Coiled tubing technology, principles, procedures & troubleshooting

Presented by:

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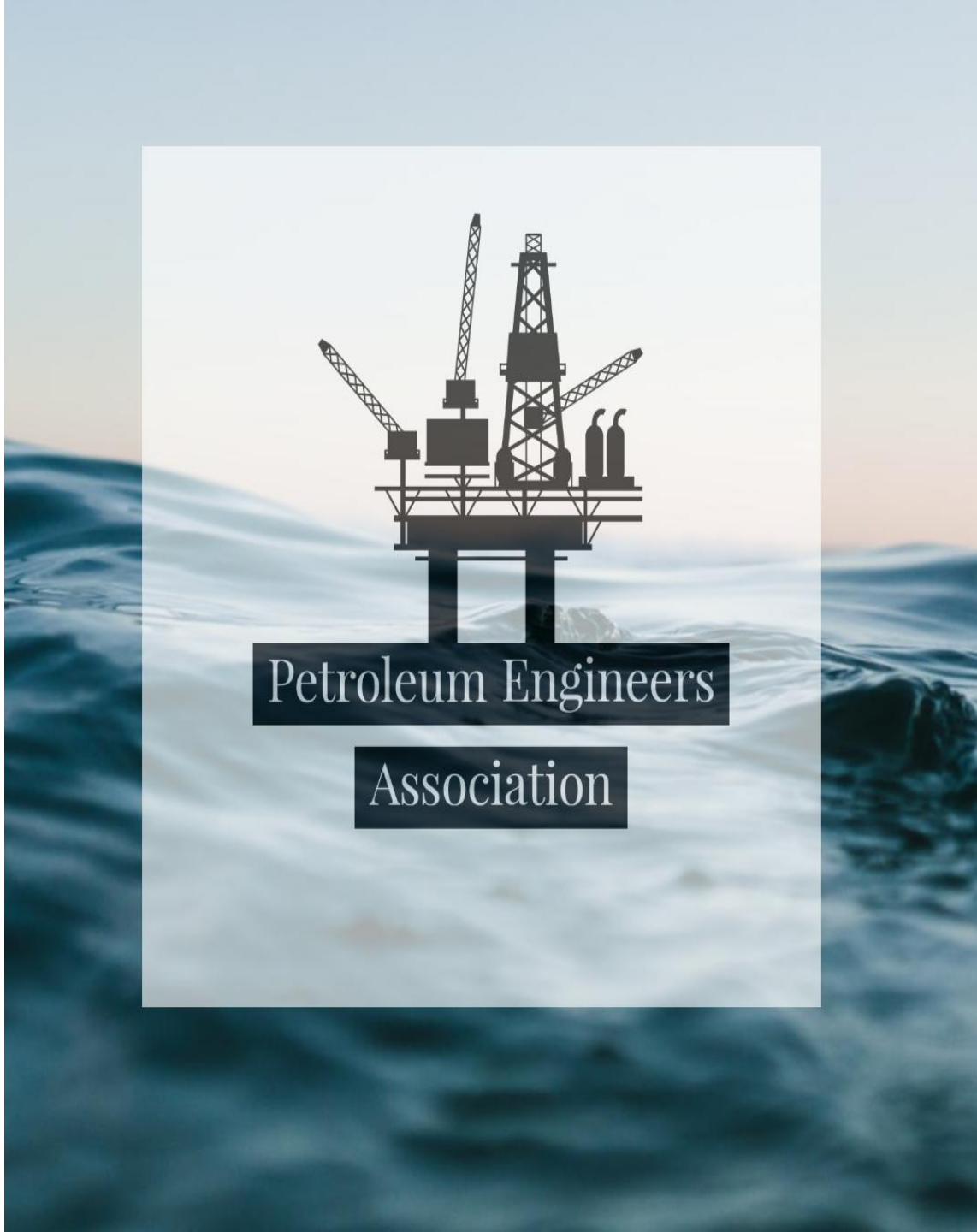
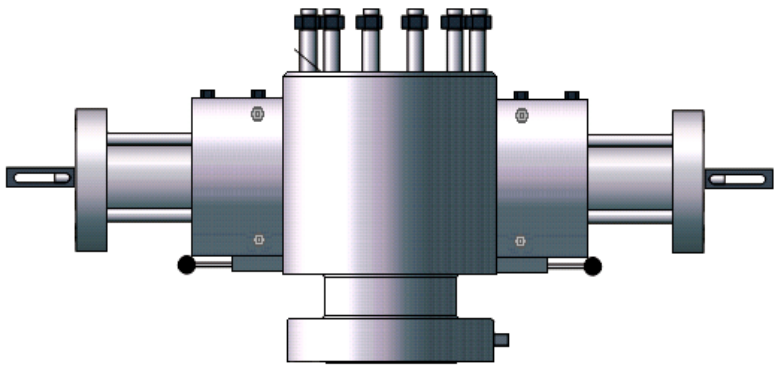


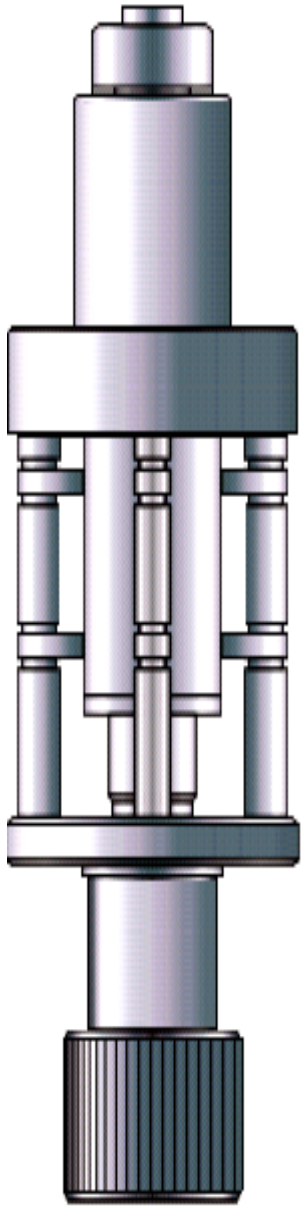
Pressure containment device (primary barrier)-Closed barrier

- ❑Installed above BOP & below injector head
- ❑Dual assembly used for extreme well conditions
- ❑Hydraulic activation from control cabin
- ❑Can be redressed during operation with pressure isolated
- ❑Leak tight (zero leak)
- ❑There are 4 types of stripper:

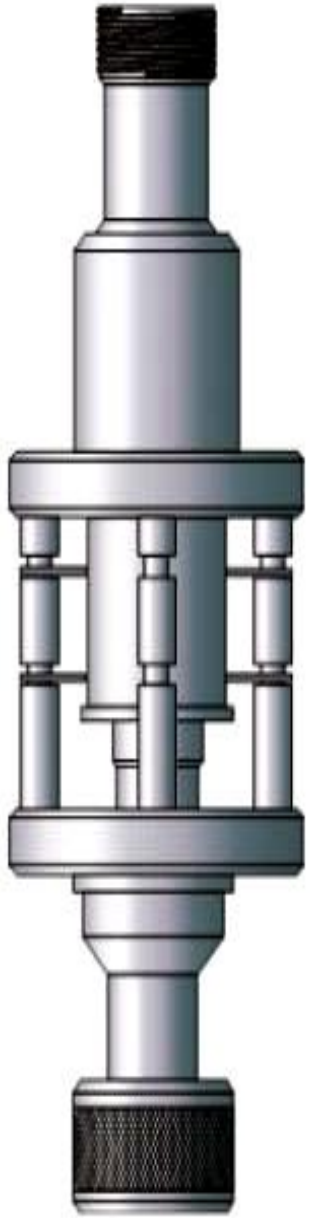
1. Conventional Stripper (old type)
2. Tandem Stripper
3. Side Door Stripper
4. Radial Stripper



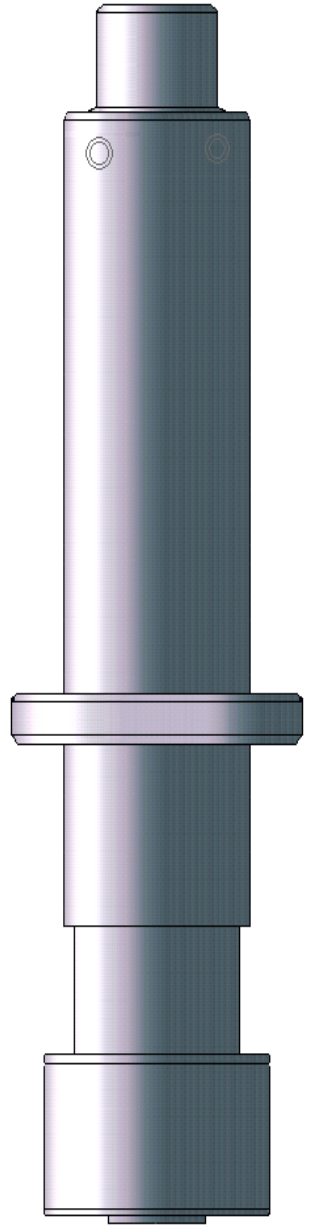
Radial stripper



Side door stripper



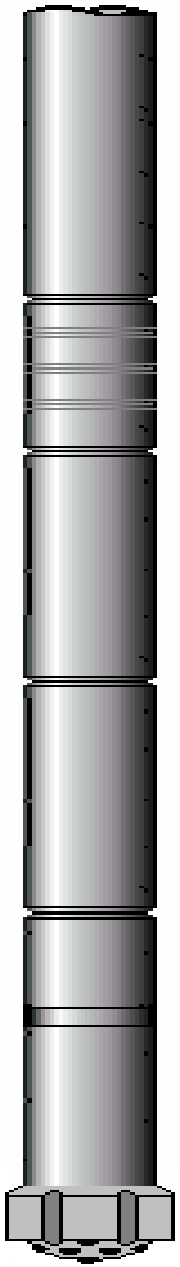
Tandem stripper



Conventional stripper

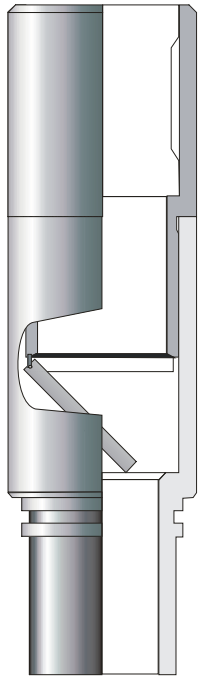
Bottom hole assembly: standard BHA consists of the following components:

