# The Inflatable Packer – A Most Versatile Tool

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## Summary

The inflatable packer is introduced showing its basic construction. Its versatility is demonstrated by reviewing a broad range of uses, such as, well testing, fracturing, monitoring, pumping, cementing, well repair and swaging. For each case, a brief description is given of the requirements of the application and of the way in which an inflatable packer is used to meet those requirements. Some of the more unusual applications of inflatable packers are presented in closing.

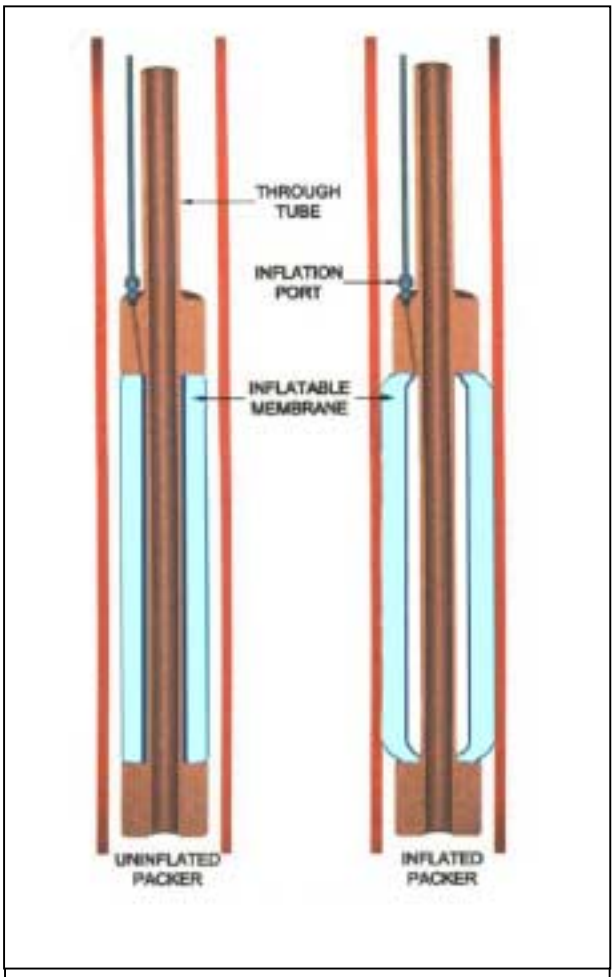


**Figure 1 - Basic Packer**

## Introduction

If you work for a company that manufactures inflatable packers and someone asks you what you do, how do you answer? You've got to assume that the person asking has no idea what an inflatable packer is and try to describe a tool that is used in a myriad of different ways in as few words as possible, or at least until your questioner's eyes glaze over. My stock answer is to say we make down-hole tools for the drilling industry. This tends to satisfy most people unless they, like you, work in that industry. Fortunately, these people want more details, so I can go on to say, it's like a heavy duty rubber hose that inflates when it's pressurized and so can be used to block a hole temporarily or permanently. Why would you want to do that? Why, indeed, is the subject of this paper. Before going on to that though, we might just mention figure 1 and note that most inflatable packers also have a steel pipe running through the middle providing communication from above to below the inflated element.

## Grout Injection

One of the applications most people associate with inflatable packers is cement grouting for hole stability, foundation improvement or water-proofing. In all these cases, an inflatable packer is run into a hole and inflated to allow a grout, under pressure, to be injected into the ground. Although cement grout is the most common any kind of grout, e.g. bentonite, epoxy, or specialized water-proofing or structural agents, can be used. Moreover, injection may be at low, medium or high pressure depending on the intent of the treatment, the fluid used, the ground conditions, the injection depth, etc.

Obviously, the tool that's used to seal the end of the injection pipe to the formation must be able to accommodate all of these variations. An inflatable packer fills the bill precisely. They can be made of materials that provide the required chemical and corrosion resistance. They can also be made to suit a variety of different pressure ratings, installation and inflation methods.

For grouting and many other packer applications, it is often necessary to access a particular zone in a completed well. In this case use of a straddle or double packer assembly ensures a high integrity seal between the zone of interest and the remainder of the bore. A straddle assembly simply uses two inflatable packers, one placed above the test area and the other below it with the two usually linked by a pipe that provides access to the zone. These two packers are usually inflated simultaneously on a common line but may be inflated separately to suit some applications.

