ACORK Borehole Observatory

OCEAN DRILLING PROGRAM

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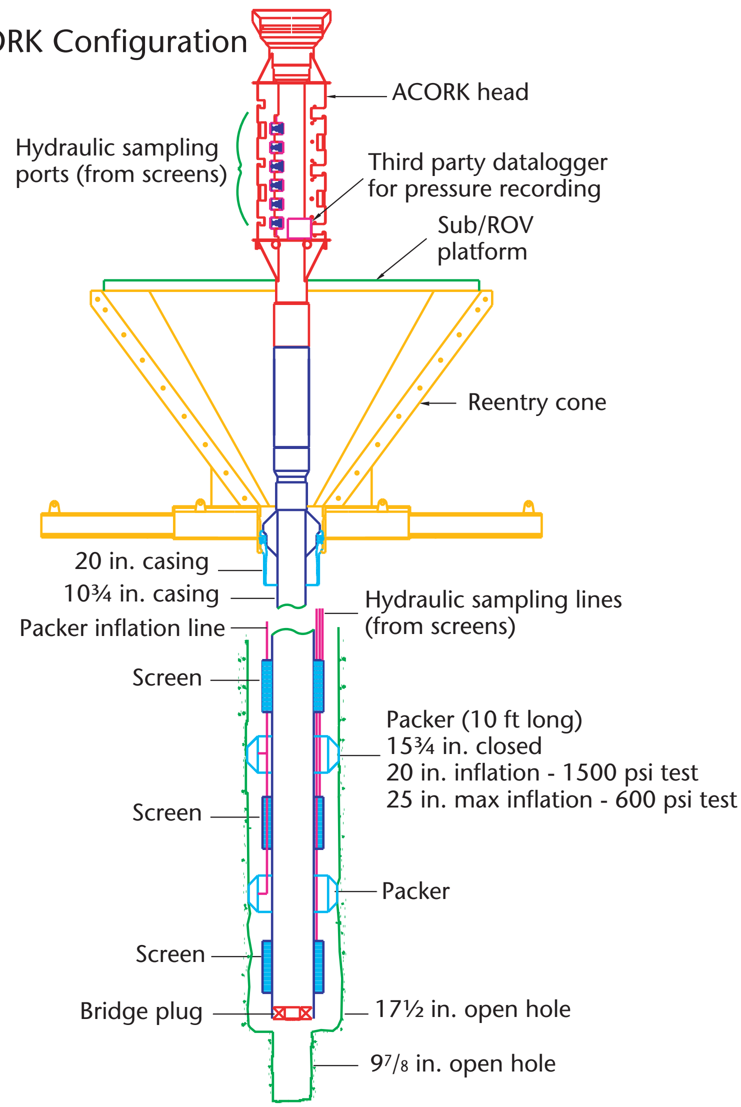
Scientific Application

The ACORK (Advanced Circulation Obviation Retrofit Kit) is designed to isolate multiple zones in a borehole for independent zone investigation. ACORKs allow subseafloor biosphere studies in the context of their hydrological, chemical, microbiological, and thermal regimes, as well as hydrologic responses to seismic ground motion, tides, and barometric loading. Multiple holes could be used to determine lateral gradients and geological property variations. After the ACORK head and casing are installed, the hole may be deepened with coring or drilling operations. The ACORK casing can be sealed with a bridge plug at the bottom to allow installation and servicing of secondary instrument packages and sensor strings. Remotely operated vehicles (ROVs) or submersibles can retrieve ACORK data and samples for shore-based study. Future ACORK installations may be connected to subsea communication cables for real-time data transmission.

