AHC

Active Heave Compensator

OCEAN DRILLING PROGRAM

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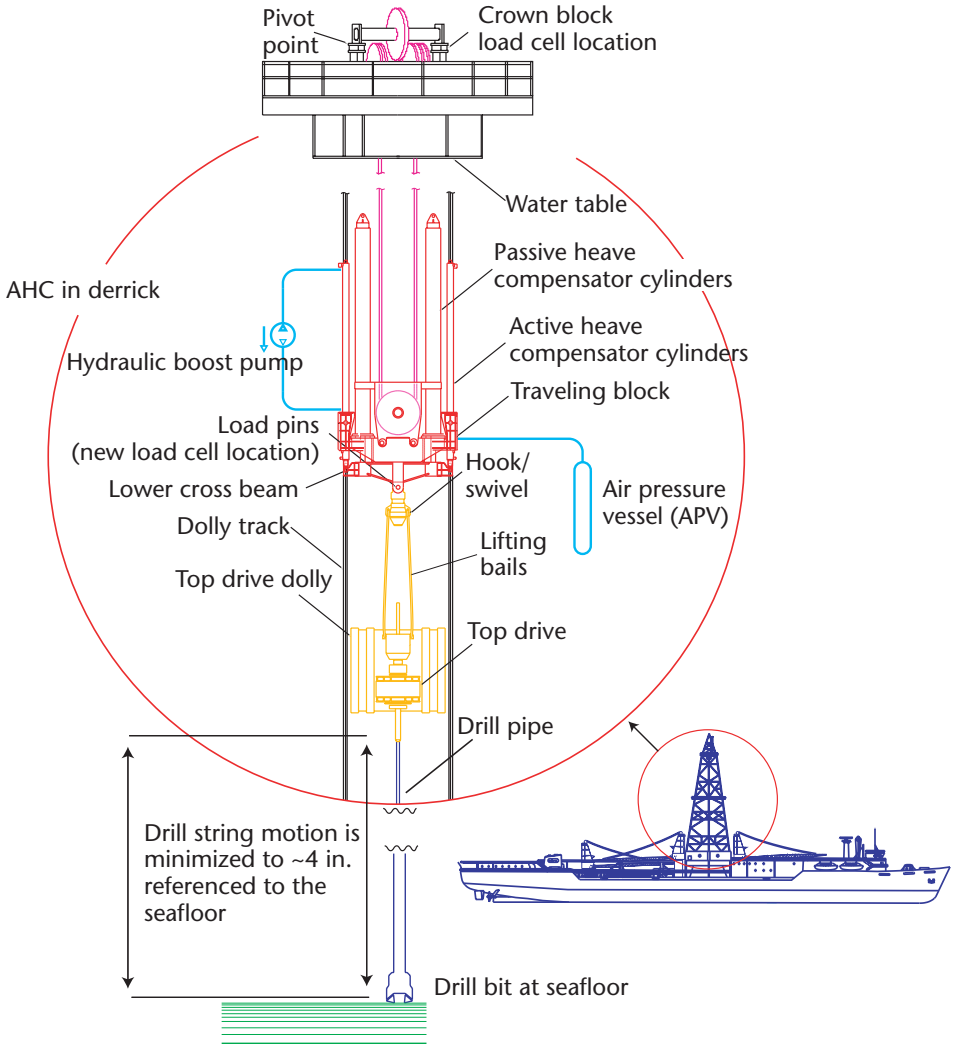
Scientific Application

Successful coring and drilling on land is dependent on the selection of coring tools and bits to match the lithology to achieve high core recovery or rate of penetration (ROP) during drilling. Most downhole drilling and coring problems are caused by unconsolidated or fractured formations and unstable holes with the associated hole cleaning problems. Vertical ship movement (heave) provides a third dimension to this problematical equation. Heave compensators reduce the effect of vertical ship heave on the drill string and coring tools. Without heave compensation, optimal ocean coring and borehole completions would require calm seas, with large amounts of downtime spent waiting on weather.



Schematic of the AHC in the derrick on the *JOIDES Resolution* with inset diagram showing equipment details.

