Hoisting

This chapter covers the following items

- Draw-works
- Hoisting tackle; including crown and traveling blocks, hooks and elevators
- Deadline anchors
- Drilling lines
- Derrick

**Draw-works**

- Heart of the rig
- Enabling equipment to be run in and out of the hole
- Provide power for making or breaking joints
- Principle components: drumshaft group, catshaft and coring reel group, main drive shaft and jacketshaft group, rotary component group, and controls

**Drumshaft group**

- Hoisting drum to reel the line to raise and lower loads
- Brakes; used to stop the movement using the brake lever
- Cooling system; water cooling system to remove heat generated during braking
- Auxiliary brakes; hydrodynamic (hydromatic) or eddy current (uses magnetic forces)
  - With hydromatic, braking effect increases with weight (depth) increase
  - Hydromatic used when electric supply on rig limited
  - On diesel electric rig use eddy current brake
  - Eddy current braking effect depends upon the intensity of the electromagnetic current

**Catshaft and coring reel group**

- Comprises the catheads, the catshaft assembly and the coring drum
Catheads are spool-shaped, rotating drum powered by the jacketshaft assembly
Consists of friction and mechanical rotating heads
Friction catheads used to transport heavy objects around the rig floor by means of a manila rope
The mechanical catheads comprises the makeup catheads on the drillers side and the brake-out catheads on the opposite side
Mechanical catheads are spooled with a suitable length of wire line connected to the tongs
The tongs on the driller’s side is called make-up tongs and on the other side called break-out tongs
Coring reel drum contains sufficient small diameter (9/16 in) wire line to reach the bottom f the hole
Used for lowering and retrieving any device to the hole bottom

Main drive shaft and jacket group

On many modern rigs
Used to generate electricity
Electric cables used to deliver power to motors attached main drive power to the main drive shaft, rotary table and mud pumps
Main drive shaft equipped with two sprockets connected by roller chains to high- and low-drive sprockets on the jackshaft
The jackshaft connected to catshaft and drumshaft through roller chains and sprockets
Engagement of the high- or low-drive sprockets, catshaft or hoisting drumshaft is achieved by sliding gear clutches
This engagement is driven with four-speed gear box
Reverse is obtained by reversing the rotation of the D.C. electric motors

Rotary countershaft group

Required when the rotary table is powered directly from the draw-works
Comprises all components required to transfer rotary motion to the rotary table
Includes the rotary countershaft, drive-chain and sprockets, air clutch, inertia brake and controls
In modern rigs, the rotary table is powered by a separate D.C. motor and drive shaft assembly

Hoisting tackle

Block and tackle system used to handle weight of drill string
Continuous line is wound around a number of fixed and traveling pulleys
The line segments between sets of pulleys act to multiply the single pull exerted by the hoisting drum
This allows many thousands of pounds of drill string or casing to be lowered into or pulled from hole
It includes different components: crown block, traveling block and drilling hook, dead line anchor and weight indicator, and drilling line

Crown block

Means of taking wire line from the hoisting drum to the traveling block
Number of pulleys fastened to the top of the derrick
The drilling line is reeved around the crown block and traveling block sheaves
One end comes to an anchoring clamp called dead line anchor
The other end goes to the hoisting drum described as fast line
During hoisting the drum spools more fast line than the distance traveled by the traveling block
The speed of the dead line is zero while that of the fast line is equal to the number of drilling line times the speed of the traveling block
Crown block must be positioned such that the fast line sheave is close to the center line of the hoisting drum
The angle formed by the fast line and the vertical is called fleet angle.

- Fleet angle should be less than 1.5 deg.
- Crown block is a steel framework with the sheaves mounted parallel on a shaft.
- The sheaves are mounted on a double-row tapered roller bearings to minimize friction.
- A sheave for the line from coring reel shaft is also on the block.
- Small sheave for the manila rope from friction catheads may be also found.

**Traveling block and drilling hook**

- Similar to the crown block.
- Manufactured from high quality steel, each mounted on large diameter of anti-friction bearings.
- Sheaves diameter should be 30-35 times the diameter of the drilling line to prevent excessive wear and increase fatigue life of line.
- Manufactured to be
  - Short and slim for less room
  - Heavy to overcome the drilling line friction
  - Free of protrusions and sharp edges for safety of workers.
- Combined with the hook into one unit named “Hook Block”.
- The hook is used to connect the traveling block to the swivel and the rest of the drill string.

**Deadline anchor and weight indicators**

- A base and slightly rotatable drum attached to the rig floor.
- Provide a means of securing the dead line and measuring the hook load.
- Hook load measured by a sensitive load cell or pressure transformer.
- A pressure signal is sent to the rig floor through a fluid filled hose connected to a weight indicator.
The weight indicators has two pointers; one shows total hook load and other weight on bit

Drilling line

- A wire rope made up of number of strands wound around a steel core
- Each strand contains a number of small wires wound around central core
- Several types of wire ropes:
  - Round strand
  - Flattened strand
  - Locked coil
  - Half locked
  - Multi-strand
- Difference in
  - Internal structure
  - Weight per unit length
  - Breaking strength
  - Number of wires in each strand
  - Number of strands
  - Type of core
- In oil well drilling, round-strand wire are only used

