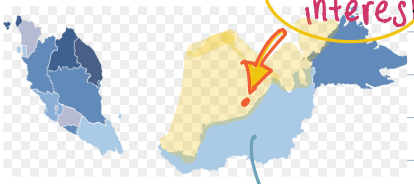
Chapter 1.

Operator : → "oil company" e.g:

PETRONAS

bears over all responsibility for drilling operations

to locate area of interest



engage Geologist ②

ExxonMobil

hire drilling consultant ①

OPC

Fraser Well Management

hire landman to acquire rights ③

hire drilling contractors ④

VELESTO energy

sapura energy

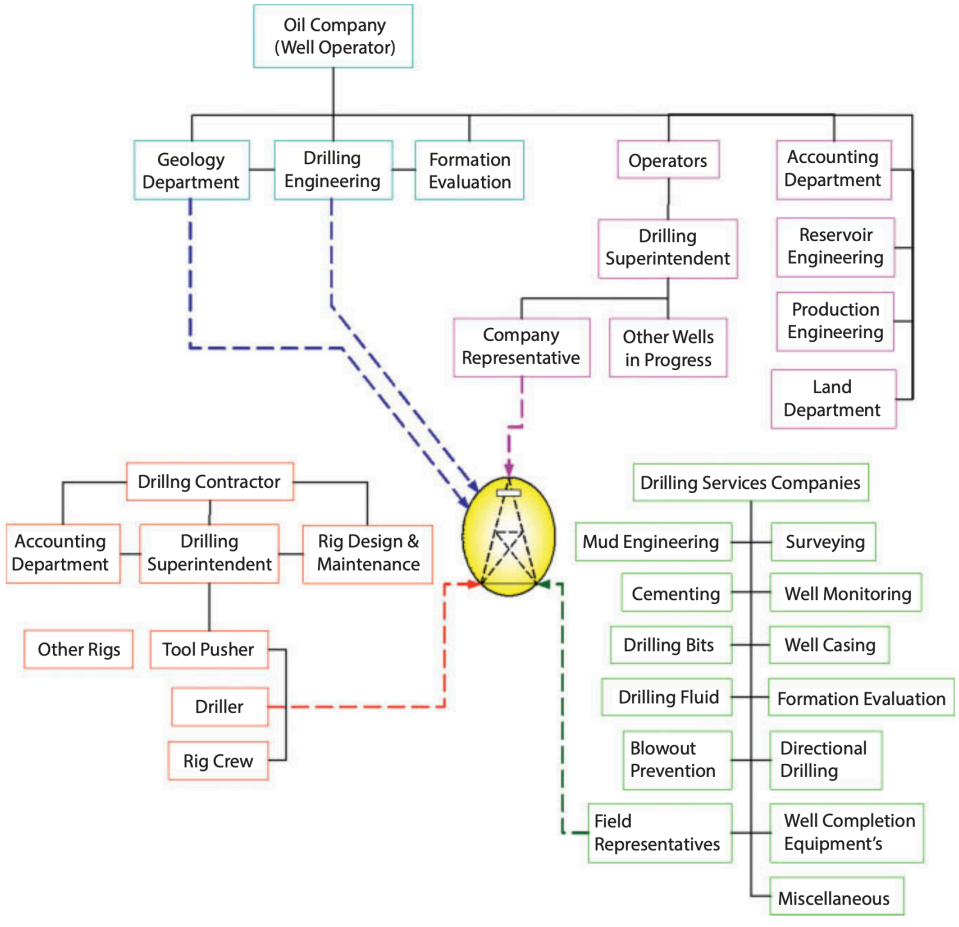
- to do the actual "drilling"
- maintain rigs & equipments

contract type → Day rate

Contractor provides :
- rigs
- personnel

Turnkey

Contractor to provide
- Well design
- rigs
- personnel
- consumables



Drilling Process

I. Budgeting

- well specs & obj.
- data acquisition
- budget cost worksheet
- rig scheduling

II. Planning

- Construct Well Team & Goals
- Geological Prognasis
- Well obj. finalized n approved

