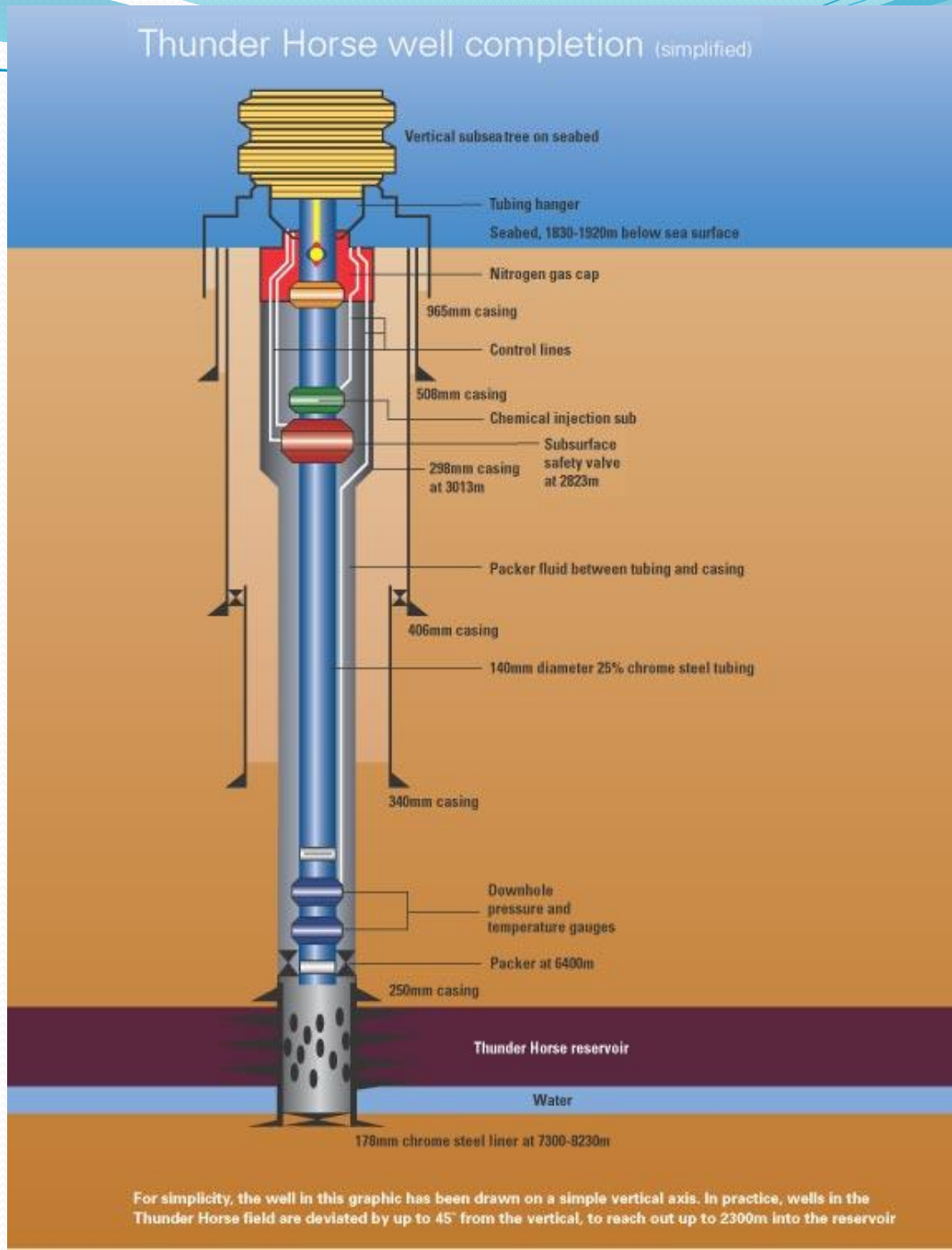
Chapter 10 – Completion Hardware

Many devices are included in well completions, especially in offshore wells, deep wells, or special situations

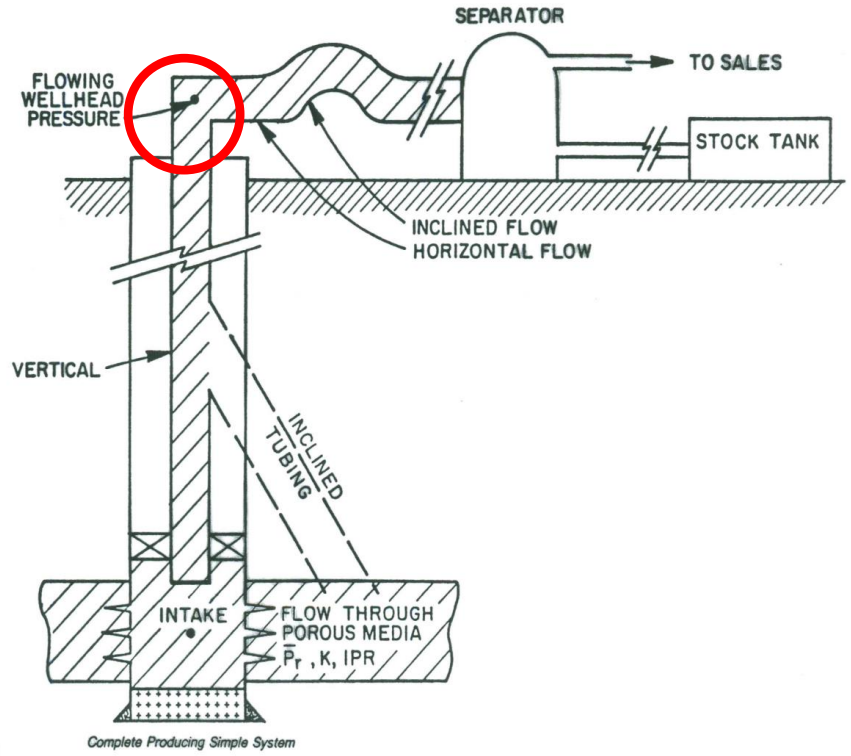


Types of Equipment

- Trees, Tubing Hanger and Wellhead system
- Subsurface Safety Valve
- Packers
- Expansion Devices, Anchor Latches
- Landing Nipples, Locks and Sleeves
- Mandrels and Gauges
- Capillary Line and Cable Clamps
- Loss Control and Reservoir Isolation Valves
- Crossovers
- Flow Couplings
- Modules

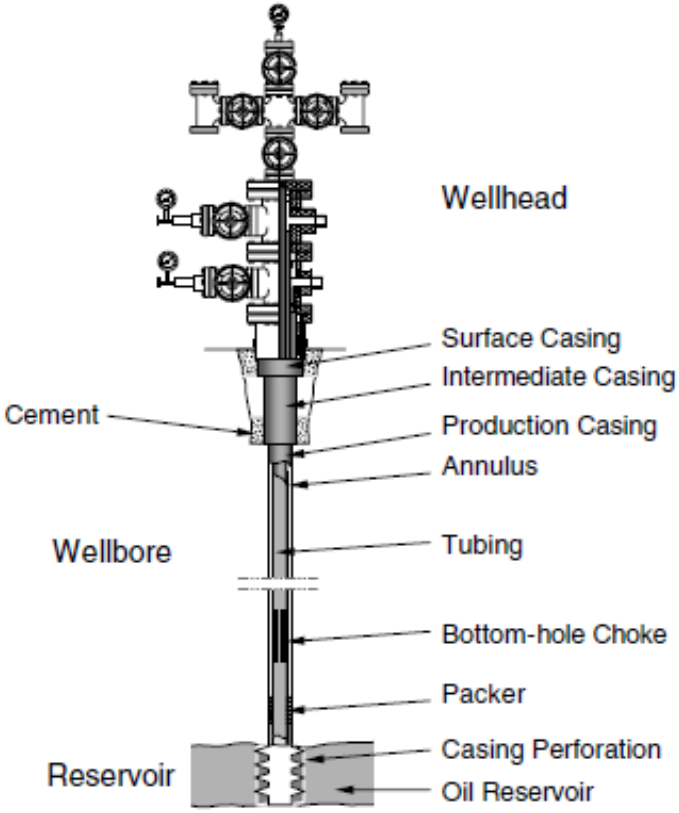
Tree Location

Photo courtesy George King



Functions of the Tree

- Provide the primary method of closing in a well
- Isolate the well from adjacent wells
- Connect a flowline
- Provide vertical access for well interventions
- Interface with tubing hanger and support the tubing
- Connect or interface the tree to the wellhead



Tree Valves

- Swab valve on top; Master valves normally on vertical portion; wing valves to side
- This photo shows dual master valve tree – flow path is through wing valve. Swab valve is removed for a wireline run

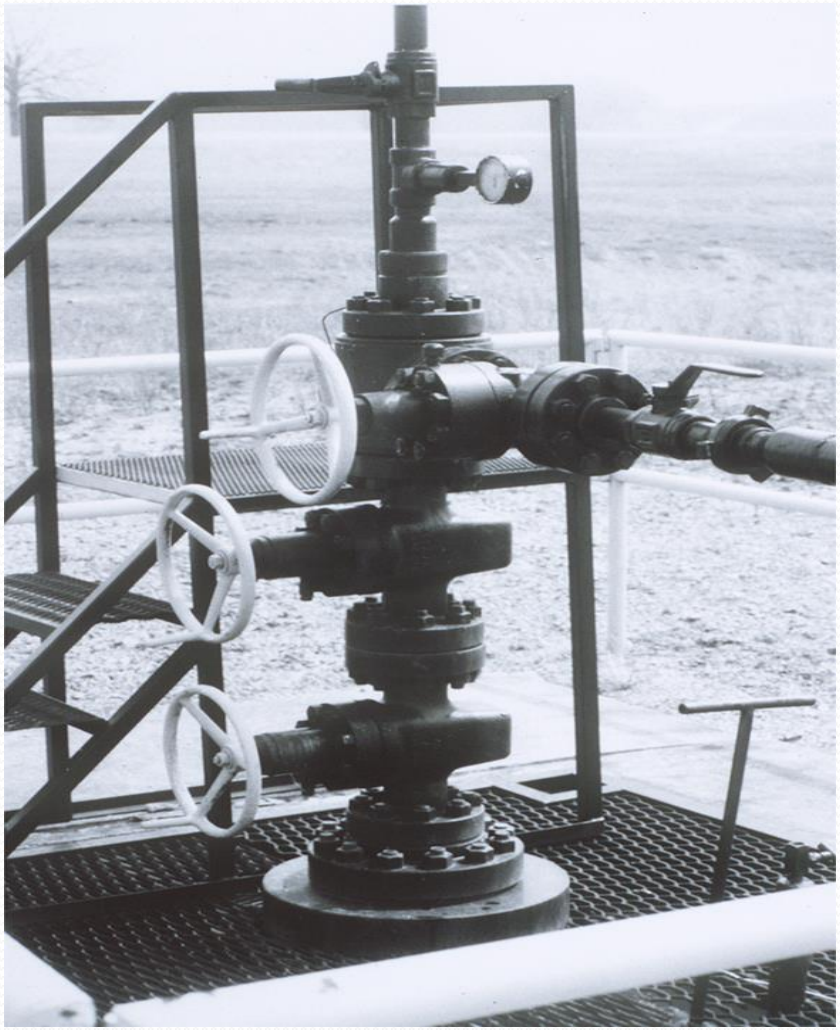
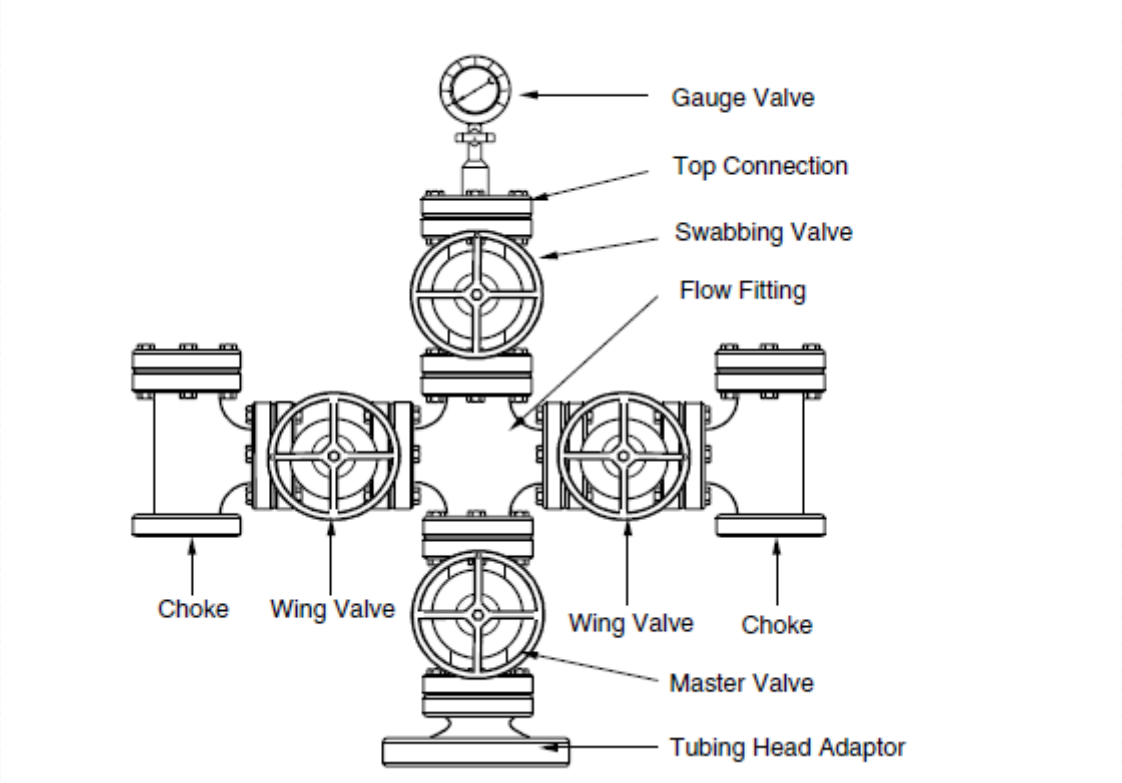


