Core Bits

OCEAN DRILLING PROGRAM

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Scientific Application

A core bit (Figs. 1, 2) is a drilling tool with a hole through the center that removes sediment rock and allows the core pedestal to pass through the bit and into the core barrel. The Ocean Drilling Program (ODP) employs different coring systems and bits to obtain continuous cores in all types of oceanic sediments and igneous basement.

Once a coring system is selected based on the expected lithology, the engineer determines which type of core bit to use. As coring conditions change, the coring bit can be changed in an attempt to improve the recovery and rate of penetration with that coring system. The type of bit used depends on the expected lithology and past bit performance in the area or in a similar lithology. Once a bit is removed, it is "graded" (i.e., it is examined to determine wear on the cutting structure, gauge, bearings, etc., based on industry standards) to optimize coring performance.

Coring System Bits

There are three coring systems. Each uses different bottom-hole assemblies (BHA) and types of core bits:

I. Advanced Piston Corer (APC) (see the APC tool sheet) and Extended Core Barrel (XCB) (see the XCB tool sheet) (both systems use the same BHA),

II. Rotary Core Barrel (RCB) (see the RCB tool sheet), and

III. Advanced Diamond Core Barrel (ADCB) (see the ADCB tool sheet).

Bottom-Hole Assembly Operation

The BHA for each coring system is slightly different, but in general consists of a primary core bit, outer core barrel (OCB), short sub assembly, and drill collars. The OCB supports the wireline retrievable inner core barrel, which receives and carries the core. Drill collars are heavyweight pipes that apply weight to the bit on the bottom of the OCB. The BHA is run on the drill pipe string, which is rotated at the surface to drive the bit (except the Motor-Driven Core Barrel [MDCB]) and advance the BHA (see the BHA tool sheet for more information). The MDCB and Pressure Core Sampler (PCS) are compatible with the APC/XCB BHA.

Core Bit Types

Core bits are classified according to the cutting structure and type of bearings. There are five basic types of bits used by ODP based on their function or structure: drag,

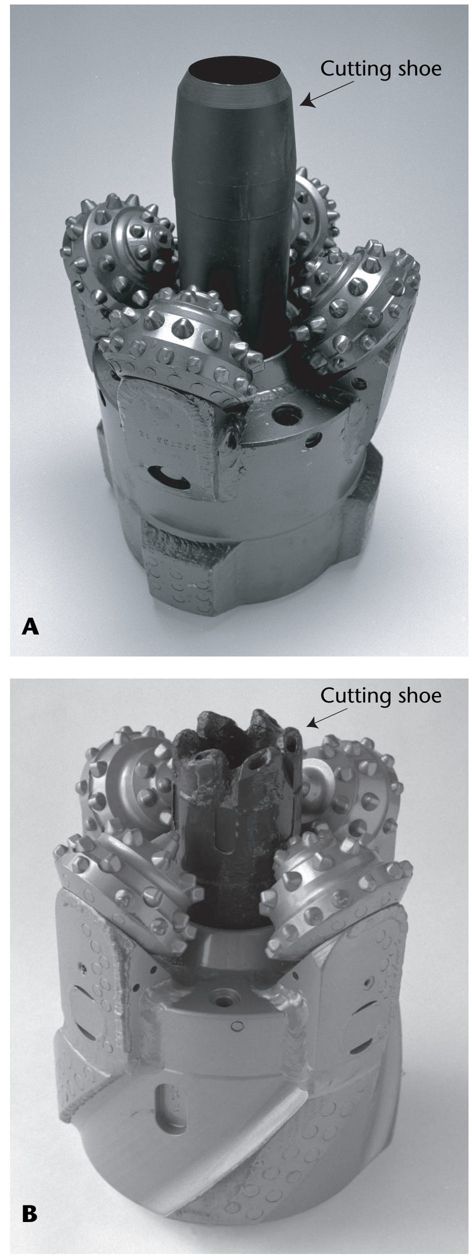

Figure 1. A. APC/XCB four roller cone bit with an APC cutting shoe. B. APC/XCB four roller cone core bit with the XCB cutting shoe.

