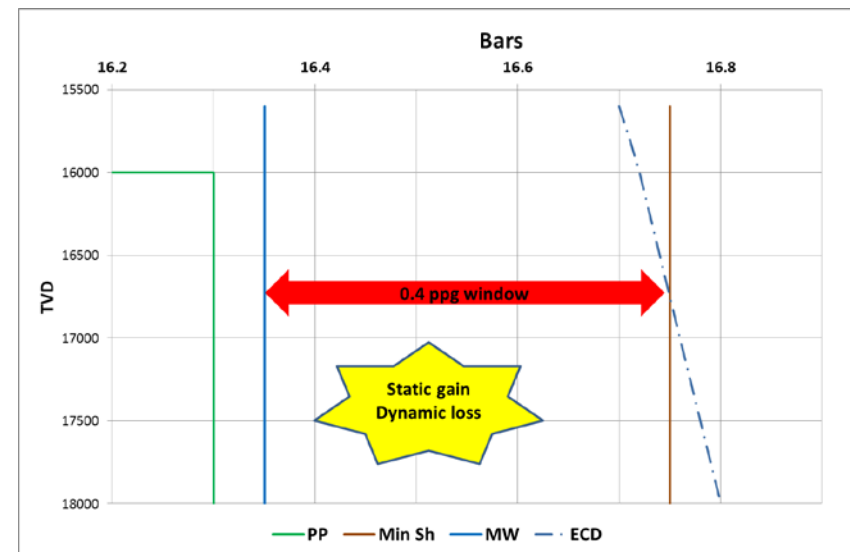
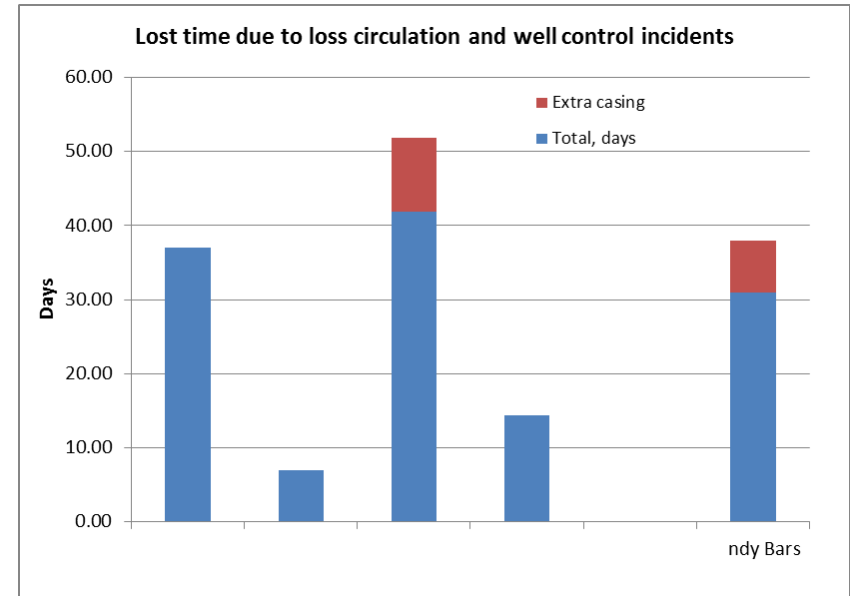


