Chapter 10 – Completion Hardware

Lecture 2
Packers
Expansion Devices
Tubing
Landing Nipples, Locks & Sliding Sleeves

Packer Functions

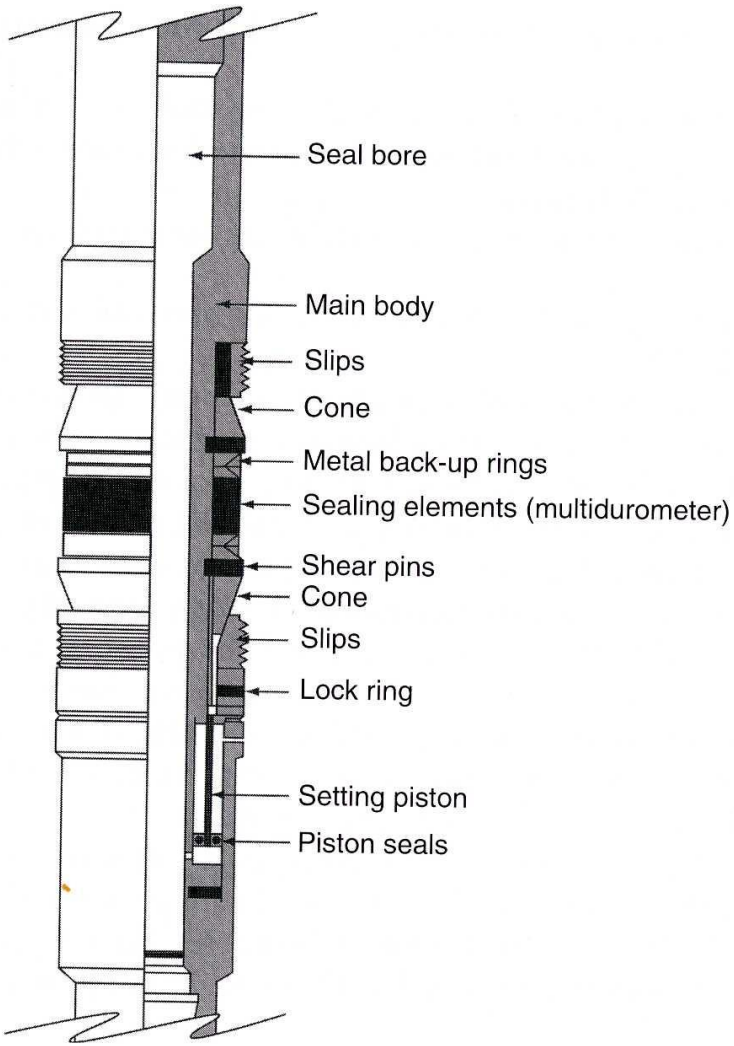
- Isolate the annulus to provide sufficient barriers or casing corrosion prevention (production packer)
- Isolate different production zones for zonal isolation (e.g. downhole flow control wells)
- Isolate gravel and sand (gravel pack packer and sump packer)
- Provide an annular seal in conjunction with an ASV
- Provide a repair or isolation capability (e.g. straddle pakcers)

Production Packer

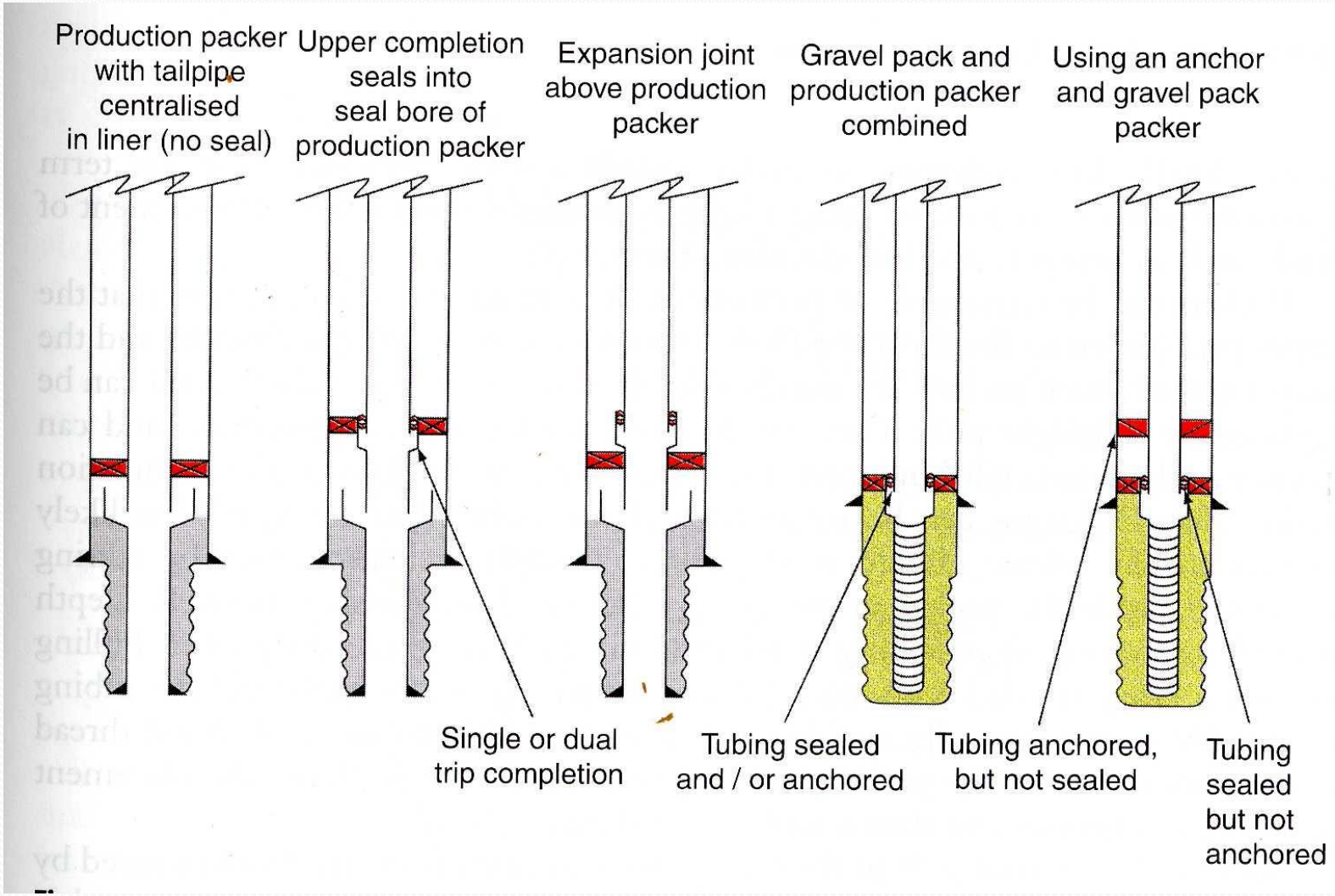
All packers set by applying compressive force to the packing element.

First the slips move outward and grip the inside of the casing. The compressive force causes a sleeve to ride over the cone element and apply compression to the packing element. The packing element expands and contacts the casing wall.

This setting action happens in a fraction of a second.



Packer Configurations



Types of Packers

- Permanent Packers - cannot be entirely retrieved and reinstalled in the wellbore. This type of packer is normally run and set separately on electric cable or slickline, a workstring, and the tubing is stabbed into or over the packer.

- Retrievable Packers - designed to be retrieved and reinstalled in the wellbore. Retrievable packers are normally run integrally with the tubing string and are set with either mechanical manipulation or hydraulic pressure.

- Other considerations – setting method and connection to the tubing

Retrievable Packers

- Setting Methods
  - Mechanically set
  - Hydraulically set
  - Wireline-set
  - Hydraulic setting tool (sealbore-retrievable)
- Typical operating ranges
  - General use 275°F 6500-7500 psi
  - HPHT 350°F 10,000 psi

Permanent Packers

- Setting Method
  - Electric line/wireline-set
  - Hydraulically set
  - Mechanically set
  - Hydraulic setting tools
- Typical operating ranges
  - General use 325°F 15,000 psi
  - HPHT 450°F 20,000 psi

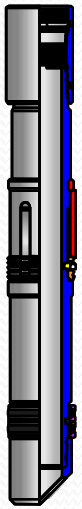
Setting Method

- Mechanical – Rotation, compression, tension
- Hydraulic – pumping fluid in to shear a pin
- Electric line – uses an explosive tool to create the compression. Usually a permanent packer is more likely to be set this way.

