**From:** Smith, Trevor (GOM DWD)
**Sent:** Sat Jun 12 13:37:00 2010
**To:** Anderson, Paul (Airenergi); Austin, Julian; Breidenthal, Chase; Dominick, Leon A (DPM); Gkaras, Vassilis; Ibarra, Jim; Lanan, Kevin T; Loya, Darrell (MULLEN ENERGY); Owen, Les L; Schwebel, John; Sinsabaugh, David (LINK PROJECT SERVICES); Vicic, John; Munstereifel, Eric J (Delta Marine Tec); Hughes, John D; Bond, Stan L; Nichols, Mark; Wellings, James S; Smith, Fred (Trendsetter); Petruska, David J; Devers, Kevin J; Cargol, Mike (UNKNOWN BUSINESS PARTNER); Webber, Michael W; Elliott, Mark (FAITHFUL & GOULD INC); Timmons, Shana; Killeen, Joseph P; Mataway, Tom
**Subject:** 2010-06-10 Flex Joint Overshot Review Rev0.ppt
**Importance:** Normal
**Attachments:** 2010-06-10 Flex Joint Overshot Review Rev0.ppt

<<...>>
For Information - this is the presentation we made to the Government Science team on Thursday. We also reviewed the backup slides with them.
Trevor

# Agenda

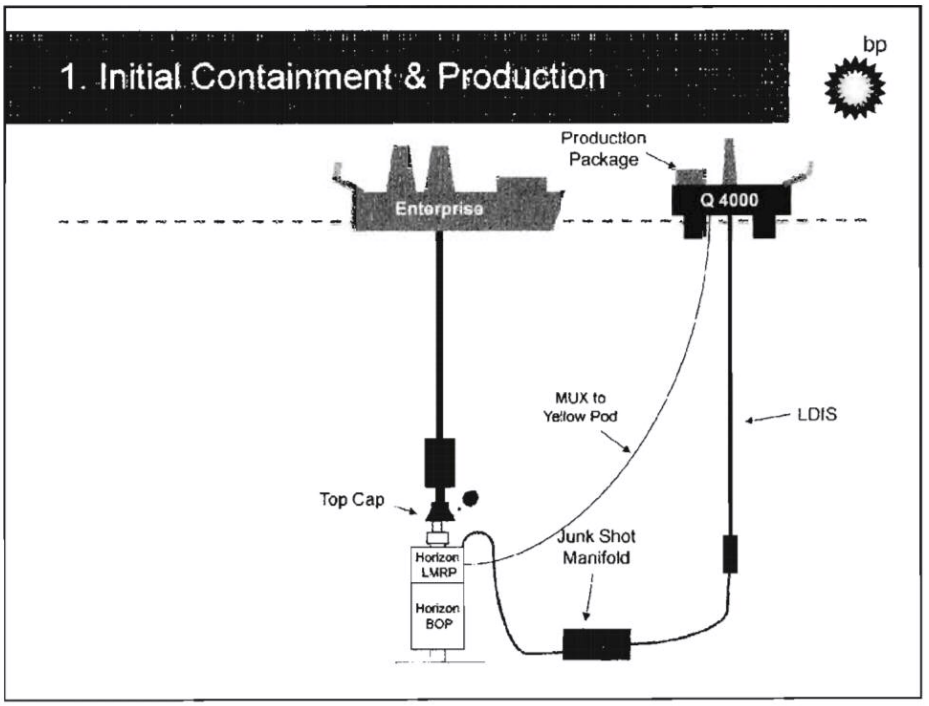
bp

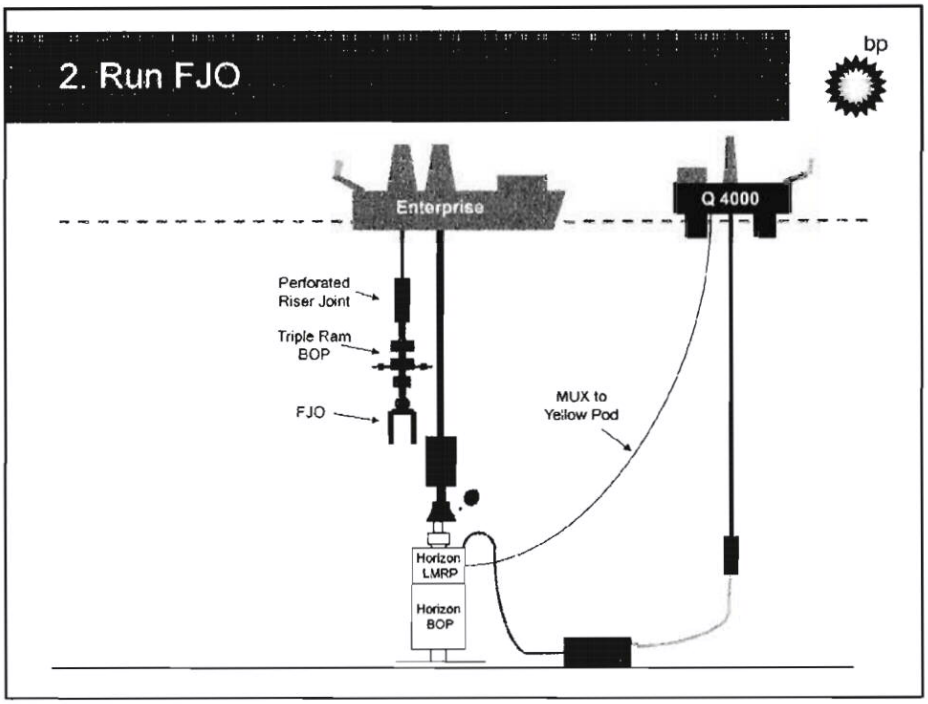
1. Context overview –Trevor Smith
2. Review of "Clamp & Grout" FJO design and the limits we found
   - design review - Julian Austin
   - grout testing - Vassilis Gkaras
3. Review of "Slips and Packers" FJO design which we are now building
   - Slips and packer background – John Vicic
   - FJO design and analysis – Julian Austin
   - FJO slip and packer test plan - John Vicic
4. 5) Field trip to visit the fabrication shop where the FJO is being built.