1. Connector: inline and outline
2. Check valve 1
3. Check valve 2
4. Release sub
5. Circulation sub
6. Tool

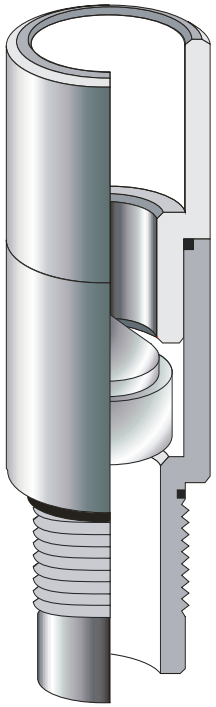


❑Check valves types (internal primary barrier):

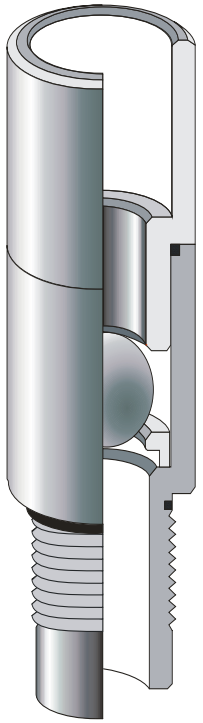
1. Ball check valve: metal to metal seal and use when no requirement for ball activated tool
2. Dart or dome check valve: similar to ball type
3. Flapper check valve: full bore design and enables launching of balls



Flapper



Dart or dome



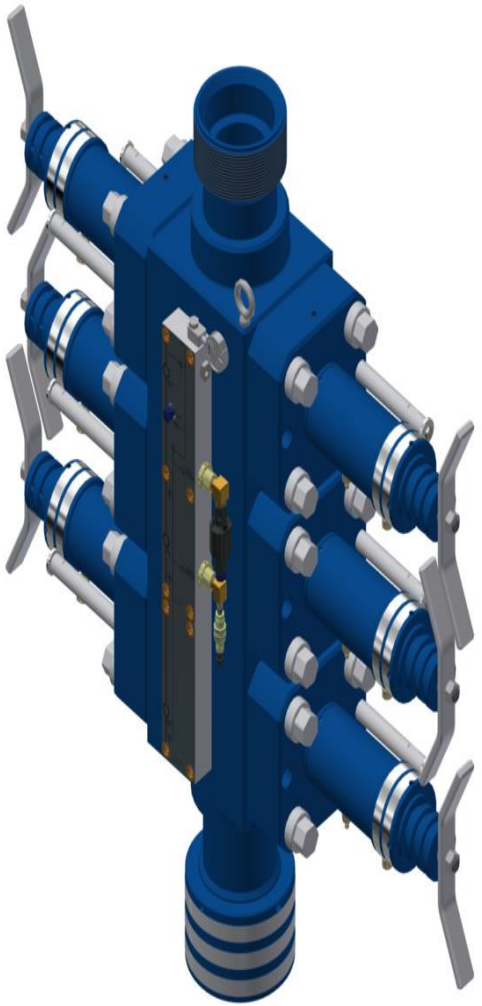
Ball & seat

Pressure containment devices (secondary barrier): blow out preventers BOPs

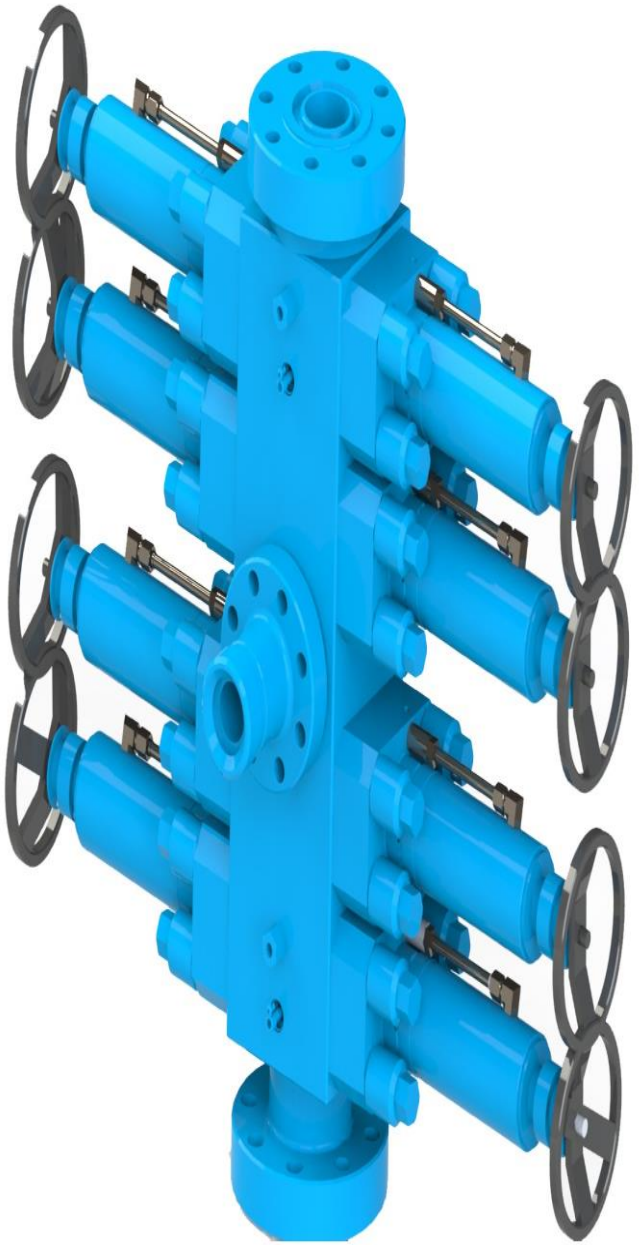
There are 2 types of preventers: Ram type & Annular type (closable barrier)

- Ram type: there are 3 types:
  1. Dual
  2. Triple
  3. Quad
- Annular type:
  1. Seals around different ODs
  2. Used with long BHAs
  3. Closes from bottom to up
  4. Well pressures support the closing
  5. Seals with and without pipe in BOP

Combi



Triple



Quad

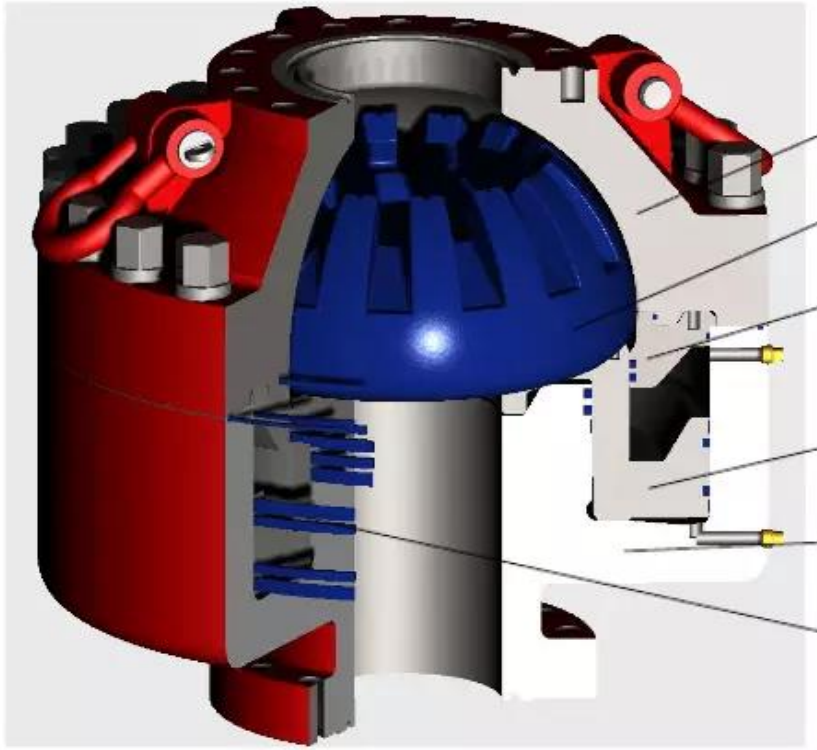
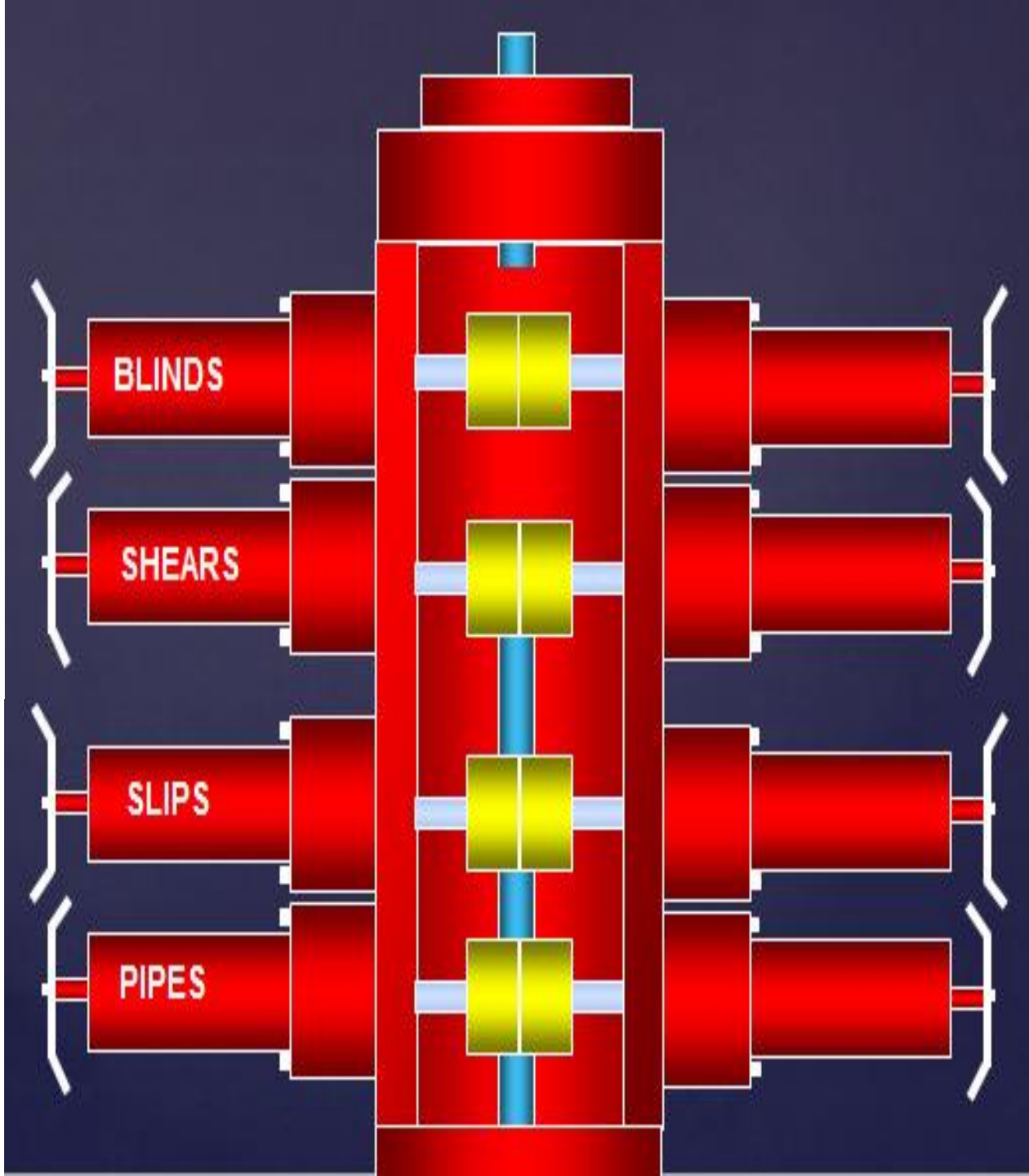