## Cementing Systems

Grout injection is also common in casing installation applications and, naturally enough, inflatable packers are also used in this situation. There are many different cementing methods for casing and many of these can use inflatable packers to simplify the process of obtaining a high quality cement seal between the casing and the formation. Figure 2 shows some of the methods that employ inflatable packers for casing cementing. Briefly these are:

- Tremie method for shallow bores.
  Uses an inflatable packer mounted on the casing and inflated by a small bore tube run in the annulus to surface. Cement is placed using a tremie pipe that is also run in the annulus.
- Double packer grouting for medium depth bores.
  This system also uses a casing mounted packer that is inflated from the surface but cement is placed via a one-way valve above the packer and straddle packers run inside the casing.
- Single shot for deep bores.
  In this case the casing packer is inflated using a mechanical sealing tool that runs inside the casing. On reaching a preset pressure, a valve above the packer opens to provide access to the annulus for cementing. There are many different configurations of this system available but all employ some form of casing cementing valve and tooling to inflate the packer and place the cement.

In all cases, the advantage of using an inflatable packer cementing system is that the borehole can be completed to finished depth prior to installing the casing, since the inflatable packer protects the bore below the packer from any possible cement contamination.

These methods are not limited to steel casing or even threaded casings as the heart of the system, the casing packer, can be mounted on any casing type. For example, with PVC casing, the packer is manufactured on a thin wall steel tube that is then slid over and cemented to a length of PVC. A similar system may be employed for fiberglass casing and for premium threaded oilfield casing.

## Cemented Liners

The packer cementing methods outlined above are also applicable to re-lining applications. Here the same options are available, the only real difference being that the new casing or liner is run and cemented inside an old, existing casing instead of an open-hole. Clearly, the advantage of isolating the casing/liner cement from the producing region is very important for re-lines as it totally removes the requirement to kill and re-develop the well. Furthermore, in most cases, all re-lining operations using an inflatable packer based system can be performed without the use of a drill rig – only a crane or simple lifting system is required.

By judicious selection of inflatable packer type, location and appropriate inflation and cementing methods it is even possible to re-line just a portion of a well leaving the top of the liner at any arbitrary depth below surface. This type of operation normally involves the use of straddle packers for casing packer inflation and cementing, though mechanical tools similar to the system indicated for deep bores may also be used.

