Packers and Flowmeters

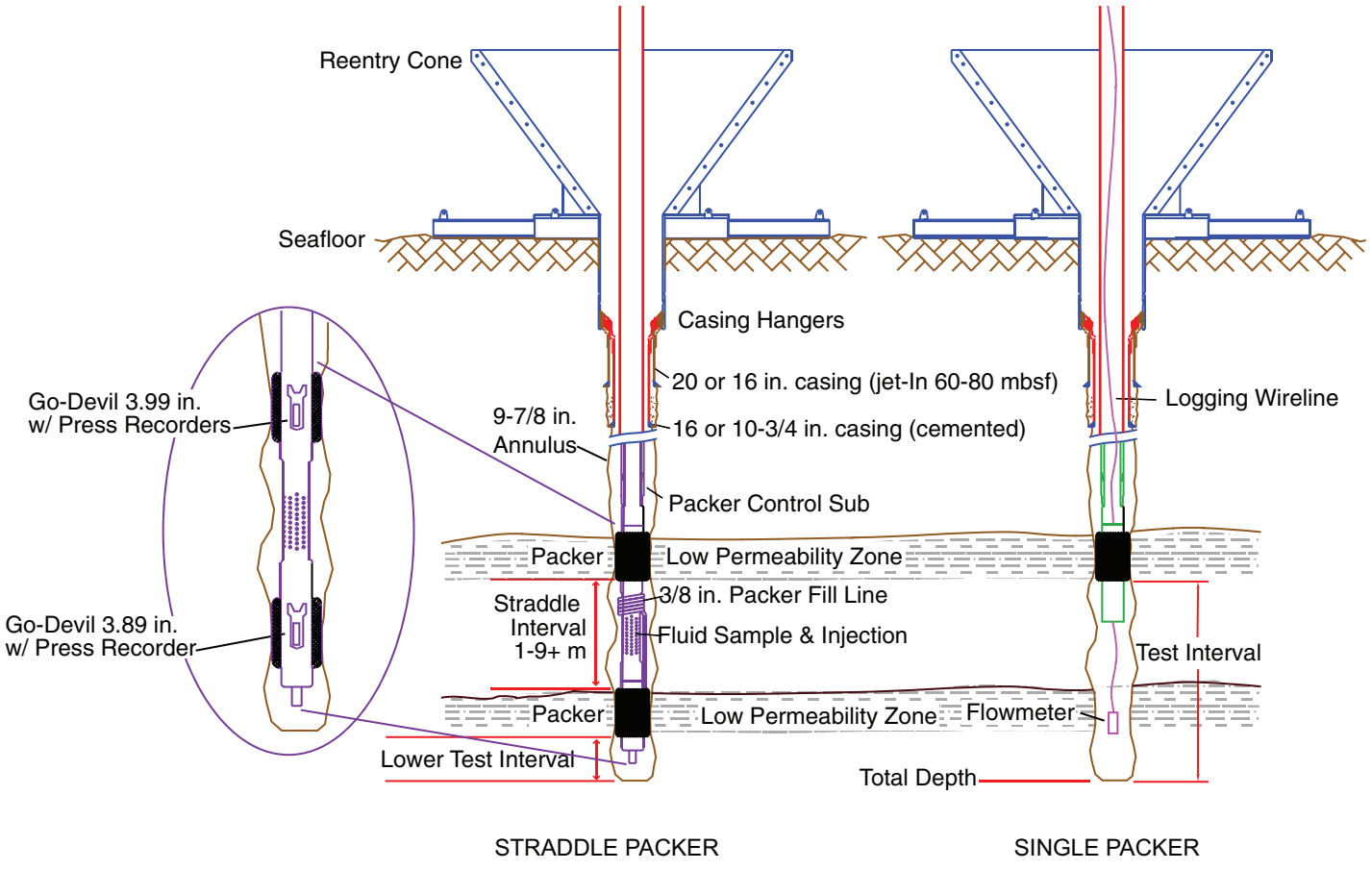
JOIDES Resolution Science Operator

Scientific Application

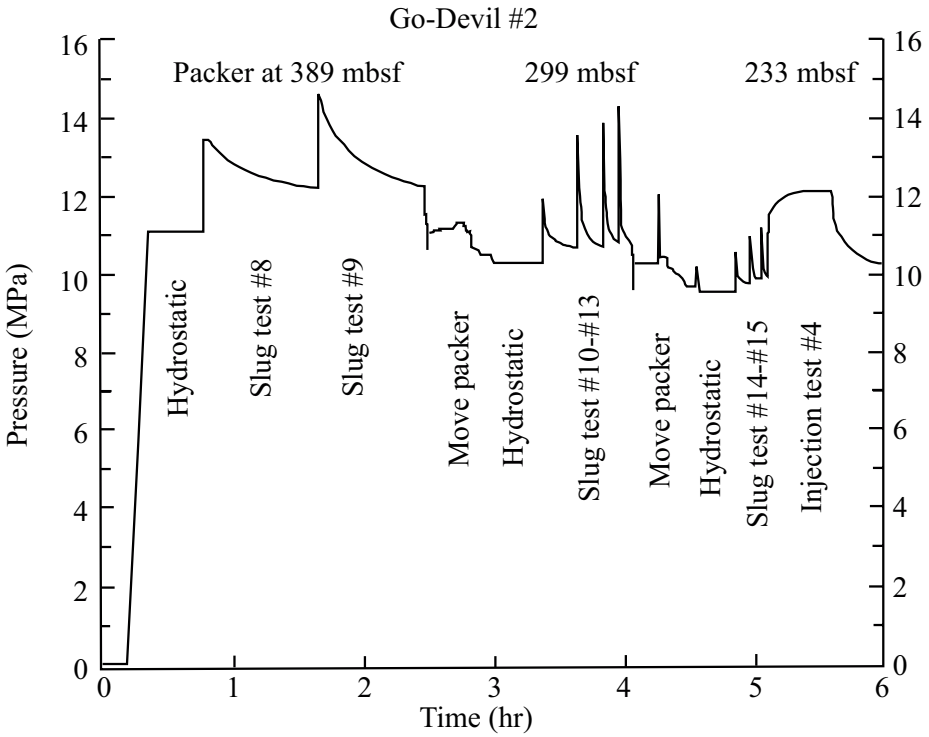
Packers

A "packer" is an inflatable rubber element that inflates to seal the annular space between the drill string and the borehole wall. While there are different types of packers, IODP runs one, or two in tandem assemblies, on drill string into a pre-existing ~9⅞ in. hole (cored, drilled, or cased) and inflates it with seawater to hydraulically isolate a borehole section from the annulus and tidal effects of the open ocean. Isolating the borehole from the open ocean allows measurement of pore pressure and in situ hydrological properties of the formation. Formation fluids may be sampled if the formation is permeable.

It is possible to derive formation permeability and porosity in an isolated open-hole section using a straddle packer (i.e., two packers) by applying pump pressure with pulse, slug, or constant-rate injection tests.



Schematic compares Straddle and Single Packers in a borehole. The Straddle Packer uses two packers to isolate a test interval between them, and the packers can be moved and reset. A second interval can be tested as well from the bottom packer to total depth. The Straddle Packer is used for hydrological testing as well as pulse and constant rate injection tests. The Single Packer uses one packer and tests the entire borehole below the packer. A flowmeter is shown on the logging wireline in the Single Packer schematic.



Graph of a packer injection test taken during Leg 118 showing pressure at the recorder depth vs. time. The chart shows the hydrostatic pressure, the pressure buildup from pumping water into the formation, and the subsequent pressure decay (fall-off) after pumping ceases. The rate of pressure decay indicates the relative permeability of the exposed interval with adjustments for interval height, viscoisity, etc.). The packer was moved to test different intervals in this chart.