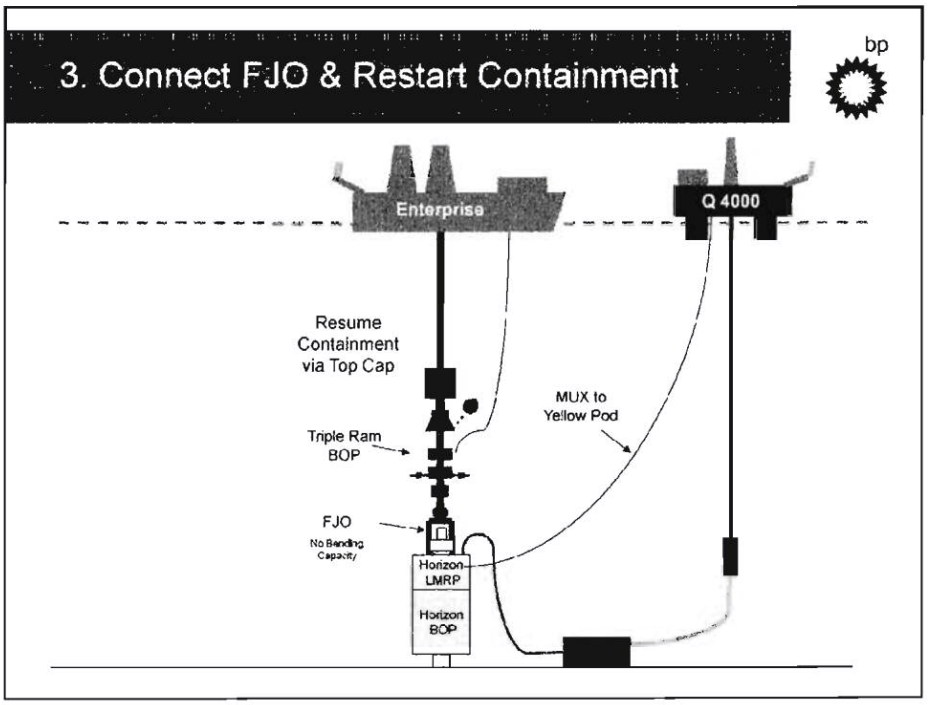
## Context

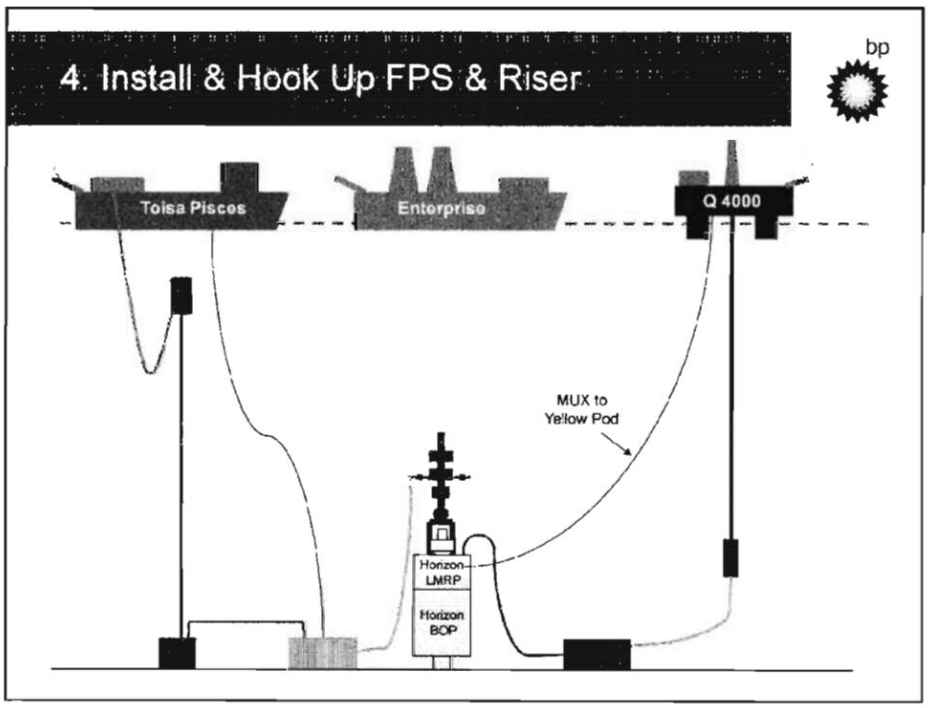
bp

1. Currently well is flowing to Enterprise drillship (at ~15000 BPD)
2. Readying Q4000 semi to take additional flow – via Horizon BOP via former Top Kill manifold system – uses existing connections
3. Building longer term containment system(s) – new manifold, freestanding riser(s), processing ship(s), and storage tanker
   - These new systems require new connections to the Horizon BOP via three options:
     a) "Flange Connection Spool" and "Capping Stack" BOP
     b) "Flex Joint Overshot" and "Capping Stack" BOP **This review**
     c) "Latch Cap" on flexjoint riser stub and flow tree
4. Potential to pull LMRP and install Capping Stack also remains in play


