Subsea Tree Systems

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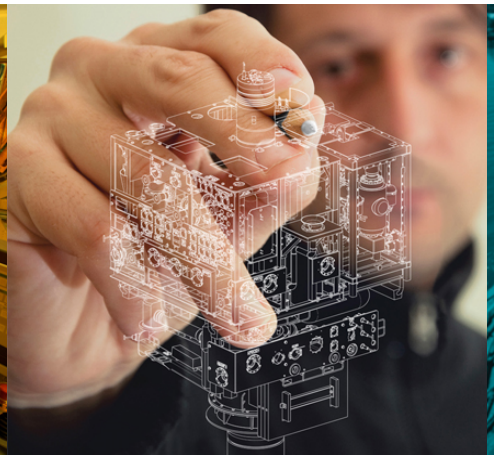
FMC Technologies

We put you first.
And keep you ahead.

Subsea Trees

Agenda

- Introduction
- Tree System Comparisons
- EHXT System Overview
- EVDT System Overview
- Which way to go?
- Additional Information
- Questions

WHAT IS A TREE & WHAT DOES IT DO ?

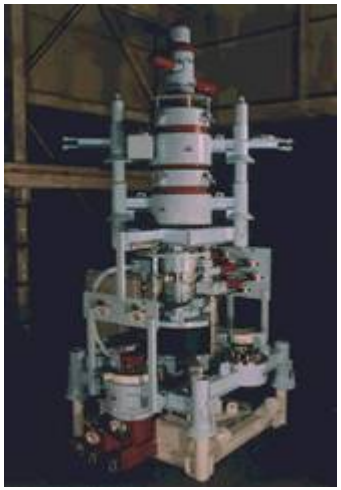
- A christmas tree is an assembly of valves, spools and fittings for an oil well. Although commonly referred to as Christmas Tree, the complexity of subsea Tree has increased so much that it does not resemble christmas tree any more.

- The function of a christmas tree is to both prevent the release of oil and gas from an oil well into the environment and also to direct and control the flow of formation fluids from the well.

Evolution of Subsea Trees by Application Water Depth

Mudline Tree

Diverless Tree
(Guideposts/Guidelines)



Guidelineless (GLL)
Tree (Funnels)

Diver Assist Tree

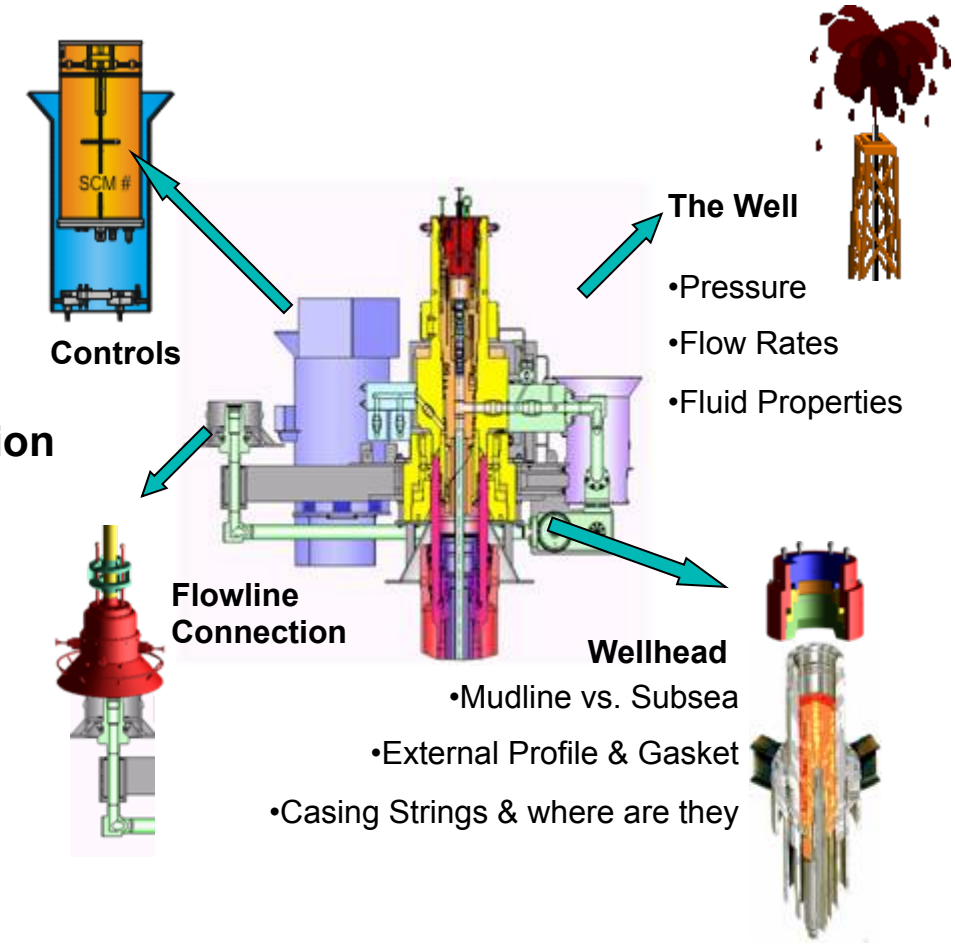
Water Depth (Feet)	Surface Vessel	Type of Tree
< 400	**Jack-up**	**Mudline – Diver Assist**
200-800	**Floating Vessel**	**Diver Assist**
800-2500	**Floating Vessel**	**Diverless**
> 2500	**Floating Vessel**	**Guidelineless**

Tree System Comparisons

Interface Considerations

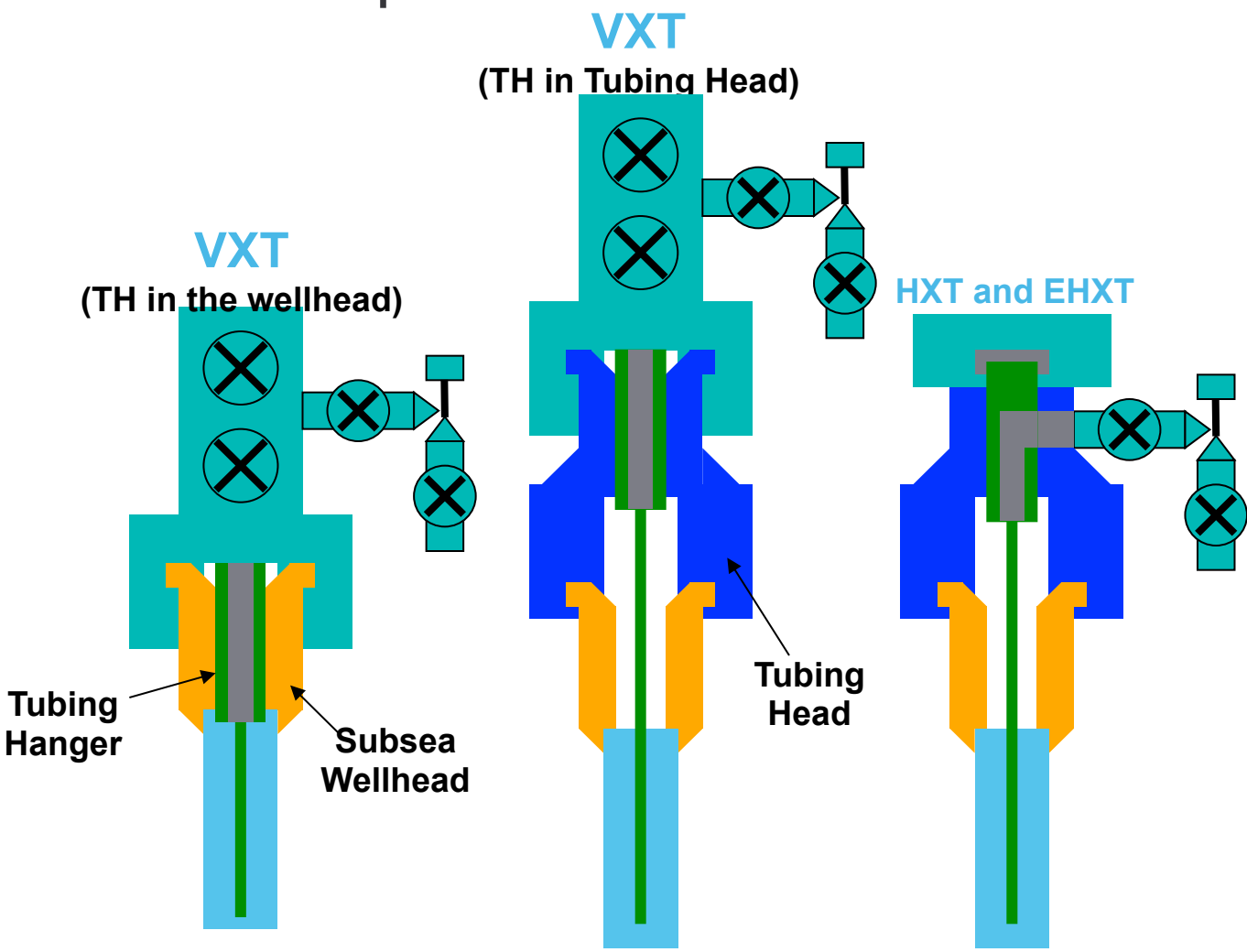
Four interfaces govern tree design

- The Well
  - **Tubing Size, Pressure, Temperature, Material Class**
- Controls
  - **Direct, Piloted, E-H, Different Vendors**
- Flowlines
  - **Pipeline Size, Pressure, Connection Type, Different Vendors**
- The Wellhead
  - **Mudline, Clamp Hub, Mandrel, Different Vendors**



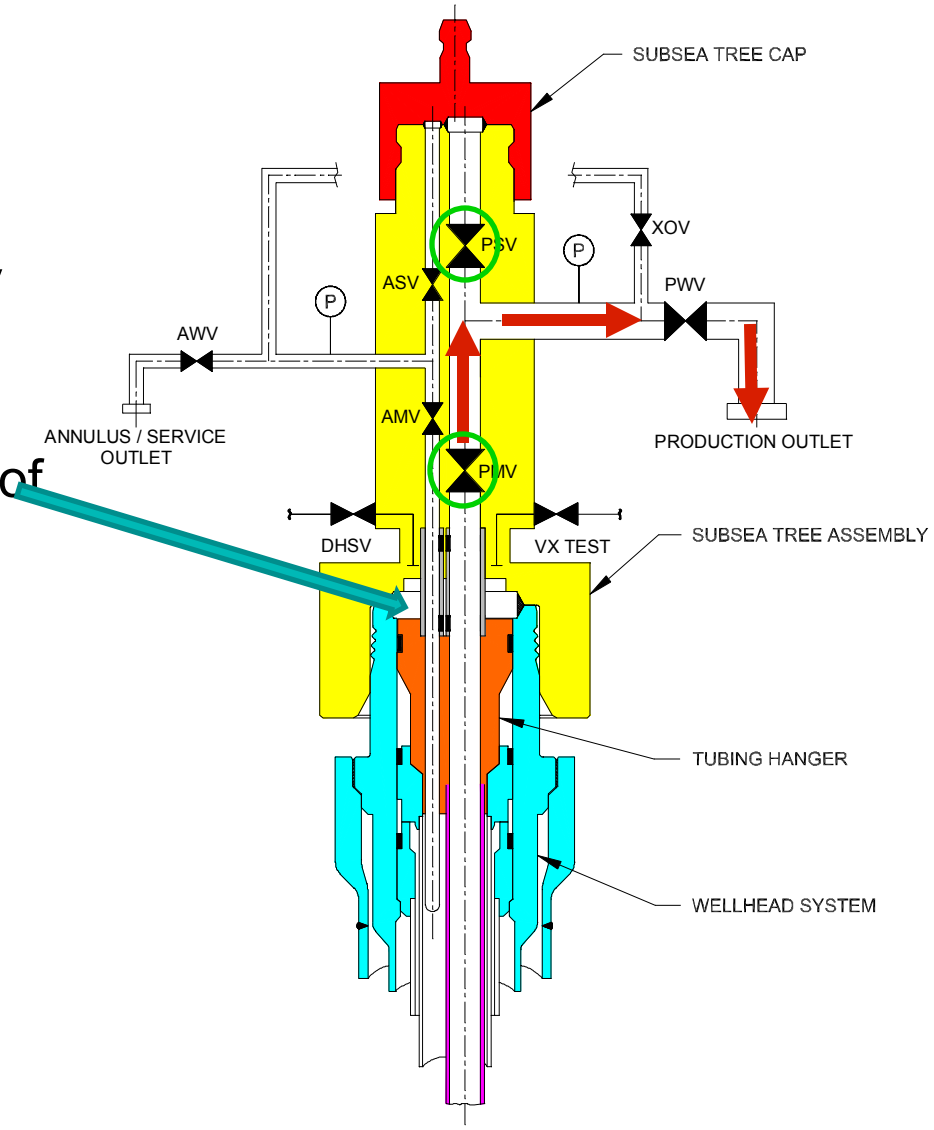
Three Types of Subsea Completions

- The type of completion defines where the tubing hanger resides (in the wellhead, in the tubing head or in the tree)
- Anything above the tubing hanger can be removed without disturbing the well