The 8¼ to 8½ in. outer diameter (OD) packer element can be expanded to as much as twice the uninflated diameter (~16 in.); however, full inflation produces a weaker hydraulic seal that withstands less differential test pressure. Effective formation testing in an open hole requires that all packers be positioned in low-permeability borehole sections that are relatively in-gauge and have smooth bores. Wireline logs such as caliper, borehole televiewer, resistivity, density, and sonic logs are typically run before packer tests to identify permeable test intervals and good seal sections. The logging information allows the bottom-hole assembly (BHA) and packer(s) to be spaced out accordingly. Logs and experiments can be run through an uninflated packer; however, wireline operations through an inflated packer require special safety measures because the packer grips the borehole wall. The packer immobilizes the BHA, but the top of the pipe at the rig floor can still move up and down, requiring drill string heave compensation to avoid tearing the packer loose.

The drill string packer can be run in several combinations:

- A single-element packer is used to isolate the interval below the packer to the bottom of the hole.
- Two packers can be run together, acting as a single packer to increase the seal length. Pressure gages can be run to confirm the seal.
- A "straddle packer" incorporates two separate packers to span the test interval so it can be sampled or exposed to injection tests. The packers are separated by 1 to 9 m long drill pipe pup joint(s). The interval between the straddle packers and the interval from the bottom packer to the bottom of the hole can be tested separately. The straddle packer elements are connected by ⅜ in. stainless steel tubing (strapped on the outside the drill pipe spacer) to ensure that neither element can be inflated if there is a hydraulic failure. A pressure recorder can be hung below the lower Go-Devil to test for leakage from the straddled interval.

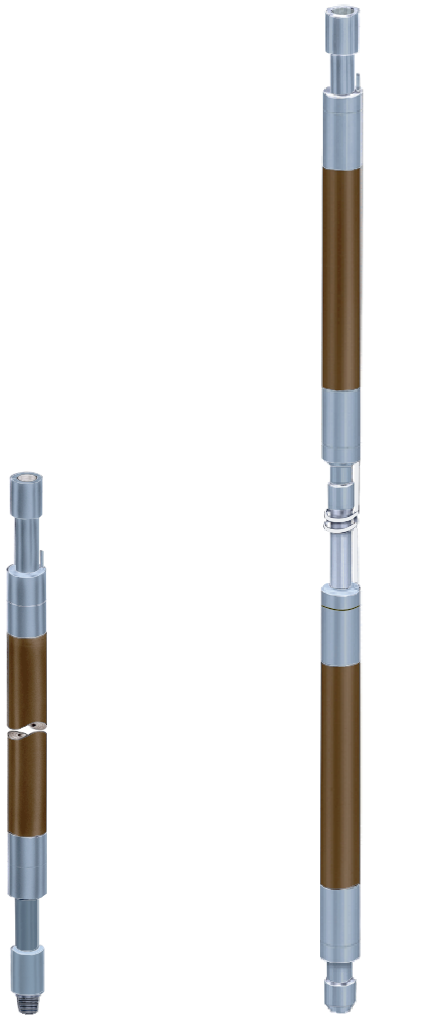
Flowmeters

A flowmeter is run on the wireline to measure the flow rate of the fluid pumped into the hole. The flow rate can be measured throughout the open hole. Within cased hole, the flow rate is 100%. Below the casing, flow rates decrease as a portion of the fluid flows into the formation, providing information about permeability in the borehole (i.e., flow rate decreases below high permeability sections).

Operation

Packer Operation

The packers typically used by IODP are made by TAM International, Inc., of Houston, Texas. The 8¼ in. TAM packer



Single Packer Straddle Packer

Figure shows examples of a straddle and single TAM packer. A straddle packer assembly consists of two single packers separated by a 1-9 m perforated spacer.

assembly consists of an internal steel strength member, an expandable internal rubber bladder, and an 8¼ to 8½ in. OD outer rubber cover. A Go-Devil plug is dropped down the drill pipe and lands in a seating nipple in the pipe (see Packer Control Sub figure). The Go-Devil seals the drill pipe so pump pressure can inflate the packer bladder with seawater pumped down the drill string. The seawater presses the rubber bladder outward to grip and seal against the borehole wall. The bladder cover has an embedded expandable (woven stainless steel) strength member.