Photo courtesy George King

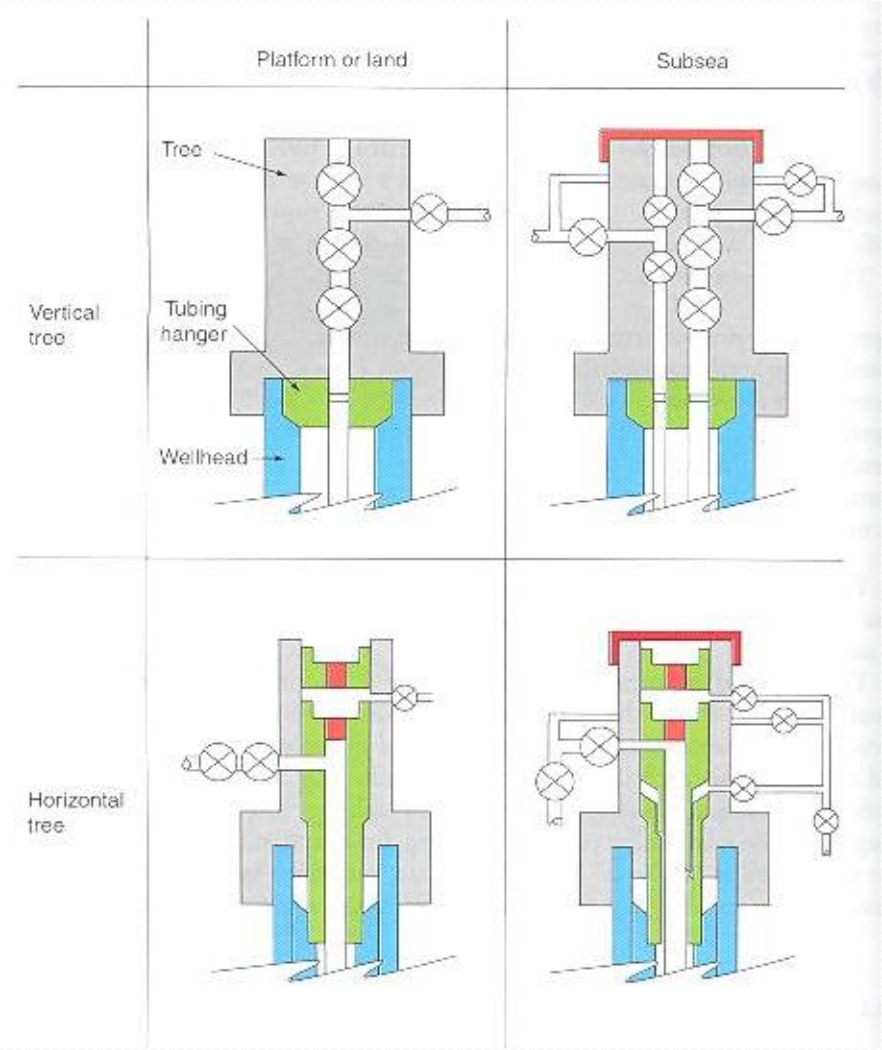
Tree Valves


Gauge Valve
Top Connection
Swabbing Valve
Flow Fitting
Choke
Wing Valve
Wing Valve
Choke
Master Valve
Tubing Head Adaptor

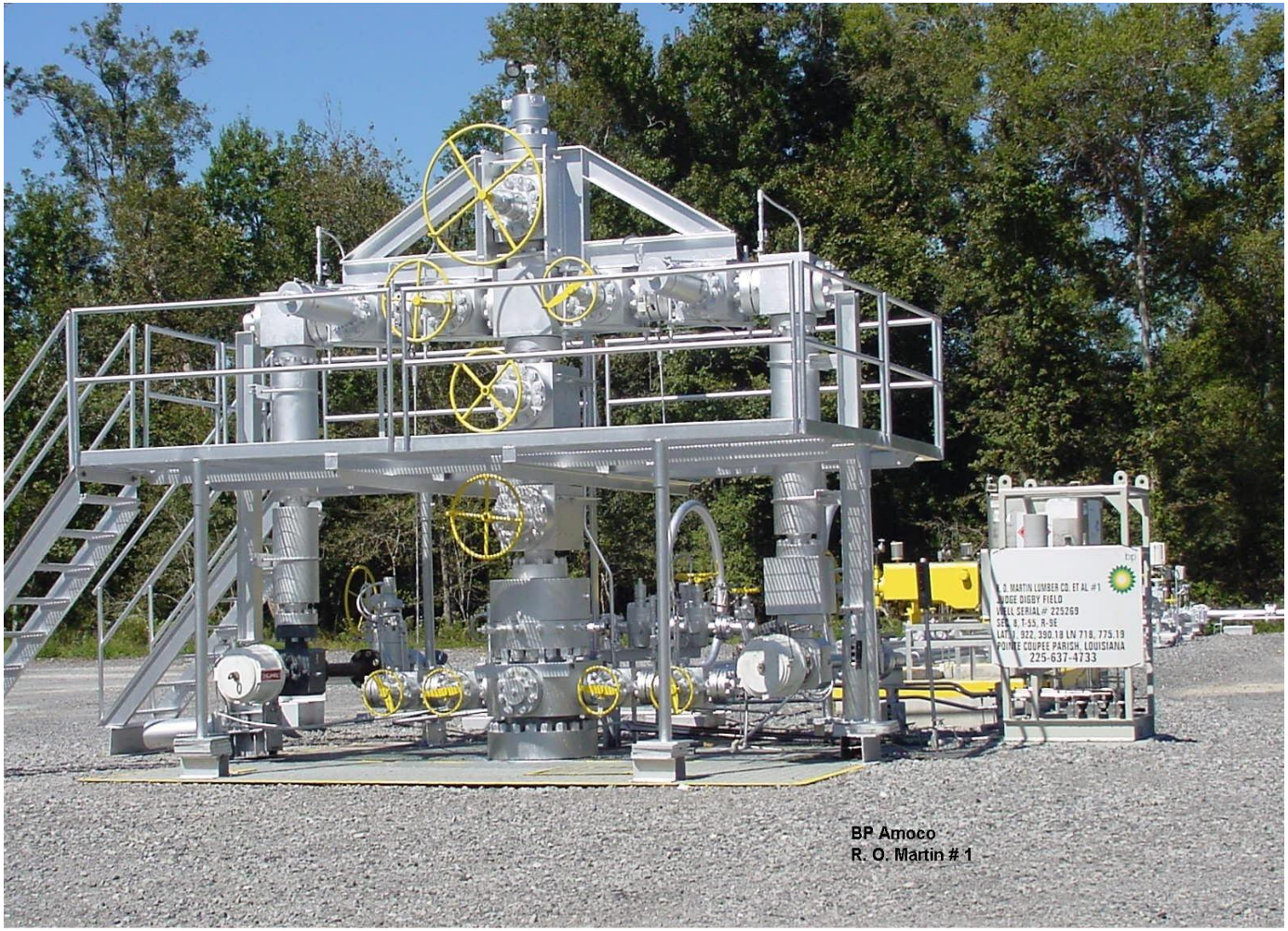
Tree Types

- Conventional trees are vertical trees. They typically have one or more master valves in the vertical bore. The tree must therefore be removed for a well workover.

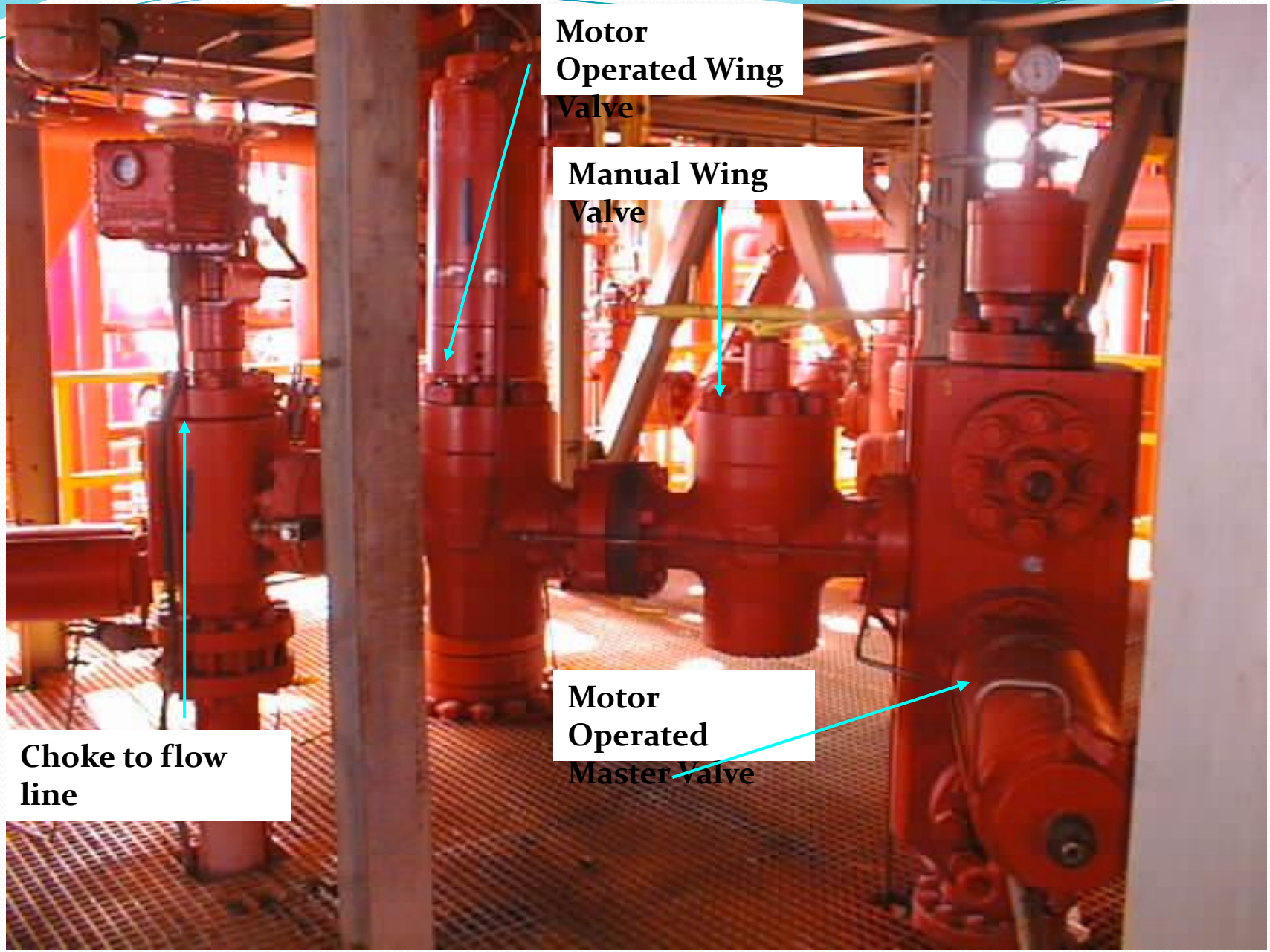
- Horizontal, or Spool trees were developed to avoid the issues with a valve in the main bore. A BOP can be placed on a horizontal tree and the well safely worked over without removing the tree.

