

Drill String



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Scientific Application

The “drill string” is composed of “knobbies,” drill pipe, a bottom-hole assembly (see the BHA tool sheet), and a bit (see the Core Bit tool sheet). It is used to deploy and retrieve (i.e., “run” and “pull”) all of ODP’s coring/drilling BHAs, reentry structures, completion hardware, and associated equipment. A drill string undergoes higher tensile, bending, and torque stresses than standard pipe; thus, the tool joints have shoulders that provide stiffness to prevent bending and breaking. The drill string can be run to a maximum coring/drilling depth of ~8375 m in moderate weather (at 6° roll with 100,000 lb overpull and a typical BHA). All drill string elements have a 4.125 in. (10.47 cm) minimum internal diameter (ID) throughout to allow other tools to pass through; therefore, the drill string is compatible with the ODP coring systems, water samplers, temperature/pressure probes, and logging tools. This compatibility reduces pipe trips and maximizes the time spent drilling a hole or recovering core to achieve the science objectives.

Tool Operation

The drill string is supported by the top drive (in the derrick), which

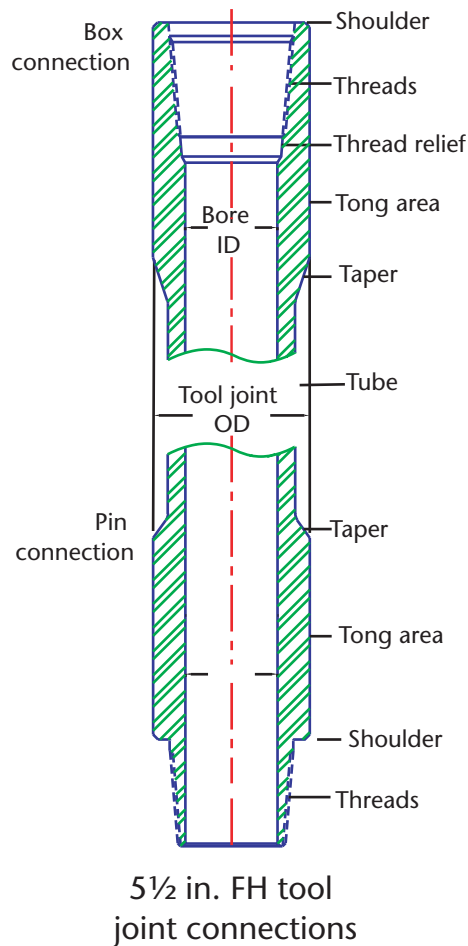


Figure 1. Schematic of the box and pin ends of a joint of pipe. The tube section is cut away to shorten the drawing. ID = internal diameter, OD = outside diameter, FH = full note.

rotates the drill string at the surface to drive the bit and allow the drill string to advance downhole. The drill string is tapered to maximize strength and hanging length by using lighter 5 in. outside diameter (OD) drill pipe (Fig. 1)

on bottom to reduce the weight and stronger 5 1/2 in. OD drill pipe on top where bending stresses are higher. The drill string is run using a “dual elevator” system, which uses two heavy lift “elevators” to support the pipe tool joint rather than tooth-type dies in “slips.” The individual drill pipe “joints” are manufactured in nominal 31.6 ft (9.65 m) lengths; however, the pipe is handled on the ship in three-joint “stands” (or “triples”) for speed in running, pulling, and storing the pipe (Fig. 2). Short lengths of drill pipe called “pup joints” are available in 5, 10, and 15 ft lengths to adjust (i.e., “space-out”) the drill string length, where required, for spudding a hole, landing heavy equipment, or running underreamers inside casing.

Two drill strings are maintained on the ship: (a) a ~6900 m working string in the horizontal pipe racker and (b) a ~5000 m backup string in storage in the ship’s riser hold. The drill strings in use on the *JOIDES Resolution* are inspected and refurbished (i.e., thread repairs and recoating) every 1 1/2 to 2 years. In addition, two backup strings are available onshore: (a) a ~6900 m working string and (b) one 3000 m emergency Condition 2 (i.e., the remaining tube thickness is 70% to 80% of the original specification) backup string maintained onshore in storage.

Knobbies are heavy-wall pipe with tool joint-sized “knobs” to reduce the bending stresses as the pipe moves through the curved guide horn and exits the bottom of the ship when tripping pipe. Knobbies are run between the top drive and 5½ in. drill pipe (i.e., at the top of the drill pipe). As the hole is deepened, the knobbies are removed by the rig crew and replaced with 5½ in. pipe as required by depth and weather. In exceptionally rough weather, aluminum “wear knots” can be added to the upper portion of the 5½ in. drill pipe to reduce bending stresses in the guide horn.

