trajectories, creating a sense of motion and complexity. The right side of the slide is a solid black background where the text is placed.

What information are we missing?

- Mud Weight
- Casing Plans
- Landing String Configurations
- Drill String Configurations

The Possibilities



Increases in BOP Weight, water depth, riser size, and casing strings drive higher hook loads

Based on current projections approx. 1300 ton at the elevator with dynamic considerations.

Subsea System



20Kpsi Pressure
Control Equipment

**SUBSEA
PACKAGE**

Subsea System

Current Industry Subsea 20kpsi Challenges

- Wellhead connector & stack mandrel
 - Vetco / Cameron / Drillquip
- Choke and Kill hoses
 - Larger Moonpool – Weight & Bend Radius increase
 - 20 lbs/ft heavier than 15K and 12 foot bend radius
- Choke and Kill stabs - Being Developed by NOV
- Subsea failsafe valves
 - True Fail-safe w/spring assist or pressure assist like 15K?
- Riser buoyancy dia. 62” – Based on mud weight
- Tension ring - 5.0M w/6.0M ring has been discussed (recommend 4.5m to handle 16 x 285k tensioners)

Subsea System

Current Assumptions and Overview

- 5,000 Psi Working Pressure on Control System (No Change from Today)
- Shear System will utilize the LFS™, LFCST™, and Depth Compensated Bottles
- 6th Generation Electronics (AADvance™)
- Diverter/Rotary Table 75-1/2"
- Riser Buoyancy 62"
- Choke and Kill Lines 7.25" OD x 4.5" ID 20,000 psi
- Mud Boost Line 5" OD x 4" ID 7,500 psi
- Tension Ring 4.5M Lbs.
- Running Tool, Spider and Gimbal for Riser 1500 Tons
- Slip Joint 65' Stroke 19-1/2" minimum bore
- 7 Ram Cavity Stack both Annulars in LMRP, Configurable Design
- Stack Flex Loops versus Coflexip Hoses
- Riser Designed for 16 lb. Mud at 12,000' water depth
- Conduits 2.875" OD x 2.323" ID 5,000 psi
- Oil States 6,000 psi Flex Joint

Subsea System

18 3/4" 15K and 20K Comparison Chart Dimensions and Weights

	Dimensions H x W x D	Estimated Weights
6 Ram 18-3/4" 15K Stack	600" x 250" x 212" (15240 mm x 6350 mm x 5385 mm)	878,269 lbs. (398.4 MT)
6 <u>Ram</u> 18-3/4" 20K Stack	700" x 240" x 212" (17780 mm x 6096 mm x 5385 mm)	1,092,080 lbs. (496 MT)
7 Ram 18-3/4" 15K Stack	676" x 240" x 212" (17170 mm x 6096 mm x 5385 mm)	951,090 lbs. (432 MT)
7 <u>Ram</u> 18-3/4" 20K Stack	762" x 240" x 212" (19355 mm x 6096 mm x 5385 mm)	1,192,180 lbs. (541 MT)
8 <u>Ram</u> 18-3/4" 20K Stack	790" x 240" x 212" (20066 mm x 6096 mm x 5385 mm)	1,237,390 lbs. (562 MT)

Subsea System



**20Kpsi Pressure
Control Equipment**

20Kpsi RAM BOP

Subsea System



20Kpsi Single Ram (Patents Pending) Body Forging

Subsea System



20Kpsi Single Ram (Patents Pending) Body and Door Forging

Subsea System



Subsea System

20Kpsi Riser Assumptions

- Design Water Depth – 12,000 Ft.
- Maximum Design Mud Weight – 16.0 PPG at 12,000 Ft.
- Riser Joint Length – 75 Ft.
- Riser Tension Capacity 4,000,000 Lb. (I-Class)
- Total Riser Tension Available – 16 X 285K = 4.56 Million Pounds
- Choke & Kill Lines – 7.25" X 4.5" 20,000 PSI Rated
- Boost Line – 5" X 4" 7,500 PSI Rated
- Hydraulic Lines 2.875" X 2.323" 5,000 PSI Rated
- Riser Buoyancy Diameter – 62 In.
- Running Tools, Spider & Gimbal Rated 1,500 Tons

Subsea System

21-1/2" X 1" X 75' 20K Riser Slick Joint

	Qty	Unit Wt. (Lb)	Ext. Wt. (Lb)
Main Tube - 21-1/2" OD X 1.0" Wall Main Tube	1	16772	16772
Upper Flange	1	2930	2930
Nuts	8	22	176
Seal Sub	1	241	241
Lower Flange	1	3100	3100
Retaining Washers	8	12	96
Bolts	8	63	504
Choke & Kill Lines - 7.25" O.D. X 4.0" I.D.	2	7479	14958
Boost Line - 5" O.D. X 4" I.D.	1	1841	1841
Conduit Lines - 2.875" O.D. X 2.323" I.D.	2	587	1174
Clamps	6	85	510
Sub-Total			42302
Misc. & Contingency (5%)	1		2115.1
Total Slick Joint Weight in Air			44417.1

Subsea System

21-1/2" X 1" X 75' 20K Riser Buoyed Joints

	Slick Riser Weight	Buoyancy Air Weight	Joint Air Weight	Joint Uplift	Joint Wet Weight
62" Dia 2,000 Ft Buoyancy	44417	21792	66209	42624	-4008
62" Dia 4,000 Ft Buoyancy	44417	27328	71745	37096	1520
62" Dia 6,000 Ft Buoyancy	44417	31832	76249	32592	6024
62" Dia 8,000 Ft Buoyancy	44417	31496	75913	32928	5688
62" Dia 9,000 Ft Buoyancy	44417	32328	76745	32096	6520
62" Dia 10,000 Ft Buoyancy	44417	33168	77585	31256	7360
62" Dia 11,000 Ft Buoyancy	44417	34280	78697	30144	8472
62" Dia 12,000 Ft Buoyancy	44417	35944	80361	28480	10136
Slick Joint	44417	0	44417	0	38616

Riser & BOP Stack

Landing Weight – 12,000 Ft.

NOV 20K System - 7 Cavity Stack - 12,000 Ft WD 16.0 PPG @12,000 Ft.
 21-1/2" X 1" Wall Riser - Uplift required 62" Diameter Buoyancy, 75 ft
 Buoyancy breaks every 2000 ft to 8000 ft

Component	Inventory	Qty.	Joint Length	Total Length	Dry Weight Excluding Buoyancy Modules	Dry Weight of Buoyancy Modules	Lift	Joint Dry Weight	Net Submerged Weight
			(feet)		(pounds)	(pounds)	(pounds)	(pounds)	(kips)
Running Tool	2	1	4.5	4.5	7215	0	0	7215	7.6
Landing Joint		1	75	75	26010	0	0	26010	27.3
Inner Barrel	1 Tel. Jt. +	1	4.5	4.5	18600	0	0	18600	19.5
Outer Barrel	spare	1	74.7	74.7	72895	0	0	72895	76.5
Tension Ring - 74"	1	1	0	0	48999	0	0	48999	51.4
Hands Free Gooseneck	1	1	0	0	48701	0	0	48701	51.1
Moonpool Hoses		1	0	0	35000	0	0	35000	36.8
Fill Valve	1	1	10.5	10.5	12556	0	0	12556	10.9
Buoyant - 2000 ft Binary x 1 wall	21	21	75	1575	44417	21792	42624	66209	-48.4
Buoyant - 4000 ft Standard x 1 wall	27	27	75	2025	44417	27328	37096	71745	81.1
Buoyant - 6000 ft Standard x 1 wall	27	27	75	2025	44417	31832	32592	76249	197.8
Buoyant - 8000 ft Ultralight x 1 wall	26	26	75	1950	44417	31496	32928	75913	182.1
Buoyant - 9000 ft Ultralight x 1 wall	14	14	75	1050	44417	32328	32096	76745	109.2
Buoyant - 10000 ft Ultralight x 1 wall	13	13	75	975	44417	33168	31256	77585	111.9
Buoyant - 11000 ft Ultralight x 1 wall	13	13	75	975	44417	34280	30144	78697	125.8
Buoyant - 12000 ft Ultralight x 1 wall	9	8	75	600	44417	35944	28480	80361	90.2
Slick 1 Wall Joint	10	10	75	750	44417	0	0	44417	386.2
LMRP		1	25.9	25.9	479050	0	0	479050	416.5
BOP		1	35.91	35.91	713130	0	0	713130	620.0
				12156 Ft.				2553.7	Static Load at the elevators (KIPS)
								1276.8	Static Load at the elevators (Tons)
								223.2	Available Dynamic Head Room (Tons)

