Achieving exceptional reliability thru key initiatives on an enabling drilling technology

Principles that have allowed for a near perfect operating performance of the Continuous Circulation System

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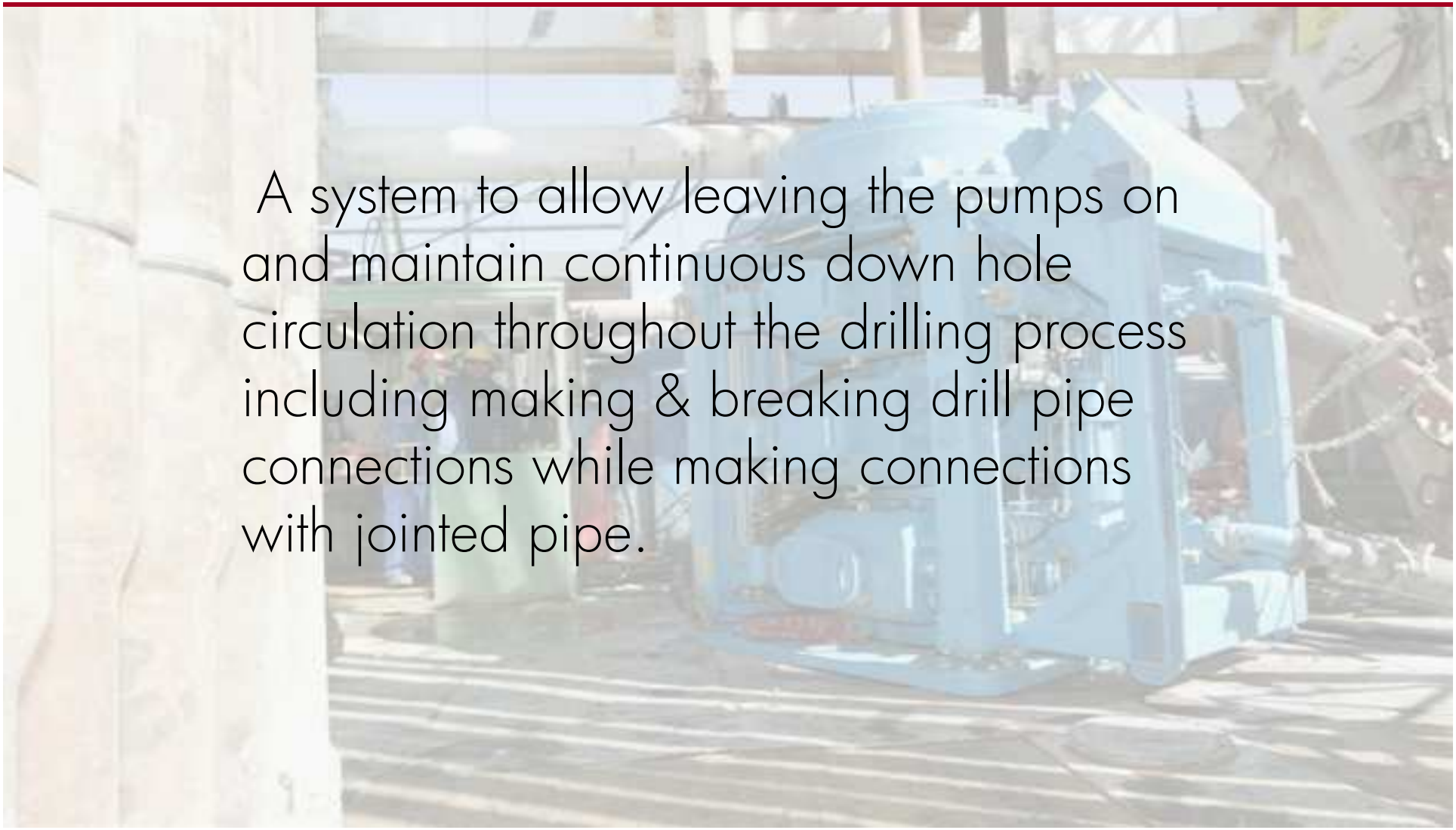
Maintaining and Achieving Success

- Continuous Circulation System Overview
- Philosophy and Principles of Design
- Training, Implementation and Tracking
- Testing
- Reliability Statistics/Case histories
- Summary Comments

What is the CCS



A system to allow leaving the pumps on and maintain continuous down hole circulation throughout the drilling process including making & breaking drill pipe connections while making connections with jointed pipe.

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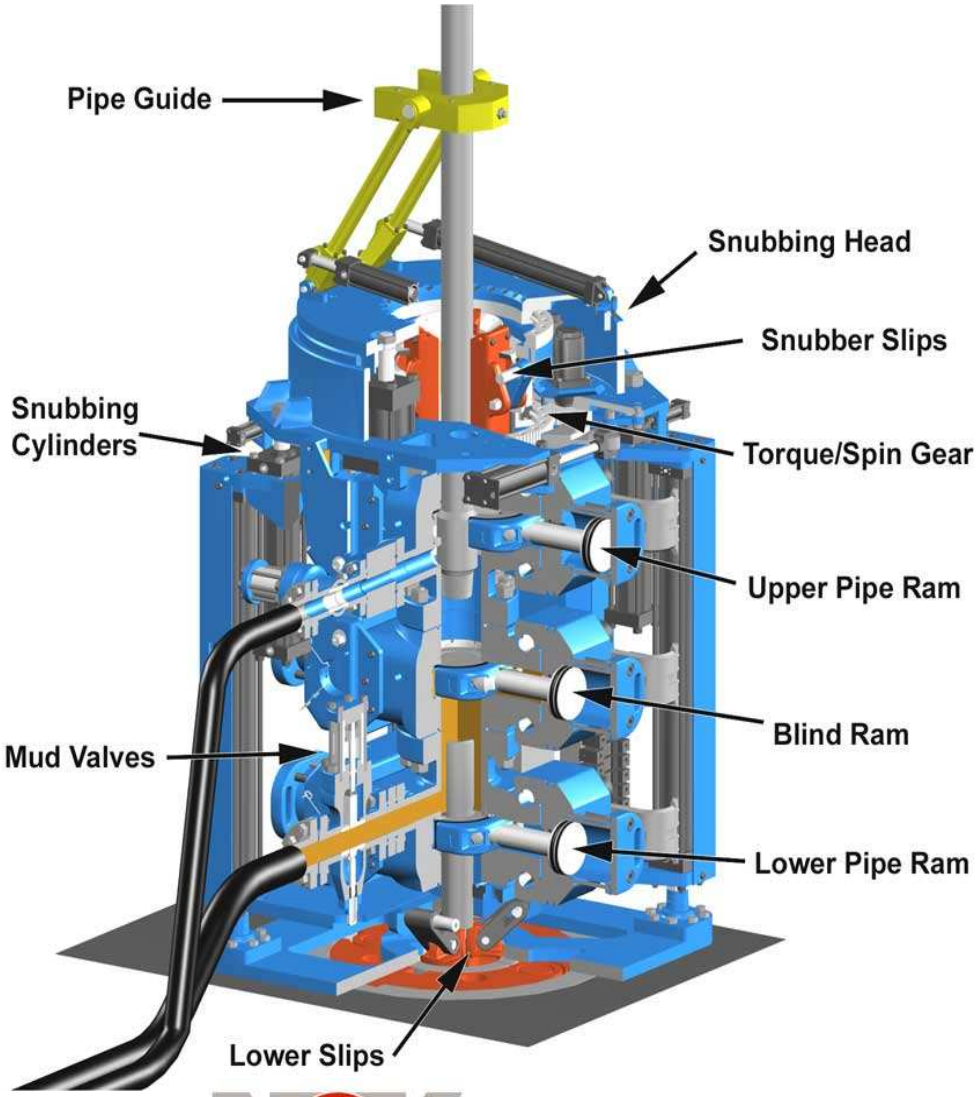
Components of the CCS