Production Packer Ascessories

- Seal units
- Polished bore receptacles
- Seal extensions
- Mill-out extensions
- Overshot tubing seal dividers
- Packer plugs

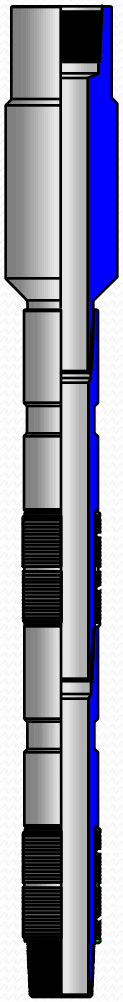
Stab in Tubing Connections



Collet Latch

Seals

Anchor

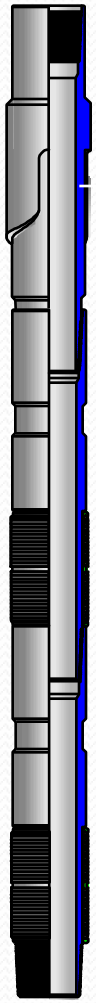


No-Go Shoulder

Seals

Seals

Locator



J-Profile

Seals

Seals

J-Latch

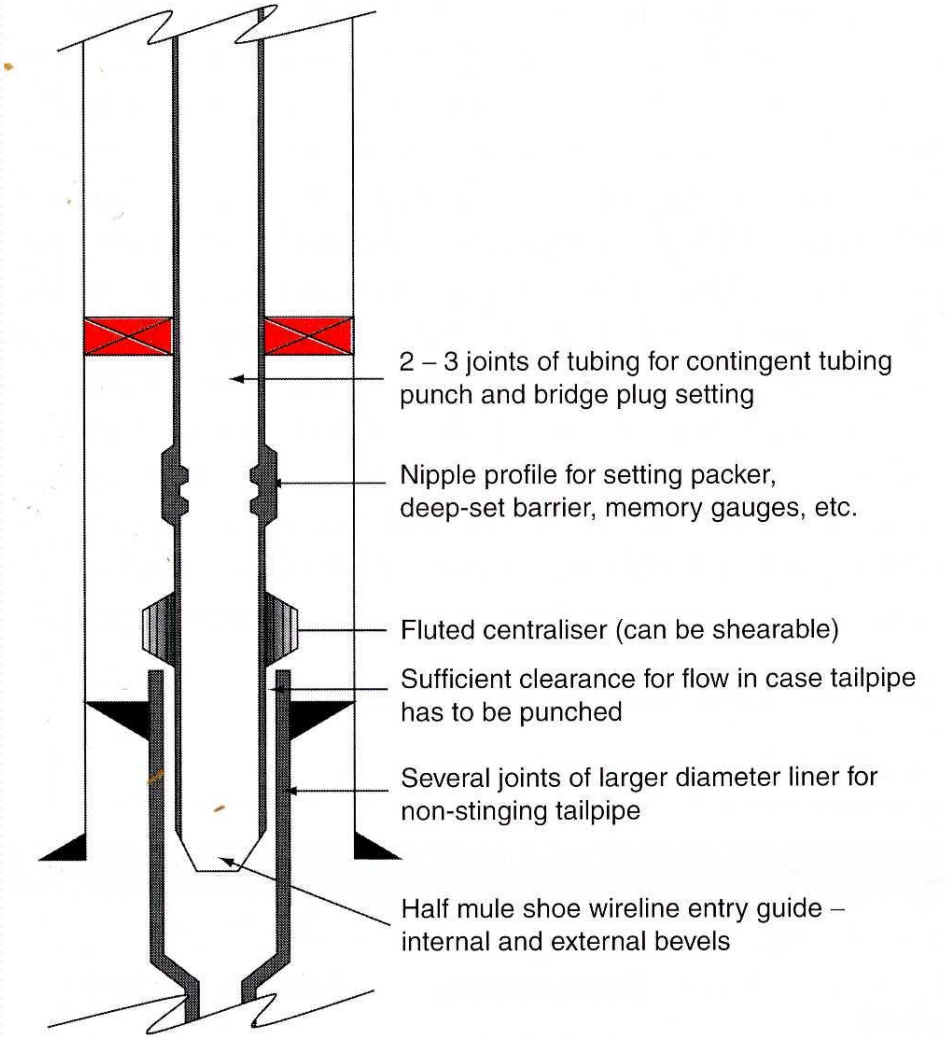
Old Retrievable Packer for Servicing

Anchor – Packer with no seal

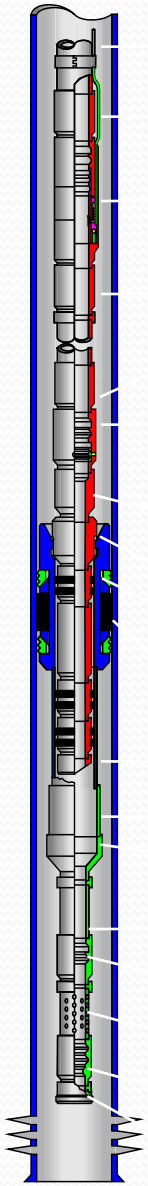
- Prevent tubing movement in pumped wells – especially sucker rod pumped wells
- Prevent tubing movement (and reduce associated stresses) when the tubing is sealed into a gravel pack packer
- Transfer tubing loads to the casing in weight-sensitive applications such as Tension Leg Platforms (TLPs)

Packer Tailpipe

- A common completion design is to use a production packer and to sting (but not seal) this into a sand control completion or cemented liner.
- This design allows a plug to be set below the packer for contingent tophole workovers. The plug can be punched open if it gets stuck.



Single-String Permanent Packer Completion



Hydraulic Control Line

Flow Coupling

Tubing-Retrievable Safety Valve

Flow Coupling

Flow Coupling

Sliding Side-Door Circulating Device

Flow Coupling

Straight Slot Locator

Seal Units and Accessories

Permanent Packer

Sealbore Extension

Millout Extension

Adapter

Tubing Joint or Pup

X Landing Nipple

Perforated Pup Joint

Landing Nipple

Wireline Re-entry Guide

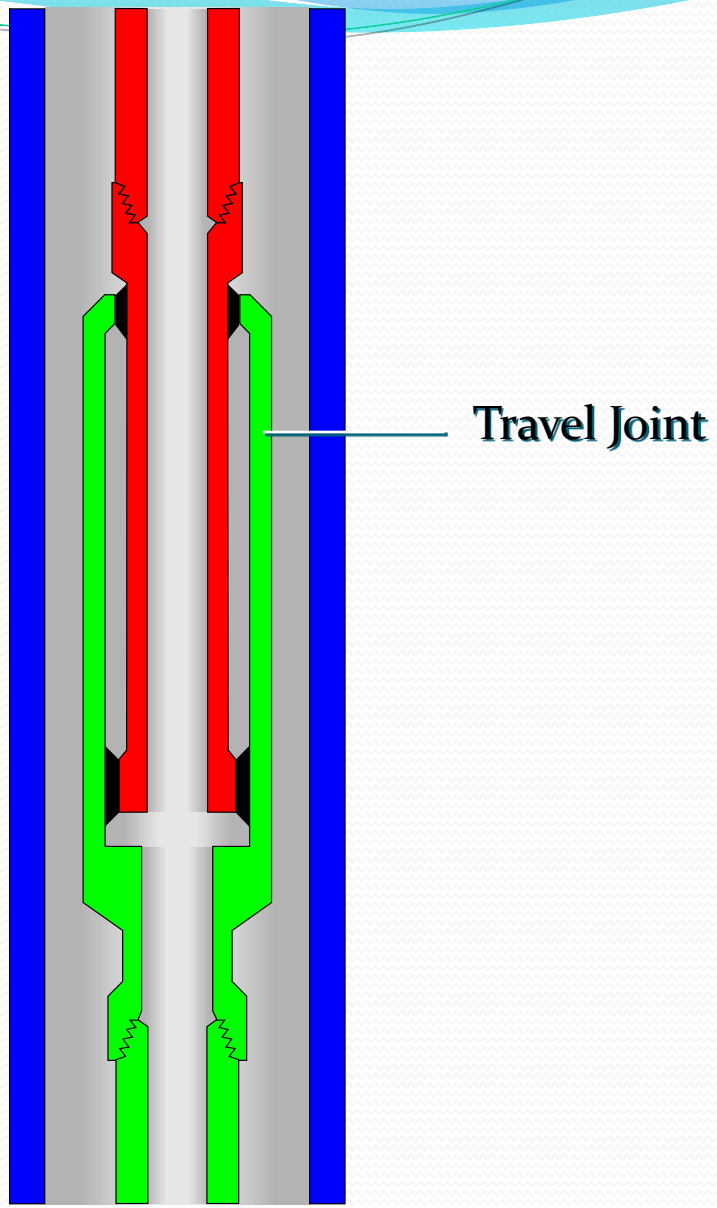
Method of Connecting Packer to Tubing

- Determines Method of allowing for downhole expansion
- Packer can be threaded onto tubing (fixed connection, no movement at this point); tubing can be stabbed to receptacle on top of the packer (fixed connection, no movement at this point); seal assembly may be used to allow for movement at the connection

Expansion Devices

- Extra-long Tubing Seal Receptacle (ELTSR)
- Telescoping Joint/Travel Joint

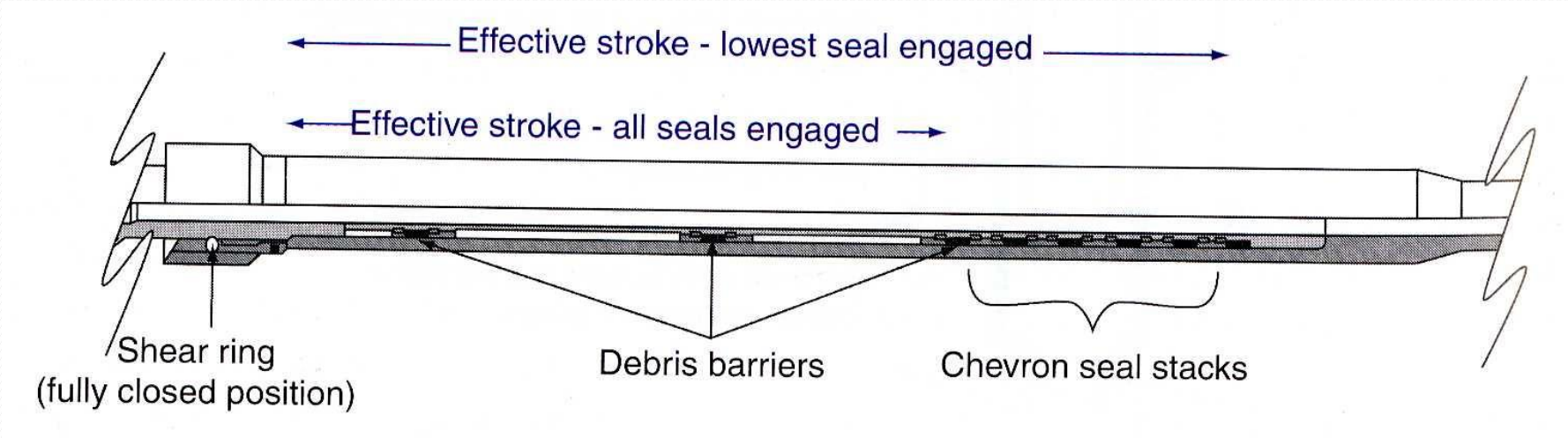
- Expansion devices are used to allow for movement which reduces stresses on packers and tubing, from thermal and downhole changes in pressue



Polished Bore Receptacle

- PBR is a general term for any polished bore which receives a stab-in type seal assembly. ELTSR's employ a stab over design.