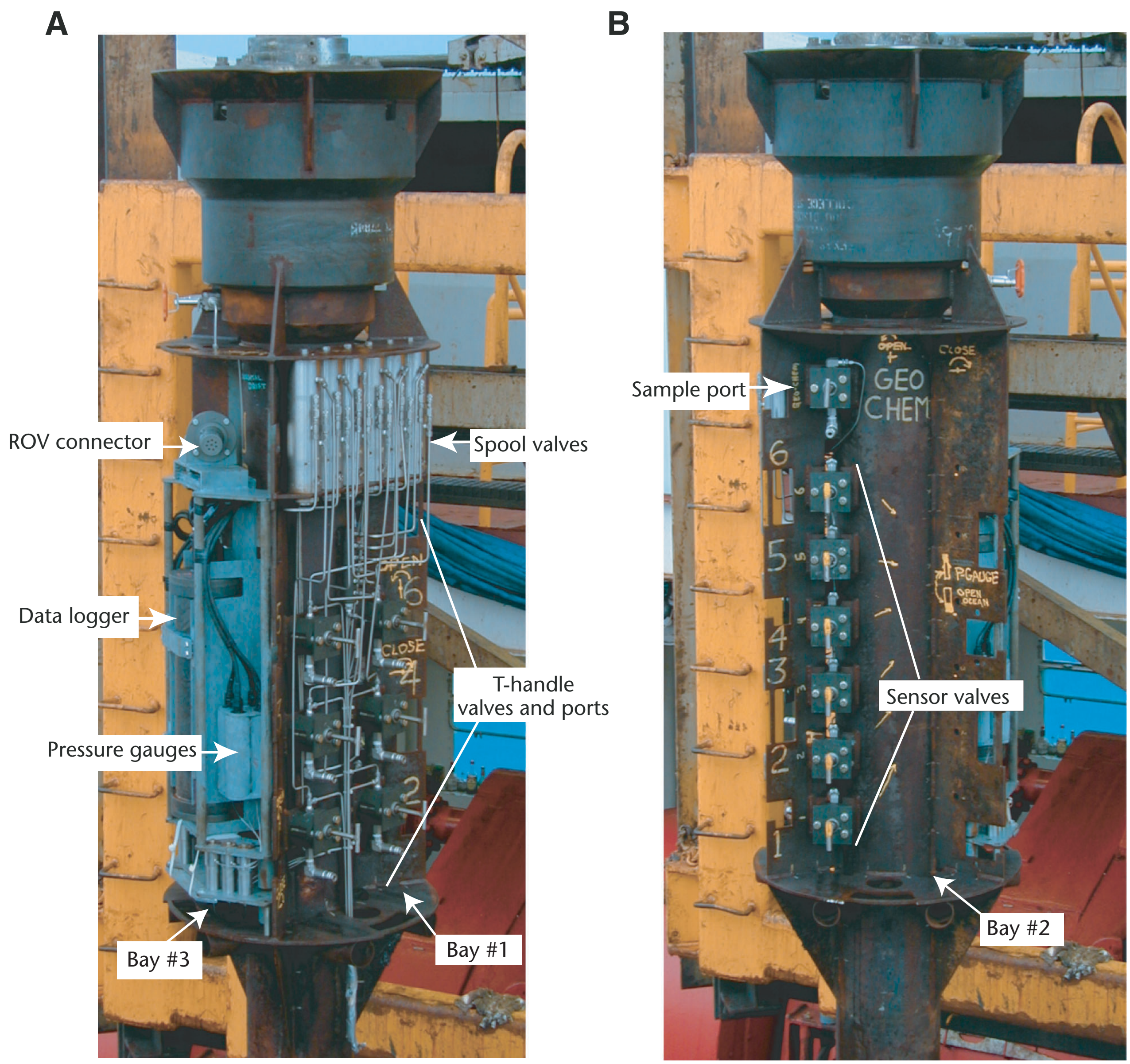
ACORK Configuration



Schematic of an ACORK installed in a reentry cone. The ACORK features downhole external casing packers to seal off zones and screened sampling sections mounted on the outside of the casing. The screened sections are connected by hydraulic sampling tubing to the T-handle valves and ports (valve manifold) in the ACORK head. The valve manifold allows pressure recording and fluid sampling. The ACORK head sits above the reentry cone to allow the ROVs/submersibles access to sample and download data.

Tool Operations

Core, open-hole logs, or logging-while-drilling (LWD) data are required to identify the individual test zones. A reentry cone and surface casing are drilled or jetted in to stabilize the upper hole and to provide a reentry point. A 17½ in. hole is drilled for the ACORK assembly. The



Photographs of the ACORK head showing the three instrument bays. The ACORK head is a 30 in. diameter cylindrical frame fabricated from 3/8 in. steel around a section of 11-3/4 in. casing. It houses components in each of three 120° wide, 60 in. high bays that are bounded above and below by circular horizontal bulkheads and divided from one another by radial webs. (A) Bay #3 (left) houses the ROV connector, data logger, and pressure gauges. Bay #1 (right) houses the T-handle valves and ports and connecting tubing to downhole screen sections. (B) Bay #2 houses a sample port valve manifold for geochemical sampling and six three-way sensor valves. The sensor valves are tied in to the pumping valves and ports on Bay #1 to protect the pressure gauges from pressure surges when pumping or sampling fluids. Photographs by Adam Klaus.