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Components of the CCS

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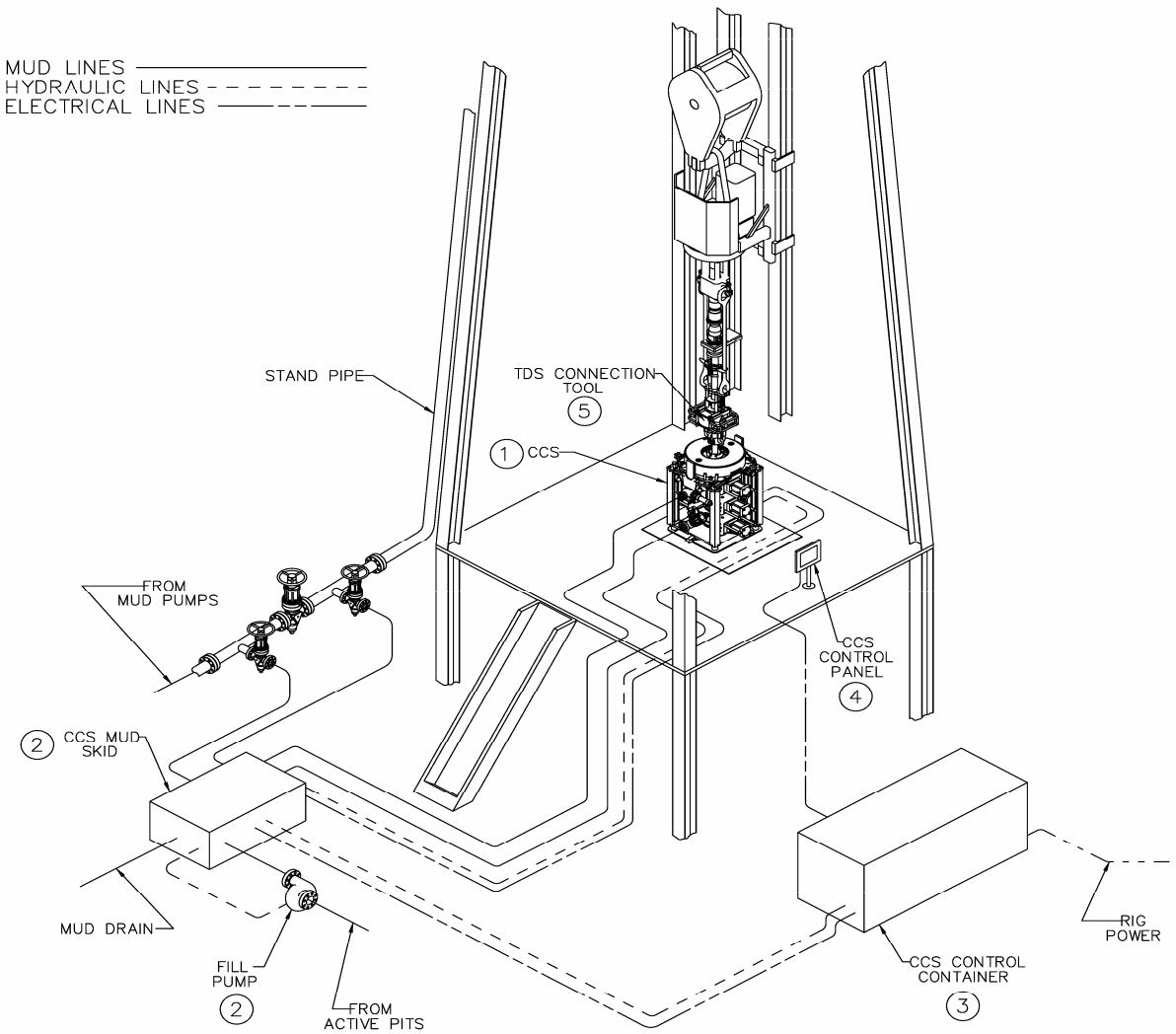
Rig Layout



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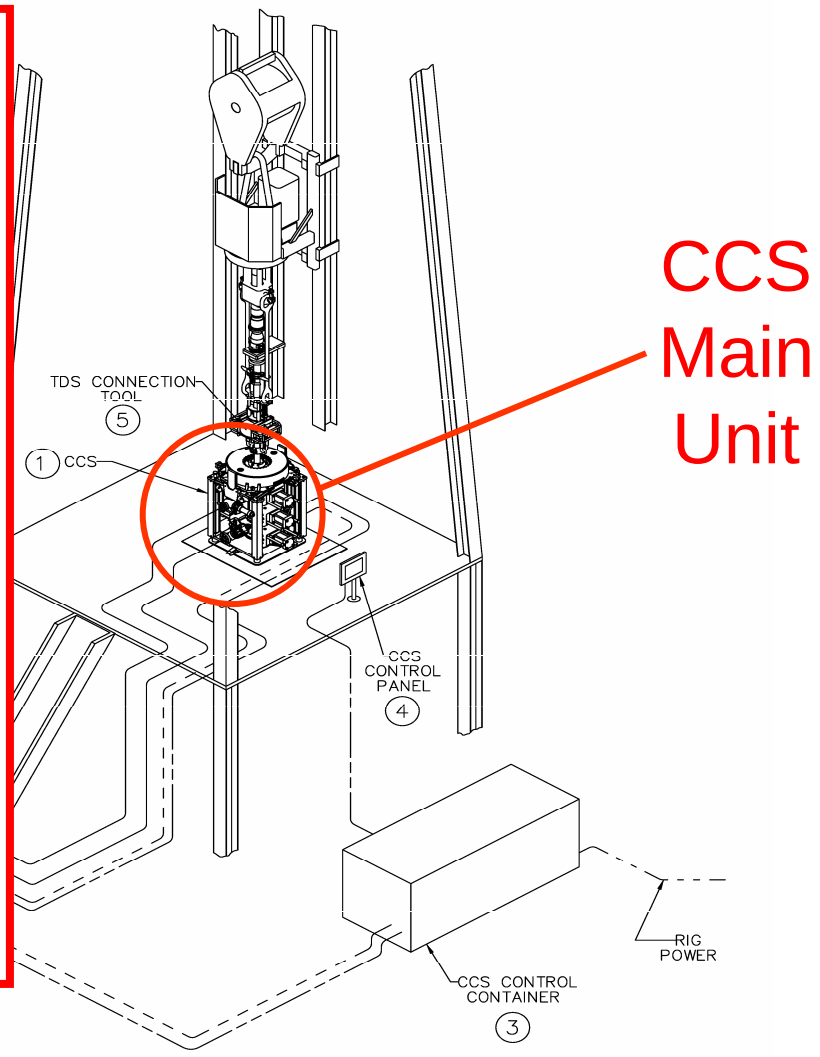
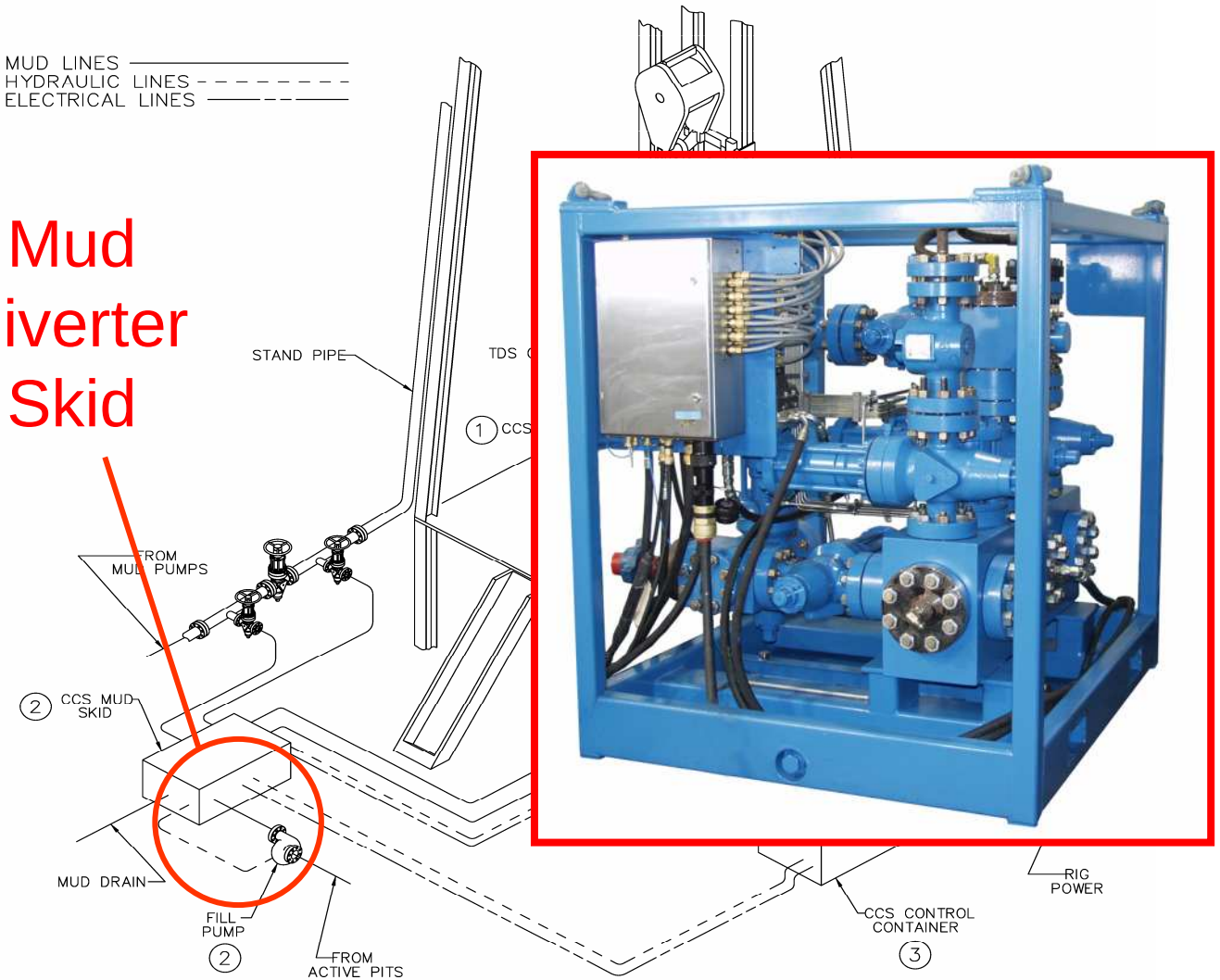
Rig Layout