- PRBs can be included at the top of a drilling liner

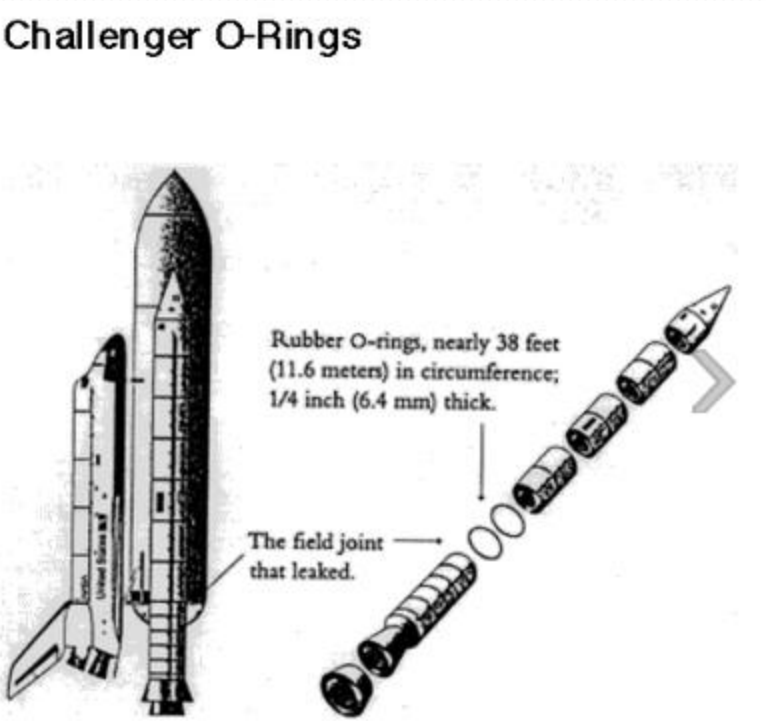


Elastomeric Seals

- All expansion devices (and many other completion devices) require elastomeric seals
- Elastomer trademarks
  - Aflas
  - Chemraz
  - Kalraz
  - Viton
  - Fluorel
- Non-Elastomer trademarks
  - PEEK
  - Ryton
  - Teflon

Space Shuttle Challenger

- O-ring seal in the right solid rocket booster failed at liftoff causing the shuttle to break apart 73 seconds after takeoff.



Seals and Packer Elements Guidelines (1 of 3)

Compound[1]	Nitrile[6]	Fluorocarbon[6]	Aflas[4,6]	Chemraz[3]	EPDM
Service Temperature °F (°C)	-10° to 275°F (-23 to 135°C)	-10 to 400°F (-23 to 204°C)	100 - 400°F (38 to 204°C)	40 to 400°F (4 to 204°C)	-30 to 300°F (-34 to 149°C)
Pressure (2) psi (MPa)	10,000 (69)	9000 (62.1)	8000 (55.2)	6000 (41.4)	3000 (20.7)
Environments					
H_2S	NR	A	A	A	NR
CO_2	A	B	B	A	NR
CH_4 (Methane)	B	A	A	A	NR
Hydrocarbons (Sweet Crude)	A	A	A	A	NR

A: Satisfactory B: Little or No Effect C: Swells NR: Not RecommendedNT: Not Tested

Note: These materials are mainly used as O-rings.
All pressure tests were done using 6 mil (0.006-in.) gaps; larger radial gaps will reduce pressure rating.
Backup rings must be used above 250°F (121.1°C) and 4000 psi (27.6 MPa).
Backup rings must be used above 350°F (176.7°C) and 5000 psi (34.5 MPa).
Water-soluble inhibitors only. Good for O-rings, packer elements, and molded seals.

Seals and Packer Elements Guidelines (2 of 3)

Compound[1]	Nitrile[6]	Fluorocarbon[6]	Aflas[4,6]	Chemraz[3]	EPDM
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Pressure(2) psi (MPa)	10,000 (69)	9000 (62.1)	8000 (55.2)	6000 (41.4)	3000 (20.7)
Environments					
Xylene	NR	A	B	A	NR
Alcohols	A	C	B	A	B
Zinc Bromide	NR	A	A	A	NT
Inhibitors	B(5)	NR	A	A	NT

A: Satisfactory B: Little or No Effect C: Swells NR: Not RecommendedNT: Not Tested

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Seals and Packer Elements Guidelines (3 of 3)

Compound[1]	Nitrile[6]	Fluorocarbon[6]	Aflas[4,6]	Chemraz[3]	EPDM
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Pressure(2) psi (MPa)	10,000 (69)	9000 (62.1)	8000 (55.2)	6000 (41.4)	3000 (20.7)
Environments					
Salt Water	A	A	A	A	A
Steam	NR	NT	B	B	A
Diesel	B	A	B	A	NR
Hydrochloric Acid (HCl)	NR	A	A	A	NR

A: Satisfactory B: Little or No Effect C: Swells NR: Not RecommendedNT: Not Tested

Note: These materials are mainly used as O-rings.
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Water-soluble inhibitors only. Good for O-rings, packer elements, and molded seals.

Tubular Devices

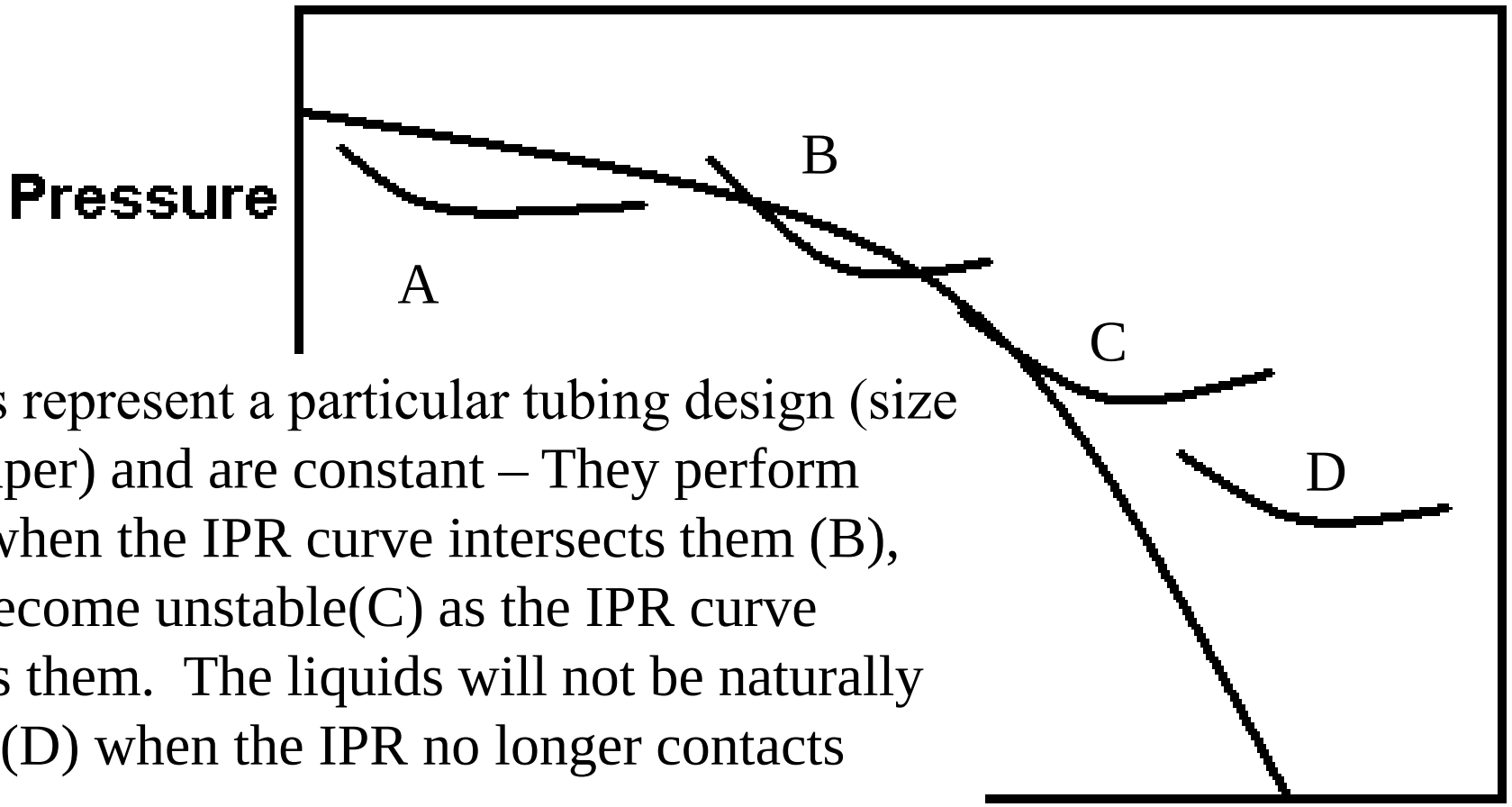
- Tubing
- Landing Nipples (and their associated locks)
- Sliding Sleeves (or sliding side doors)
- Flow Couplings
- Blast Joints
- Crossovers
- Pup Joints