1. Initial Containment & Production
bp
Production Package
Enterprise
Q 4000
MUX to Yellow Pod
LDIS
Top Cap
Junk Shot Manifold
Horizon LMRP
Horizon BOP


2. Run FJO
bp
Enterprise
Q 4000
Perforated Riser Joint
Triple Ram BOP
FJO
MUX to Yellow Pod
Horizon LMRP
Horizon BOP


3. Connect FJO & Restart Containment
bp
Enterprise
Q 4000
Resume Containment via Top Cap
MUX to Yellow Pod
Triple Ram BOP
FJO
No Bending Capacity
Horizon LMRP
Horizon BOP


4. Install & Hook Up FPS & Riser
bp
Toisa Pisces
Enterprise
Q 4000
MUX to
Yellow Pod
Horizon
LMRP
Horizon
BOP

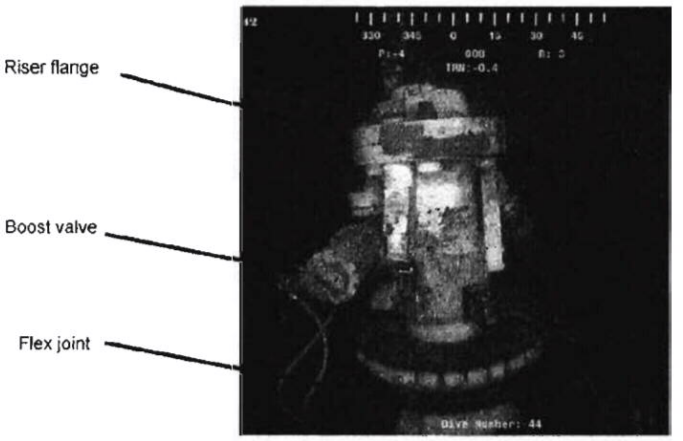
## Summary of Flexjoint Connection Options

bp

1. Flex Joint Overshot – Clamp and Grout
2. Grip and Seal version

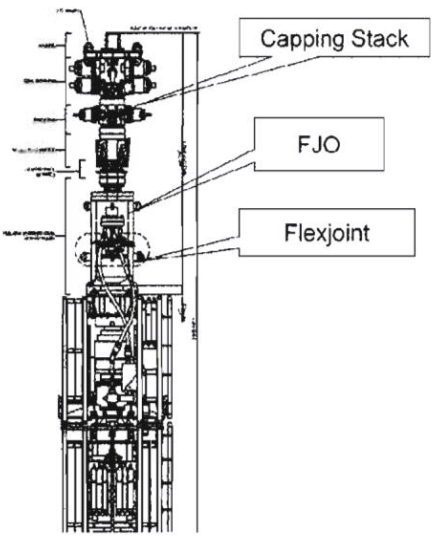
# Riser Flange and Flex Joint Assembly

bp



## Installed FJO Layout

bp

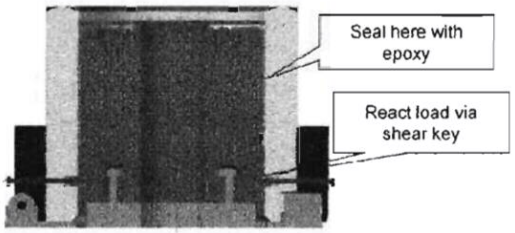


## Summary of Flexjoint Connection Options

bp

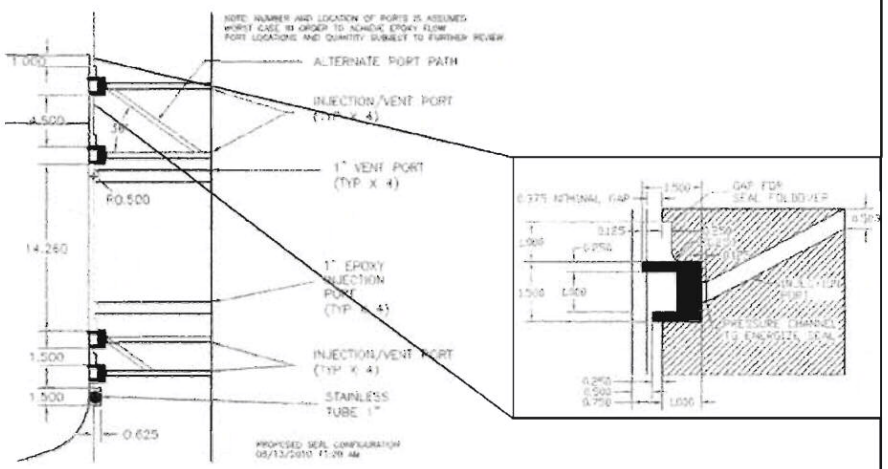
1. **Flex Joint Overshot – Clamp and Grout**
2. Grip and Seal version

# 1. "Clamp and Grout"




- Achieves the seal by grouting the gap between the overshot and the flexjoint bowl with an epoxy resin or cement grout
- Reacts the force via a shear key onto a load ring beneath the flexjoint bowl

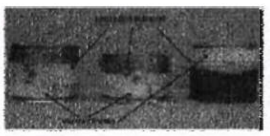
# Ring Seals Design



# Epoxy Resin Testing

bp

- Sandia National Labs tasked to develop procedures for evaluation of mechanical properties of potential epoxy products
- Epoxy products:
  - Thermal Chem 4 (TC-4)
  - UltraSeal Liquid Bridge Plug
- Testing conditions:
  - 40degF
  - Injection in molds with presence of brine
  - One metal platen of molds epoxy painted
- Methods
  - Direct Pull Tension test
  - Pipe in pipe shear test



Square "o" ring for alignment and sealing during curing of the epoxy.