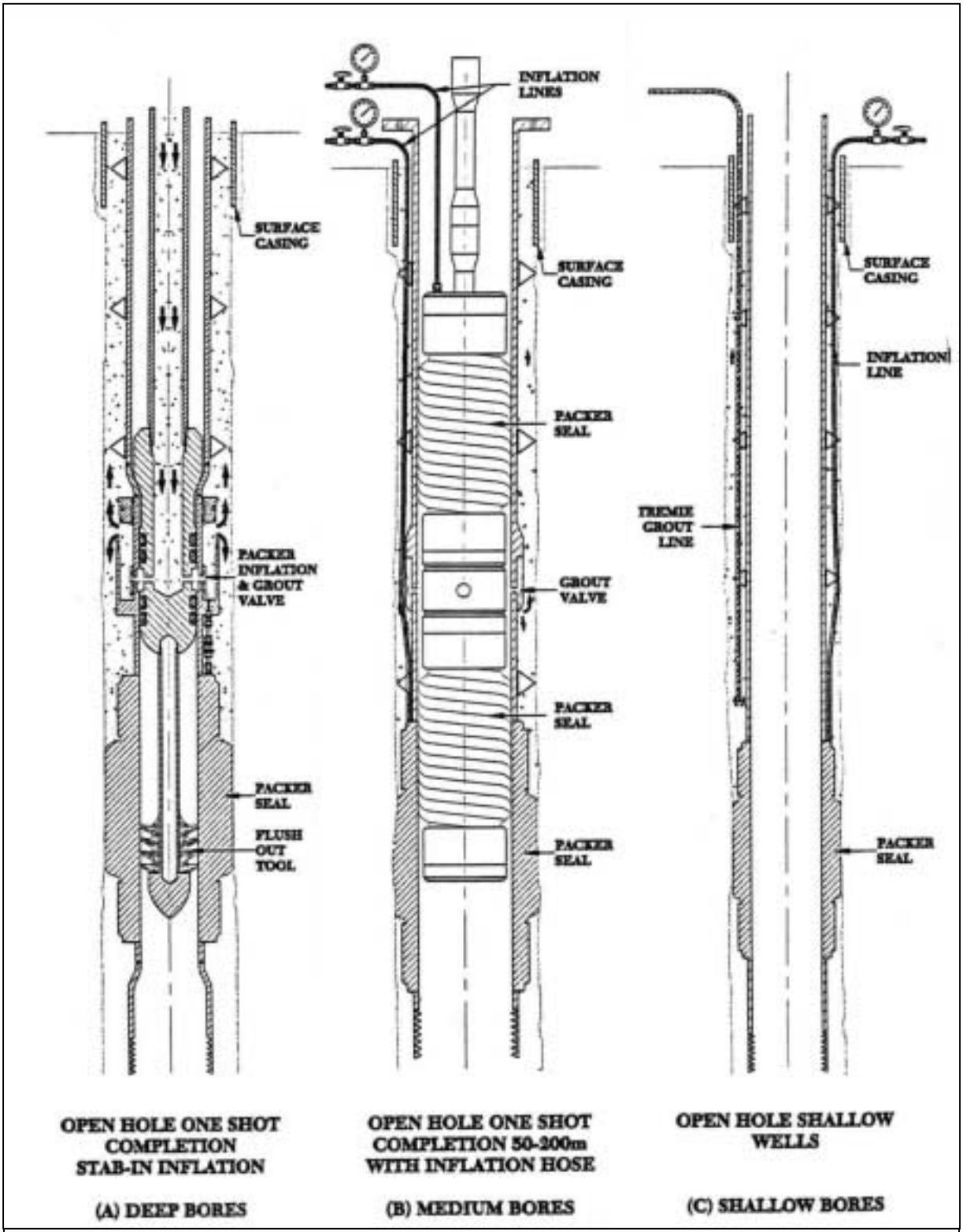


**Figure 2 - Casing Cementing Methods**

## Well Screen Installation

Figure 3 below shows a special type of inflatable packer called a “Grab-Packer”. These were specially developed for water well screen installation. The Grab-Packer is installed into the screen at surface and inflated to anchor the screen to the lowering pipe. These packers have exposed steel strips with non-slip grit treatment to provide high capacity anchoring with relatively low inflation pressures.