- This are generally all considered to be ‘tubular goods’

Tubing

- Size
- Grade
- Weight
- Threaded Connection

Tubing Performance Curves with Inflow Performance Relationship

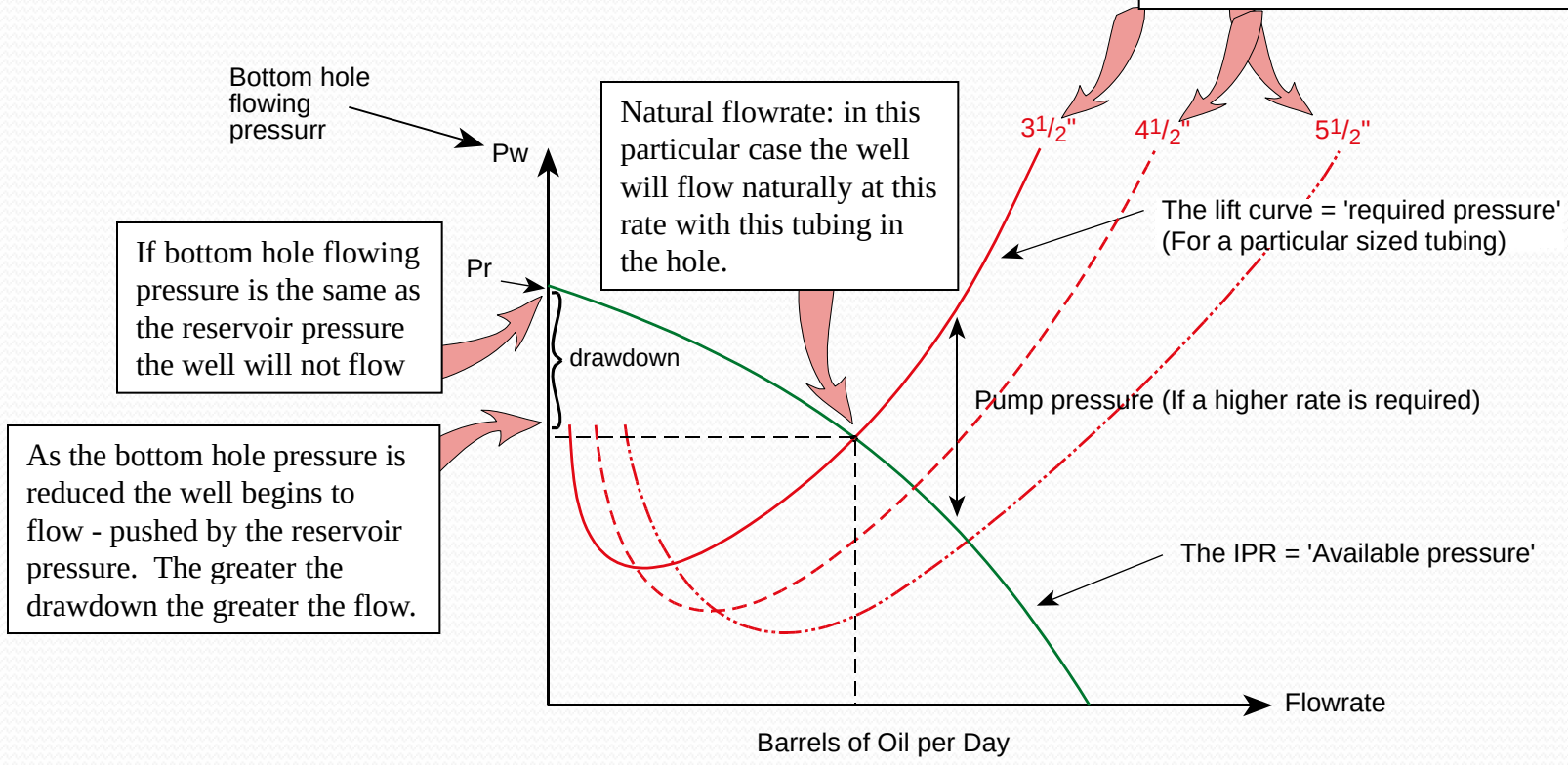


TPC's represent a particular tubing design (size and taper) and are constant – They perform well when the IPR curve intersects them (B), and become unstable(C) as the IPR curve passes them. The liquids will not be naturally lifted (D) when the IPR no longer contacts them.

Production Rate and Tubing Sizing

- The pressure drops are plotted against flowrate to give
  - inflow performance relationship or IPR
  - the tubing performance curve or lift curve

Tubing Performance Curves: Calculated by computer or taken from tables, to predict the pressure loss up the tubing. Depends upon rate , type of fluid (oil vs gas), gas-oil-ratio, water content etc. for different tubing sizes.



Inflow Performance Relationship (IPR) and tubing Performance Curves

API Tubing Table (1 of 4)

Tubing Size		Nominal Weight		Grade	Wall Thick-ness	Inside Dia.	Threaded Coupling				Coll. Resist.	Internal Yield Press.	T & C Non-Upset	T & C Upset	Barrels per	Lin. ft per
								Coupling Outside Dia.								
Nom. in.	OD in.	T & C Non-Upset lb/ft	T & C Upset lb/ft				Drift Dia. in.	Non-Upset in.	Upset Reg. in.	Upset Spec. in.	psi	psi	lb	lb	lin. ft	Barrel
¾	1.050	1.14	1.20	H-40	0.113	0.824	0.730	1.313	1.660		7200	7530	6,360	13,300	0.0007	1516.13
	1.050	1.14	1.20	J-55	0.113	0.824	0.730	1.313	1.660		9370	10,360	8,740	18,290	0.0007	1516.13
	1.050	1.14	1.20	C-75	0.113	0.824	0.730	1.313	1.660		12,250	14,120	11,920	24,940	0.0007	1516.13
	1.050	1.14	1.20	N-80	0.113	0.824	0.730	1.313	1.660		12,970	15,070	12,710	26,610	0.0007	1516.13
1	1.315	1.70	1.80	H-40	0.133	1.049	0.955	1.660	1.900		6820	7080	10,960	19,760	0.0011	935.49
	1.315	1.70	1.80	J-55	0.133	1.049	0.955	1.660	1.900		8860	9730	15,060	27,160	0.0011	935.49
	1.315	1.70	1.80	C-75	0.133	1.049	0.955	1.660	1.900		11,590	13,270	20,540	37,040	0.0011	935.49
	1.315	1.70	1.80	N-80	0.133	1.049	0.955	1.660	1.900		12,270	14,160	21,910	39,510	0.0011	935.49
1 ¼	1.660			H-40	0.125	1.410					5220	5270			0.0019	517.79
	1.660	2.30	2.40	H-40	0.140	1.380	1.286	2.065	2.200		5790	5900	15,530	26,740	0.0018	540.55
	1.660			J-55	0.125	1.410					6790	7250			0.0019	517.79
	1.660	2.30	2.40	J-55	0.140	1.380	1.286	2.065	2.200		7530	8120	21,360	36,770	0.0018	540.55
	1.660	2.30	2.40	C-75	0.140	1.380	1.286	2.065	2.200		9840	11,070	29,120	50,140	0.0018	540.55
	1.660	2.30	2.40	N-80	0.140	1.380	1.286	2.065	2.200		10,420	11,810	31,060	53,480	0.0018	540.55

API/SPEC 5A, 5AC, 5AX Tubing and Casing

Grade	Strength			H_2S	Spec.
	Yield		Tensile		
	Min.	Max.	Min.		
H-40	40,000	--	60,000	Yes	5A
J-55	55,000	80,000	75,000	Yes	5A
K-55	55,000	80,000	95,000	Yes	5A
N-80	80,000	110,000	100,000	?	5A
C-75	75,000	90,000	95,000	Yes	5AC
L-80	80,000	95,000	95,000	Yes	5AC
C-95	95,000	110,000	105,000	?	5AC
P-105	105,000	135,000	120,000	No	5AX
P-110	110,000	140,000	125,000	No	5AX