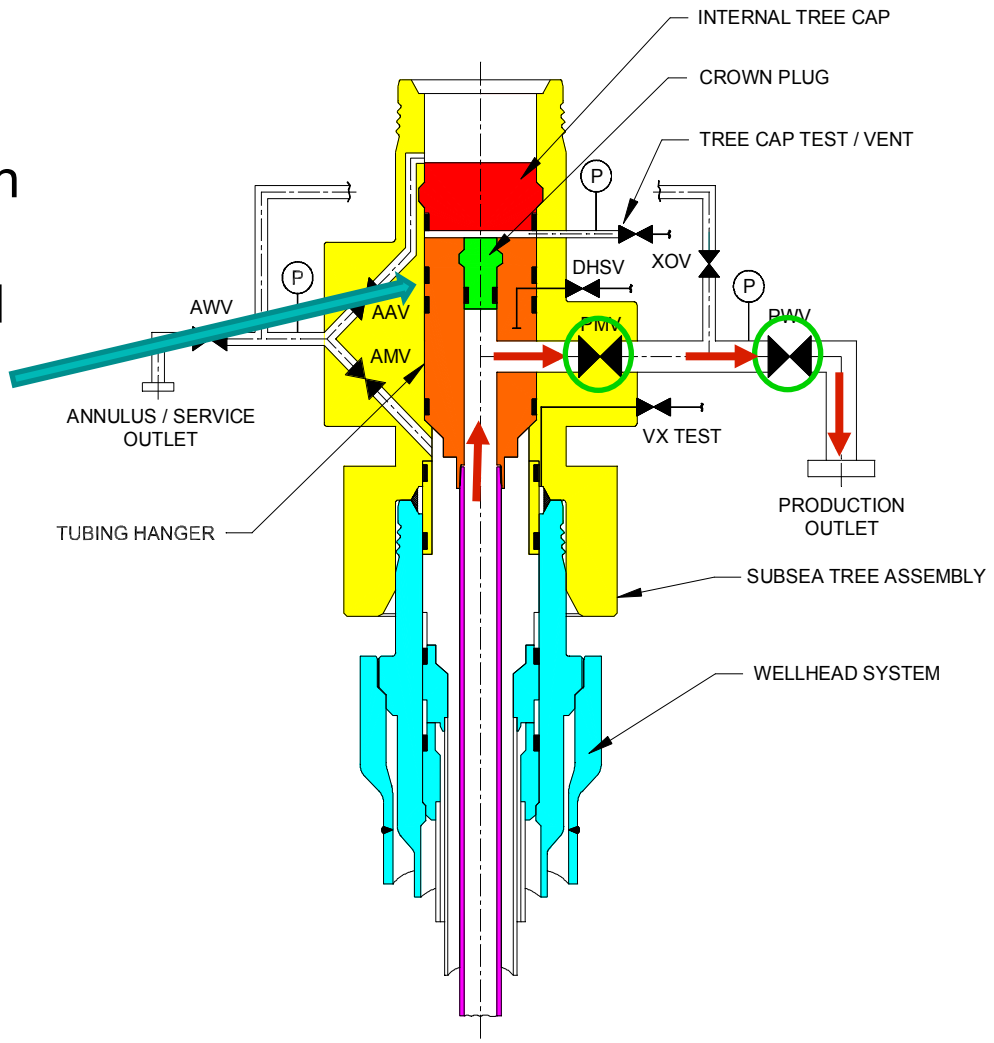
Vertical vs. Horizontal

- Vertical
  - Tree valves stacked vertically on top of tubing hanger
  - Downhole functions provided through bottom of tree to top of tubing hanger
  - Production tubing and tubing hanger installed prior to VXT

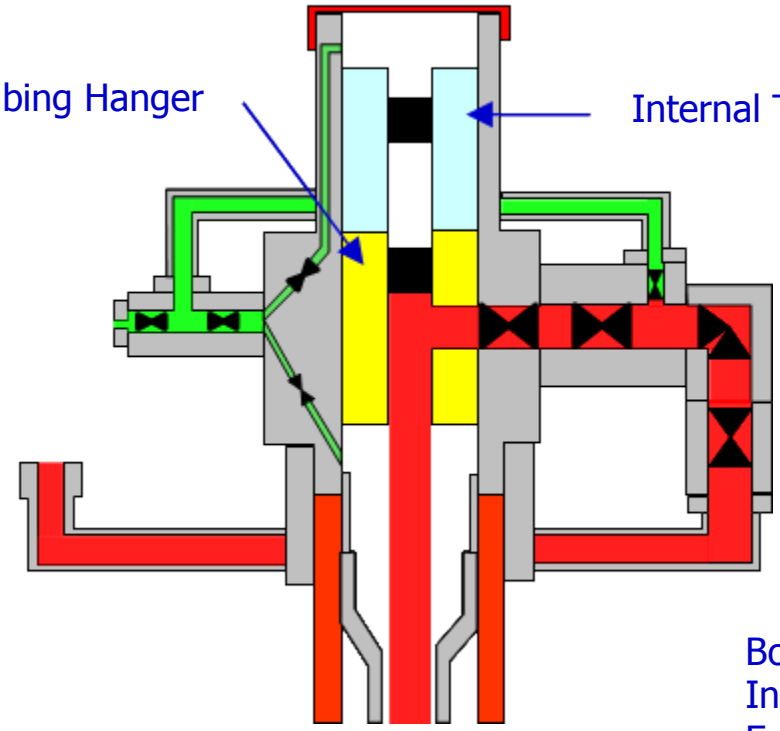


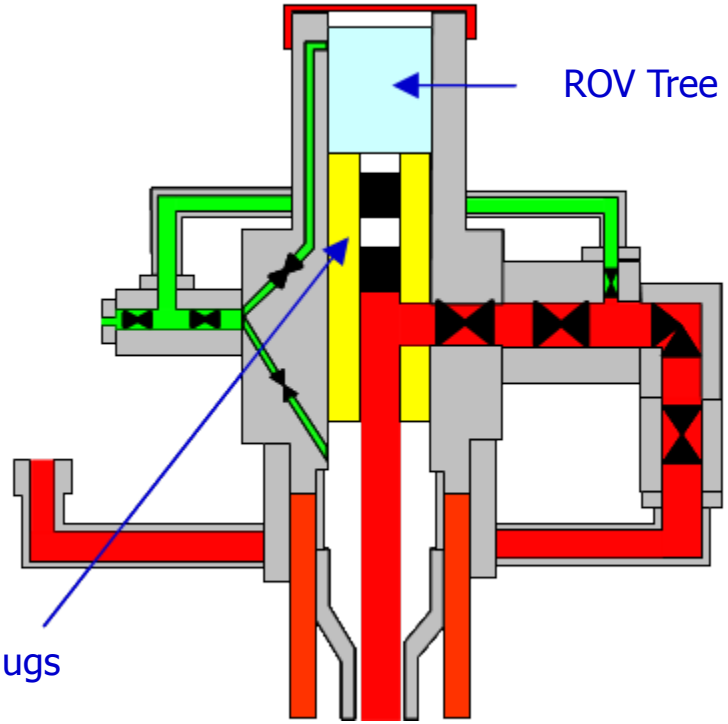
Vertical vs. Horizontal

- Horizontal
  - Production fluid flows through side of tubing hanger
  - Downhole functions provided through penetrators on side of tubing hanger
  - HXT installed prior to production tubing and tubing hanger