# Epoxy Resins Testing

bp

- TC-4
  - + Able to cure at 40degF
  - + Stronger in tension than Ultra-Seal
  - − More viscous than Ultra-Seal → possibility to be injected in annulus through subsea piping to be confirmed
- UltraSeal
  - + More fluid than TC-4 (viscosity similar to hydraulic oil, easily injectable in annulus space)
  - + More elastic than TC-4
  - − Not possible to cure at 40degF
- **More research/ experimentation was necessary to optimize ingredient ratio for balance of strength & curing time**

## Summary of Flexjoint Connection Options

bp

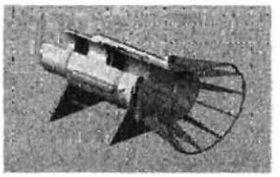
1. Flex Joint Overshot – Clamp and Grout
2. **Grip and Seal version**

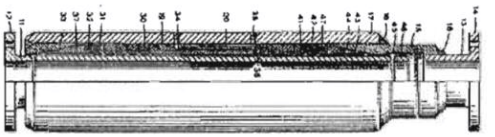
# Overshot and Slip Seal Equipment

bp

- Slip and seal connections have successful history in the oilfield for more than 50 years
  - Wellhead casing hanger – API 6A 15 ksi, +250 F

  - Pipeline connectors – to 48" ANSI 600





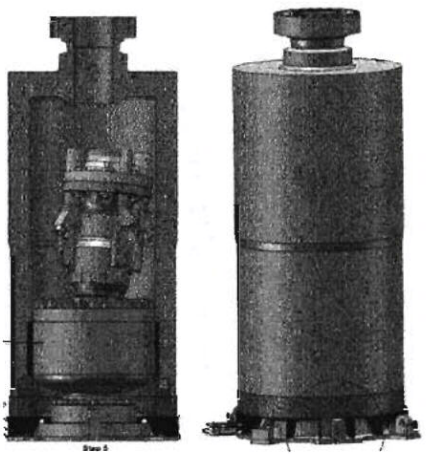
# 2. Flexjoint Overshot – Grip and Seal version

bp

**Overview**
- overshot can envelops flexjoint and grips on to flexjoint with slips and seals with a rubber packer stack
- Independent of flexjoint after installation
- 4700 psia design

**Challenges**
- BOP angle TBD – FJO may jam during installation
- Site preparation

**Status**
- Currently under fabrication
- Slips & Packer testing is being planned
- Site Integration Test scope being developed



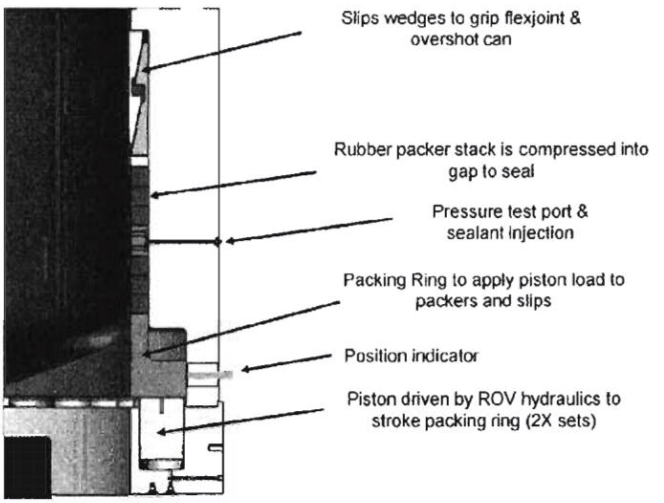
Grip and Seal Detail on Next slide

# Flex Joint Overshot Key Risks

bp

| ID | Risk | Mitigation |
|---|---|---|
| 1 | FJO jams at installation (BOP angle 2 degrees ) | • test fit-up with inclination at onshore trial<br>• modify design for installation at angle<br>• drill-string installation provides installation control |
| 2 | Slips engagement on FJ | • validation testing to confirm slips engagement<br>• remove paint on FJ |
| 3 | Packer Seals do not hold full working pressure | • conduct validation testing<br>• full scale seal tests at onshore SIT<br>• inject sealant to stop leaks<br>• increase piston pressure to compress seals further |
| 4 | Hydrate formation during installation | • apply learning from Top Hat(s) experience<br>• modeling flow, chemicals & equipment design |
| 5 | Removing Mud Boost valve actuator creates leak | • cutting tool selection, cut placement and timing to minimize risk<br>• temporary condition pending FJO installation |