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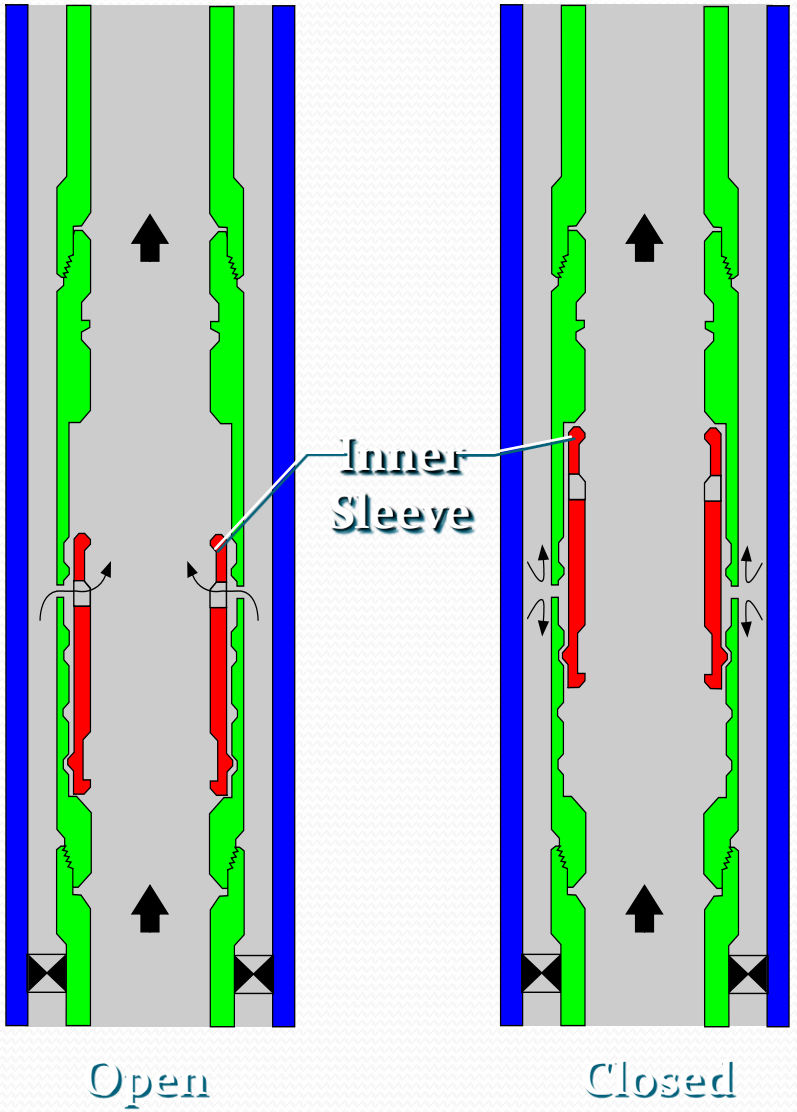
Corrosion Resistant Alloys

Steel	**Location**	**Relative Cost**
Carbon Steel	Wytch Farm, UK	1
13%Cr	S.N.Sea, Trinidad	3
Super 13%Cr	Rhum, Tuscaloosa	5
Duplex SS	Miller, T. Horse	8-10
Austenitic SS	Miller, Congo - Liners	12-15
Nickel Alloys	Middle East (825)	20
Hastelloy	Gulf Of Mexico (G3)	>20

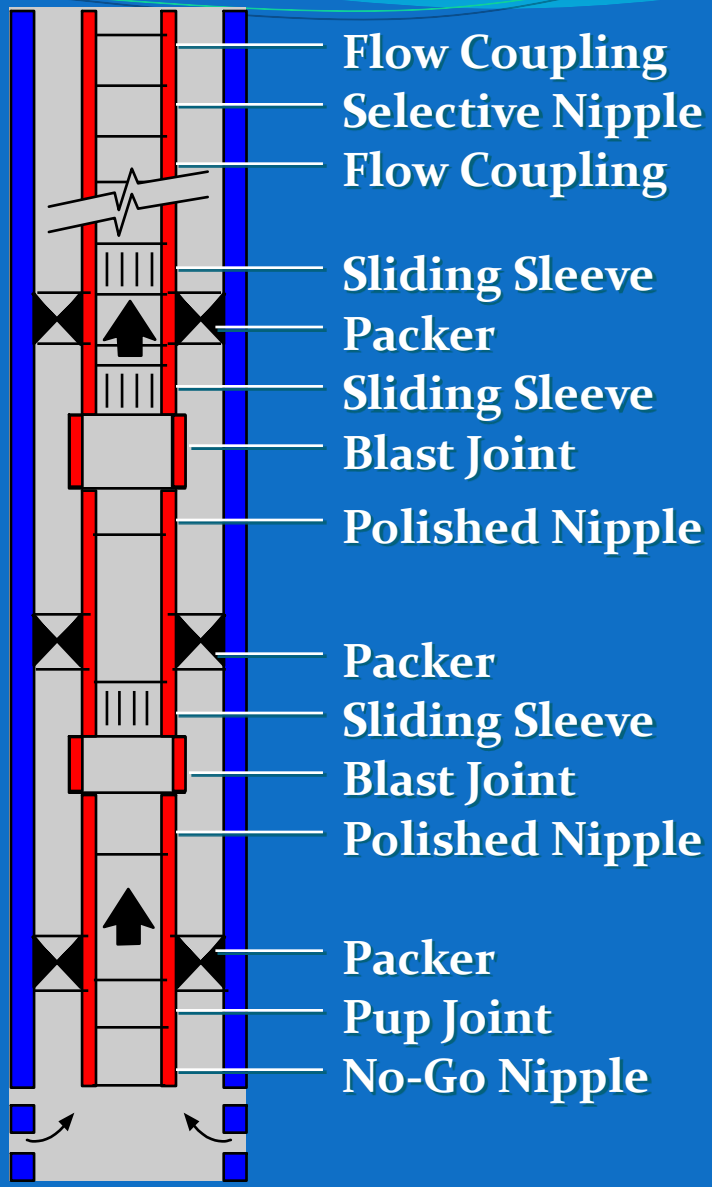
Sliding Sleeves/Side Doors

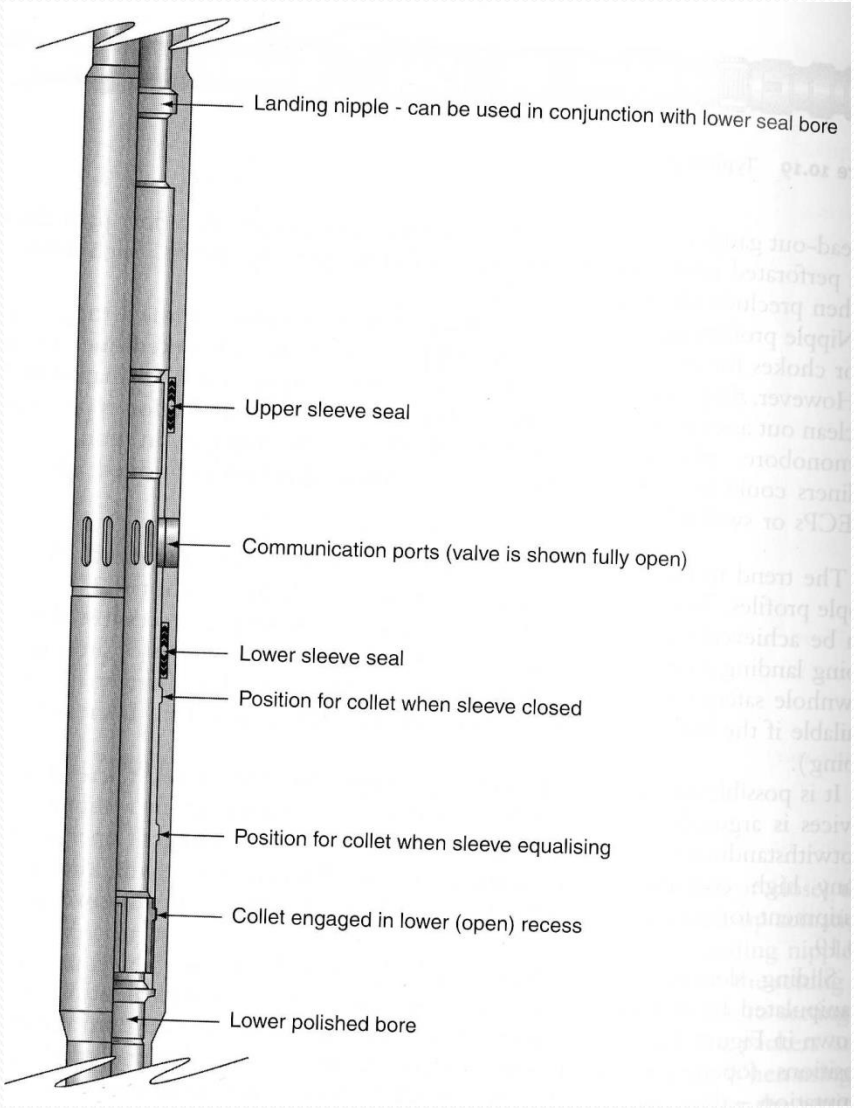
- Device used to allow communication (fluid flow) between the tubing and the tubing-casing annulus
- Typical used for
  - Circulation of the completion
  - Production of zones between packers in multi-reservoir completions

Sliding Sleeve



Sliding Sleeve for Multi-Zone Selective Completion




Landing nipple - can be used in conjunction with lower seal bore
Upper sleeve seal
Communication ports (valve is shown fully open)
Lower sleeve seal
Position for collet when sleeve closed
Position for collet when sleeve equalising
Collet engaged in lower (open) recess
Lower polished bore

Sliding Sleeves/Side Doors

- Designed to provide flow area equal to, or greater than the ID of the tubing string
- May be jar up to open/down to close, or the opposite

Bridge Plug

- Device set in the tubing string to close off the tubing
- May be permanent or retrievable
- Harder to set then a wireline plug in a landing nipple (?)