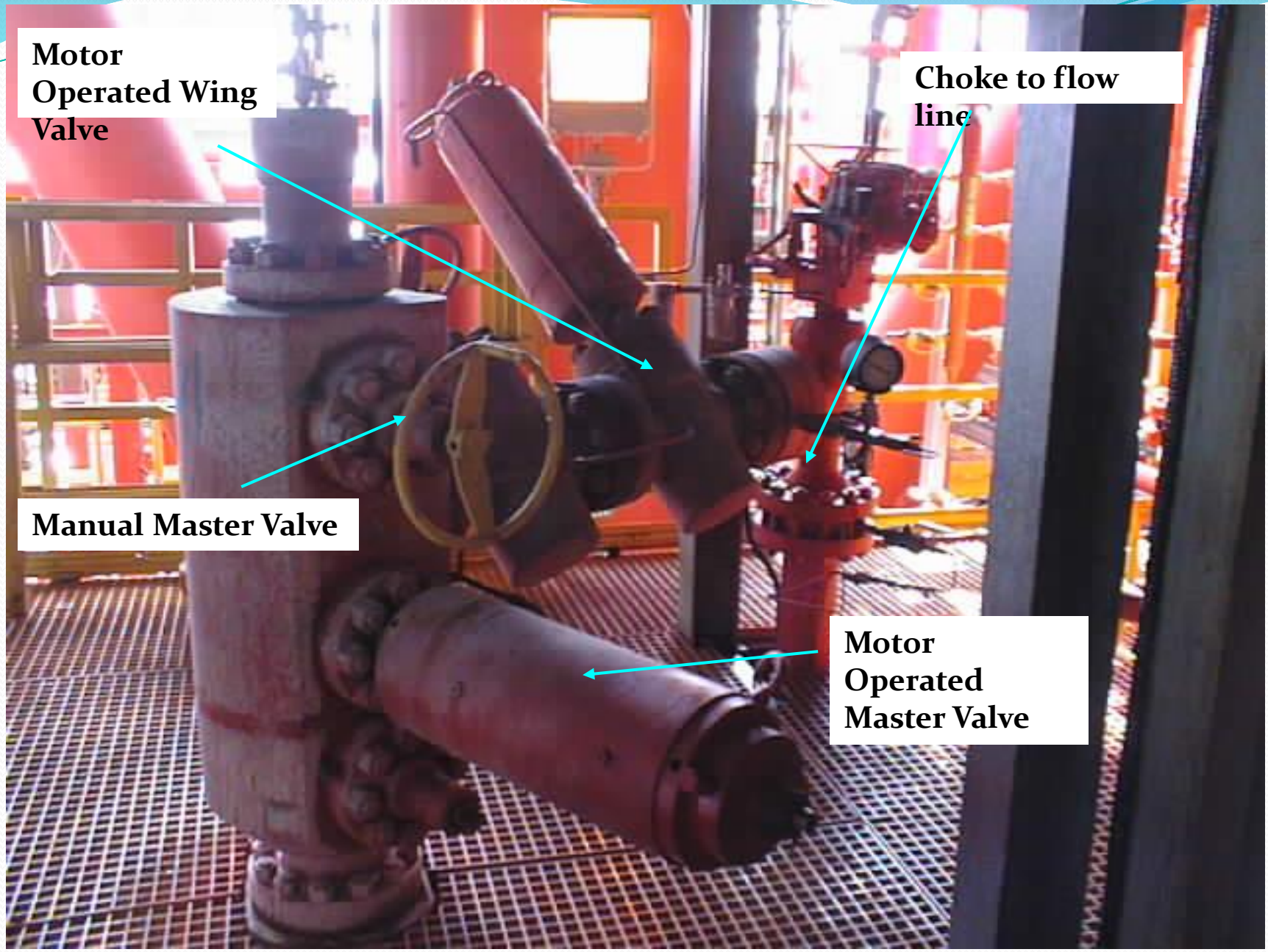


Large Land Tree



BP Amoco
R. O. Martin # 1

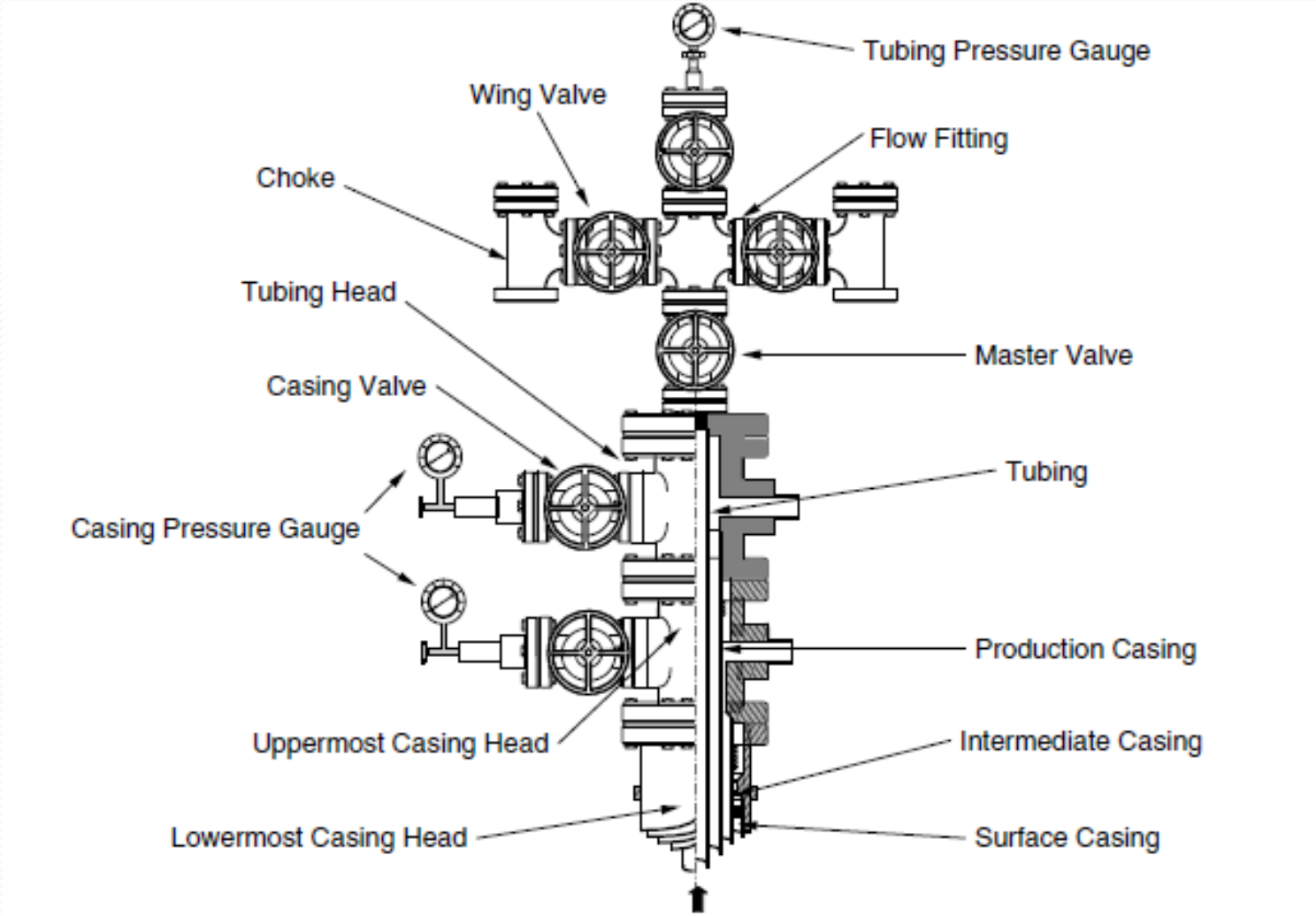

Motor Operated Wing Valve
Manual Wing Valve
Choke to flow line
Motor Operated Master Valve


Motor Operated Wing Valve
Choke to flow line
Manual Master Valve
Motor Operated Master Valve

Tree sits on top of Wellhead

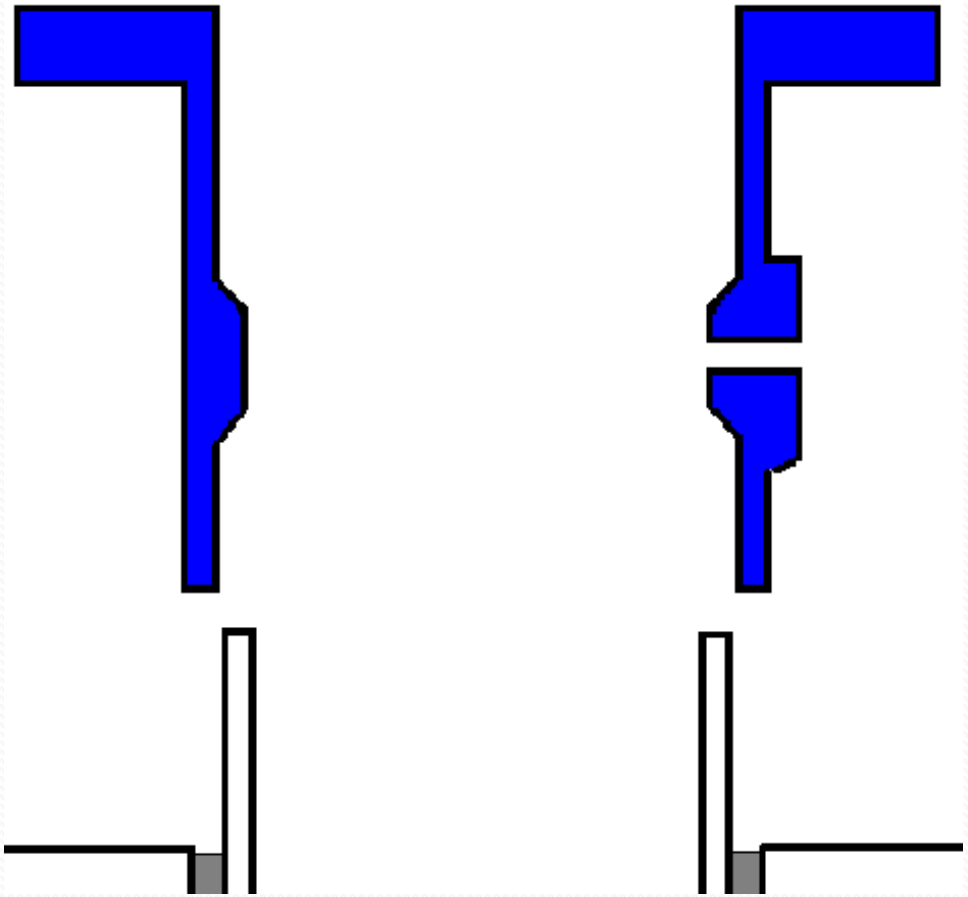
- The wellhead is equipment which is part of the well's casing operation.
- Casing strings are normally land in, and supported by the wellhead via the casing hanger
- The tubing string also lands in the well head and is supported by the tubing hanger

Wellhead and Tree Connection

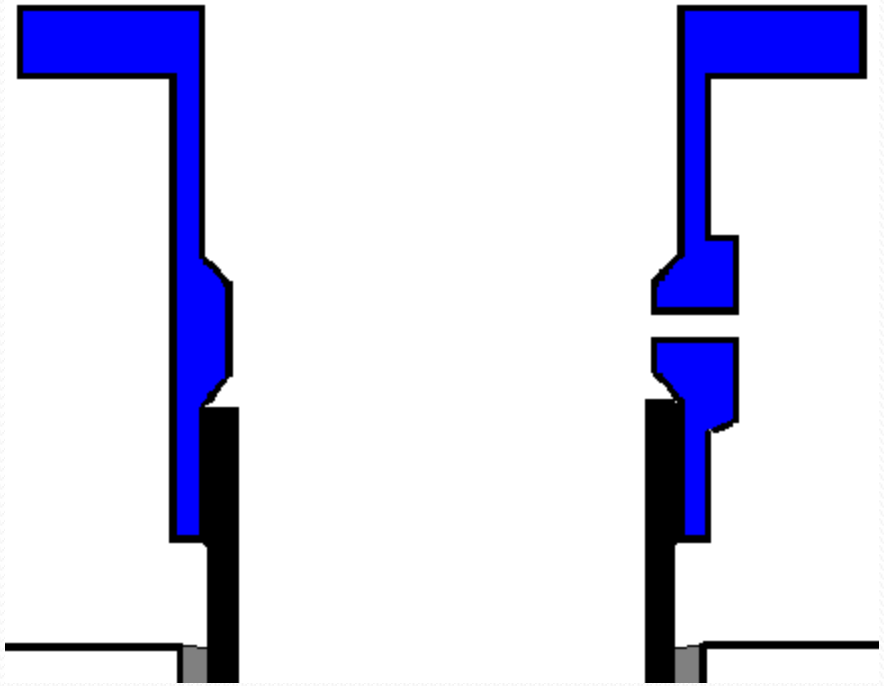


Wellhead

- The wellhead flange attaches to the first cemented surface casing string designed to hold pressure.

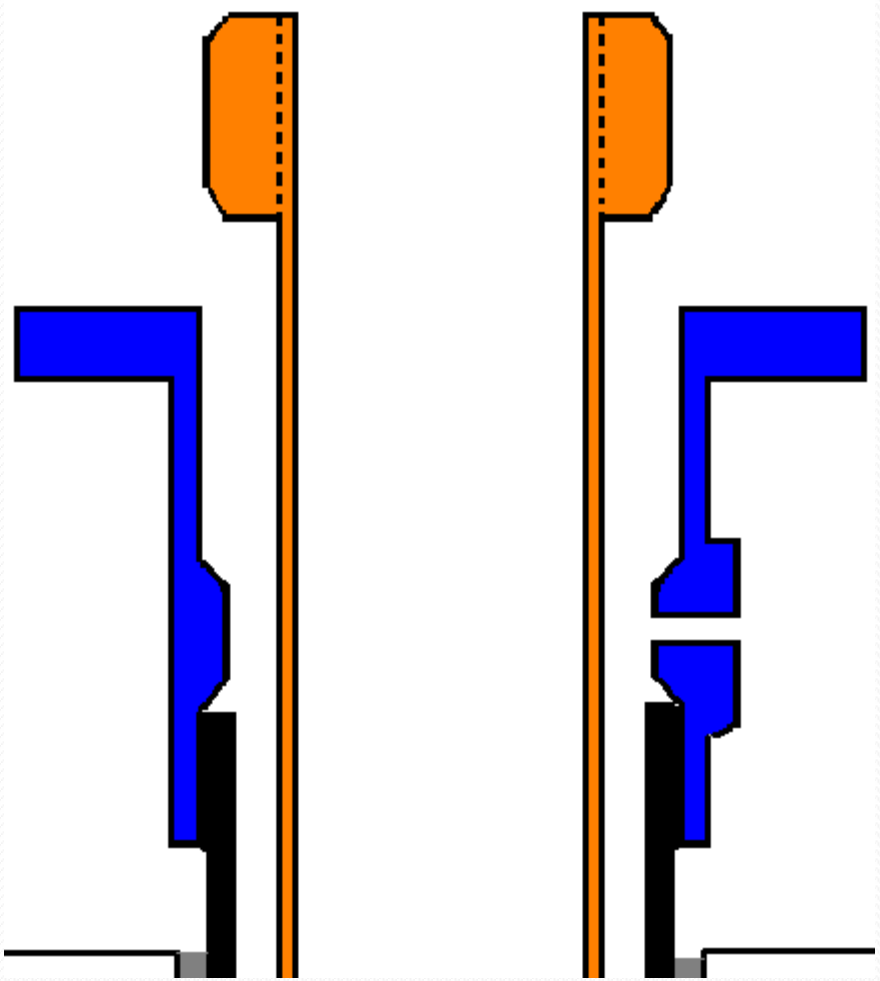


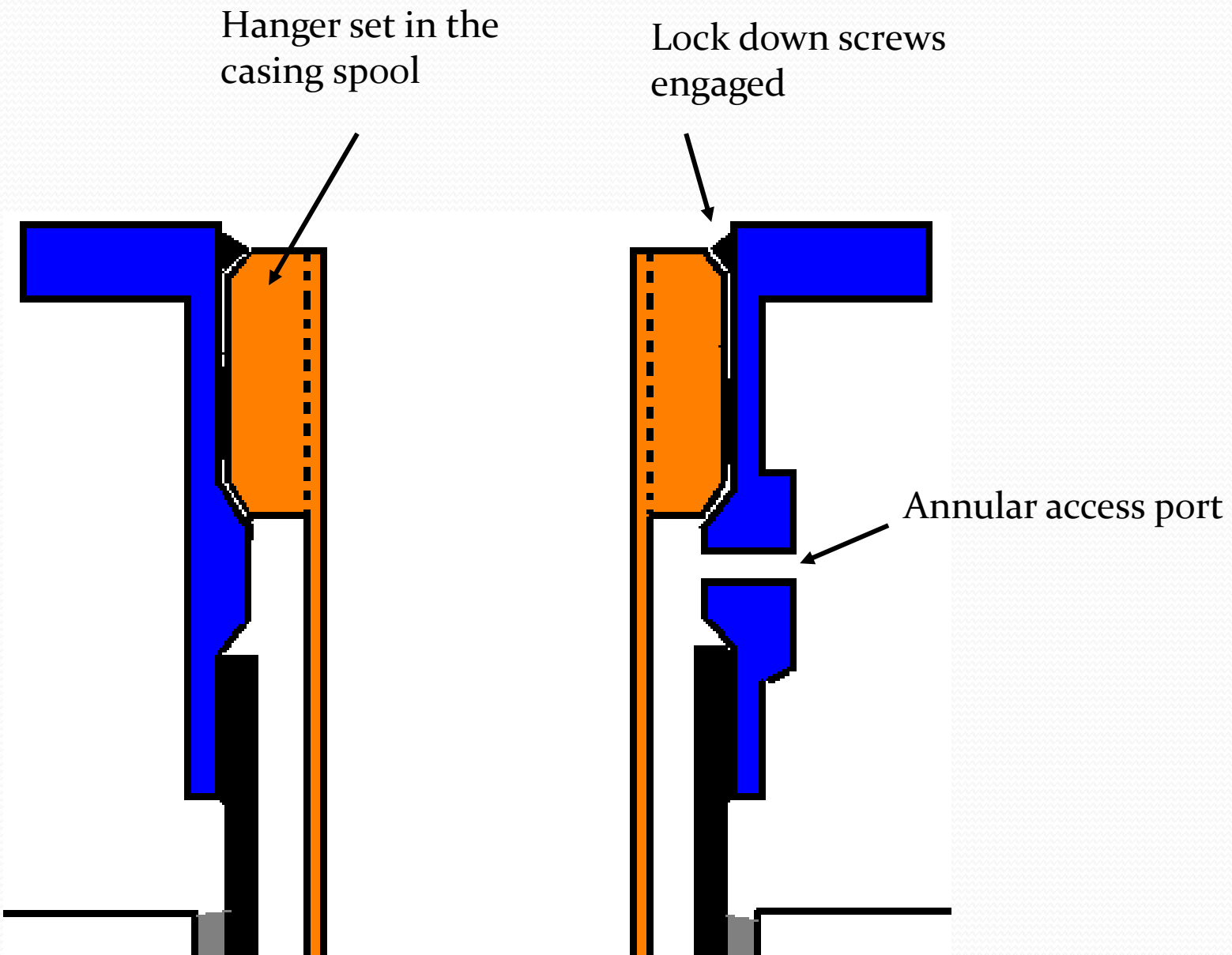
- Well flange attachment to the casing may be by welding, forming, threaded connection or set screws