# ECDM System

November, 2014

# Objective

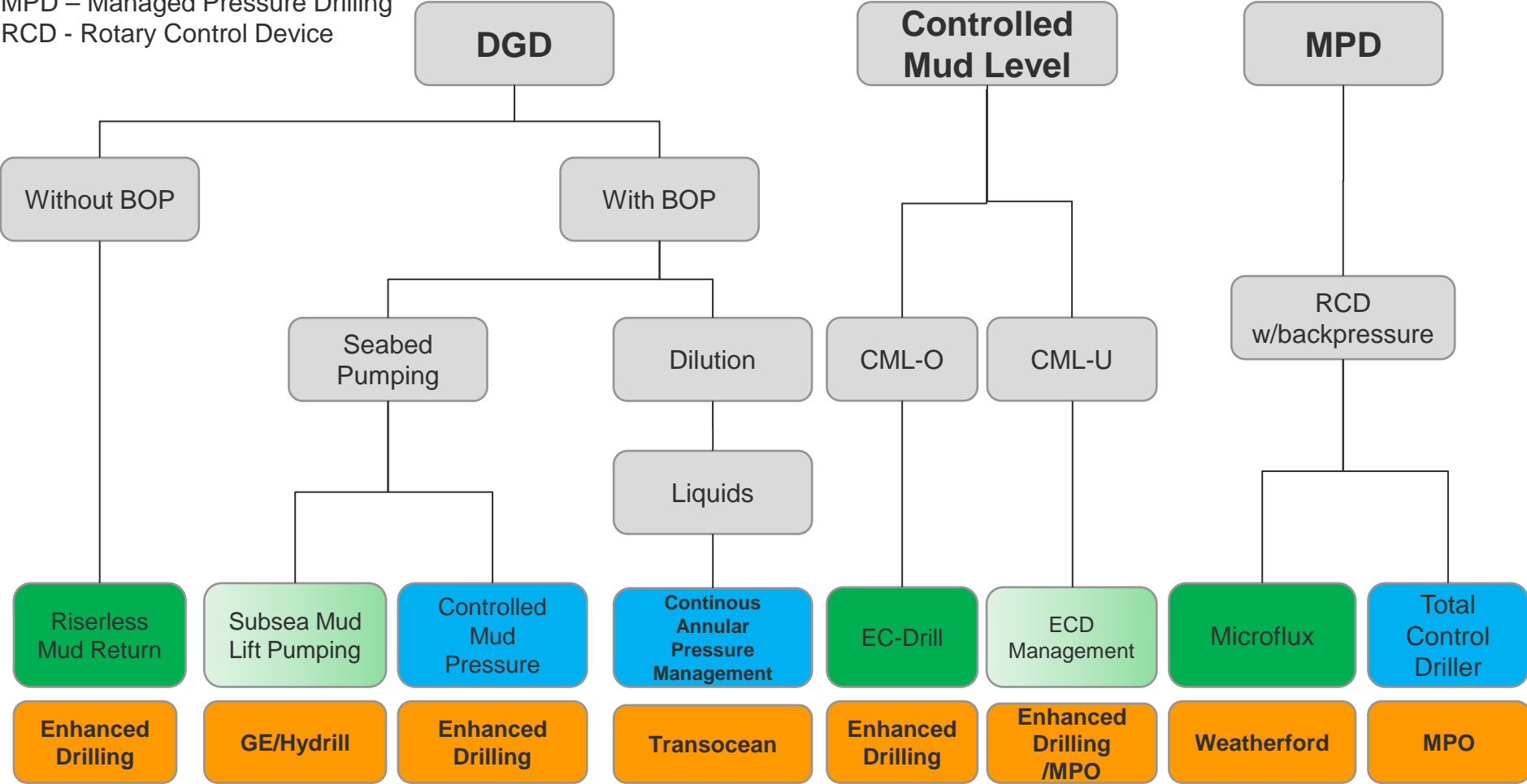
- Enhance the ability to safely and efficiently drill deep-water wells
  - High uncertainty in pore and fracture pressure gradients
  - Narrow drilling margins
- Develop system for bottom-hole pressure control
  - Avoid loss circulation by controlling bottom hole pressure
  - Enhanced kick detection
  - Avoid pressure fluctuation at connections