Landing Nipples

- Short tubular sections that include a groove referred to as a ‘profile’
- Used for
  - Setting plugs for pressure testing, isolation and well suspension (e.g. removal of the BOP)
  - Setting check valves (standing valves) for pressure testing
  - Hanging off downhole pressure gauges
  - Setting downhole chokes
  - Positioning an old storm choke

Profiles and Nipples

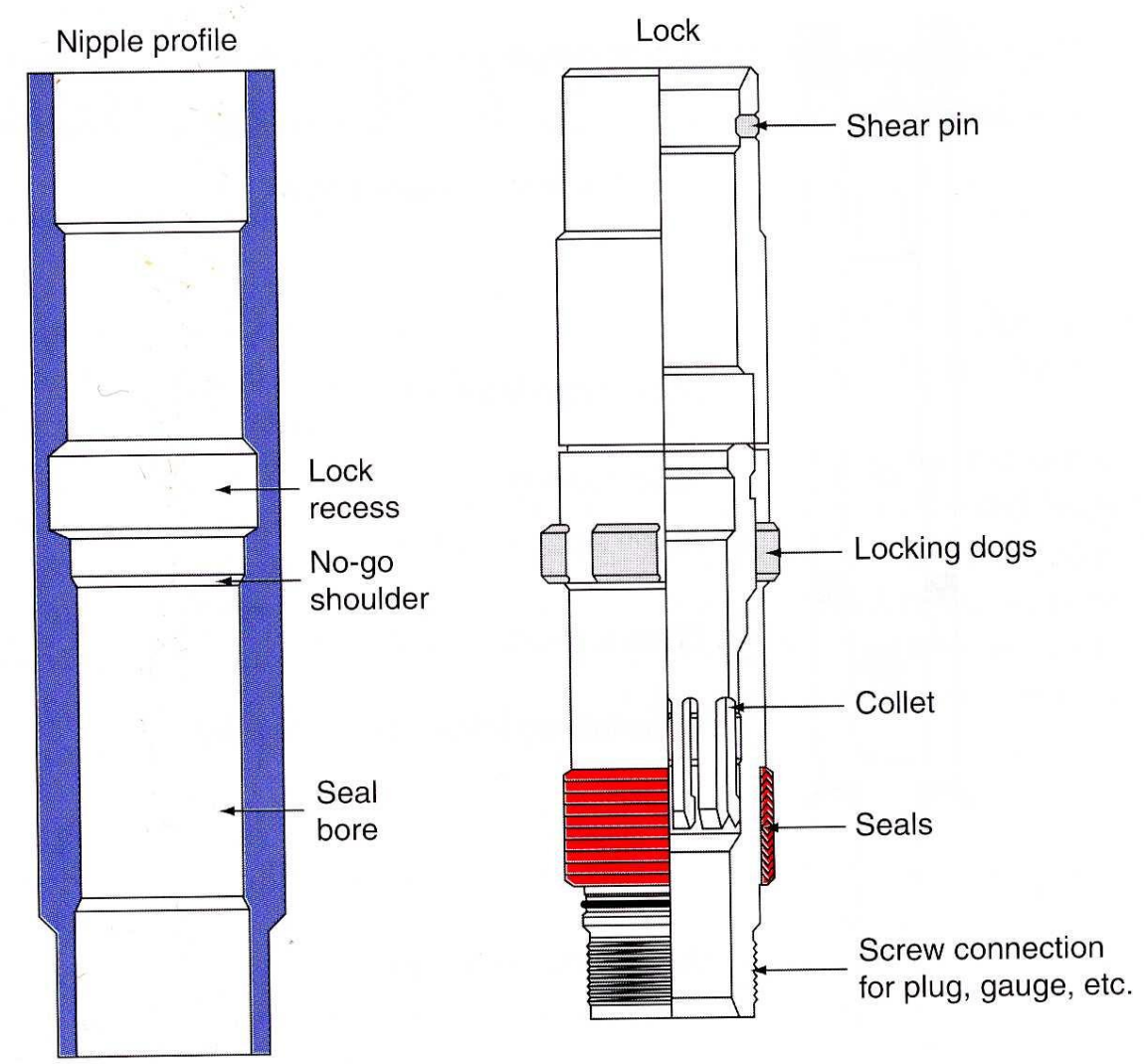
- **Landing Nipple – has a specific internal profile.**
  - **Contains a lock profile**
  - **Contains a seal profile**
- **Used for:**
  - **Checking depth measurement when using wireline and CT**
  - **Plug well from above or below for testing**
  - **ScSSV's, DH chokes and regulators may be hung-off**
  - **DH gauges may be hung-off**
  - **Installation of pumps, test sections, and other equipment**

Landing Nipple

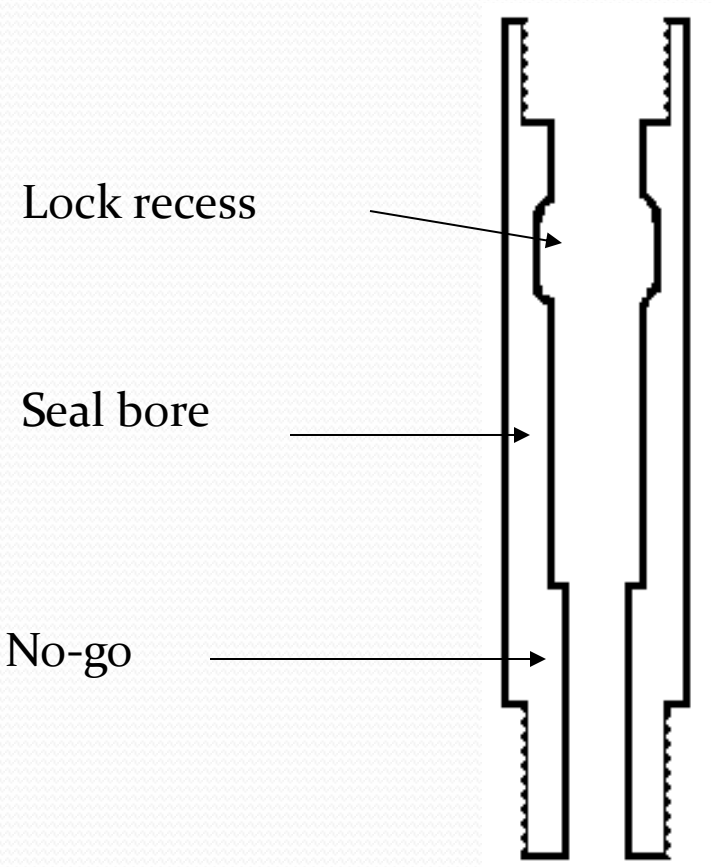
- No-go type
- Selective type (do not include a no-go)

- No-go's provide positive setting information but restrict ID of tubing if multiple no-go's are used.

- Selective landing nipples do not introduce reductions in diameter but may be more difficult to positively set devices in them