Round-strand ropes

- Widely used in most hoisting operation; oil or mining
- More economical than others
- Consists of six strands wound over a fiber core or a small wire rope
- The wire rope described by the number of strands
- Described as:
  - Type A: either 6x9/9/1; means 6 strands each consists of 9 outer wires, 9 inner wires, and one central core, or 6x19, meaning 6 strands each contains 19 wires
  - Type C: either 6x10/5/5/1 or 6x21
  - Also described by the type of lay: Lang’s lay or ordinary (regular) lay
Lang’s lay, wires and strands are twisted in the same directions; right hand or left hand
This type of twist increases wire rope resistance to wear
Ordinary lay; wires and strands twisted in opposite direction
Advantage, easier to install and handle than lang’s lay

Drilling line design considerations

Typical line is round-strand, Lang’s lay, 6x19 construction with independent wire rope core (IWRC)
Sizes varies from ½ to 2 in (51 mm)
Described by nominal diameter, mass per unit length and nominal strength
Specifications given in API Spec 9A

Static and dynamic load

Static crown load for two sheaves (SCL) = fast-line load + hook load + deadline load

\[
SCL = \frac{W}{2} + W + \frac{W}{2} = 2W \quad \text{.................................................(1)}
\]

For three sheaves

\[
SCL = \frac{W}{4} + W + \frac{W}{4} = \frac{3}{2}W \quad \text{.................................................(2)}
\]

For N lines

\[
SCL = \frac{W}{N} + W + \frac{W}{N} = (1 + \frac{2}{N})W \quad \text{.................................................(3)}
\]

Under dynamic conditions

Hook load (HL)

\[
W = \frac{FLxK(1 - K^{N})}{(1 - K)} \quad \text{.................................................(4)}
\]

Fast line load (FL)
\[
\begin{align*}
FL &= \frac{W(1-K)}{K(1-K^N)} \quad \text{(5)} \\
\text{Block and tackle efficiency (EF)}
\end{align*}
\]

\[
\begin{align*}
EF &= \frac{W(1-K^N)}{N(1-K)} \quad \text{(6)} \\
\text{Fast line during lowering (FL)}
\end{align*}
\]

\[
\begin{align*}
FL_{\text{lowering}} &= \frac{WK-N(1-K)}{(1-K^N)} \quad \text{(7)} \\
\text{Dead line load (DL)}
\end{align*}
\]

\[
\begin{align*}
DL &= \frac{HLxK^N}{NxEF} \quad \text{(8)} \\
\text{Design factor (DF)}
\end{align*}
\]

\[
\begin{align*}
DF &= \frac{\text{nominal strength of wire rope (lb)}}{\text{Fastline load}} \quad \text{(9)} \\
\text{Power requirement (P)}
\end{align*}
\]

\[
\begin{align*}
P &= \left( \frac{HL}{NxEF} \right) xN x V_L = \frac{HLxV}{EF} \quad \text{(10)} \\
\text{in horse power} \quad \text{(11)}
\end{align*}
\]

\[
\begin{align*}
P &= \frac{HLxV}{EFx33000} \quad \text{(11)} \\
\text{Ton-miles of a drilling line}
\end{align*}
\]

\[
\begin{align*}
T_r &= 4WD + W_e(L_s + D)D + 2CD \quad \text{(12)}
\end{align*}
\]
\[ T_r = \frac{D(L_s + D)W_e}{10560000} + \frac{D(M + C/2)}{2640000} \text{ ton-mile} \quad \text{(13)} \]

**Drilling operation**

\[ T_d = 3(T_r \times d_2 + T_r \times d_1) = 3(T_2 + T_1) \quad \text{(14)} \]

**Coring operation**

\[ T_c = 2(T_2 + T_1) \quad \text{(15)} \]

**Setting casing operation**

\[ T_s = \frac{D(L_s + D)W_{es}}{10560000} + \frac{MD}{2640000} \text{ ton-mile} \quad \text{(16)} \]

The total ton-mile is calculated and the cut of length is determined from the tales depending on the size of the wire and the ton-mile between two cut-offs.

<table>
<thead>
<tr>
<th>Wire rope diameter</th>
<th>Ton-mile between cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>1 1/8</td>
<td>800</td>
</tr>
<tr>
<td>1 1/4</td>
<td>1100</td>
</tr>
<tr>
<td>1 3/8</td>
<td>1900</td>
</tr>
<tr>
<td>1 1/2</td>
<td>2600</td>
</tr>
</tbody>
</table>

API gives a table for the length of cut-off in terms of drum laps

**Derricks**

- Structure of square cross-section constructed of special structure steel
- Yield strength greater than 33,000 psi
- Consists of four legs connected by horizontal structures
- Equipped with a substructure (derrick floor)
The structure height above the ground varies with the substructure.

- For base size 24-26 ft, height is 7.25 ft
- For base 30 ft, height can be 7.25, 10, or 14 ft
- Rating of the derricks is based on pipes setback load and wind velocity.

Derricks are designated by:

- **Height**: the vertical distance along the neutral axis of the derrick leg from the top of the derrick floor joists to the bottom of the water table.
- **Base square**: the distance from the heel to heel of the adjacent legs at the top of the base plate.
- **Window opening**: distance measured parallel to the center line of the derrick from the top of the base plate.
- **Water table opening**: an opening in the top of the derrick in which the crown block is fit.
- **Gin-pole**: used to hoist the crown block to its place at the water table opening.
- **Gin-pole clearance**: the distance between the header of the gin pole and the top of the crown block.

**Types of steel derrick**

- **Standard**: which is a bolted structure.
- **Portable (mast)**: moved as one unit on a truck or dismantled into a number of pin-jointed section, each is one truck load.