CCS Main Unit

Rig Layout



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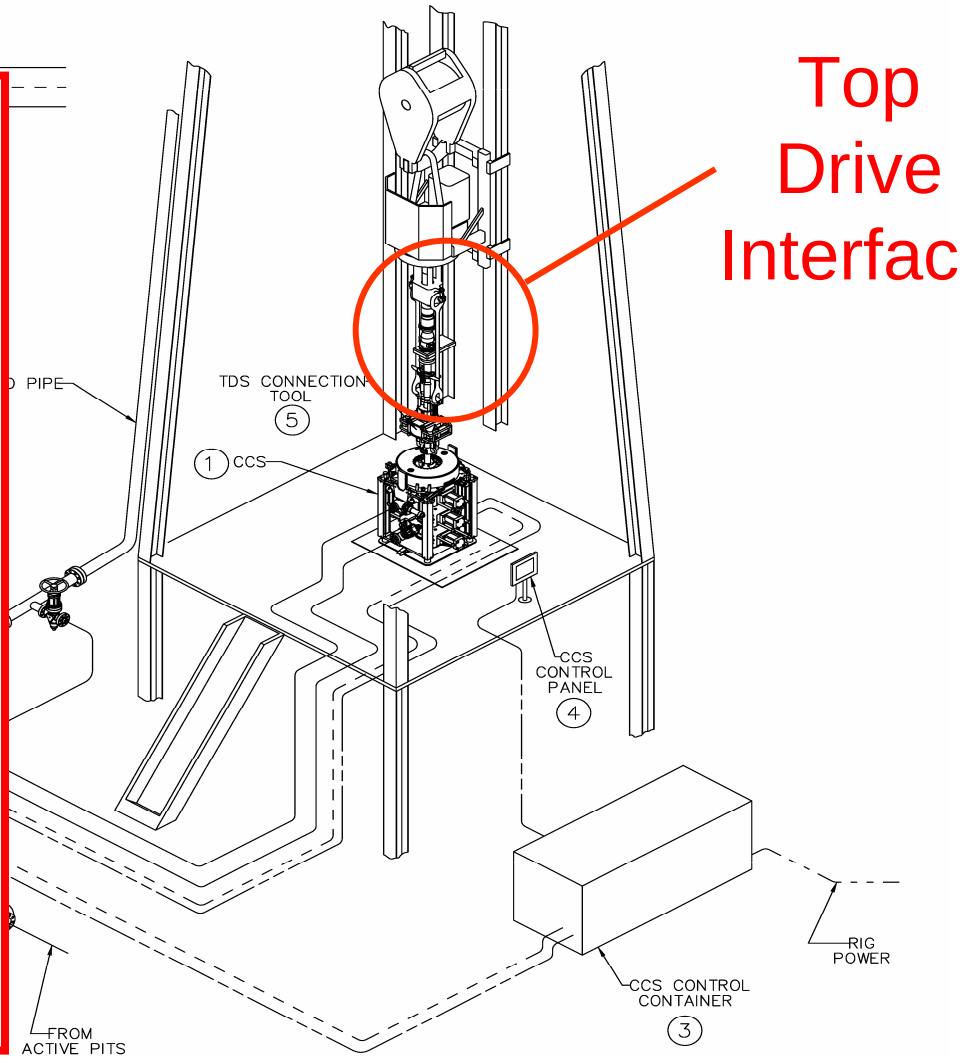
Rig Layout

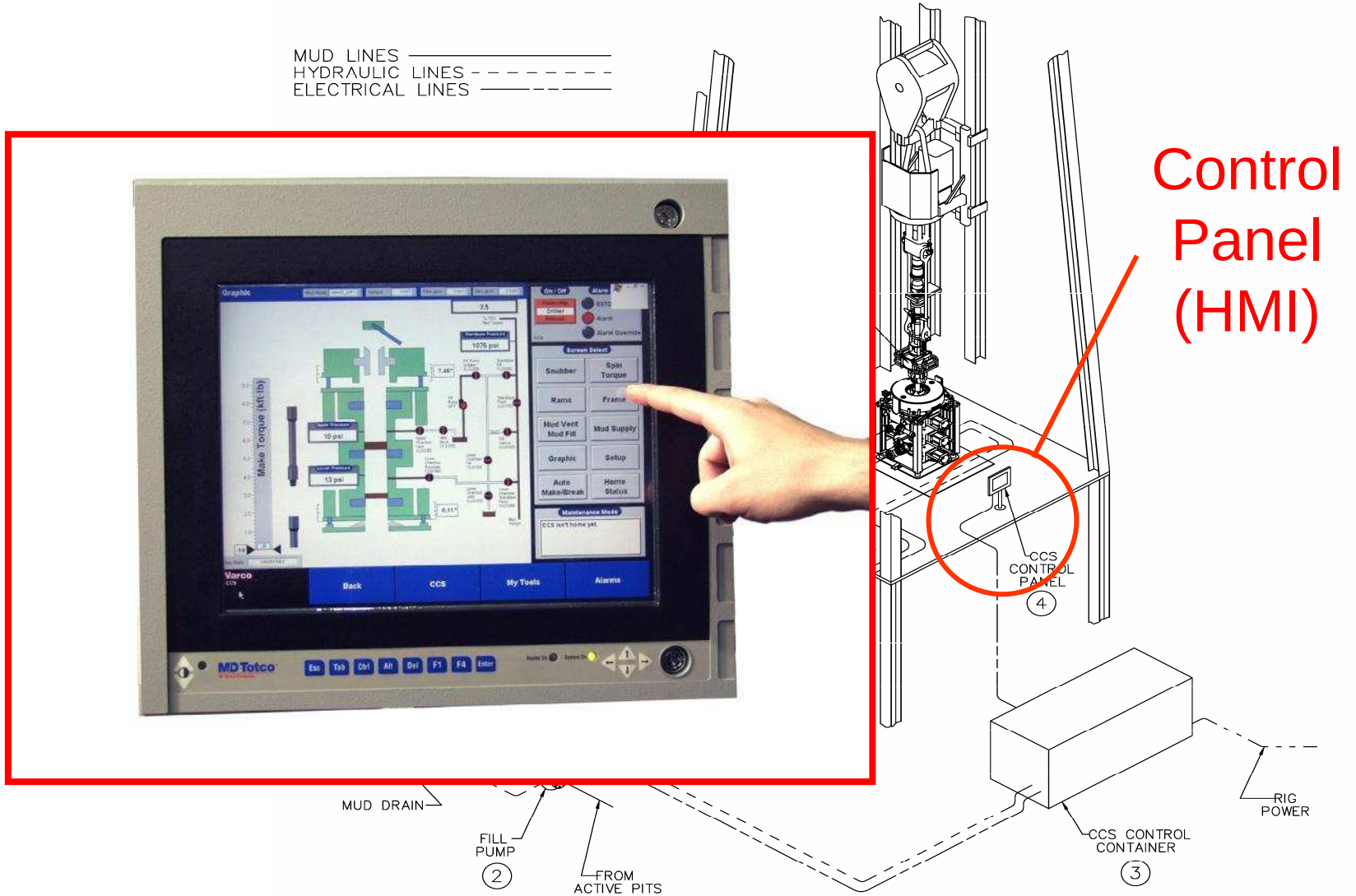


Top Drive Interface

Rig Layout

Control Container

Rig Layout



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System Components and Layout

CCS Main Unit

Top Drive Interface

Mud Diverter Skid

Control Panel (HMI)

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CCS Specifications

- Working Pressure: 5,000 psi
- API Bore size: 9"
- Drill pipe size range: 3-1/2" to 5-7/8"
- Torque capacity: 70,000 ft-lbs
- Mud circulation: 1000 gpm

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Philosophy of Design

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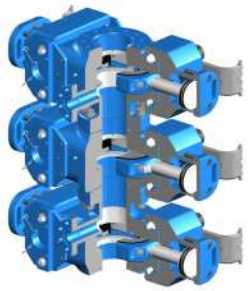
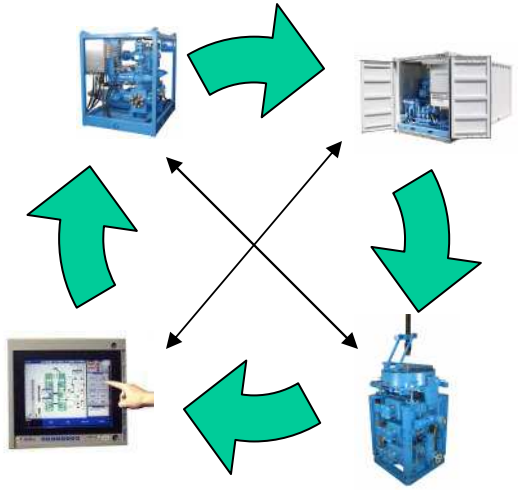
Principles of Design

