Bottom-Hole Assembly

OCEAN DRILLING PROGRAM
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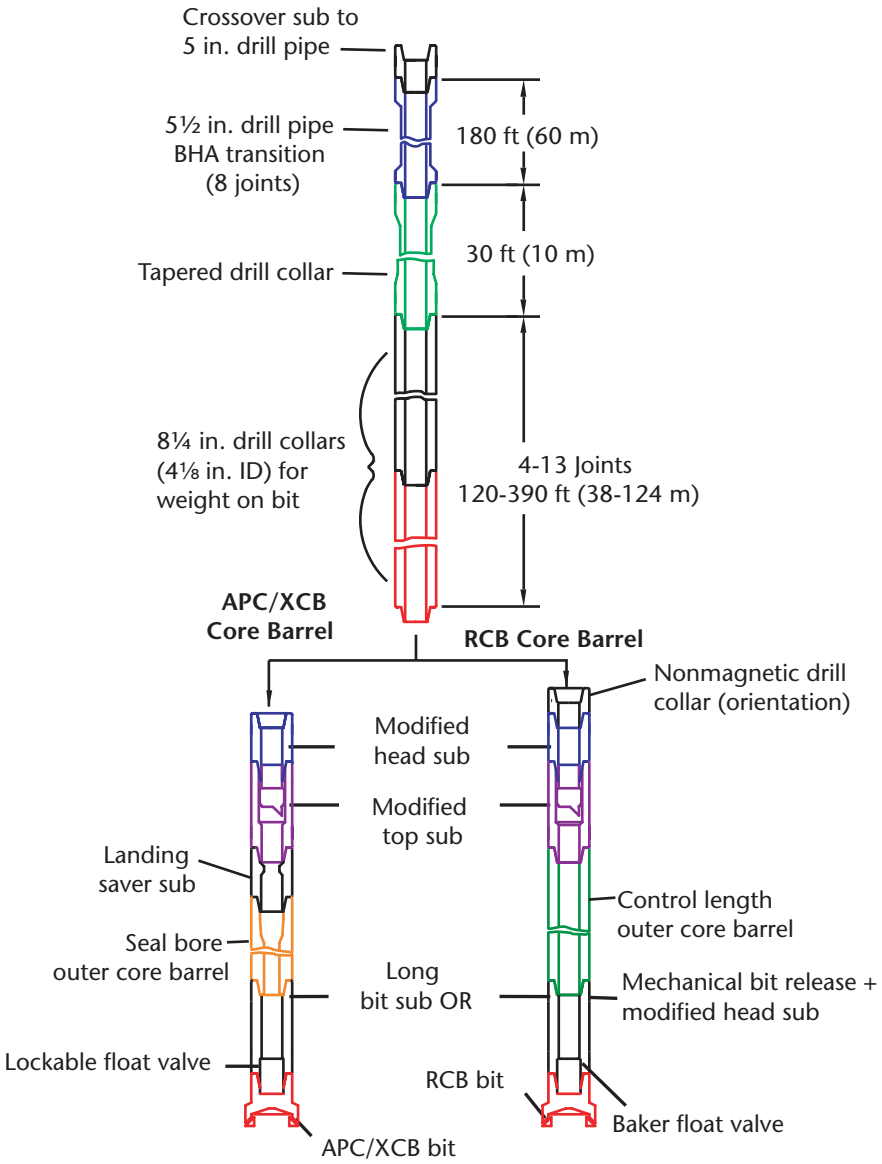
Scientific Application

The bottom-hole assembly (BHA) is the component of the drill string that includes the core bit, outer core barrel, various subs, and the drill collars. It hangs below the drill pipe and provides weight to the drill or core bit to induce the teeth to penetrate the formation, thereby drilling a hole or recovering core to meet the scientific objectives of the cruise. The Ocean Drilling Program (ODP) employs different coring tools to obtain continuous, relatively undisturbed cores in all types of oceanic sediments and igneous basement. ODP uses three primary coring systems, each with a different BHA:

- The Advanced Piston Corer (APC) and Extended Core Barrel (XCB), which use the same BHA; the Pressure Core Sampler (PCS) and Motor-Driven Core Barrel (MDCB) are also compatible with this BHA (note: the MDCB needs an additional sub when it is run);
- The Rotary Core Barrel (RCB), and
- The Advanced Diamond Core Barrel (ADCB).



Schematic of the APC/XCB and RCB BHAs.