Riser & BOP Stack

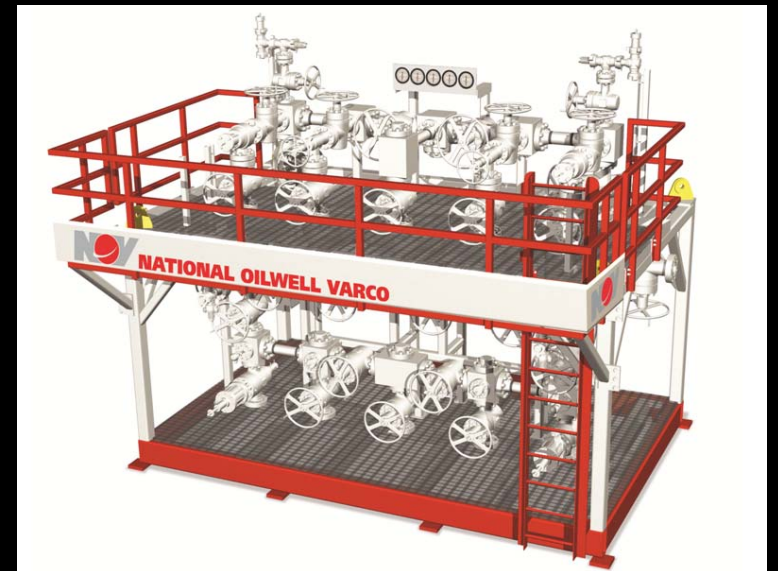
Landing Weight – 12,000 Ft.

NOV 20K System - 7 Cavity Stack - 10,000 Ft WD 16.0 Mud PPG @12,000 Ft.
 21-1/2" X 7/8" Wall & 21-1/2" X 1-1/16" Wall Riser - 62" Diameter Standard & Ultralight Buoyancy, 75 ft
 Buoyancy breaks every 2000 ft to 8000 ft

Component	Inventory	Qty.	Joint Length (feet)	Total Length	Dry Weight Excluding Buoyancy Modules (pounds)	Dry Weight of Buoyancy Modules (pounds)	Lift (pounds)	Joint Dry Weight (pounds)	Net Submerged Weight (kips)	
Running Tool	2	1			7215			7215	7.6	
Landing Joint		1	75	75	26010	0	0	26010	27.3	
Inner Barrel	1 Tel. Jt. +	1	4.5	4.5	18600			18600	19.5	
Outer Barrel	spare	1	74.7	74.7	72895			72895	76.5	
Tension Ring - 74"	1	1	0	0	48999			48999	51.4	
Hands Free Gooseneck	1	1	0	0	48701			48701	51.1	
Moonpool Hoses		1	0	0	35000			35000	36.8	
Fill Valve	1	1	10.5	10.5	12556	0	0	12556	10.9	
Buoyant - 2000 ft Binary x 7/8 wall	21	21	75	1575	40195	21792	42550	61987	-124.0	
Buoyant - 4000 ft Ultralight x 7/8 wall	27	27	75	2025	40195	27328	37018	67523	-16.0	
Buoyant - 6000 ft Ultralight x 7/8 wall	27	27	75	2025	40195	31832	32513	72027	100.8	
Buoyant - 8000 ft Ultralight x 7/8 wall	26	26	75	1950	40195	31496	32851	71691	88.6	
Buoyant - 9000 ft Ultralight x 1-1/16 wall	14	14	75	1050	43296	32328	32016	75624	96.7	
Buoyant - 10000 ft Ultralight x 1-1/16 wall	13	7	75	525	43296	33168	31180	76464	54.0	
Buoyant - 11000 ft Ultralight x 1-1/16 wall	13	0	75	0	43296	34280	30067	77576	0.0	
Buoyant - 12000 ft Ultralight x 1-1/16 wall	9	0	75	0	43296	35944	28402	79240	0.0	
Slick 1-1/16 Wall Joint	10	10	75	750	43296	0	0	43296	376.4	
LMRP		1		25.9	479050	0	0	479050	416.5	
BOP		1	50	30.69	713130	0	0	713130	620.0	
				10121.3						
								1894.2		Static Load at the elevators (KIPS)
								947.1		Static Load at the elevators (Tons)
								552.9		Available Dynamic Head Room (Tons)

Choke & Kill

- Typical Weight of 3-1/16" 15K – 81,500 lbs
- Estimated Weight of 3-1/16" 20K – 105,000 lbs
- Estimated Weight of 4" 20K – 165,000 lbs



Moon Pool System

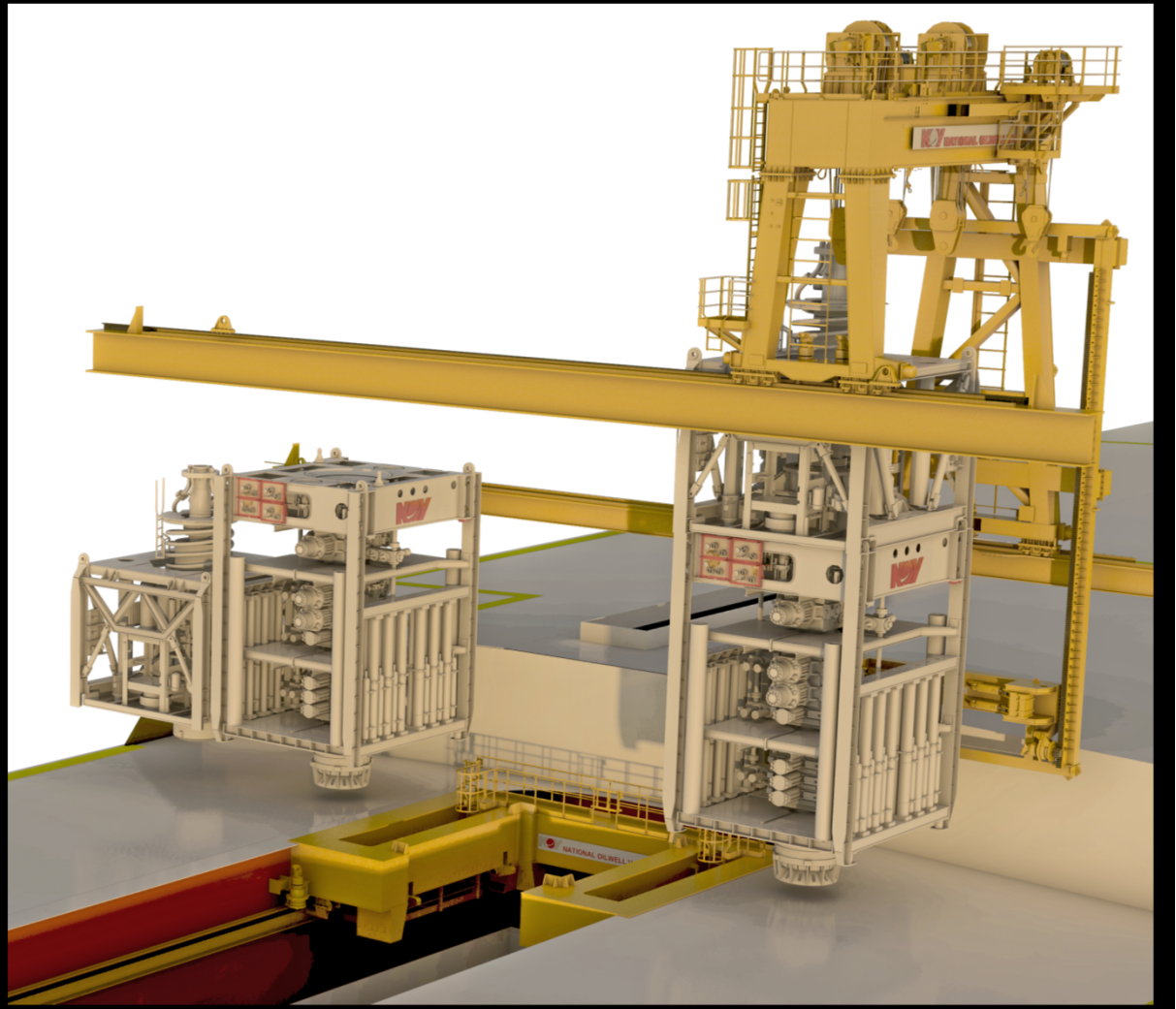


BOP Handling

- BOP Overhead Crane
- BOP Trolley
- BOP Seafixing (2 off)
- Test Stump Retractor (2 off)

Optional machines:

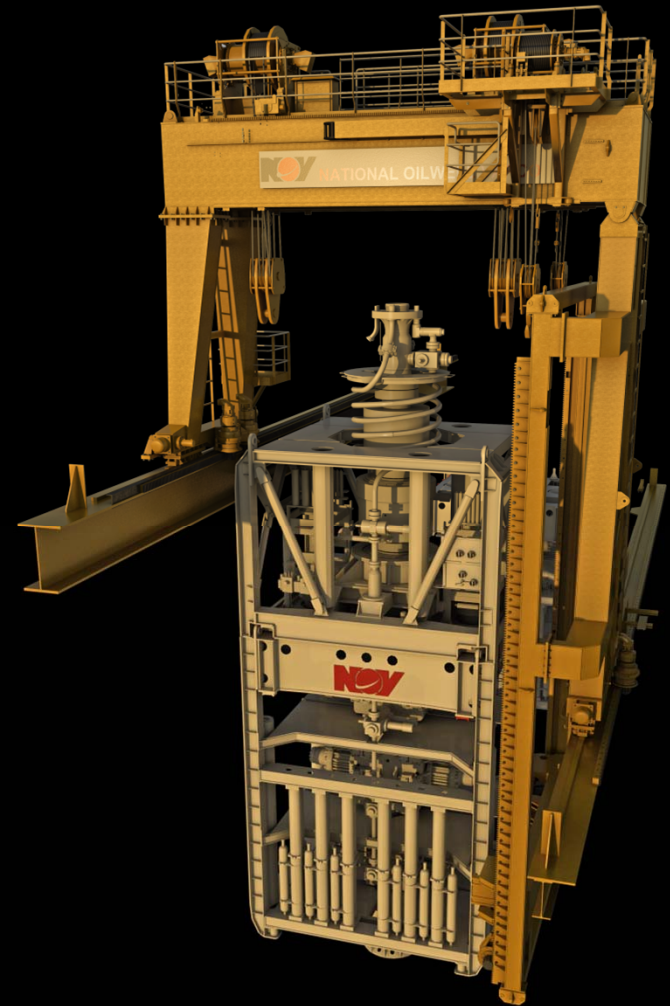
- LMRP Seafixing
- Trip Saver Adapter



BOP Overhead Crane

20K BOP Overhead Crane:

- Main winch: 2 x 300t or 4 x 175t
- Aux winch: 2 x 35t
- Vertical traveling Guide machine on crane leg.
- Electric/Hydraulic drive system



BOP Trolley

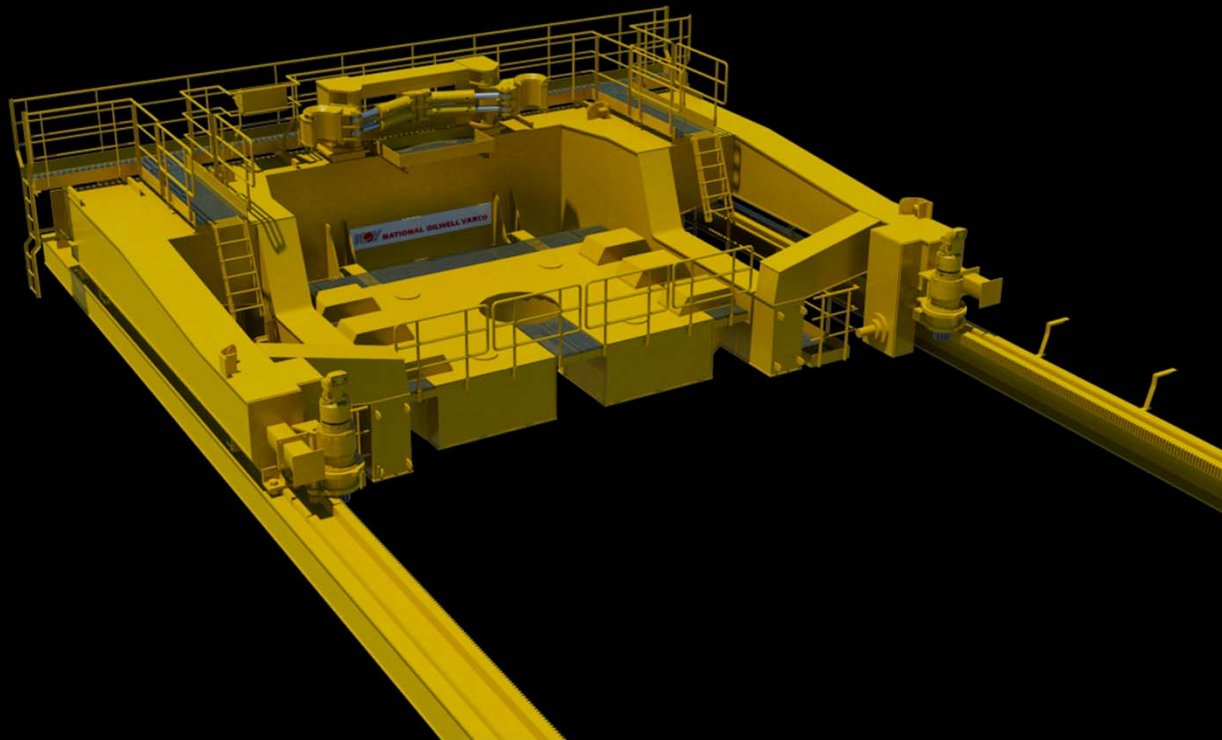
BOP TROLLEY:

- BOP mode: SWL 650 t
- Trip saver mode: SWL 1200 t

Hinged Gearbox system



Hang Off Bolts

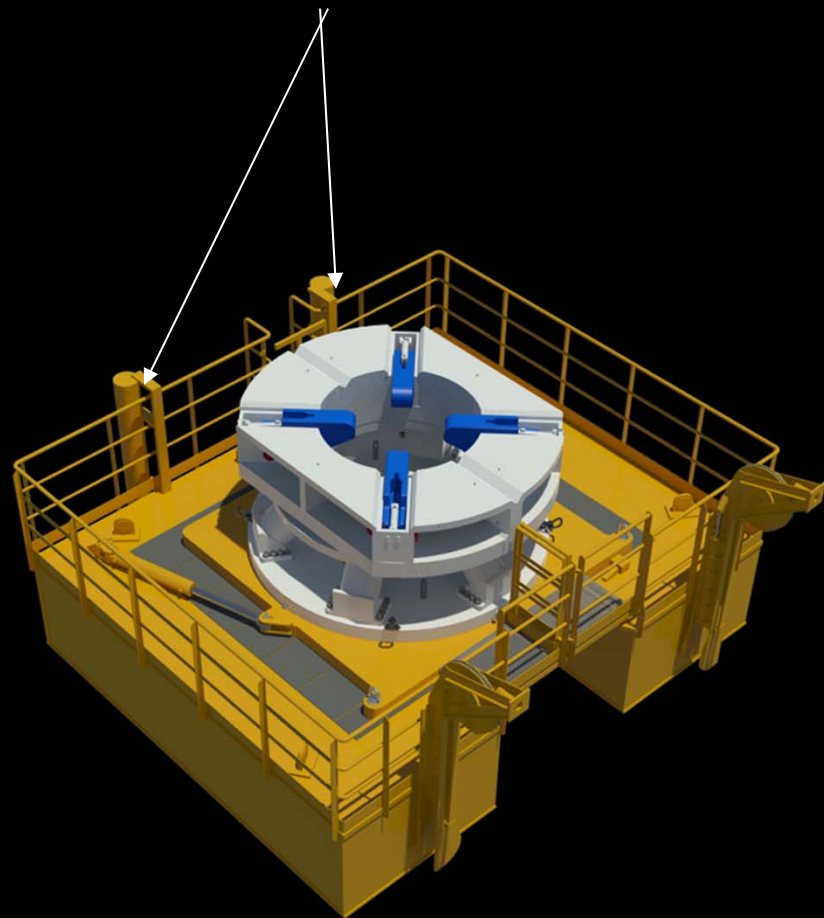


Trip Saver Operation

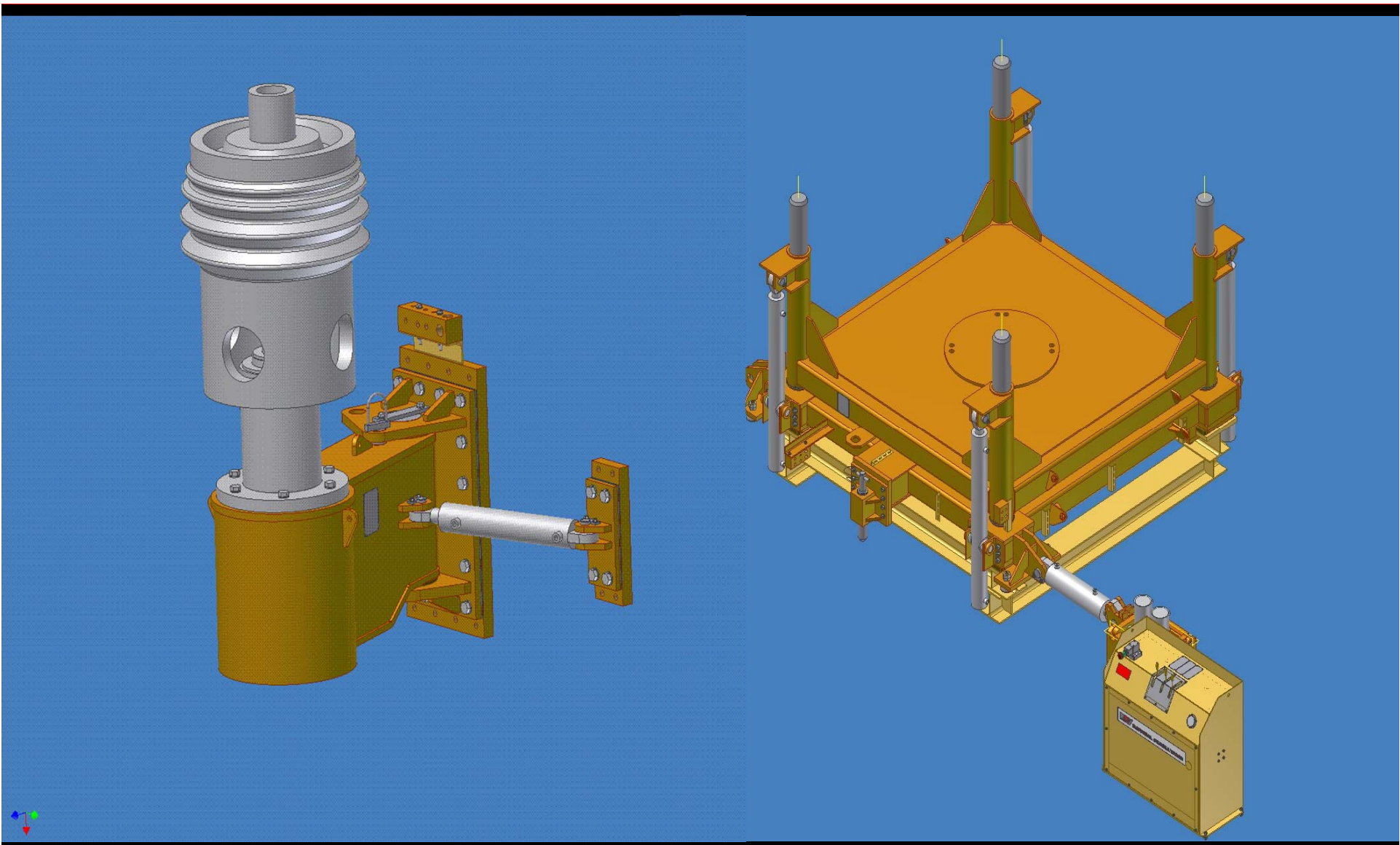
Trip Saver:

- Adapter	30t
- Splitting unit	10t
- Gimbal (split version)	20t
- <u>Spider (split version)</u>	<u>10t</u>
Total	70t

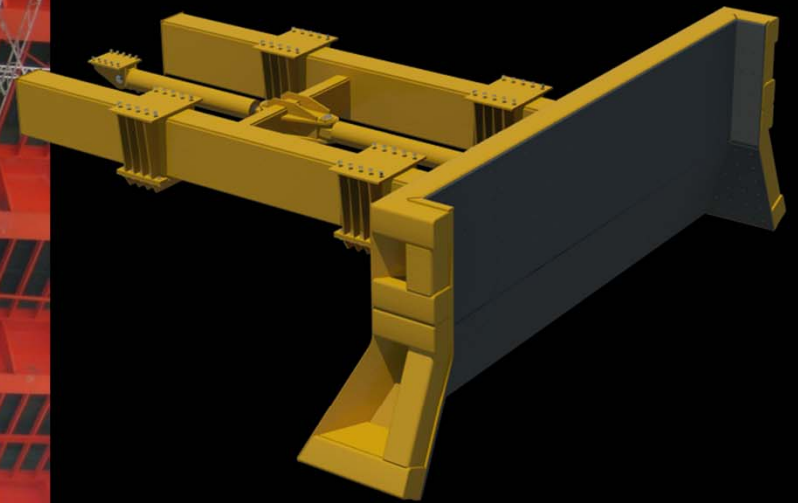
Attach guide spear for safe handling
by BOP Overhead Crane



Test Stump Retractor



Under Hull Guide



- Bigger Under Hull guides:
- Fixed skirt
 - Foldable skirt

X-mas Tree Handling

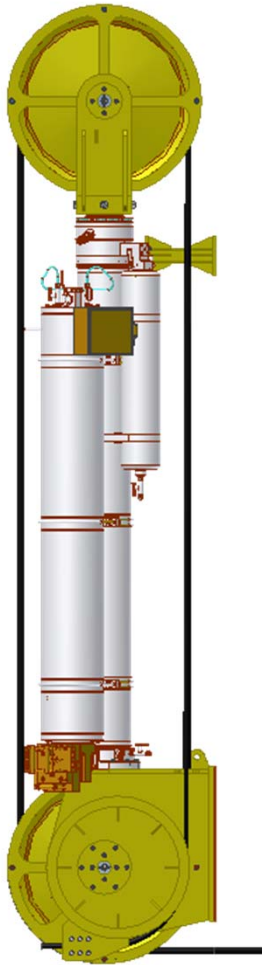
- X-Mas Tree height & weight requirement:
- Decides X-Mas Tree handling solution
 - Decides Drill floor elevation
 - Oil companies concerned about damages to X-Mas Tree during handling



Riser Tensioning Systems

Drilling Riser Tension Wireline Riser
Tensioners

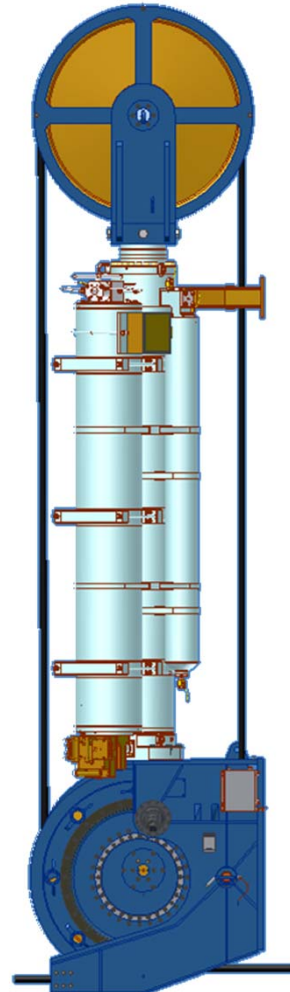
Different sizes



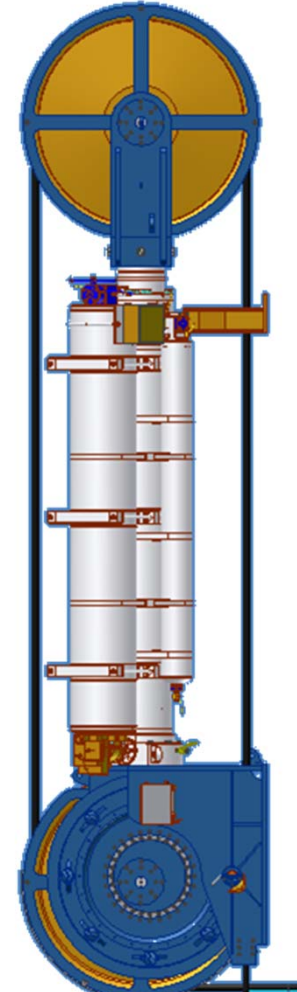
120 kips



200 kips



250 kips



280 kips

Different layouts and operation window

In our portfolio right now:

- 8 x 120 = 960 kips
- 8 x 200 = 1600 kips
- 8 x 250 = 2000 kips
- 12 x 200 = 2400 kips
- 10 x 250 = 2500 kips
- 12 x 250 = 3000 kips
- 16 x 200 = 3200 kips
- 12 x 280 = 3360 kips
- 14 x 250 = 3500 kips
- 16 x 225 = 3600 kips
- 16 x 250 = 4000 kips
- 16 x 280 = 4480 kips

Wiretravel up to 65ft/19,8m

Max operation 3,2m/s

Add-ons:

Fluid drain units.

High speed relief valves.