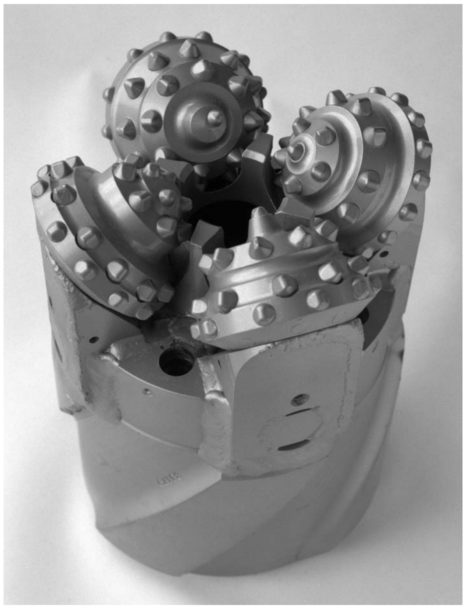

Figure 2. RCB four roller cone bit.

scraper, abrasive, roller cone, and hammer.

Drag-type bits have a flat chisel-like surface to plane away soft formations (i.e., clay and chalk).

Polycrystalline diamond compact (PDC) bits use multiple tungsten carbide studs with artificial diamond cutting surfaces in a claw-like scraping action to remove soft formations (e.g., clay and chalk) up to hard claystone and limestone.

Diamond bits use either surface-set or impregnated diamonds to abrade (i.e., sanding-like process) hard formations like shale or basalt.

Roller cone bits rotate cone-shaped rollers encrusted with teeth to remove soft to hard formations through a combination of scraping and crushing processes.

Hammer bits use percussion to crush the hard rock around the core.

Smaller bits called "shoes" are screwed onto the bottom of the inner core barrel (e.g., APC [Fig. 1A], XCB [Fig. 1B], MDCB, and PCS tools). The shoes on the inner core barrel protrude below the primary roller cone bit and trim the formation to core size. In contrast, the primary core bits in the RCB (Figs. 2, 3) and ADCB systems cut away most of the formation to create the core (i.e., there is no shoe). ODP most commonly uses a four roller cone type bit.

I. APC/XCB System Core Bits

Tool Operation

The APC/XCB coring system can use three types of bits for coring soft to firm sediments:

11$^{7}/_{16}$ in. four roller cone bit with tungsten carbide chisel teeth (Fig. 1),

10$^{1}/_{8}$ in. PDC "anti-whirl" (Fig. 4) bits, which are rarely used, or

10$^{1}/_{8}$ in. tungsten carbide blade "drag" bits, which are also rarely used.

Design Features and Benefits

1) Formation Compatibility

APC/XCB bits are compatible with sediments ranging from soft silts, sands, and sticky clays to moderately firm limestones, claystones, and dolomites.

Benefit: One bit can core a wide range of sediments without a trip to change bits.

2) Large Bit Throat

The APC/XCB bit throat has a 3.80-in. opening.

Benefits: The APC/XCB bit is compatible with the PCS and MDCB coring shoes; water samplers; temperature probes; and logging tools, which can pass through the bit throat without requiring a trip to remove the bit or drop it; therefore, coring and logging operations can be resumed without a trip.

APC/XCB Specifications

Maximum inner core barrel length: 9.5 m

APC/XCB bit throat diameter: 9.652 cm (3.80 in.)

APC shoe throat diameter: 6.197 cm (2.440 in.)

XCB shoe throat diameter: 5.872 cm (2.312 in.)

APC/XCB Typical Operating Ranges

1) Formation

APC: sediments ranging from soft to firm silts/carbonates/chalks/clays.
XCB: firm to moderately firm limestones, claystones, dolomites, and with limited penetration in chert or basalt.

2) Depth Range

APC: limited by piston core barrel penetration in stiff or laminated firm/soft formations (i.e., to "refusal") and by wireline overpull to retrieve the core barrel (~100–300 mbsf).
XCB: limited by core shoe survival in hard formations (typically used from APC refusal depth to ~500 mbsf).

3) Mean Recovery

APC: ~100%.
XCB: ~55%–75% in sediments and ~15%–35% in basalt. Not recommended for penetration in basalt other than to sample basement.

