
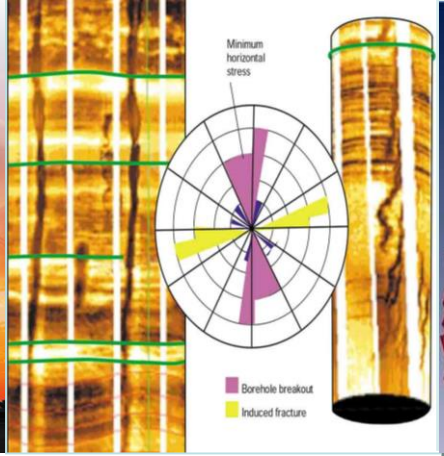

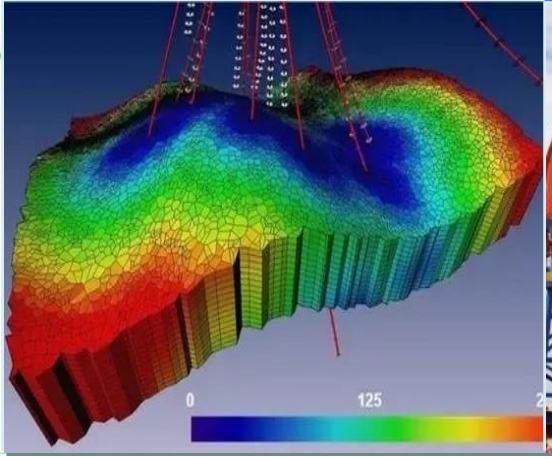



# Fundamentals of petroleum Engineering

## Part : 7
## Workover and analysis well problems

By
Petroleum Engineer
**Abbas Radhi Abbas**
Iraq / Missan / 2020

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**Contents**
Workover and analysis well problems

1. Define of workover
2. Applications of workover operation
3. Types of workover operation
4. Analysis well problem
5. Well operations through the life of a well

# Contents



1. Define of workover
2. Application of  Workover operation?
3. Types of workover operation
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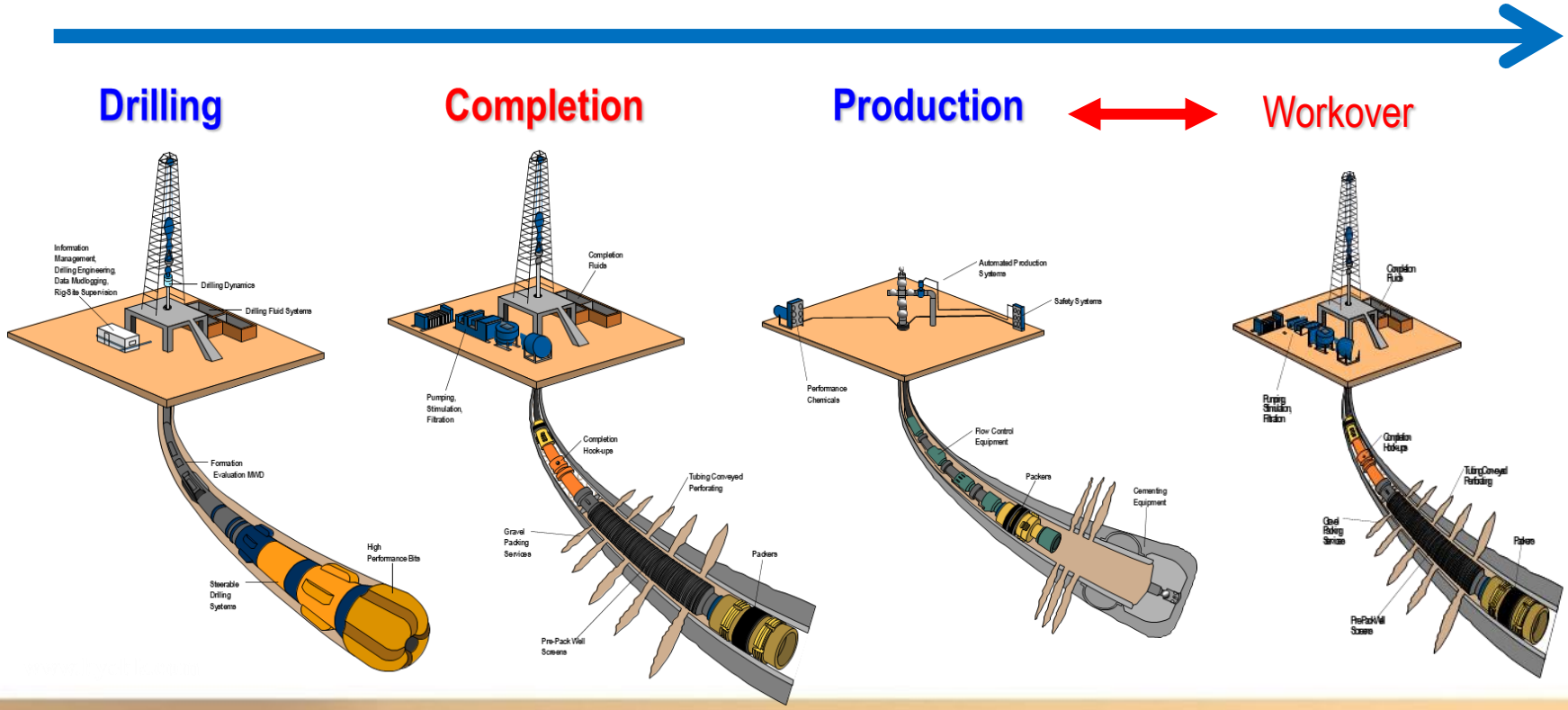
# 1. Define of workover

Workover : is defined as every operation, for any purpose, which is done in the well after the well completion and put well in to production; by using a rig ( drilling rig or workover rig ) or rigless operation .



# Contents



1. Define of workover
2. **Application of Workover operation?**
3. Types of workover operation
4. Analysis well problem
5. Well operations through the life of a well

# 2. Application of Workover Operations

**There is a long list of work over operations that can be conducted in active or inactive wells, as follows:**

1. Repairing of down hole tools and equipment due to malfunction or damage
2. Repairing of well head and surface installations
3. Mechanic clean up of solid deposits
4. Sand production control
5. Artificial lift equipment installation and maintenance
6. Formation stimulations
7. Isolation of non wanted producing intervals
8. Remedial cementing
9. Routine well maintenance & well servicing

# 2. Application of Workover Operations

10. Re-entry Well operations
11. Formation testing
12. Well control operations in cased hole
13. Well re-completion
14. Fishing operations
15. Changes in well function or in well objectives
16. Well suspension and temporarily abandonment
17. Well abandonment
18. Etc .

# Contents

1. Define of workover
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3. Types of workover operation
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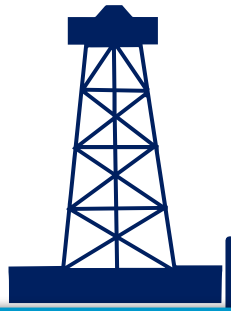
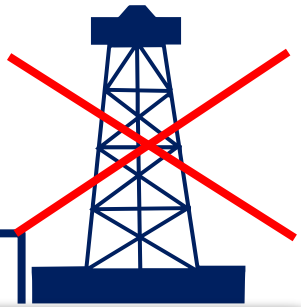
# 3.Types of Workover Operation



**( Workover Operations )**



**1.Rig Operation**

1. Workover Rig
2. Drilling Rig

**2.Rigless Operation (Well intervention)**

1. Coiled tubing
2. Wireline logging
3. Slick Line Unit
4. Snubbing Unit

## 1. Rig Operation

### Uses for workover Rig

- Milling packer & Bridge plug
- Hard fishing
- Perforate (TCP)
- Install tubing or downhole equipment
- Install artificial lift equipment (ESP …ect)
- Plug off old zones
- Make well repairs
- Plug and abandon
- etc



Workover Rig

## 2.Rigless Operation (Well Intervention)

**Well intervention:**

An operation carried out on an oil or gas well to extend its producing life by improving performance or providing access to stranded or additional hydrocarbon reserves

**Well life cycle :**



# 3.Types of Workover Operation

## 2.Rigless Operation (Well Intervention)

1. Coiled Tubing Unit (flexible coiled tubing)
2. Snubbing Unit
3. Wireline logging Unit
4. Slick Line Unit

# Rigless Operation (Well Intervention)



Coiled tubing



Slik-line unit

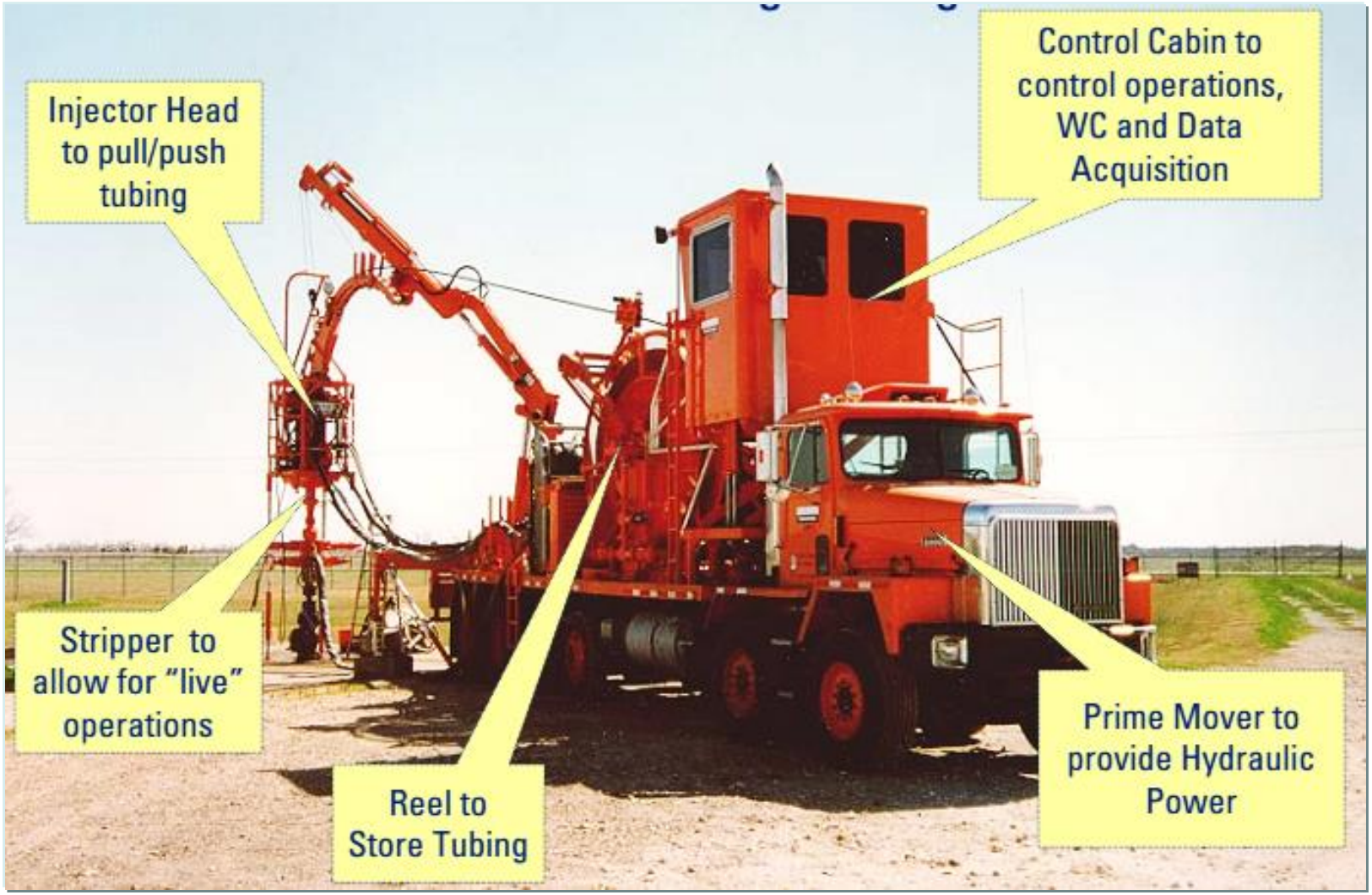


Workover rig



snubbing unit

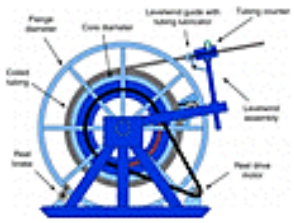
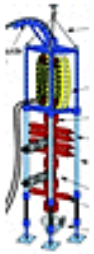
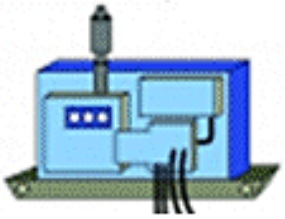
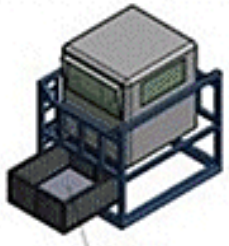
# 1.Coiled Tubing Equipment