Design Features

1) Large Internal Diameter/ Compatibility

All the elements in the drill string have a 4.125 in. (10.47 cm) opening throughout.

Benefit: The drill string is compatible with all the ODP coring systems, water samplers, temperature/pressure probes, and logging tools. In addition, pumping pressure losses in long drill strings are reduced, thereby, improving hydraulics for hole cleaning.

2) High Strength Pipe

The drill string is made of high tensile strength S-140 steel, which is more brittle than typical drill pipe but stronger, with a tensile strength of 140,000 psi. There are many types of drill pipe, but typical drill pipe has a strength of ~95,000 psi. The strength benefits of the S-140 pipe outweigh the increased brittleness, but the brit-

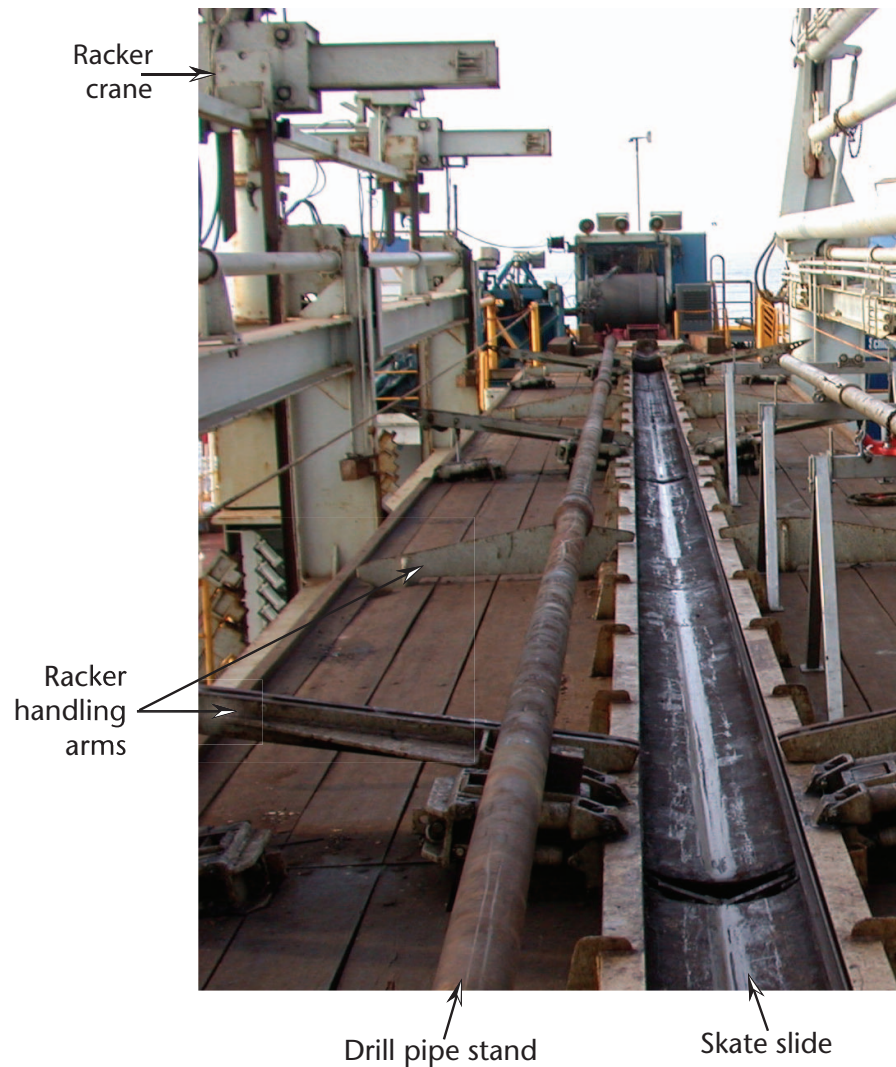


Figure 2. Photo shows a stand of drill pipe and the skate slide the stand sits in before it is made up to the drill string. The photo is looking toward the back of the ship and shows a portion of the racker crane (left), which moves pipe to and from the horizontal racker and riser hold storage.

tleness requires special handling. It is essential to avoid notch damage (stress concentration points) (see Design Feature 4). ODP acquired S-135 pipe early in the program, and that is used in the backup drill string (135,000 psi tensile strength).

Benefit: The stronger pipe can support heavier hanging loads for longer drill strings, run heavier casing strings and reentry installations and equipment, and

provide more “overpull” force to free struck pipe.

3) Triple Lengths

The drill pipe “joints” are made in 31.6 ft (9.6 m) lengths and are run and stored horizontally on the ship in three-joint sections known as “triples” or “stands” (Fig. 3).