Figure 1 FH35-35/70 Annular BOP (Between bonnet and shell is flange connection)



Pressure containment devices (tertiary barrier): shear/seal BOP

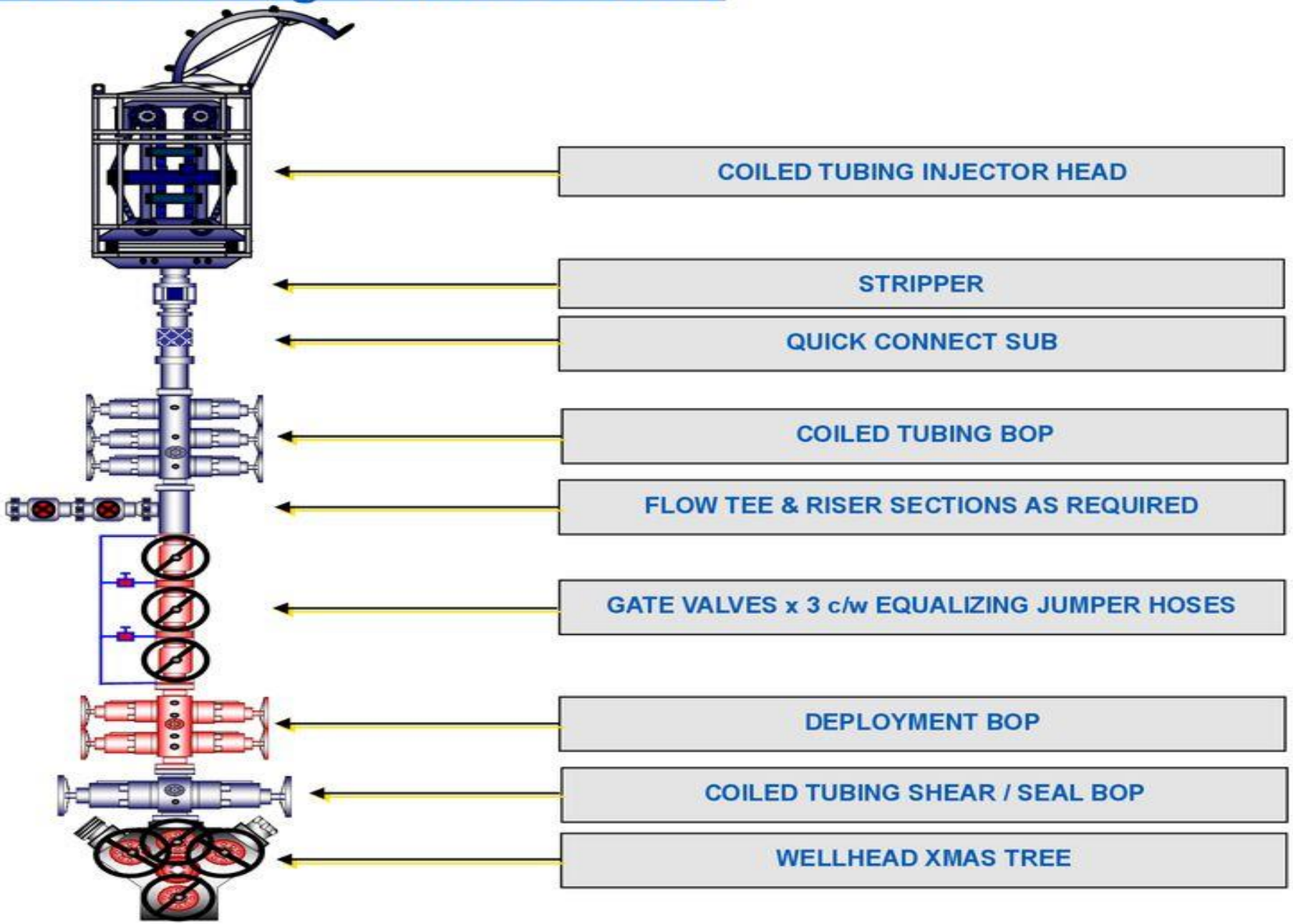
This BOP is the third line of defense, as it is used in case of primary and secondary barriers failed

When it is activated, CT will be dropped down the hole then secure the well and close SWV and UMV

CT dropped in the well is afterwards planned to be fished

After activation, CT drops in hole and seal will be achieved

Typical Coiled Tubing Surface Stack



Cement plug using CT

Sometimes we need to isolate long production interval, so we can achieve that by 2 ways:

- ❑Setting MBPT and dump 3m of cement above it (using E-line)
- ❑Set cement plug if interval is long (using CT)

Steps for setting cement plug using CT:

- ❑Calculate cement plug volume
- ❑Kill the well by bull heading
- ❑Pressure test surface equipment and RIH CT to desired depth
- ❑Ensure that there is circulation in the well with minimum losses
- ❑With CT at bottom of interval to be plugged, pump spacer in CT (i.e. 5bbl) followed by cement then start POOH CT to top interval while synchronizing CT speed and pumping rate till all cement out of CT. POOH CT to surface and then wait for cement to dry. Test it after drying and tag top of cement

Balanced Cement Plug

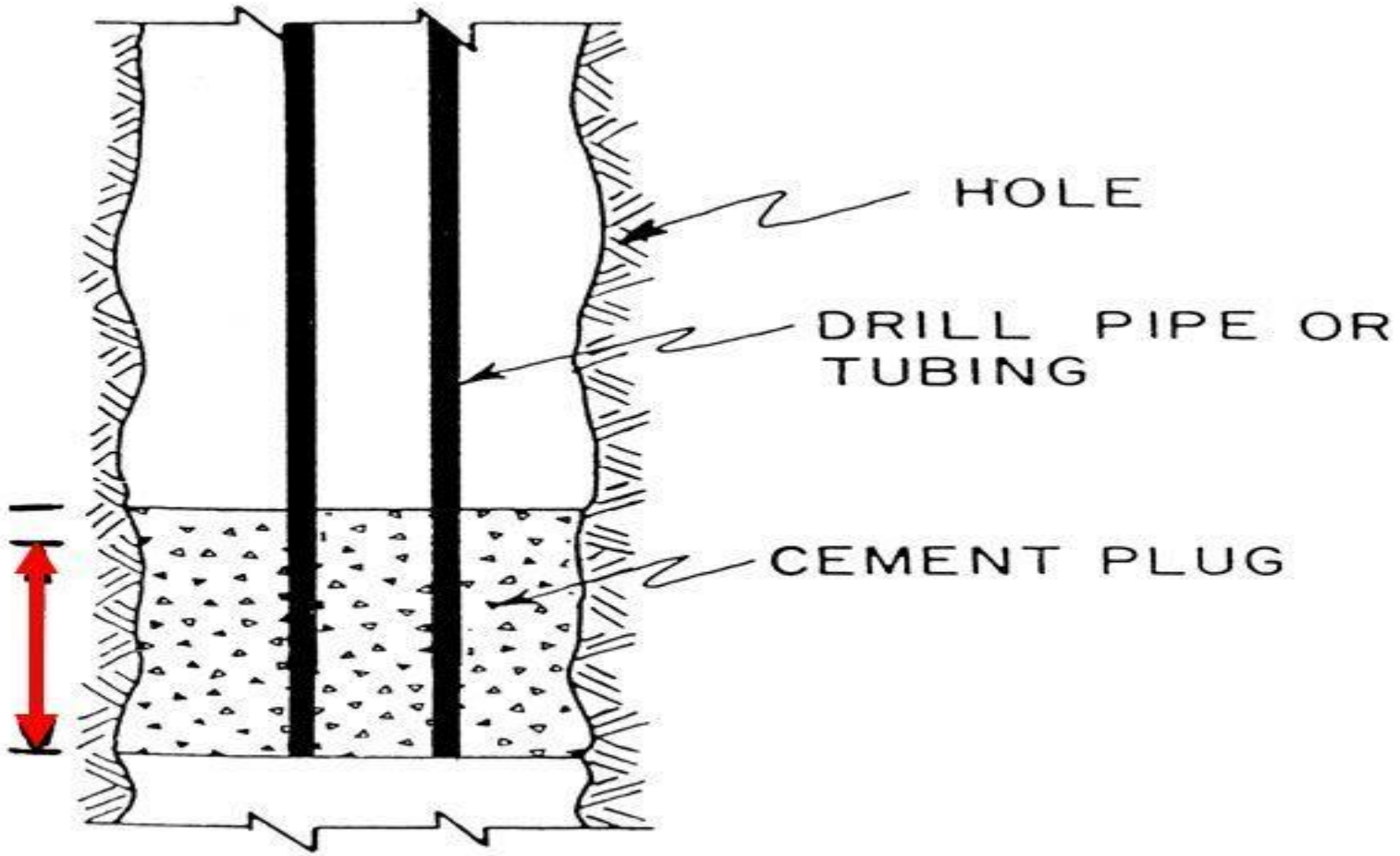
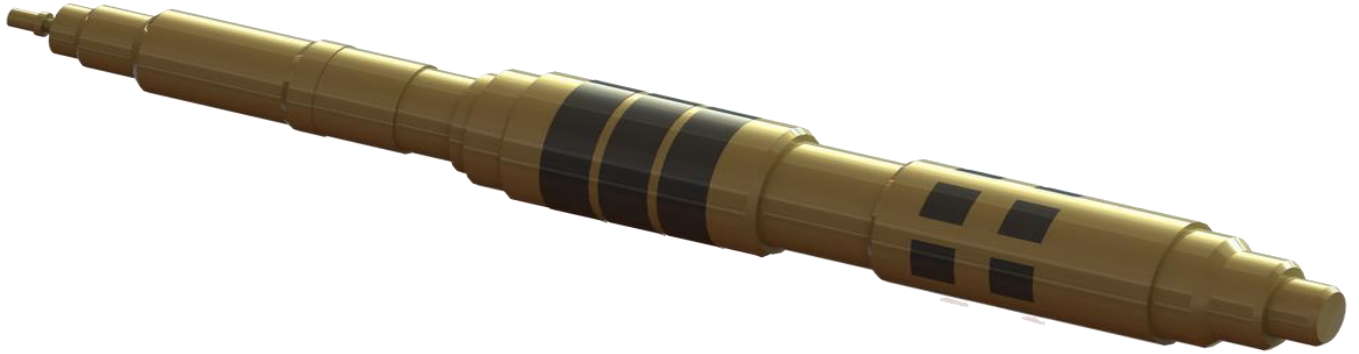