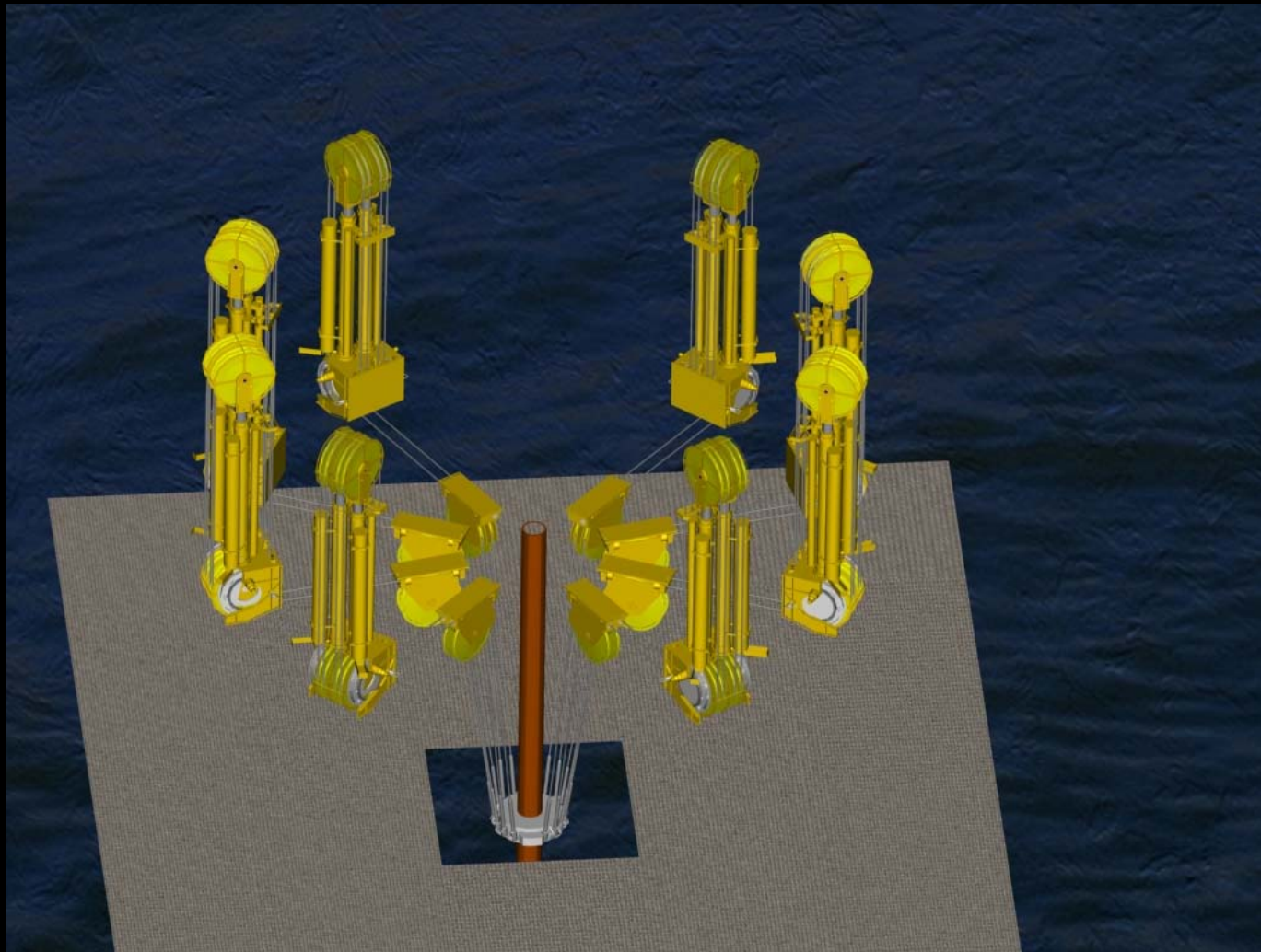
NiCr coated HPA.

Individual tensioner control.

Telescopic idler arm.

Wire reel.

16 x 280 kips



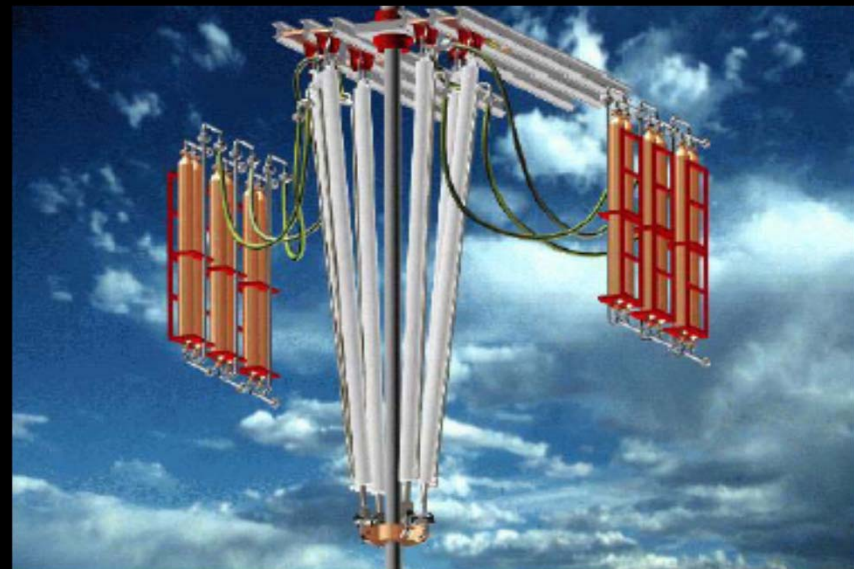
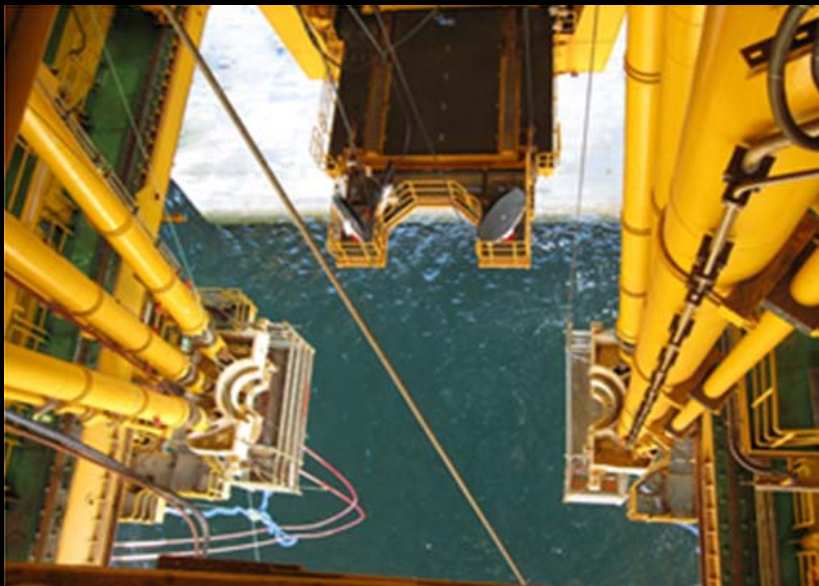
Wire Line Riser Tensioners



Moon Pool Systems

N-Line Riser Tensioners

- Alternative to WRT
- Consists of six Cylinders directly attached to the riser (via a tensioner ring)
- Designed for Semi's and Drill ships



Hoisting Systems

Active Heave Drilling™

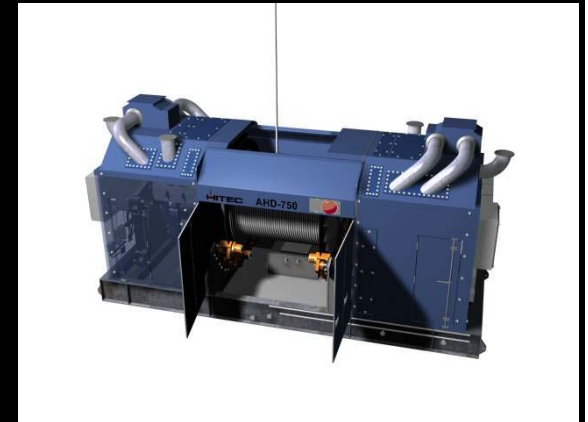
Transition SSGD – AHD

- SSGD

- Superior in motion control
- Complete bi-directional control
- Low response time in acceleration
- SSGD + Motion control with proper motion reference input, (MRU) → AHD

- AHD

- → Compensation with Drawworks



Hoisting Systems

Active Heave Drilling™

Design Criteria

- AC-Driven, Pro-active, Heave Compensating Drawworks
 - Larger operational window
 - Lower COG
 - Compensation of heavy weights
- Easier and more efficient operation with high system availability
 - Compensated landing functions
 - Set down weight control
 - Over pull limitations control