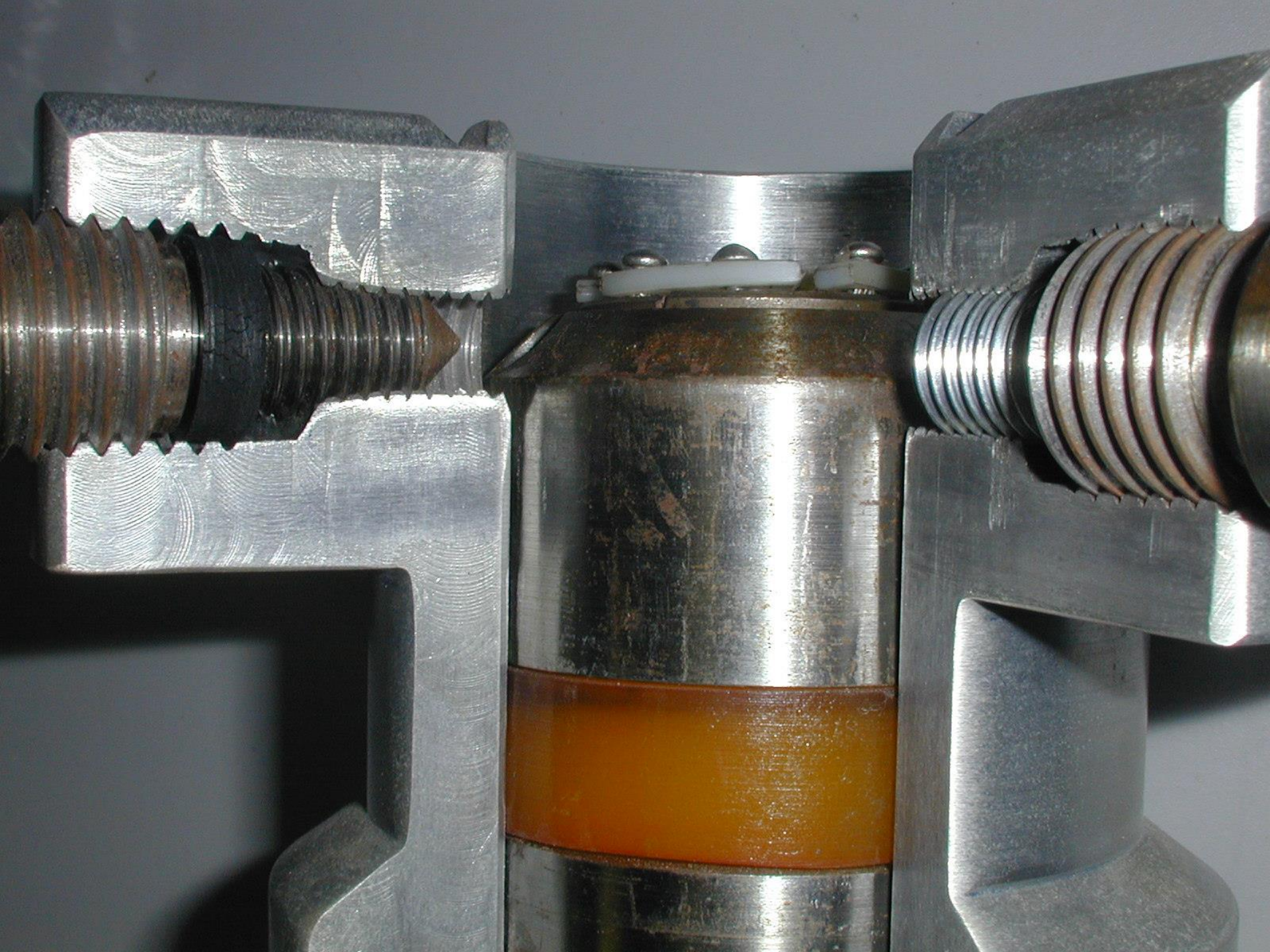


Casing strings land in bowl of wellhead

- The second string of casing is run and the hanger is landed in the bowl.

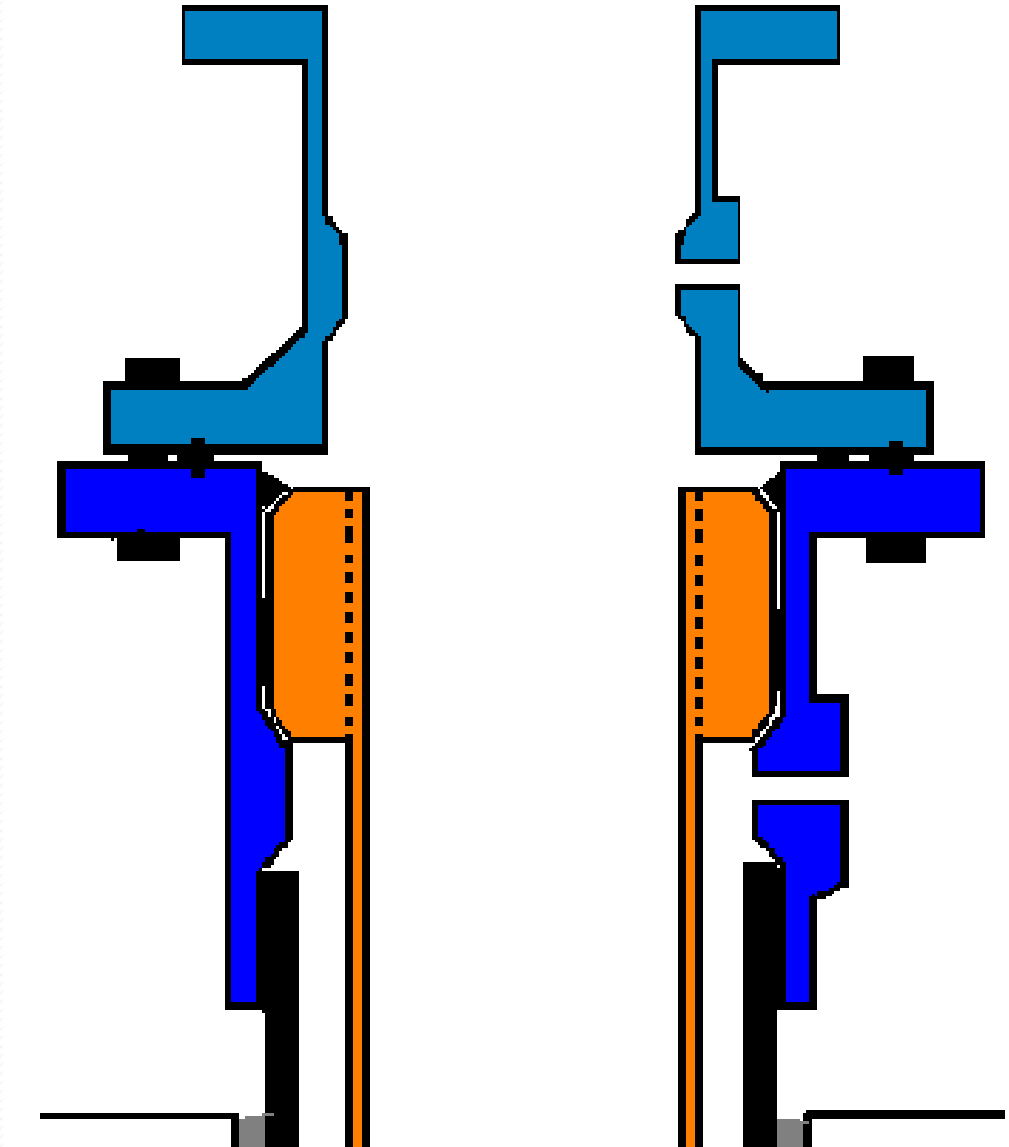



Hanger set in the casing spool
Lock down screws engaged
Annular access port

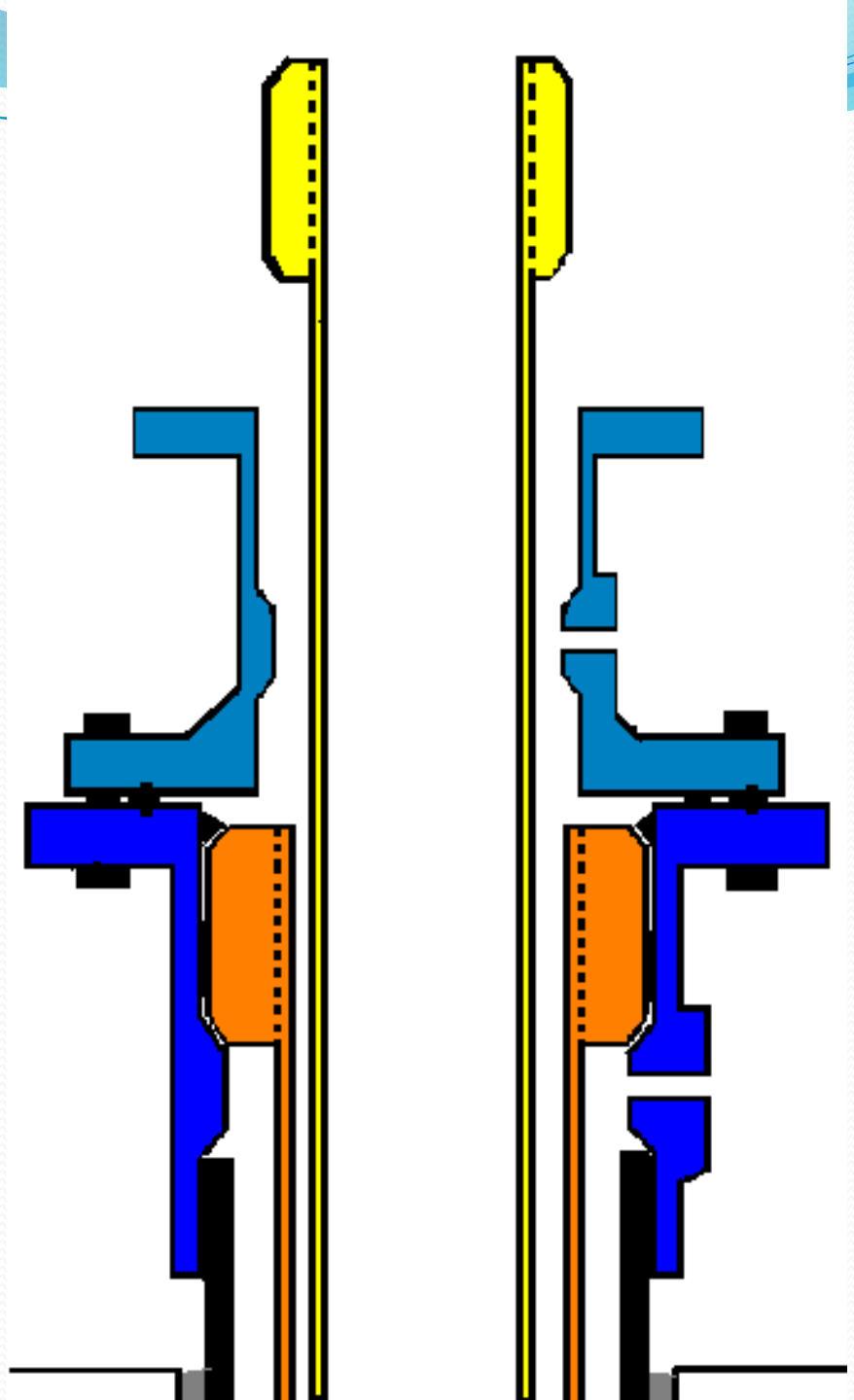


Tubing Spool

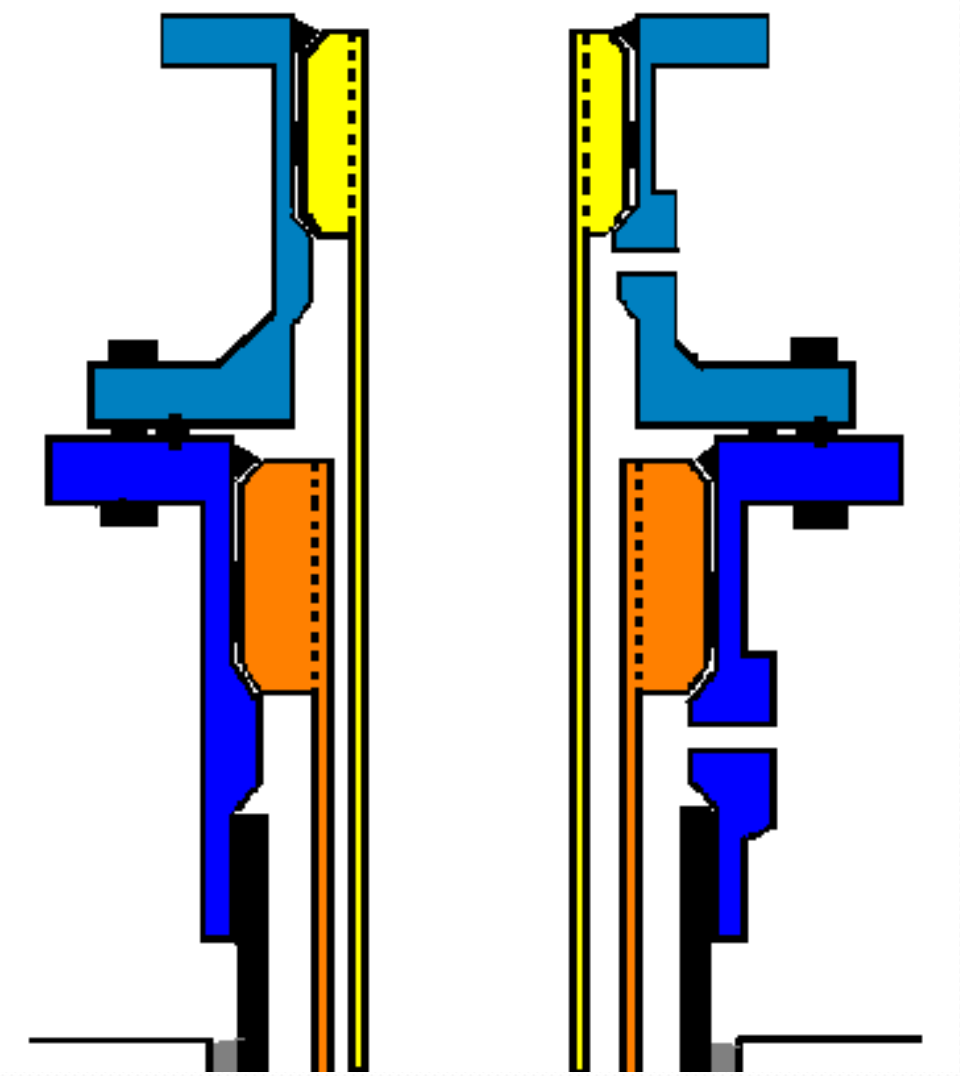
- Tubing spool follows.
- This is the ‘bowl’ where the tubing hanger will seat and hang from