III. Design

- well plan completed
- AFE submitted
- Well plan approved

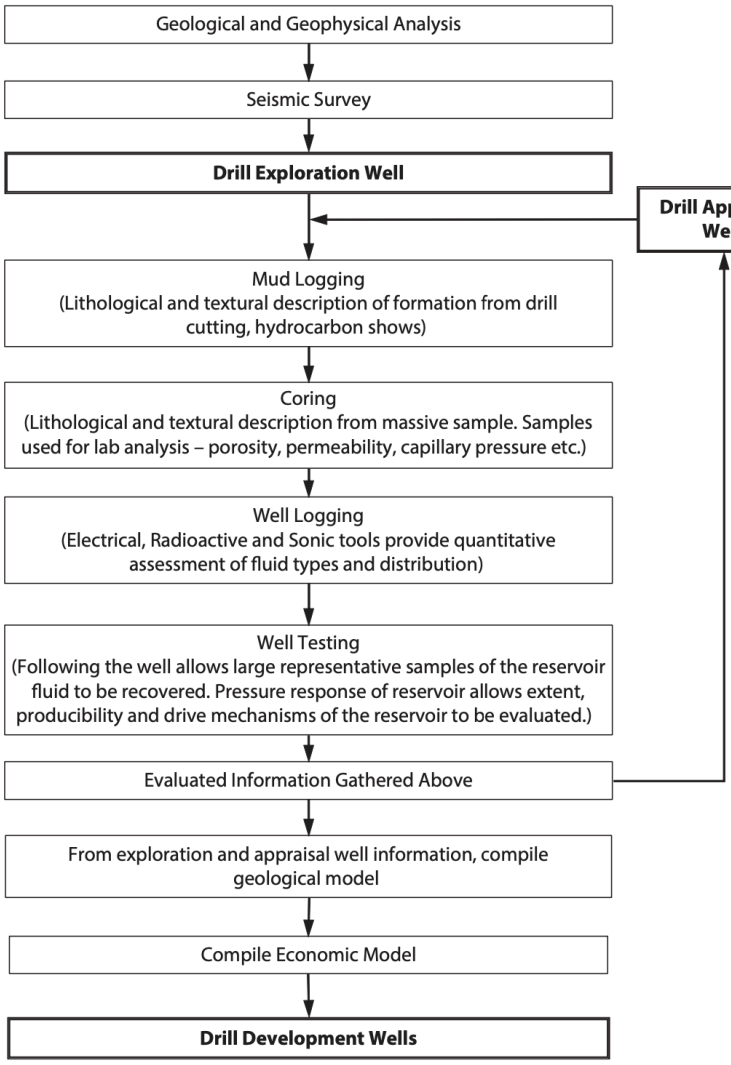
Optimization

- Drilling program completed
- Drilling program applied
- Pre-spud meeting

Execution

- Spud well
- Complete / Test / P & A
- Handover to Prod.

Post Drill Analysis



Steps in drilling O & G.

1. obtain **Seismic Log**
2. obtain **concession**
3. calculate **reserve**
   - if high → proceed with well
4. obtain **permit** from Gov.
5. prepare drilling & completion program
6. ask for **bids** from drilling contractors on : i. Footage
   ii. Daywork
7. if required, modify **drilling programme.**
8. construct roads, location / platforms for **access**
9. conduct **pre-spud meeting**
   further modification if necessary.
10. drill well

Types of wells

i. exploration well (wildcat well)
- drilled during initial phase of exploration
- to determine presence of H.C, obtain GnG datas, production potential, fluid samples.

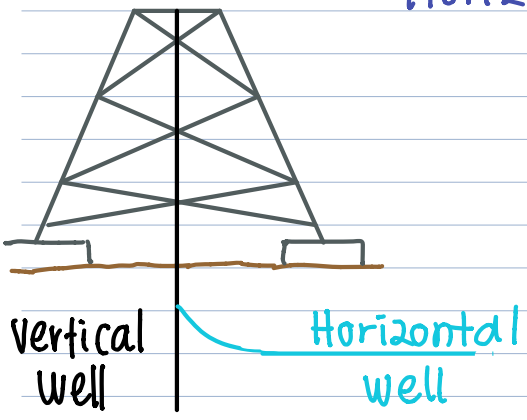
ii. appraisal well
- to test economic viability / commerciability
- conducted through various well test / through combustion of oil from oil produced.

iii. Development Well (Prod. Well)
└ drilled in proved production field/area to extract H.C

iv. Abandonment Well
└ if no H.C is found, → wells need to be closed. to avoid env. impact.
during exp/appraisal

v. Re-entry → recompletion
→ for sidetracking / deepening

Drilling Techniques



Vertical - for drilling straight down - for shallow & land.
- common during early days

Horizontal - drilling horizontally to reach target zone
↳ drill to penetrate reservoir at a shallow angle
or
to expose more of low permeability reservoir to the wellbore.
↳ ex. Frac

Directional - process of directing wellbore along a trajectory to a predetermined target.
↳ implement on off-shore (fixed platform rig)
↳ **Application**: major surface obstruction
- re-use of old wells to explore new oil
- relief well to control blow out.

Drilling Operations Personnels

Operating company

→ Senior drilling Supervisor / company man

- → company representative on rig
- → ensure drilling [operation is run as planned.]

roles

- # meet objectives
- # adhere to drilling prog.

background requirements

Eng. Grad. with 5-10 years Drilling Exp.

Drilling Eng.

1. conduct preliminary studies & estimate well duration + cost [during initial prospect evaluation]
   → flAuthority for Expenditure
   [once AFEs are approved]
2. To design, coordinate & monitor overall well program

→ managing rig side people

Why they must work with Geologist.

- develop understanding of drilling Geology
- identify anomalies during operations
- Estimate expected P_{pore} & fracture gradient.
- Selecting casing sizes & setting depths.
- Develop drilling mud program.
- Prepare drilling OP.