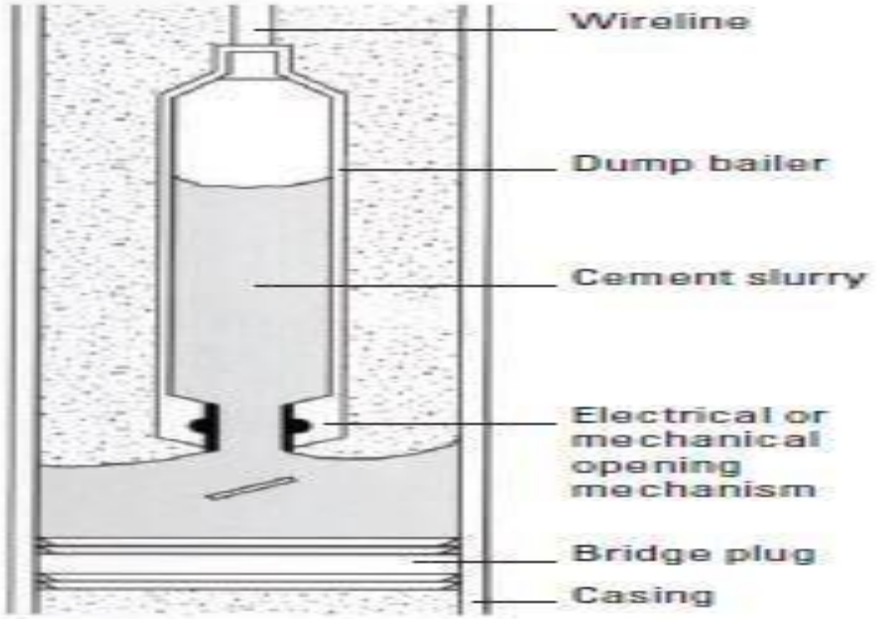
Fig. 3.11- Placement technique used for setting cement plug.

Wireline mechanical set bridge plug



Wireline retrievable bridge plug

Dumping of cement above bridge plug using wireline



Nitrogen kick off or lifting

- Another term for **nitrogen** lift, the use of **nitrogen** gas circulated into the production conduit to displace liquids and reduce the hydrostatic pressure created by the fluid column
- **Nitrogen** lifting is a common technique used to initiate production on a well following workover or overbalanced completion
- A coiled tubing string is generally used to apply the treatment, which involves running to depth while pumping high-pressure nitrogen gas. Once the kill-fluid column is unloaded and the well is capable of natural flow, the coiled tubing string is removed and the well is prepared for production
- Bringing a well on with nitrogen lift to get the initial flow rate or to get it to steady state flow. Commonly used after workovers to jet back heavy brines until the hydrocarbons with associated gas flow into the well and begin natural production

N2 tank

N2 pump

NITROGEN GAS LIFTING WITH COILED TUBING

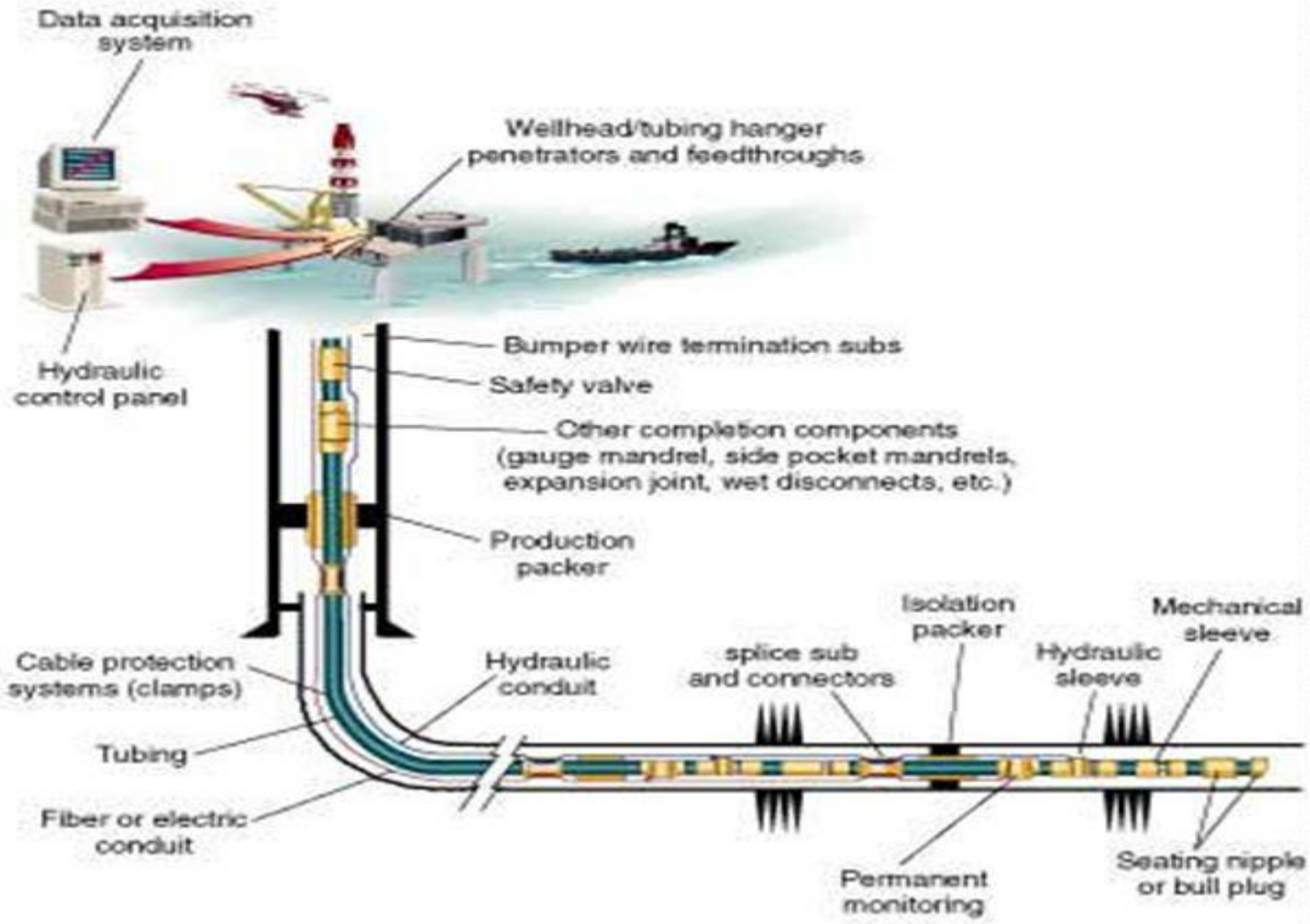
CT conveyed perforation

- The use of **tubing**, drill pipe or coiled **tubing** to convey **perforating** guns to the required depth. Initially, the technique was developed as a means for conveying the gun string on the production **tubing**, with the guns remaining in the well until they are removed during the first workover.
- Deviations above 70 degrees will require coiled tubing to reach the target depth for most situations.
- CT perforating is ideal for live wells. Pressure control techniques are used to run long gun strings and either drop off or retrieve the guns without having to kill the well.
- Depth control is achieved by integrating a casing collar locator and gamma ray detector.
- Perforation is carried out in highly deviated and horizontal wells.

Open and close SSD's in horizontal completion

- Horizontal completions have continued to increase in length and complexity, which has made their design considerably more challenging for completion engineers
- A shifting tool and wireline or CT are used to shift the sleeve open or closed
- Traditional intervention operations with coiled tubing (CT) in extended reach horizontal wells might be difficult to access due to lockup from frictional forces and operational inefficiencies. Using conventional shifting tools requires multiple runs to shift open and close multiple sliding sleeve doors (SSD)

Horizontal Completion



Well stimulation

- **Definition**: well stimulation is a well intervention method performed on an oil, gas or water well to increase production/injection by improving the flow of hydrocarbons from the drainage area to the wellbore or increase water injection

- Well stimulation technique is used for extending the perforation tunnels and fractures

- Types of well stimulation technique:
  1. Acidizing
  2. Hydraulic fracturing

1. **Acidizing**: is also termed as acid stimulation, which refers to using reactive acids to increase permeability in wells
   - ➢ It dissolves various acid-soluble solids naturally present in the rock matrix or as formation damage
   - ➢ There are 2 types of acidizing: matrix acidizing, fracture acidizing. It is characterized by injection rate and pressure

Matrix acidizing: acid is pumped into the formation below the fracture pressure

It removes acid-soluble damage

This method is used for both carbonate and sandstone formations

Fracture acidizing: acid is pumped into the wellbore, above the fracture pressure of reservoir rock. It creates long and open channels.