# Bottom Hole Pressure control systems

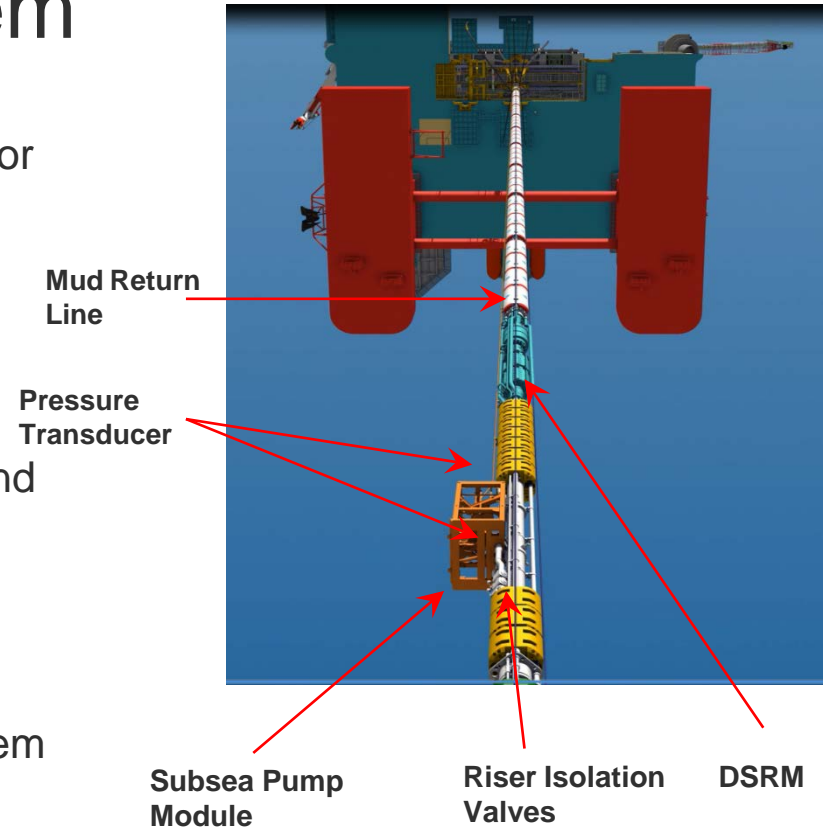
- Field proven
- Pilot
- Future

DGD – Dual Gradient Drilling  
 MPD – Managed Pressure Drilling  
 RCD - Rotary Control Device



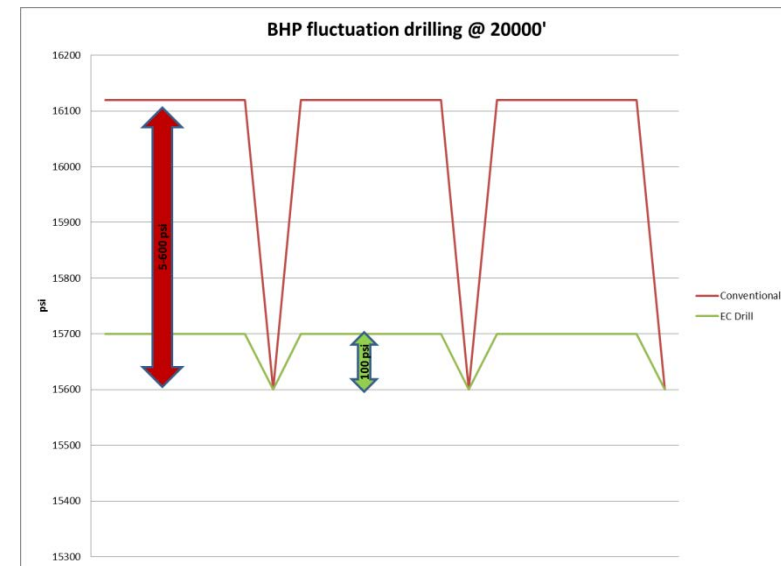
# ECD-Management system

- ECDM system is a controlled mud level system for controlling bottom hole pressure
- The dynamic effect on the bottom hole pressure (ECD) is reduced by lowering and controlling the fluid level in the riser.
- A subsea pump module is installed in the riser and returns the drilling fluid back to the rig through a dedicated mud return line
- ECDM consist of the following sub systems:
  - Enhanced Drilling - Mid riser pumping system and control
  - DSRM (Delta Seal Riser Module) MPO
  - Riser Gas Handler and tie-in to rig fluid system – Maersk
- Planned to be installed on the Maersk Developer Q3 2014