I. APC/XCB/RCB BHA

Tool Operation

The BHA is run on the bottom of the drill string (see the Drill String tool sheet), below the drill pipe. Weight is applied to the bit by releasing drill string tension or "slacking-off weight." The top drive rotates the drill string at the ship's drill floor to drive the bit and advance the BHA. The BHA consists of a primary core bit, bit sub, outer core barrel (OCB), short sub assemblies, drill collars, transition section (composed of six joints of 5½ in. drill pipe and tapered drill collar [TDC]), 5½ in. transition drill pipe, and a crossover sub to 5 in. drill pipe. The OCB supports the inner core barrel during coring. Short sub assemblies are added to the OCB as required to

provide landing seats, latch windows, or seal surfaces for the inner core barrel. Drill collars are heavyweight pipes run above the OCB to apply additional weight to the core or drill bit beneath. A nonmagnetic drill collar may be run above the OCB if the core will be oriented or hole directional readings are taken.

Design Features

1) Compatibility

The individual elements of the BHA can be reconfigured to be compatible with a wide range of ODP coring, sampling, and logging tool systems.

Benefit: The same basic BHA elements can be used with several coring systems and drilling tools for use in different formations.

2) Large Internal Diameter

The drill pipe and drill collars have a 4.25 in. opening throughout (or internal diameter [ID]).

Benefit: The drill pipe and BHA are compatible with other coring systems, coring shoes, water samplers, temperature/pressure probes, and logging tools; thus, these tools can pass through the drill pipe and drill collars, eliminating pipe trips to run sampling instruments. In addition, a large ID reduces pumping pressure losses in long drill strings, thereby, significantly improving hydraulics.

3) Modified Connections

As the weight of the BHA is applied to the bit, the force on the BHA can change from tension to compression and the drill collars can begin to stand up and start bending. The 6⅝ in. full-hole "modified" drill collar connections have been strengthened by lengthening the pins 2 in. to stiffen the connection.

Benefit: A modified connection reduces bending stresses and connection failures caused by bending and allows bare rock (unsupported) spudding to begin a hole.

4) Hole Deviation

The heavy and stiff BHA acts like a pendulum weight as it hangs from the relatively light and flexible drill pipe.

Benefit: This keeps the hole relatively vertical without stabilizers.

5) Seal Bore Drill Collars (SBDCs)

The APC/XCB outer core barrels are SBDC, with an 8¼ in. outer diameter (OD) and a 3.820 in. ID smooth honed seal bore section. They are 31 ft, 10⅛ in. long.

Benefit: The smaller ID allows the APC inner core barrel piston seals to seal during the piston coring stroke.

6) Control Length Drill Collars (CLDCs)

The standard 8¼ in. OD x 4⅛ in. ID outer core barrels are 30 ft fixed length.

Benefit: The fixed length simplifies length space-out requirements for the inner core barrel assemblies.

7) Drill Collar Subs

The BHA can be reconfigured by adding short sub assemblies to the OCB as required (e.g., landing sub, top sub, and head sub).

Benefit: This provides landing seats, latch windows, or seal surfaces and length space-out for the inner core barrel.

8) Nonmagnetic Drill Collar (NMDC)

A drill collar made of nonmagnetic chrome nickel steel may be run above the OCB.

Benefit: This allows the core to be oriented and hole directional readings to be taken.

9) Tapered Drill Collar (TDC)

A 30 ft long tapered drill collar changes OD from 7$^{3}/_{16}$ in. to 5$^{11}/_{16}$ in. to provide a gradual change in cross-sectional area.

Benefit: The gradual change in cross-section reduces bending stresses in the transition from BHA to drill string.

10) Transition 5½ in. Drill Pipe

Two stands (six joints) of 5½ in. drill pipe are run at the top of the BHA to reduce bending stresses between the BHA and drill pipe.

Benefit: This reduces premature drill string failures.

Specifications

Maximum Drill Collar Length:
9.5 m

Internal Diameter:
10.79 cm (4.25 in.)

Connection:
6⅝ in. full-hole modified drill collar connections have been modified by lengthening the pins 2 in. to stiffen the connection.

Typical Operating Range

Depth Range:
No depth limitations

Typical APC/XCB BHA:
APC/XCB bit, bit sub, seal bore drill collar, landing sub, top sub, head sub, NMDC, five CLDCs, tapered drill collar, six joints of 5½ in. drill pipe, and a crossover to 5 in. drill pipe.

Typical RCB BHA:
RCB bit, mechanical bit release (MBR), head sub, CLDC, top sub, head sub, seven to ten CLDCs, tapered drill collar, six joints of 5½ in. drill pipe, and a crossover to 5 in. drill pipe.