Traditional and Enhanced Horizontal Trees



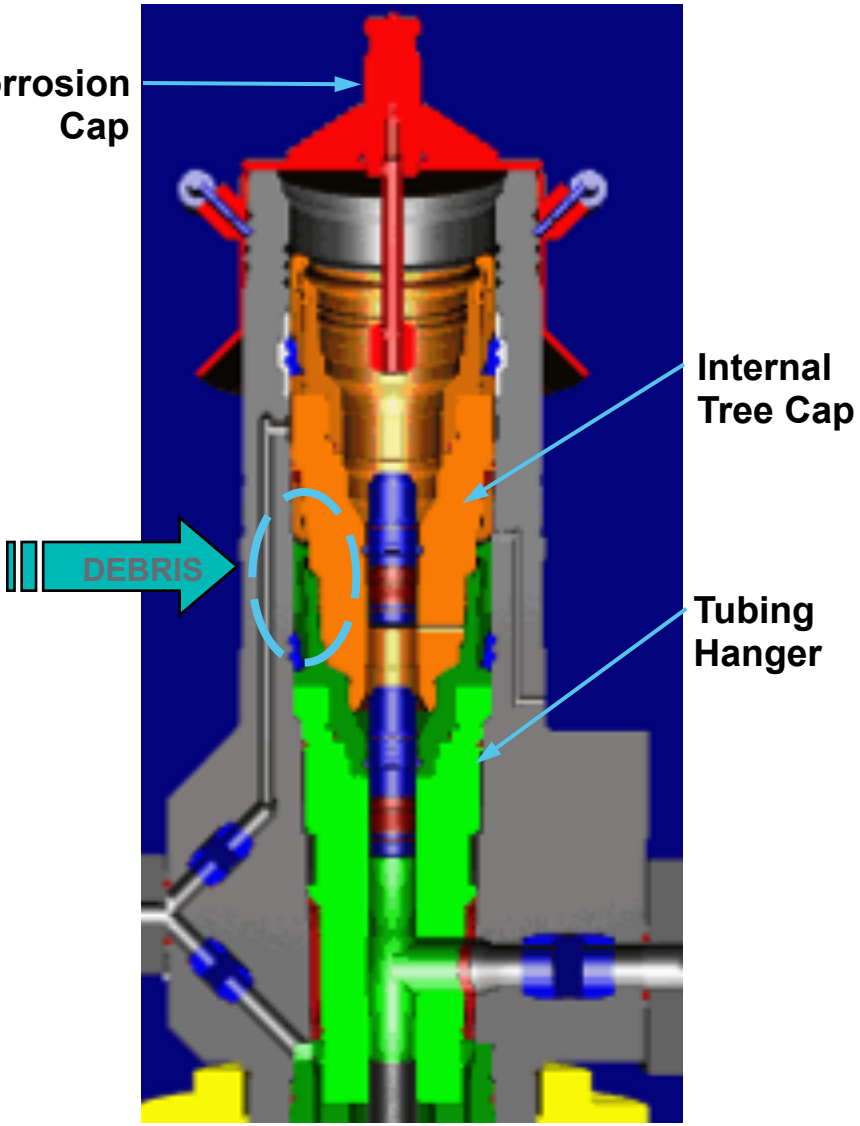


Traditional HXT

Enhanced HXT

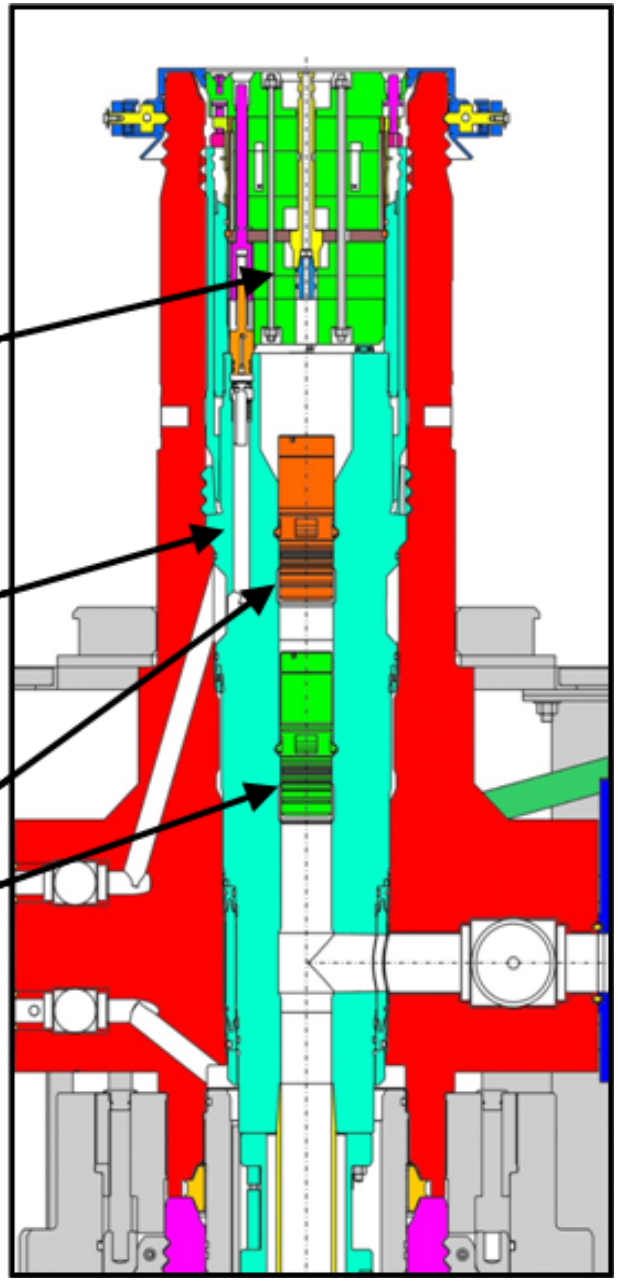
Traditional Horizontal Tree Design

- Secondary seal and lockdown barriers provided on Internal Tree Cap
- No. 1 reliability issue with installing HXT's is setting the internal tree cap through the BOP (industry wide problem)
- Trapped debris between tubing hanger and tree cap makes it difficult to land and lock cap in tree body, resulting in miss-trips
- Riser cleanliness is critical, requires wash trips and/or bailing runs (contingency time)

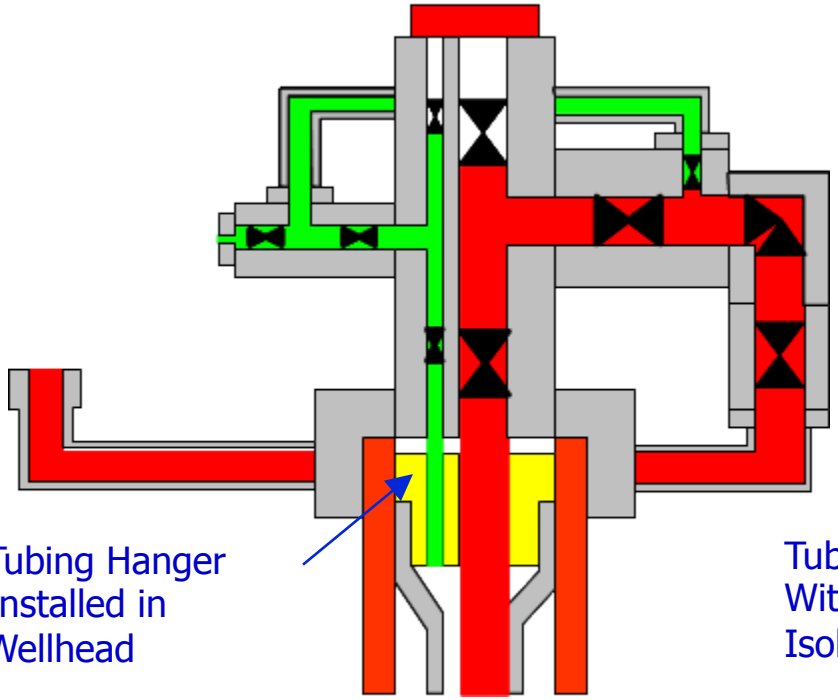


Enhanced Horizontal Tree

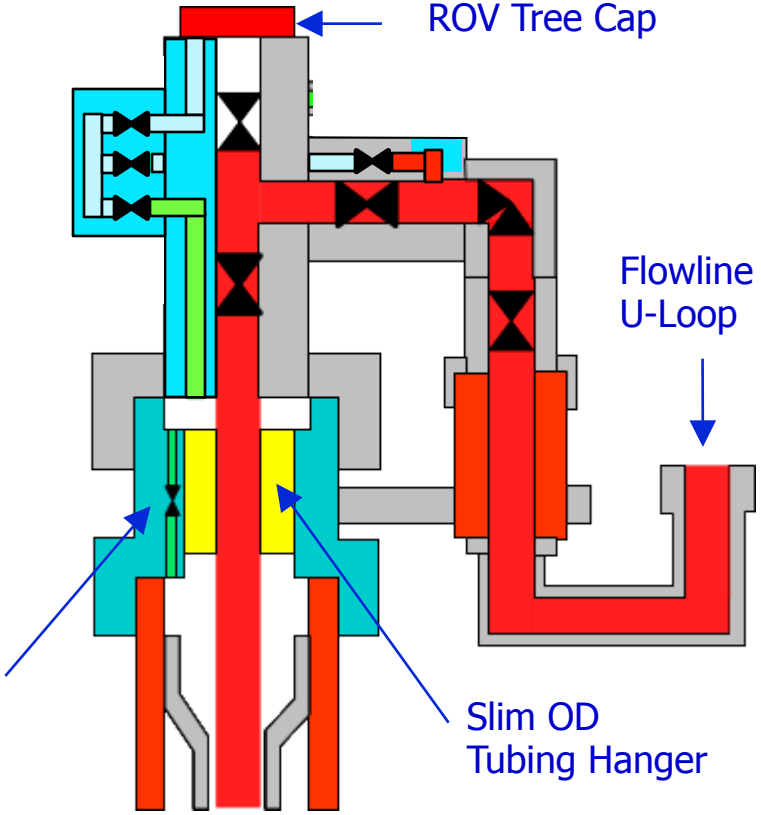
- Debris Trap Eliminated
- ROV Tree Cap installed after BOP is removed, resulting in significant operational time savings
- Enhanced Tubing Hanger combines Internal Tree Cap and Tubing Hanger into one piece
- Upper and lower wireline plugs are installed in back-to-back fashion in extended tubing hanger to improve wireline efficiency



Traditional and Enhanced Vertical Trees



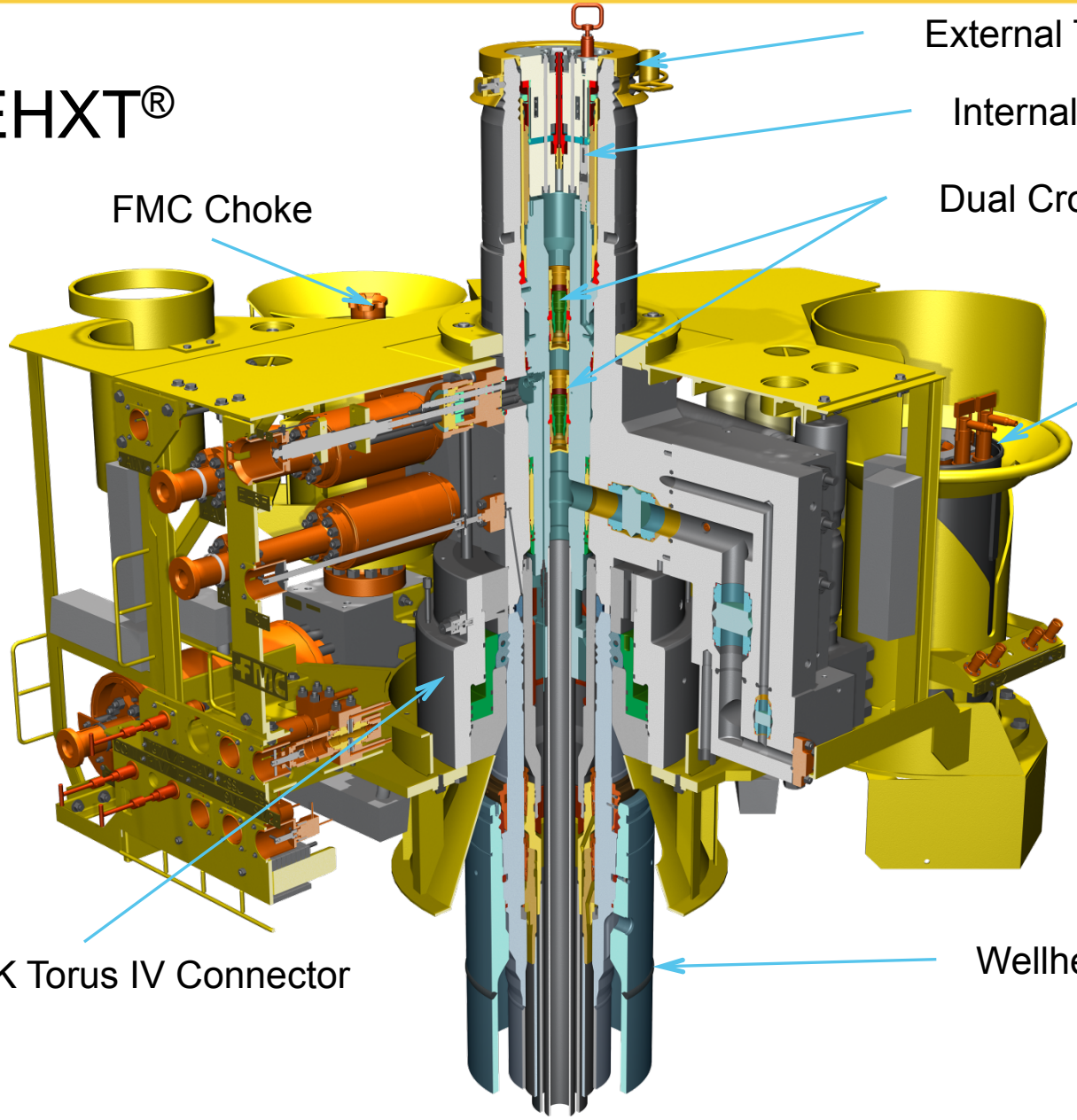
Traditional VXT



Enhanced VXT (EVDT)