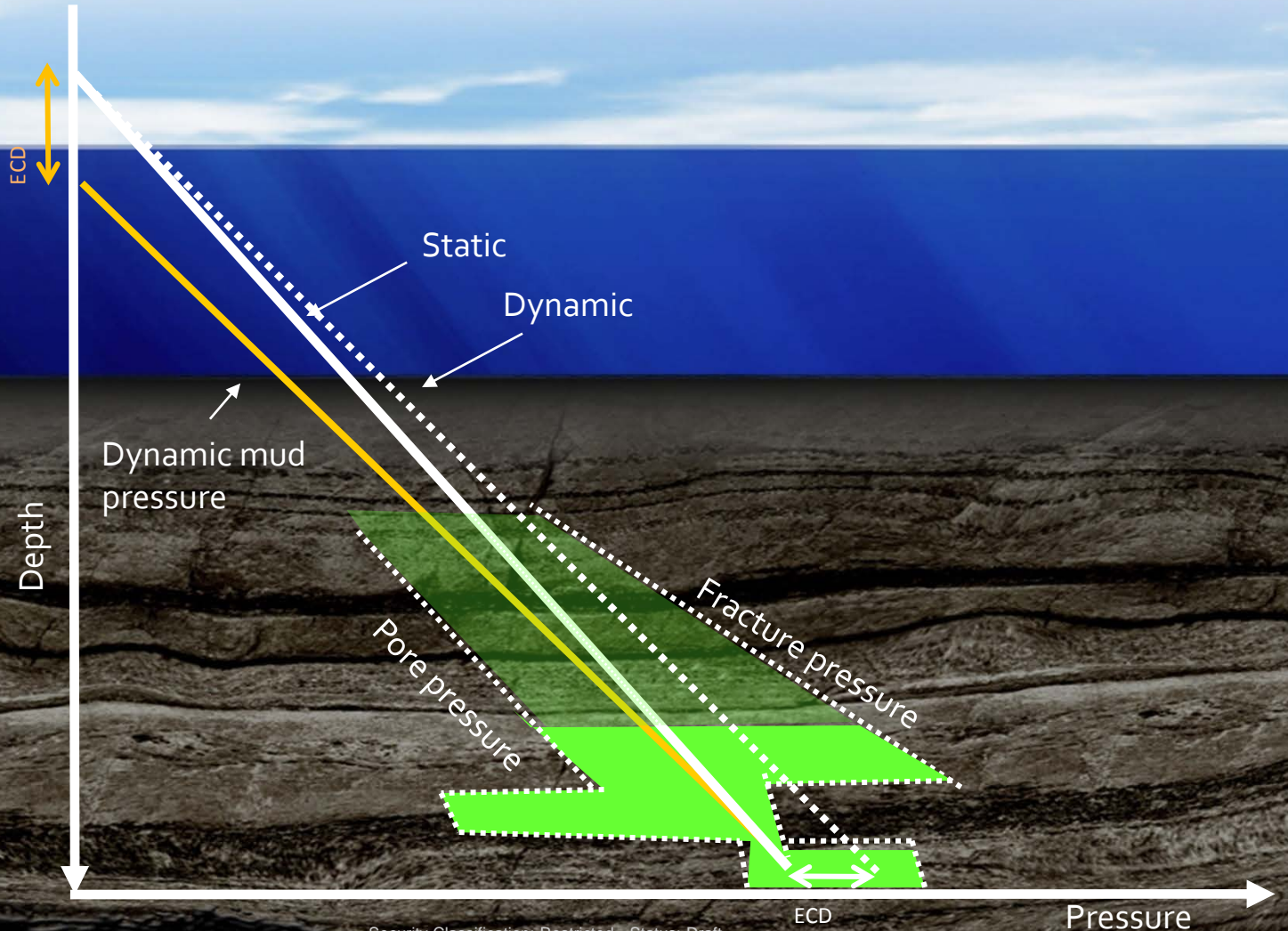


# ECDM Management - well control

- ECDM system will not change well design
- Option to continue drilling conventional
  - isolate ECDM system
- All well control will be handled conventionally
  - ECDM system will be isolated above BOP
- Safer than conventional system
  - Enhanced Kick Detection
    - Influx/loss detection by change in pump speed
    - Additional personnel observing well
  - Limit influx potential
    - Potential for higher MW than conventional
  - Limited pressure fluctuation at connection

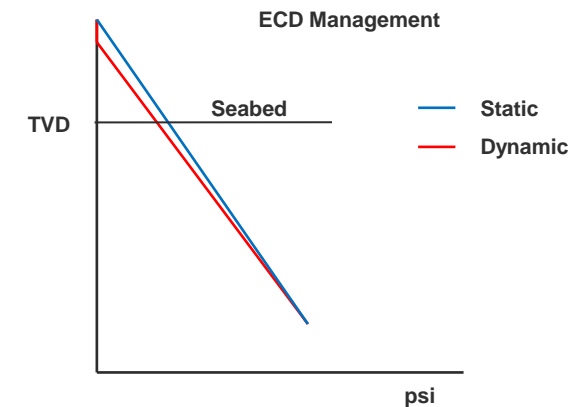
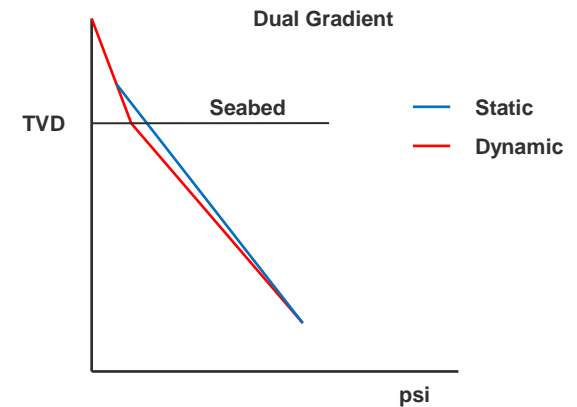