Drilling Contractor

main personnel → **Senior Tool Pusher / Rig Manager**

- coordinates drilling contractor's function on rig
- main contact with Senior drilling supervisor

Toolpusher

- in charge of rig & liase with companyman

Other key personnels →

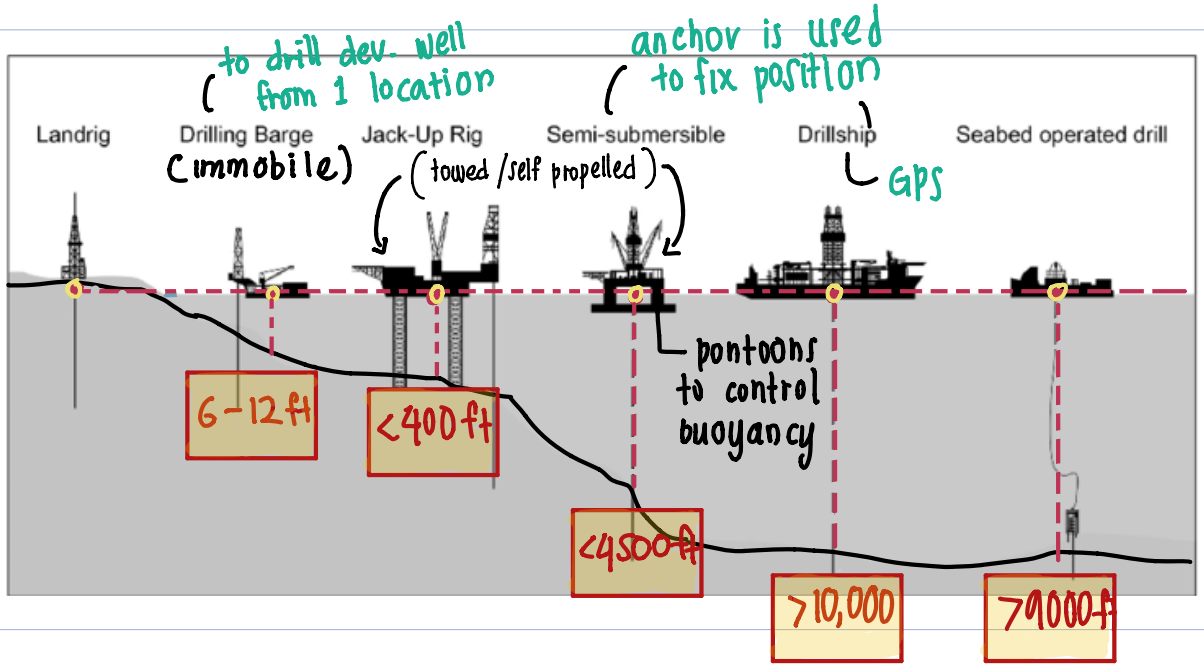
- Drilling Crew
- Engineering Crew
- Marine Crew
- Subsea Engineer
- Medics
- Radio Operator.