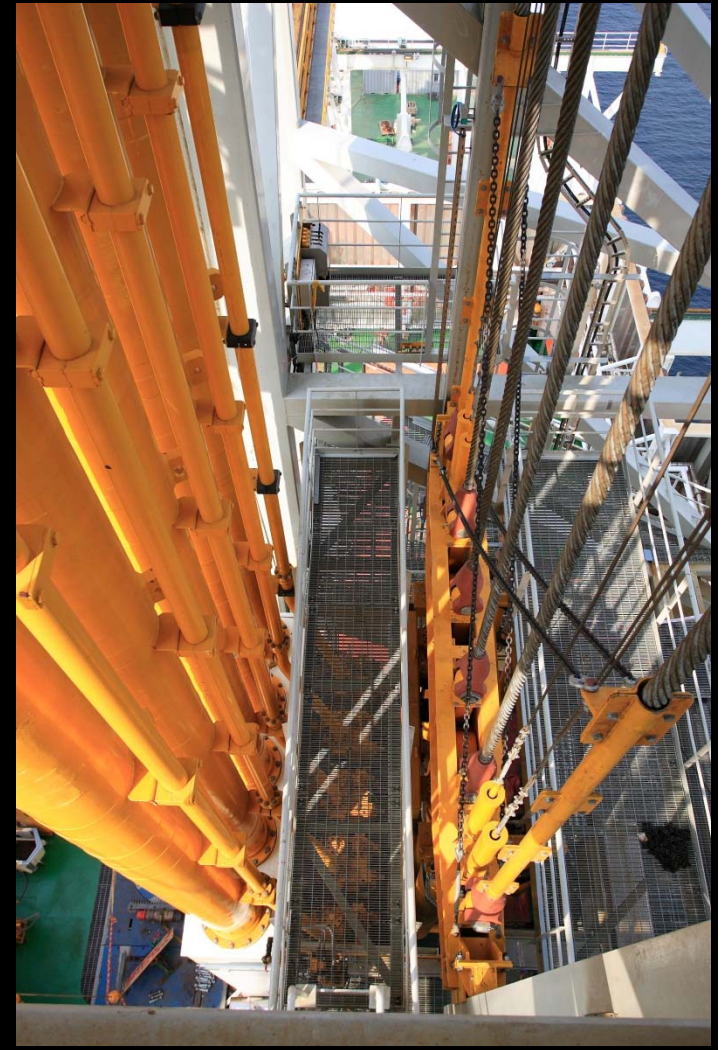
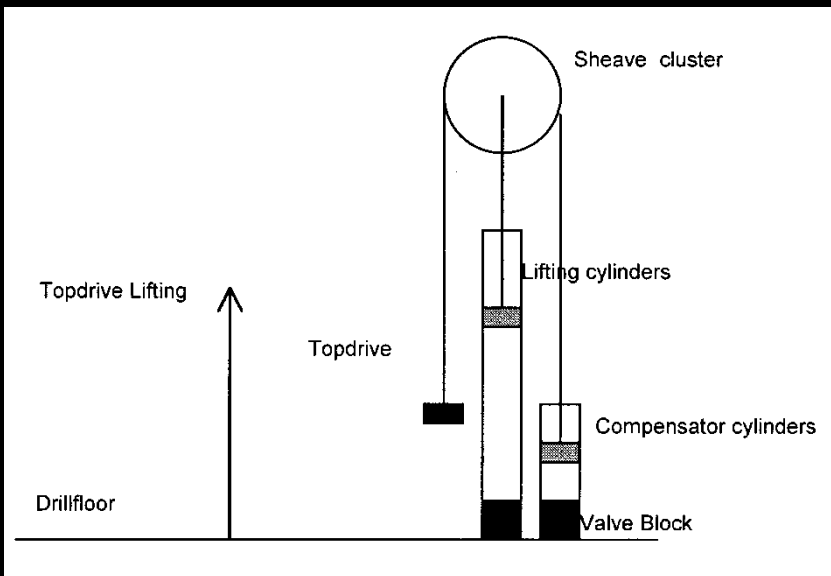


Today NOV can provide AHD drawworks from 500 to 1600 ton

Hoisting Systems

Cylinder Rig Features / Benefits

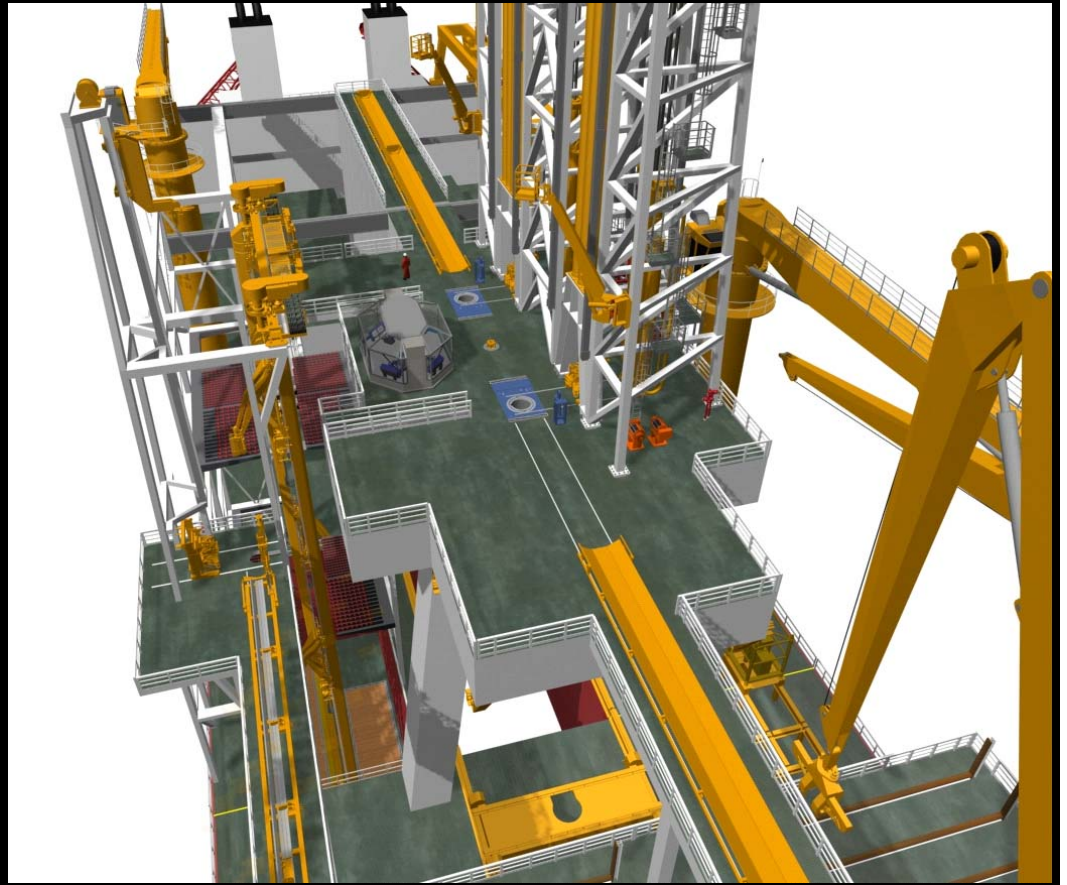
- Separate Hoisting and Compensation Systems
- Regeneration of Energy from Lowering to Hoisting
- Multiple Redundant Hydraulic Pumps
- Backup Hoisting Capability



Hoisting Systems

Cylinder Rig Features / Benefits

- Open Drillfloor with Less Equipment Overhead
- Deck Crane Access to Drillfloor
- Low Drillfloor Noise Levels
- Low Elevator Interface