# Controlled Mud Level managing the downhole pressure



# ECDM vs Dual Gradient system

	ECM Management	Dual Gradient
Pumping	Controlled Mud Level – Mid riser pumping	Seabed pump module
Gradient	Single fluid gradient	Dual fluid gradient
Bottom Hole Pressure (BHP)	Reduced riser level controlling BHP	Controlled fluid interface controlling BHP
Well Control	Conventional well control. ECDM system isolated.	System part of well control system



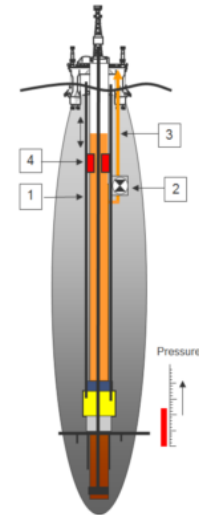
# Controlled Mud Level – TR3534

- The operations are split into two different categories:
- a) CML-O operations – the riser fluid level always maintains hydrostatic overbalance
- b) CML-U operations – the riser fluid level may not provide hydrostatic overbalance
- To determine CML-O vs CML-U:
  - Minimum fluid level shall be defined based on how low the fluid level can go in a worst case scenario.

The system consists of the following main components:

1. Riser interface joint
2. Subsea pump system
3. Fluid return conduit
4. CML annular\*

\*Not required in CML-O operations





# ECDM – Components

## Top fill pumps (2)

- One pump runs with constant rate 100 gpm.
- Mud is injected to create downwards flow towards MRJ outlet, replace static mud above the outlet and cooling/lubricating the slip joint

## Modified Riser Joint (MRJ)

- With pressure sensors above subsea pump outlet. Pressure sensors monitor the riser level
- Double block valves with ROV interface called RIV (Riser Isolation Valve). And double SWI (Sea water inlet valves)

## Subsea pump module (SPM)

- Dry docked to riser - 3 centrifugal pumps in series
- Changes in SPM rpm/power indicate kick/loss
- Two subsea cameras

## Mud Return Line (MRL)

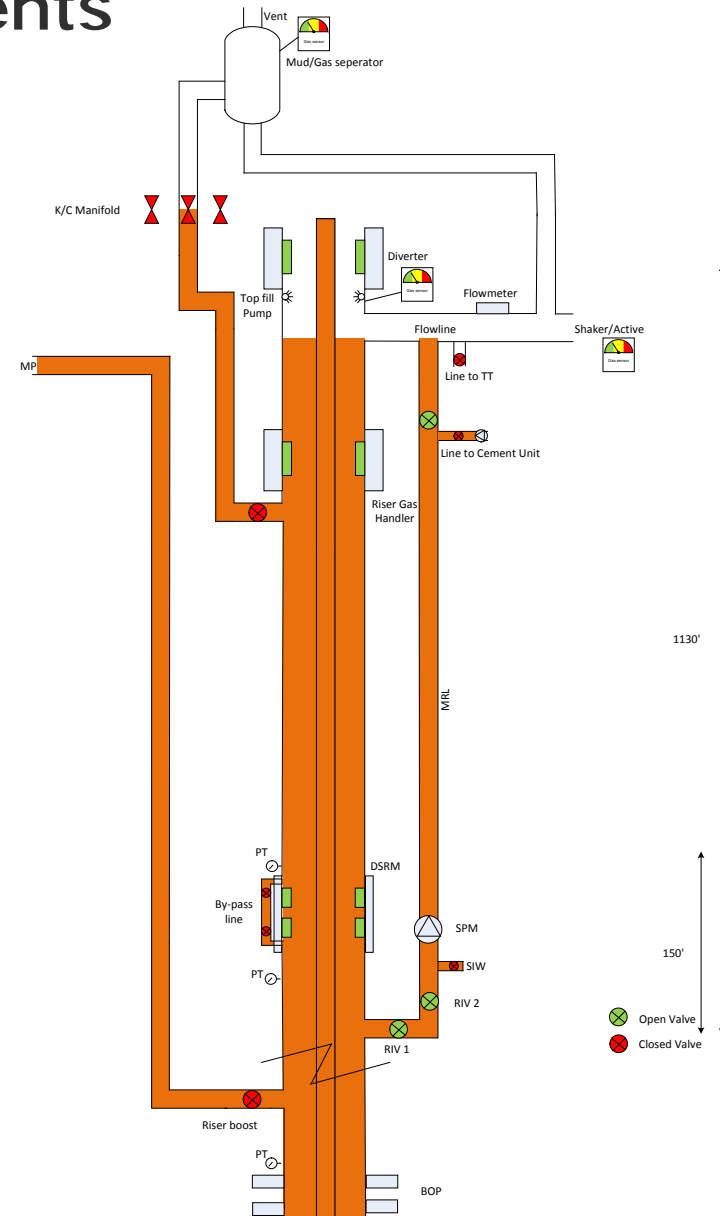
- 6.07 inch return line (5.5 inch connections) along riser
- Flexible hose from termination joint below gas handler to rig