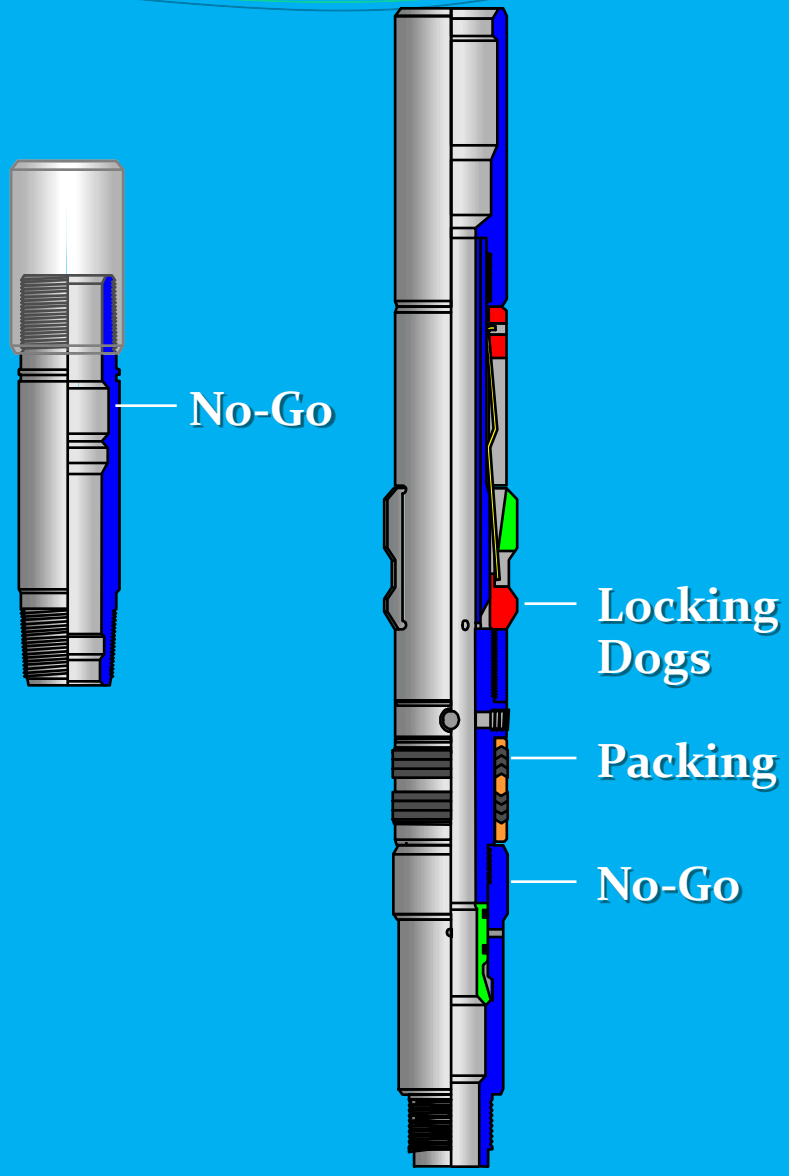


Non-Selective Nipples

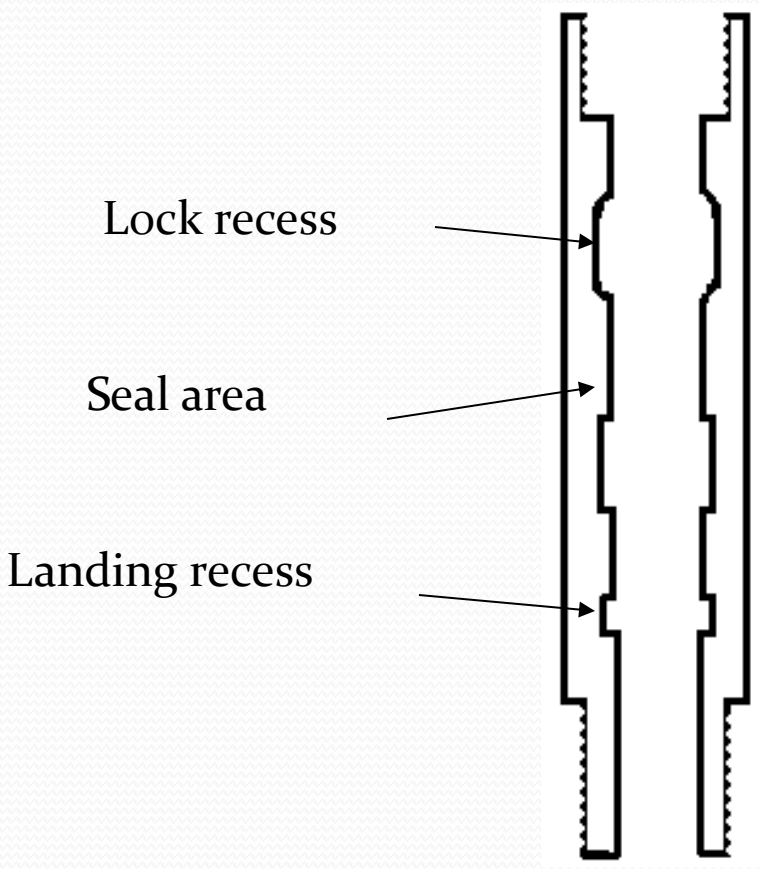


A single non selective nipple is usually all that is run in a well and it is usually at the bottom.

No-Go Landing Nipple and Lock Mandrel



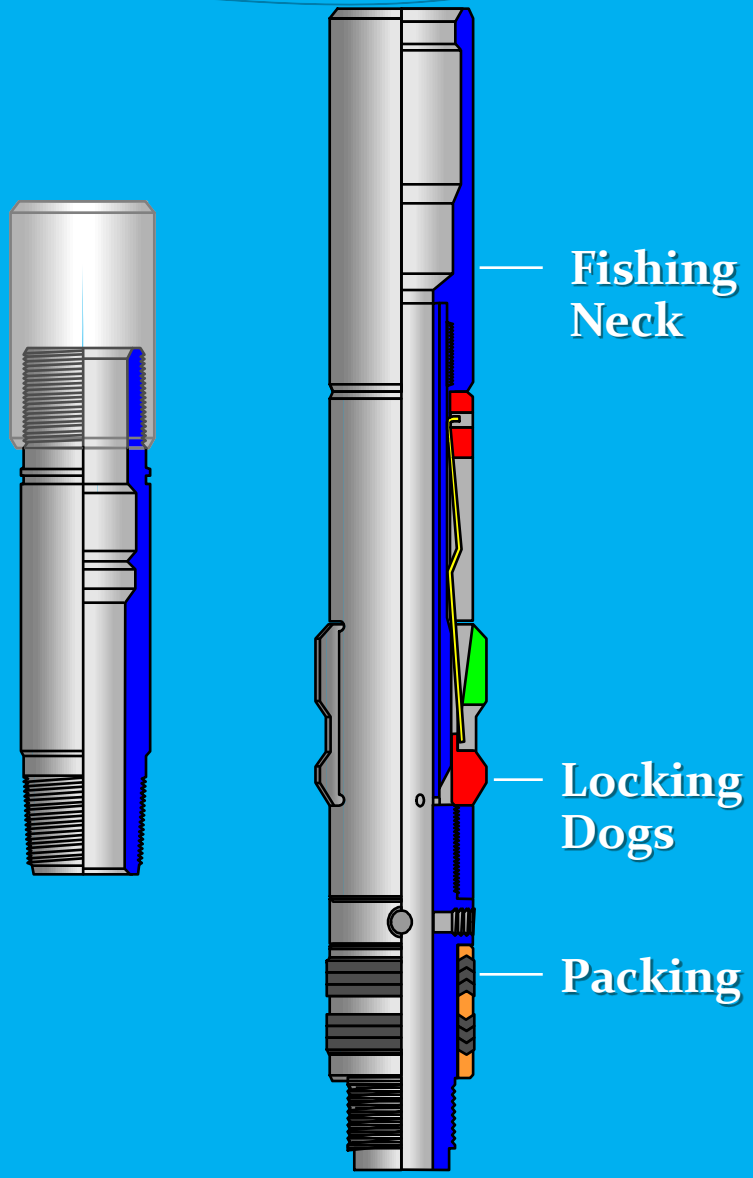
Selective Nipples

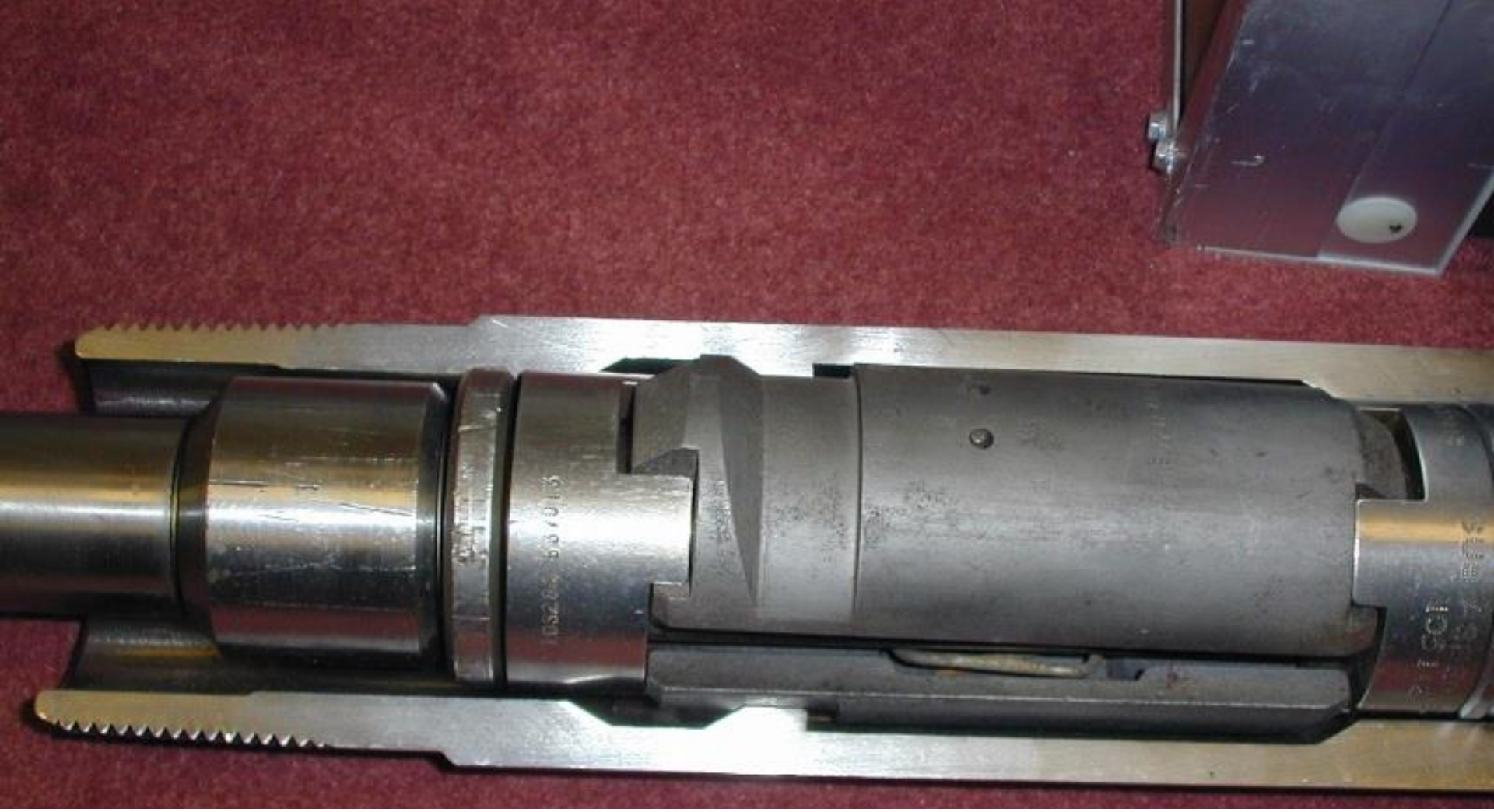


Essentially full opening (about 0.1" less ID than pipe)

Allows running multiple profiles, each with same ID. Set is determined by running tool.