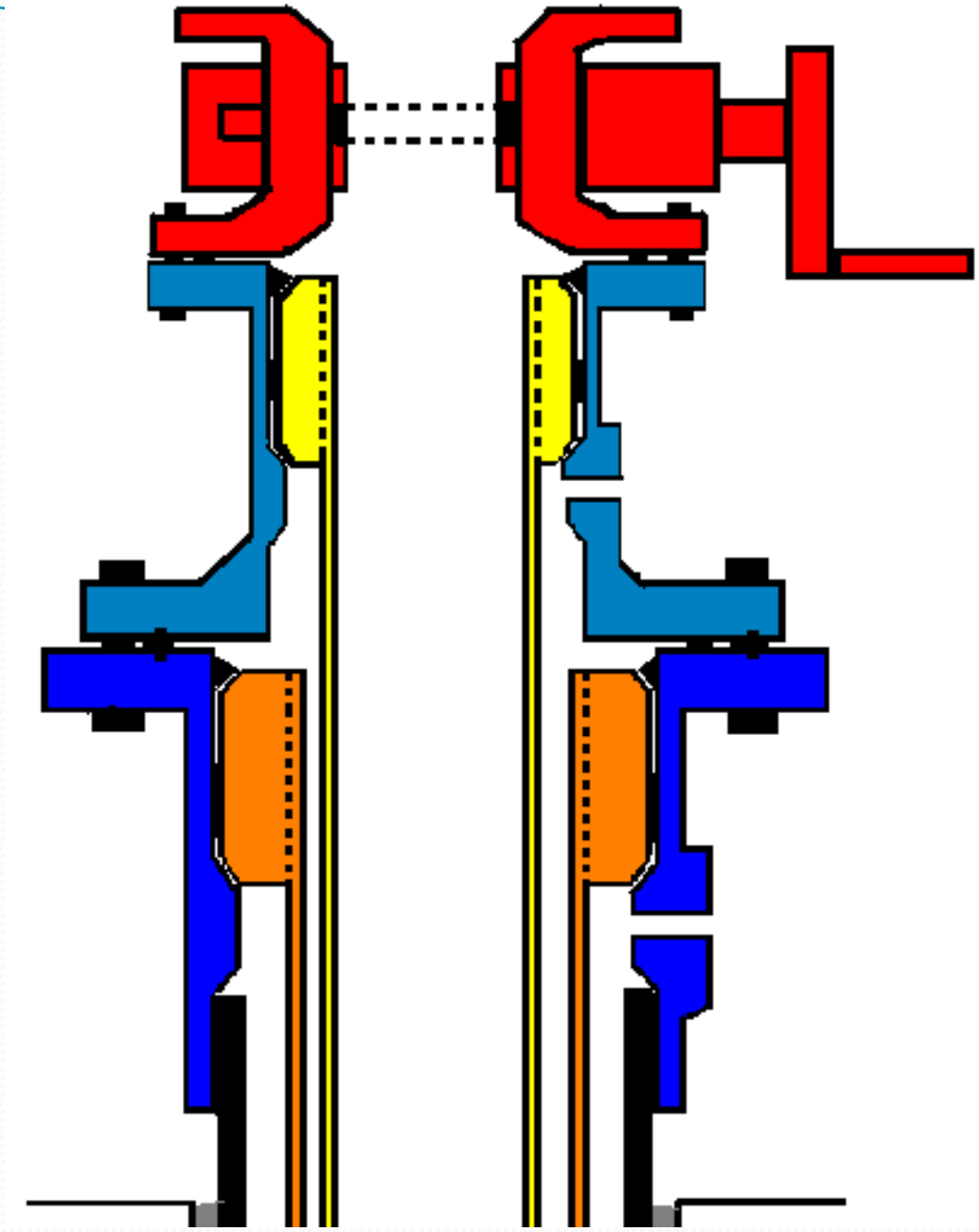
- The tubing is landed in the spool.



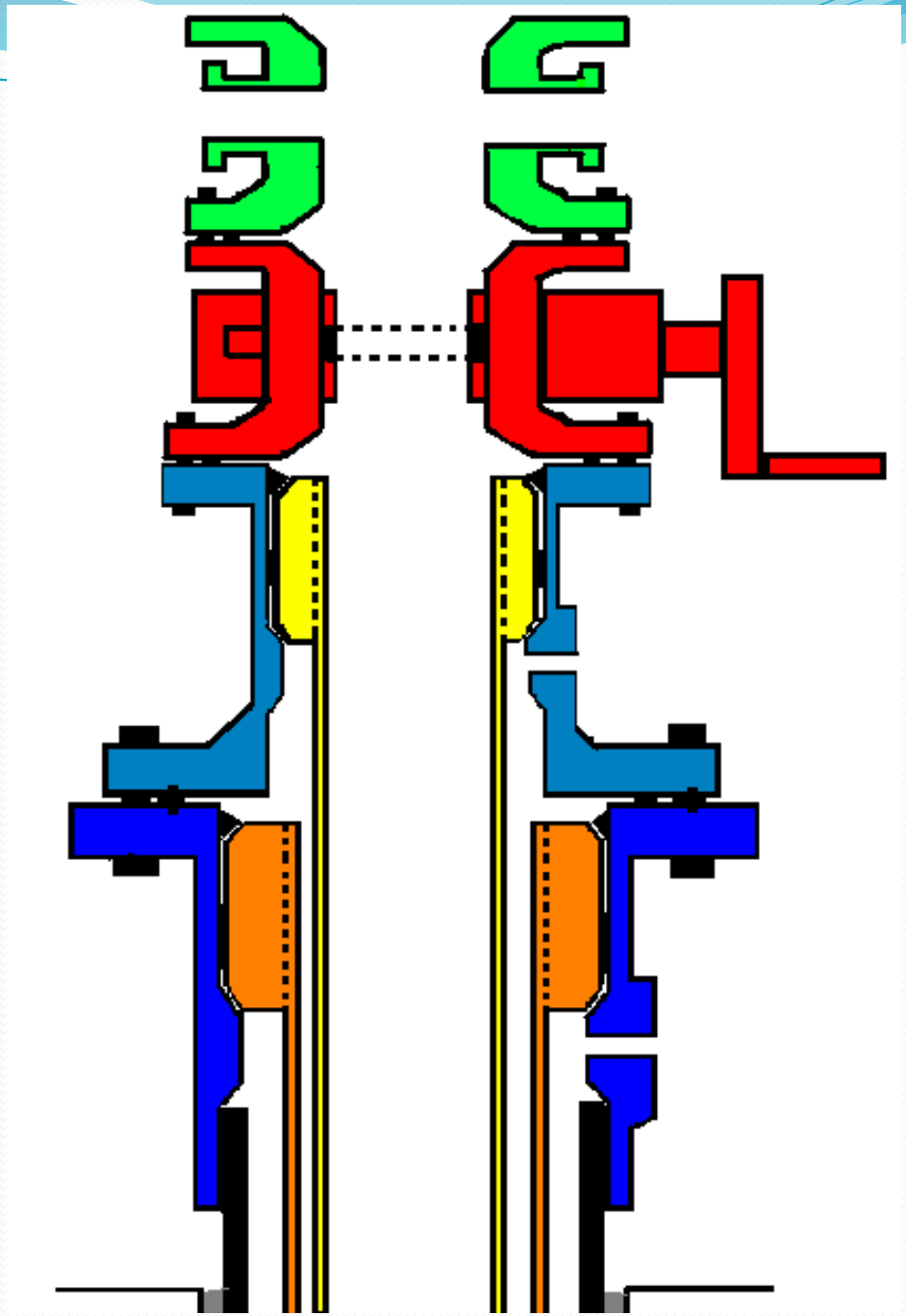
- Lock down pins are engaged and the seal activated.



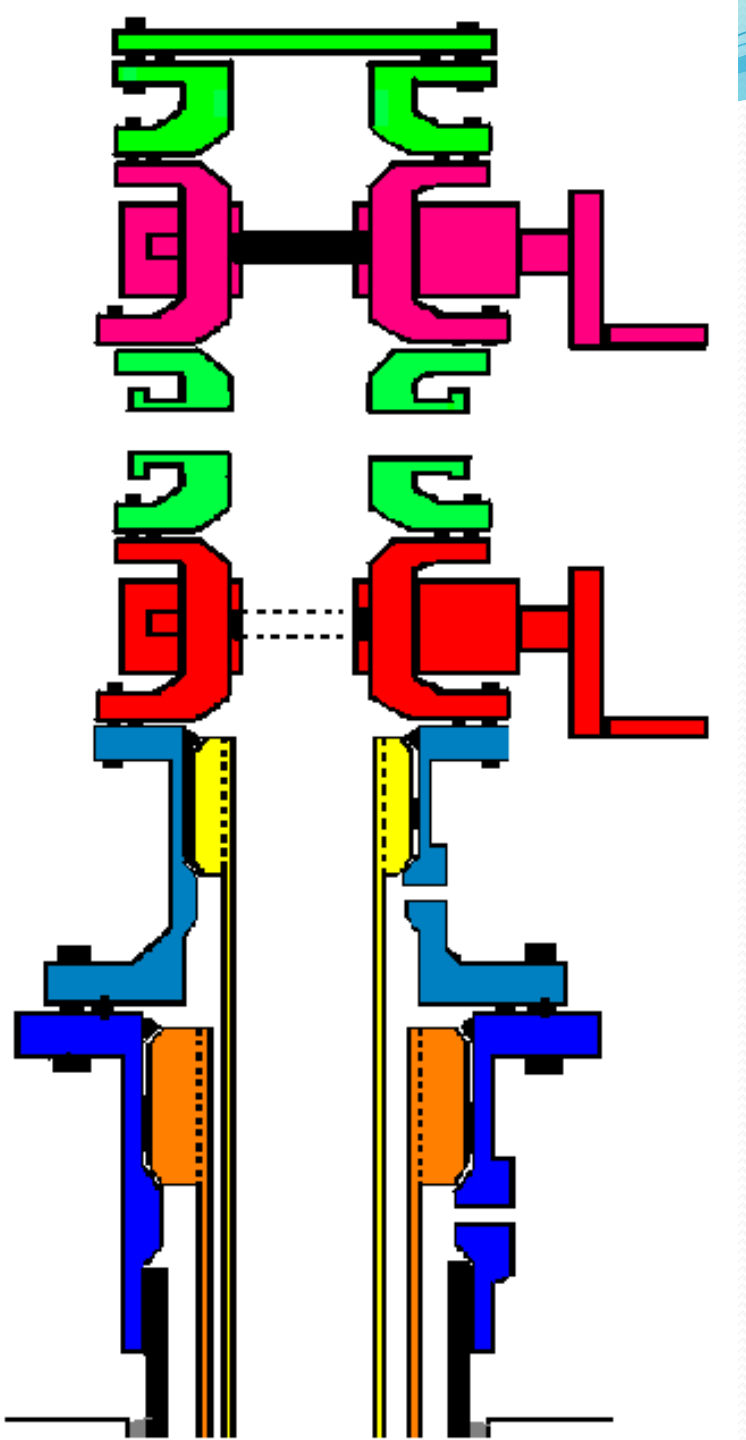
- One or two full opening master valves come next.



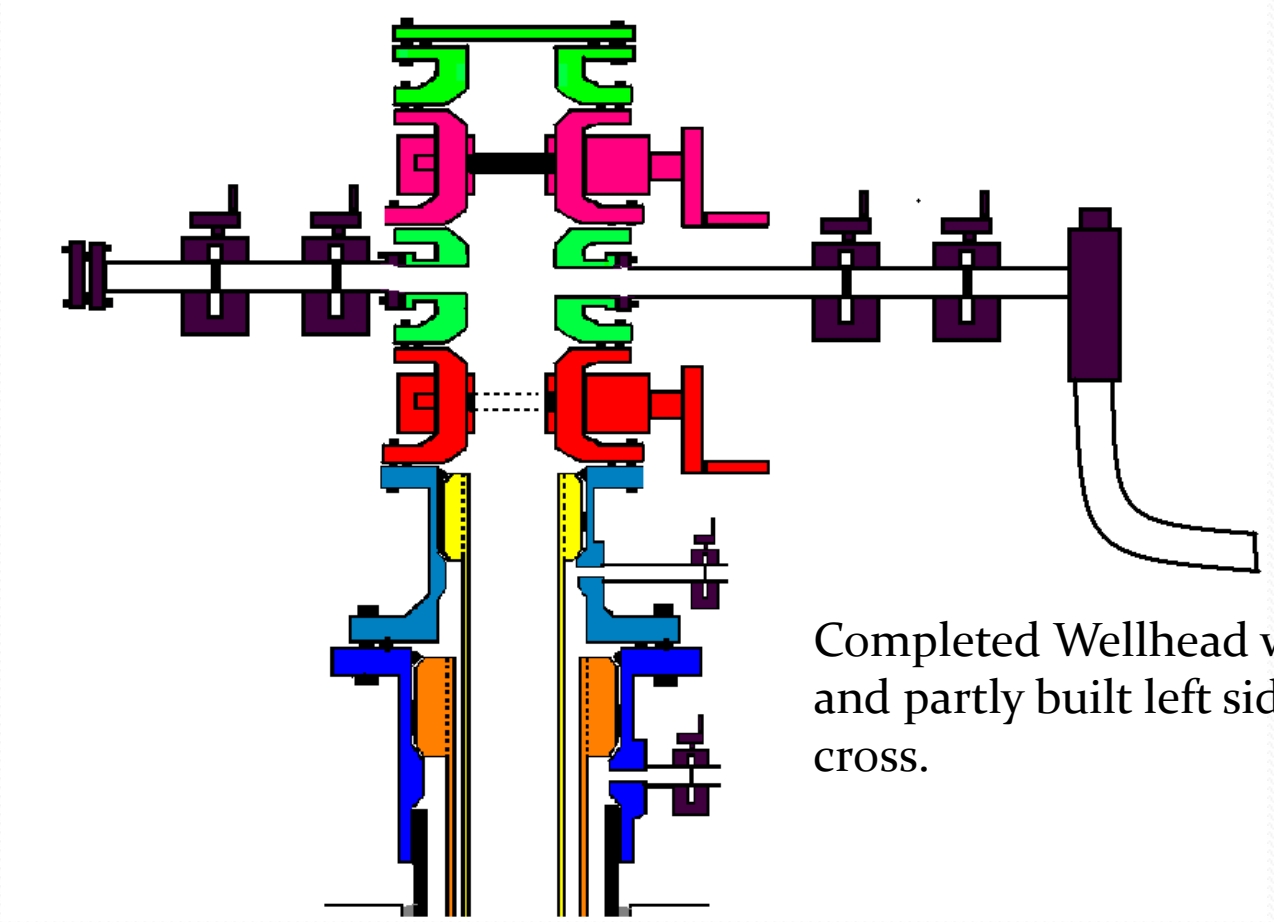
- Followed by the flow T or Cross.



- The tree before adding control valves.



Wellhead w/Tree Built-up



Completed Wellhead with choke and partly built left side of flow cross.