EHXT System Overview

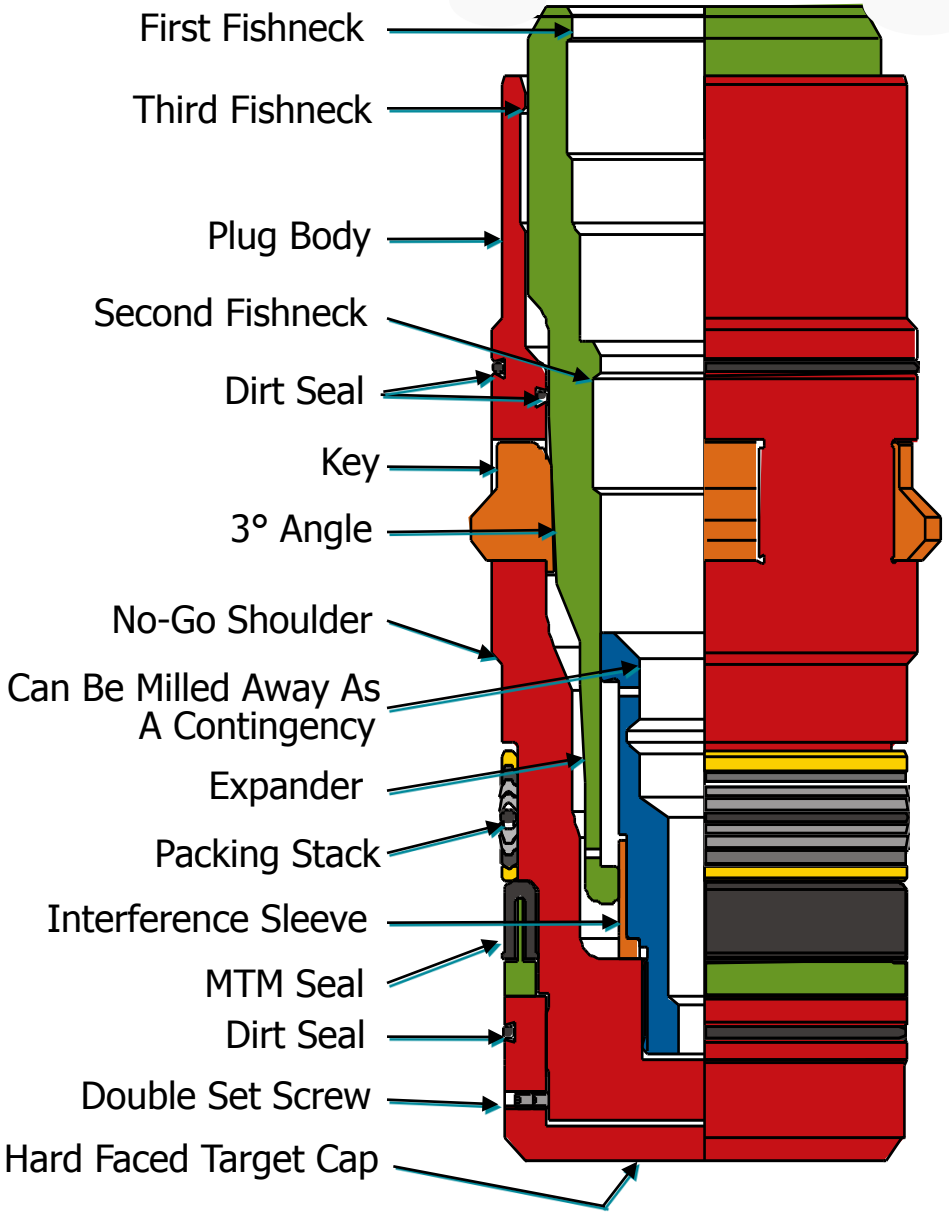
15K EHXT®


External Tree Cap
Internal Tree Cap
FMC Choke
Dual Crown Plugs
SCM
18-3/4” 15K Torus IV Connector
Wellhead System

EHXT System Components

Crown Plugs

- Halliburton SSP crown plug with FMC metal-to-metal seal
- Primary OD seal is FMC's proprietary SBMS-II
- Secondary PTFE chevron packing stack
- 10,000 psi or 15,000 psi working pressure from above and below
- Rigidly locked design



Tubing Hanger Features

- Suspends weight of tubing string
- Provides seals to isolate production pressure/fluid from annulus and environment
- Accommodates up to 7” tubing
- Hangoff capacity of 1,000,000 lbs
- Passively orientated in tree during installation by key/helix arrangement
- Features two Halliburton SSP crown plugs with FMC SBMS-II metal seals
- Run on hydraulic THRT with pressure balanced pistons
- Enables running up to 9 downhole lines in standard configuration (6 hydraulic + 3 max electric)

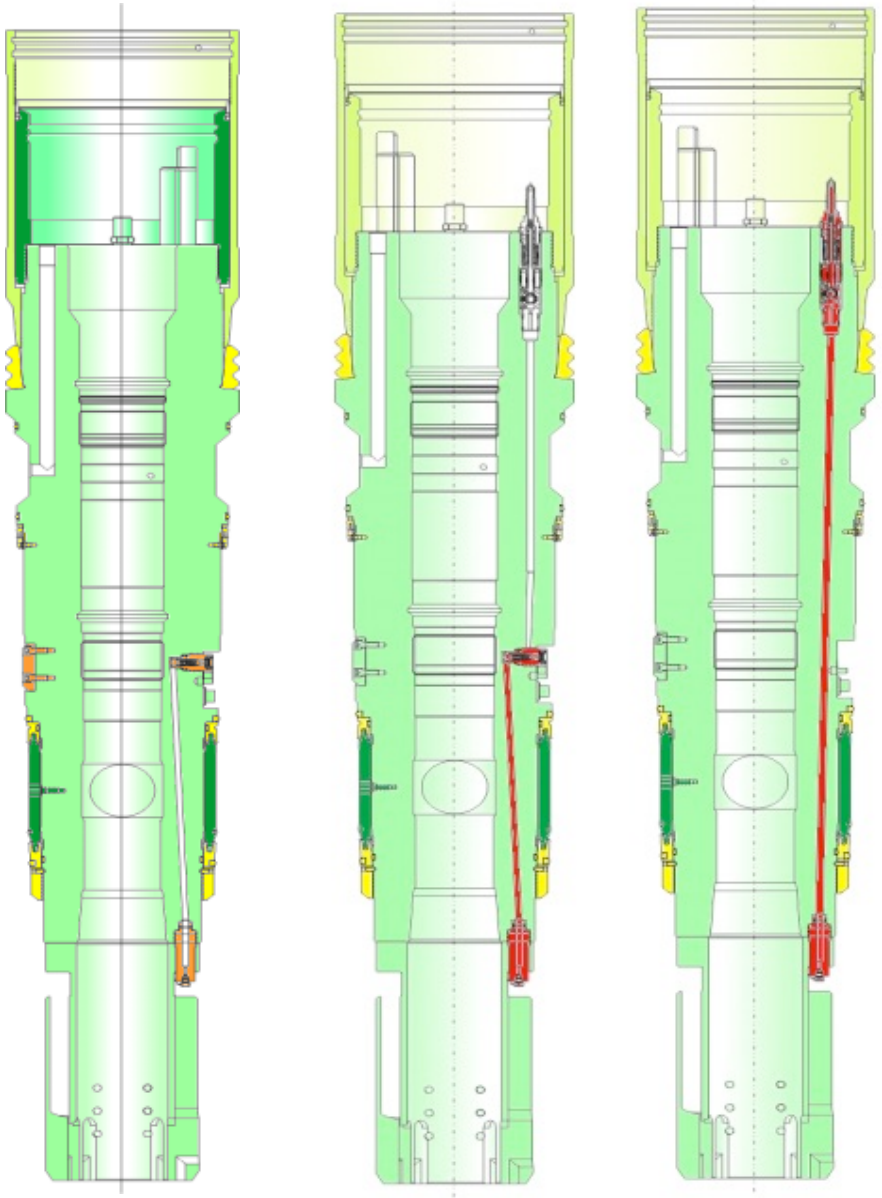
Tubing Hanger

Vertical Access Options

- SCSSV and SMART WELL lines
- Poppet gate valve designed not to open during BOP seal test
- Poppet Gate Valves provide dual metal sealing barriers for downhole fluid lines

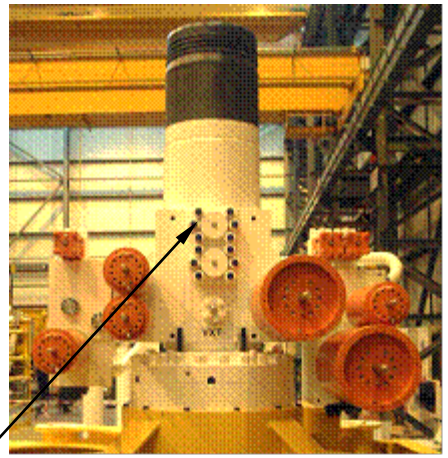
Poppet GVs

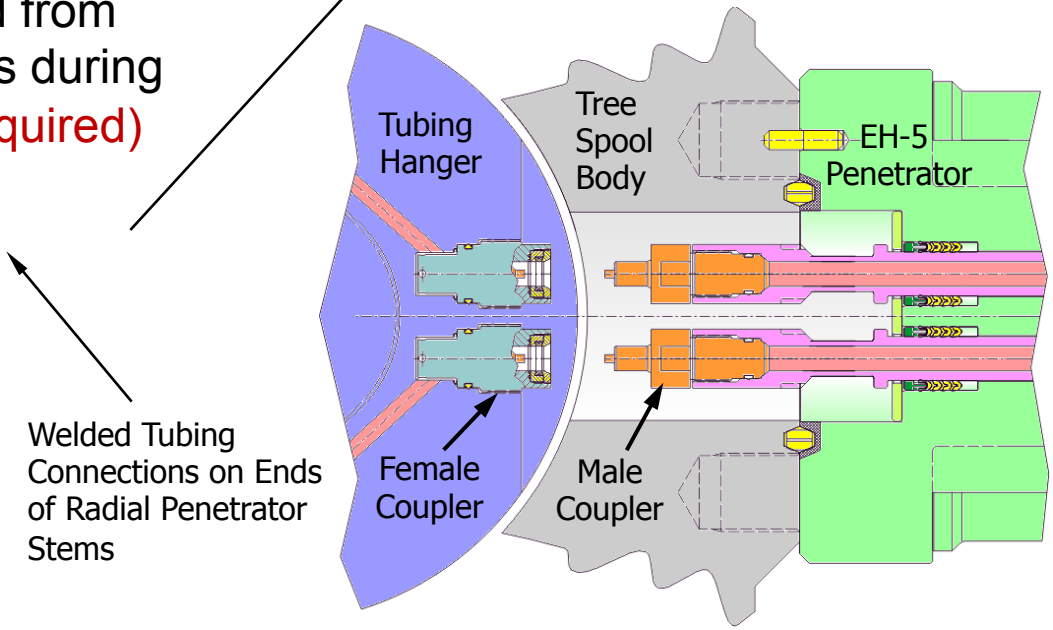
Plugs



EH-5 Radial Penetrator

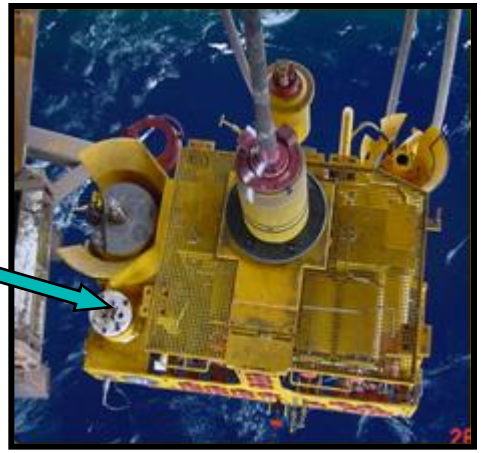
- Enables 9 downhole control lines through 2 penetrators with option for tenth line and third penetrator
- Horizontal couplers are recessed and protected from debris while running TH, unlike systems with vertical couplers which are susceptible to debris fouling
- Penetrator couplers are isolated from completion and orientation loads during TH land out (Soft landing not required)