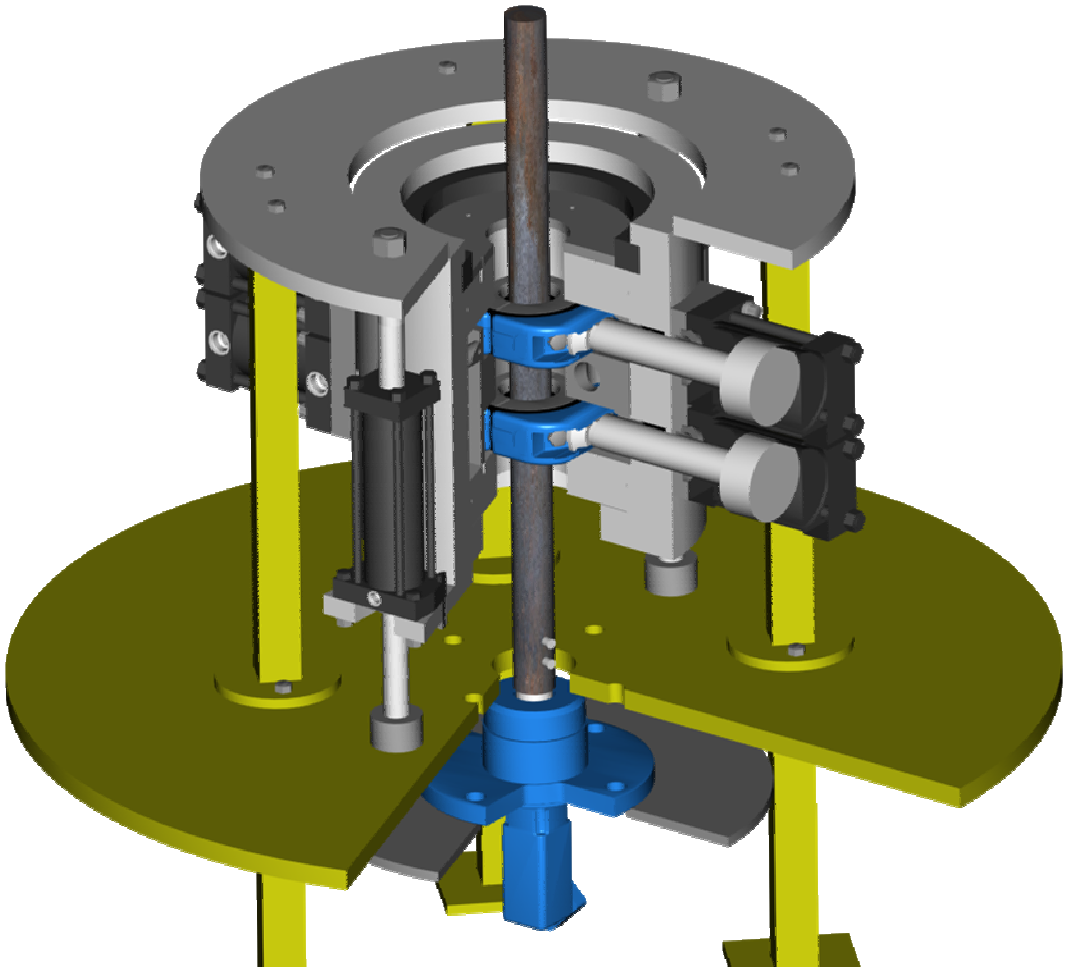
- Redundancy where Practical
  - Personnel
  - Valves
  - Hydraulic Pumps
  - Multiple Operational modes
- Use of Field proven Technology
  - BOP's
  - Slips
  - Rams



- Profibus communications network
  - Redundancy where Practical



Test Fixtures: Ram Rubber



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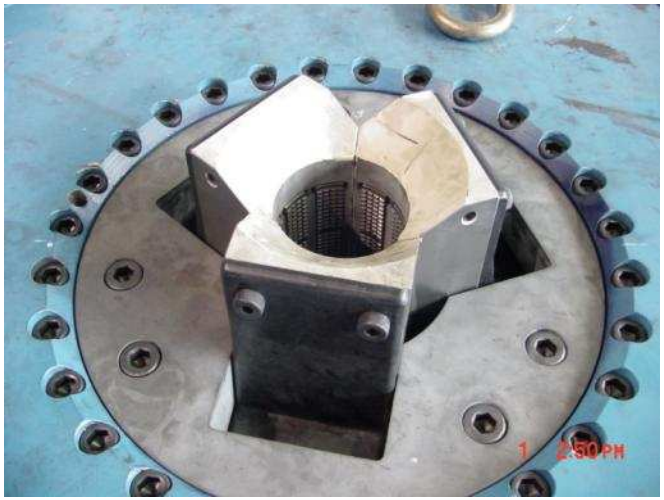
Test Fixtures: Tool Joint Torque Testing



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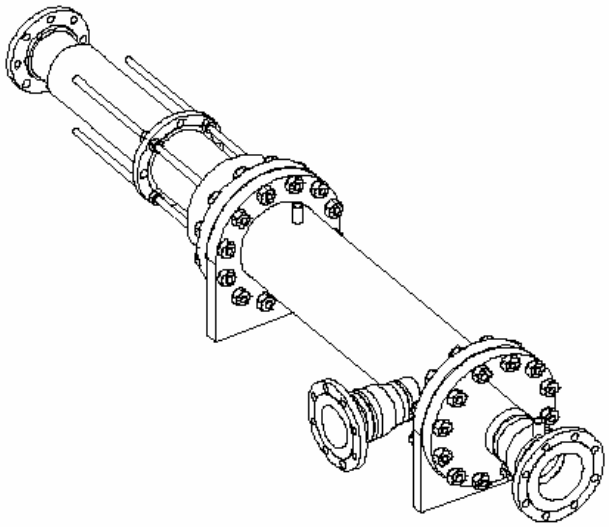
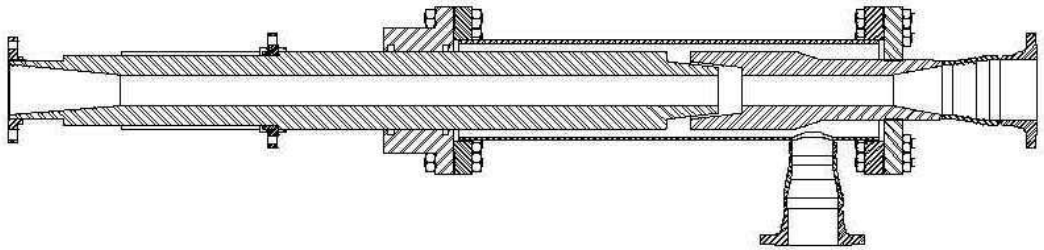
Pipe dope retention tests





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Training School

- Comprehensive dedicated school 80 hours
  - All service technicians must attend
    - Must attend every two years refresher
  - Electrical schematic reviews
  - System Hardware and Software updates
  - Lessons Learned Review

- Selective process
  - Service Engineers are top performers at the NOV training center

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Competency training

- Competency training

THE QUALIFICATION PROCESS

– The qualification process includes educational, training, and evaluation activities.