Drilling Equipment

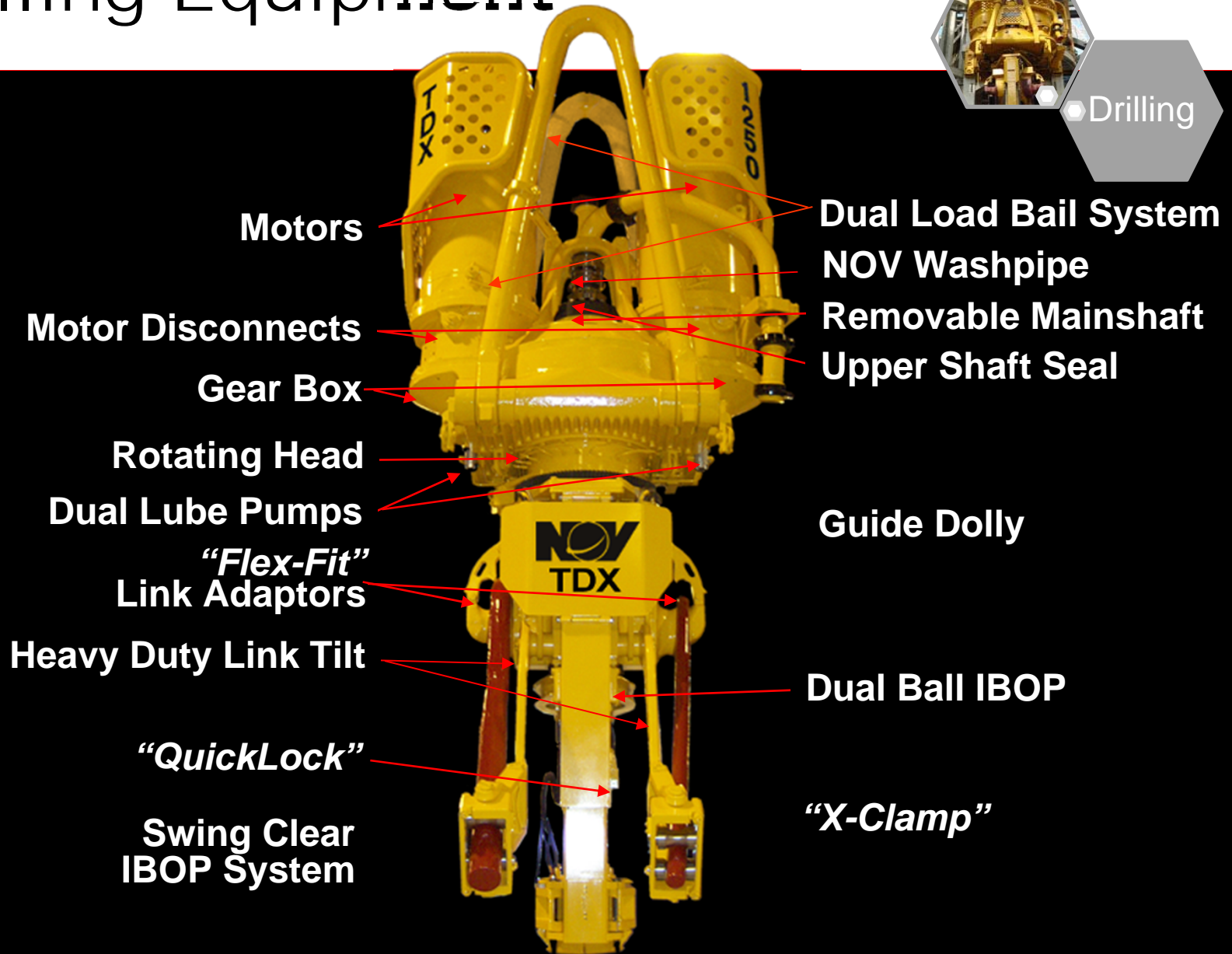
- Top Drive
- Pipe Handling
- Roughneck
- Handling Tools



Drilling Equipment



● Drilling

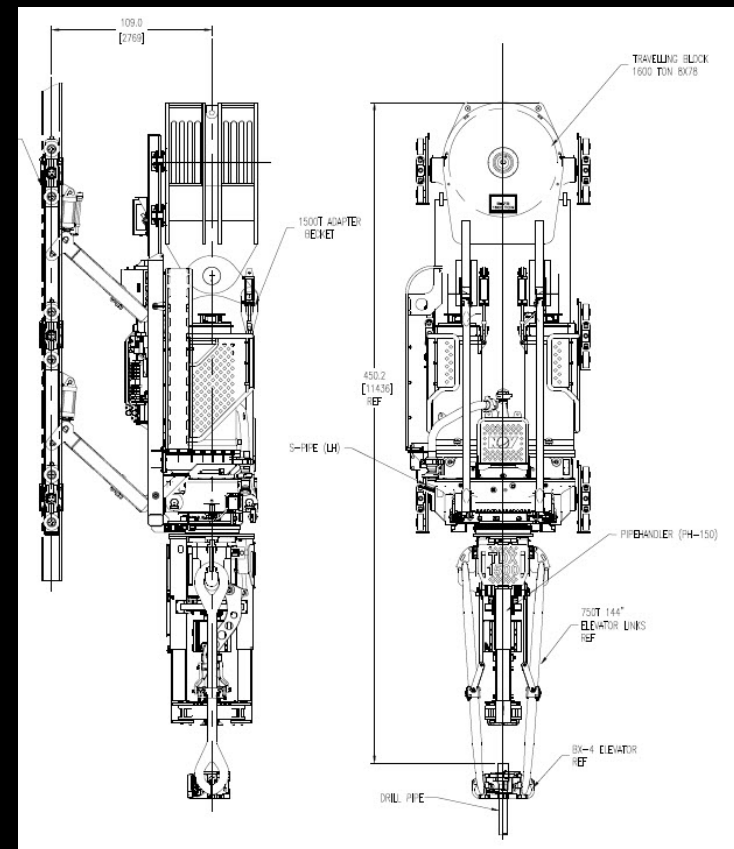


Drilling Equipment



Drilling

- Next Step in TDX Evolution
- **TDX 1500**
 - 1230 Ton Rotating Load Capacity
 - Water Cooled AC or PM Motor Option
 - 1500 Hoisting Capacity (API 8C)
 - 1500 tons at the Elevators
- **Incremental Modification to Existing TDX 1250 Design**
 - Link Adaptor Redesign
 - Bails Change to System Links
 - IBOP Redesign for Higher Pressure
 - Possible Pipe Handler X-Clamp Design*



Pipe Handling

■ HR-IV

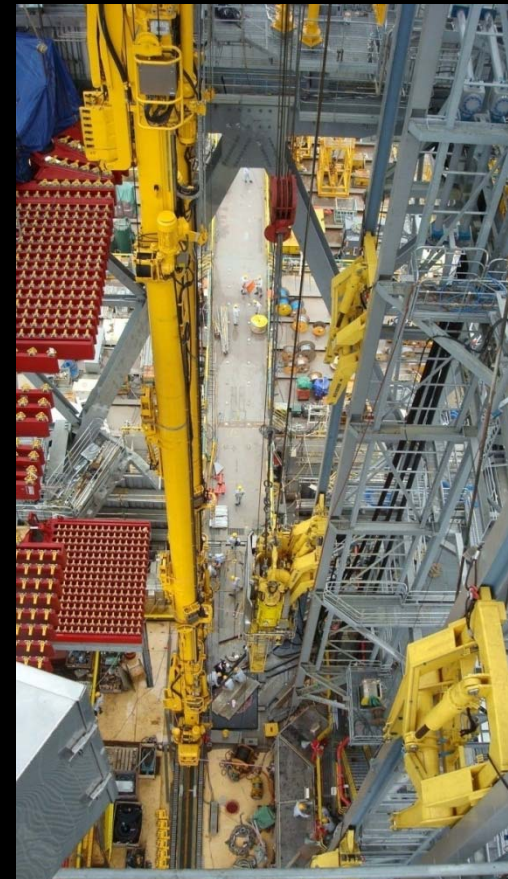
- Hydraulic Column Racker
- 188" Reach
- Can Handle 3 ½" to 22" Tubular
- SWL: 30,864lbs (at 106")
 - 22,046 lbs (at 130")
 - 15,211lbs (>130")
- Fully Multi Machine Control Embedded
- Will be NOVA Compliant
- Tripping and Stand-Building Modes
- Handles Drill Pipe, Drill Collar and Casing
- Can be Configured as Part of a Dual or Single Activity System
- Integrates with all NOV Drill Floor Equipment



Pipe Handling

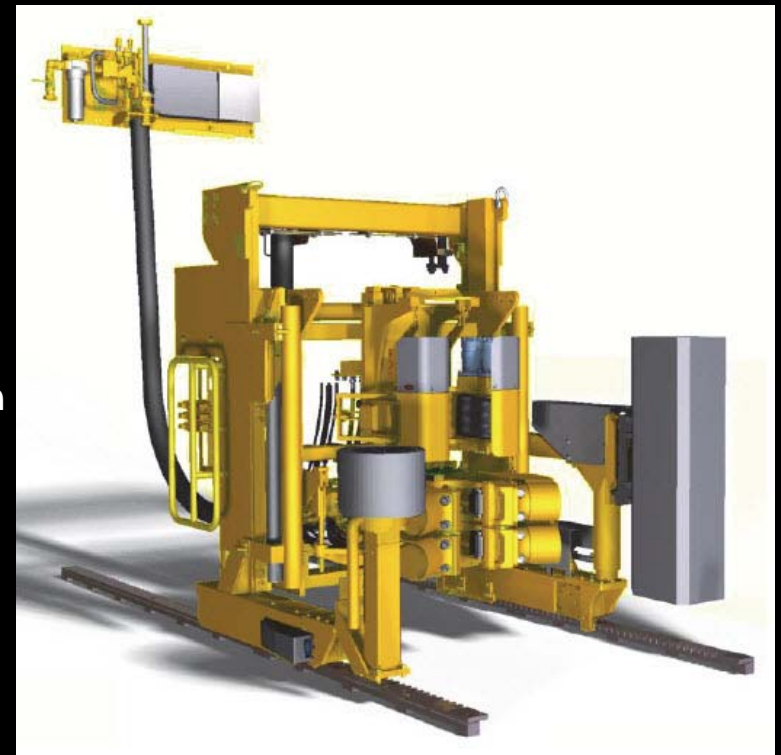
■ PRS

- Electric Column Racker
- 180" Reach
- Can Handle 3 ½" to 22" Tubular (with Large Jaw Install)
- SWL: 30,864lbs (at 106")
 - 22,046 lbs (at 130")
 - 15,211lbs (>130")
- Will be NOVA Compliant
- Tripping and Singles Modes
- Stand Building with PLS System
- Handles Drill Pipe, Drill Collar and Casing
- Can be Configured as Part of a Dual or Single Activity System
- Integrates with all NOV Drill Floor Equipment