# 1.Coiled Tubing Equipment

The package of equipment required to run a coiled tubing operation. Four basic components are required:

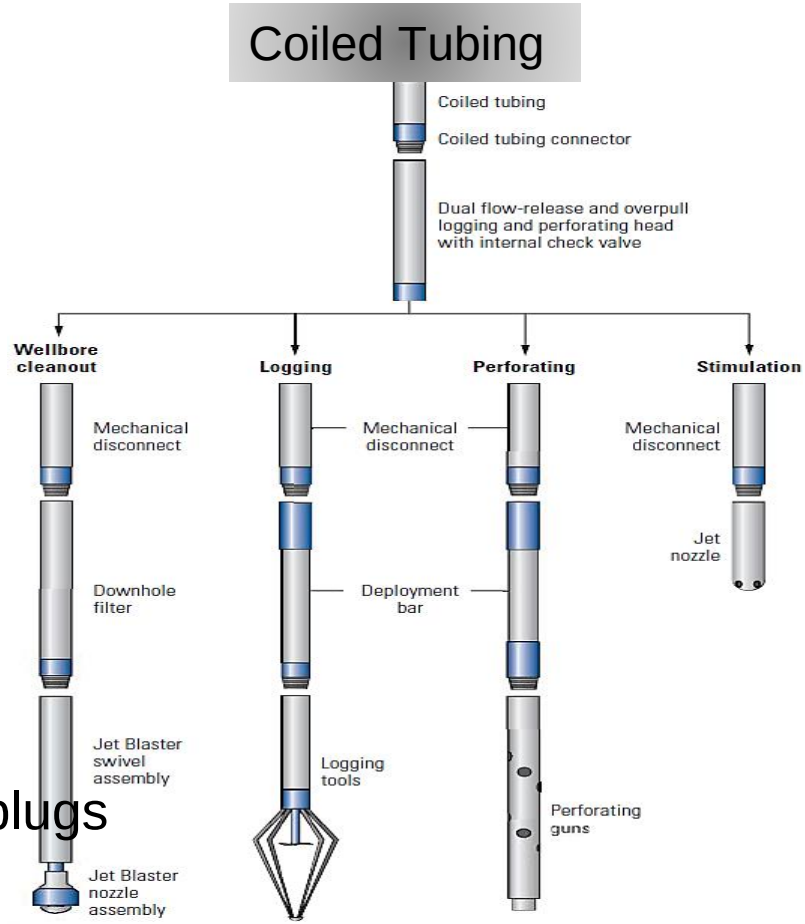
1. **Reel :** to store and transport the coiled tubing string
2. **Injector head :** to provide the tractive effort to run and retrieve the coiled tubing string
3. **Control cabin :** from which the equipment operator controls and monitors the operation
4. **Power Uint :** that generates the necessary hydraulic and pneumatic power required by the other components.

| Reel | Injector Head | Power Unit | Control Cabin |
|---|---|---|---|
|  |  |  |  |
| For storage and transport of the CT | Provides the surface drive force to run and retrieve the CT | Generate hydraulic and pneumatic power required to operate the CT unit | From which the equipment operator monitors and control the CT |

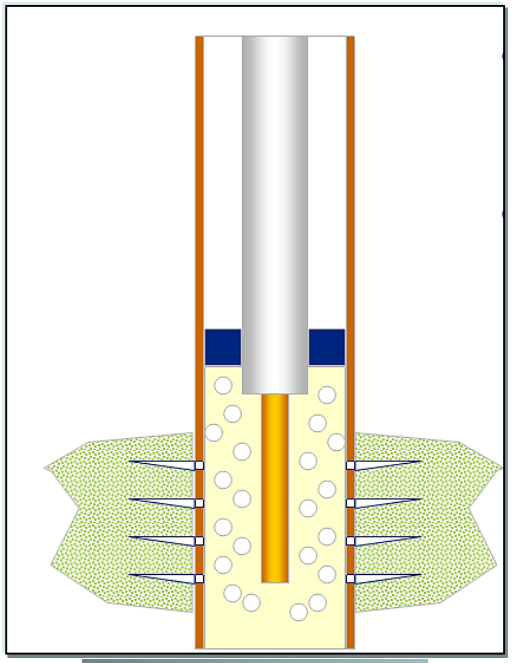
# 1.Coiled Tubing Applications

**CT : use in vertical , deviated and horizontal wells , many Application but not limited such as :**

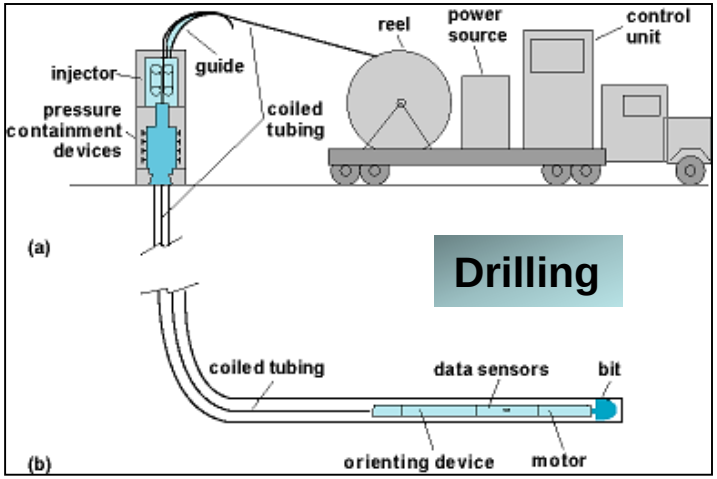
1. Drilling
2. Logging
3. Perforating
4. Stimulation ( Acidizing , fracturing)
5. Nitrogen lifting
6. Removal sand from wellbore
7. Wellbore cleanout ( asphalt…etc)
8. Remedial cementing
9. Setting and retrieving bridge plugs
10. Running packer
11. CT an flow line
12. Removal Wax , Scale and hydrate plugs
13. fishing
14. Etc……

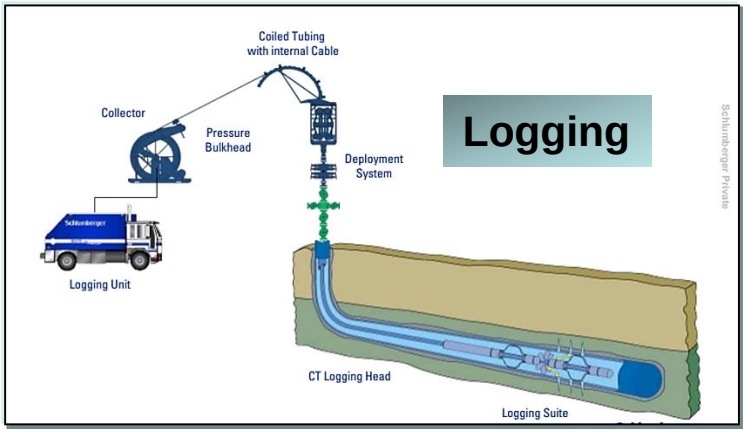


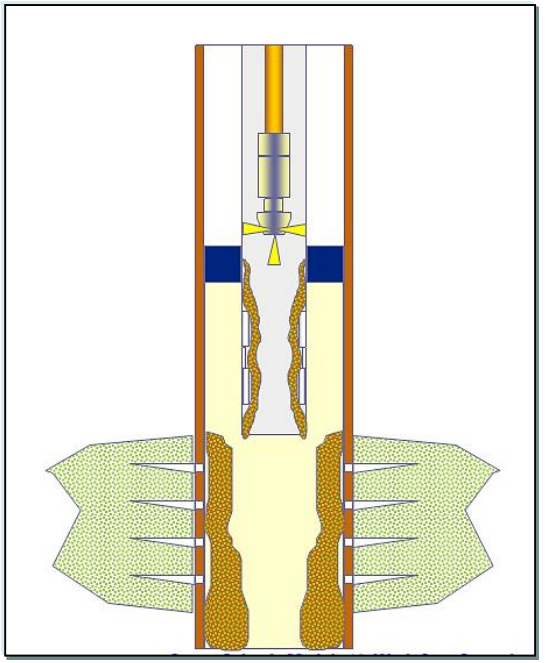
# 1.Coiled Tubing Applications



Nitrogen lifting



Removal Wax ,
Scale and hydrate plugs

# 2.Snubbing units

Snubbing units : use hydraulic pressure and rams to introduce small, coupled tubing into the well, if necessary, against pressures above 5000 psi. The tubing is stronger and can be rotated so that tougher cleanout or fishing jobs can be accomplished. Snubbing units are used for the same type of jobs as are coiled tubing units, but their compactness is an advantage in offshore work. They are slow and expensive, but in the right applications, they are the more economical way to accomplish the task.



# 3.Wireline logging

Cased hole logging very important for  Diagnostic problems before do workover

## Cased Hole logging

1.Cement evaluation log :

- normal CBL , VDL , GR , CCL
- Image cement evaluation

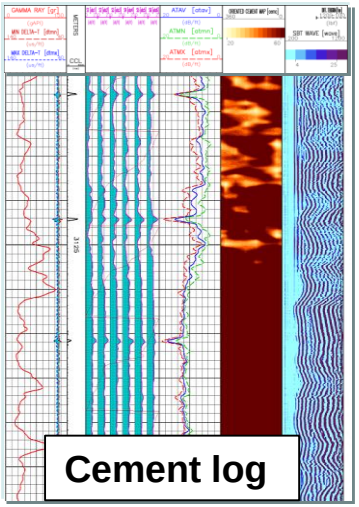
SBT , URS , RIB , RBT , USI , USIT , CAST , SCMT

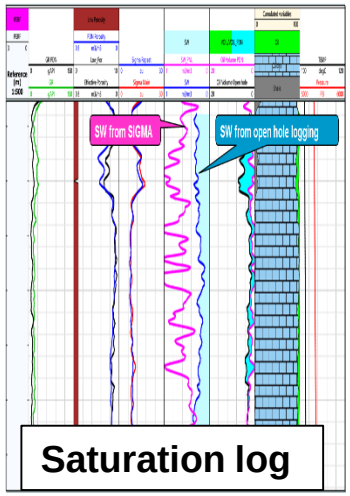
2. production logging tools ( PLT)

3. saturation log ( RST , RST-pro , PNN , TDT , PNX , RMT

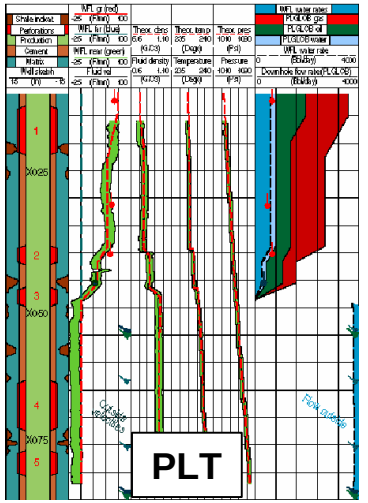
4. Casing inspection log ( MFC , MIT , USIT , EET )

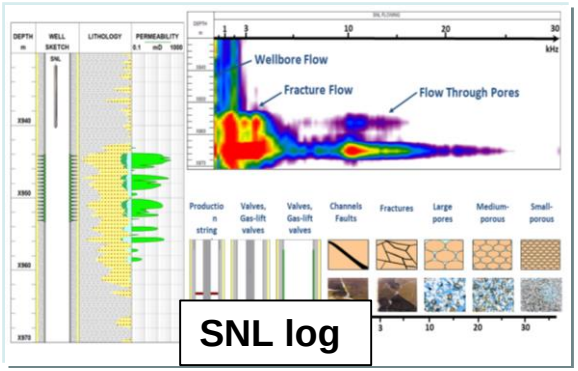
5. SNL (SPECTRAL noise log ) .