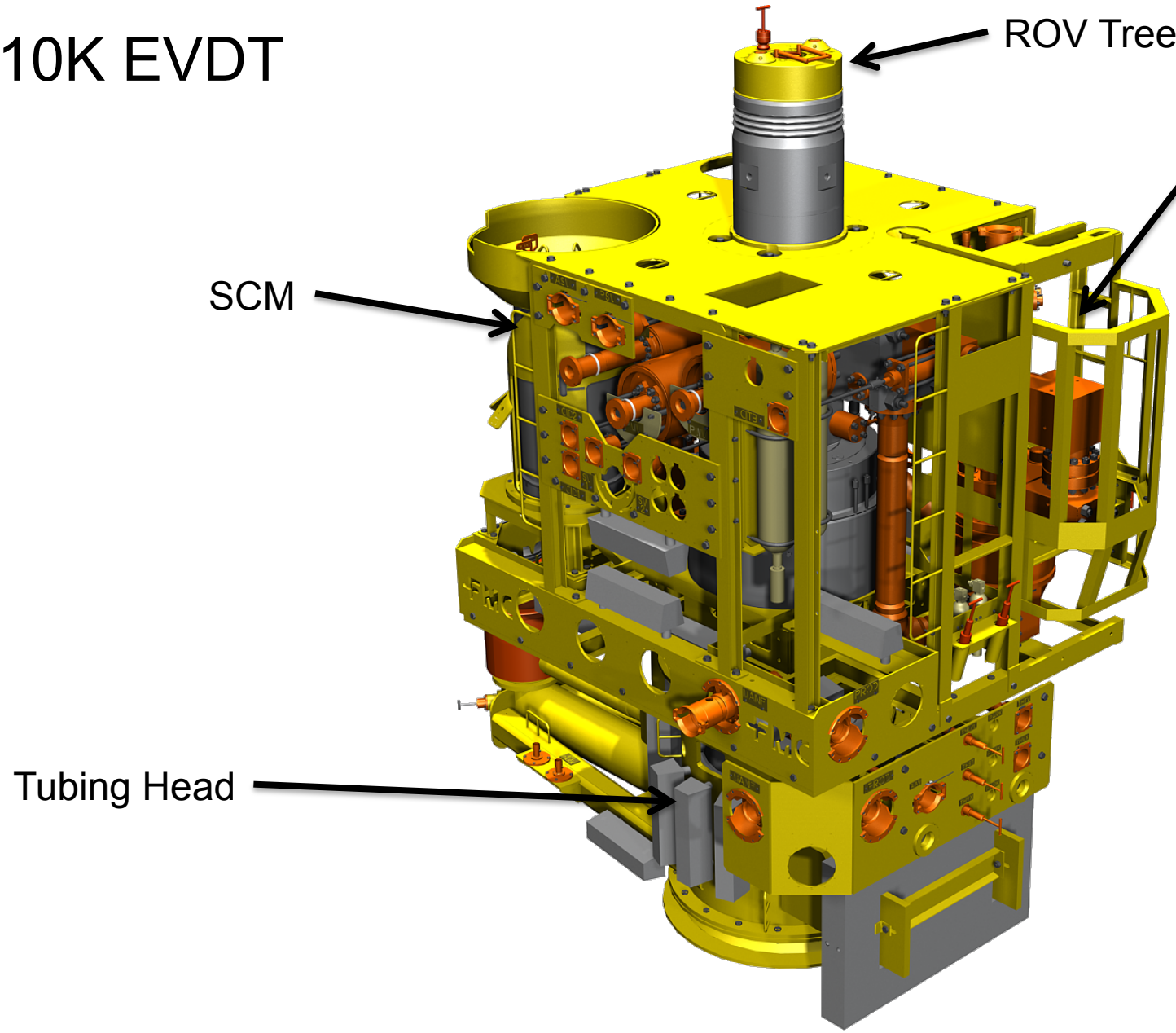
ROV Tree Cap

- Provides installation time savings of two or more days in deepwater
- Eliminates time in well completion program for wash trips and bailing runs
- Time savings doubles during workovers
- Weighs less than 150 lbs in water, easy for ROV to handle
- Stored on tree frame during tree installation
- Installation occurs off rig's critical time path



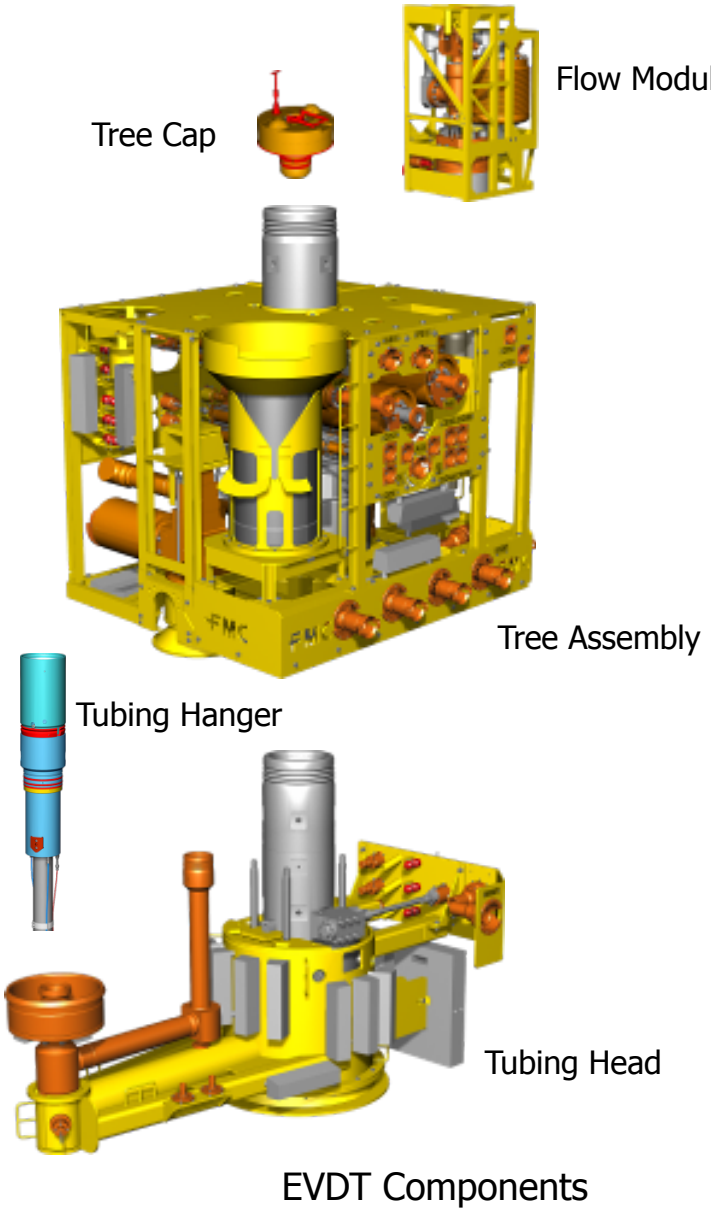
EVDT System Overview

10K EVDT



What is an EVDT?

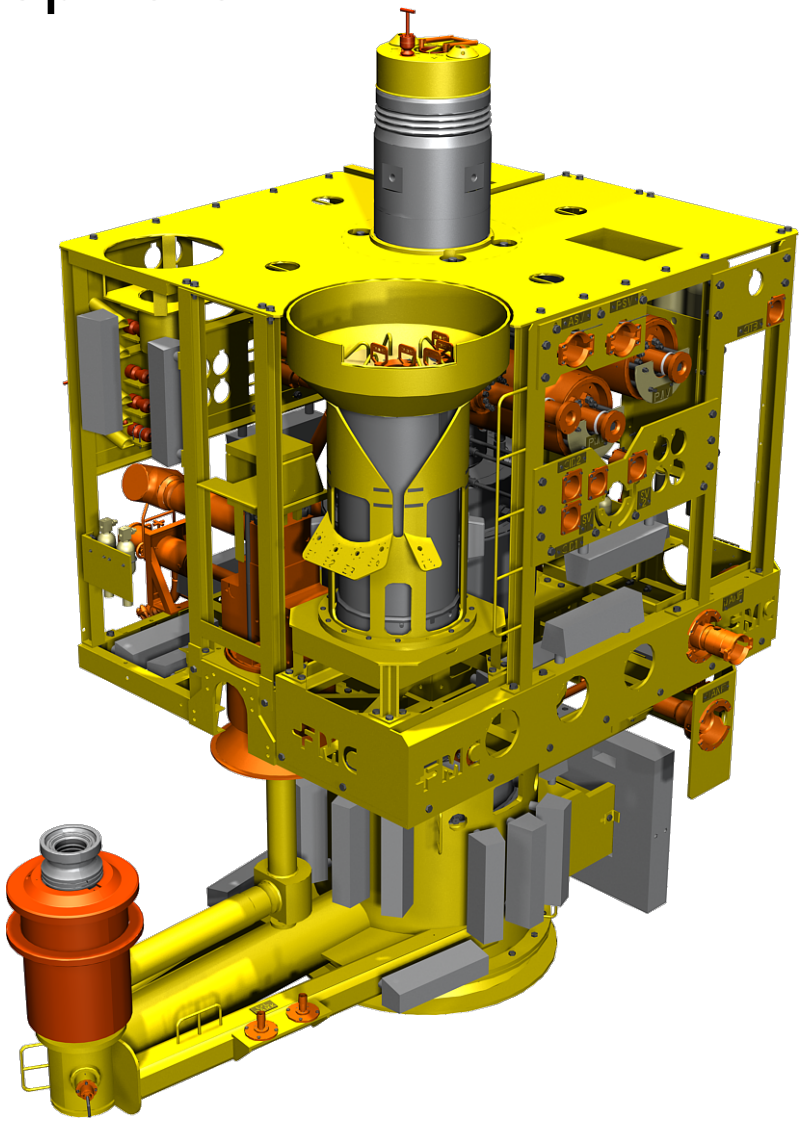
- EVDT stands for "Enhanced Vertical Deepwater Tree"
- An evolution of existing tree designs, incorporating innovative features aimed for enhancements in reliability and rig time savings
- EVDT is a vertical monobore tree system that utilizes a slimbore (13-5/8") tubing hanger system, ROV tree cap and IWOCS controls thru flying leads
- Configurable in 5"-10K, 7"-10K, 5"-15K and 4"-20K



