1.1 INTRODUCTION

Casing is an essential part of drilling and completion of an oil and gas well. There are two different jobs that a casing must be designed for. The first is to allow you to safely drill the well and resist any forces or conditions that are imposed on it during drilling, without sustaining significant damage. The second is to act through the life of the well to meet the well objectives without requiring a work over. The design criteria for each string of casing are different during drilling and during the remainder of the life of the well. Computer programs make detailed casing designs routinely possible, including tri-axial analysis.

1.2 FUNCTIONS OF CASING

To keep the hole open and to provide a support for weak, or fractured formations. In the later case, if the hole is left un -cased, the formation may cave- in and re -drilling of the hole will then become necessary.

- To isolate porous media with different fluid / pressure regimes from contaminating the pay zone. This is actually achieved through the combined presence of cement and casing. Therefore, production from a specified can be made.
- To prevent contamination of near- surface fresh – water zones.
- To provide a passage for hydro-carbon fluid, most production operations are carried out through special tubing which are run inside the casing.
- To provide a stable connection for the well-head equipment (e.g.; X-mass tree). The casing is also served to connect the blowout prevention equipment (BOP), which is used to control the well while drilling.
- To provide a hole of known diameter and depth to facilitate the running of testing and completion equipments.

1.3 TYPE OF CASINGS

In actual practice it would be much cheaper to drill a single size hole to total depth (TD), probably with a small diameter drill bit and then case the hole from the surface to the TD. However, the presence of high pressurized zones at different depths along the well bore, and the presence of weak, unconsolidated formations or sloughing shaly zones necessitates running casing to seal off these troublesome zones and to allow of drilling to TD. Different sizes of casing are therefore run to case off the various sections of hole, a large size of casing run at the surface followed by one or several intermediate casings and finally a small size casing for production purpose. Many different size combinations are run in different parts of the world. The types of casing currently used are as follows:

1.3.1 STOVE CASING

These are the marine conductor or foundation pile for offshore drilling and is run to prevent washout of near surface unconsolidated formations, to provide a circulation system for the drilling mud and to ensure the stability of the ground surface upon which the rig is sited. This pipe does not carry any well head equipment and can be driven into the ground with a pile driver. The normal size for a Stove pipe ranges from 26 in (660.4 mm) to 42 in (1066.8 mm).

1.3.2 CONDUCTOR CASING

The first casing is usually called the conductor casing. It may be driven into the ground with a pile driver or it may be cemented inside a drilled hole. The shoe depth selected for the conductor casing should be strong enough to withstand fracturing during drilling the next hole interval which is assumed to have no hydrocarbon bearing intervals. The purposes of this casing are to –

- Conduct drilling fluid returns back up to the rig during surface hole drilling so that a closed circulation system can be established.
- Protect unconsolidated surface formations from being eroded away by the drilling fluid.
- Some times support the weight of the well head and BOPs.

Conductor pipe is always cemented to the surface. Typical size for a conductor casing is $18^{5/8}$ in (473 mm) to 20 in (508 mm) in Middle East and 30 in (762 mm) in North Sea exploration.

1.3.3 SURFACE CASING

The surface casing is the first casing that is set deep enough for the formations at shoe to withstand pressure from a kicking formation further down. Surface casing is treated as conductor casing if no hydrocarbon are expected in the next hole interval or alternatively as intermediate casing in the event that hydrocarbons are expected in the next phase of drilling. Surface casing is run to prevent caving of weak formations that are encountered at shallow depths. This casing should be set in competent rocks such as hard lime stones. This will ensure that the formation at the casing shoe will not fracture at high hydrostatic pressure which may be used later. The purposes of the surface casing are to—

- Allow a BOP to be nippled up so that the well can be drilled deeper.
- Protect fresh water sources close to the surface from pollution by the drilling fluid.
- Isolate unconsolidated formations that might fall into the well- bore and cause problem.
- Support the weight of all casing string run below the surface pipe.

A typical size of this casing is $13^{3/8}$ in (340 mm) in the Middle East and $18^{5/8}$ in (473 mm) or 20 in (508 mm) in North Sea operations.

1.3.4 INTERMEDIATE CASING

Depending upon the depth of the well and the anticipated problem in drilling the well, such as abnormal pressure formations, heaving formations or lost circulation zones, it may be necessary to set a number of intermediate strings of casing to seal off the long open hole or zones causing trouble. A shallow well may not need an intermediate casing; a deep well may need several. The intermediate casing serves as strong posts between the surface casing and the production casing. Good cementation of this casing must be ensured to prevent communication behind the casing between the lower hydrocarbon zones and upper water formations. Multistage cementing may be used to cement long strings of intermediate casing. The primary purpose of the intermediate casing are to –

- Increase the pressure integrity of the well so that it can be safely deepened.
- Protect any directional work done e.g. kicking off a directional well is often done under surface casing and is then protected by the first intermediate casing.

- Consolidate progress already made.

The most common size of this casing is $9^{5/8}$ in (244.5 mm).

1.3.5 PRODUCTION CASING

The production casing is often called oil string. It houses the completion tubing, through which hydrocarbons will flow from the reservoir. If the completion tubing were to leak, the production casing must be able to withstand the pressure. Sometimes the production casing is cemented in place with the casing shoe above the reservoir and another hole section drilled. This may be protected with a liner rather than a string of casing. It is run to isolate producing zones, to provide reservoir fluid control, and to permit selective production in multizone production. This is the string through which the well will be completed. The purpose of this casing is to –

- Isolate the producing zones from the other formations.
- Provide a work shaft of a known diameter to the pay zone.
- Protect the production tubing and other equipments.