Cement log

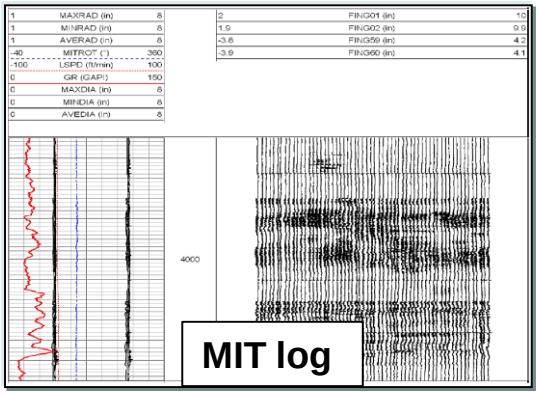


Saturation log


PLT



SNL log


MIT log

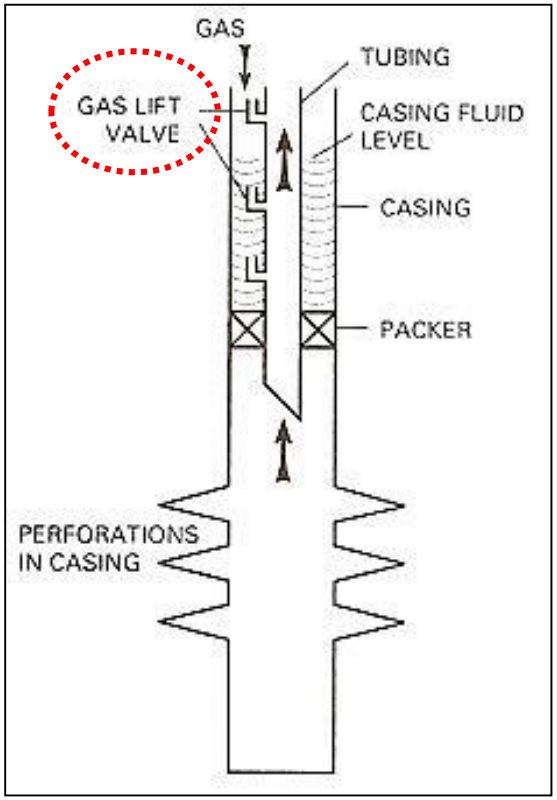
# 4.Slickline Applications

**Slickline** :is a thin cable introduced into a well to deliver and retrieve tools downhole. use in vertical and deviated wells . slicklines are single-strand non-electric cables lowered into oil and gas wells from the surface. Used to place and recover wellbore equipment, such as

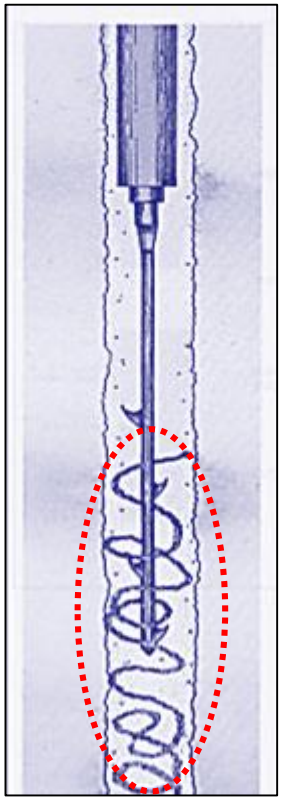
1. Plugs,
2. Memory Gauges
3. Retrievable safety valves
4. Retrieving gas lift valves
5. Open and close SSD
6. Perforation
7. Fishing ( some time ).
8. etc



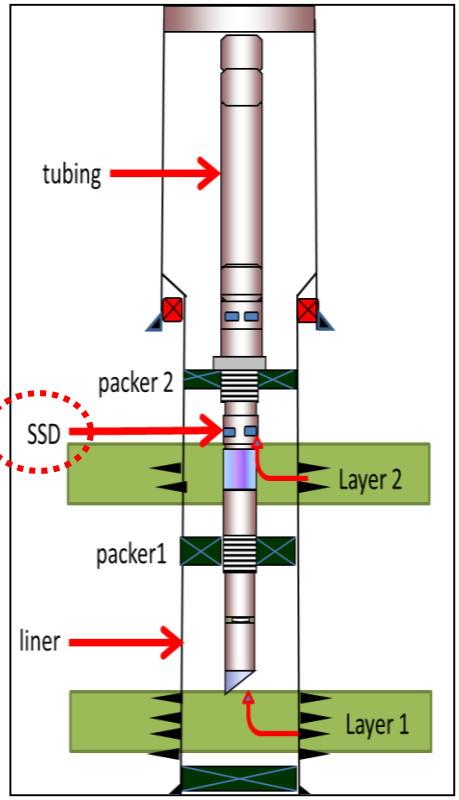
# 4.Slickline Applications



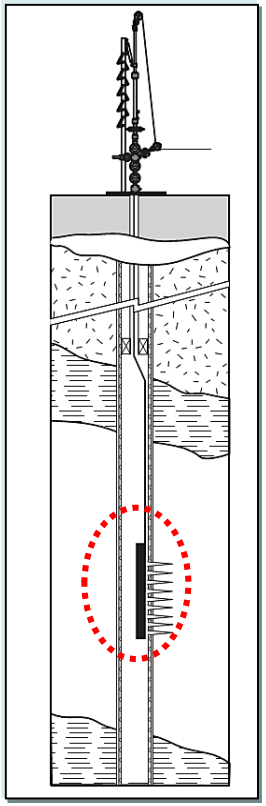

retrieving gas lift valves



Fishing



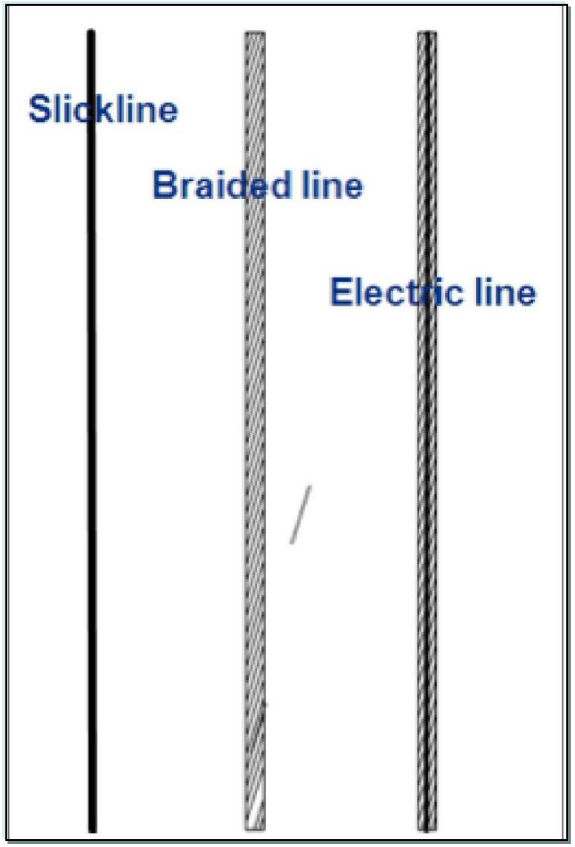

Open and close SSD



Perforation

# 4.Slikline Applications

Three type of line :




1. **Slikline :** is a thin cable introduced into a well to deliver and retrieve tools downhole. are single-strand non-electric cables lowered into oil and gas wells from the surface.

2. **Braided line :** can contain an inner core of insulated wires which provide power to equipment located at the end of the cable, normally referred to as electric line. Provides a pathway for electrical telemetry for communication between the surface and equipment at the end of the cable.

3. **Wireline:** Electric cables lowered into oil and gas wells from the surface. Use for open and cased hole logging

# Contents

1. Define of workover
2. Application of  Workover operation?
3. Types of workover operation



4. Analysis well problem
5. Well operations through the  life of a well

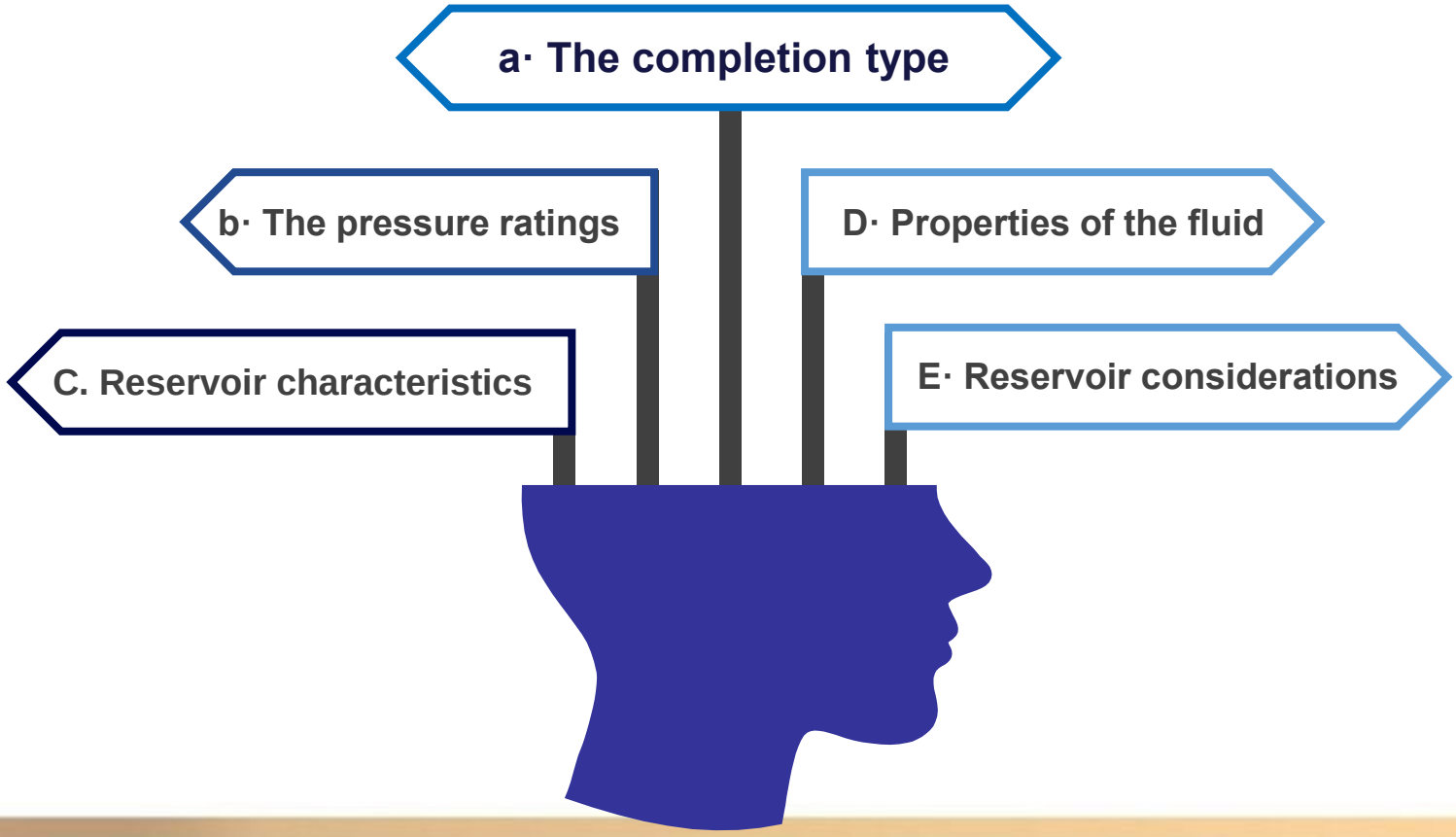
## WELL ASSESSMENT – DETERMINING THE PROBLEM

Prior to performing a workover, the well problem be analyzed to determine the cause of the problem. It is important important to determine whether the problem is associated with properties of the reservoir or with the well itself. A through pre-workover evaluation can increase the cost effectiveness of the entire operation.

1. Well and Completion Characteristics ·
2. Well History ·
3. Offset Well Performance ·
4. Geological Data, Maps and Cross Sections ·
5. Open-hole Logs and Core Data ·
6. Well Tests ·
7. Production Logs ·
8. Special Surveys

## 1.Well and Completion Characteristics…..

The current condition of the well may limit the types operations that can be performed during a workover. 5 Factors to consider include :



## 1.Well and Completion Characteristics…..

The current condition of the well may limit the types operations that can be performed during a workover. Factors to consider include

**a· The completion type** and down-hole equipment in place may preclude the use of certain workover operations or require additional procedures, such as pulling the tubing, prior to performing the workover.

**b· The pressure ratings** of casing, tubing and wellhead equipment are critical to operations that require application of pressure – e.g., stimulation treatments, squeeze cementing, and sand control. Pressure ratings are also important if the well is being recompleted to a higher-pressure interval.

## 1.Well and Completion Characteristics…….

**C. Reservoir characteristics** : such as pressure, sand consolidation, and susceptibility to damage can influence the success of workover operations or at least dictate the use of special procedures.

**D· Properties of the fluid** currently being produced, as well as any new fluids to be produced as a result of the workover, must be known. These properties are important because of the potential for hazards, such as H2S, which may require protective equipment for personnel. In addition, the corrosivity of the fluid is critical in establishing the quality and cost of equipment to be used in the workover.