Drill string packer(s) are run on the drill string as part of the BHA and are positioned over the desired interval based on logging depths. When the drill string is freely suspended without heave compensation (running in and out of the hole), the packer element(s) remain uninflated. When the packer is in position, a wireline retrievable Go-Devil with two GRC (vendor) pressure recorders (covered with a special core barrel and retaining catcher) is free-fall deployed and pumped down the drill string at ~200-250 gpm to increase the speed. The Go-Devil lands in a "seating nipple" at the packer, and a hydrostatic pressure baseline is recorded for 10-15 min.

The rig pumps are typically used to inflate the packer element(s) with seawater to ~1200 to 1500 psi maximum. When the packer elements inflate and start to grip the borehole wall, air is bled off the heave compensator, which lowers the drill string to set down ~15,000 lb weight on the packer (~12,000 lb of weight/1000 psi of test pressure) to prevent packer movement from the piston effect of test pressures.

To inflate and deflate a packer, a Packer Control Sub is used. It also provides a way to run a pressure instrument in the hole. The Packer Control Sub has an internal "control tube" that connects two or more packers hydraulically. Lowering the drill string ~20 cm (8 in.) shifts the packer control sleeve down, isolates the inflated packer element, and opens the bore to the interval below the upper packer. The heave compensator is positioned at mid-stroke, and ~15-20 min is required for the pressure pulse to decay. A typical set-down weight of 15,000 lb requires a BHA of approximately six 8¼ in. drill collars above the packer. IODP recommends running several drill collars below the packer to help set it. The packer elements are not designed to support much more than ~15,000 lb weight.

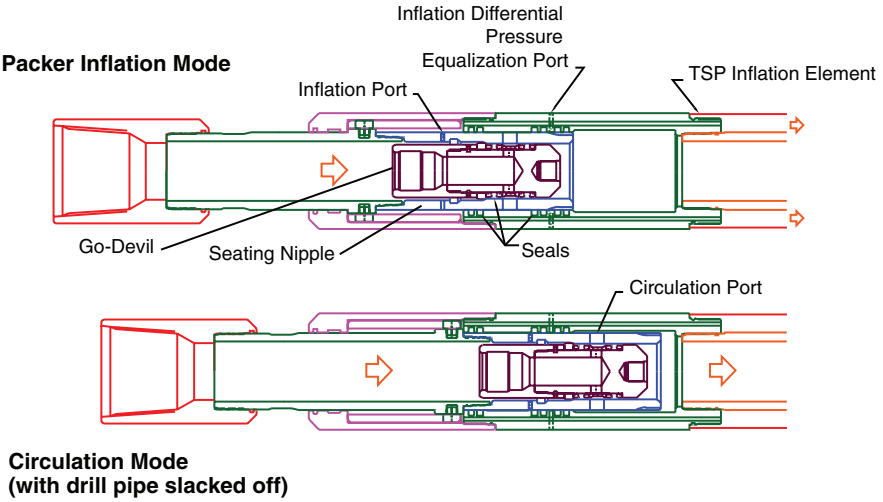
Formation fluids may be sampled before pump tests if the formation is permeable enough. Go-Devils can be used to activate multiple packers and open or close valves for formation testing. The Go-Devil and pressure recorders are retrieved with the coring wireline.

After formation testing is completed, the packer(s) are deflated by using the heave compensator to pull the drill string upward and open the deflation ports. The straddle packer element deflates passively in ~30 min, and it can be moved and reset (~2-3 times) if the element is not damaged. When straddle packers are used, pulse, slug, or constant-rate injection tests may be run to determine the formation transmissivity (from which permeability can be derived) and (less accurately) storage coefficient. Storage coefficient is directly related to formation porosity. The cementing-unit pump is typically used to apply pressure (~500 to 1500 psi) to the isolated open-hole section. Test pressures typically do not exceed 1500 psi (unless formation hydro-fracture is attempted), and pump rates typically do not exceed 3-5 bbl/min. All pumped (injection) volumes should be measured using a standpipe meter or

the volume tanks on the cementing unit. Pressure pulses may require up to 30 min to decay, and multiple tests (2 to 4) may be run.