- North Slope Wellhead/Tree

Tubing Hanger

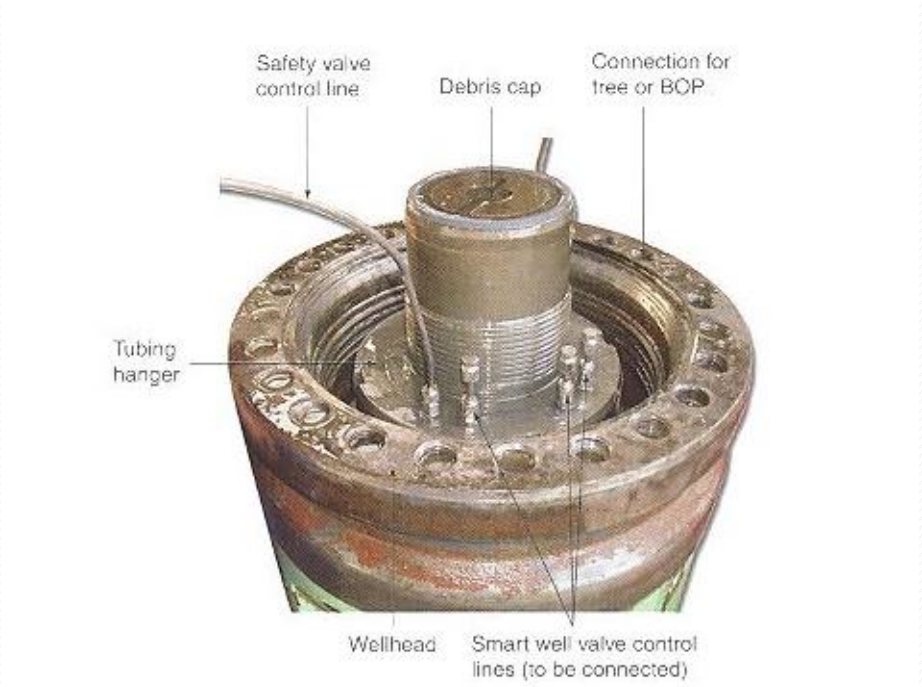
- Has a donut shape
- Locating nut helps to orient and land hanger in the bowl of the wellhead

Cables and Controls Lines

- Cables and control lines for all devices must pass through the tubing hanger

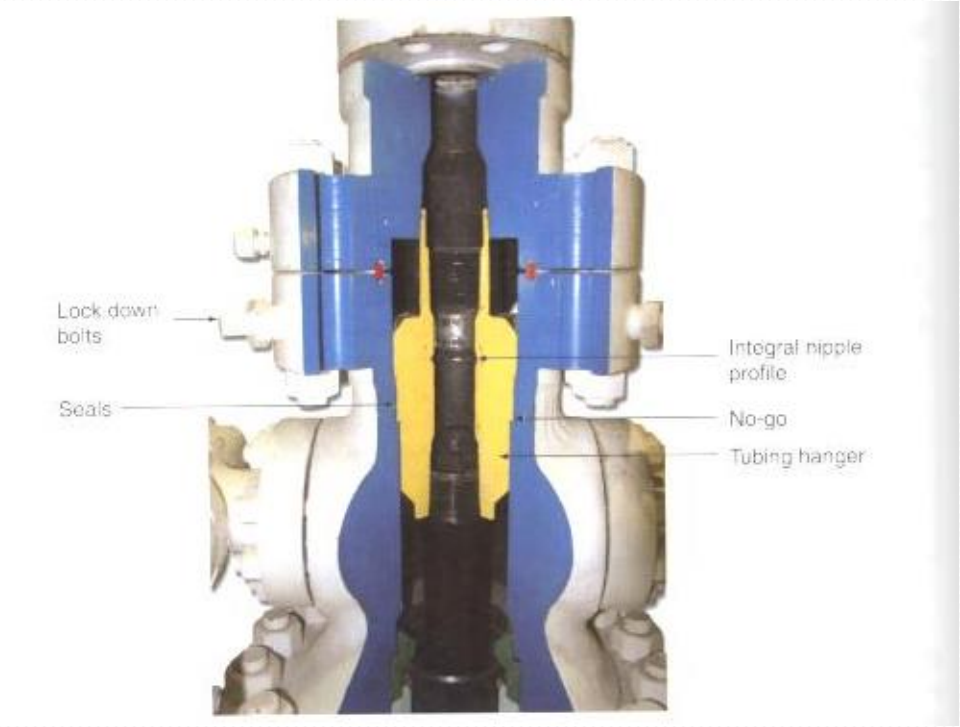
Platform Tubing Hanger

- View of the tubing hanger with a debris cap in place.
- All cables are run through the hanger as shown

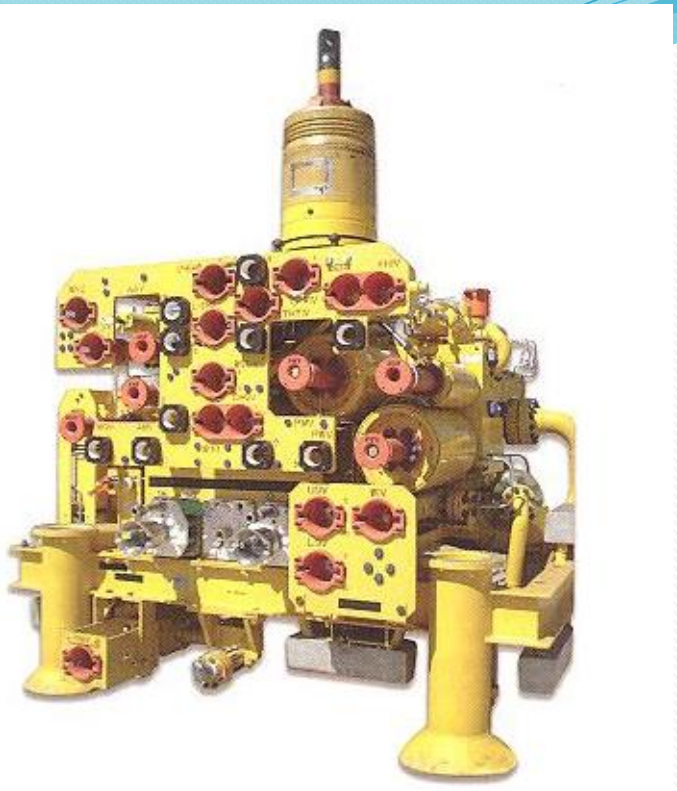


Cross-section View of Tubing Hanger

- Tubing hanger includes seals and lock down bolts



Horizontal Subsea Tree



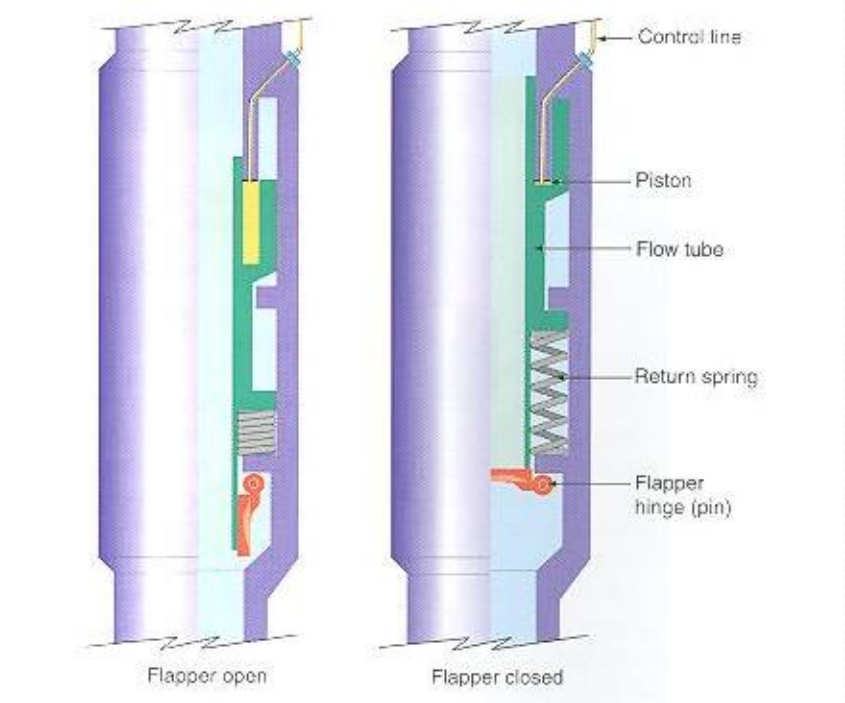
- Horizontal Tree with Tubing Hanger

Surface Controlled Sub-surface Safety Valve

- A surface controlled subsurface safety valve is used downhole as a safety device
- The valve is held open by continuous hydraulic pressure from a control line run from the surface
- If the control line is severed, the pressure is lost and the valve closes
- Latest developments are in remote controlled electric valves

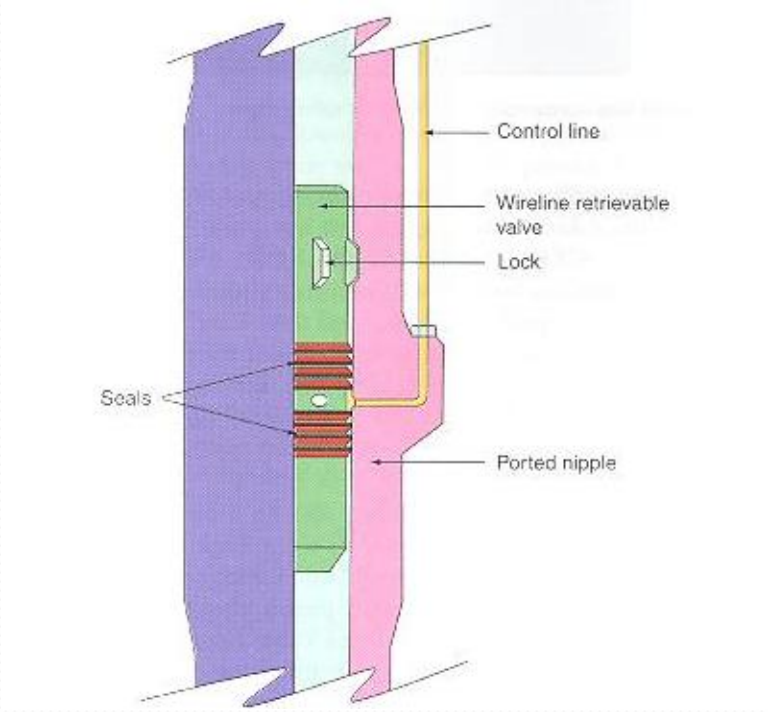
Subsurface Safety Valve (SCSSSV)

- Tubing Retrievable SCSSSV's are run integral with tubing
- May use either a flapper or ball valve



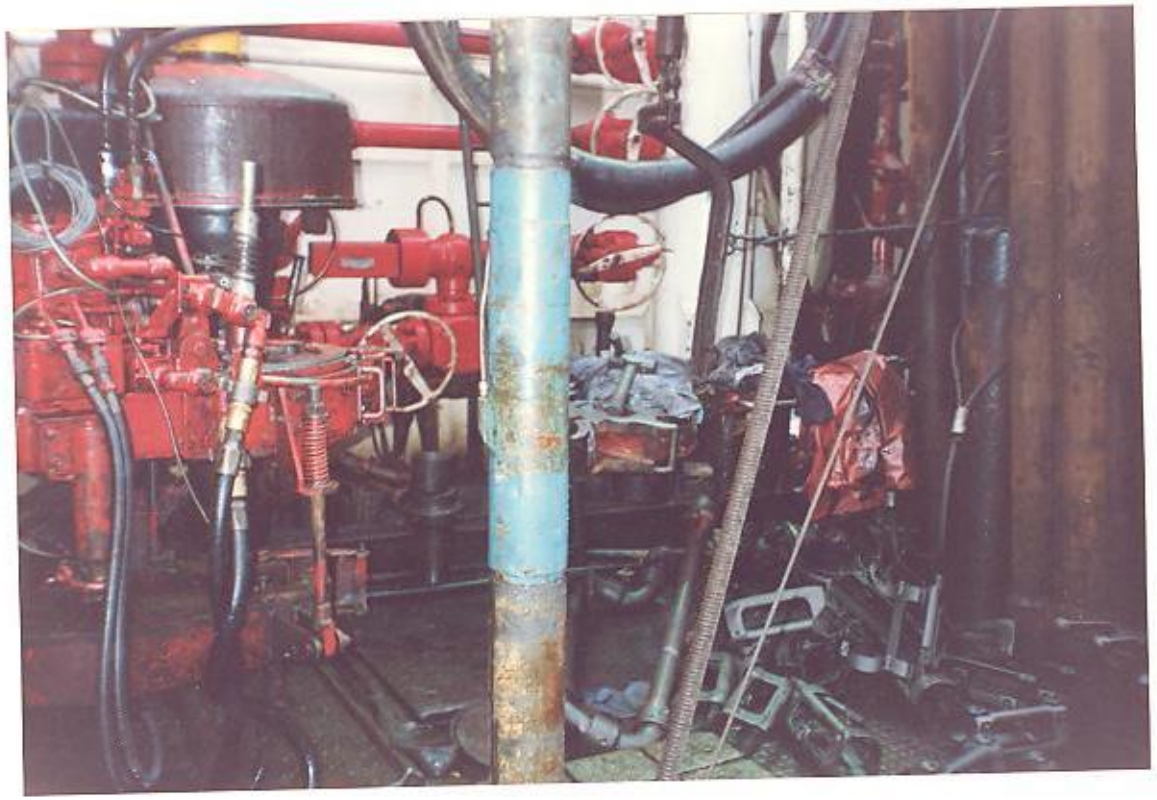
Subsurface Safety Valve (SCSSSV)

- Wireline Retrievable SCSSSV's use a landing nipple specifically designed to accept the safety valve



SCSSSV

- Wireline Retrievable SCSSSV landing nipple w/ hydraulic control line attached



Control Line

- ¼” contol line connects to valve body and delivers hydraulic fluid (pressure) to keep valve in open position
- Control line is typically wrapped around the tubing
- Amine fluids in annulus can cause corrosion cracking of the control line!

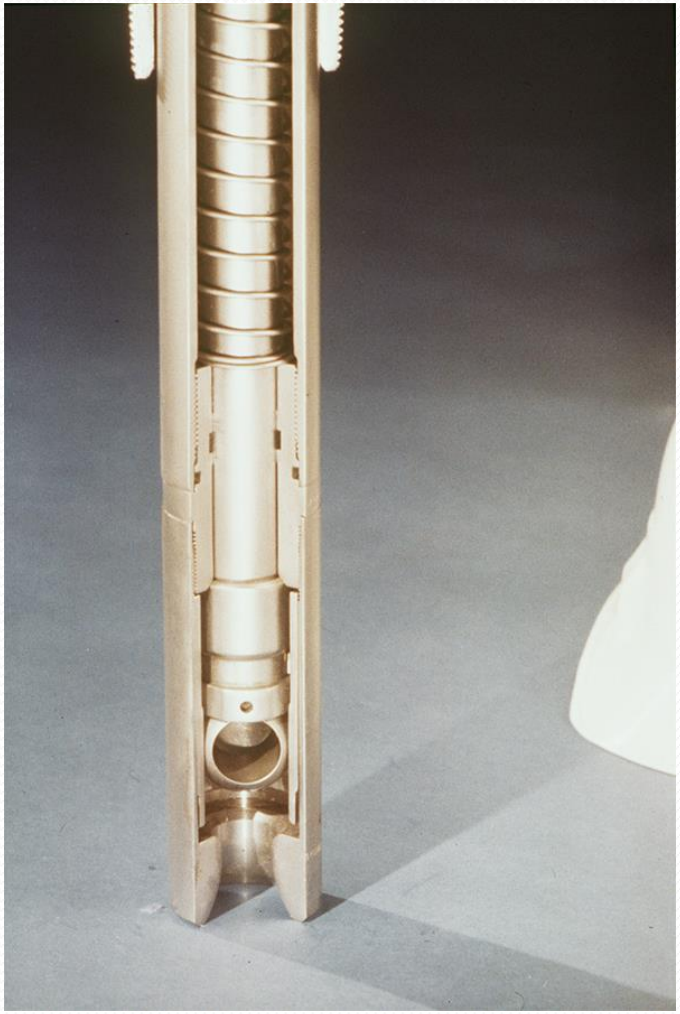
Options

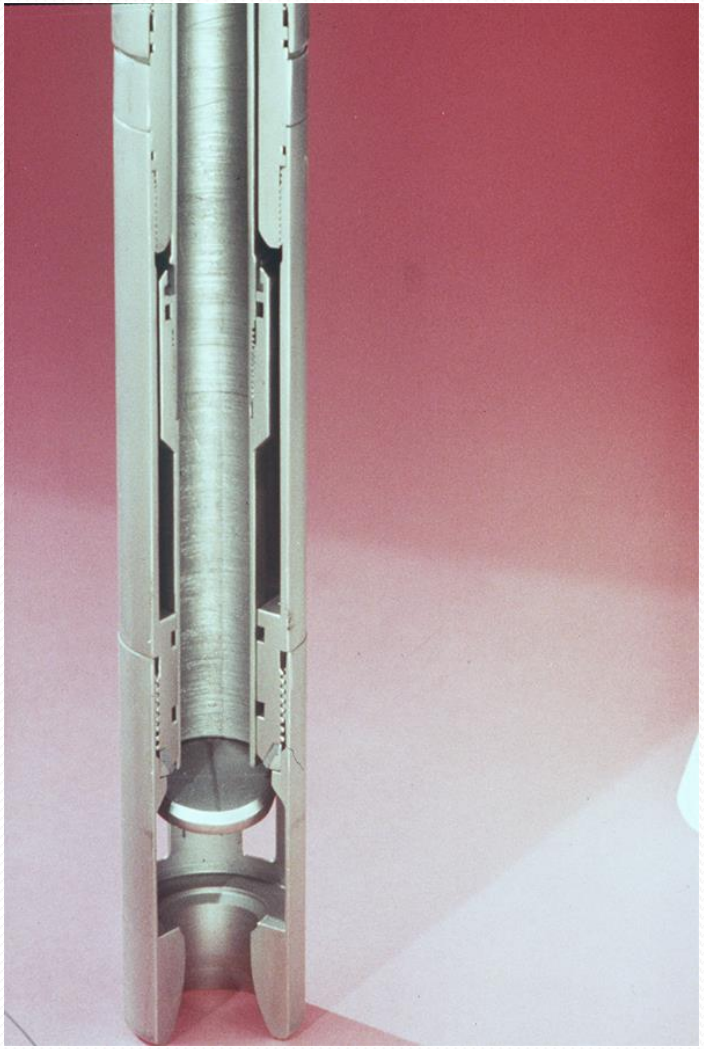
- Tubing Retrievable/Wireline Retrievable
- Ball Valve/Flapper Valve

