Inflatable Packers: Inflation Media and Associated Factors

Inflatable packers may be inflated hydraulically or pneumatically, with either method having relative merits, as well as drawbacks. These issues will be analysed in further detail below.

Depth, density of liquid (S.G) and the depth of water per meter down hole are used to calculate down hole pressures. Pressure is commonly calculated using kPa though psi and bar are also used.

It is important to note that for every 1 meter of water down hole a pressure of 10kPa is exerted (See fig 1).

\[
\text{Pressure (kPa) = Depth (m) x 10kPa x S.G} \\
\text{(S.G = Specific gravity or density of drilling fluid)}
\]

- Depth = 100m
- S.G (water) = 1.0
- Water Pressure = 10kPa
- Pressure = 100 x 1.0 x 10
  \[
  = 1000\text{kPa (145psi)}
  \]

The above calculation is used as part of fundamental drilling practices however it is also used in conjunction with the gas inflation of inflatable packers. In order to achieve a predetermined pressure (x) to seal the borehole with the above specifications the packer must be inflated to 645psi at the surface which equates to 500psi down hole. Therefore the surface equipment must be able to safely support additional inflation pressures.

Hydraulic inflation with water is the most commonly used inflation media for inflatable packers. Water is incompressible; hence a given volume (x) needed to inflate an inflatable packer to a given diameter at surface level, remains as (x) volume at, say, 100 meters down hole. Water, when used as an inflation medium, provides a positive dynamic seal in a borehole, and can be operated at lower pressures compared to pneumatically inflated packers, this can be extremely useful especially when inflating into soft ground formations where it is likely to yield under higher inflation pressures.

Hydraulically inflated packers are very easy to monitor on inflation, both for total water volume and for pressure. As a result, hydraulically inflated packers are less likely to rupture when operated in elastic or plastic yield formations and ‘wash out’ zones. Once water volume increases or pressure decreases it may be clear that the packer is yielding the ground formation or inflating into a washout. Additional benefits of hydraulic inflation include (usually) the ready availability of water as an inflation medium, combining low cost with environmental friendliness. Safety considerations factor in greatly, as the risk of explosive decompression is minimised greatly using water over air or any other gas.
One of the few drawbacks to hydraulic inflation is the difficulty of achieving positive deflation in the presence of sufficient hydrostatic head pressure down hole. This also becomes a problem in a dry hole where the weight of the water in the inflation tube is enough to prevent adequate deflation. However, these problems are generally overcome by incorporating a dump valve into the inflatable packer design, or via a separate deflation line using gas or air to purge and deflate the packer.

Pneumatic inflation means the packer is gas inflated using bottled (compressed) nitrogen, or compressed air. Nitrogen is a preferred inflation medium, as it is an inert gas, that is, it is chemically non-reactive (though only in a relative sense). Nitrogen, given sufficient pressure, heat and presence of catalysts may become more reactive. This process is not, however, encountered with respect to its use as an inflatable packer inflation medium.

Pneumatically inflated packer systems often give little indication of overpressure during operation. Should the packer be inflated in a ‘wash out’ zone, or strata prone to elastic or plastic deformation down hole, the packer is liable to overinflate and rupture, with the operator having little control or forewarning. Further, in deep hole and/or high aquifer situations, significant quantities of bottled nitrogen will be needed. As nitrogen is released down hole into the packer, the pressure of the water above it will compress the gas therefore more nitrogen is required to achieve the volume required to fully inflate the packer.

As well, it must be kept in mind that rubber is permeable to gases, with the relative permeability assessed as a function of time and pressure. This permits an insensible loss of inflation gas, and hence of inflatable packer working pressure. Rubber permeability to gases permits the migration of gas under pressure into the rubber polymer matrix, which can, over time, lead to delaminating of the packer element. As well, inflatable packer elements subject to relatively high gas inflation pressures, over time, can exhibit embolisms, or pockets of decompressed nitrogen under the exterior surface of the rubber element, a condition sometimes referred to as ‘packer pox’.

Other concerns with gas inflation include the cost of bottled gas, as well as, the logistics of conveying it to (often) remote locations. Safety factors cannot be ignored. Inflatable packers must never be gas inflated in free air. Should the inflatable packer element rupture, explosive decompression will occur which is more than capable of seriously injuring bystanders.

Likewise, the use of reactive gases such as hydrogen (H) and oxygen (O) as inflation medium must be prohibited. Compressed air is sometimes used to inflate packers, however, as air contains 21% oxygen care must be taken to restrict its use to low pressure though all conditions and factors must be taken
into consideration before operation of any inflatable packers or ancillary equipment bearing pressure.

The caveats and drawbacks of nitrogen or air inflation of inflatable packer may seem considerable, yet pneumatic inflation remains highly viable. Pneumatic inflated packer systems can be inflated and deflated rapidly, which represents considerable time, and hence cost savings for operators. As mentioned previously, pneumatically inflated packers operating below a significant static head (water) pressure are easily deflated, retrieved, and redeployed. The gas inflation line typically serves as the return deflation line, which simplifies construction of pneumatic inflatable packer systems.