EVDT Components

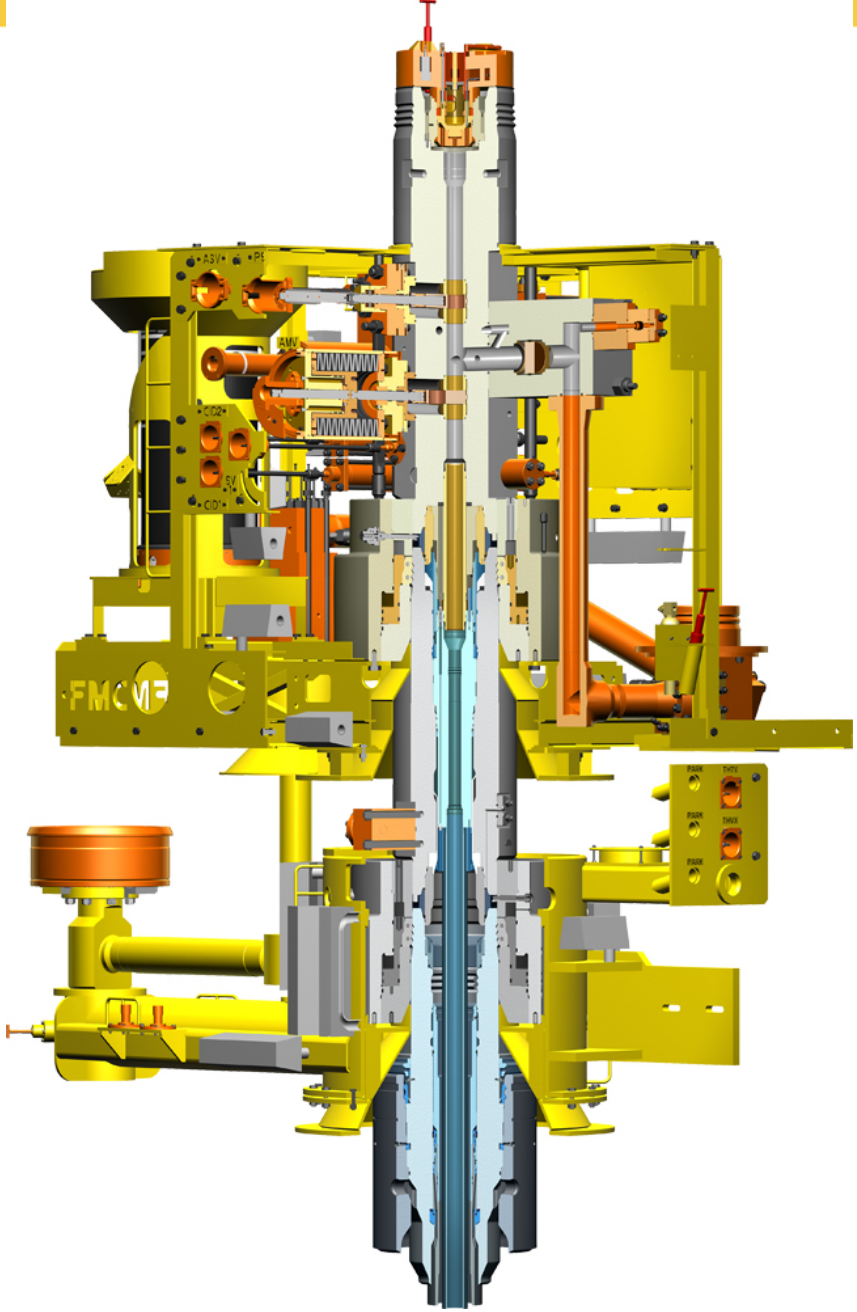
Main Benefits of EVDT for Deepwater

- Risk reduction - Provides option to pull tree without having to pull completion (critical for complex 30,000 ft. well)
- Incorporation of reconfigurable flow module and bolt-on gas lift system allows one tree design to be used for producers and injectors
- Tubing hanger allows for eleven downhole lines (critical for chemical injection and Smart Well completions)
- Components and tooling applicable for broader range of applications (shallow water, surface BOP, tree on wellhead)

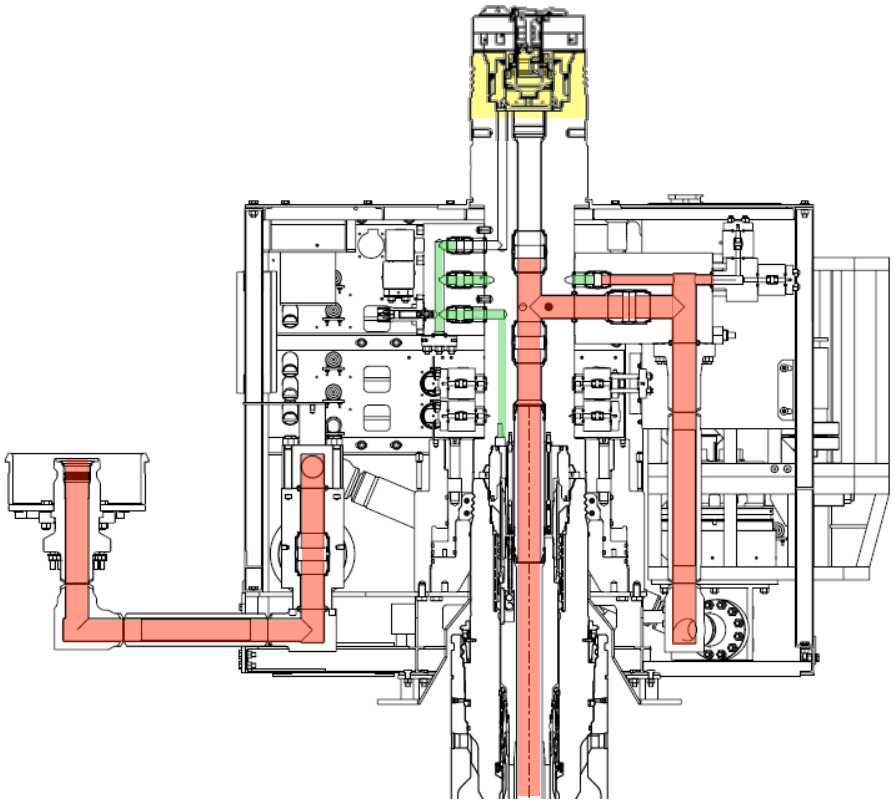


EVDT – Primary Features

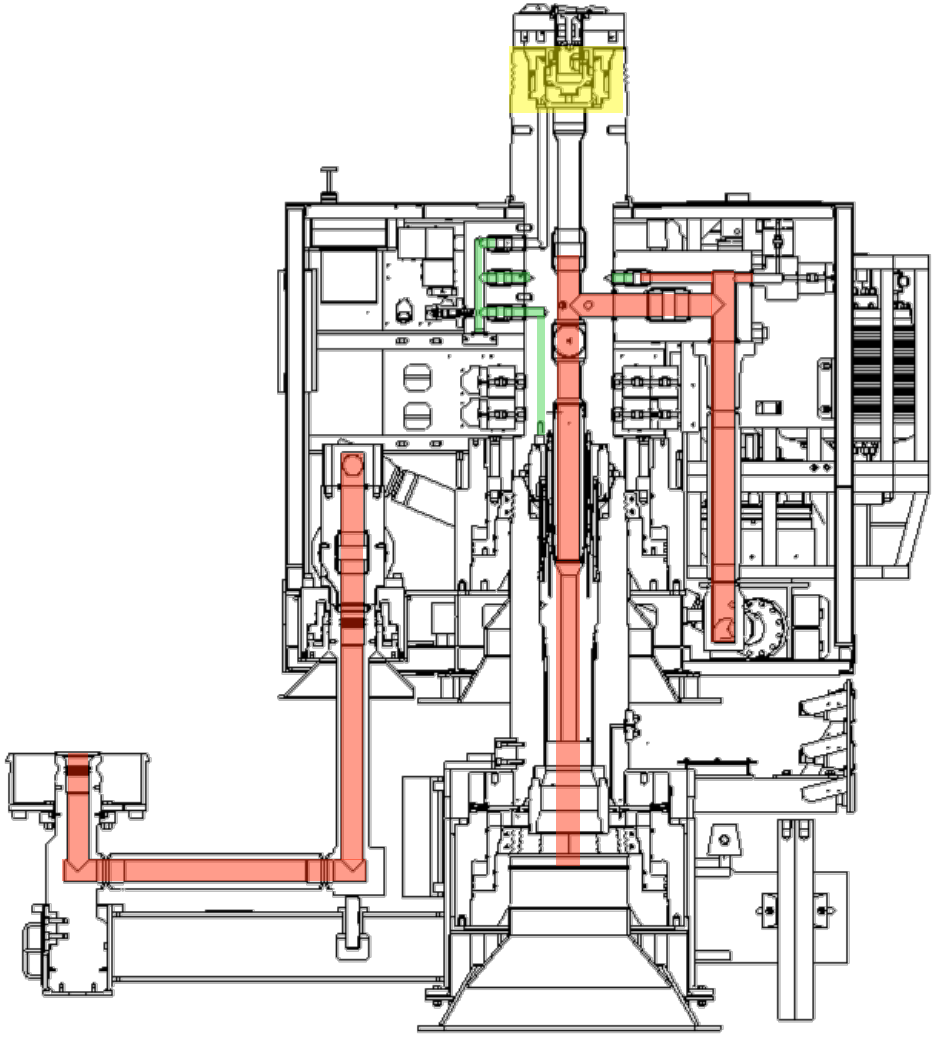
- Slim bore tubing hanger compatible with Subsea or Surface BOP
- BOP-on-Tree – allows a variety of installations and workover options
- Allows for tubing head or in wellhead completion
- Flow module incorporated for flexibility of retrieval and reconfiguration
- Compatible with smart wells downhole completions
- Fiber optics can be routed thru tree as well as fiber optics sensors mounted in tree



EVDT System Options



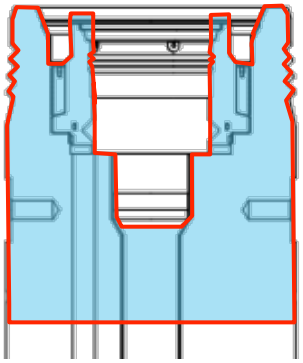
In the Wellhead Version

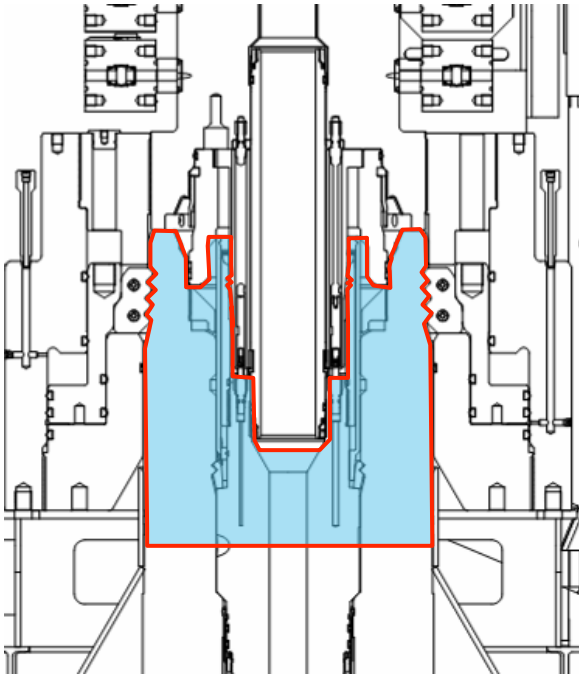


Tubing Head Version

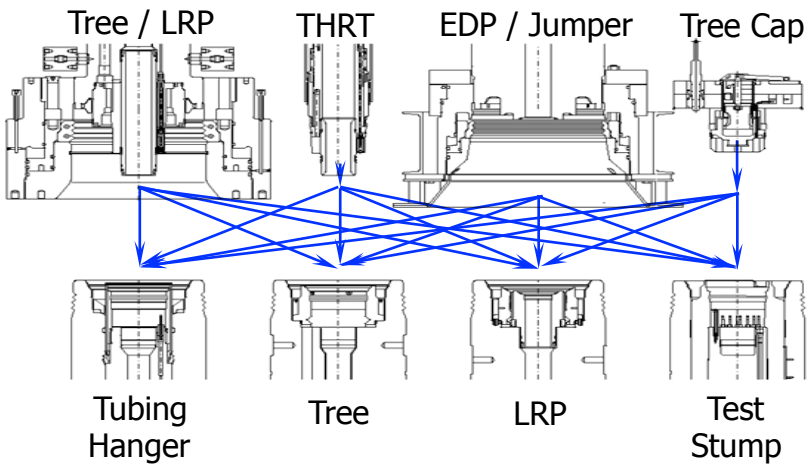
EVDT – Common Interfaces

- Provides BOP-on-Tree interface at all upward looking interfaces
- Allows tooling to be interchangeably used for all components (sized for 7” bore and 15K pressures)
- Eliminates the need for an open water riser system