Limitation
Bare rock (unsupported) spud-ins to start a hole must restrict weight on bit to the length of the drill collars buried (i.e., supported in the hole) to avoid bending and breaking the BHA. This reduces the available weight on bit and slows the rate of penetration.

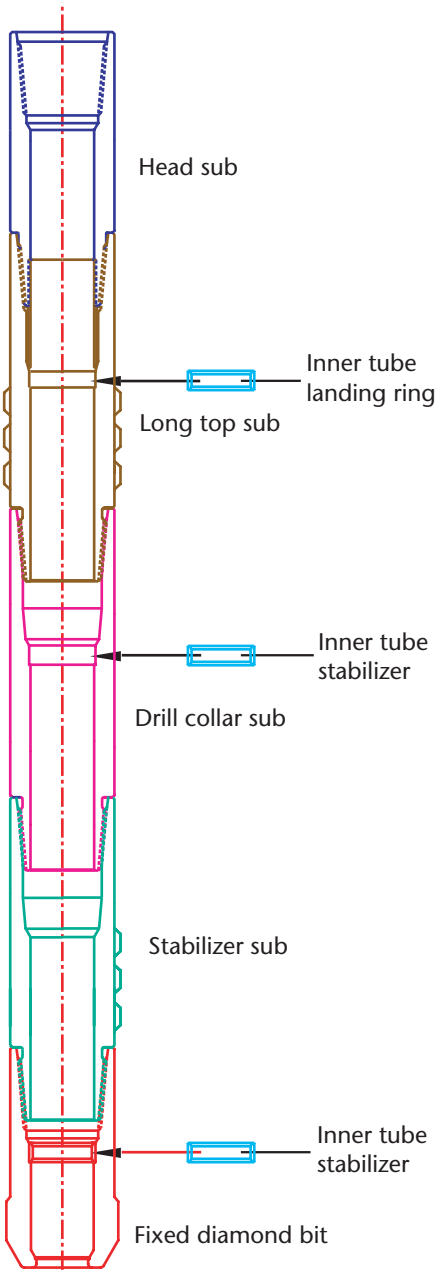
II. Advanced Diamond Core Barrel (ADCB) BHA

Tool Operation
The ADCB coring system uses a 7¼ in. OD (184 mm) "PQ3" mining-style thin-kerf diamond bit with a 6¾ in. BHA for coring in firm to hard sediments or basement. The bit only requires eight to ten drill collars (each 6¾ in. [171 mm] diameter) for adequate weight on bit. However, the 7¼ in. hole does not have sufficient clearance for the 7 in. OD (178 mm) tool joints on the 5 in. drill pipe to pass through; therefore, additional 6¾ in. drill collars must be used to allow the ADCB BHA to advance.

Design Features

1) Improved Hole Stability

The 7¼ in. (184 mm) thin-kerf diamond bit produces a smaller hole, and the 6¾ in. (171 mm) smooth



Schematic of the 6¾ in. 15-ft version of the ADCB BHA.

BHA provides a "packed hole" with a narrow ¼ in. (6.3 mm) annulus.

Benefit: Hole stability has historically been better in smaller diameter holes, and smooth BHAs in packed holes eliminate upsets that can hang up in more rugose holes. Upsets are enlarged sections of pipe connections that provide metal thickness to cut robust rotary threads with shoulders.

2) Smoother Hole Wall

The gentle abrasive action of the thin-kerf diamond bit minimizes hole disturbance and produces a hole with a smoother wall.

Benefit: Hole stability and wireline logging quality are improved by reducing the mechanical disturbance to fractured or loosely cemented formations, which minimizes the sloughing and instability problems associated with rugose holes.

Typical Operating Range
Depth Range:
Limited only by the number of 6¾ in. drill collars available (~300 m).

Drill Collars:
6¾ in. OD (171.45 mm) with 5½ in. full-hole modified connections.

Typical ADCB BHA:
Bit, stabilizer sub, OCB, long top sub with stabilizer and landing ring and latch sleeve, head sub, shock sub, eight to ten drill collars each 6¾ in. in diameter for weight on bit (plus five to six stands for penetration), crossover to 5 in. drill pipe.

Limitations
BHA must have a ±20 m deep predrilled hole for support (i.e., BHA cannot be used for bare rock spuds).

Penetration is limited by the number of 6¾ in. drill collars available (~300 m).

The OCB is normally run as a 15 ft (4.75 m) core barrel length.

The ADCB BHA is smaller and thinner walled than larger more robust BHAs; therefore, it requires gentler handling and makeup.