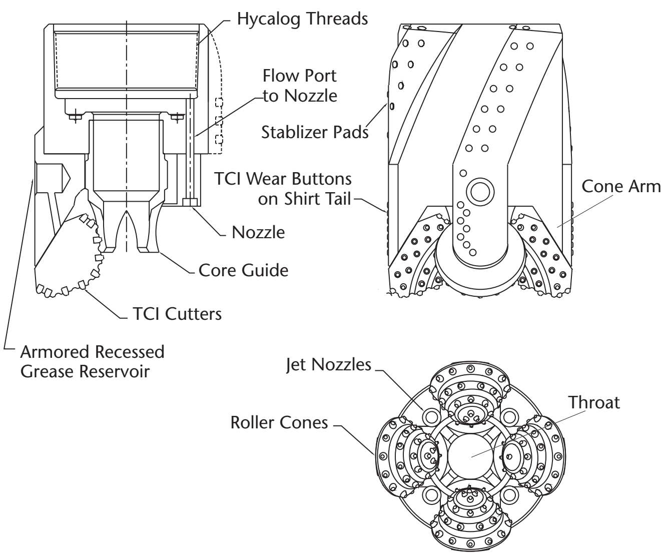

Figure 3. Schematic of the four roller cone core bit used by the RCB coring system.

4) Rate of Core Recovery

Depends on water depth (i.e., wireline time) and formation. Penetration rate usually slows with depth.
APC: ~28.5–9.5 m/hr.
XCB: ~19.0–4.5 m/hr.

5) Rate of Penetration

Depends on rock properties. Penetration rate usually slows with depth.
APC: averages ~70–30 m/hr.
XCB: averages ~30–12 m/hr.

Limitation

Recovery is poor in laminated firm/soft (e.g., chert/clay) or granular sediments (e.g., sand, fractured rock, or rubble).

II. RCB Core Bits

Tool Operation

The RCB coring system typically uses roller cone type bits (Fig. 2) for firm sediments to very hard igneous rocks. PDC RCB bits (Fig. 4) have been used occasionally in firm sediments, as they core faster and can last longer under the right conditions; however, PDC bits cannot be used in igneous rocks. The diameter of RCB roller cone bits is $9^{7}/_{8}$ in., and the diameter of PDC bits is $10^{1}/_{8}$ in.

There are four classes of $9^{7}/_{8}$ in. RCB four roller cone bits (Fig. 5) with different cutting structures designed for different formation types:

C-3 bits have long extension chisel teeth and are used in soft sediments,

C-4 bits have medium extension chisel teeth and are used in firm to hard sediments (e.g., dolomite and mudstone) and limited upper basement,

C-7 bits have short extension conical teeth for coring/drilling hard sediment and igneous basement, and

C-9 bits have short extension hemispherical teeth for coring/drilling very hard igneous basement.

Design Features and Benefits

1) Tool Compatibility

RCB bits have a 2.312-in. opening through the bit throat that enables the Water Sampler Temperature Probe (WSTP) and the Davis-Villinger Temperature Probe (DVTP) to be run through the bit in firm formations without hard layers. The RCB bit must be dropped with the mechanical bit release to permit wireline logging.

Benefit: WSTP and DVTP tools can be run through RCB bits so no time is lost for bit trips.

2) Rugged Design

The four cone-arm segments are welded together in the throat area and are armored (faced with hard nickel-chrome) on the leading edge and upper arm areas.

Benefit: Reduces the chance of catastrophic cone-arm failure while drilling with heavy weight on bit in hard and abrasive formations.

3) Ductile Teeth

The bit teeth are made with a finer-grained tungsten carbide to increase tooth ductility, and the teeth are pressed into smaller holes using greater force.

Benefits: Reduces tooth breakage and loss due to rough drilling in

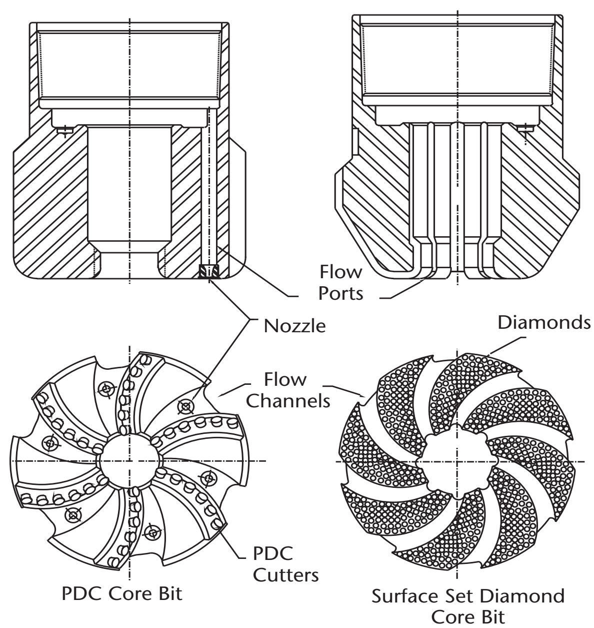

Figure 4. Side and bottom view schematics of PDC and diamond bits. The PDC bit is used in friable lithologies (e.g., limestone or claystone). The surface set diamond bit is used with sediments.

fractured rock and reduces tooth losses at high temperatures.