THE ASSESSMENT PROCESS

– Determine
– Record
– Report

Continued Shop and ON the Job Training

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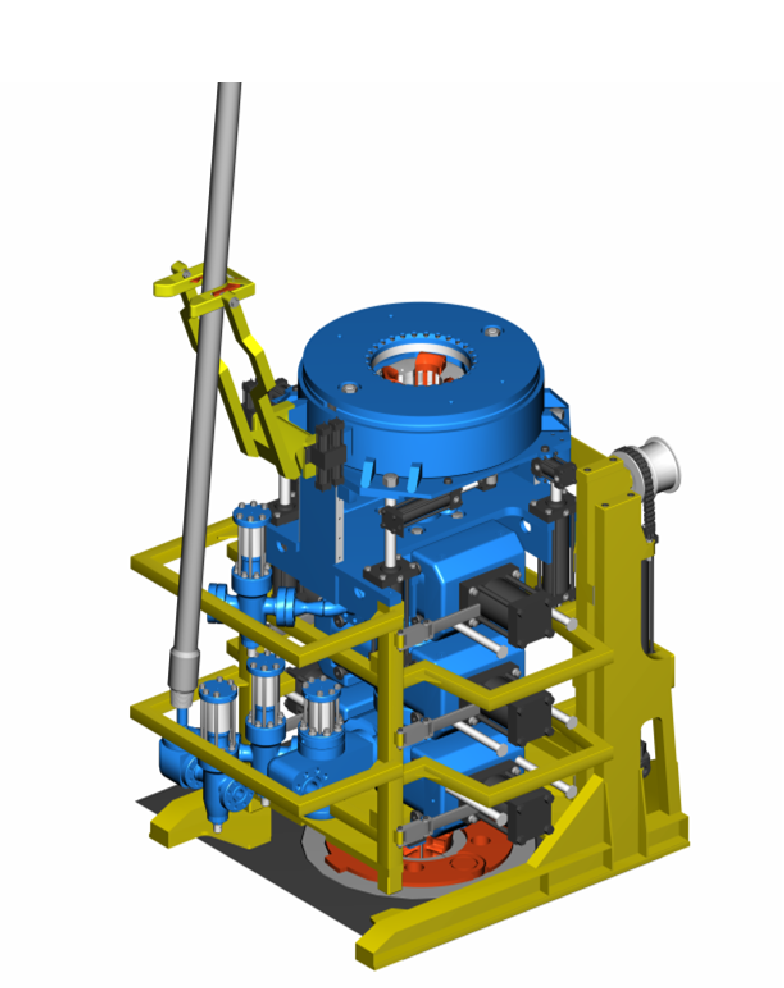
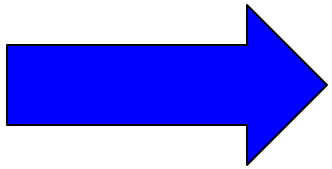
Complicated Tool

- The CCS is a tool fit for Purpose
  - Complicated tool
    - Snubbing
    - Iron rough neck
    - Mud flow management
    - Pressure containment
    - String hang-off
  - Complicated Controls
    - Electronic / Hydraulics
- Complexity has lead to an evolutionary design improvement process

Proto-type to Commercial





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Records & Reporting

- Daily Record & Report for client and service contractor

NO Secrets

Daily Report


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Continuous Circulation System Daily Report

Issues Log


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Continuous Circulation System Issues Log

Maintenance Log


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Continuous Circulation System Maintenance Log

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Real-time Monitoring

e-Hawk SERVICE CENTER

International Assistance

Client Engineers Office

Mobile Engineer (SME)

Client Rig

NOV Subject Matter Expert (HOME)

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Function Acceptance Test

- Performed prior to shipment of equipment to job site
  - Full Report made and reviewed with focus on fixing all issues
  - Customer witnessed
- On site after rig commissioning
  - Performed in non critical section of Well
    - FAT specific procedure completed

Test fixtures

- Norway

- Houston
- Egypt

Maintenance between Jobs

5 year overhaul

- Thorough between well maintenance
  - Rebuild all valves
  - Fully lubricate all moving components
  - Replace the BOP wear sleeves
  - Monitor fluids
  - Monitor corrosion
  - 3rd party review of electrical components
  - Outfitted with all new replacement parts
    - Consumables

Consumables

- Tracking
  - Number of connections made
  - Stripping length
  - Preventative consumable replacement schedule
  - Full complement of spares
    - Insert tool container picture……

RIH & POOH With 5.1 VAM EIS Drill Pipe

DATE	23/11/2008									
CONNECTION DEPTH (BIT)										
CONNECTION DEPTH (MEASURED)										
CONNECTION TYPE (RIH or POOH)										
CONNECTION NUMBER	1	2	3	4	5	6	7	8	9	10
CO-OPERATOR NAME										
CONNECTION START TIME										
CONNECTION END TIME										
UPR CLOSE & TAG TOP OF TOOLJOINT @ = (cm)										
LPR CLOSE & TAG BOTTOM OF TOOLJOINT @ = (cm)										
DISTANCE BETWEEN UPR AND LPR = 124.4 cm	124	124	124	124	124	124	124	124	124	124
DIFFERENCE = (cm)	0	0	0	0	0	0	0	0	0	0
TOOLJOINT LENGTH = (cm)	124	124	124	124	124	124	124	124	124	124
SLIPS SET @ = (cm)										
CHAMBER PRESSURE DROP @ BREAK = (BAR)										
CHAMBER PRESSURE DROP @ MAKE = (BAR)										
STANDPIPE PRESSURE DURING CONNECTION = (BAR)										
FLOW RATE DURING CONNECTION = LTR/PM										
FILL ORIFICE BEAN SIZE										
CONNECTION COMPLETED IN SEQUENCE OR MANUAL ?										
FILL ORIFICE BEAN INSPECTED/CHANGED CONNECTION #										
UPPER RAMS CHANGED AFTER CONNECTION #										
LOWER RAMS CHANGED AFTER CONNECTION #										
MIDDLE BLIND RAMS CHANGED AFTER CONNECTION #										
SNUBBER DIES CHANGED AFTER CONNECTION #										
SNUBBER BEARINGS GREASED AFTER CONNECTION #										
SNUBBER TOP HAT CAP BOLTS VISUALLY CHECKED AFTER CONNECTION #										
SNUBBER TOP HAT CAP BOLTS/SNUBBER SLIP ENGAGE CYLINDERS CHECKED AFTER CONNECTION #										
TORQUE SYSTEM GREASED AFTER CONNECTION #										
TOMBSTONES GREASED AFTER CONNECTION #										
WEAR RINGS & SEAL SEATS REMOVED/CLEANED & REFITTED AFTER CONNECTION #										
DP SLIPS DIES CHANGED AFTER CONNECTION #										
WEEKLY CHECKS AS PER MTS 095 COMPLETED										

E-HAWK TEL: +1 713 980 8516 HOUSTON TECH SUPPORT TEL: +1 832 657 7329 MONTROSE TECH SUPPORT TEL: +44 1674 677222
ROUTINE MAINTENANCE
SNUBBER DIES TO BE RENEWED = 30 CONNECTIONS
MIDDLE BLIND RAMS = 150 CONNECTIONS
LOWER PIPE RAMS = 75 CONNECTIONS
GREASE SNUBBER/BULL GEAR = 10 CONNECTIONS
CHECK HPU PRESSURES/TEMPERATURE EVERY HOUR, RECORD SAME ON HPU PRESSURE/TEMPERATURE RECORD SHEET
CHECK FILL ORIFICE BEAN FOR WEAR = 25 CONNECTIONS
UPPER PIPE RAMS = 35 CONNECTIONS OR 40%
LOWER PIPE RAMS = 75 CONNECTIONS
MIDDLE BLIND RAMS = 150 CONNECTIONS
CHECK TORQUE ON SNUBBER 'TOP HAT' CAP BOLTS (1200ft/lbs) = WHEN UPRs ARE CHANGED OUT
CHECK TORQUE ON SNUBBER 'TOP HAT' CAP BOLTS (1200ft/lbs) = WHEN UPRs ARE CHANGED OUT. CHECK TORQUE ON SNUBBER SLIP ENGAGE CYLINDER BASE RETAINING BOLTS (450ft/lbs) = 15 CONNECTIONS
REMOVE & INSPECT/CLEAN UPPER/LOWER & MIDDLE WEAR RINGS & SEAL SEATS (IF OPERATIONS PERMIT) = 100 CONNECTIONS
DP SLIP DIES TO BE RENEWED = 100 CONNECTIONS

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End Of well Report

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Equipment Description:	**Pressure Vessel's**	**Date:**	**3/5/2009 16:32**
Part #:	**20010113 (Upper & Lower), 22021839 (Middle)**	**Workscope Ref:**	**Section # 6**
Serial #'s:			