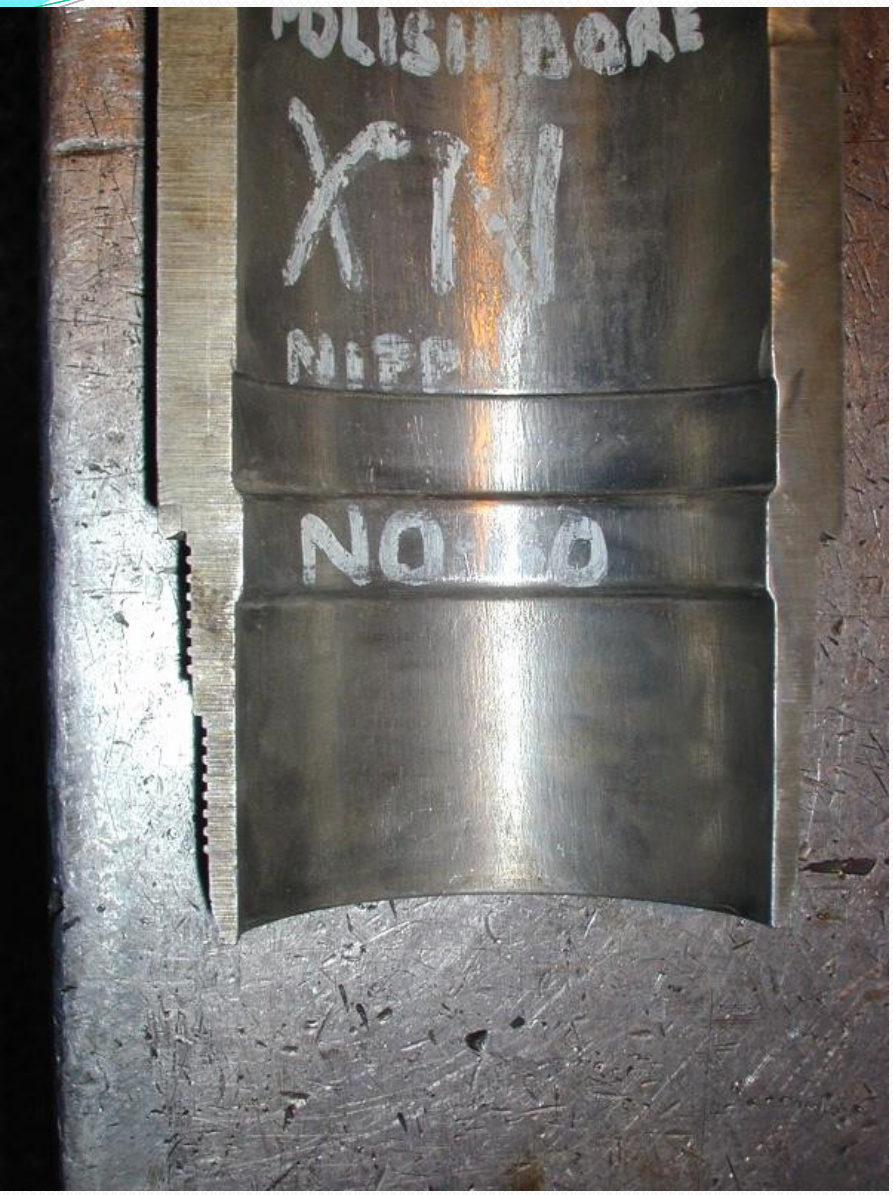
Selective Nipple with Lock Mandrel





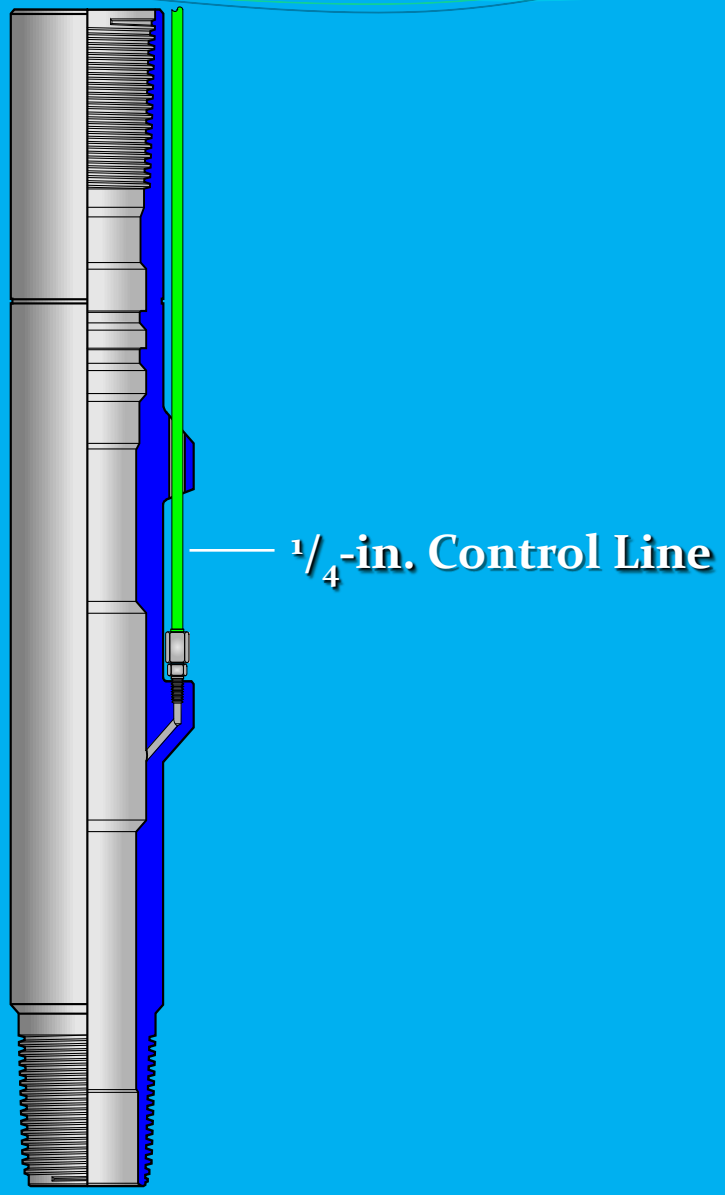
S Profile with plug installed. Showing locking section.

XN (left) and X profile (right). X profiles allow several to be run in series in the string (same size plug passes through each). Only one XN can be run (on the bottom).

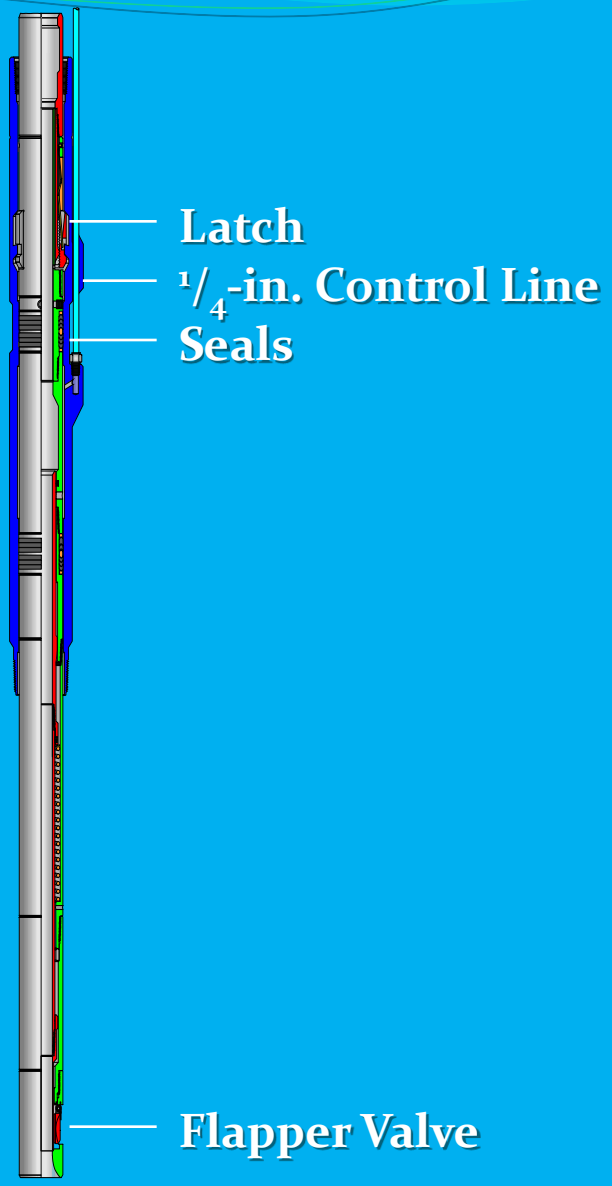

POLISH BORE
XH
NiPd


POLISH BORE
8550

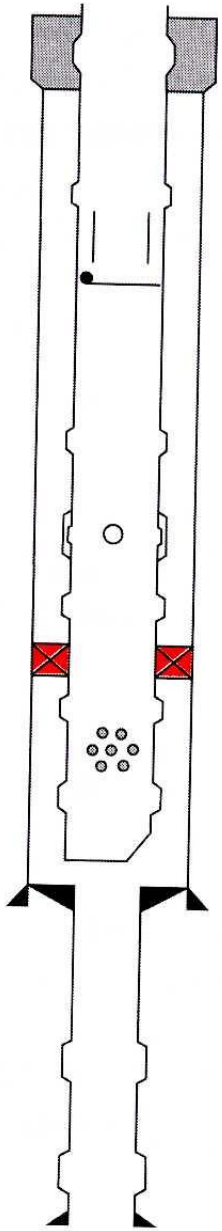
SCSSV Nipple



Valve Latched in Safety-Valve Landing Nipple



Typical Locations for profiles



1. Tubing hanger
2. Part of a downhole safety valve
3. Mid position of tubing
4. Sliding sleeve
5. Above a packer or seal
6. Below a packer or seal
7. In the tailpipe below a perforated joint
8. Within a liner or screen