ACORK assembly typically consists of 10¾ in. casing, screened casing joints, tubing to provide a hydraulic connection back to the seafloor, inflatable external casing packers to isolate the test zones, and a multiple valve manifold. A mud motor and underreamer are typically run ahead of the ACORK casing to work through tight spots in the open hole. A bridge plug is set in the bottom of the ACORK casing to seal off the casing and isolate the borehole from sea level hydrostatic effects. A third-party scientific sensor string may be set inside the ACORK casing to acquire additional scientific data.

Design Features

1) Casing Design

A reentry cone and 20 in. casing are jetted in or underreamed to a preselected depth <120 m.

Benefit: This stabilizes the upper hole and provides a reentry point for additional operations like coring, LWD, and ACORK completion.

2) Multiple Zone Isolation

Multiple zones may be isolated in the open hole with the ACORK casing, multiple external casing packers, and multiple screened joints. The elastomers on the external casing packers are expanded in open borehole (or in the surface casing) to provide a hydrologic seal to isolate formation intervals.

Benefit: Multiple intervals in the borehole can be isolated for pressure monitoring, fluid sampling, and other scientific experiments.

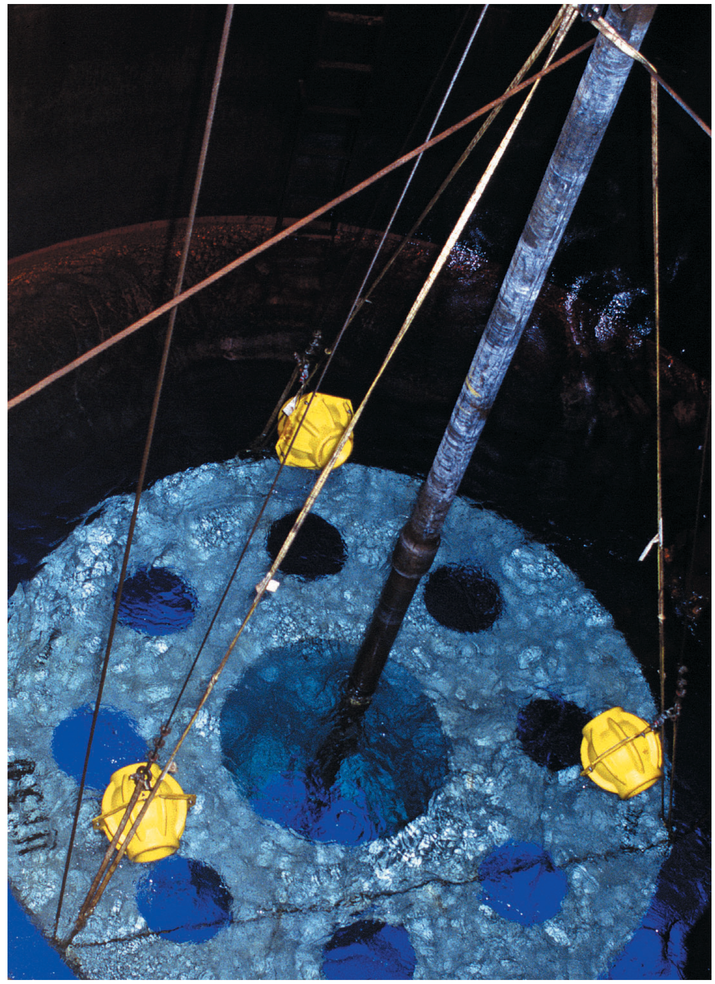
3) Formation Pressure and Fluid Sampling (third-party tool supplied by scientist)

Multiple hydraulic sampling tubes are run from the ACORK head to the individually isolated zones to monitor in situ pressure. These tubes also provide fluid sampling ports for each zone via valves on the ACORK head. Separate fluid sampling and pressure-monitoring lines can be run from each interval.

Benefit: The tubes can allow formation fluid samples to be recovered at the ACORK head for seafloor experiments and for surface geochemical and microbiological analysis. Permeability tests can be performed while monitoring pressure (e.g., injecting fluid into the borehole). Two adjacent ACORKs allow for hydrological tests (pulse, injection, and fluid production) across holes.