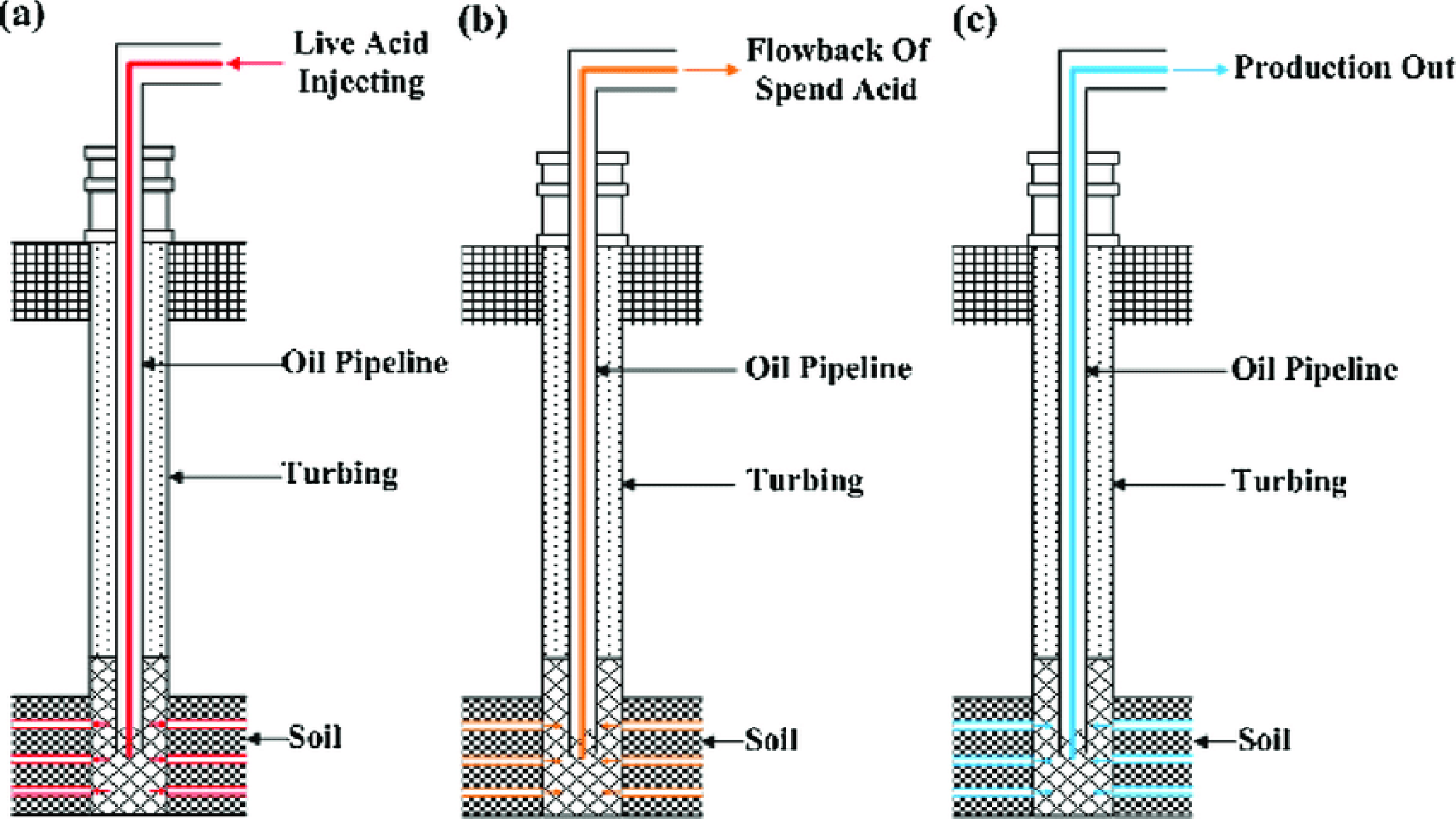
It is usually carried out in carbonate reservoirs, which have lower permeability than sandstone.

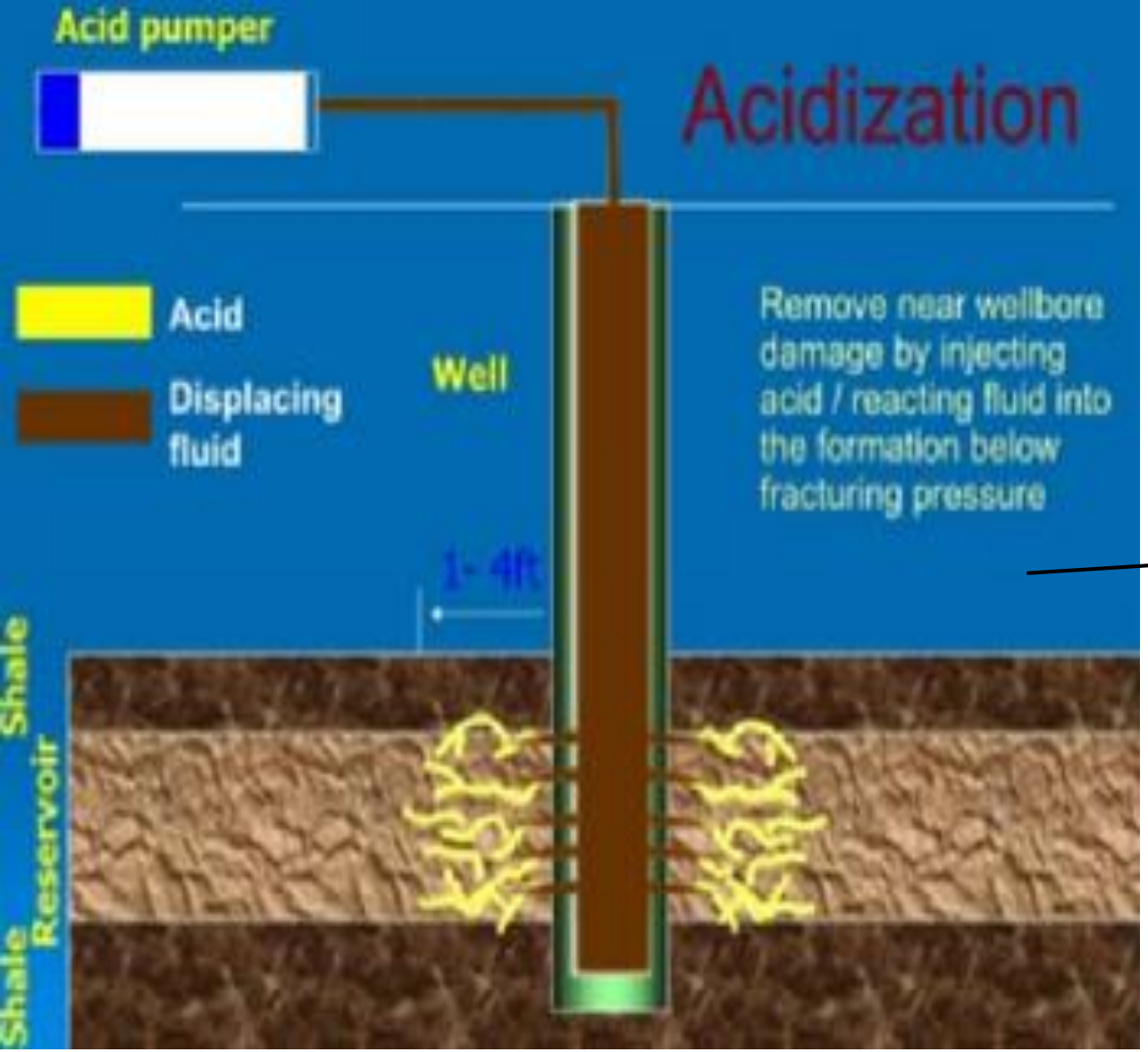
Acid types used in acidizing:

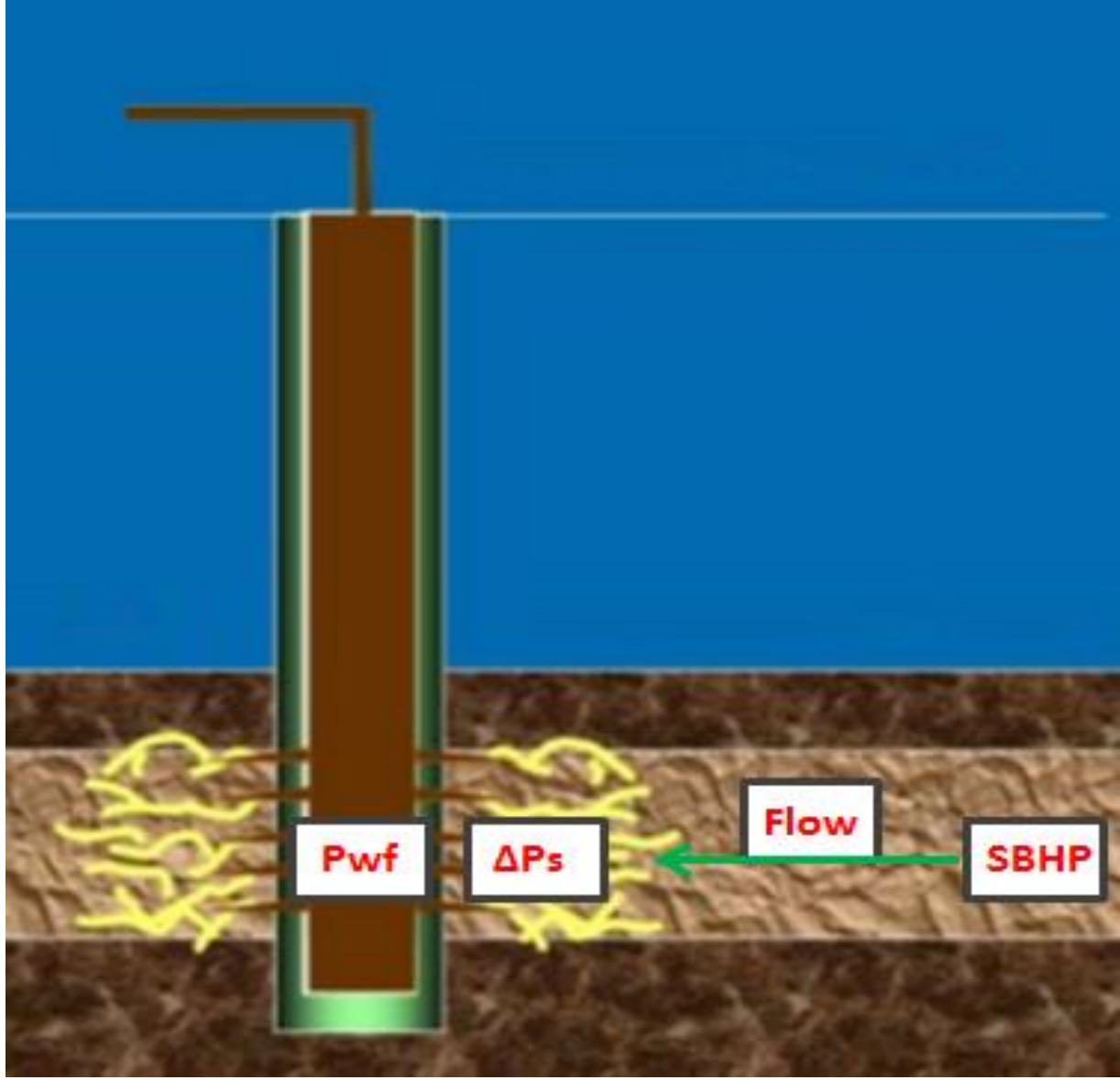
Organic acids: acetic acid CH_3COOH, formic acid $HCOOH$

Non-organic acids: hydrochloric acid HCL, hydrofluoric acid HF, mud acid HCL-HF

Acid additives: corrosion inhibitor, friction reducer, surfactant, iron sequestering agent, diverting agent, non-emulsifier, anti-clay


(a)
Live Acid
Injecting
Oil Pipeline
Turbing
Soil
(b)
Flowback Of
Spend Acid
Oil Pipeline
Turbing
Soil
(c)
Production Out
Oil Pipeline
Turbing
Soil





During stimulation

Post stimulation

2.<u>Hydraulic fracturing</u>: is usually termed as fracking or hydro-fracking.