## Delta Seal Riser Module (DSRM)

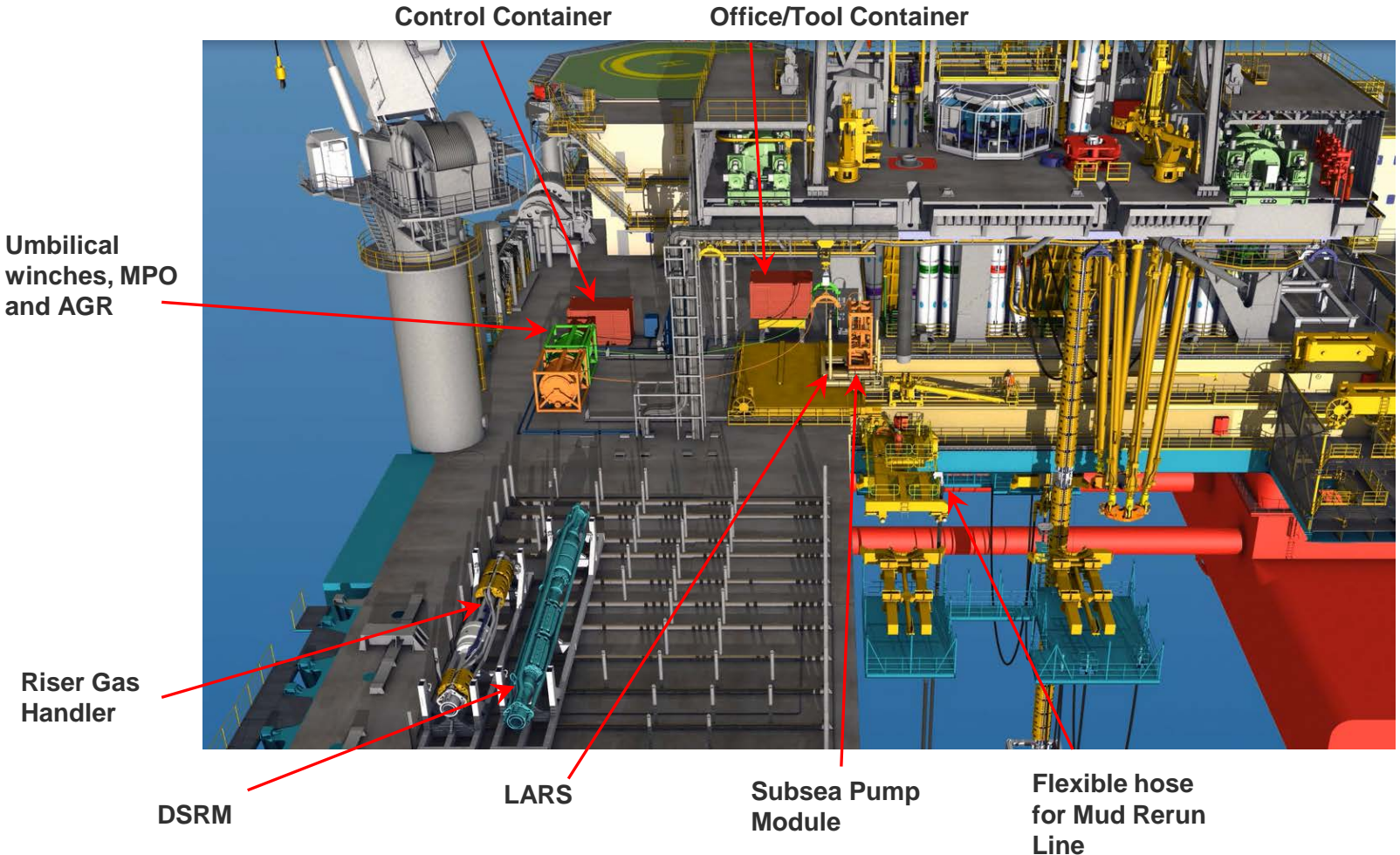
- Upper annular for connection - Riser Drilling Device (RDD) Without sleeve installed
- Lower Quick Closing Annular (QCA)
  - For underbalance situation