4) External Casing Screens

Screens are mounted on the outside of the casing to protect the sampling point. The screens are added by welding metal ribs lengthwise on a casing joint and wrapping metal wire continuously around the ribs and casing while controlling the gap between the wraps. The gap size between the wraps creates the primary mesh size. A cap is installed on the bottom of the wrap, and ceramic beads are poured inside the annular space between the casing and the wire wrap, creating a secondary mesh. The size of the mesh depends on the grain size of the sediment.



The ROV platform for the ACORK is deployed by wireline through the moonpool and down the drill string to the ACORK. Yellow spheres are reflectors for sonar location.

Benefit: Prevents the fluid sampling lines from being plugged by sediment.

5) Osmotic Sampler (third-party tool supplied by scientist)

Modular downhole osmotic fluid sampler can sample and store in situ fluids.

Benefit: Formation fluids can be accessed for long-term geochemical evaluation.

6) Data Logger with Memory (third-party tool supplied by scientist)

Temperature and pressure data can be recorded and stored in the data logger unit mounted on the ACORK head at the seafloor.

Benefit: Because the number of submersibles and ROVs is limited, data may not be retrieved for several years. The data are stored and then downloaded when a submersible or ROV is available.

7) Sensor String (third-party tool supplied by scientists)

The inside of the ACORK casing string is available for third-party scientific instruments. Instruments may be hung at multiple depths to collect temperature, seismic, and other scientific data.

Benefit: Determine in situ formation temperature to calculate heat flow. Monitor temperatures and pressures for indication of chronic or periodic subsea flows and hydrological transients.

8) Bridge Plug

A bridge plug may be installed at the bottom (or top) of the ACORK casing (10¾ in.) to isolate the annulus from seawater hydrostatic effects.

Benefit: Provides complete isolation of the open hole below the ACORK casing from the open ocean.

9) Instrument Hanger

The hanger seals off the top of the ACORK casing and allows sensor strings and seismic packages to be installed inside the casing. Instruments may be set in the open hole if a bridge plug is not required.

Benefit: Provides additional simultaneous opportunities for scientific experiments and data collection/ correlation.

10) Submersible/ROV Operations

The ACORK head assembly extends above the reentry cone and provides a landing platform for access by submersibles or ROVs.

Benefit: Data and fluid samples can be retrieved by submersible/ROV operations without a drill ship. In addition the data logger and sensor string can be replaced.

ACORK Specifications

Hydraulic Connector

Aeroquip Type FD72 "push-on/ pull-off" male hydraulic connector

Electrical Connector

Wet-mateable single pole RS-232 connector to data logger for ROV intervention

Minimum Internal Diameter through ACORK

Based on casing size and weight (e.g., 10¾ in. 40.5 lb/ft casing has an internal API drift diameter of 9.894 in.; 6⅝ in. 24.0 lb/ft casing has an internal drift diameter of 5.796 in.).

External Casing Packer Element

Expands 2–7 in., depending on outer diameter of casing (e.g., a 15¾ in. outer diameter external casing packer expands to 17–22 in.).

Underreamer Size

Based on casing and packer outer diameter (e.g., a 17½ in. underreamer would be used for 10¾ in. casing).

Limitations

A reentry cone and surface casing must be set prior to drilling a hole for the ACORK assembly.

Core, LWD logs, or open-hole logs are required to identify the individual test zones and the setting depths for packers and screens.

Third-party instrument strings (thermistor, seismometers, etc.) must be compatible with ACORK casing internal diameter.

The formations must be stable enough to remain open during ACORK completion operations.

Osmotic fluid samplers are slow-acting passive devices that may require ship intervention for recovery.

Current borehole fluid-sampling techniques are limited to pressured intervals with active flow or to slow acting downhole osmotic samplers.

Borehole fluid sampling is limited by the long time period required to displace the seawater from the small ¼ in. sampling tube with formation fluids. Long lengths of small tubing limits fluid flow to very low flow rates. Submersibles and ROVs can apply pump suction to the sample tubes but can only draw a 32 ft (13.8 psi) vacuum unless the formation flows. A powered pump and larger tubing may be required to remove the seawater from the tubing and borehole annulus.

Proponents Need to Consider

Depth of surface casing to stabilize top hole.

Number and height of zones to be sampled by screened casing joints.

Setting depth of ACORK casing string. The risk of not reaching setting depth with ACORK casing increases with depth.

Size of ACORK casing string (ranges from 6⅝ to 10¾ in.). The risk of not reaching setting depth increases with the larger casing sizes.

Diameter of open hole. The risk of not reaching the setting depth increases with the increase in borehole diameter and formation instability.