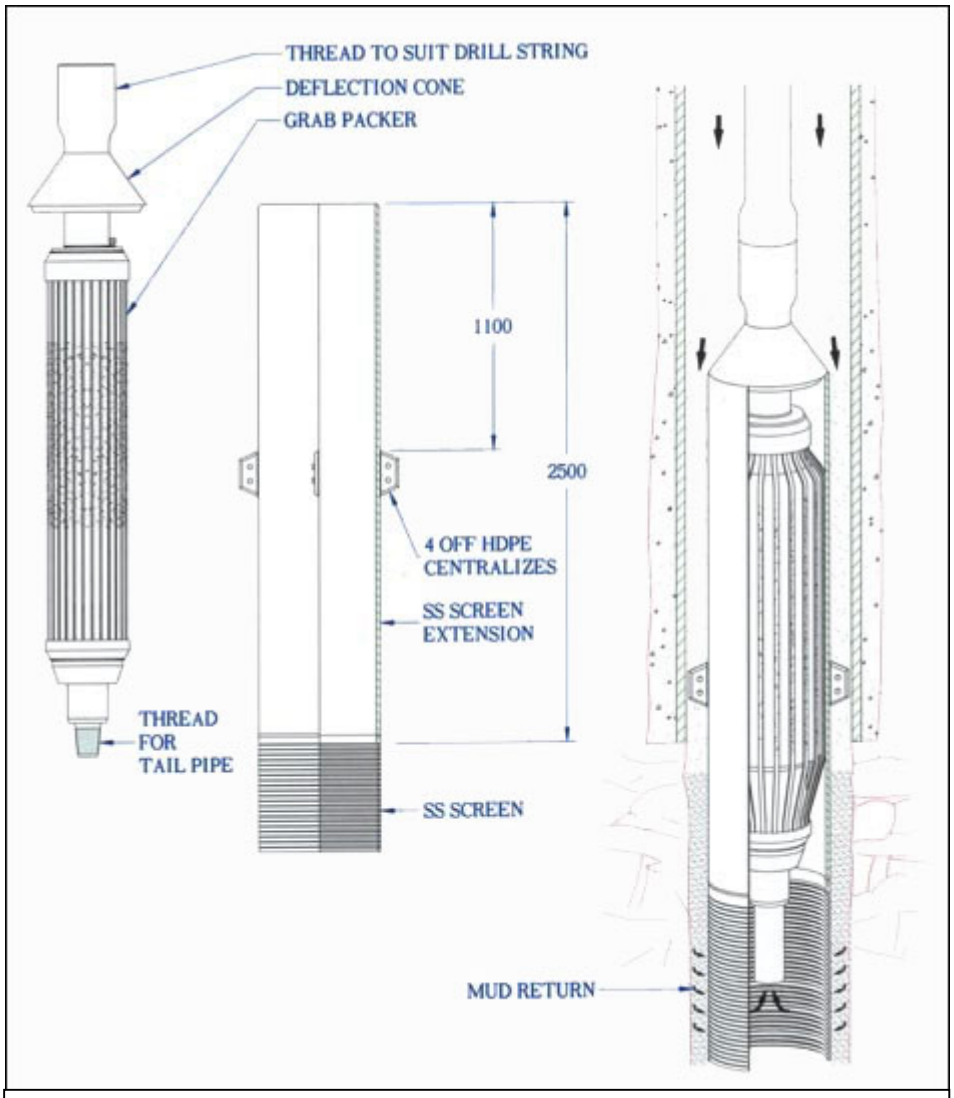


**Figure 3 - Screen Installation & Gravel Packing**

The grab-packer is used to run the screen to depth, support it during gravel packing and then gently release it without any danger of damaging the top of the screen or riser pipe.

## Screen Packers

Clearly, once the screen has been positioned and gravel packed, it must then be sealed back to the casing to prevent production of the gravel pack. Several different methods of achieving this seal are shown in figure 4.

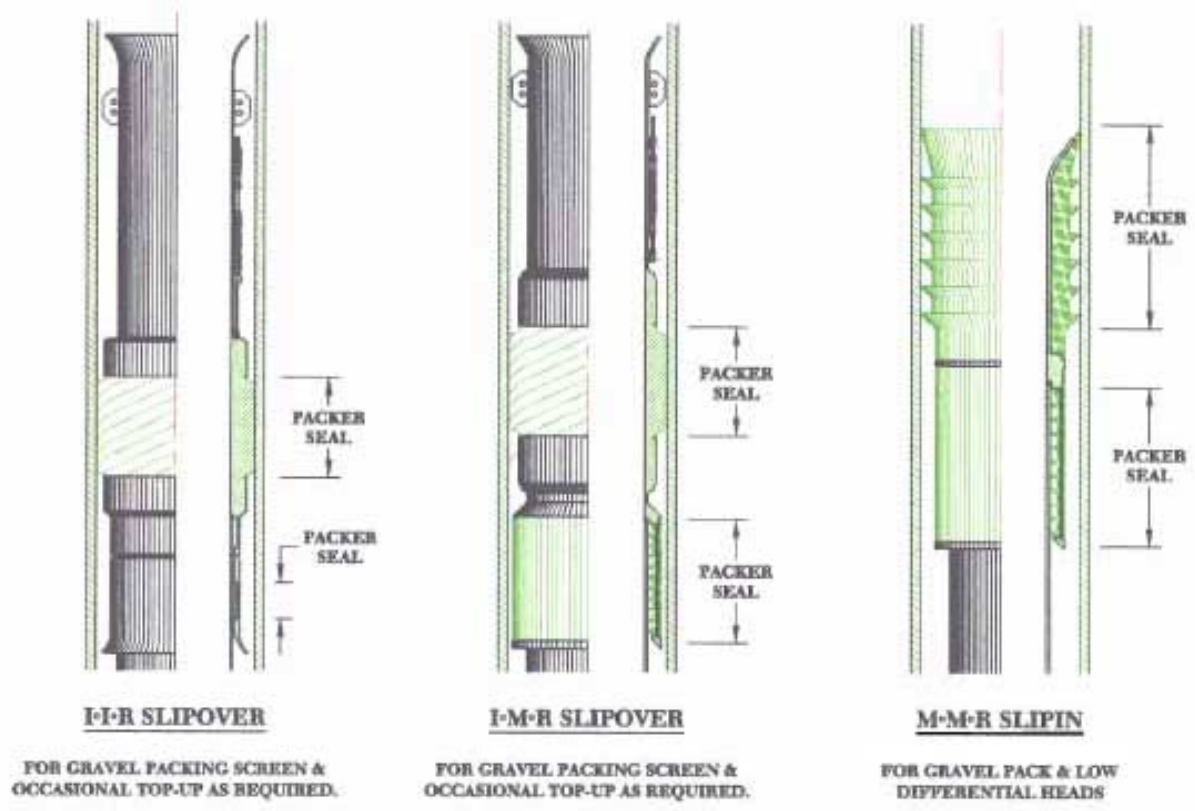


**Figure 4 - Slip-over Screen Packers**

All of these screen seals are of the slip-over type, which means they're designed to slip over the top of the screen and provide a seam both there and at the casing. The IIR Slipover type features inflatable packers for sealing at both locations, the screen seal being accomplished by a packer that inflates inwards. The IMR type uses a mechanical seal on the top of the screen and an inflatable packer to seal into the casing. The MMR type uses mechanical seals, basically high efficiency K-rubber type seals, for both the screen and the casing.