Flowmeter Operation

A flowmeter/sinker bar/Go-Devil assembly can be run on the logging wireline. After inflating the packer, the logging line is sheared off the Go-Devil by pressuring up to 2000 psi. The flowmeter is lowered below the packer (~50 m) and calibrated by pumping at several rates. Flowmeter readings typically are taken at 10 m intervals (to total depth [TD]) for ~10-20 min at each interval. The flowmeter/Go-Devil assembly is retrieved by wireline



Schematic of the Packer Control Sub on the TAM Straddle Packer (TSP) showing inflation and circulation flow path.

Features

Compatibility

The drill string packer BHA is compatible with wireline logging tools. It may be possible to accomplish both logging and packer measurements during a single pipe trip.

Multiple Tests

A packer can be set, moved, and reset (up to three times) if the element is not damaged so that multiple tests can be attempted during one trip in the hole.

Specifications

Packer

- TAM International, Inc., model TAMJAY Packer, 8¼ in. OD element, stroked out length 3.12 m (10.2 ft), 3.97 in. internal diameter (ID), connection 5½ in. IF box up and pin down
- Minimum ID: Single packer 3.94 in., straddle nonrotating packer 3.84 in., and rotating packer 3.84 in.
- Packer Inflation Pressure: typically ~500 to 1000 psi (~half of planned test pressure), 1500 psi maximum
- Set down weight on packer: ~12,000 lb weight/1000 psi test pressure, 15,000 lb maximum
- Drill string movement to shift control tube: ~20 cm (8 in.)
- Typical Packer BHA: 9 to $9^{5}/_{8}$ in. bit, crossover, 1 joint 5½ in. drill pipe, 8¼ in. packer, crossover, ~5 each 8¼ in. OD drill collars, tapered drill collar, crossover to 5 in. drill pipe. BHA length ~70 m, weight ~18,000 lb

Pressure Recorders

- Micro-Smart Pressure Recorders

  The Micro-Smart HT-750 pressure recorder typically records pressure and temperataure at 1-sec intervals. It is run below the Go-Devil in a special core barrel tube with a retaining catcher.

  Micro-Smart mechanical self-contained pressure recorders are available in three pressure ranges (0-5000, 0-10,000, and 0-15,000 psi) and can record up to 570 hours at 1 s increments. IODP only uses the 10,000 and 15,000 psi models. For a single packer, two recorders are free-fall deployed inside a 12 ft long inner core barrel tube attached to the Go-Devil. For straddle packers, one recorder is attached to the lower Go-Devil and one or two to the upper Go-Devil.

- Surface Pressure Recorder

  IODP uses RigWatch standpipe data for surface pressure.

Operating Range

Temperature

- Packer elements and seals are rated to ~100°C. Special high-temperature elastomers (i.e., packer elements and inner seals) rated to 120°C were used (Leg 111– Hole 504B) at tempera-

tures of 120°-145°C, but lasted for only one setting.

- Depth Limit: None

Limitations

Packer Damage

The rubber elements on packers are made of elastomers that can be damaged by contact with jagged formations. Moving a set packer before it has relaxed back to normal size may damage the element.

Hole Damage from Packers

The packer expands with hydraulic force to firmly contact the formation; however, over-inflation can fracture the formation or burst the packer element. Packers can also reduce the hydrostatic pressure, causing a formation to flow or cave-in, resulting in stuck pipe.

Temperature

The packer elements are made of an elastomer that has an operating temperature range of 100°-120°C.

TAM Nonrotating Packer

The TAM drill string straddle packers are a nonrotating design that is deployed with the drill string. They should be kept in tension and are not compatible with a coring and rotating BHA; therefore, a separate trip is required to run the packer.

TAM Rotatable Packer

The TAM rotatable packer was designed for use as a single packer for testing and drilling ahead; however, tests (Legs 110, 123, and 130) indicate that it may be more suitable for tests in unstable pre-drilled reentry holes that may require some reaming or cleanout.