## Riser Gas Handler

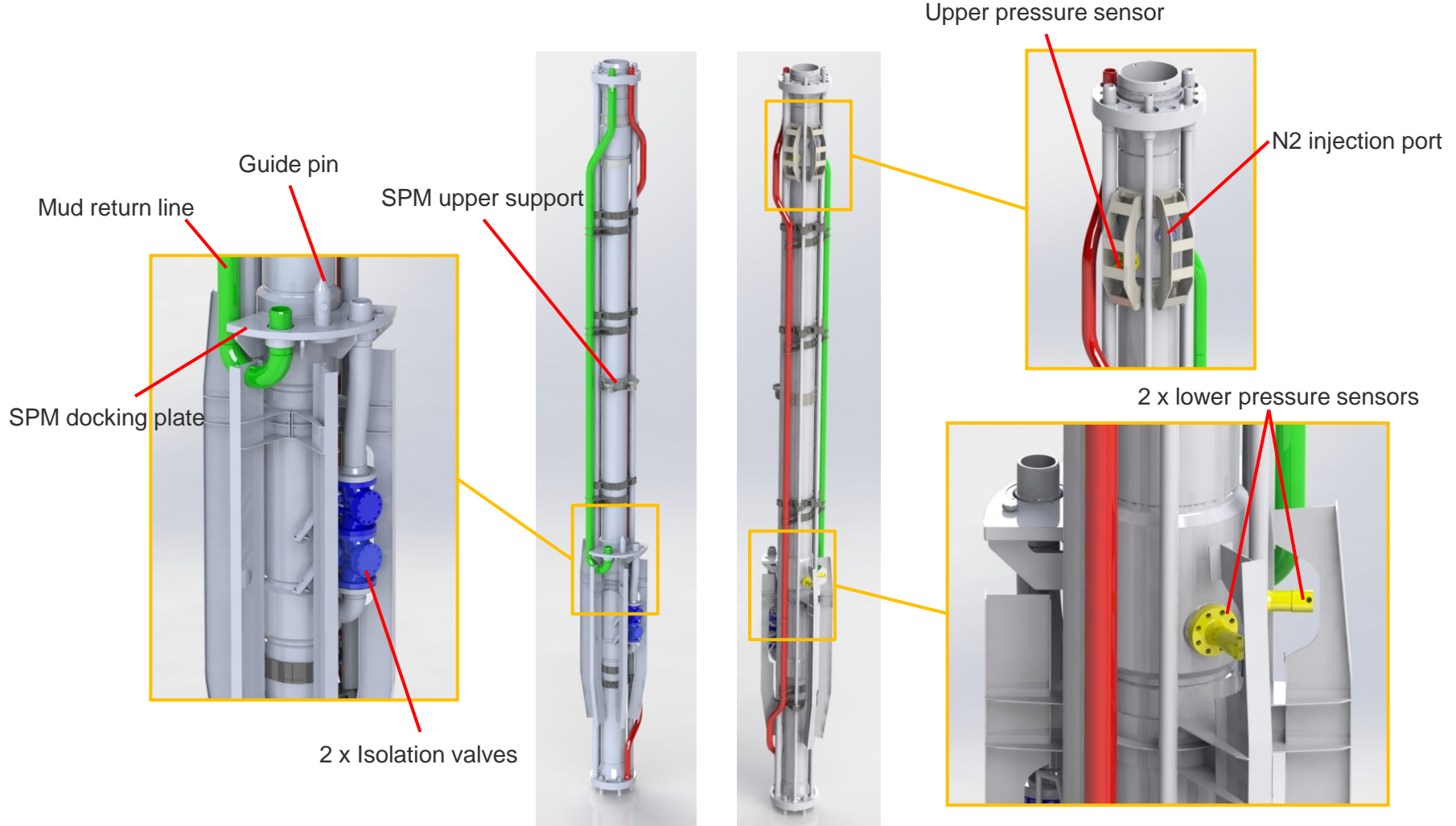
- Utilized for verifying and handling potential gas in riser