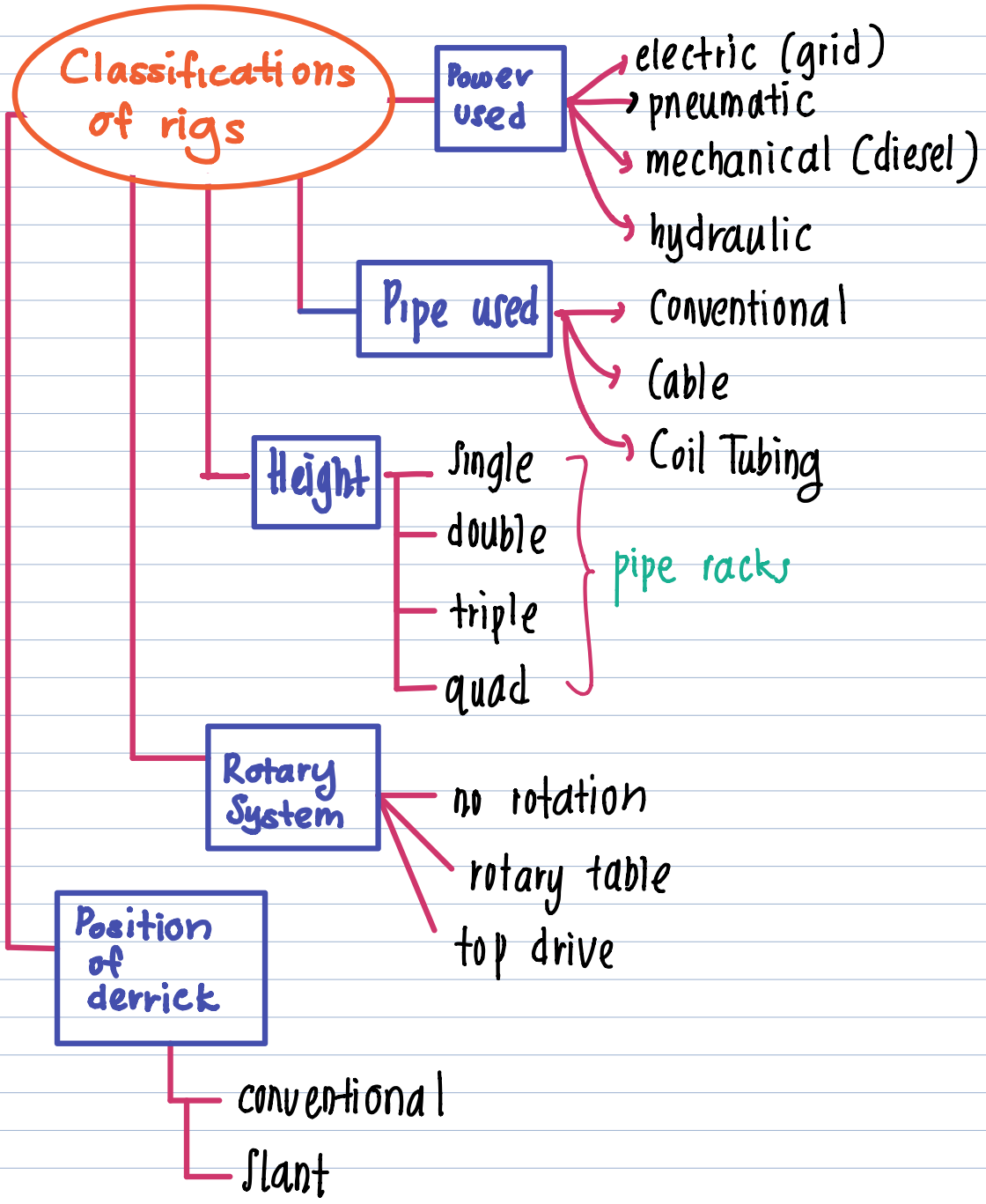
Drilling Crew

- **Driller** — operate Pumps, drawworks via driller & rotary table console
- **Derrickman** — work @ 90 ft above rig floor on derrick handle sections of drill pipe
- **Pumpman** — assist derickman & responsible for maintenance & smooth operation of mud pump
- **Rougneck**
  - low ranking member of drilling crew.
  - works on rig floor.

Maintenance Crew

- **Head of Maintenance**
  - control maintenance scheduling activities
  - In charge of all maintenance operations on the rigs.
- **Rig Electrician** — maintenance & repairs electrical equipment.
- **Rig Mechanic** — maintenance & repair of mechanical equipment.
- **Motorman** - maintenance of Prime movers


to drill dev. well from 1 location
anchor is used to fix position
Landrig
Drilling Barge (immobile)
Jack-Up Rig (towed / self propelled)
Semi-submersible
Drillship
GPS
Seabed operated drill
pontoons to control buoyancy
6-12 ft
<400 ft
<4500 ft
>10,000
>9000 ft


Classifications of rigs
Power used
electric (grid)
pneumatic
mechanical (diesel)
hydraulic
Pipe used
Conventional
Cable
Coil Tubing
Height
single
double
triple
quad
pipe racks
Rotary System
no rotation
rotary table
top drive
Position of derrick
conventional
slant

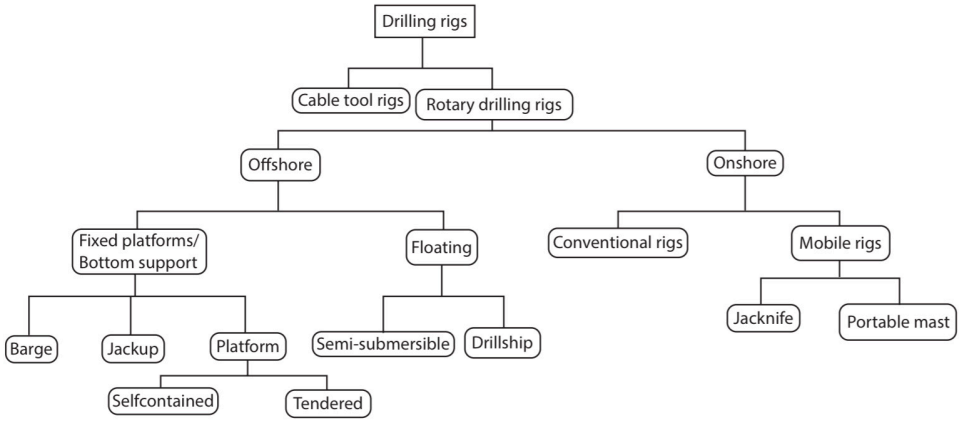


Figure 2.25 Different types of rotary drilling rigs.

Drilling Process Subsystem

I. Power Gen. System
II. Hoisting System
III. Circulating System
IV. Rotary System
V. Well control system
VI. Data acquisition & monitoring system.