# FJO – Grip and Seal arrangement

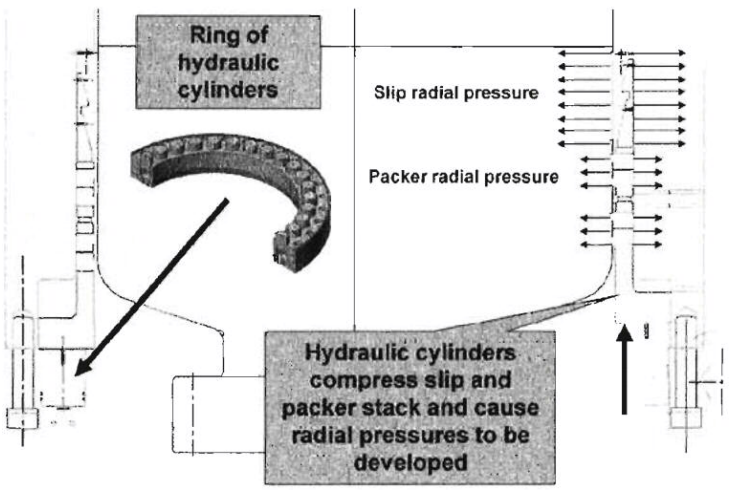


## FJO – Grip and Seal Analysis

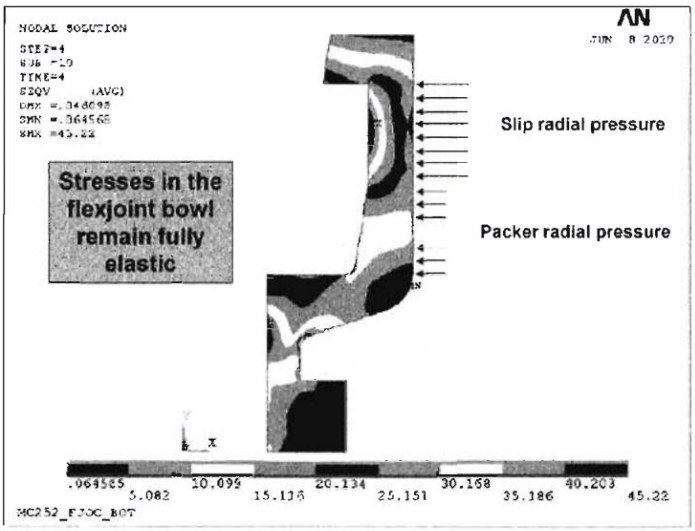
bp

- Finite element analysis of the flexjoint bowl and overshot pressure can carried out to understand:
  - Stresses in the components
  - Deflections of the components
- Pressure loadings derived from Oil States standard design calculations
- Design basis requires that:
  - Components remain substantially elastic
  - Deflections do not compromise gripping strength
- Motion study to ensure full stroke is available