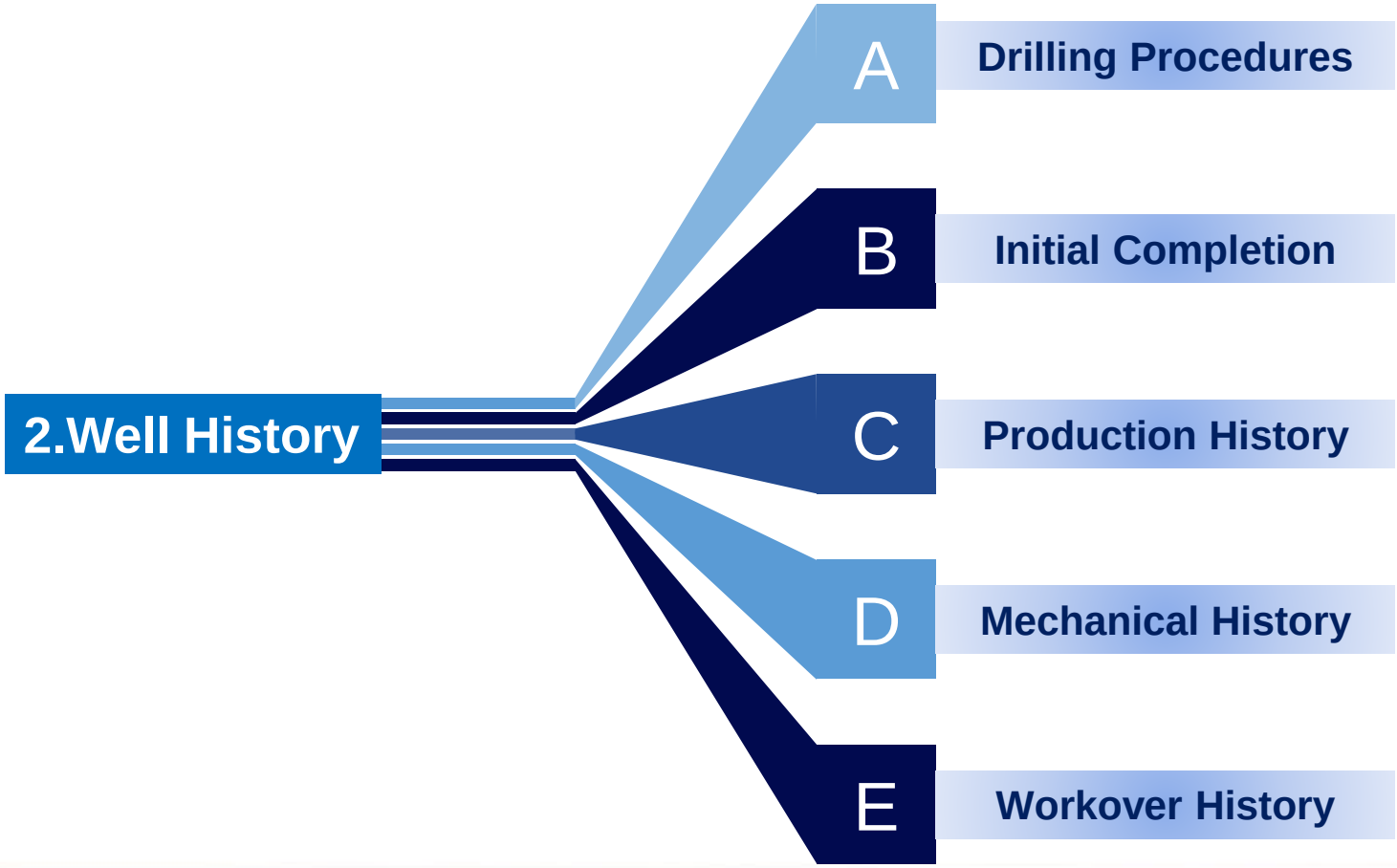
## 1.Well and Completion Characteristics

**E· Reservoir considerations** such as recovery desired, type of drive mechanism relative structure position, current and allowable productivity, forecasted behavior, and possible recovery by offset wells must be considered when planning the type of workover operation to perform. These factors must be considered both for the current producing zone(s) and for alternate or future producing zones.

,

## 2.Well History

Six Factors to consider when evaluating the well history include :----



## 2.Well History

Factors to consider when evaluating the well history include :

### A Drilling Procedures

What procedures were used to drill the well? Did the fluids used cause or have the potential to cause formation damage? Were there indications of lost returns?

### B Initial Completion

When was the well completed? The age of the well gives information regarding the likelihood of corroded casing, weak tubulars, or damaged down-hole equipment.

## 2.Well History

Factors to consider when evaluating the well history include :----

C **Production History** – The nature and reservoir pressure of produced fluids (both current and past0 should be determined. The rates and ratios of gas-oil and water-oil production, the dates water or gas production first appeared, changes in oil production capability and trends in surface pressures should also be considered. ·

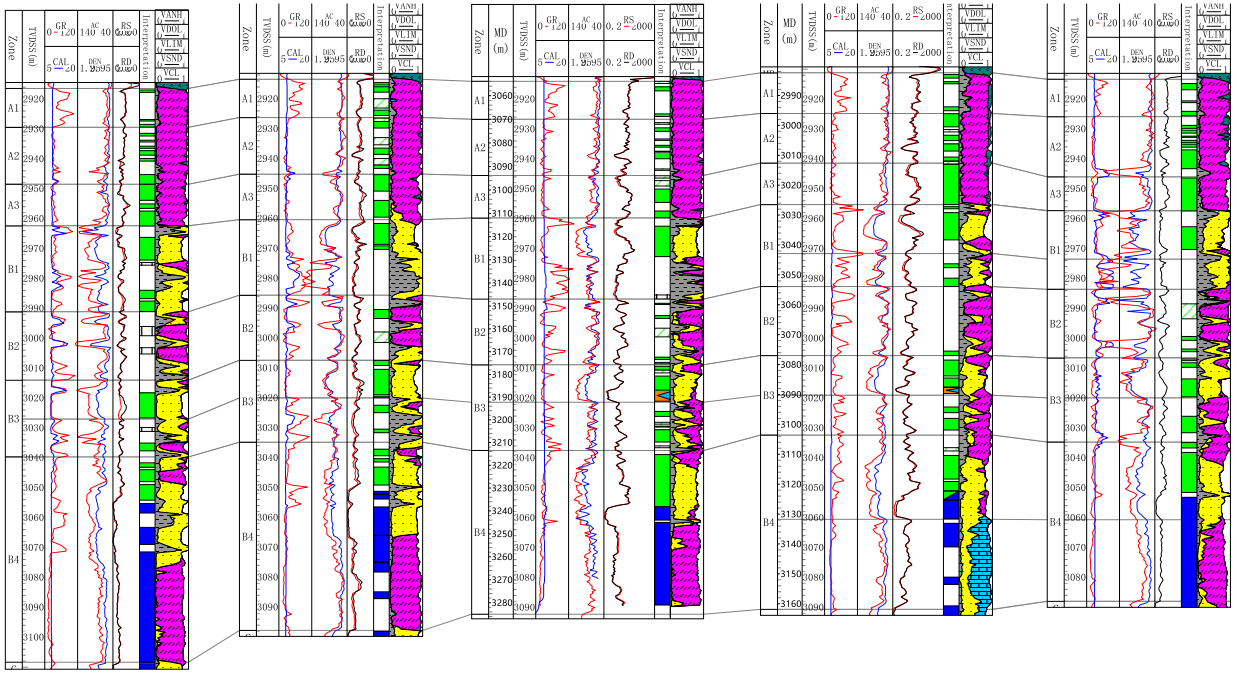
D **Mechanical History** – A good mechanical review may preclude the successful application of some workover techniques. Factors to consider include wellbore restrictions, pipe made weak from corrosion, known poor cement jobs, and perforations sealed by squeeze cement jobs. The corrosion history, including tubular caliper records, should be consulted if applicable. ·

E **Workover History** – The results of past well servicing and workover operations should be studied, including procedures used. Reasons for, and results of, past workover operations may give indications of the source of the current problem.

# 4.Analysis Well problems

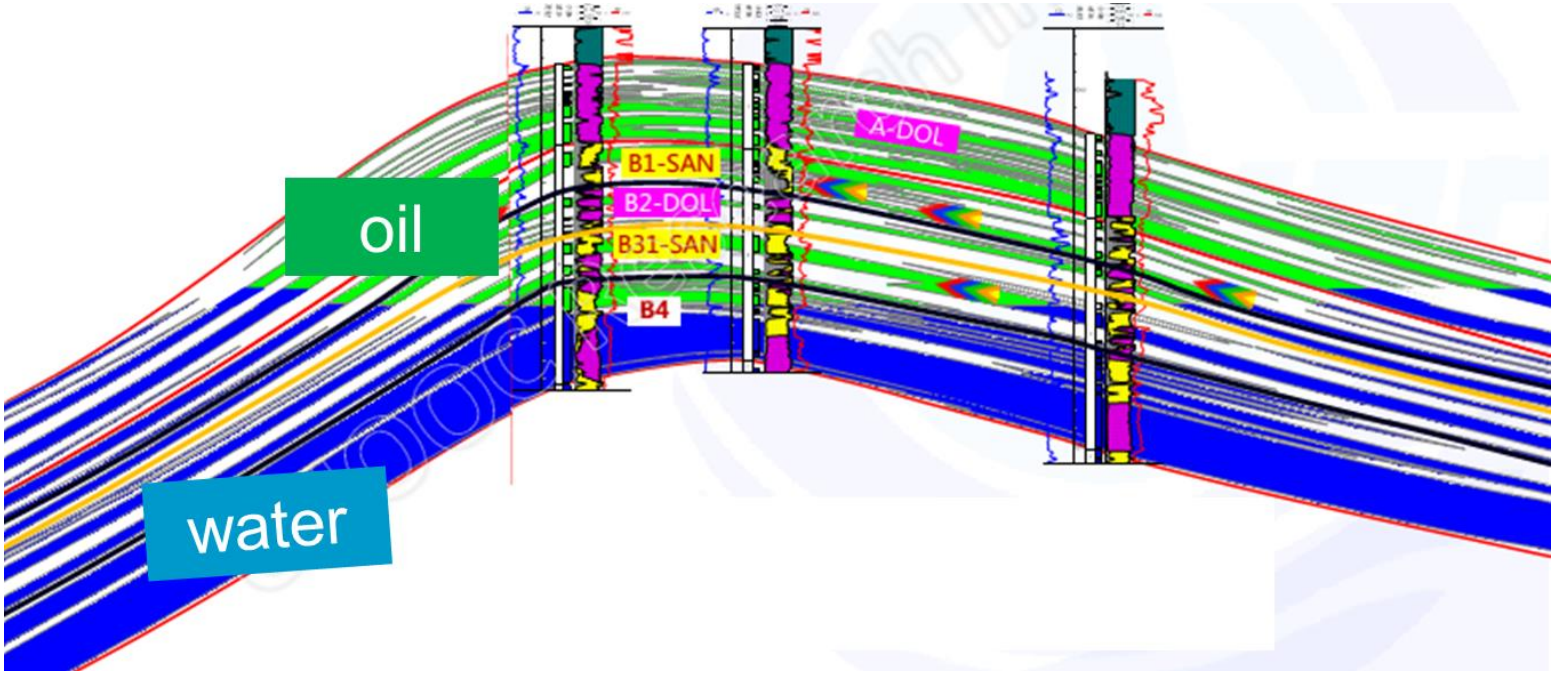
## 3. Offset Well Performance

The history, workover experience, and performance of offset wells can be compared to that of the well in question. These data can give insite into the behavior of the well being considered. However, it is necessary to be sure that the offset wells being compared reflect conditions and reservoir properties of the well under considerations.



## 4. Geological data and cross section

- Geological data, such as stratigraphic cross sections and structure maps, show the position of the well in the current reservoir or in a potential recompletion zone.



## 5. Open Hole Logging

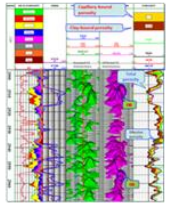
### Open Hole logging

#### Conventional log

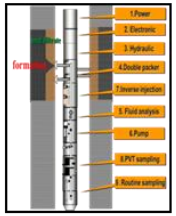
1. Lithology logs
   - SP
   - GR
2. Porosity logs :
   - Density
   - Neutron
   - Sonic
   - NMR
3. Resistivity logs :
   - in Water base mud ( MSFL & DLL)
   - In oil base mud use induction ( DIL & AIT)
4. Caliper log

#### High tech log

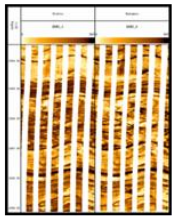
1. Nuclear magnetic resonance log (NMR)
2. Modular dynamic formation tester (MDT)
3. Full bore Formation Micro Imager(FMI)
4. Sidewall core (SWC)



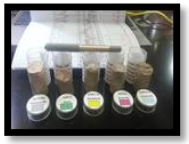
(NMR)



(MDT)