Iron Roughnecks

- **Iron Roughnecks**
- **Pedestal and Track Solutions**
- **MPT-270**
 - Track Mount Modular Roughneck
 - New Design High Capacity Modular Torque Wrench 200k lbs.ft
 - Based on MPT 200 Design with Exception of Torque Wrench
- **ST-160**
 - Pedestal Mount Modular Roughneck
 - Fully Automated
 - Based on ST-120 Design
 - Modular Design to Accommodate NOV Pipe Module
 - Accommodates Casing Tongs (NOV Supply and 3rd Party)



Pipe Handling Summary



- **Main Development Steps**
- **Top Drive (TDX 1500)**
 - Rotating Link Adaptor
 - Bail Design
 - Lower IBOP design
 - Pipe Handler Throat Size (driven by tubular size)
- **Pipe Handling**
 - Existing Column Rackers Capable
 - Tubular Weights Can be Accommodated
- **Iron Roughneck**
 - More Than Capable of Torque Requirements
 - Larger Drilling Tubular May Drive Larger TW Throat Size



Handling Tools

- What is required:
 - Weldless Links
 - BX7 Hydraulic Elevator
 - RST - Rotary Support Table
 - MBH1250 with Landing String Slips
 - PS495 Hydraulic Power Slip
 - Casing Equipment

Weldless Links

Max. available: 1,250t

1,500t links to be designed and developed

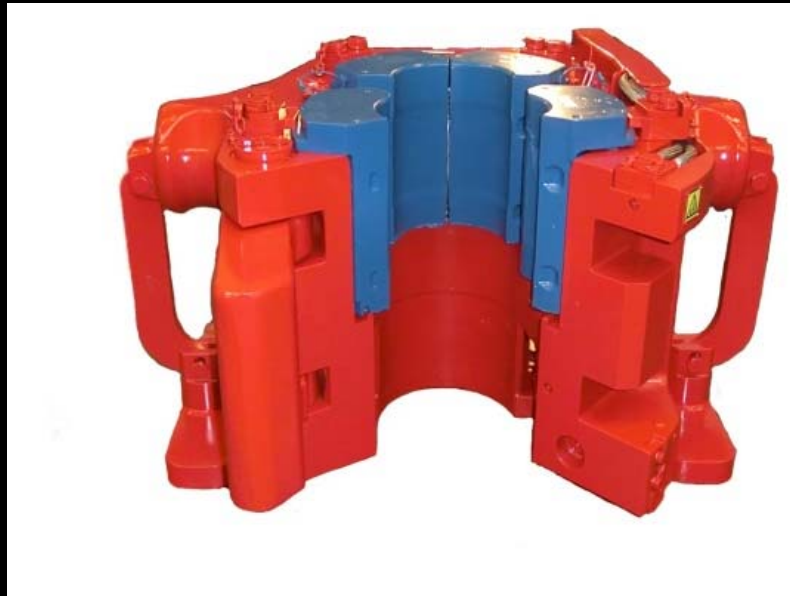


BX-7 Hydraulic Elevator

Max. available: 1,250t (riser/square shoulder/45° tool joints)

Can be rated to 1,500t with a 2.25 : 1 S.F. for Riser Running Tool and 1,250t for Landing Strings (with 18 degree TJ).

Lead time +/- 6-8 month



RST – Rotary Support Table

Max. currently available:
RST755 – 75 ½", 1375
tons.

Can be designed to 1,500t
(static only), and 1,250t
(rotation)

Special provisions for riser
spider to land on topcover
in order to by-pass main
bearing



MBH1250 w/Landing String Slips

Max. available: 1,250t with LSS*
and LSB**

Lead time: design completed and
tested

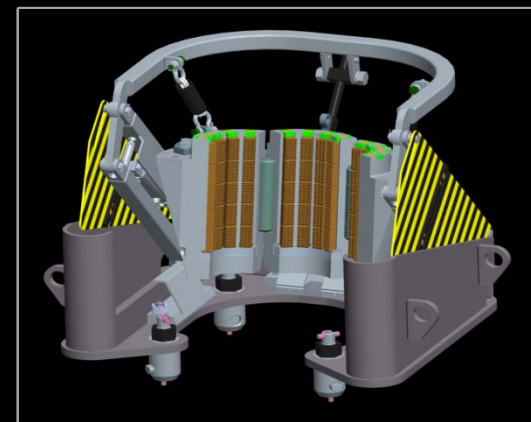
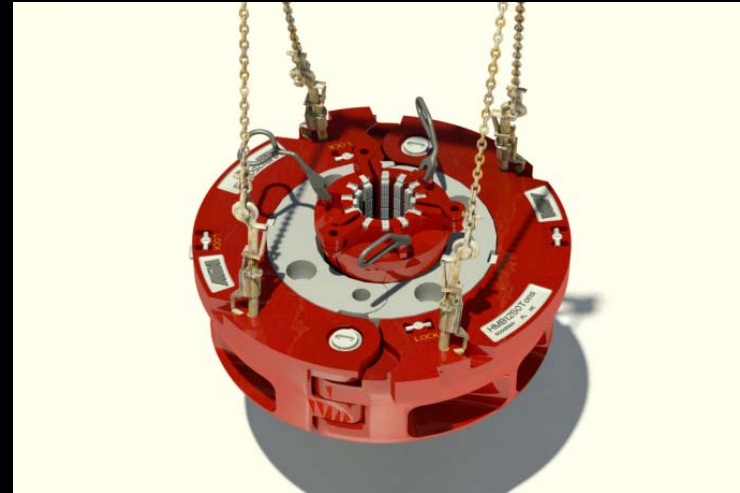
Special Slip Lifter tool (SLT) to run
heavy landing string slips

Lead time 8 month

NOTE: 1,500 not required/possible

* Landing String slips

** Landing String Bowl



PS495 Hydraulic Power Slip

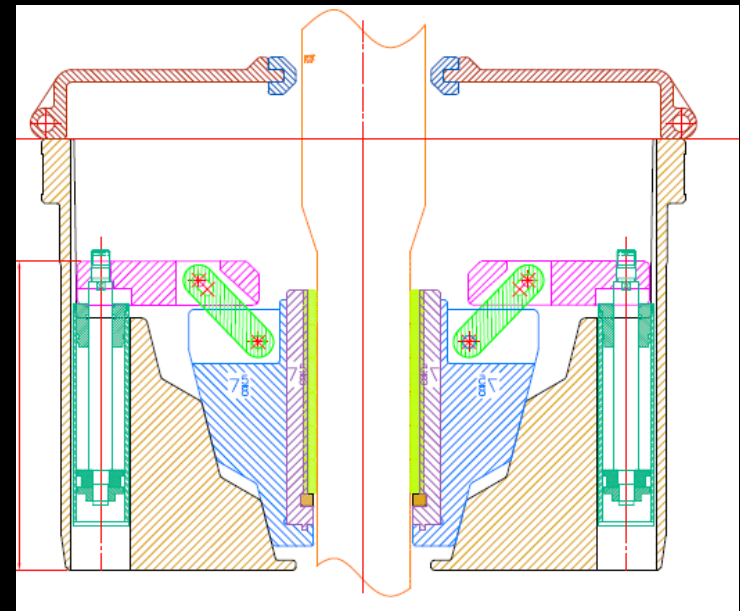
1,250 – 1,500t capacity

For Drill-pipe only (up to 7.5/8" DP)

Currently in designing phase

Prototype available within 12 month

Production unit expected available
Q1/Q2 2014



Wrap-up

The 20,000 psi/high hookload challenge cannot be addressed at the BOP alone.

Every system must be evaluated and modified as needed.

NOV is the only manufacturer with the breadth and depth to address the complete drilling package from the stack to the crown.



NOV | Rig Solutions | rig@nov.com