Item #	Activity	Required Yes/No	Inspection Report	Completed By	Date Completed	Comments
	Upper Pressure Vessel, Part # 20010113, Serial #					
6.1	Open pressure vessel doors.	✓	✓	BR & MG	18/12/08	Upper doors can only be opened once snubber has been raised 2"
6.2	Remove ram blocks from ram shafts, remove ram rubbers from ram blocks, dress any damage to blocks using a file.	✓	✓	BR & MG	19/12/08	Ref MTS 073, Issue 1, Rev D
6.3	Inspect ram shafts for damage & any leakage.	✓	✓	BR & MG	19/12/08	Photographs to be taken
6.4	Remove pressure vessel door cartridge seal carriers for inspection/cleaning, inspect springs for any damage, replace as required, clean all mud residue from seating area.	✓	✓	BR & MG	19/12/08	" "
6.5	Remove wear ring retaining side pads.	✓	✓	BR & MG	19/12/08	" "
6.6	Remove lower wear ring from upper pressure vessel, clean all mud residue from seating area & wear ring, inspect wear ring for erosion.	✓	✓	BR & MG	19/12/08	6 x 7/16" UNC x 2" LG jacking bolts rqd, photographs to be taken
6.7	Remove upper seal seat from upper pressure vessel, clean all mud residue from seating area & seal seat, inspect seal seat for erosion.	✓	✓	BR & MG	19/12/08	Photographs to be taken
6.8	Grease wear ring seating area in upper pressure vessel, grease lower wear ring & refit wear ring in upper pressure vessel, refit wear ring retaining side pads.	✓	✓	BR & MG	19/12/08	" "
6.9	Grease seal seat seating area in upper pressure vessel, grease upper seal seat & refit seal seat to upper pressure vessel.	✓	✓	BR & MG	19/12/08	" "
6.10	Grease cartridge seal seating area & refit pressure vessel door cartridge seals.	✓	✓	GT	30/12/08	" "
6.11	Rotate all pressure vessel door lock bars checking for freedom of movement, remove all mud residue from lock bar grooves.	✓	✓	GT	30/12/08	" "
6.12	Check pressure vessel doors for sagging, re-shim doors if required once doors are closed	✓	✓	GT	30/12/08	" "
6.13	Refit ram block assemblies to ram shafts, lubricate all ram blocks using grease, lightly lubricate external of cartridge seals, lightly lubricate lockbar grooves on pressure vessel doors, close pressure vessel doors.	✓	✓	GT	30/12/08	**Ref MTS 073, Issue 1, Rev D**
6.14	Once pressure vessel doors are closed & lock bars locked, remove all pressure vessel lockbar locking bolts from lockbar holder assembly for inspection/replacement	✓	✓	MH & GW	06/01/09	
6.15	Remove J-Plates from pressure vessel and clean all mud residue from behind the J-plate, inspect all door rollers for freedom of movement, replace as required	✓	✓	GT	30/12/08	
6.16	Refit all J-Plates to pressure vessel	✓	✓	GT	30/12/08	
6.17	Refit lockbar locking bolts into lockbar holder assembly, check security of lock bar safety clip	✓	✓	MH & GW	06/01/09	

Rig Survey

- Comprehensive pre-installation Rig Survey

Rentals CCS Pre - Survey Information

Introduction: The information requested below is required to confirm how CCS will be integrated into the existing rig systems and prepare NOV Engineering for a rig site survey.

1) Drill Pipe:
   a. Size?
   b. Type?
   c. Length?
   d. Make up torque and expected down hole make up?

2) When continuous circulation is needed, what is the lightest the drill string is expected to weigh?

3) What is the stand pipe size and pressure rating?

4) Rig Specific Data
   a. What type of rig is it? Jack-up, etc.
   b. Who is the classification authority (i.e. ABS, Lloyds Register, etc.)

5) Does the bottom-hole assembly utilize filters or screens?

6) Is High-Speed internet available?

7) Rig Floor Equipment:
   a. Top Dive Make and Model?
   b. Derrick height?

8) What is the stand pipe size and pressure rating?

9) What is the expected flow rate?

10) Drilling Program;
   a. Estimated hole depth and length?
   b. Estimated well bore pressure?
   c. Mud type and weight?
   d. Estimated job duration?
   e. Is H2S expected?
   f. Is the well considered to be HPHT?

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Daily Logs

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Continuous Circulation System Daily Report

Date:	13 November 2008	**Day:**	60	**Company:**	StatoilHydro
Well:	A - 3	**Rig:**	Kvitebjørn	**Location:**	Norwegian Sector, North Sea
Operations @ 06:00	Pumping out of open hole with BHA with wet CCS connections.				
Current MD:	5726 mtr	**Inclination:**	35.07° @ 5391.87 Az	**TVD:**	4232m

CCS & Rig Operations Summary last 24 Hours:

Pumped OOH to 5450 m with 2 x wet CCS connections. Reamed & re-logged 8 1/2" open hole to TD with 10 wet CCS connections . Circulated BU and displace well to 1.97 sg Cs/K mud. Pumped OOH from 5726-5650 m. Assisted with PCWD operations

OPERATIONS DETAIL

From	To	Time	CCS	RIG
6:00	6:19	0:19	Standby for CCS connection. Assisted with PCWD operations.	Pumped OOH with BHA from 5517m with 1100 lpm, SPP 212 bar, PWS choke 36 bar, EMW 1.94 sg.
6:19	6:42	0:23	CCS Wet connection # 101 POOH	CCS wet connection POOH
6:42	6:59	0:17	Standby for CCS connection. Assisted with PCWD operations.	Pumped OOH with BHA to 5450m with 1100 lpm, SPP 212 bar, PWS choke 36 bar, EMW 1.94 sg.
6:59	7:23	0:24	CCS Wet connection # 102 POOH	CCS wet connection POOH
7:23	8:20	0:57	Standby for CCS connection. Assisted with PCWD operations.	Down-linked and reset Sonic/Minitron tools. Took survey to check sonic tool.
8:20	8:43	0:23	CCS Wet connection # 103 RIH	CCS wet connection RIH
8:43	9:01	0:18	Standby for CCS connection. Assisted with PCWD operations.	Reamed 8 1/2" hole from 5450 - 5570m with 1000 lpm, SPP 190 bar, 80 rpm, torque 36-38 kNm, PWS choke 38-39 bar, EMW 1.94 sg.
9:01	9:21	0:20	CCS Wet connection # 104 RIH	CCS wet connection RIH
9:21	9:32	0:11	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream 8 1/2" hole from 5450 - 5570m with 1000 lpm, SPP 190 bar, 80 rpm, torque 36-38 kNm, PWS choke 38-39 bar, EMW 1.94 sg.
9:32	9:52	0:20	CCS Wet connection # 105 RIH	CCS wet connection RIH
9:52	10:08	0:16	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream 8 1/2" hole from 5450 - 5570m with 1000 lpm, SPP 190 bar, 80 rpm, torque 36-38 kNm, PWS choke 38-39 bar, EMW 1.94 sg.
10:08	10:27	0:19	CCS Wet connection # 106 RIH	CCS wet connection RIH
10:27	10:41	0:14	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream 8 1/2" hole from 5450 - 5570m with 1000 lpm, SPP 190 bar, 80 rpm, torque 36-38 kNm, PWS choke 38-39 bar, EMW 1.94 sg.
10:41	11:01	0:20	CCS Wet connection # 107 RIH	CCS wet connection RIH
11:01	11:37	0:36	Standby for CCS connection. Assisted with PCWD operations.	Reamed & re-logged 8 1/2" hole from 5570 - 5721m with 1000 lpm, SPP 190 bar, 80 rpm, torque 38-40 kNm, PWS choke 37-39 bar, ROP 60 m/hr, EMW 1.94 sg.
11:37	11:58	0:21	CCS Wet connection # 108 RIH	CCS wet connection RIH
11:58	12:46	0:48	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream & re-log 8 1/2" hole from 5570 - 5721m with 1000 lpm, SPP 190 bar, 80 rpm, torque 38-40 kNm, PWS choke 37-39 bar, ROP 60 m/hr, EMW 1.94 sg.
12:46	13:05	0:19	CCS Wet connection # 109 RIH	CCS wet connection RIH
13:05	13:38	0:33	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream & re-log 8 1/2" hole from 5570 - 5721m with 1000 lpm, SPP 190 bar, 80 rpm, torque 38-40 kNm, PWS choke 37-39 bar, ROP 60 m/hr, EMW 1.94 sg.
13:38	13:57	0:19	CCS Wet connection # 110 RIH	CCS wet connection RIH
13:57	14:31	0:34	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream & re-log 8 1/2" hole from 5570 - 5721m with 1000 lpm, SPP 190 bar, 80 rpm, torque 38-40 kNm, PWS choke 37-39 bar, ROP 60 m/hr, EMW 1.94 sg.
14:31	14:51	0:20	CCS Wet connection # 111 RIH	CCS wet connection RIH
14:51	15:33	0:42	Standby for CCS connection. Assisted with PCWD operations.	Continued to ream & re-log 8 1/2" hole from 5570 - 5721m with 1000 lpm, SPP 190 bar, 80 rpm, torque 38-40 kNm, PWS choke 37-39 bar, ROP 60 m/hr, EMW 1.94 sg.
15:33	15:54	0:21	CCS Wet connection # 112 RIH	CCS wet connection RIH

Next 24 hours: Pump OOH to 5450 m. Rig down CCS from well centre. Resume POOH according to HPHT procedure. Commence final rig down of CCS equipment

Safety Issues:	**Operations Issues:**

Consumables: 2 x Ram Rubbers, part # 20011625

ESS Type:		5" NC50 VAM EIS		**Serial #:**		50.16522.3.07.ID3½"			**Part #:**		20034625.090		
Pipe Dope Type:		Jet-Lube NCS-30-ECF	**Start:**	1	**Part #:**		**Used:**	0	**Left:**	1	**Qty Due/Date:**		
RRA Type:	Pipe 5"	**Part #:** 20011625	**Start:**	225	**Received:**		**Used:**	12	**Left:**	213	**Qty Due/Date:**		
RRA Type:	CSO	**Part #:** 20022960	**Start:**	6	**Received:**		**Used:**	2	**Left:**	4	**Qty Due/Date:**		
HCU Operational Hrs:		176	**HCU Pressures/Temp:**		**Pump # 1:**	2800 psi	**Pump # 2:**	3100 psi	**Pump # 3:**	3000 psi			
Make Torque:		58kNm/42,778 ftlbs			**Break Torque:**			67.8kNm/50,000 ftlbs					