# FJO – Grip and Seal radial pressures

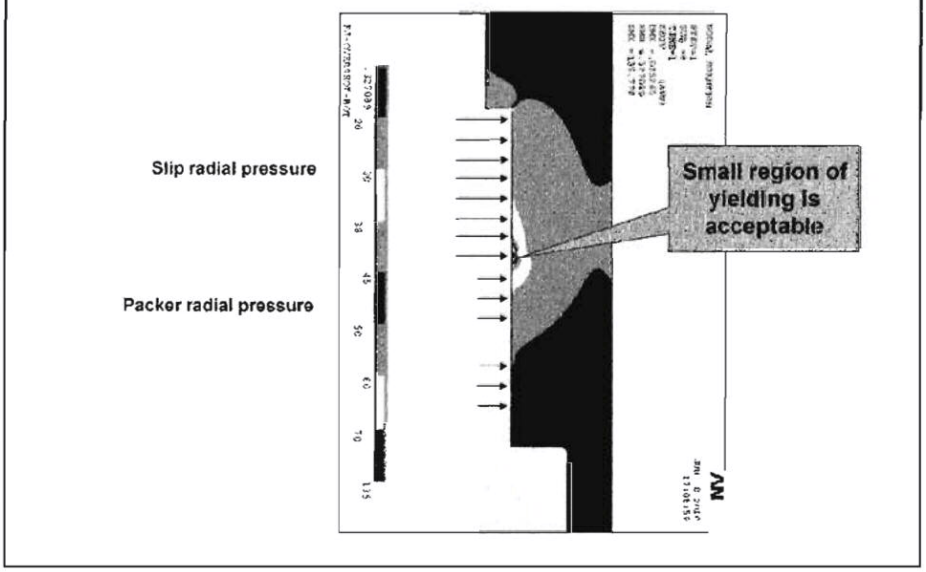


# FJO – Grip and Seal stresses - flexjoint

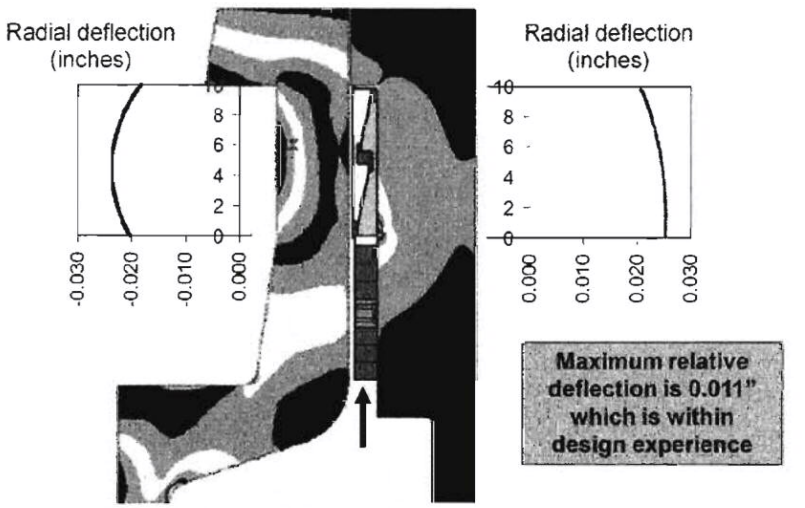


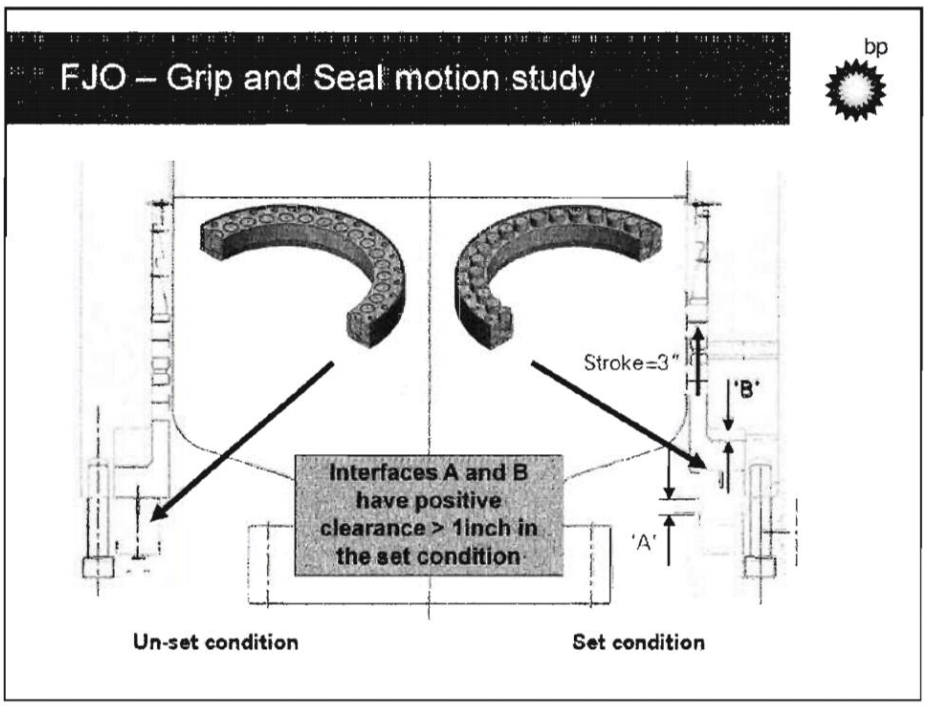
# FJO – Grip and Seal stresses - overshot

bp



# FJO – Grip and Seal deflections



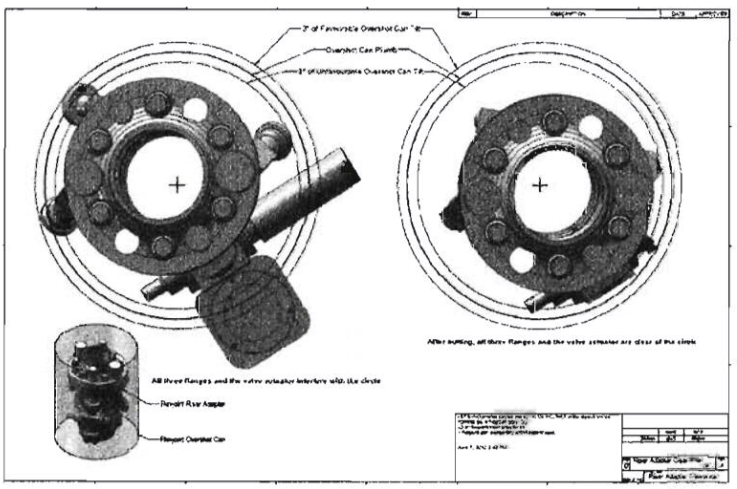

FJO – Grip and Seal motion study
bp
Stroke=3"
'B'
'A'
Interfaces A and B have positive clearance > 1inch in the set condition
Un-set condition
Set condition

# 24 Inch Seal and Grip Connector Validation Test

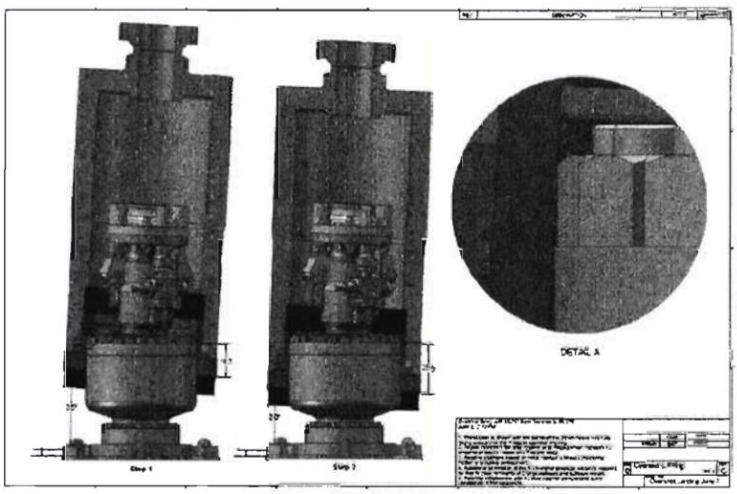
bp

- 24" PEC -8" slip at the same ramp angle of 12.5 degrees for very similar contact pressures and tooth shear stresses as the FJO with the PEC at 4700 psi.
- Hardness - carefully selected test nipple to prove that the contact pressure is also sufficient to bite into the flex joint.
- Teeth - similar shear stresses in the teeth would prove that they are low enough to maintain the integrity of the teeth. A post test inspection of the teeth and pipe would be a good indicator for the expected performance of the FJO slips.
- 3/8" radial gap -connector is to designed to make a 3/8" jump to min pipe, a test nipple will be made to min OD to force the gap.
- Seals in the same compound as the FJO, Seal test performed at the same rubber pressure required to seal 4700 psi.
- Seals will be pressured for 1 hour hold and released- 3x cycles.
- Seals with damage- retested with increased hydraulic pressure and then sealant injection.