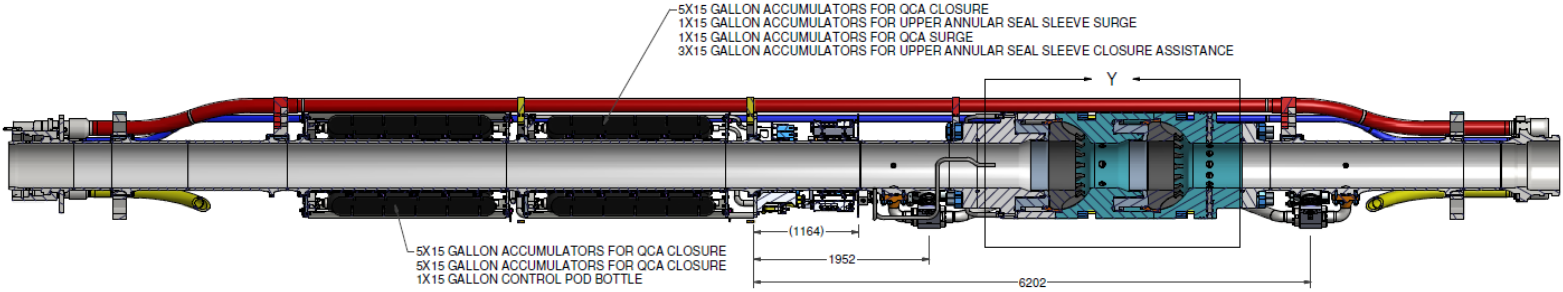
# ECDM System



# Enhanced Drilling Modified Riser Joint (MRJ)

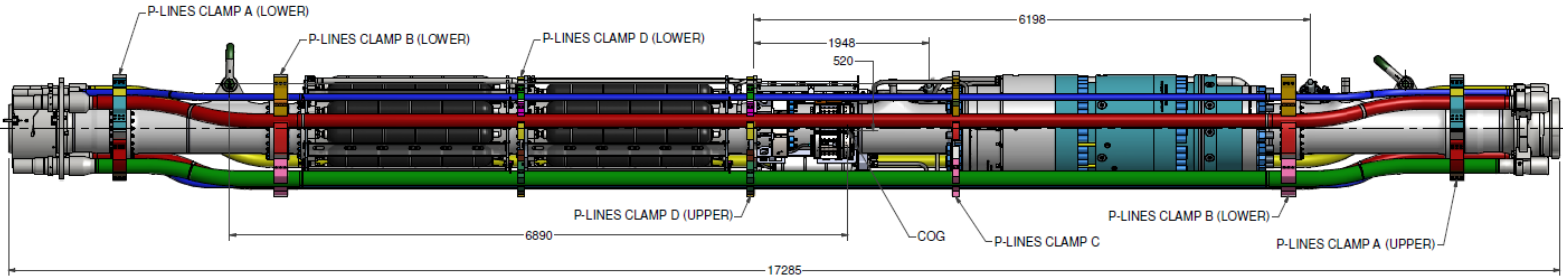


# MPO – Delta Seal Riser Module

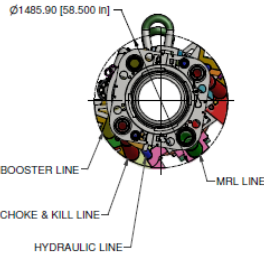


SECTION A-A ( 1 : 28 )

	OD	ID
CHOKE & KILL LINE	6"	4"
HYDRAULIC LINE	2.875"	2.125"
BOOSTER LINE	5.5"	4.5"
MRL LINE	6.5/8"	6"
BY PASS LINE	4.5"	3.62"



FRONT VIEW ( 1 : 28 )



LIFE SIDE VIEW ( 1 : 28 )