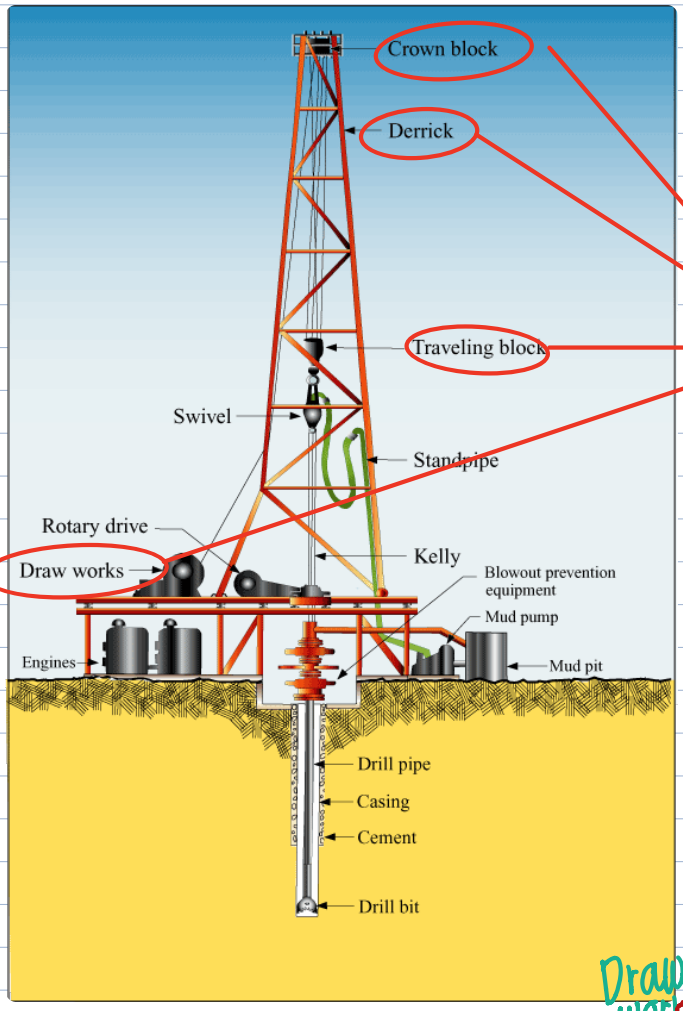
Rig Components

Derrick – provide vertical height req. for raising/lowering drill string

Travelling Block & Tackle : # crown block # drilling line
Travelling block

Drawworks
- control centre from which driller operates the rig
- provide hoisting + braking power req. to raise/lower heavy strings of the pipe.
- drum of the drawworks is connected to the electric motor & gearing system.

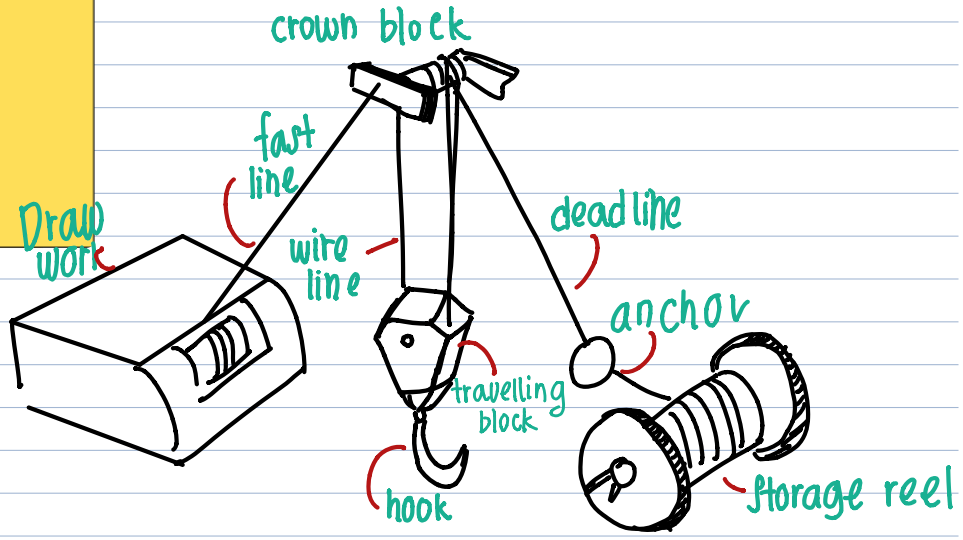
[Drilling Process Subsystem]



Hoisting System

↳ To lower/raise

[drill strings - casing string
- other S.S equipments
out of hole]



$$F_d = W + \frac{W}{EN} + \frac{W}{N}$$

$$= W\left[\frac{1 + E + EN}{EN}\right]$$

$$F_f = \frac{W}{EN}$$

The tensile load will be a function of the inefficiency.

Tensile Load

$$F_f = F_d = \frac{W}{N}$$

W = total load supported by lines (lbs)

N = no. of lines

Drilling Terms

making connection : Periodic process of adding new joints of drillpipe to the drillstring.

making trip :- taking the drillstring out of hole to change bit/alter BHA & lowering them back into the hole.

↳ Steps: raise kelly above rotary table → set slips → break kelly,

Rig Power System — Transmitted via mech drivers, AC/DC rectifier

- System with Highest power consumption:
  - I. Hoisting
  - II. Fluid Circulation
  - III. Rotary
- Avg. Total Power : 1000 - 3000 hp
- (Prime Movers)
  - Internal combustion diesel engines
  - from electric or power supply from existing power line.

Major Components
- Drawworks
- Mudpumps
- rotary table

Rotary Power Req.