# Site Preparation



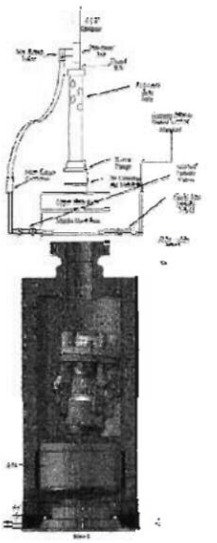
# Flex Joint Landing



# Hydrate remediation

bp

- Hydrate formation temperature ≈70deg F
- Hydrate remediation options:
  - glycol,
  - MeOH and/or
  - Displacement of water with $N_2$
- Delivery mechanism options include:
  - Drilling vessel from Installation drilling string bore
  - Installation WorkOver Control System (IWOCS)
- Key issue: try to ensure outflow of oil through bottom during installation (with fallback chemicals delivery)

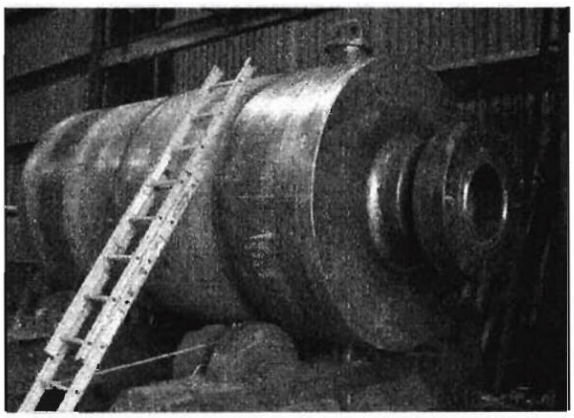


## Site Integration Trials – outline scope

bp

- Investigate installability under representative conditions
  - BOP angle
  - Flexjoint angle
  - Packers & Slips protection
  - Slips engagement risks
  - Evaluation of guidance/protection systems
- Annulus test of seals (on similar flexjoint)
  - Test hydraulics & position indication
  - Seal damage tests and limits of increased pressure on packer
  - Leak repair by injection of sealant (e.g. Sealtite)

## Current Status



# FJO Installation - Estimated Durations

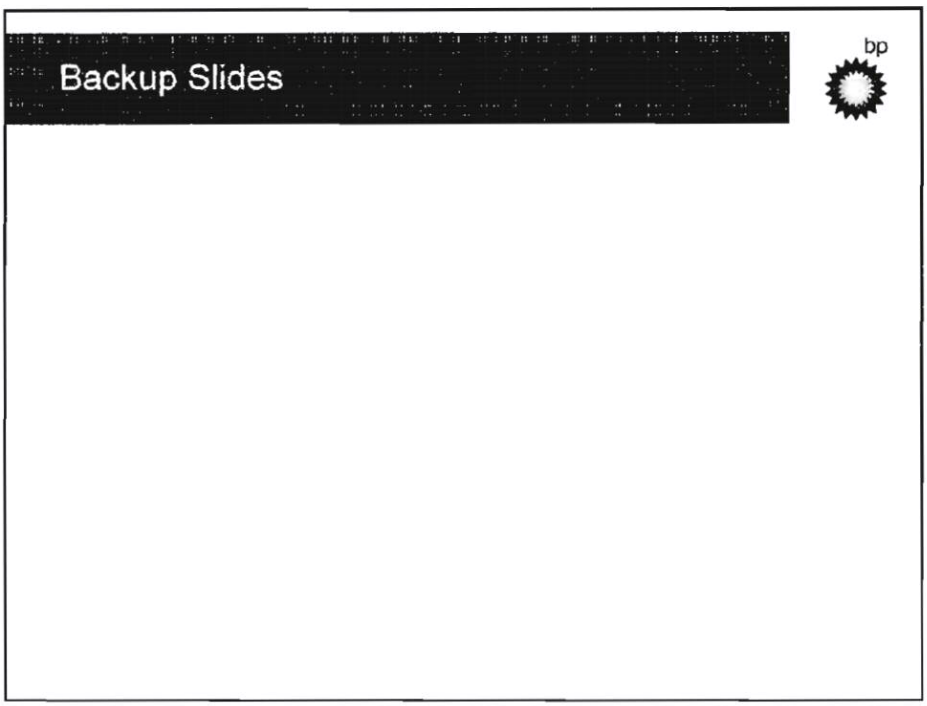
bp

| Flexjoint Overshot | Critical Path Duration P50 | Critical Path Duration P90 | Offline Duration | Comments |
|---|---|---|---|---|
| | | | | |
| Run FJO on Vessel Rigging | | | 5 | |
| Demo Padeyes, Grating, Hydraulic line and Mudboost Actuator | 12 | 16 | 48-56 | 95% offline activites |
| Rig Remove / clear Top Hat. Commence loss of Containment | 2 | 2 | | |
| Reposition Rig clear. Vessel move in | 6 | 6 | | |
| Align FJO with Vessel over BOP | 2 | 2 | | |
| Set / Lock FJO | 10 | 12 | | |
| Align Stack 2nd Vessel | 0 | 4 | | P50 considers running assembly as single unit. |
| Set / Lock Stack | 4 | 6 | | |
| Vessel out / Rig In | 4 | 6 | | |
| Rig places TH over Stack | 4 | 6 | | |
| Critical Path | 44 | 60 | 53-61 | |

## Next Steps

bp

- Complete Machining
- Slips & Packer validation tests
- Assemble Overshot (seals, ROV hydraulics, chemicals delivery)
- SIT tests
- Replace Packers & Slips
- Ready for shipment offshore (target 24 June, zero float)


Backup Slides
bp

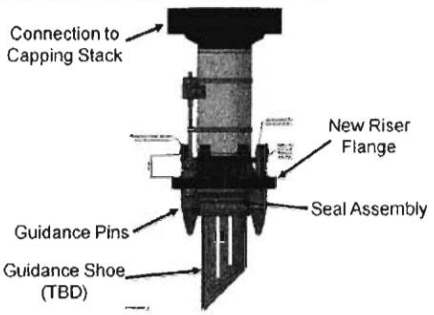
# 1. Flange Connection Spool

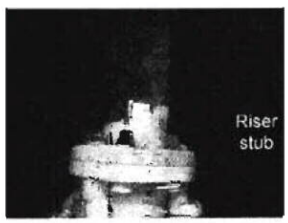
bp

**Overview**
- spool with new riser flange and seal assembly is connected to mating flange on Horizon LMRP Flexjoint.
- 9000 psia capable