This stimulation method has 2 major steps:

- ❑Create crack in the rock formation
- ❑Proppant injection

The objective of hydraulic fracturing is to increase well productivity by creating a highly conductive path.

In hydraulic fracturing the rock is fractured by a pressurized liquid, the conductivity is maintained by propping with sand to hold the fracture faces apart

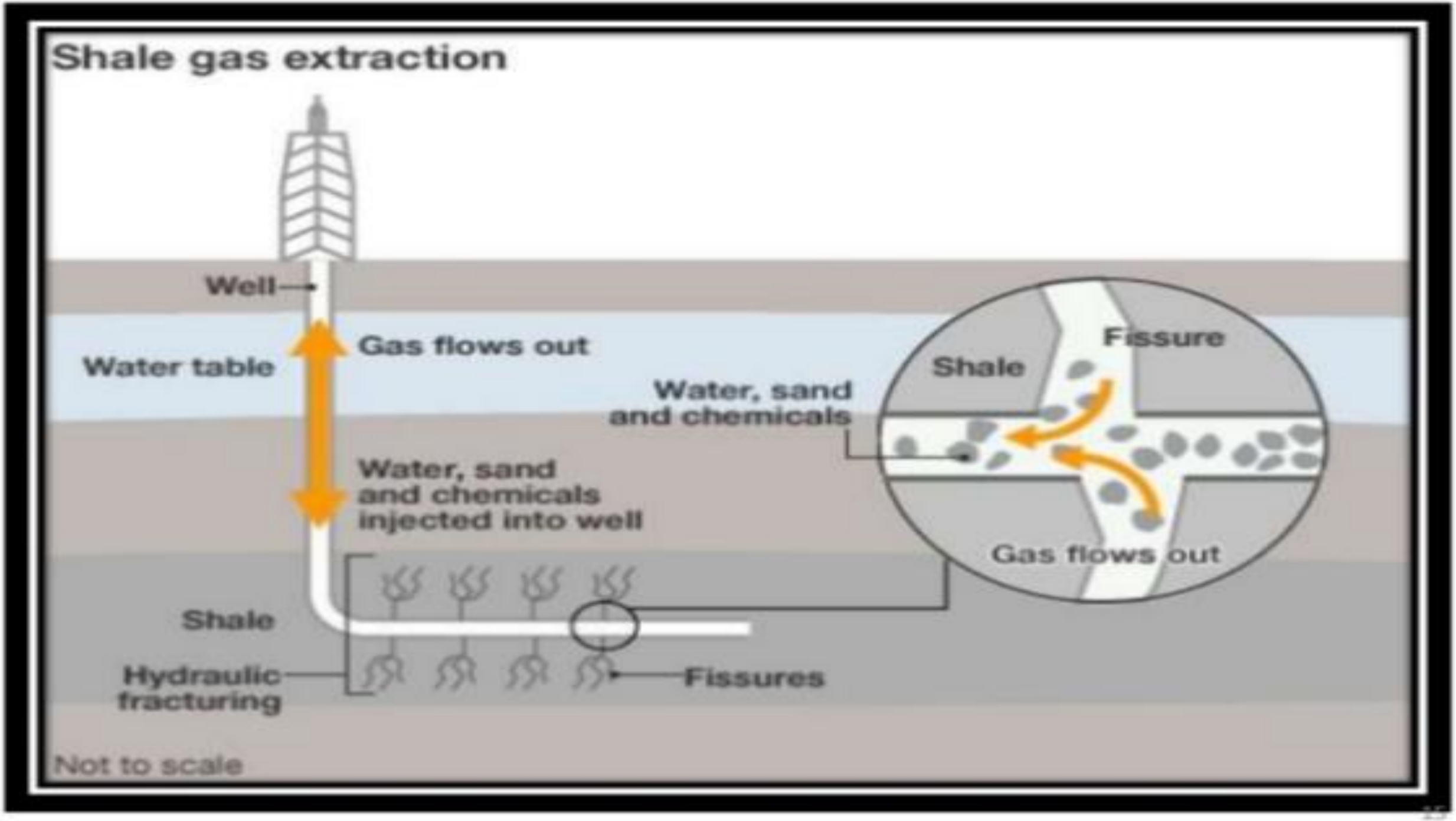
Composition of fracture fluid: water, proppant, gelling agent, foaming agent, compressed gases (N2, CO2, air), corrosion inhibitors

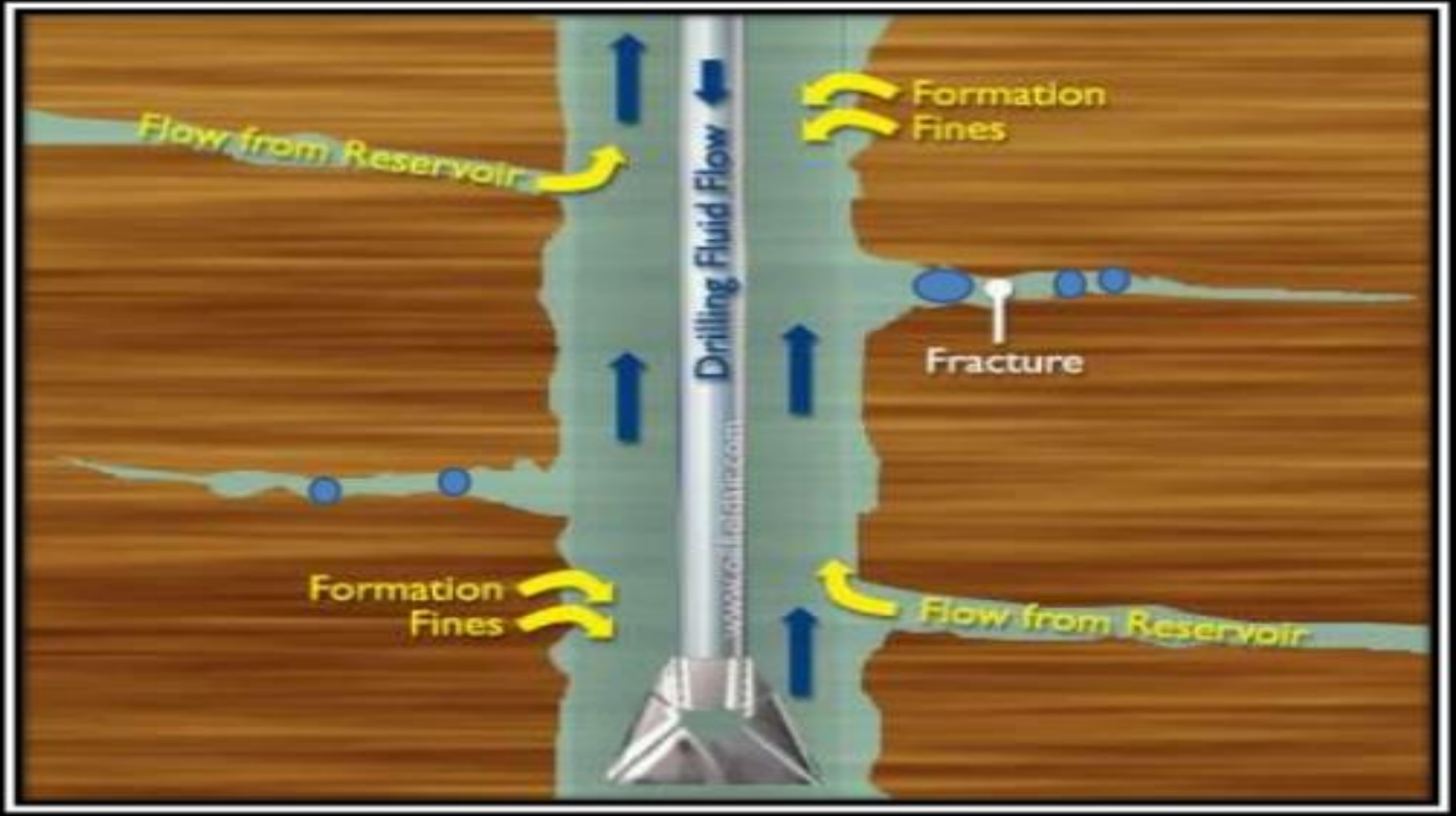
Hydraulic fracturing stages:

1. Spearhead stage: mixing water with acid, used to clear debris and create path way
2. Pad stage: inject fluid before proppant to break the formation
3. Proppant stage: injection of water and sand and remains in formation
4. Flush stage: at last fresh water is pumped into wellbore

Proppant: the proppant is a granular material that prevents the created fractures from closing after the fracturing treatment

Types of proppant: silica sand, resin-coated sand, bauxite, ceramics


Shale gas extraction
Well
Water table
Gas flows out
Water, sand
and chemicals
injected into well
Shale
Hydraulic
fracturing
Fissures
Not to scale
Shale
Fissure
Water, sand
and chemicals
Gas flows out


Flow from Reservoir
Drilling Fluid Flow
Formation
Fines
Fracture
Formation
Fines
Flow from Reservoir