- Vertical Hole Drilling.
  - Torque : < 15 kft. lbs
  - Power : < 100 hp
- Directional Drilling
  - Torque : > 80 kft. lbs
  - Power : > 100 hp

Input Power

$$P_i = \frac{Q_f H}{2545}$$

P_i = Input Power (hp)

Q_f = Rate of fuel consumption (lbs/hr)

H = heating value

Output Power

$$P_o = \frac{2\pi NT}{33,000}$$

P_o = Output Power (hp)

N = Engine Rotary Speed (rpm)

T = Output Torque (ft.lbs)

$$\text{Eff} = \frac{P_o}{P_i} \times 100\%$$

Criteria in Selecting Suitable Drilling Rigs

I. Static Tension in fast line when upward motion is impending

II. Max. hook hp, hoisting speed, derrick load

III. actual derrick load

IV. Derrick efficiency factor.

example : load : 300 lb N = 8
hp : 500 hp E = 0.841

i. Static Tension Line in Fast line when upward motion is impending.

$$F_f = \frac{W}{EN} = \frac{300,000}{0.841(8)} = 44,590 \text{ lbf.}$$

ii. Max hook horsepower

$$P_h = E \cdot P_i = 0.841(500)$$
$$= 420.5 \text{ hp}$$

iii. Max hoisting speed

$$V_h = \frac{P_h}{W}$$
$$= \frac{420.5 \text{ hp} \left[33,000 \frac{\text{ft.lbf/min}}{\text{hp}}\right]}{300,000 \text{ lbf}}$$
$$= 46.3 \text{ ft/min}$$

Thus, time req. to pull 90ft stand is,

$$t = \frac{90 \text{ ft}}{46.3 \text{ ft/min}} = 1.9 \text{ min.}$$

The actual derrick load is given by;

$$F_d = \left[\frac{1 + E + EN}{EN}\right] W = \left[\frac{1 + 0.841 + 0.841(8)}{0.841(8)}\right] [300,000]$$
$$= 382,090 \text{ lbf}$$

Max eq. load

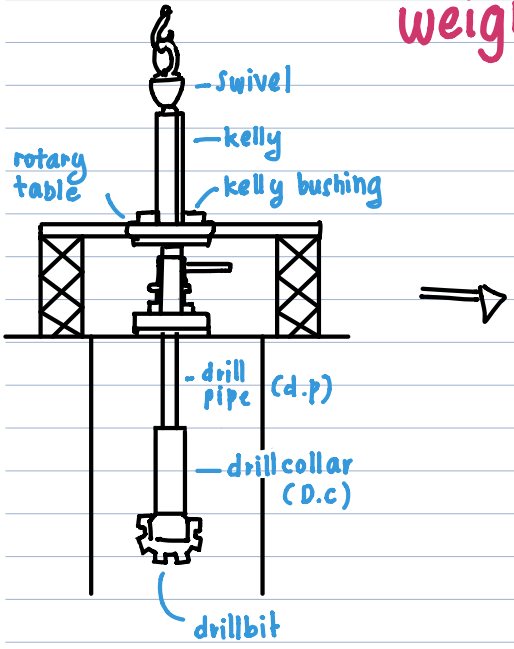
$$F_{de} = \left(\frac{N+4}{N}\right) W = \frac{8+4}{8} (300,000) = 450,000 \text{ lbf}$$

Derrick eff. factor

$$E_d = \left[\frac{F_d}{F_{de}}\right] = \frac{382,090}{450,000} = 0.849 = 84.9\%.$$

Rotating System

- **Swivel** - support weight of drillstring & permits rotation
- **Kelly** : Square / hexagonal shaped → for easy gripping.
  :- Torque is transmitted through kelly bushing
- **Slips** : used to prevent drillstring from falling.
- **Rotary Drive** - Provide power to turn rotary table
- **Drillpipe** : specified by : a) Outer Diameter c) Steel grade
  b) Weight/foot d) range length
- **Drill collar**
  "Thick walled heavy steel pipe" used to apply the weight on bit (WOB)



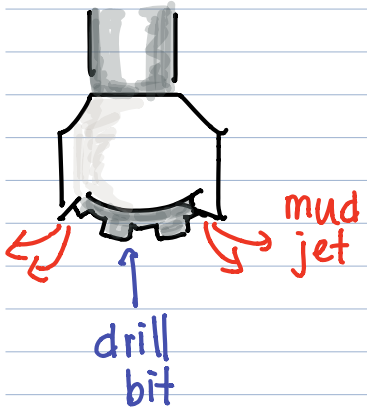
- rotation of the drillstring is enabled via a hexagonal section of the pipe; "kelly" which is 15m long, located in the rotary table.
- d.P & D.C r referred to as "tubulars"
- manually operated "tongs" r used to make up & break out the drillstrings.

Drill Bit

- usually becomes dull after 5-25 hrs of operation

↳ Factors in selecting :- composition of formation - drilling parameters.
hardness of formation

Cutting action is supported by powerful jets of drilling fluid which r discharged under high P through "nozzles" located at the side of the bit.