Benefit: Increases the speed in running, pulling, and handling the pipe and reduces wear to the pipe tool-joint threads. Typical running speeds are ~700 m/



Figure 3. Drill pipe stands are stored in the horizontal pipe racker, which is located behind the derrick and rig floor.

hr and typical pulling speeds are ~550 m/hr, depending on weather and string length and weight.

4) Dual Elevator System

The drill string is run using a “dual elevator” system, which uses two “elevators” (or lift collars) to support the pipe tool joint rather than toothed friction-type “slips” that could notch and create stress concentration (weak) points in the tube of the high-strength drill pipe (Fig. 4).

Benefit: Elevators provide a positive and stronger support under the tool joint than a slip, and reduce notch damage to the pipe tube; thus, the pipe can be used longer.

5) Coating

The drill pipe is coated inside and outside with an inorganic zinc anti-corrosion compound.

Benefit: The internal coating reduces the formation of rust, which can act as a contaminant during coring, and the coating reduces saltwater “corrosion pitting” (i.e., a reduction in tube wall thickness), which can degrade strength during horizontal storage. Rust can hamper thread makeup and handling; thus, an external coating is applied to reduce rust.

6) Threaded Connections

The drill pipe has threaded connections, which are rotary shouldered “tool joints” designed for rotation in the open ocean (i.e., without a constraining riser). The 5 in. drill pipe has 5½ in. full hole (FH) tool joints (7 in. OD), and the 5½ in. drill pipe has 5½ in. internal flush (IF) tool joints (7¾ in. OD). The 5½ in. FH connections in the drill string have been enlarged to a 4.125 in. (10.47 cm) ID.

Benefit: The shouldered tool joints prevent bending and breaking. The threaded connections are in heavy tension and are made up with high torque to prevent the pipe from unscrewing during use.

7) Pipe Inspection

Current protocol calls for the pipe to be inspected every 1½ to 2 years using nondestructive electromagnetic induction (EMI) or ultrasound inspection techniques.

Benefit: The pipe inspection helps to identify defects in pipe joints to avoid catastrophic failures that could lead to loss of the drill string. Condition 1 pipe has at least 80% remaining wall thickness and is reconditioned if possible. Condition 2 pipe has 80% to 70% remaining wall thickness and is stored for an emergency backup string if it meets tool joint length criteria (i.e., there is enough length in the tool joint to be gripped by power tong jaws).

Drill String Specifications

For drill pipe tube and pipe strength specifications, see Table 1. For drill pipe tool joint specifications see Table 2.

Drill Pipe Joint Length:
31.6 ft (9.6 m)

Minimum Internal Diameter:
4.125 in. (10.47 cm)

Minimum Tensile Strength:
140,000 psi

Table 1. Drill pipe tube and pipe strength specifications.

Drill Pipe Tube OD (in.)	Drill Pipe Tube ID (in.)	Nominal Weight Tube (lb/ft)	Adjusted Overall Joint Weight (lb/ft)	API Steel Grade	100% Tensile Strength (lb)	Cond. 1 Pipe 80% Tensile Strength (lb)
5	4.276	19.50	22.1	S-140	738,443	590,754
5½	4.500	26.67	31.9	S-140	1,099,557	879,645

Note: Cond. = condition, API = American Petroleum Institute

Table 2. Drill pipe tool joint specifications.

Drill Pipe Tube OD (in.)	API Tool Joint Threads (in.)	Tool Joint OD (in.)	Tool Joint ID (in.)	Tool Joint Makeup Torque (ft/lb)	Burst Strength (psi)	Collapse Strength (psi)
5	5½ Full Hole	7.00	4-1/8 * (*bored to 4-1/8)	28,000	10,000	5,000
5½	5½ Internal Flush	7¾	4-1/8	48,000	10,000	5,000

Note: OD = outside diameter, API = American Petroleum Institute, ID = internal diameter.

Typical Operating Range Limitations

Depth Range: 8375 m

Typical Drill String Configuration: BHA with crossover to ~3500 m of 5 in. drill pipe, 5 × 5½ in. drill pipe crossovers, and 5½ in. drill pipe as required for total length. Knobby joints are added as required below the top drive and replaced with drill pipe as required.

The depth limit of a tapered 5 in. × 5½ in. S-140 drill string is ~ 8375 m in moderate weather (at 6° roll with 100,000 lb overpull).

The minimum ID through the drill string is 4.125 in. (10.47 cm). The Advanced Piston Corer/Extended Core Barrel (APC/XCB) BHA has a 3.75 in. ID restriction in the seat-



Figure 4. Making a drill pipe connection on the rig floor. The elevator (red clamp at the bottom of the picture) supports the box [or upper] end of the drill pipe and holds the weight of the entire drill string during a connection.

ing nipple and the APC/XCB bit ID is 3.80 in. Therefore, the APC/XCB shoes and instruments that pass through the drill string, seating nipple, and bit must have an OD less than 3.75 in.