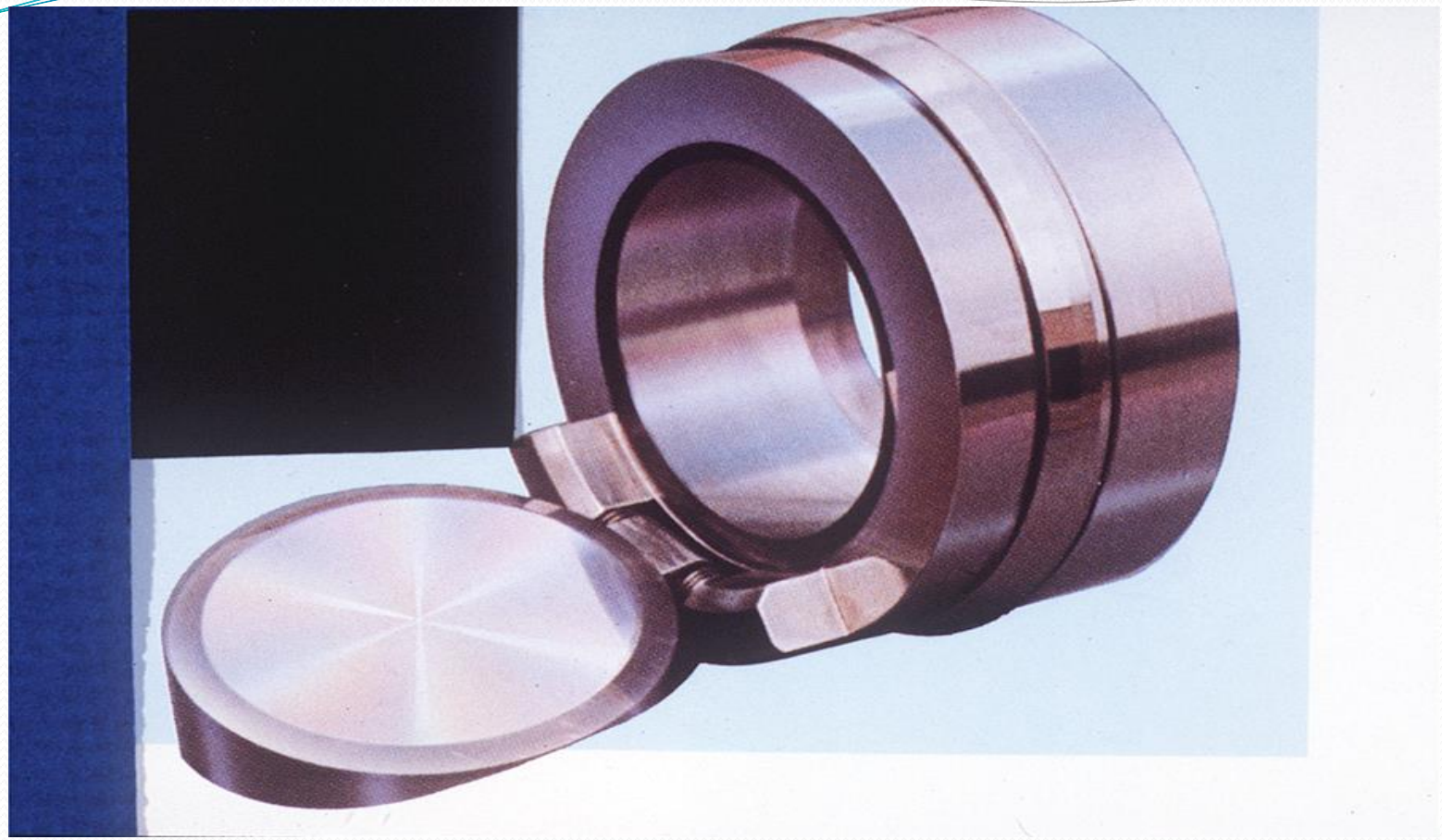
Valve Reliability

- Malfunction rates of several recent SCSSV installations have caused an examination of causes:
- Failure causes:
  - Piston failures and leaks within the valves
  - Control line crushing
  - Control line splice failures
  - Control line junctions with the valve
  - Valve damage (hinge pins and sealing surfaces)

Types

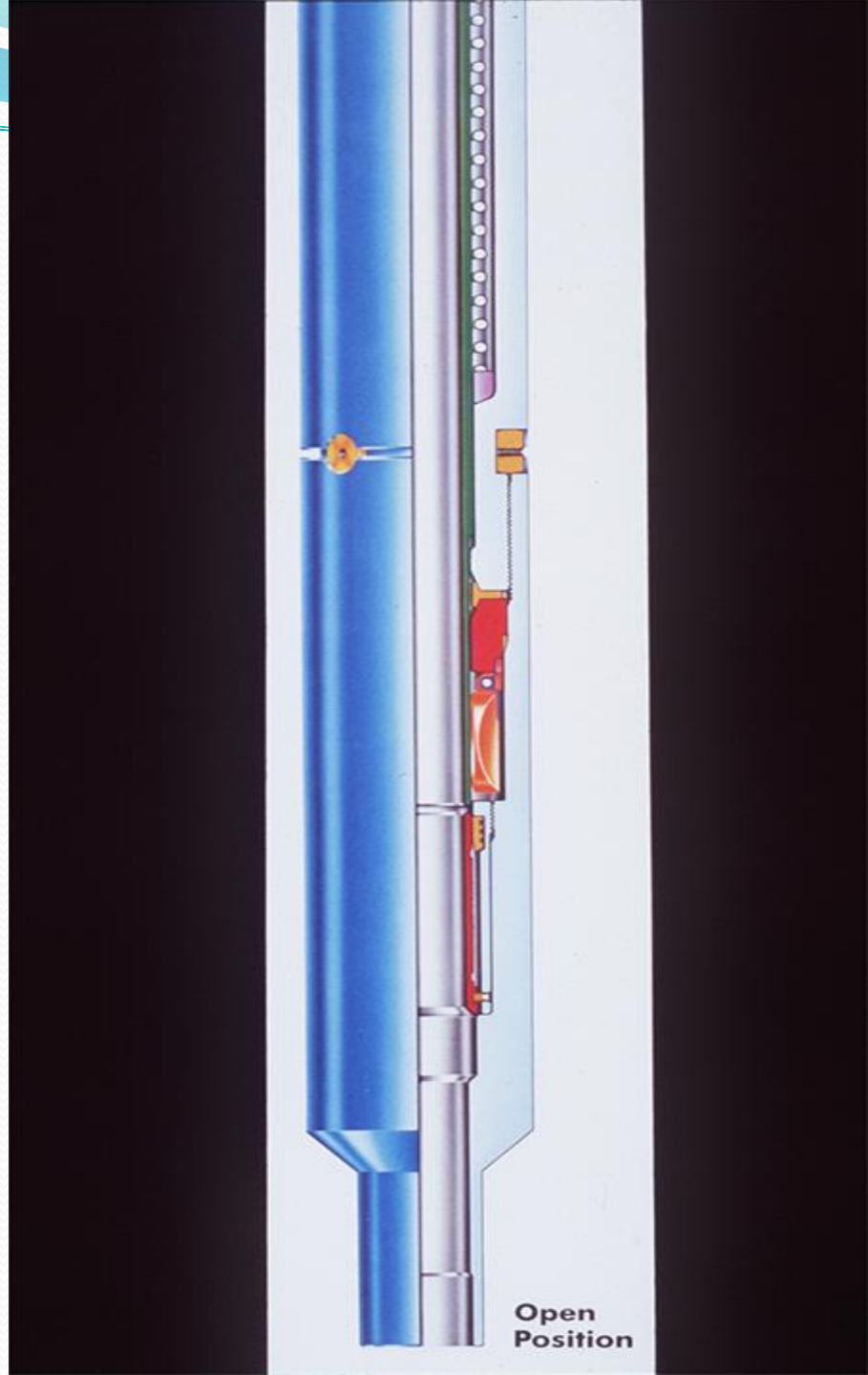




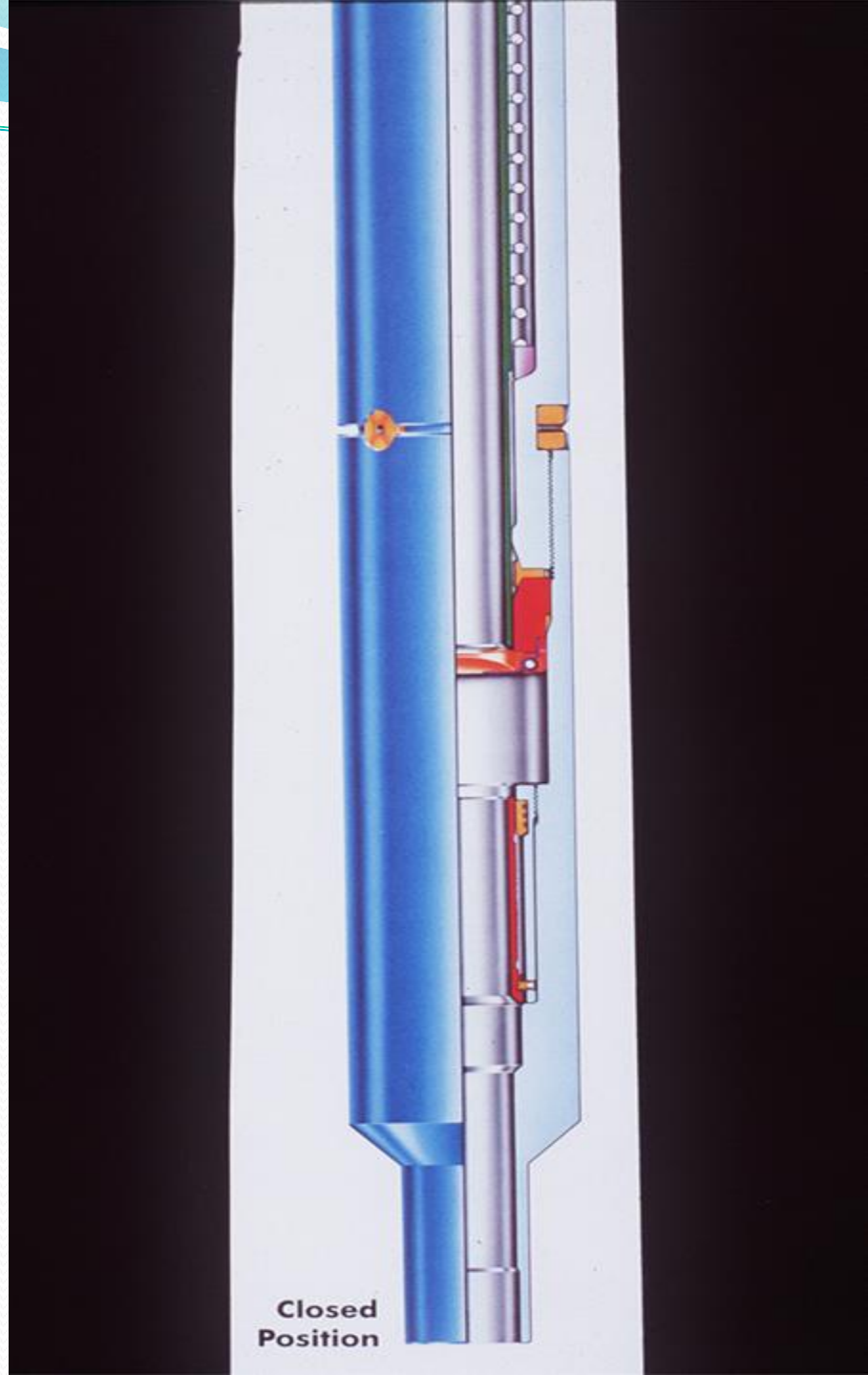


- Initially, flapper / seat combinations are capable of sealing 15,000 psi + (bubble tight). After time?????

- Flapper type SSSV - tubing retrievable.
- Shown in the open position - hydraulic pressure from the surface opposes the mechanical spring pressure and holds the valve open.
- In deep water models (deep set necessities), the spring is replaced by a nitrogen charge or balance line.



- Tubing conveyed, flapper type SSSV.
- Shown closed, with tube retracted.
- Pressure Equalization is required before opening.
- Best method of pressure equalization is to pump in from surface.