+ a good drillbit should provides
  - longest working life
  - lowest cost/ft of hole drilled.
  - good RPM

+ Rate of penetration (ROP) depends on :
  - RPM
  - Hydraulic Eff.
  - Mud properties
  - W.O.B

Types i. Roller Cone – features
- used in soft – very hard formations
- gauge protection
- small → large diameter
- conventional & extended jet bits
- bearings (can fail)
  - roller
  - sealed
  - journal

Types : a) Milled Tooth
- Selection based on formation hardness

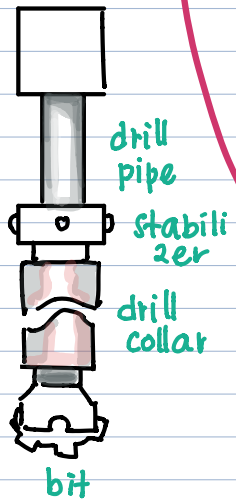
- IADC series 1 :- soft → medium
  - rock cutting mechanism : Gauging
- IADC series 2 : medium - hard
  - rock cutting mechanism : Scraping
- IADC series 3 : hard - very hard
  - rock cutting mechanism : chiselling

b) **Insert Drill bit** - available in 5 series, no. 4 → 8
  - For very hard formations
- rock cutting mechanism: Chipping & crushing.

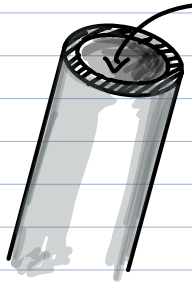
ii. **PDC - polycrystalline Diamond Compact**
  - fitted with diamonds
  - gives - better R.O.P
    - longer life
    - suitability for drilling at high RPM.

Drill String Components

Kelly
- hexagonal / square
- 40 ft / 54 ft in length
- attached to a swivel & fits into a matching slot in the rotary table.
- Function: to transmit rotation & weight to the drill bit
  - to carry total weight of the drill string



Drill pipe - seamless pipe with threaded joints at either end known as tool joints.



hollow — to allow fluids / transmitting lines to pass through

- 27 ft → 30 ft / pipe

Drill collar - Thick-wall, heavy length of pipe
- keep drillstring in tension

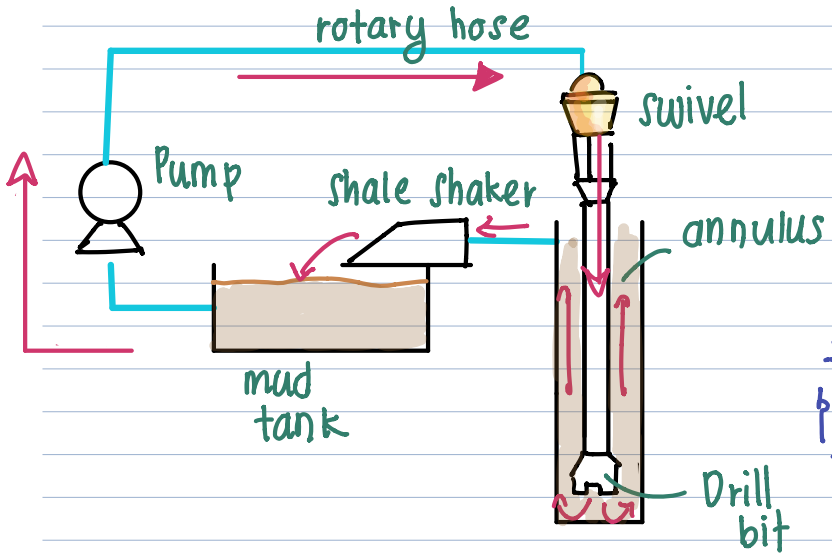
Stabilizer - hold, increase / decrease hole angle
- stabilize drilling process

Mud Circulating System

- mud is continuously circulated down the drillstring, out through the nozzle in the bit → back to the surface through the annulus

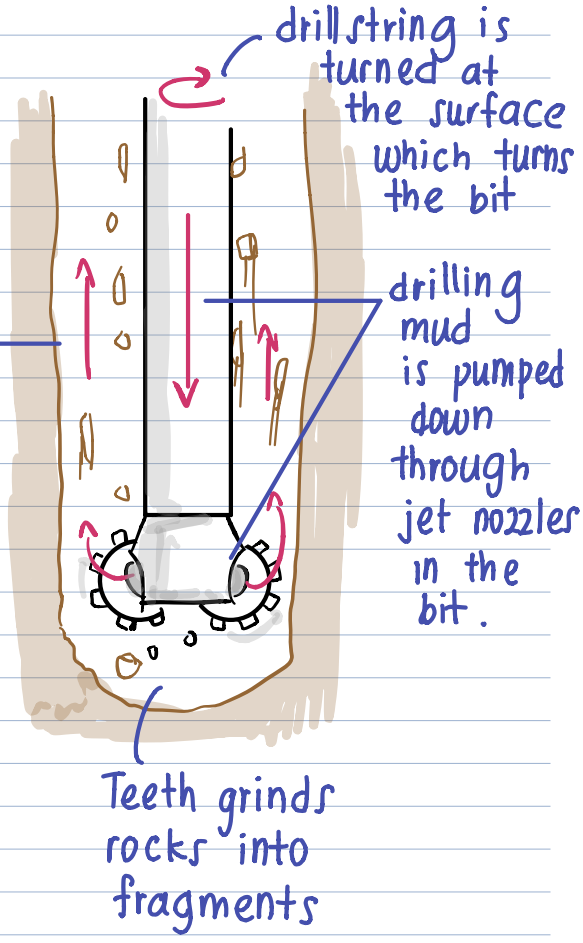
application :- Clean rock cuttings in the borehole