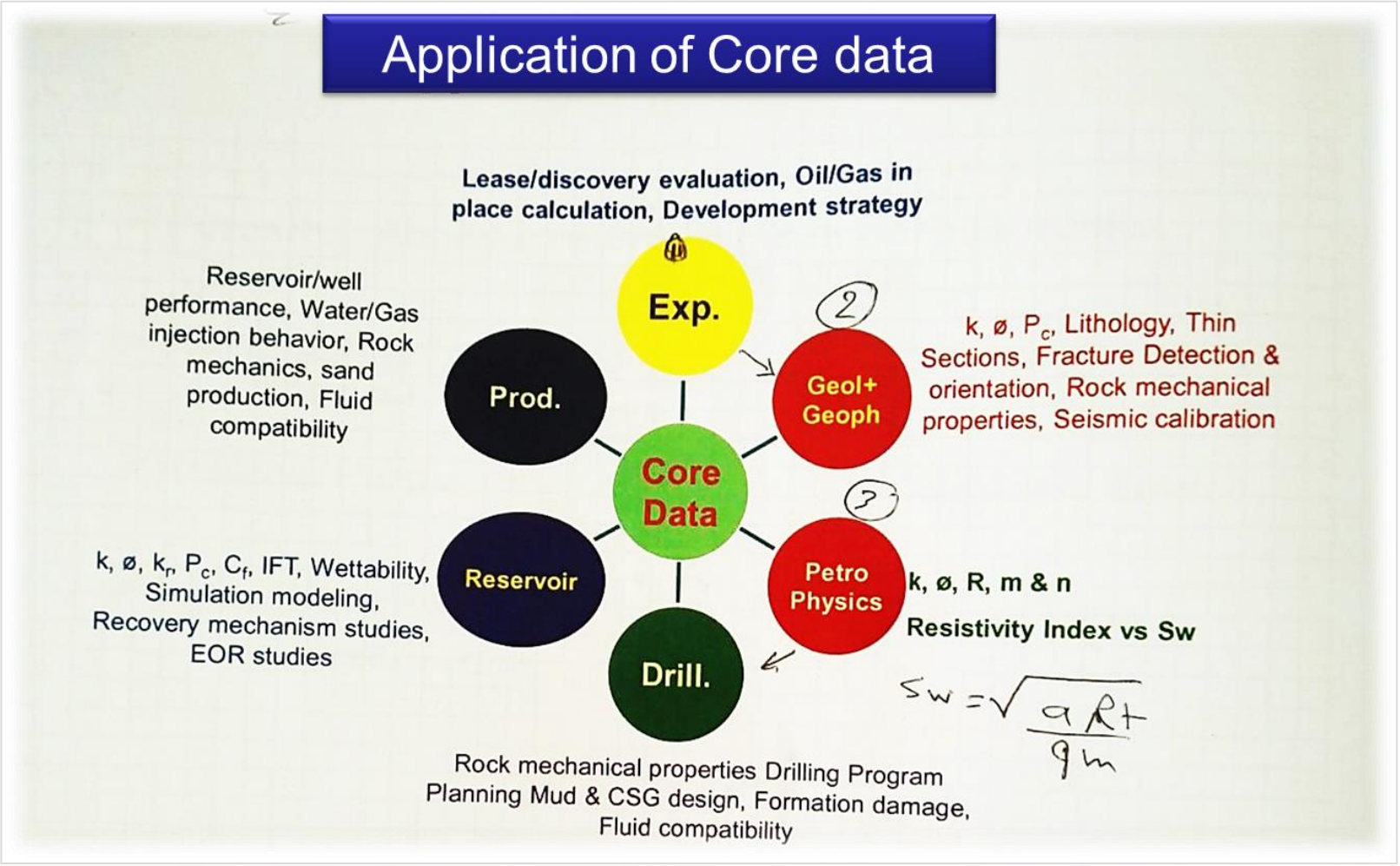


(FMI)



(SWC)

## 6. Core Data


Application of Core data
Lease/discovery evaluation, Oil/Gas in place calculation, Development strategy
Exp.
Reservoir/well performance, Water/Gas injection behavior, Rock mechanics, sand production, Fluid compatibility
Prod.
Geol+ Geoph
k, ø, Pc, Lithology, Thin Sections, Fracture Detection & orientation, Rock mechanical properties, Seismic calibration
Core Data
k, ø, kr, Pc, Cf, IFT, Wettability, Simulation modeling, Recovery mechanism studies, EOR studies
Reservoir
Petro Physics
k, ø, R, m & n
Resistivity Index vs Sw
Drill.
Rock mechanical properties Drilling Program Planning Mud & CSG design, Formation damage, Fluid compatibility

## 7. Test use for Diagnostic problems :

### 1.Well Test

1. Static pressure test
2. Drawdown test
3. Build-up test
4. Injection test
5. fall-off test
6. Interference test and pulse test
7. Isochronal test,

### 2.Cased Hole logging

1.Cement evaluation log :

- normal CBL , VDL , GR , CCL
- Image cement evaluation

SBT , URS , RIB , RBT , USI , USIT , CAST , SCMT .

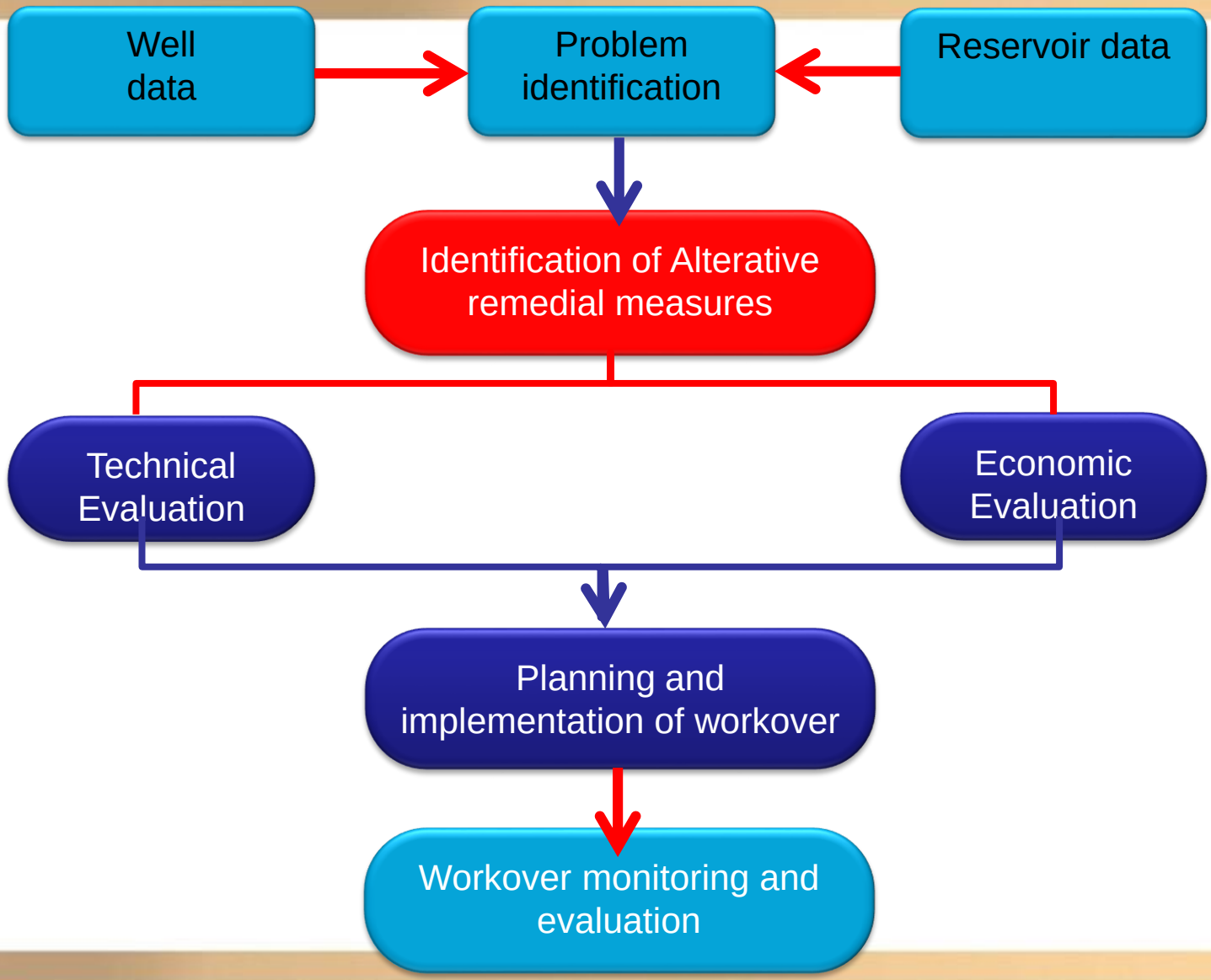
2. production logging tools ( PLT)

3. saturation log ( RST , RMT , PNN , PNX , TDT)

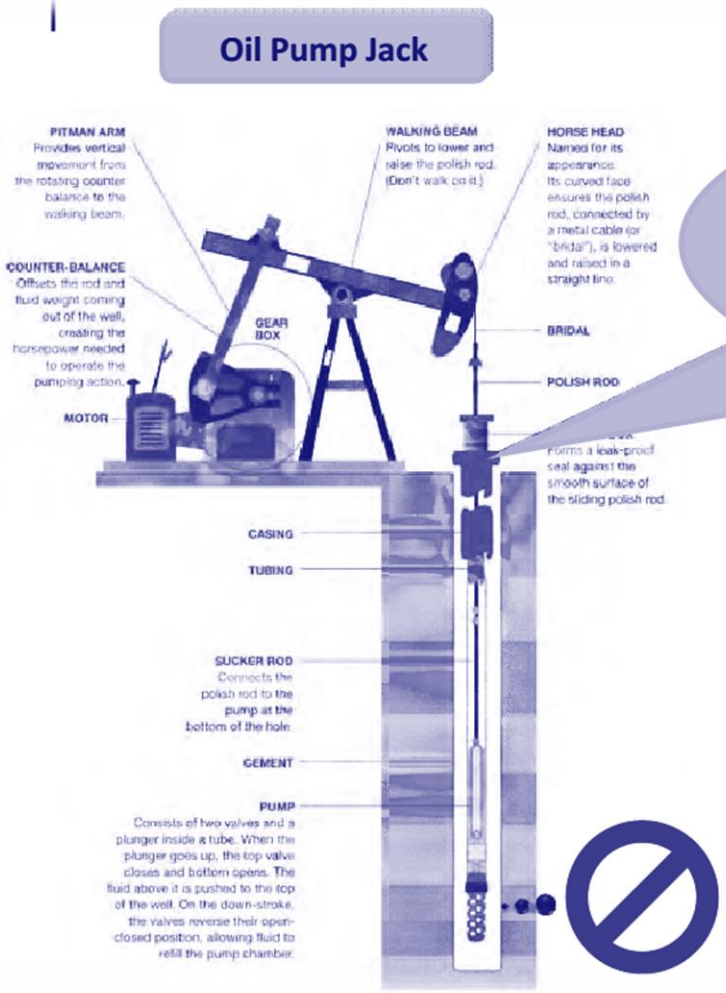
4. Casing inspection log ( MFC , MIT USIT , ETT)

5. SNL (SPECTRAL noise log )

# 4.Analysis Well problems



# 4.Analysis Well problems




**Production Problems!!**

- Oil STOPPED?
- Sand, scale or paraffin problems?
- Pump not working?
- High oil viscosity?
- Rod parted?

I need to get my well producing!
How do I fix it? What's wrong?

I need to start with a
Remedial workover.



# Contents

1. Define of workover
2. Application of  Workover operation?
3. Types of workover operation
4. Analysis well problem



**5. Well operations through the  life of a well**

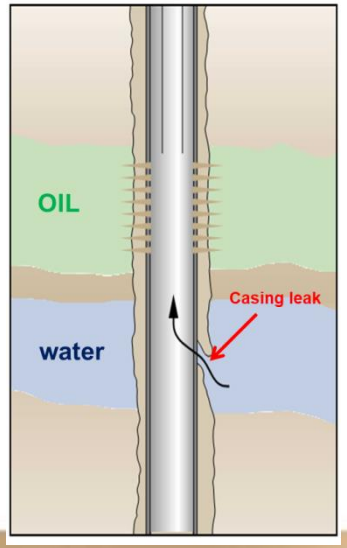
# 5.Well operations through the life of a well

1. Data acquisition
2. Integrity monitoring and repair
3. Water or gas shut-off
4. Debris removal and sand control
5. Sidetrack and well Deeping
6. Tubing replacement
7. Flow assurance
8. Stimulation
9. Perforating
10. Using Artificial- lift
11. Convert well to injector

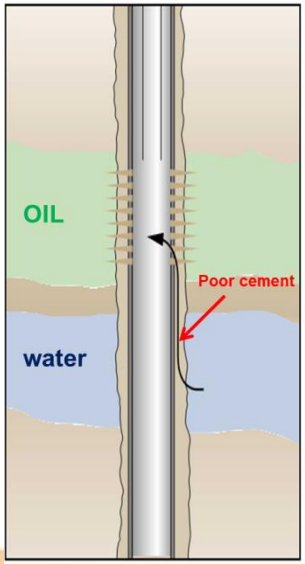


# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **1- Data acquisition** | All data acquisition support of :<br><br>1. decision to determine the water problem then do water shut-off<br><br>2. Determine the reservoir pressure decline | using :<br>1-production logging tools ( PLT)<br>2- saturation logging<br>3- well test |