Mud Pump Rate: 600 - 1000 lpm
SPP: 62 - 212 bar
Mud s.g.: 1.97
Temp @ Mudpits: 34℃
Drill Pipe: 5" NC50 - Vam EIS
Bit: 8½" LM 6360 D1
ECD: 1.961
Temp @ Flowline: 30℃
ROP: 60 mtr/hr
WOB: Not Applicable
Pore Pressure: 1.67 g/cm³
Frac Pressure: 1.89g/cm³
Mud Type: Cs/K mud
Losses: 0 m³
Gains: 0 m³
Programme: 0 m³
BHA: NB Stabilizer w/float, Float Sub, ARC, MWD Power Pulse, 3 Joints HWDP, Jar, 6 Joints HWDP
Last Casing: 9 7/8 @ 5454m MD (4002.6m TVD)
*** CCS NPT:** 0 hrs
*** Cumulative NPT:** 0 hrs

CCS Personnel on Site last 24 hours 06:00 - 06:00

Engineering Supervisor On-Call	Dayshift 06:00 - 18:00	Nightshift 18:00 - 06:00
David Bissett	Angus Fraser, Lead Operator Simon Poskitt, Operator	Mark Honeyman, Lead Operator Sean Waugh, Operator Martin Garrett, Operator

Engineering Supervisor Name: David Bissett **Engineering Supervisor Signature:** **Date:** 14 November 2008

Customers Name: Jostein Henden **Customers Signature:** **Date:** 14 November 2008

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Tracker

Within Tracker, "Tickets" are entered and assigned to NOV personnel to log and track customers requests for the following tasks:

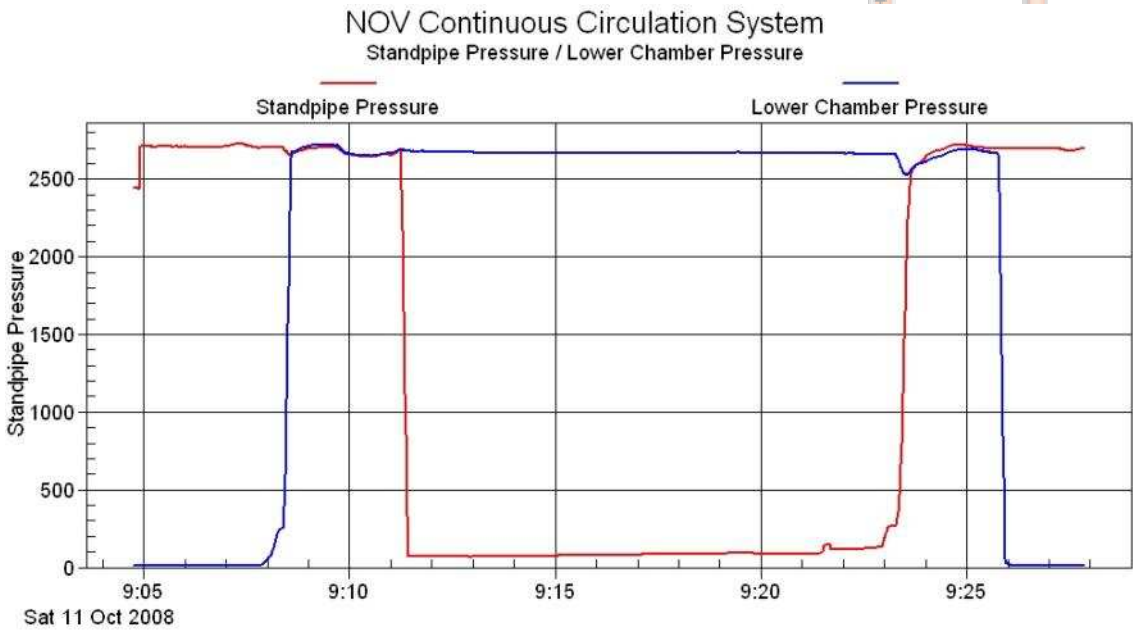
Inspections, Upgrades, Repairs, Installation and Commissioning and other interactions between NOV and our customers.

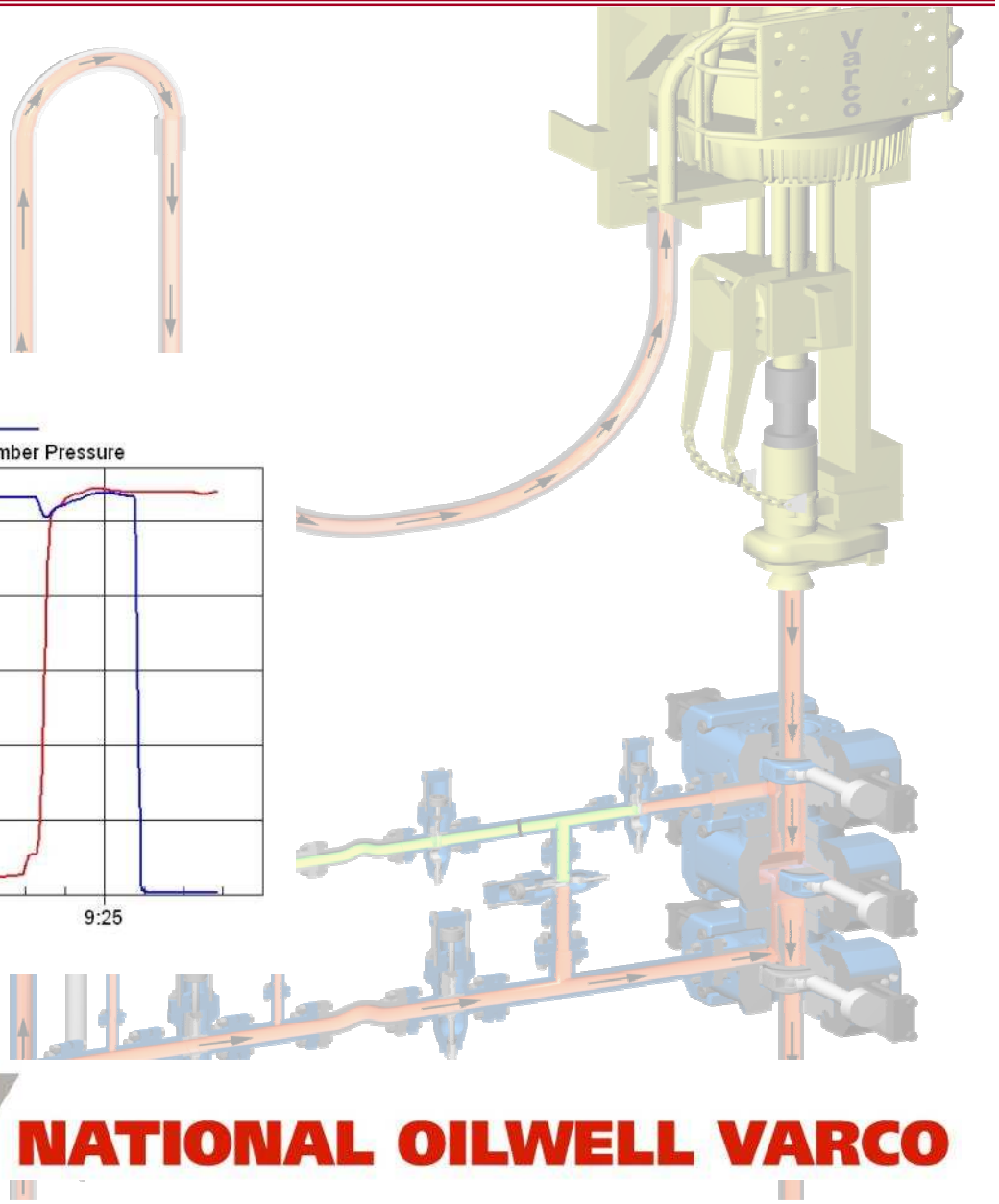
Dedicated Support Structure

- 24/7 On-call Engineering Support
- Dedicated supporting management
- Committed Operators
  - Operators with tool experience from the tool's inception
- Full time engineering staff
- Full NOV corporate support