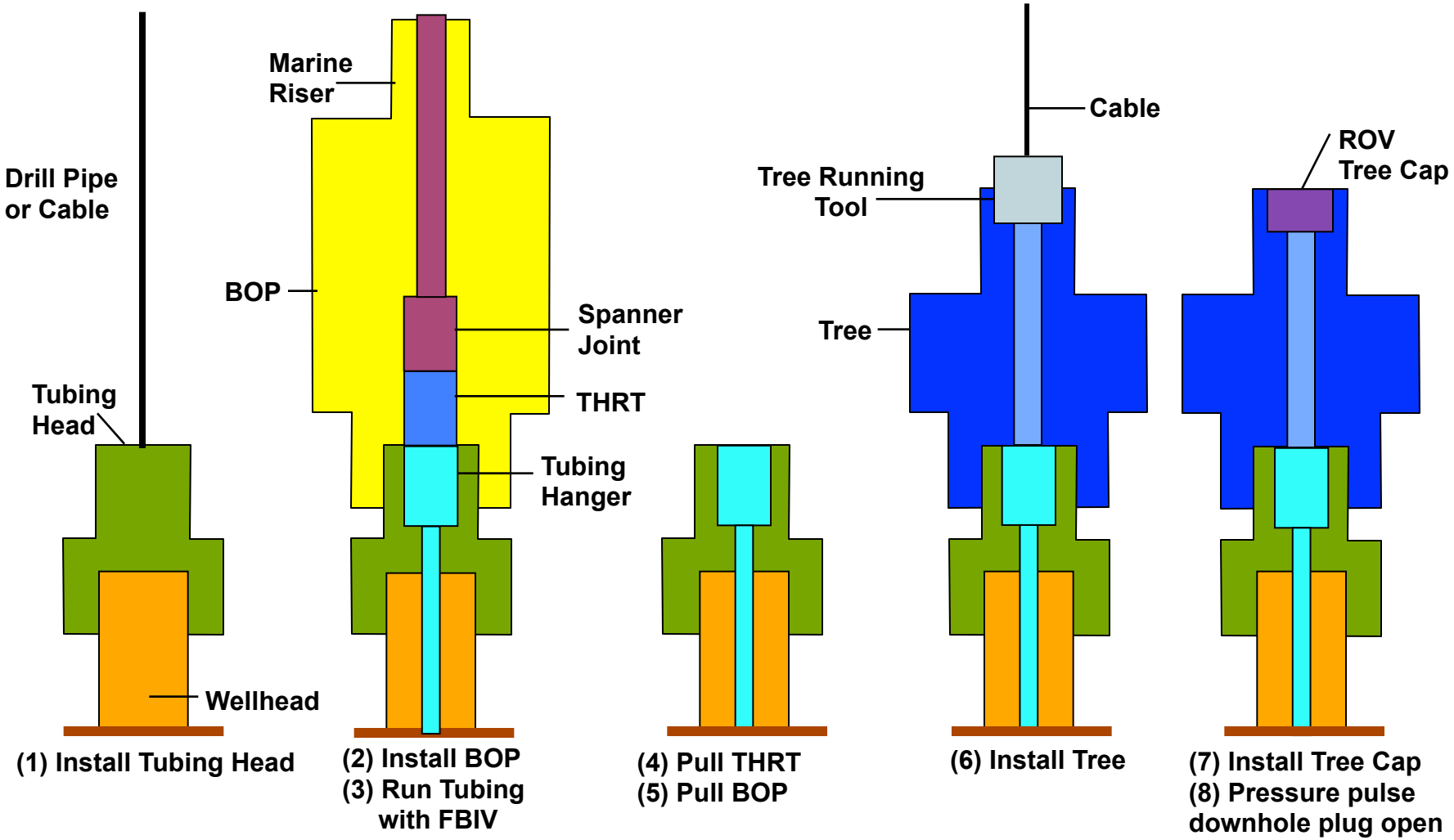




Common Interface Shown in Red

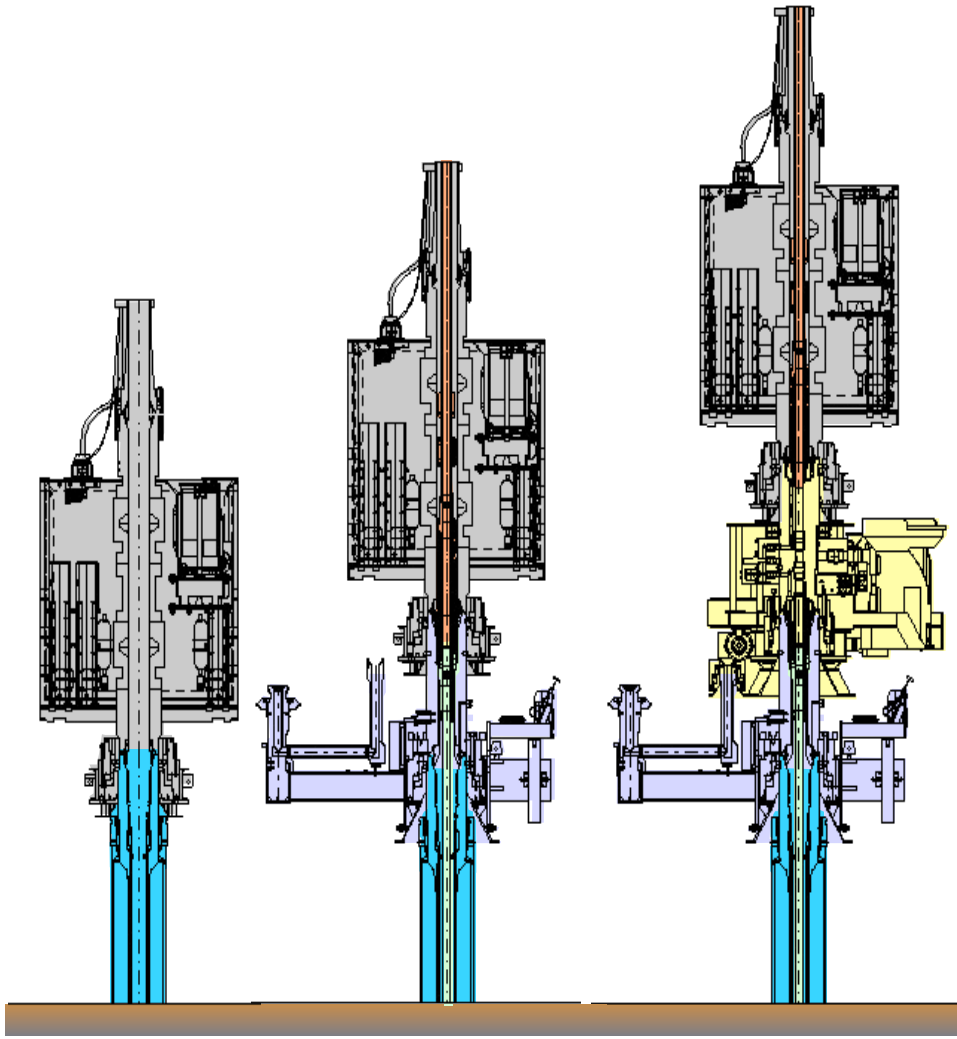


EVDT Installation Sequence



BOP-on-Tree Interface

- EVDT allows Subsea BOP and marine riser to be landed on tree
- Can use BOP and marine riser along with a landing string for installation and or interventions similar to horizontal tree
- An open water riser system is NOT REQUIRED for EVDT
- Currently, most tree systems are being installed on cable (tree on wire) and do not require either open water riser or marine riser & subsea BOP



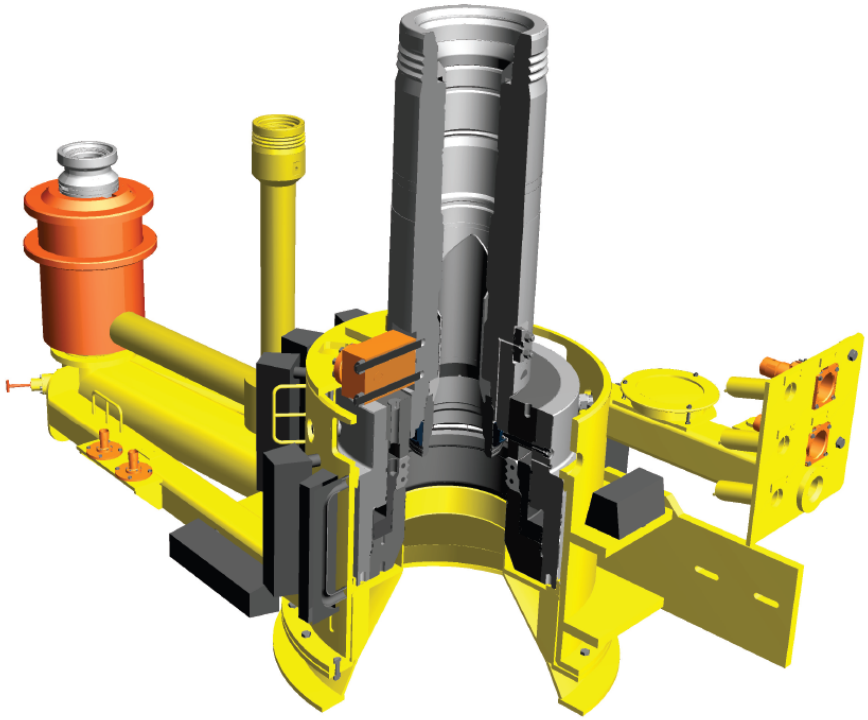
Typical BOP-on-Tree sequence

EVDT System Components

Tubing Head – Primary Features

Adobe Acrobat Document

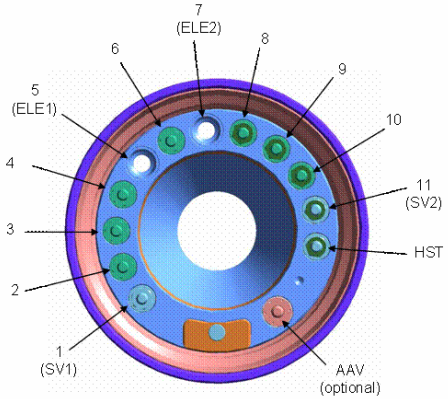
- External annulus flowpath
- Production flowloop (welded design)
- Connector secondary release rods
- ROV panel for connector lock/unlock and annulus valve operation
- Options for hydraulic or mechanical jumper connectors