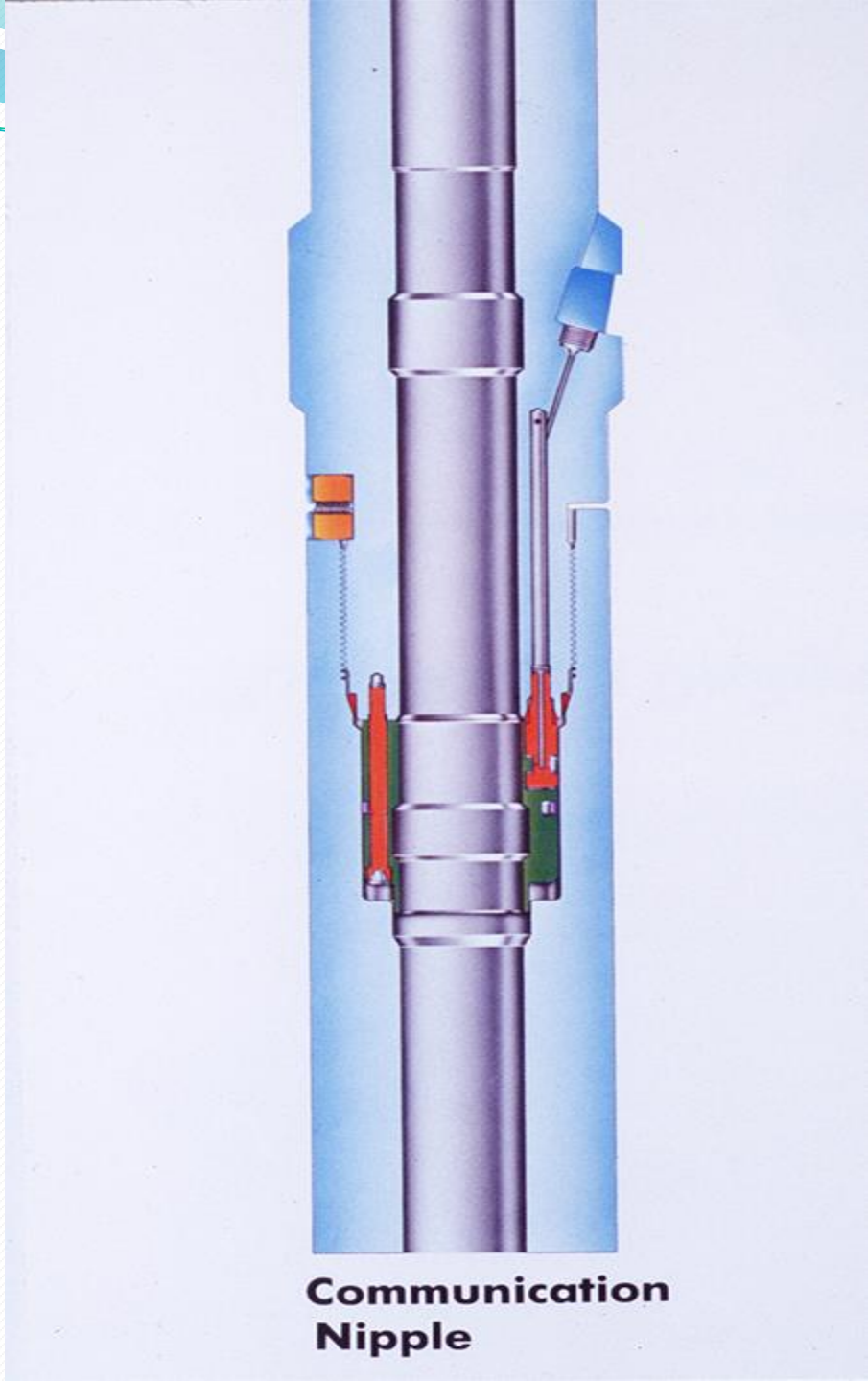
Pressure Equalization Features

- Valve cannot open against pressure from below. Must be equalized to open easily.
- Methods
  - Pump in from above: best approach whenever practical.
  - Self equalization feature in valve
    - Push-pin in flapper
    - Labyrinth seal in valve body

} Self equalization features not usually recommended – another leak path.

- Comparison of tubing retrievable and wireline retrievable valves - flapper only shown. Note – both are push-pin equalization path valves. What effect will large gas flows have on push-pin seal integrity?

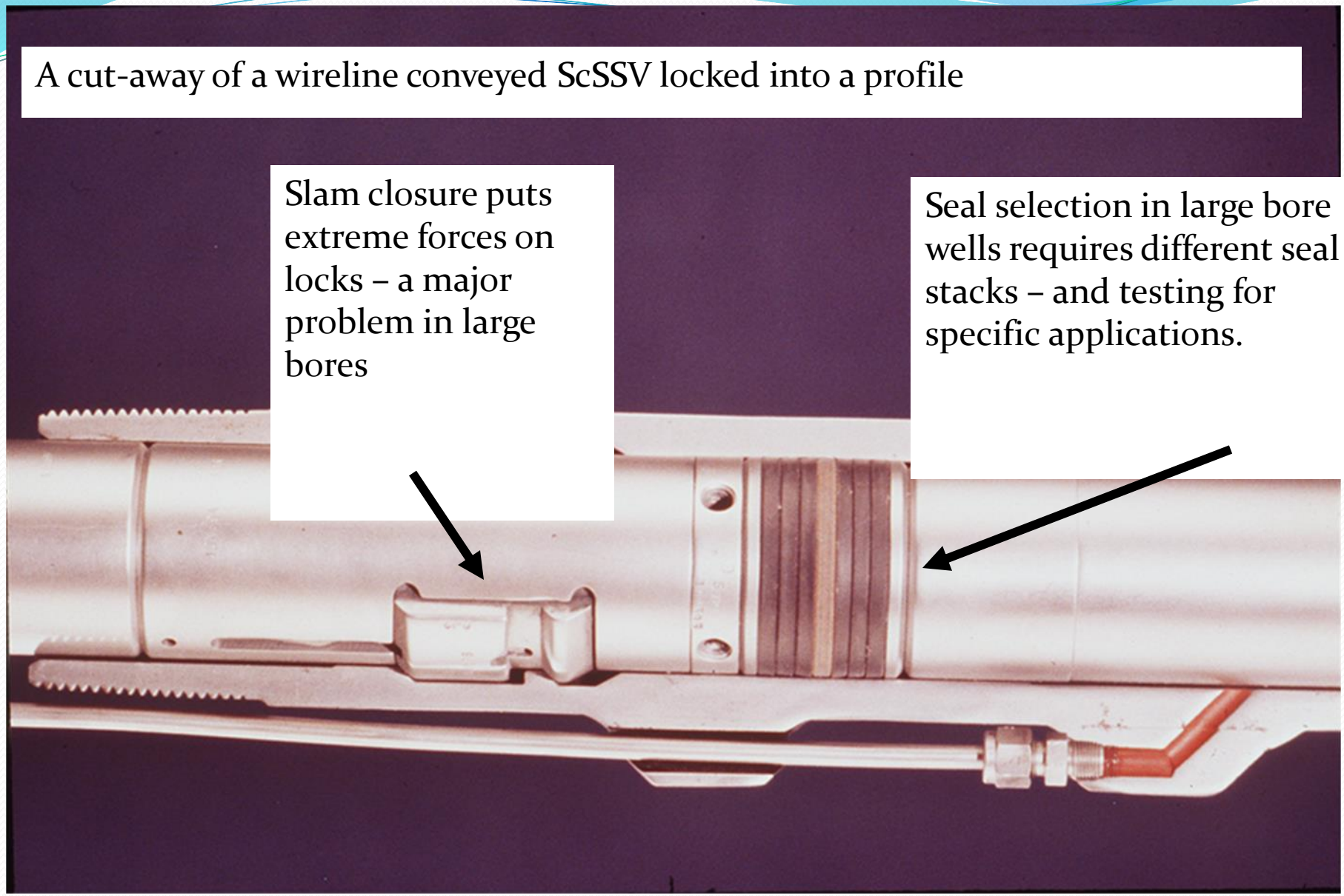
- Nipple for holding a wireline set retrievable SSSV.
- Notice the connection port at the upper right - connects the annular hydraulic line.
- The wireline valve nipple can be added above a tubing conveyed valve for extra flexibility in case of a tubing valve malfunction.

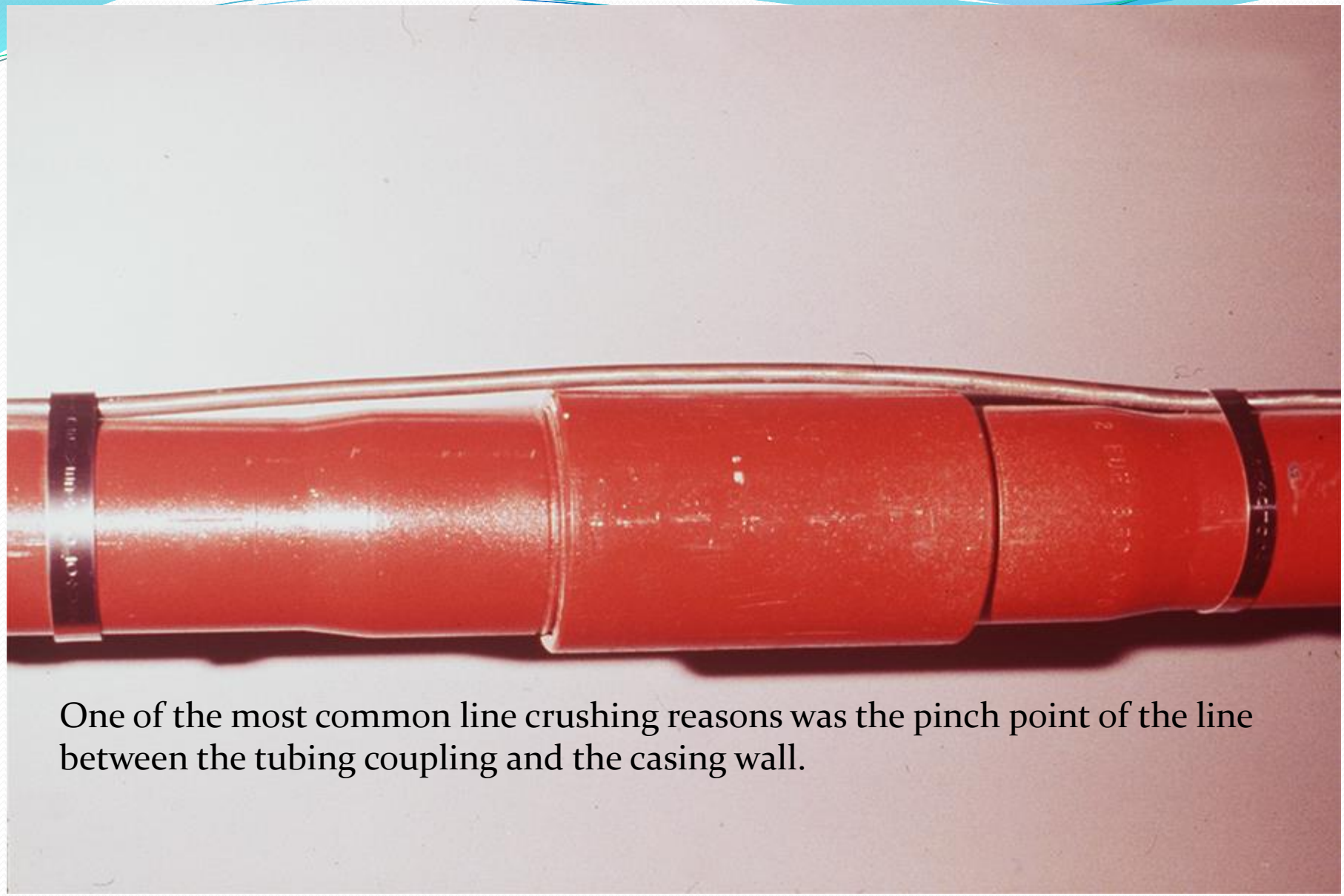


A cut-away of a wireline conveyed ScSSV locked into a profile

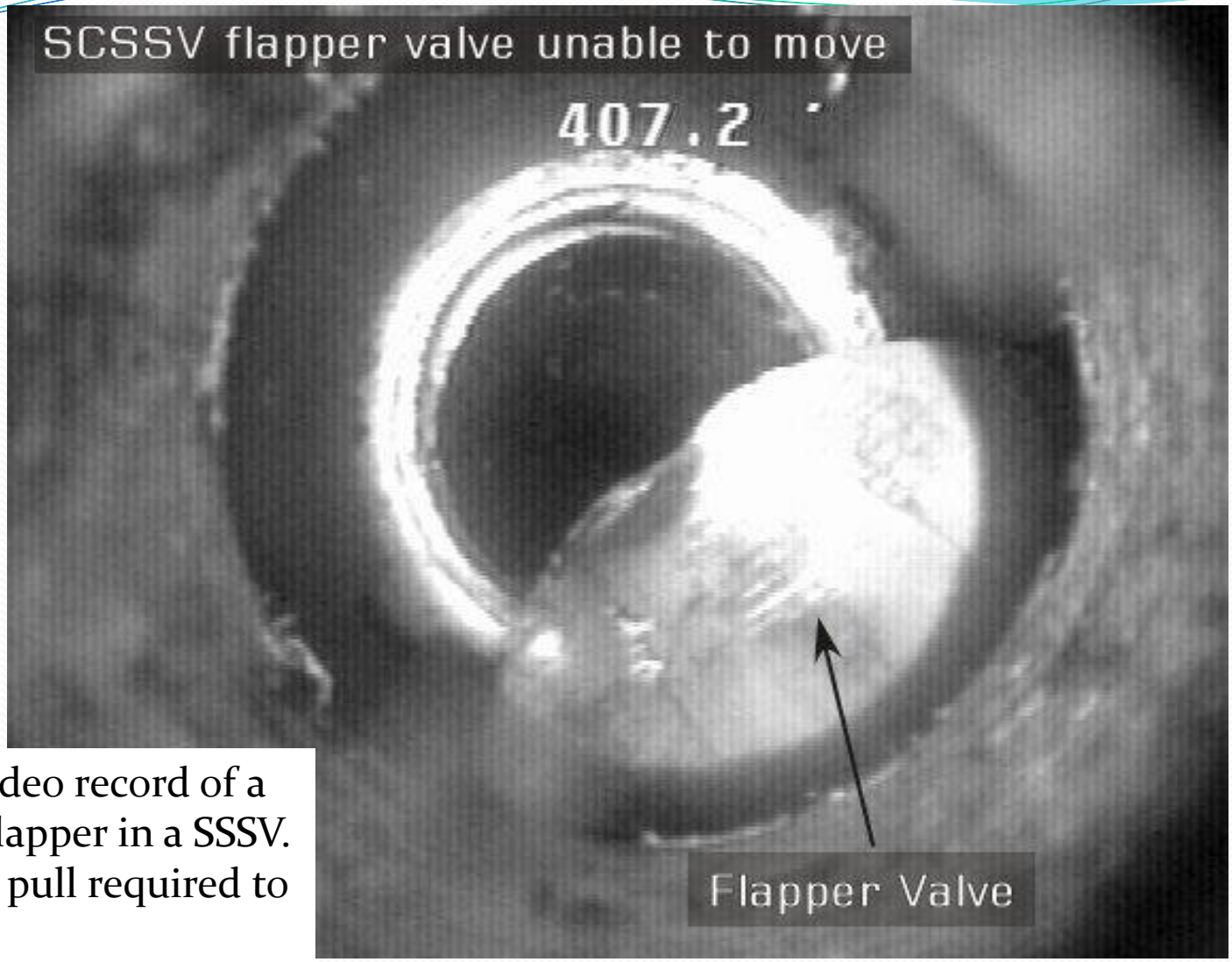
Slam closure puts extreme forces on locks – a major problem in large bores

Seal selection in large bore wells requires different seal stacks – and testing for specific applications.





One of the most common line crushing reasons was the pinch point of the line between the tubing coupling and the casing wall.



DHI Video record of a stuck flapper in a SSSV. Tubing pull required to repair.

Selection Recommendations

- API RP14A, class 2, ***MONOGRAMED*** **!** (also known as ISO 10432).
- Metallurgy matched to conditions.
- Big bore and high rate valves tested and qualified for the specific well application.
- Have best-practice installation procedures.