**Challenges**
- unbolting and removal of flange with riser stub
- landing spool over 2 projecting drill pipe sections (exposed once stub is removed), without damaging seal assembly
- making up 6 bolts with flange spool and capping stack held on drill string

**Status**
- spool is built
- guidance systems being trialed this week to select best option
- In place analysis ongoing



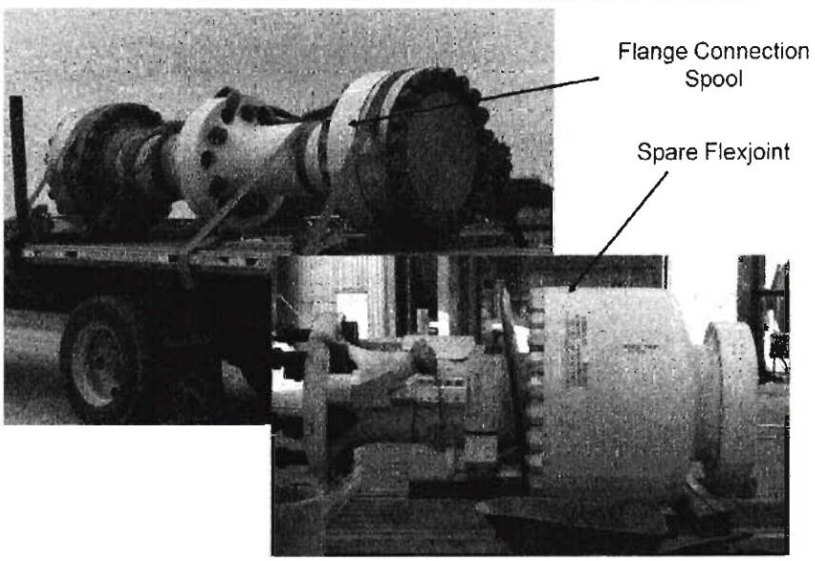
# Flange Connection Spool Risks

bp

| ID | Risk | Mitigation |
|---|---|---|
| 1 | Unable to undo flange bolts | • Perform subsea unbolting trial on another flange on Horizon riser to demonstrate feasibility (imminent) |
| 2 | Unable to easily remove flange (jammed) | • Identify / build tool to split flange (No flange distortion is evident) |
| 3 | Landing spool over 2 drill pipe stubs | • trialing guidance systems this week to select best option |
| 4 | Flange Spool seal damage during installation | • dual elastomeric seals reduce risk, accept less than full containment |
| 5 | Flexjoint angle | • onshore trials testing at up to 5 degrees inclination<br>• surveying BOP to measure angles |
| 6 | Flexjoint Integrity under 9000 psia (Rated to 5000 psia) | • analysis shows low risk of FJ rupture but risk of o-ring leakage at 9000 psia<br>• limit pressure to lower level e.g. 4700 psia |

## 1. Flange Connection Spool contd.

bp

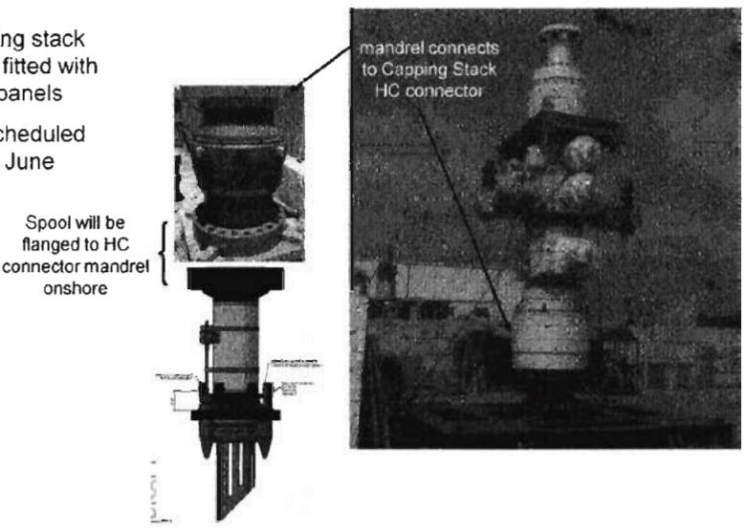


# Capping Stack

bp

**Status:**

- Capping stack being fitted with ROV panels
- SIT scheduled for 16 June



# Flange Spool Installation - Estimated Durations

bp

| Flange Connection Spool | Critical Path Duration P50 | Critical Path Duration P90 | Offline Duration | Comments |
|---|---|---|---|---|
| Run Flange Spool on Vessel Rigging | | | 5 | |
| Rig Remove / clear Top Hat. Commence loss of Containment | 2 | 2 | | |
| Reposition Rig clear. Vessel move in | 6 | 6 | | |
| Align Flange spool near BOP | 1 | 1 | | |
| Remove Flange Bolts | 18 | 24 | | |
| Install Flange Splitter | 8 | 12 | | |
| Split and Remove Flange | 18 | 24 | | |
| Deploy Flange Spool over BOP | 2 | 2 | | |
| Install / Make-up Bolts | 18 | 24 | | P50 considers running assembly as single unit. |
| Align Stack 2nd Vessel | 0 | 4 | | |
| Set / Lock Stack | 4 | 6 | | |
| Rig places TH over Capping Stack | 4 | 6 | | |
| Critical Path | 81 | 111 | 5 | |

## Riser – cut end at riser stub

bp

## Top of Flexjoint