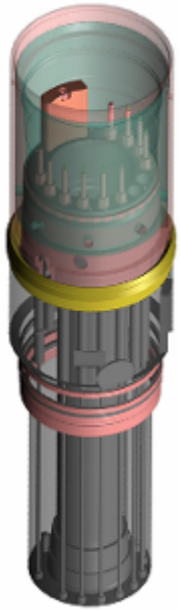


EVDT Tubing Head Assembly

Tubing Hanger Features

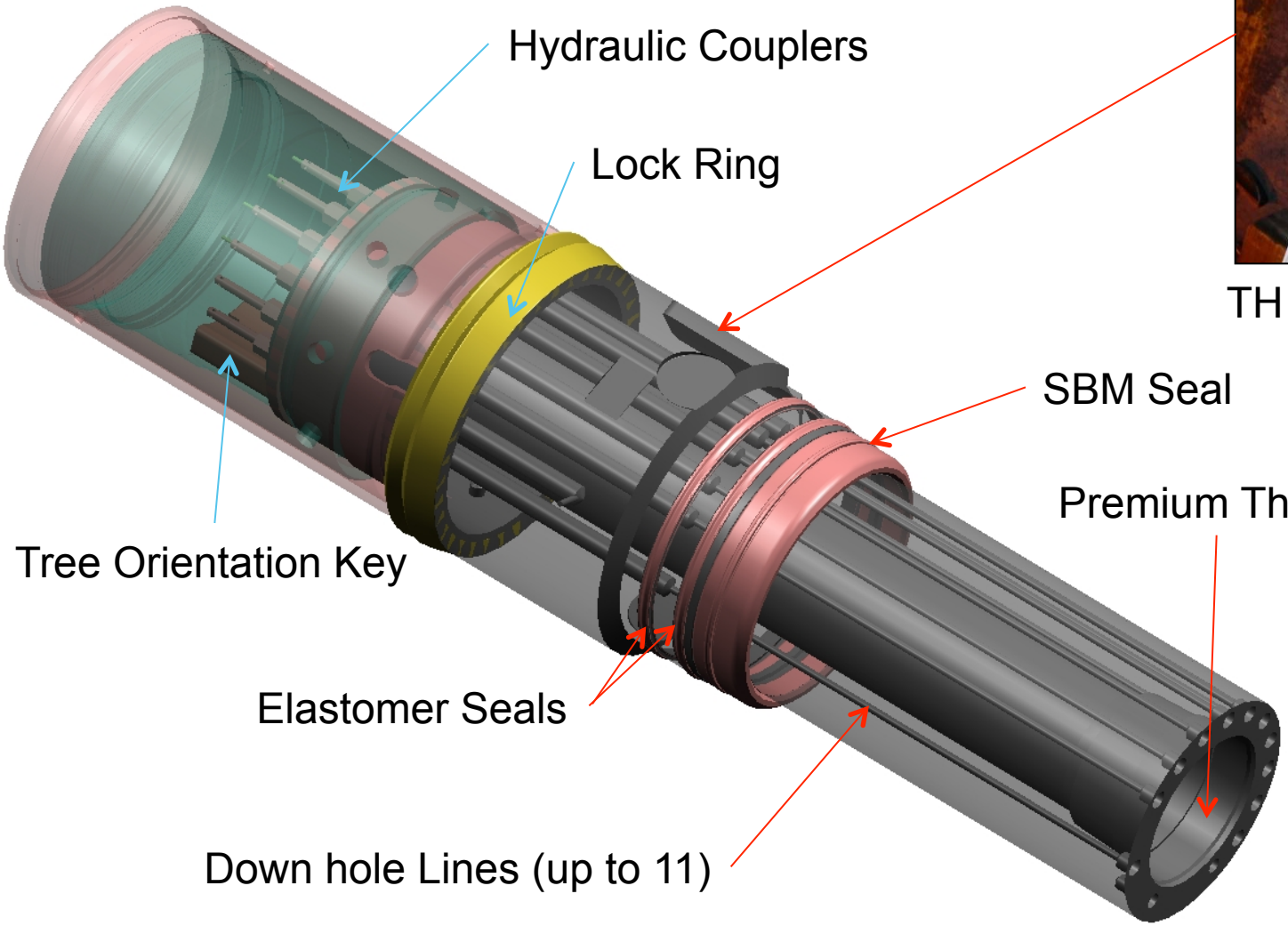
- Slimbore design: 13.4” OD (Drifts 13-5/8” BOP)
- Hanger and tooling are designed to accommodate up to a 7” bore completion
- Common design for 10K and 15K hangers (15K utilizes upgraded materials)
- Hanger can accommodate up to 11 downhole functions (Hydraulic, Electric or Optical)
- Key on TH engages helix in THD for passive alignment
- Tree orientation bushing engages TH key to provide accurate alignment
- Tree Production Stab seals with M2M seal and elastomer back up seal





5” EVDT Tubing Hanger

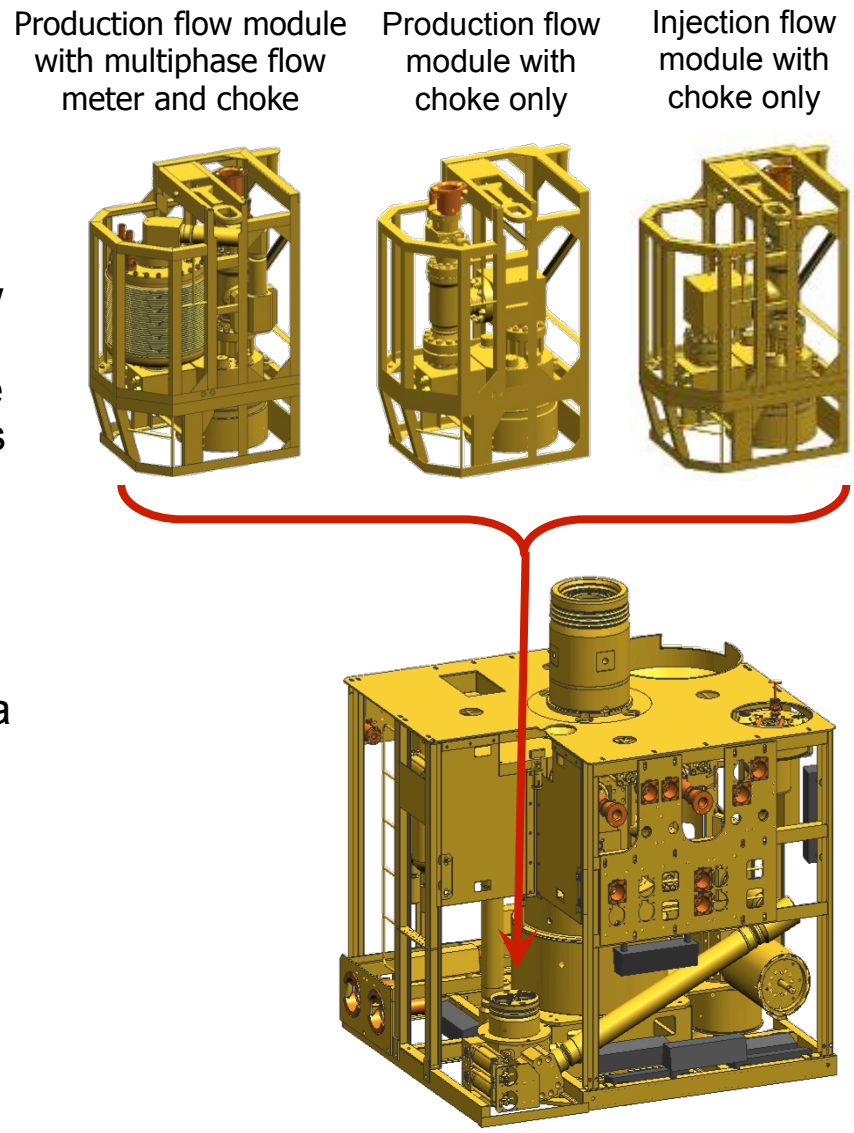
Tubing Hanger Features



TH Orientation Key

Flow Module Design

- Multi-Component Module
  - Allows production choke, multi-phase flow meter, and other equipment that may require maintenance over life of well to be incorporated into a single module which is retrievable with a smaller/cheaper vessel
- Design “future proofs” system
  - Enables modification without pulling tree
  - Add a flow meter or booster pump
  - Provides a full 5” bore inlet and outlet on a multi-bore hub so future equipment is not limited by a flow restriction
- Intervention Capabilities
  - Options for scale squeeze, pumping or other specially modules for future flowline or downhole intervention activities



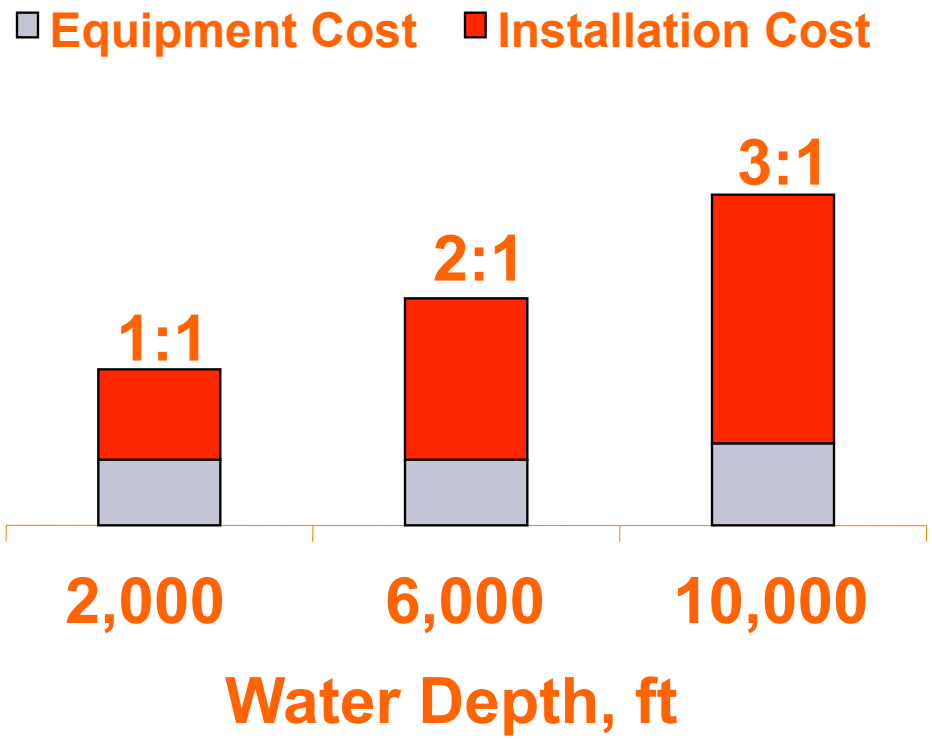
EVDT Tree Assembly

Which to go?

CAPEX and OPEX Comparisons

- **Installed CAPEX, life-of-field OPEX and workover time comparisons are provided on following two slides for the HXT and VXT**
- **HXT typically has slight installed cost advantage over VXT due to added cost of tubing head for VXT**
- **Installation time for the two tree systems is very similar**
- **VXT has time and cost advantage for tubing access workovers (such as wireline or coiled tubing work). Because these types of workovers typically occur more frequently than other types of workovers, the VXT has a life-of-field OPEX advantage.**
- **VXT has huge time and cost advantage for tree retrieval workovers because the well has to be decompleted to retrieve a HXT. Retrieving a VXT does not disturb the production tubing string.**

Equipment vs. Installation Cost by Water Depth



Additional Information

Description	API Standard	ISO Standard
Surface wellhead and tree equipment	Spec 6A	10423
Design and operation of subsea systems	RP 17A	13628-1
Materials for H2S Service	NACE MR-01-75	15156
Dynamic Risers	RP2RD	16389
Unbonded flexible pipe	Spec 17J	13628-2
TFL systems	RP 17C	13628-3
Subsea wellhead and tree equipment	Spec 17D	13628-4
Production control umbilicals	Spec 17E	13628-5
Subsea controls	Spec 17F	13628-6
Design & operation of completion/workover risers	RP 17G	13628-7
ROV interfaces	RP 17H	13628-8
ROT Intervention System	RP 17M	13628-9
Bonded flexible pipe	Spec 17K	13628-10
Flexible pipe	RP 17B	13628-11

Web Sites

• www.vetcogray.com	Vetco Gray
• www.api.org	American Petroleum Institute
• www.camerondiv.com	Cameron
• www.dril-quip.com	Dril-Quip
• www.akerkvaerner.com	Aker-Kvaerner
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Questions?