Tool Operations

PHC

The Passive Heave Compensator (PHC) is a reactive device. Using a large air cushion, the PHC attempts to isolate the drill string from the ship heave and has to overcome the friction of seals each time the ship heaves up or down. When the ship heave is <6 ft, the response time to overcome the seal friction is slow, resulting in a PHC efficiency <40%. The resulting drill string motion relative to the seafloor is ~3 ft. On the other hand, when the ship heave is >12 ft, the response time is faster and the PHC efficiency is ~85%. The resulting drill string motion is ~2 ft.

AHC

The Active Heave Compensator (AHC) is a hydraulic power assist device to overcome the PHC seal friction and the drill string guide horn friction, which act in the opposite direction of the ship motion. By monitoring AHC rod position and the ship motion via a ship mounted motion reference unit, the hydraulic forces of the AHC counteract the PHC seal fric-

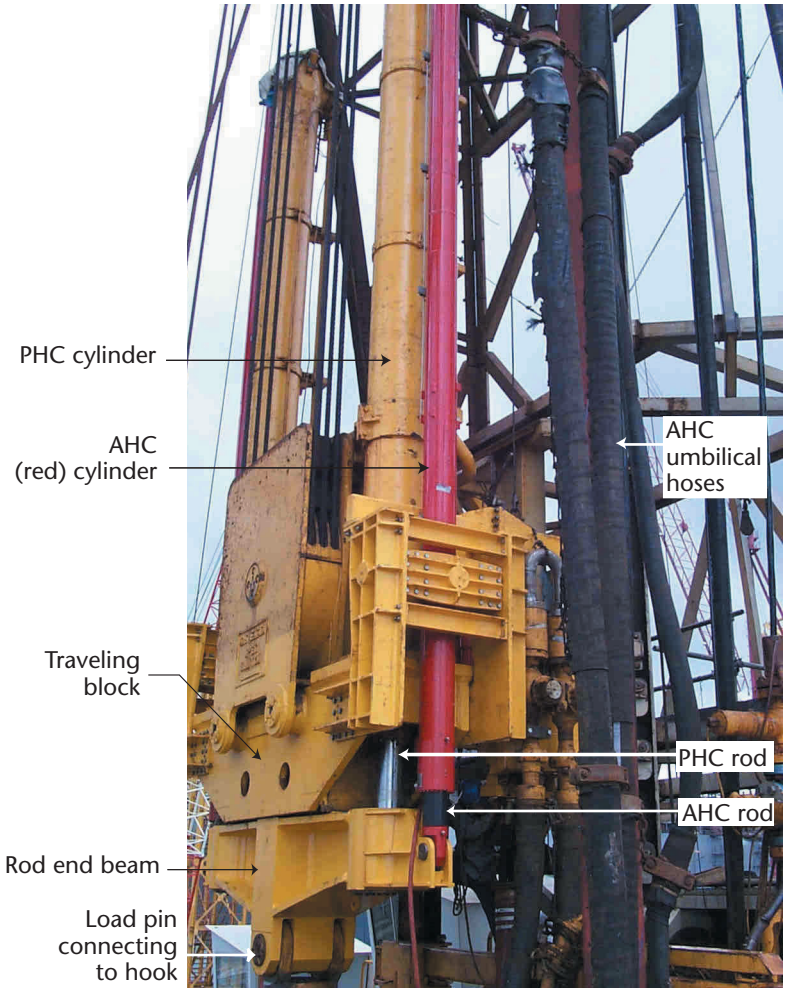
tion. Thus, the efficiency of the AHC is better than 95% for any ship heave condition, or about 4 in. at the rig floor for any heave. Prior to operation, the AHC is preloaded (biased) with the required weight on bit (WOB) using the PHC before the bit is landed on the bottom.

Design Features

1) Passive and Active Heave Compensation

Both passive and active heave compensators are installed in the derrick to reduce the effects of vertical ship motion (heave) on the drill string and coring tools.

Benefit: Both heave compensators allow coring from a heaving vessel, extending the operational weather window and improving core recovery and quality. The AHC also improves the controlled landing of both reentry cones and casing and of borehole completions such as Circulation Obviation Retrofit Kits (CORKs), Advanced CORKs (ACORKs), and instrument hangers with seismic instruments. Minimizing the motion of the borehole completion equipment also helps to ensure the integrity of the cement job, which is used to isolate the downhole formations from the ocean bottom water.