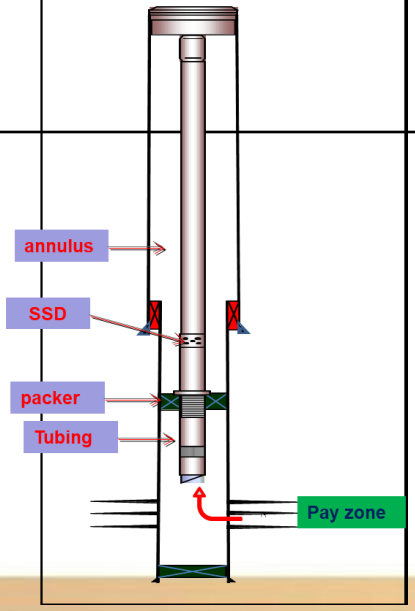



| Problem | Possible Reason |
|---|---|
| 1-High water cut | 1. Casing, tubing or packer leaks<br>2. Channel flow behind casing<br>3. Moving oil-water contact<br>4. Watered-out layer without cross flow<br>5. Fractures or faults between injector and producer<br>6. Watered-out layer with crossflow<br>7. Gravity-segregated layer<br>8. Fractures or faults from a water layer (vertical well).<br>9. Fractures or faults from a water layer (horizontal well).<br>10. Coning |



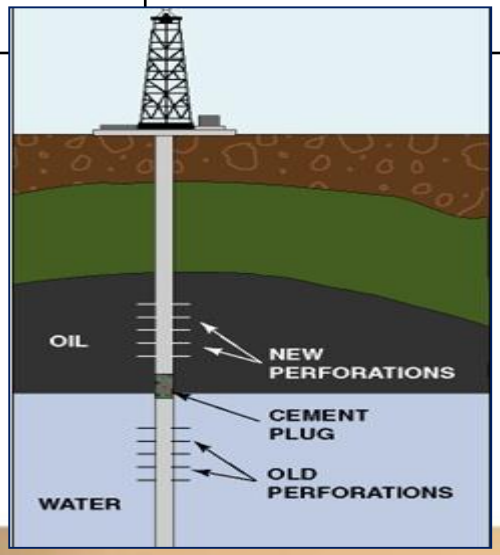
# Well operations through the life of a well

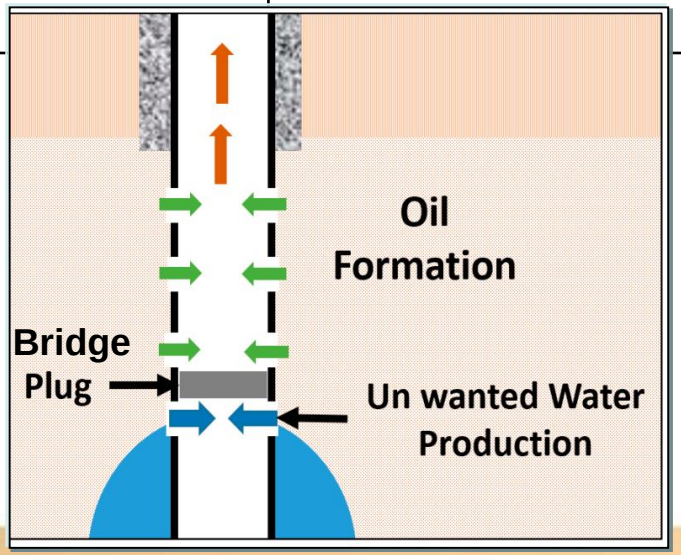
| Opportunity | Reason | Main Methods |
|---|---|---|
| **2-integrity monitoring and repair** | Maintaining integrity of the well is important some time :<br>• high pressure in annulus because poor cement<br>• or casing damage or tubing damage | 1. for poor cement do remedial .<br>2. for casing damage should solve that by many methods depend on damage size .<br>3. for tubing damage can replacing it . |



# 5.Well operations through the life of a well

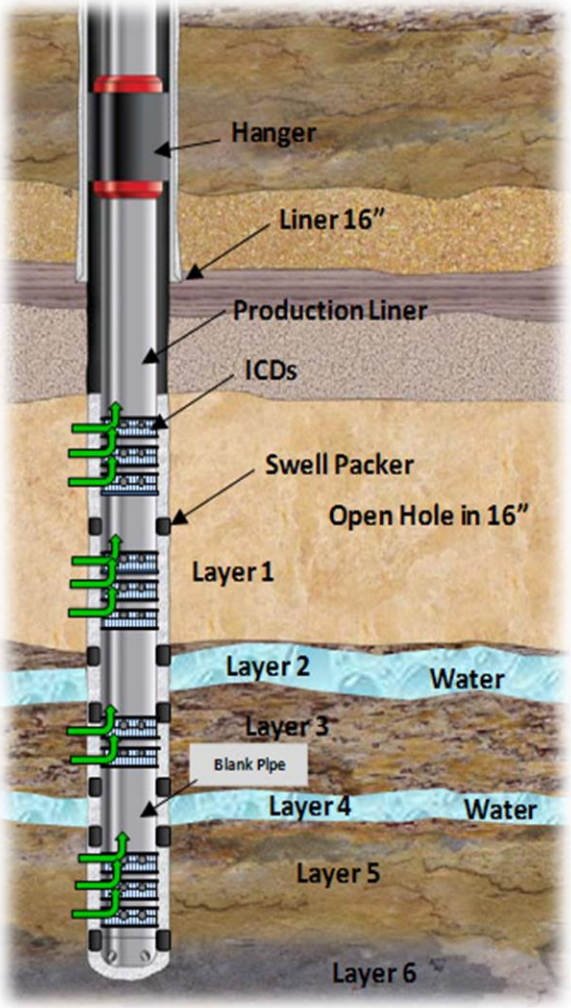
| Opportunity | Reason | Main Methods |
|---|---|---|
| **3- water shut-off** | Excess water will :<br>1. reduce tubing performance<br>2. constrain production due to surface processing limitation<br>3. maybe shut well ( stop the production ) if well natural flow | Many method using for water shut-off can do it rig less operation or by work-over rig :<br>1- through tubing bridge plug<br>2- cement plug<br>3-Bridge plug<br>4- gel squeeze<br>5- polymer squeeze<br>6- ICD , ICV |



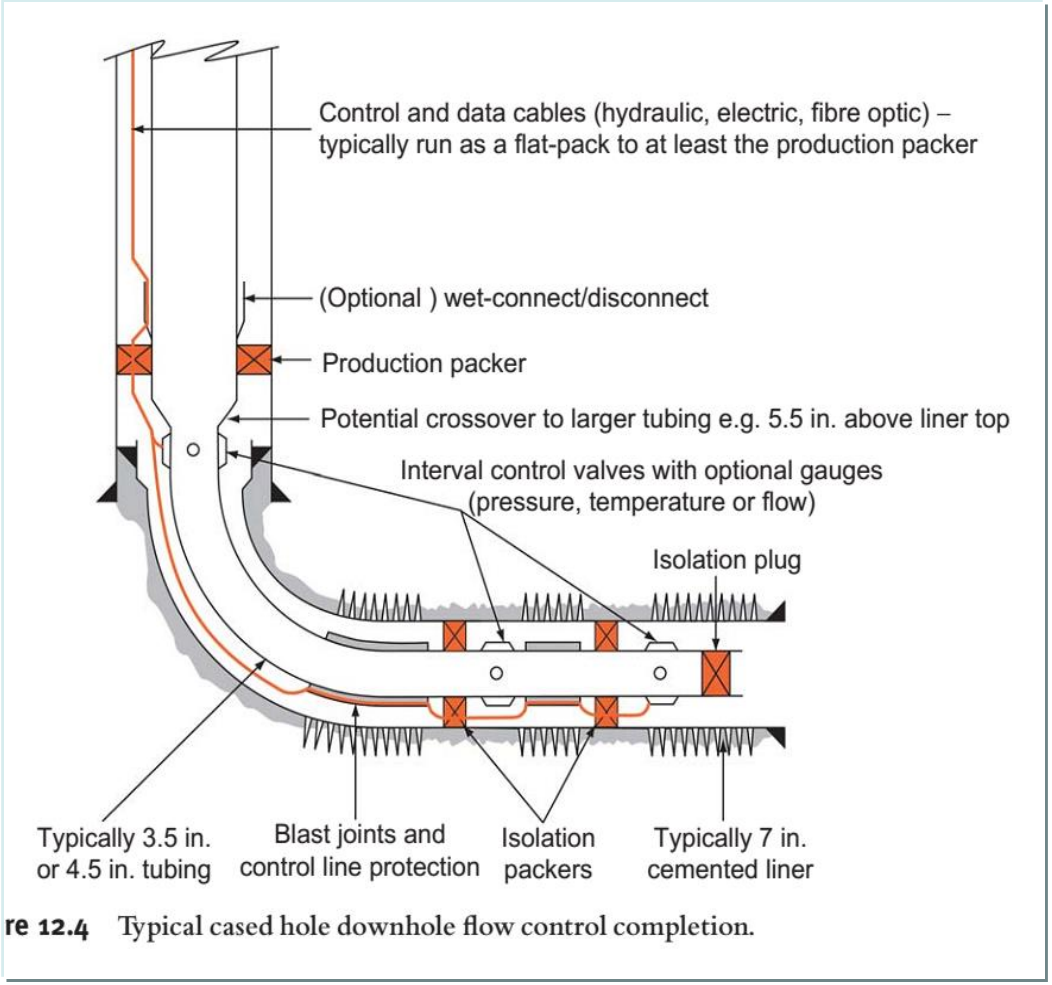



# 5.Well operations through the life of a well

## Water control using ICD in vertical and horizontal well



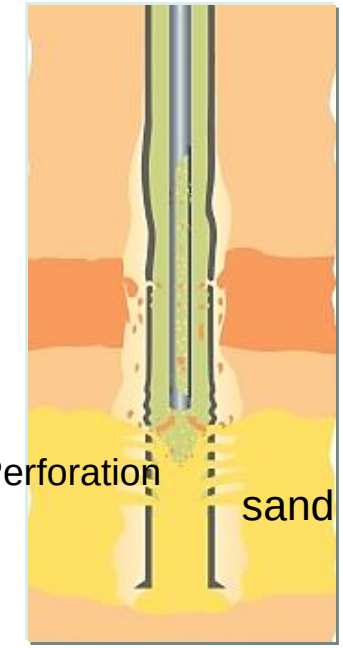

( ICD)-vertical well




re 12.4 Typical cased hole downhole flow control completion.

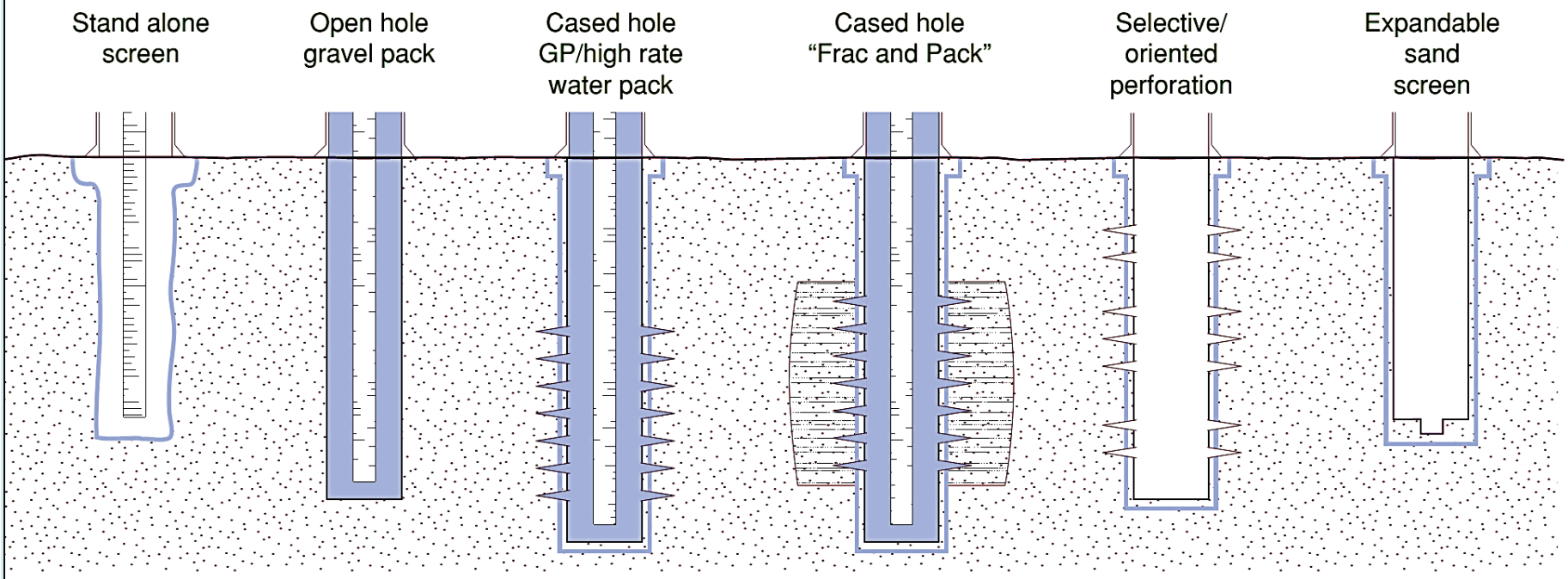
( ICD)-Horizontal well

# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **4- Debris removal and sand control**   | Many wells fill up with debris (perforating debris, sand or chalk, corrosion products, drilling materials, junk and proppant). This debris can cover production/injection intervals. | Debris can be removed by slickline (bailing), which is slow. Coiled tubing and jointed pipe (hydraulic workover unit) are more effective and can incorporate mills and jetting. Reverse circulation can be more effective than forward circulation but requires the well to be overbalanced<br>Remedial sand control is difficult; techniques include sand consolidation, insert screens and sidetracks (especially with total screen failure). |

# 5.Well operations through the life of a well

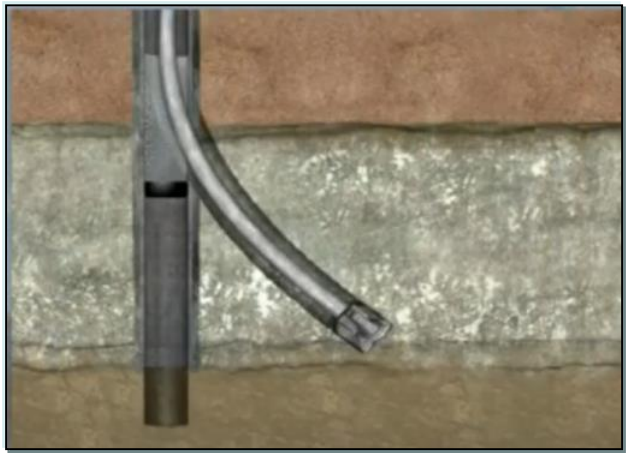
## Sand control variations.