4) Recessed and Armored Lubrication System

The cone bearing has a pressure-compensated grease reservoir that is recessed and covered with a steel plate.

Benefit: Increases bit-bearing life for increased penetration per bit by protecting the grease reservoir and bladder from abrasion damage while reaming up (i.e., rotating while pulling pipe out of the hole) to get out of a tight hole that is swelling shut or collapsing.

5) Close Catch (CC)

The core catchers were moved closer to the core trimming point at the bottom of the hole in an effort to catch the core sooner.

Benefit: Improved core recovery in fractured formations by capturing the core in the inner core barrel before it can be broken by torsional friction or wedge and jam in the bit throat.

6) Center Bit

Drilling ahead without attempting to recover core can be accomplished with a normal RCB core barrel (i.e., "washing") or by using a center bit to drill. The 2.25-in. center bit is run on a special barrel sub without a swivel (to lock it into the outer barrel for rotation) and without a check ball in the quick release (to circulate through the inner core barrel and center bit).

Benefit: Allows the hole to be alternately cored and drilled ahead (i.e., spot cored) without tripping the pipe.

7) Bit Deplugger

A bit deplugger can be run in an attempt to remove coring debris that can become jammed in the throat of the bit. The 2.25-in. deplugger nose extends through the bit throat and bit cone core trimming area.

Benefit: Reduces pipe trips to clear jammed bit throats by removing the jams downhole.

8) High-Temperature Bearing Seals

The 230°C nitrile elastomers in the standard bit bearing seal can be replaced with 300°C high-temperature elastomers to increase the seal life of bit-cone bearings and prevent premature bit-bearing failure in high-temperature holes. A special high-temperature bit with open bearings is available.

Benefit: Increases bit-bearing life for increased penetration per bit in hot holes.

RCB Specifications

Maximum inner core barrel length: 9.5 m

RCB bit throat (core diameter): 5.87 cm (2.312 in.)

RCB Typical Operating Ranges

1) Formation

RCB will drill all formation types, but it does not recover soft formations, sand, and gravel. The core quality is typically poor in soft formations with the RCB bit, which is why the APC system was adopted.

2) Depth Range

Limited to ~230°C temperature.

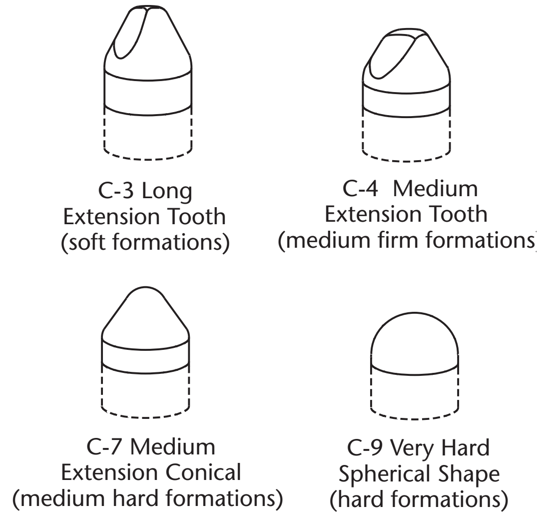

Figure 5. Tungsten carbide insert cutting options for RCB four roller cone bits. Dashed lines depict depth of insert into bit matrix.

3) Mean Recovery

Typically ~50%–75% in firm sediments and ~15%–35% in igneous or metamorphic rocks.

4) Rate of Recovery

Depends on water depth and formation, but ~19.0–1.3 m/hr.

5) Rate of Penetration

Depends on rock properties, but ~20.0–6.0 m/hr in sediment and ~4–1.5 m/hr in volcanic basement.

Limitation

Does not recover soft or unconsolidated granular sediments (e.g., sand, gravel fractured rock, or rubble).

The RCB bit must be dropped with the mechanical bit release to permit wireline logging, which means drilling/coring cannot resume after logging without a bit trip.

III. ADCB Core Bits

Refer to the ADCB system for more information on ADCB bits.