The normal size for the production casing is 7 in (177.8 mm)

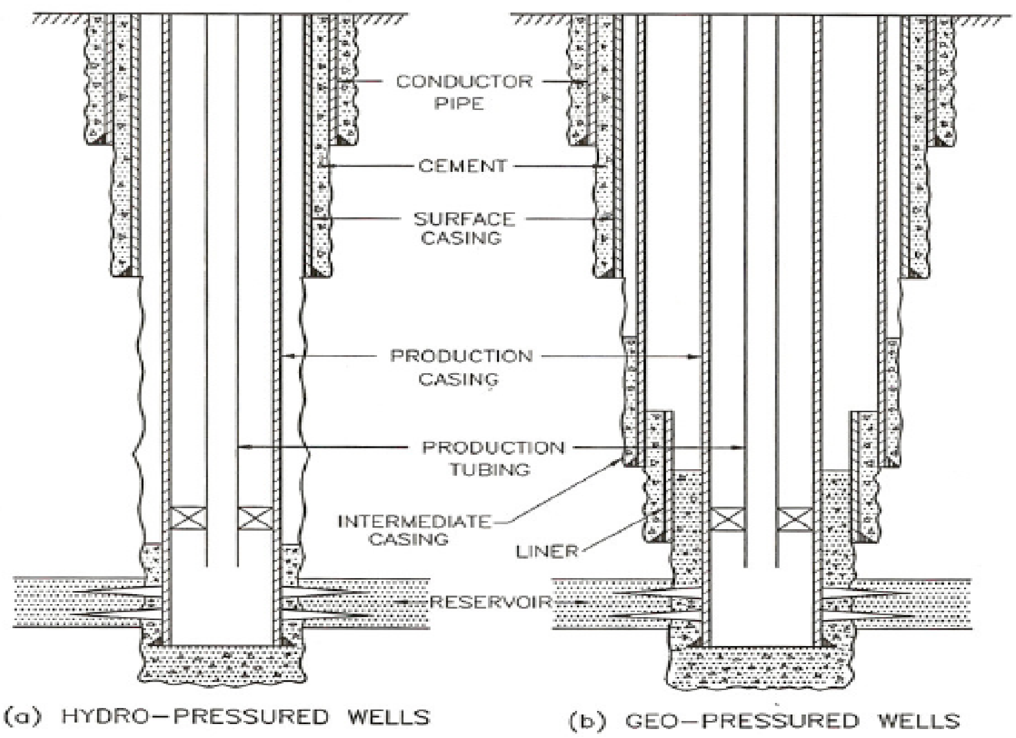

Fig. 1.1: Typical casing program showing different casing sizes and their setting depths.

1.3.6 LINER CASING

A liner is a string of casing that does not reach the surface. Liner are hung on the intermediate casing by use of a suitable arrangement of a packer and slips called a liner hanger. In liner completion both the liner and the intermediate casing act as the production string. Because a liner is set at the bottom and hung from the intermediate casing, the major design criterion for a liner is the ability to withstand the maximum collapse pressure. There are pros and cons to liners

ADVANTAGES:

- **Economics:** The cost of the liner and associated equipment is less than the cost of a full string of casing to the surface. Also running and cementing time reduced.
- **Utility:** The inside diameter of the liner is inevitably less than the ID of the production casing. This allows tools to be run as part of the completion that would be too large to fit inside the liner but could be set higher up, inside the casing.
- Small size allows completion with adequate size of production tubings.

DISADVANTAGES:

- **Complexity:** The equipment required to run a liner is much more complex than for a casing so there is more chances that something will go wrong.
- Possible leak across a liner hanger.
- Difficulty in obtaining a good primary cementation due to the narrow annulus between the liner and the hole.

1.4 TYPE OF LINERS

Drilling Liners are used to isolate lost circulation or abnormally pressurized zones to permit deeper drilling.

Production Liners are run instead of a full casing to provide isolation across the producing or injection zones.

The **Tie-beck Liners** is a section of casing extending upwards from the top of an existing liner to the surface or well head.

The **Scab Liner** is a section of casing that does not reach the surface. It is used to repair existing damaged casing. It is normally sealed with packers at top and bottom and in some cases is also cemented.

The **Scab Tie-back Liner** is a section of casing extending from the top of an existing liner but does not reach the surface. The scab Tie-back liner is usually cemented in place.

2.1 FRACTURE GRADIENT

In oil and gas well drilling the fracture gradient may be defined as the minimum total in situ stress divided by the depth. Knowledge of fracture gradient is essential to the selection of proper casing seats, for the prevention of lost circulation and to the planning of hydraulic fracturing for the purpose of increasing of well productivity in zones of low permeability. Accurate knowledge of the fracture gradient is of paramount importance in areas where selective production and injection is practiced. In such areas the adjacent reservoirs consist of several sequences of dense and porous zones such that, if a fracture is initiated (during drilling or stimulation), it can propagate, establishing communication between H/C reservoirs and can extend down to a water bearing zone.

The fracture gradient is dependent upon several factors, including type of rocks, degree of anisotropy, formation pore pressure, magnitude of overburden and degree of tectonics within the area .It follows that any analytical prediction method will have to incorporate all of the above factors in order to yield realistic values of the facture gradient.

Various methods currently used in oil industry to determine or predict fracture gradient of rock with some important definitions are as follows:

2.2 OVERBURDEN STRESS

Over burden stress σ_v is defined as the stress arising from the weight of rock over laying the zone under consideration. In geologically relaxed areas having little tectonic activity, the overburden gradient is taken as 1 psi / ft (0.2262 bar / m). In tectonically active areas as in sedimentary basins which are still undergoing some compactions or in highly faulted areas, the overburden gradient varies with depth, and average value of 0.8