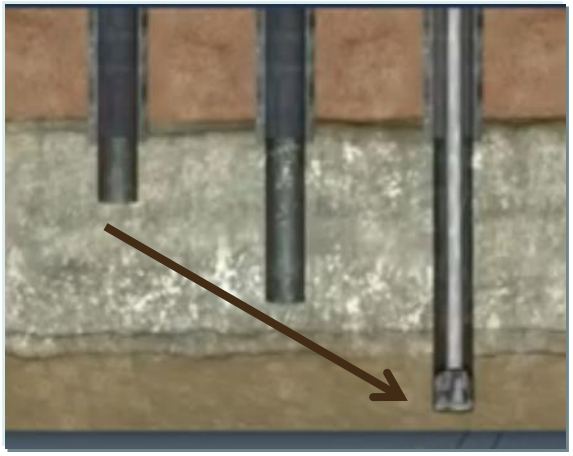

| Stand alone screen | Open hole gravel pack | Cased hole GP/high rate water pack | Cased hole "Frac and Pack" | Selective/ oriented perforation | Expandable sand screen |
|---|---|---|---|---|---|
| - very clean well sorted<br>- small uniformity coefficient | - dirtier, poorly sorted sands<br>- high rate wells with large reserves<br>- No reactive shale<br>- no significant blank sections if shale | - multiple stacked pay completions<br>- poorer quality gas sands<br>- low cost completions w/marginal economics | - multiple stacked pay completions<br>- v. laminated sands (low res pay)<br>- poorly sorted/lower kh/u tubidite sediments | - well consolidated reservoirs w/streaks of weak sand<br>- wells requiring active water and gas management | - very clean well sorted<br>-high rate wells |

# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **5.Sidetrack and well Deeping** | Completion sidetracks are to replace a failed reservoir completion and are often located close to the existing wellbore<br>Geological sidetracks move the wellboreto access new reserves | 1-Pull out original string<br>2-Close the hole bottom by cement<br>3-Use whipstock<br>4-Then go sidetrack |



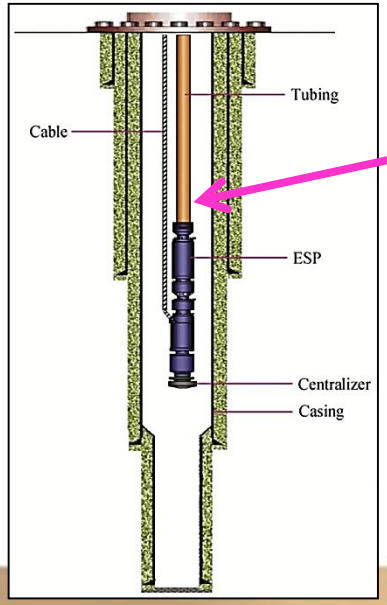
**Sidetrack**

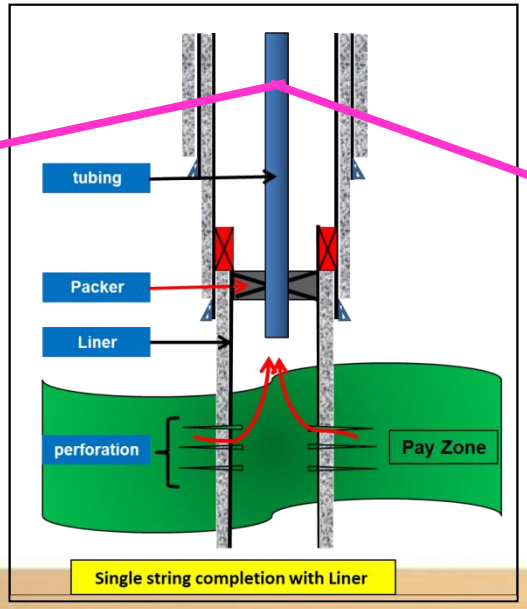


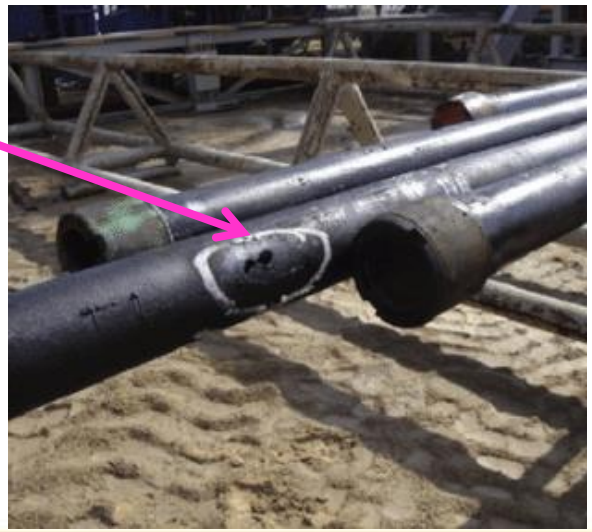
**Deeping**

# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **6-Tubing replacements** | Replacing failed tubing or components. Different tubing sizes or adding artificial lift may enhance performance | Top hole workover (reservoir remains isolated) or full workover (entire completion pulled) Techniques include straight pull (e.g. above a tubing disconnect) or chemical/mechanical cut. Packers may need to be milled. |



# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **7-Flow assurance** | The prevention of restrictions to flow caused by scale, wax, asphaltene, etc | Prevention methods include inhibitor squeezes (bullheading, coiled tubing or jointed pipe) and batch treatments. Removal techniques can involve bullheading or circulation of chemicals from surface (e.g. acids or hot oiling), pipe operations ( jetting, washing, milling, pulsation) or mechanical removal with wireline (blasting, cutting, reperforating). |



scale



wax



Asphaltene



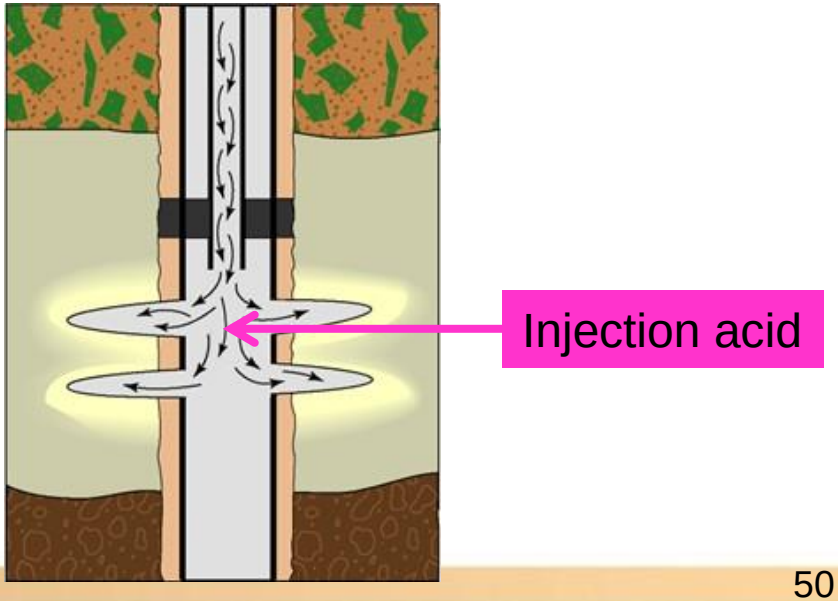
Hydrate

# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **8- Stimulation** | Stimulation can be performed during well construction or post well construction. Many stimulations have to be periodically repeated. | Most stimulations can be performed through tubing either by bullheading or with coiled tubing. Proppant fracturing |

## Sources of Formation Damage

1. Drilling
2. Workover
3. Cementing
4. Perforating
5. Completion / Gravel Packing
6. Production
7. Injection



# 5.Well operations through the life of a well

## Stimulation Technique

| Technique | Objective |
|---|---|
| **Mechanical Methods**<br>• Propped Hydraulic Fracturing<br>• Explosive Fracturing<br>• Under reaming<br>• Re – and Additional perforating | <br>Increase $r_w$<br>Increase $r_w$ and k<br>Increase $r_w$<br>Increase h |
| **Chemical Methods**<br>• Matrix Acidsing<br>• Tubing Acid Washes<br>• Other Chemical Matrix Treatments (Surfactants, Solvents Mutual Solvent Etc.) | <br>Decrease S<br>Improve well Outflow by Removing Tubing Deposits<br>Increase k |
| **Biological Methods**<br>• Microbial Stimulation | <br>Mechanism Uncertain |
| **Combined Mechanical / Chemical Methods**<br>• Acid Fracturing Including Propped Acid – Fracturing<br>• Closed Fracture Acidizing | <br>Increase $r_e$<br>Increase $r_e$ |
| **Thermal Methods**<br>• Steam Soak<br>• Heat / Gas Generation From injected chemicals<br>• Electrical Heating | <br>Decrease μ<br>Decrease μ and Improve well Outflow by increasing GOR<br>Decrease μ |

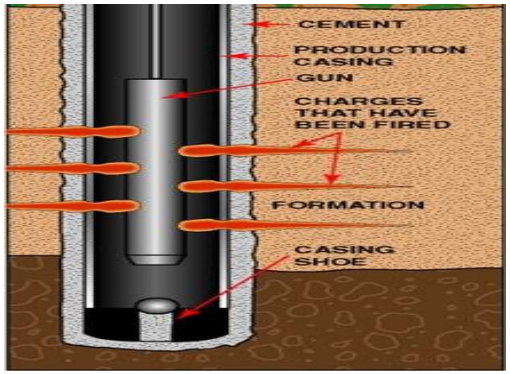
# 5.Well operations through the life of a well

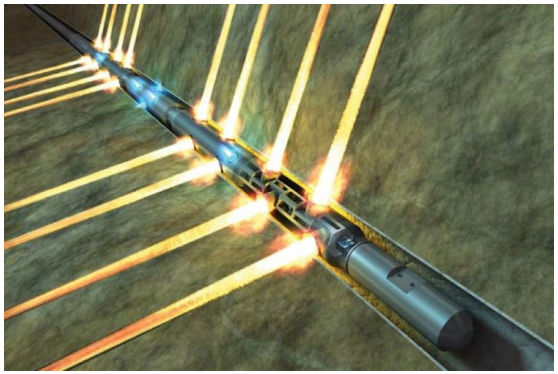
## Matrix fluid selection chart depending formation damage type to be removed

| Type Damage | Symptom | Cause | Solution |
|---|---|---|---|
| oil wet formation | Reduced oil production | Corrosion inhibitors Oil based mud. | Mutual Solvent / water wetting surface |
| Water block | Reduced gas production in low permeability or depleted formations | Increased new wellbore, water saturation Fluid loss during drilling/ work over | Surfactant / alcohol solution injected with nitrogen |
| Emulsion | Viscous near wellbore | Emulsion stabilized by surfactant or oil wet solids e.g. asphaltenes | Inject mutual solvent / demulsifer |
| Wax | Deposit on tubing or in formation | Oil cooled below cloud point | Dissolve in heated oil / solvent or disperse in surfactant solution Mechanical removed (scraping) Crystal growth inhibitor s |
| Asphaltene | Deposit in facilities, tubing or in formation | Pressure reduction (precipitation often starts near bubble point) | Mechanical removal dissolution and inhibition not very effective |
| Bacterial Slime or Deposit | Deposits (mainly in well ) and corrosked | Bacterial infestation | Bactericide prevents infestation Mechanical removed and oxidsing agents (e.g. bleach, chlorine dioxide removes deposits) |
| Sits and Clays | Reduced well inflow | Clay swelling and fines migration | Clastics –dissolve damage with HC/ HF Carbonates – HCI to dissolve formation / bypass damage |
| Inorganic Scale | Deposit on well equipment or in formation | Formation brines becoming super saturated due to T and P reduction or mixing of incompatible brines | Mechanical removal in tubing Inhibition (inject inhibitor in tubing or squeeze Into formation) Dissolution (see table A-2) |

# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **9-perforation** | This can be to add new completion intervals (e.g. identified from production logs) or to re-perforate existing intervals that are performing badly (poor initial perforating, scaled up, etc.) | Most perforating, post well construction will be through tubing (wireline or coiled tubing/jointed pipe). |

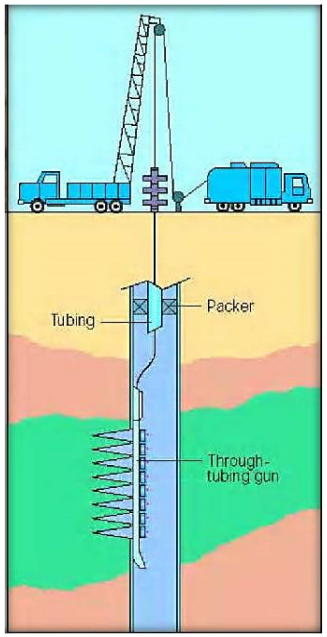


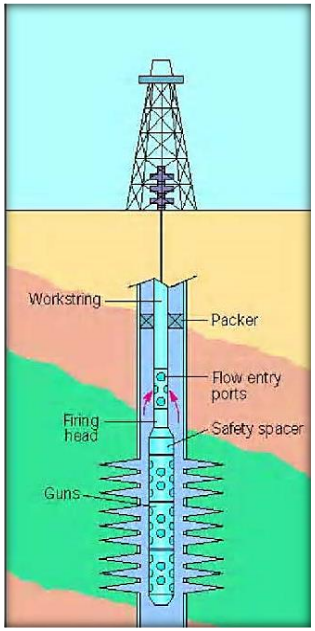


# 5.Well operations through the life of a well

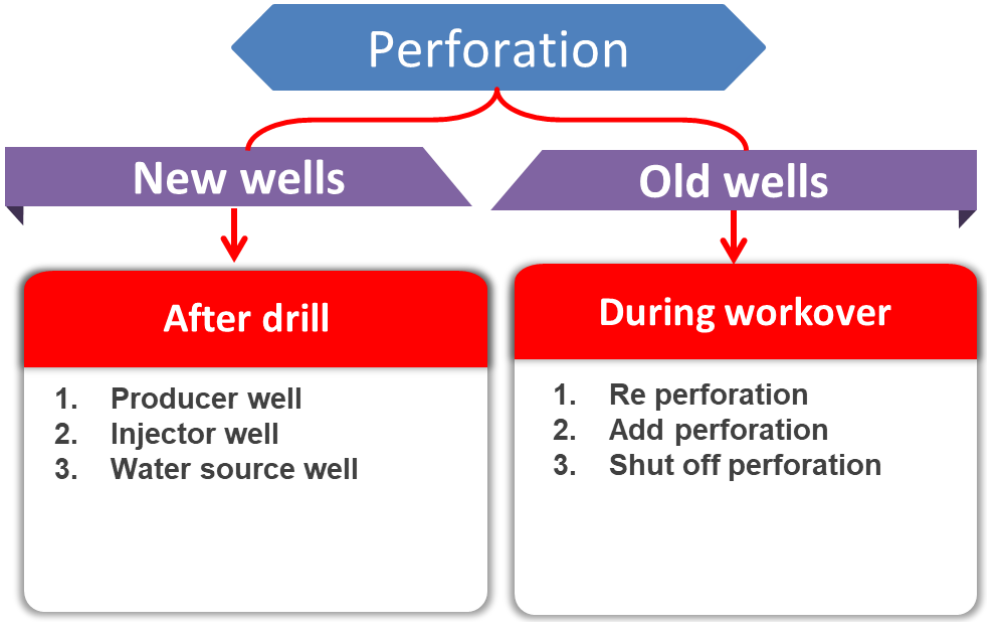
## 9-perforation




Rigless perforation

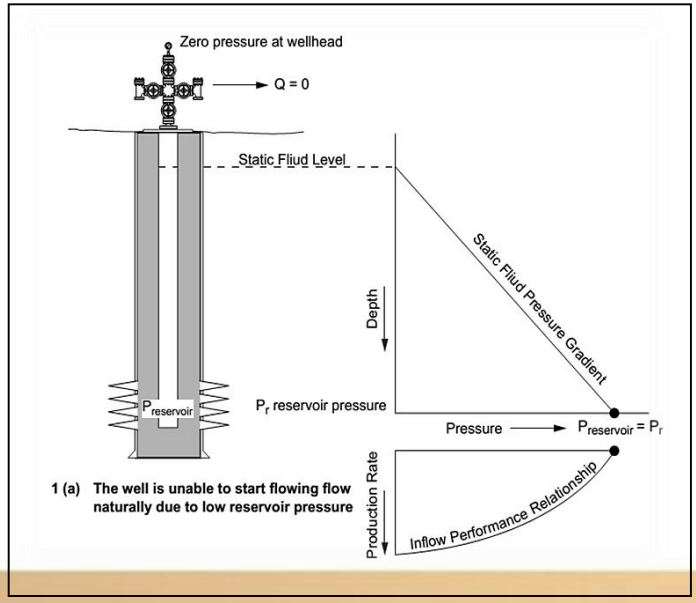



Rig perforation



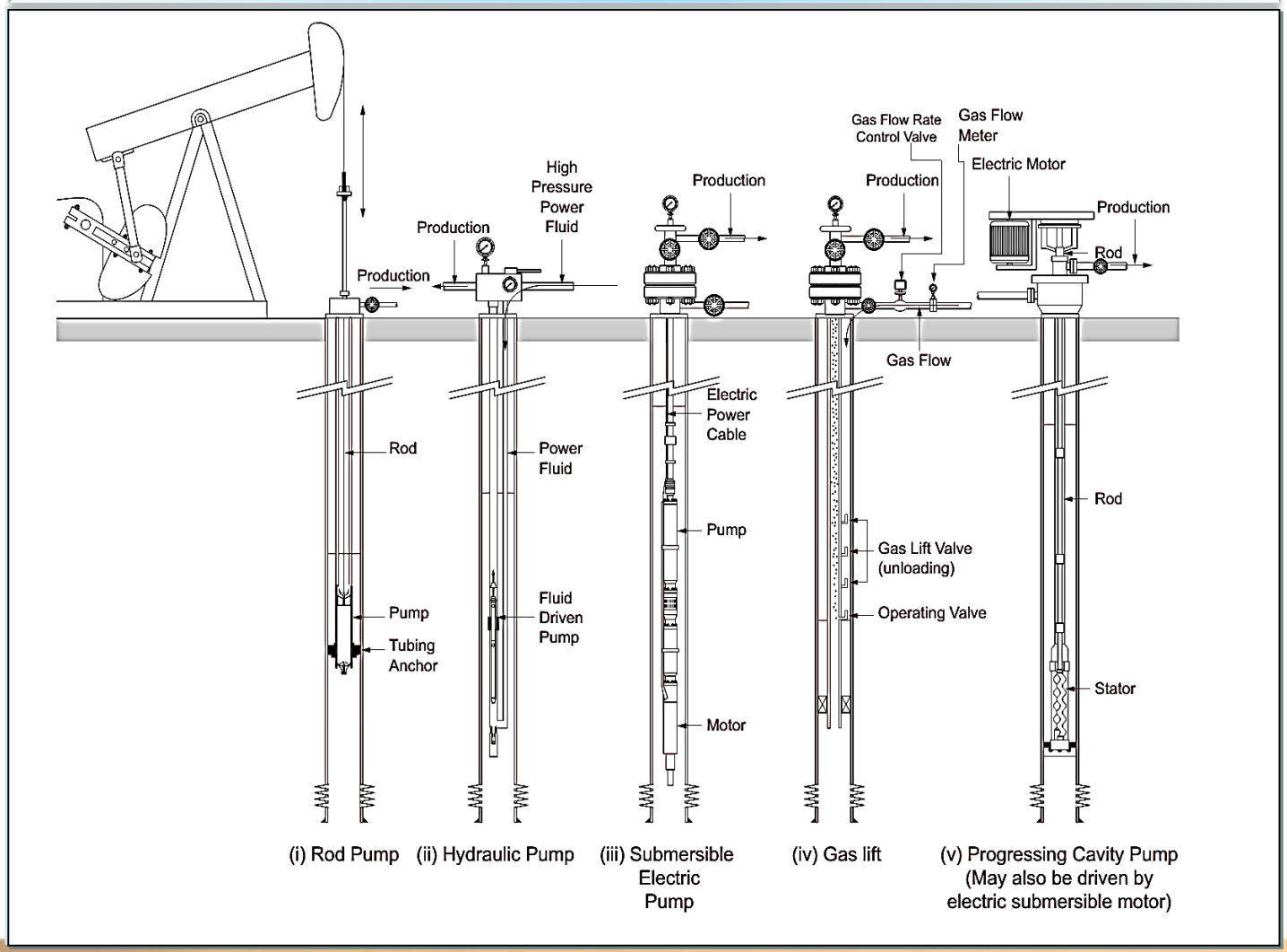
# 5.Well operations through the life of a well

| Opportunity | Reason | Main Methods |
|---|---|---|
| **10-Using Artificial- lift** | Many wells benefit from artificial lift late in field life when pressures are lower and water cuts higher. | Artificial lift can be added by through tubing interventions (gas lift, jet pumps, some rod pumps and hydraulic submersible pumps) |



# 5.Well operations through the life of a well

The most popular forms of artificial lift are illustrated in figure



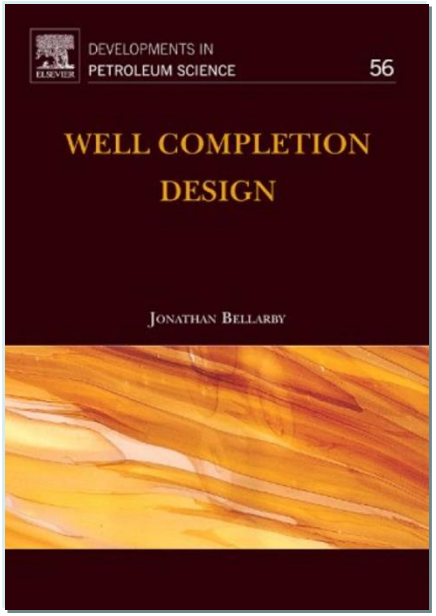
# 5.Well operations through the life of a well

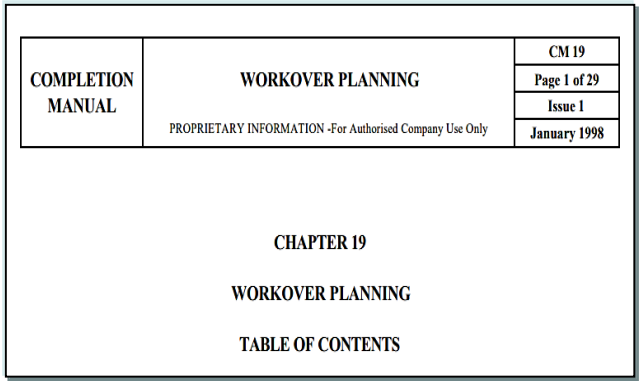
| Opportunity | Reason | Main Methods |
|---|---|---|
| **11-Conversion of duty** | As wells mature, they are frequently converted from oil/gas production to some other duty (especially injection). Injection options include water (including produced water), gas, water alternating gas (WAG), carbon dioxide and other waste streams. | Depending on the well design, no downhole intervention may be required. The production intervals may require reconfiguring (shutting off some intervals, opening up others). If the tubing metallurgy or size is not suitable for the new duty, it may need replacing |

# Thank You!

# Reference


1. Drilling Department PETRONAS CARIGALI SDN BHD – Completion manual – workover planning - 1998
2. Workover Opreations course Schlumberger
3. Slickline Training Manual Schlumberger
4. Well Completion Design –by Jonathan Bellarb

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| | | January 1998 |

CHAPTER 19

WORKOVER PLANNING

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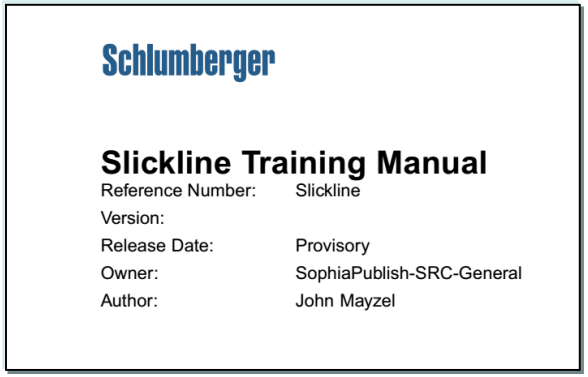

# About Authorized

| | |
|---|---|
| **Name:** | **Abbas Radhi Abbas** |
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| **Gender:** | **Male** |



| | |
|---|---|
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| Period | Education description |
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| **Certificates of Appreciation** | |
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| (2006-2010 ) | water injection engineer |
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