Scale and sand clean out

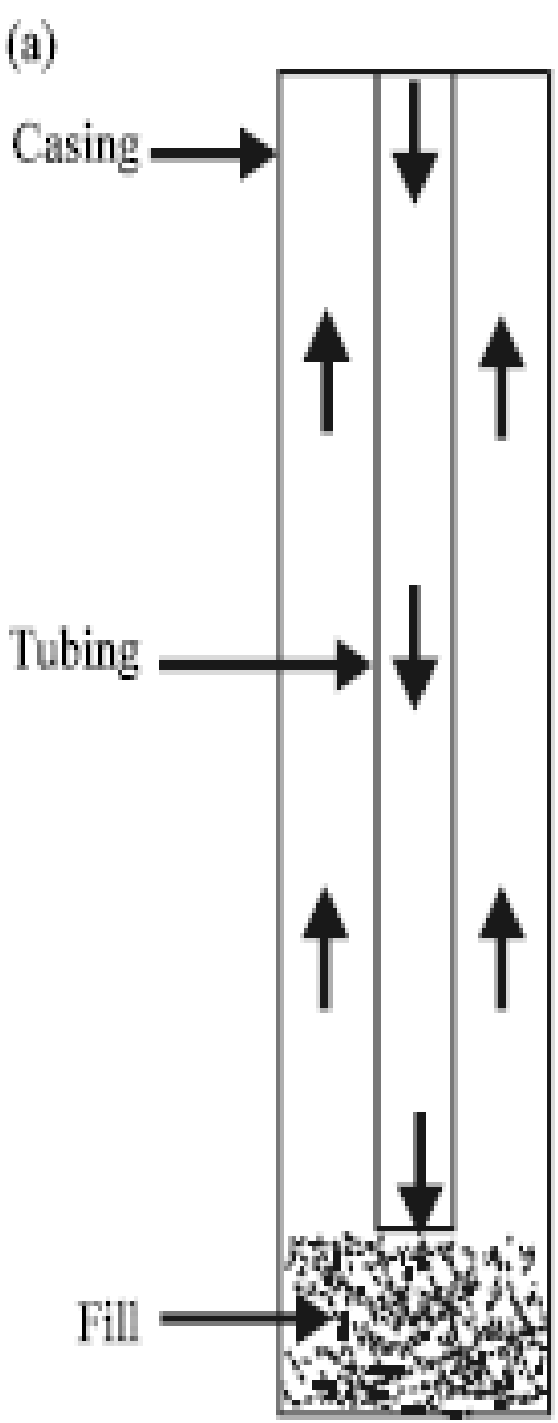
- Cleaning sand from wellbores is a major part of the coiled tubing (CT) industry. The process is a function of multiple variables including fluid properties, flow velocities, hole size and deviation, particle properties and fill penetration rate.
- It becomes even more challenging to successfully remove fill from wells with low bottom hole pressure (BHP) especially if the well is completed with smaller diameter production tubulars which reduce circulation flow cross-section and choke flow.
- The problem is further compounded by high deviation or horizontal well trajectories especially in large diameter wellbores. Several cleanout options have been developed in the past, employing a variety of different approaches.

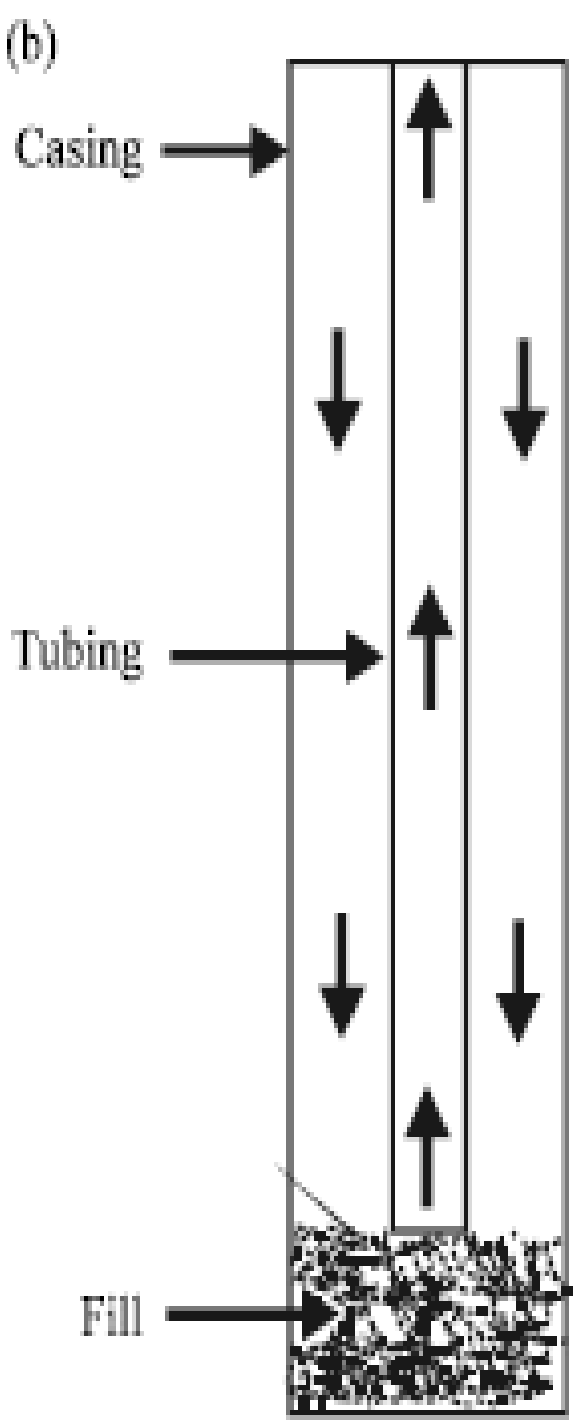
Scale and sand clean out

- CT or conventional jointed pipe often incorporates high circulation rates, special fluids, wiper trip, or reverse circulation mode to remove solids

- Many of these conventional sand cleanout methods often apply excess hydrostatic pressure on the formation, resulting in lost circulation in low formation pressure reservoirs

- The conventional solution to overcome excess hydrostatic has been to include nitrogen to reduce fluid density and thus lessen the hydrostatic head.


(a)
Casing
Tubing
Fill

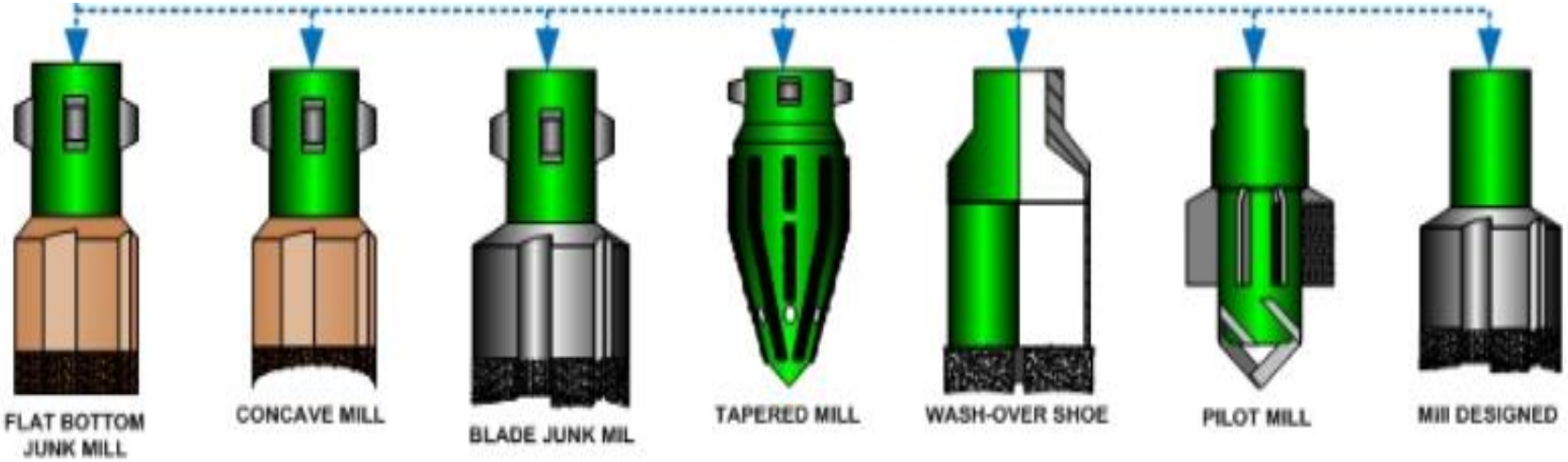

(b)
Casing
Tubing
Fill

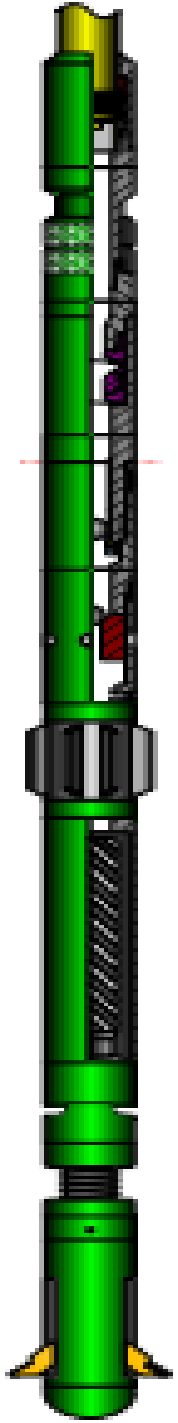
Milling

- In the last decade, the number of horizontal wells drilled in North America has risen dramatically
- As a result, there has been an associated increase in the use of the plug and perforation system and the ball-drop system used to complete these horizontal wells
- After the fracturing treatment has been completed, the bridge plugs or ball seats are subsequently milled out via the use of coiled tubing (CT)

Milling

- During the plug or ball-seat milling phase, it is difficult to control weight-on-bit at the end of the CT
- If the injector releases too much weight at surface, then the weight-on-bit is too high and the downhole motor can experience a stall
- Alternatively, if the injector is not releasing enough weight at surface, then there is insufficient weight-on-bit to mill out the plug or ball-seat
- Given that these operations are performed in horizontal wells, it is difficult to predict the optimal weight-on-bit without the presence of real-time downhole measurements





COILED TUBING CONNECTOR

EXTERNAL SLIP (RECOMMENDED)
INTERNAL SLIP (SLIMHOLE)
DIMPLE-ON (ACCEPTABLE)
ROLL-ON (NOT SUITABLE)

DEPLOYMENT QUICK CONNECTOR
E.G. "CARSAC"

OPTIONAL
FOR SAFER MAKE UP & BREAK-OUT

MOTOR HEAD ASSEMBLY
CONSISTING OF:

DUAL FLAPPER CHECK VALVE

HYDRAULIC DISCONNECT

ACTUATED BY DROP BALL

CIRCULATION SUB

ACTUATED BY DROP BALL
C/W RUPTURE DISC (TYPICALLY 5,000 PSI)

STABILSER

IF REQUIRED
TYPICALLY 1/8" - 1/4" SMALLER THAN
TUBING ID OR NIPPLE ID RESTRICTION

WORKOVER MOTOR

FOR MAXIMUM EFFICIENCY AND MOTOR
LIFE, OPERATE MOTOR AT 85% OF MAX
FLOW RATE AND 80 - 85% OF MAX LOAD

HYDRAULIC TUBING CUTTER

THREE BLADED
SELF CENTRALISING TYPE
DRESSED WITH KNIVES TO SUIT SPECIFIC
TUBING SIZE AND WEIGHT

BULLNOSE

Fishing

- Improved coiled tubing (CT) technology, development of specially-designed hydraulically-actuated service tools, and increased emphasis on cost efficiency have made coiled tubing a viable option for many fishing jobs

- Before the emergence of coiled tubing fishing technology, traditional service procedures included use of wireline to retrieve fish from oil and gas wells