How are we ultimately judged

- Graded on
  - Interrupted circulation Events
  - NPT





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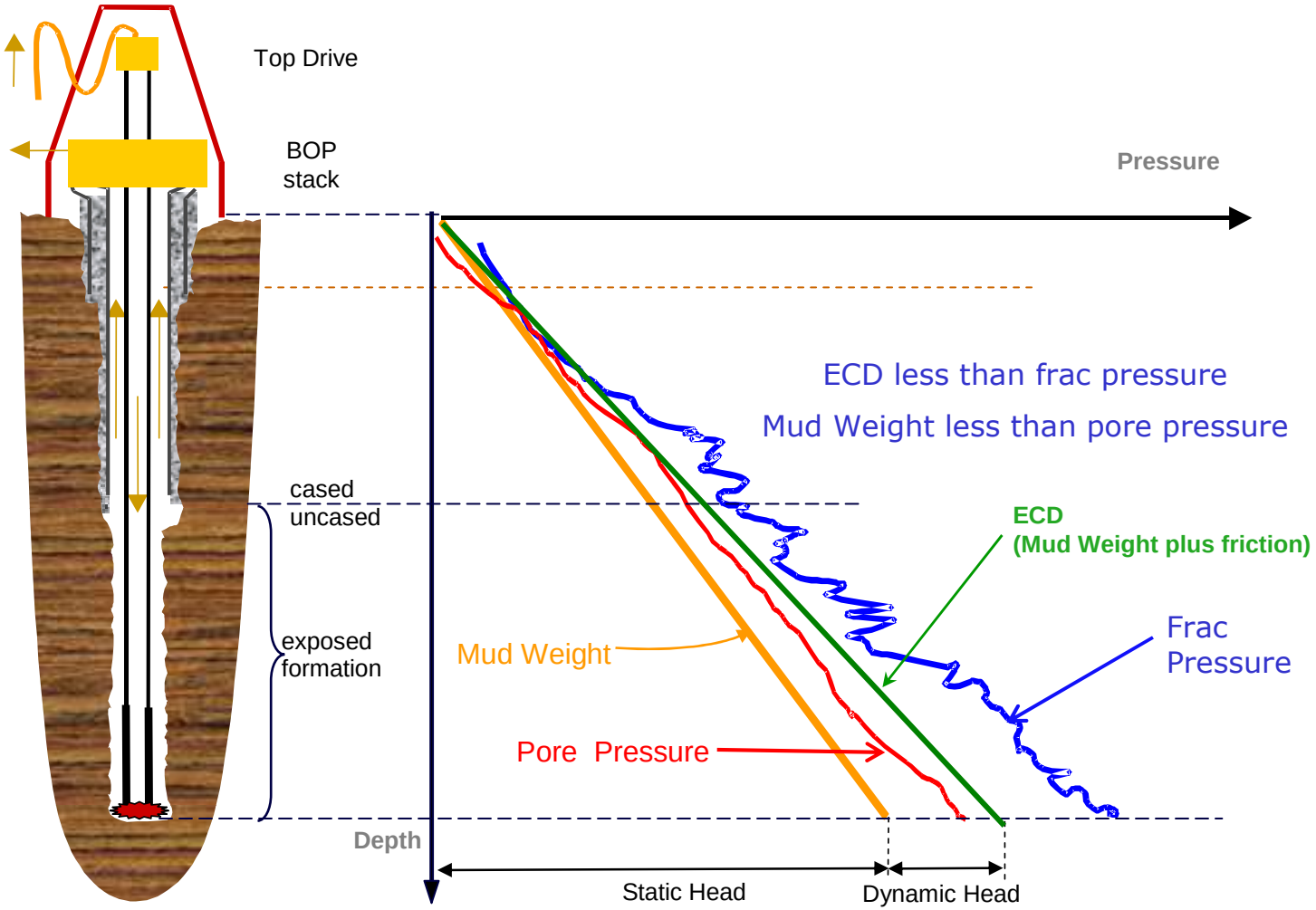
Case History



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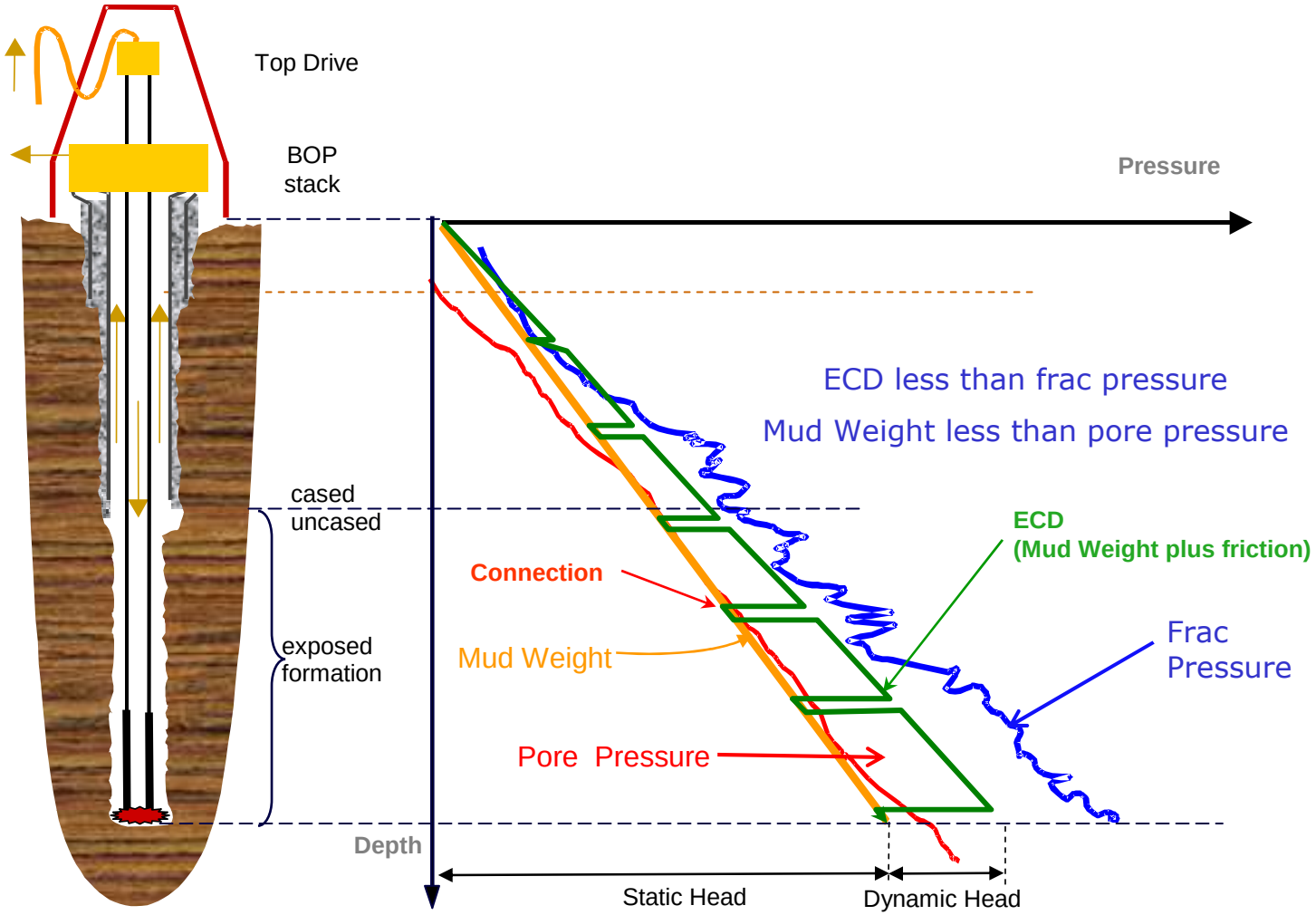
Case History Without CCS



History

Job	Operator	Date	Well	Connections	Rig	Average Connection time (Min)	Total NPT (Hr: Min)	Lost Circulation NPT (HR:MN)	Lost Circulation Event
1	BP	07/03 to 08/03	Trial	72	Oklahoma	15	N/A	N/A	0
2	ENI	03/05	Trial	82	Monte Enoc 10	N/A	N/A	N/A	0
3	ENI/ Petrobel	06/05 to 11/05	PFMD-1	521	Maedrsk Endurer	27	33	**0:03**	**1**
4	Statoil Hydro	12/05 to 03/06	S-2H	151	Scarabeo 5	15	23	0:00	0
5	Statoil Hydro	06/06	Ullrig	31	Ullrig	16	0	0:00	0
6	Statoil Hydro	09/06	34/11-A-02	4	Kvitebjorn	57	0	0:00	0
7	ENI / Petrobel	09/06 to 01/07	PFMD-2	49	Maersk Endurer	15	0	0:00	0
8	Statoil Hydro	03/07 to 07/07	A-13	226	Kvitebjorn	31	0	0:00	0
9	Statoil Hydro	10/07 to 11/07	A-12	127	Kvitebjorn	26	3	0:00	0
10	Statoil Hydro	02/08 to 03/08	N-2H	147	Scarabeo 5	22	5	0:00	0
11	Statoil Hydro	10/07 to 11/07	A12	127	Kvitebjorn	26	0	0:00	0
12	Statoil Hydro	10/08 to 11/08	A3	126	Kvitebjorn	25	0	0:00	0
13	Statoil Hydro	Still to Happen	A9		Kvitebjorn			N/A	N/A
Totals				**1756**		**23 Min**	**64 Hrs**	**3 Min**	**1**

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Summary

- Philosophy
- Principles of Design
- Training, Implementation and Tracking
- Testing
- Reliability