## Pump Packers

Another type of inflatable packer application used in water wells, both for testing and for regular production involves marrying an inflatable packer to an electric submersible pump or even a turbine pump. The former case is illustrated in Figure 5 for a production well installation. Here the packer is used to support the pump in the well and to direct the pump's output into the casing thus doing away with the need for a separate pump column. This system also has a number of other advantages such as rapid installation and removal, lower power consumption, positive casing pressure prevents contamination and packer support protects the pump and casing from physical damage.

Inflatable packers can also be used in conjunction with pumps to isolate particular sections of a well for test pumping to evaluate different aquifers, etc. Methods exist to set-up packers to suit most pumping systems e.g. electric submersibles, turbine pumps, bladder pumps, even air-lift pumps.

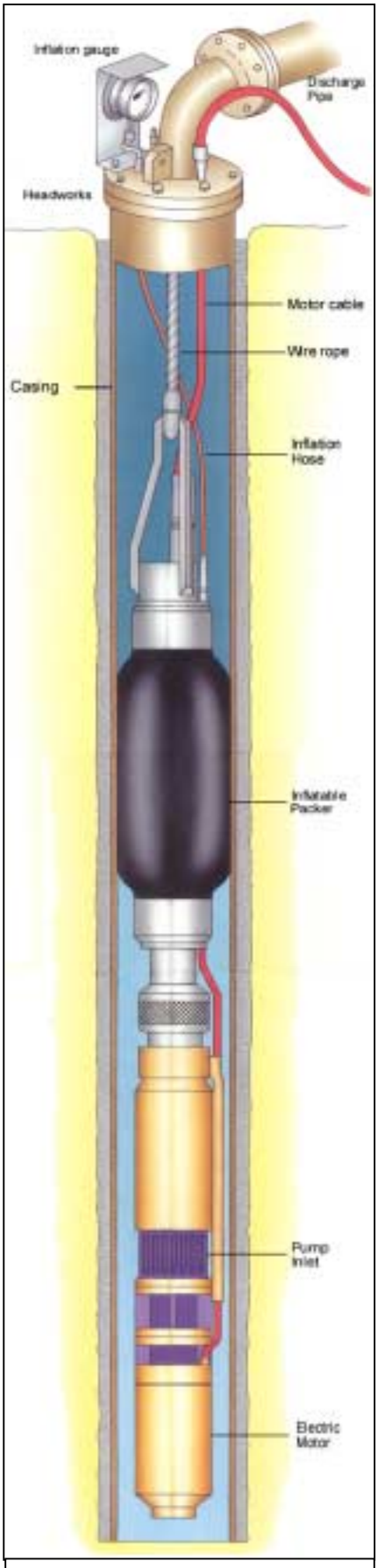


**Figure 5 - Pump Packer**

## Permeability Testing

Permeability testing is another of the traditional uses of inflatable packers that many are familiar with. Perhaps the most familiar is the wireline packer system that is designed for use in conjunction with coring operations. However, packers for permeability testing are frequently run on pipe as well, both as single packers and in straddle configuration. Even a pump-down packer system for use in horizontal wells has been developed. This system can be configured similarly to a standard wireline assembly ie. one packer in the bit and one packer in the formation, and it can also be set up for zone testing with straddle packers. The full blown version includes a down-hole fluid sampling cylinder and memory gauges for pressure recording.

In permeability testing, injection pressures may, like grouting work, be low, medium or high. They could even be negative which is the case in pumping water from a well to determine ground characteristics. (Such pumping may be carried out via air-lift, electric submersible, turbine pump, bladder pump, etc, as indicated in the previous section.)

For many test installations, it is common to use electronic pressure transducers to monitor pressures in and around the test zone. Some specifications even call for four packers to isolate the test zone, with two above and two below and with pressure monitoring on both sides of all packers.