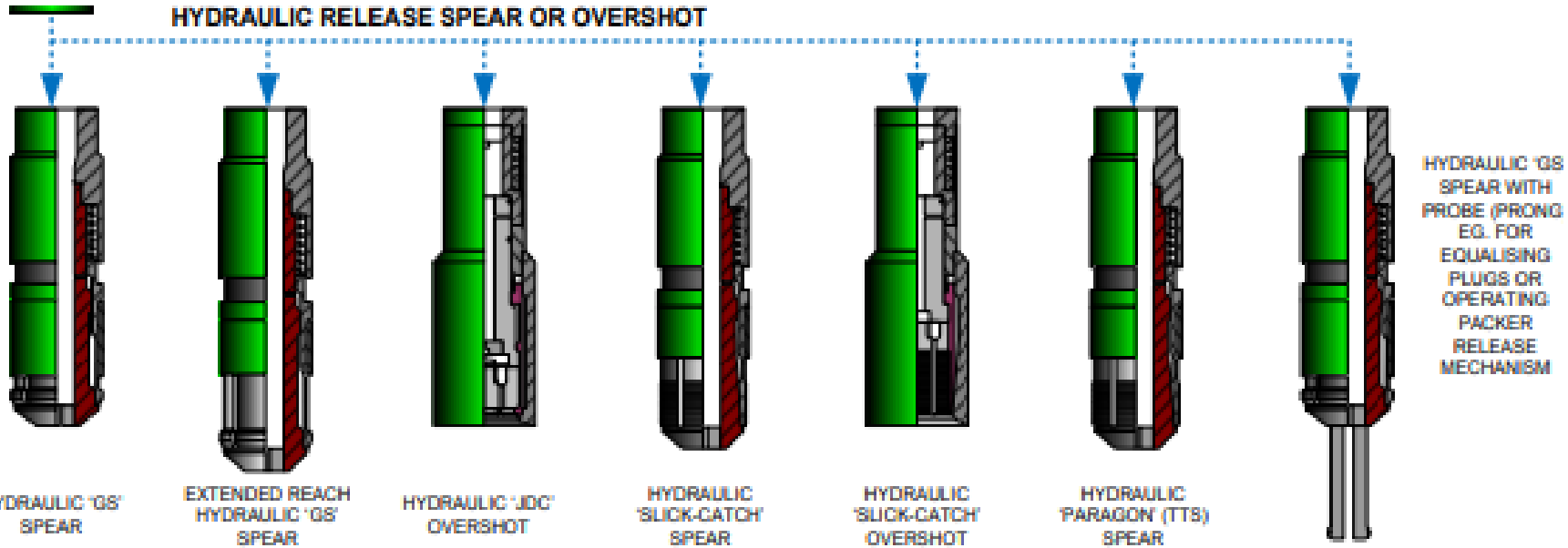
- If wireline was unsuccessful, a rig or hydraulic workover (snubbing) unit had to work over the well and remove the fish

Fishing

- The capability of CT to circulate fluids at the fish and generate high downhole forces enables the retrieval of fish in situations that would not be possible or cost effective by other service options.

- CT fishing can be performed under pressure on live, highly-deviated or horizontal wells; the job can be completed and the well returned to production within 1 to 3 days for only a fraction of the cost of a workover

HYDRAULIC RELEASE SPEAR OR OVERSHOT



HYDRAULIC 'GS' SPEAR

EXTENDED REACH HYDRAULIC 'GS' SPEAR

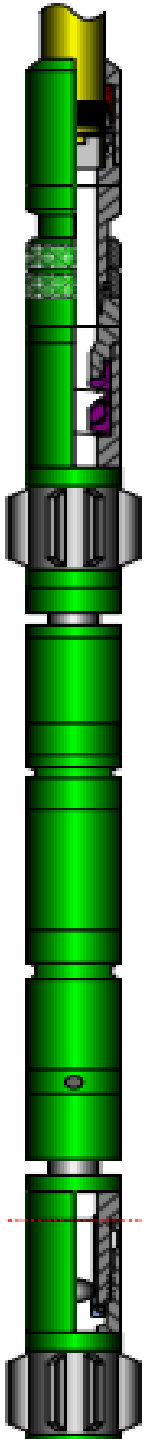
HYDRAULIC 'JDC' OVERSHOT

HYDRAULIC 'SLICK-CATCH' SPEAR

HYDRAULIC 'SLICK-CATCH' OVERSHOT

HYDRAULIC 'PARAGON' (TTS) SPEAR

HYDRAULIC 'GS' SPEAR WITH PROBE (PRONG) EG. FOR EQUALISING PLUGS OR OPERATING PACKER RELEASE MECHANISM



COILED TUBING CONNECTOR

EXTERNAL SLIP (RECOMMENDED)
INTERNAL SLIP (SLIMHOLE)
DIMPLE-ON (NOT RECOMMENDED)
ROLL-ON (NOT SUITABLE)

DEPLOYMENT QUICK CONNECTOR
EG. "CARSAC"

OPTIONAL
FOR SAFER MAKE-UP & BREAK-OUT

DUAL FLAPPER CHECK VALVE

STABILSER

IF REQUIRED

BI-DI ACCELERATOR (INTENSIFIER)

OPTIONAL. FOR INCREASING JAR HIT
BUT MUST BE USED FOR SHALLOW FISHING

WEIGHT BAR(S)

OPTIONAL. TO INCREASE JARRING "IMPULSE"
ONLY USE IF LUBRICATOR LENGTH ALLOWS

BI-DI JAR

HYDRAULIC JARS HAVE MOSTLY OBSOLETED MECHANICAL JARS.

HEAVY DUTY HYDRAULIC DISCONNECT

ACTUATED BY DROP BALL
C/W RUPTURE DISC (TYPICALLY 5,000 PSI)

STABILSER

IF REQUIRED

Pumping: the simplest form of intervention like pumping the chemicals into the well

Coiled tubing: is used when it is desired to pump chemicals directly to the bottom of the well such as circulating operations or chemical works

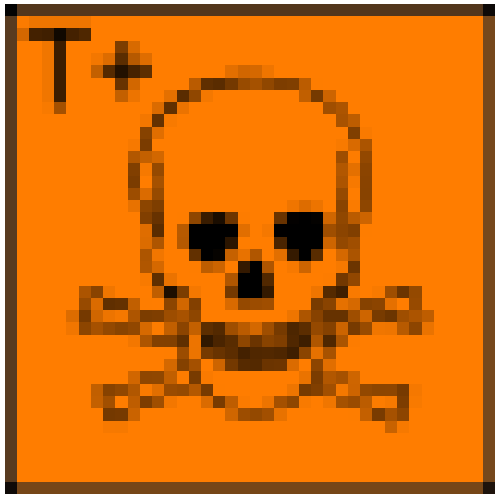
It can also be used for tasks normally done by wire line if the deviation in the well is too severe for gravity to lower the tool string and circumstances prevent use of wire line

- Pumping applications:

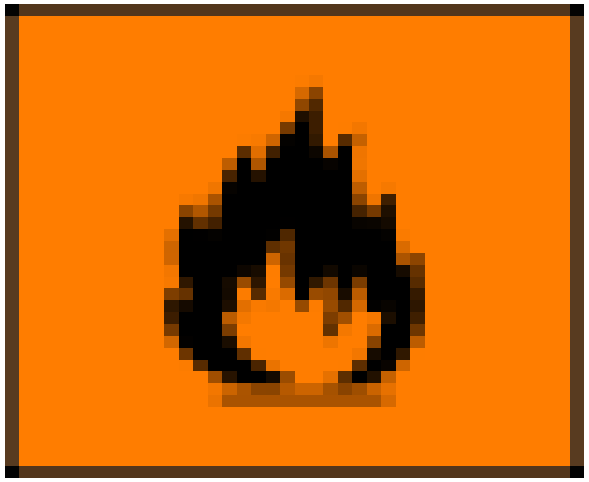
1. Removing sand or fill from a wellbore
2. Fracturing/acidizing a formation
3. Unloading a well with nitrogen
4. Gravel packing
5. Cutting tubular with fluid
6. Pumping slurry plugs
7. Zone isolation (to control flow profiles)
8. Scale removal (hydraulic)
9. Removal of wax, hydrocarbon, or hydrate plugs

Working in H2S environment

- H2S definition: h**ydrogen sulfide** is the chemical compound with the formula H_2S.
- It is a colorless gas with the characteristic foul odor of rotten eggs. It is poisonous, corrosive, and flammable.
- H_2S occurs in volcanic gases, natural gas, and in some sources of well water.
- It is heavier than air and its molar mass is 34 gr per mole while air is 28 gr per mole
- Hydrogen sulfide is slightly soluble in water and acts as a weak acid
- Hazardous to personnel, can kill at concentration of 1000ppm
- Corrosive to material and can lead to metal brittlement under pressure



Very toxic



Extremely flammable

Dangerous to the environment

Hydrogen sulfide is slightly denser than air; a mixture of H_2S and air can be explosive.

Hydrogen sulfide burns in oxygen with a blue flame to form sulfur dioxide (SO

$_2$) and water


CAUTION
H2S MAY BE PRESENT
DO NOT ENTER THIS AREA WITHOUT APPROVED H2S DETECTION EQUIPMENT


DANGER
HYDROGEN SULPHIDE
(H2S)
Poison Gas
Produced Here
EXTREME CAUTION
AUTHORIZED ADMISSION ONLY
NO SMOKING OR OPEN FLAME
MUST WEAR PERSONAL PROTECTIVE EQUIPMENT
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What is risk assessment matrix?

- A **risk assessment matrix** is an important part of the **risk** management decision-making process
- The **risk matrix** is a visual representation of the **risk analysis**. It presents the **risks** as a graph, rating them by category of probability and category of severity.
- A risk assessment matrix can help you calculate risk quickly. It does this by identifying the things that could go wrong and weighting the potential damage. This makes it easy to prioritize problems. Action will be needed in order to keep a project on course, and safe as well.
- Any risk assessment matrix means that you will need to check probabilities and consequences of risk events that might happen. The results of such assessments are used to make a top of risks in order to find the most important ones, as well as less critical ones.

Hazard analysis and risk assessment matrix with proposed actions

HAZARD LIKELIHOOD	HAZARD SEVERITY				
	Critical Illness or Injury	Severe Illness or Injury	Moderate Illness or Injury	Minor Impact	Negligible Impact
Very Likely	Requires Control	Requires Control	Requires Control	Manageable	Manageable
Likely	Requires Control	Requires Control	Manageable	Manageable and Tolerable	Tolerable
Possible	Requires Control	Manageable	Manageable and Tolerable	Tolerable	Acceptable
Unlikely	Manageable	Tolerable	Tolerable	Acceptable	Acceptable
Highly Unlikely	Tolerable	Acceptable	Acceptable	Acceptable	Acceptable