- exert Phyd which prevents formation fluid from entering the borehole
- ensure stability of hole (form mudcake)
- cool the bit
- (in some configuration) → helps move the motor to turn the bit



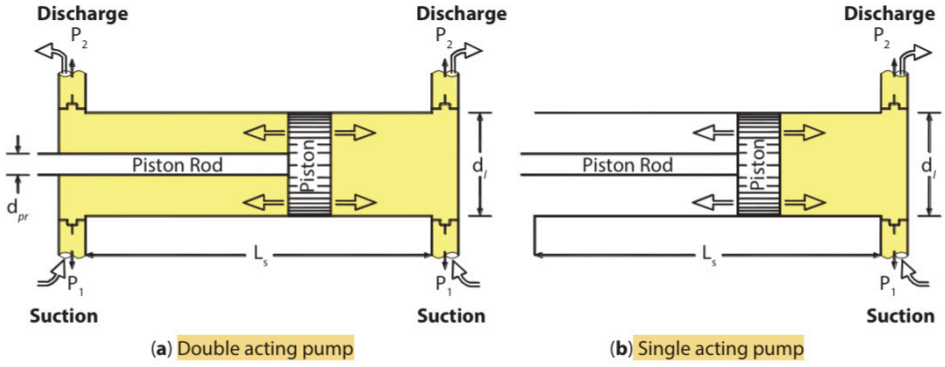
▷ typical vol req.: 100 bbl
| 60 bbl
↳ normal 7 7/8 in hole, 8000 ft

mud lifts the cutting & circulates them back to the surface where they r removed.



mud pumps

↳ reciprocating P.D pump < duplex / triplex



(a) Double acting pump (b) Single acting pump

Duplex pumps. ↳ two liners ↳ forward + backward strokes [dual acting]

Triplex pumps ↳ 3 liners ↳ forward strokes [single acting]

$$V_t = \frac{\pi}{4}\left(L_s N_c\right)\left(\frac{2D_l^2 - D_r^2}{4}\right)$$

N_c: No. of cylinders; L_s: length of stroke; D_l: piston diameter; D_r: rod Diameter

$$V_t = \left(\frac{\pi}{4} D_l^2 L_s\right) N_c$$

Actual Vol, $V_a = V_t E_v$ or $Q_a = Q_t E_v$

Pump rating → max delivery P & Q

Hydraulic Power $= P \cdot Q$

$$H_{hp} = \frac{P \cdot Q}{1714}$$

Well Control System → **Function**: Prevent further inflow of formation fluid into wellbore during kick.

⇓ by

= shutting in well @ surface

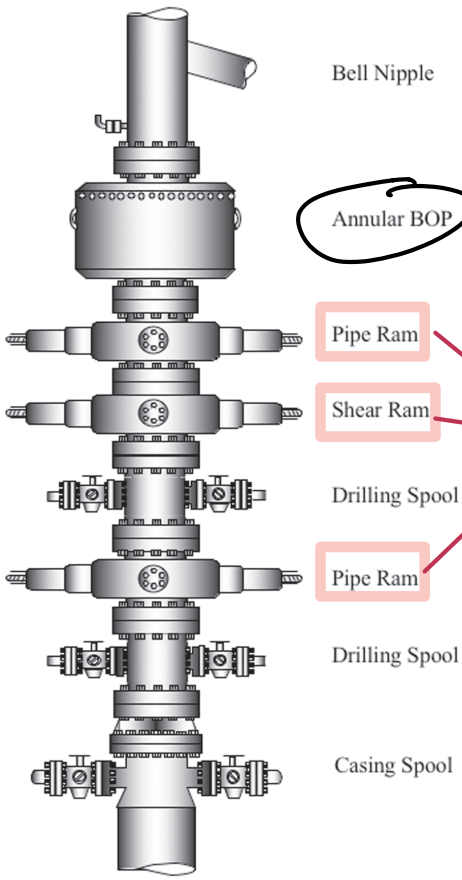
= controlling removal of formation fluid

= pump mud with higher ρ

= tripping d.p in ϟ out of hole

basic component

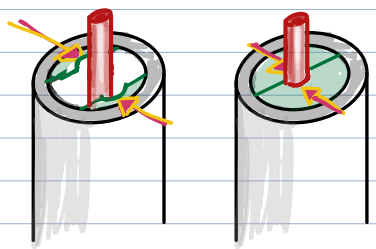
BOP



Annular Preventer: employs a synthetic rubber ring that inflates during well shut off

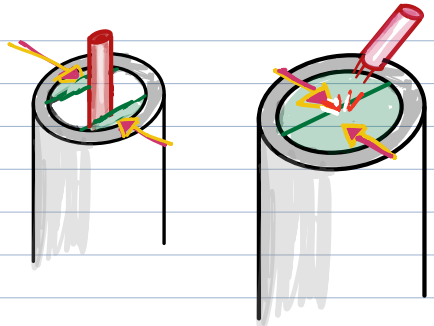
Ram Preventers

- **Pipe rams**
  - opening size = OD of D.P ⇒ Close off annular space between d.p / casing



Shear Rams

- designed to cut off the d.p



Blind rams

- used when no d.p r inside the hole