Similar to permeability testing, from an inflatable packers viewpoint, are other fluid pumping methods such as CO2 injection for treatment of bio-fouling or steam injection for soil clean-up. Such treatments bring their own special requirements, usually in terms of material selection, to allow the packer to provide long, reliable service.

## Fracturing

A specialized form of high pressure injection, usually using a straddle packer assembly, can be used to hydraulically fracture the formation or to open pre-existing fractures. For the former, inflatable packers with pressure ratings as high as 10,000 psi (700 bar) have been developed. Such packers are used to generate a new fracture, the orientation of which can be determined using an impression packer (another inflatable packer application). Knowledge of the fracture pressure and orientation allow determination of the in-situ stresses in the rock, which contributes to design decisions on mining, tunneling and other underground activities. This type of test is also referred to as “stress testing”.

One of the unique characteristics of a water (or any liquid) inflated packer that is frequently utilized for such tests, is their dynamic sealing capability. By this we mean that, owing to

the fact that a water inflated packer is basically an incompressible plug, any increase in differential pressure acting across an inflated packer leads to an increase in packer inflation pressure. The practical consequence of this is that a fracture packer can be initially inflated to a pressure well below the known fracture pressure of the formation and it's pressure will increase in response to injection pressure. The difference between the injection pressure and packer pressure can be very small, depending on details of the packer's construction which ensures there is no premature fracturing caused by the pressure exerted by the packer on the borehole wall.

The other common use of fracturing is for improvement of the yield of water bores. In this case, the object is to open, flush out and extend existing fractures in a hard rock aquifer. The pressures are lower, typically no more than 3,000 psi (210 bar), but the pumping flow rate is much higher. This high flow rate is necessary to maintain the elevated pressures required to extend the fractures as far as possible and thus maximize a well's production potential. Inflatable packers are particularly useful in this application because they offer large internal diameter to allow a large flow with low pressure loss but still provide high sealing integrity in open-hole over a large range of different borehole sizes.

## Swage Packers

A new form of packer that relies on inflatable packers but is not one itself is the Swage Packer. This consists of a thin wall tube with a profiled rubber cover that is run on an inflatable packer and set by increasing the packer inflation pressure to permanently deform the Swage Packer into sealing contact with the borehole wall. These are intended primarily for use as casing patches and for re-lining applications. In the latter, they provide an extremely slim-line seal for liners and thus are very attractive where reduction of casing diameter would otherwise lead to having to replace pumping equipment or reduce well production.

**Figure 6 - Pile reforming Packer (1.8 m diameter x 6 m long rated for 2000 psi )**

## More Obscure Applications

Shown in figure 6 is a large diameter inflatable packer that was used for reforming of collapsed piles supporting and offshore production platform. Such applications are rare but show, once again the versatility of inflatable packers and their broad range of possible applications.

More common is such applications as are embodied by a range of inflatables called "Dilatometer Sleeves". A dilatometer is a device that measures in-situ rock strength by determining its deflection under an applied load. A dilatometer sleeve (essentially an inflatable packer) applies the load and electronic sensors mounted inside the tool determine the deflection of the sleeve and consequently the formation. Simple sleeves are made from un-reinforced

rubber though more complicated types have metal inserts to remove variability of results due to rubber compression and even internally segmented chambers. A similar device recently manufactured features a double skin packer with metal electrodes and wires embedded in the rubber to allow injection and subsequent measurement of tracer fluids.

Space precludes mentioning any of the other “special” applications for inflatable packers but suffice to say that the limitations on application are only those due to our imagination. There are also several other “standard” inflatable packer applications that we haven’t even mentioned yet, such as for zone isolation in multilevel monitoring installations, permanently or temporarily plugging wells in a variety of situations, as pipe plugs for test work and remediation, etc.

It is a measure of the incredible versatility of inflatable packers that they can be configured to allow all of these diverse applications. Some require special materials for chemical resistance. Some have special physical requirements, e.g. passing sealed electric cables through a packer to operate a equipment such as a submersible pump located below the packer. Some require very low pressures to avoid formation damage whereas others require very high pressures to allow injection into tight formations. Inflatable packers have been developed to meet all these requirements in a large range of different borehole sizes.

## Conclusions

Briefly reviewing a broad range of applications of inflatable packers has highlighted their usefulness and versatility as tools for the drilling and production industries. Although not all applications have been covered and none has been dealt with in any detail, sufficient information is provided to allow appreciation of the many ways in which packers can and are being used. It is hoped that this will lead to even greater use of these unique and versatile tools and the development of even more and varied applications.