Passive and Active Heave Compensator systems in the derrick of the ship.

2) AHC Bit Lift-Off Reduction

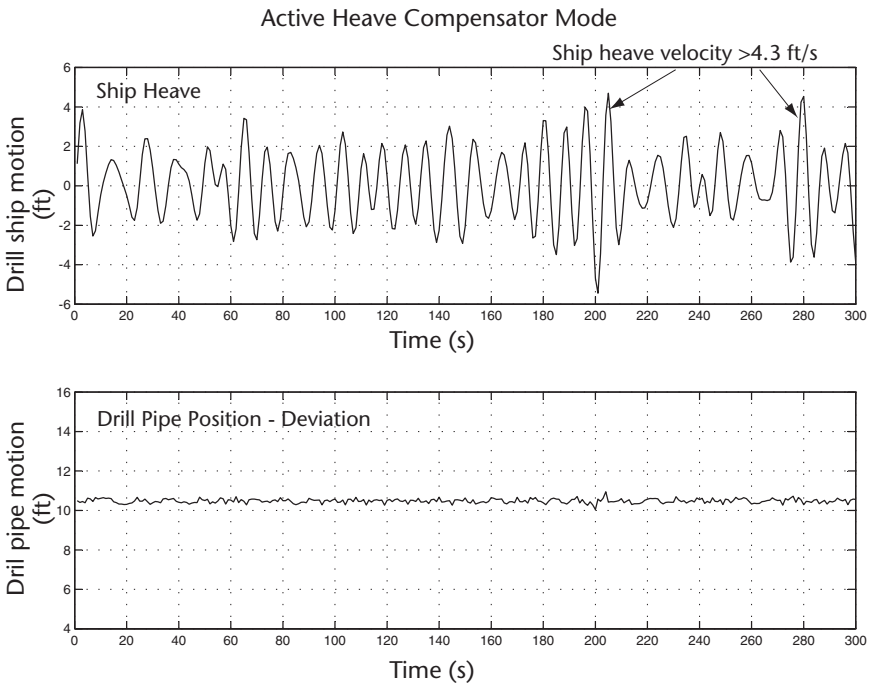
Bit lift off from the bottom of the borehole is related to drill string stiffness and ship heave. WOB requirements can be calculated to minimize lift off for specific heave conditions.

Benefit: The AHC reduces the frequency of bit lift off, which improves core quality and recovery. Another significant benefit of utilizing the AHC is the reduction in WOB fluctuations to <10,000 lb, permitting the use of mining-style diamond core bits (Advanced Diamond Core Barrel System [ADCB]) and hard rock polycrystalline diamond compact (PDC) core bits. These bits, which now provide high recovery on land, should also provide superior recovery in stratified hard/soft sediments and fractured basement rocks. The AHC is also necessary for the successful deployment of the Hard Rock Reentry System (HRRS).

3) AHC Drilling Control

The AHC stabilizes absolute drill string motion and the resulting drilling parameters (WOB, reaction torque, and rpm variations) that affect coring performance and drilling ROP.

Benefit: The AHC maintains a more constant WOB, which reduces torque variations at the bit. Smoother torque reduces core breakage as the core enters the core bit and results in improved quality of the recovered core. A constant WOB and bit rpm also improve the drilling ROP. Coring tools are less tolerant than rotary bit drilling of cyclic WOB, bit lift



The two graphs compare ship heave motion (top) and drill pipe motion (bottom) with the AHC in use during Leg 189. Ship heave motion was substantially reduced for the drill pipe when the AHC was used. Typical ship heave in this diagram is ~4 ft, except for the two excursions marked in the top diagram at 200 and 280 s. Drill pipe deviation is defined as drill string motion. It is referenced to sea bottom, but measured at the rig floor. Typical deviation in this diagram is 4.8 in., except for the two excursions indicated where maximum ship velocity was exceeded. Historical data indicate that the maximum drill pipe deviation is 4.8 in. The range is the same in both graphs (12 ft).

offs, and bit landings that result from ship heave.

4) AHC Tool Improvements

Existing coring tools perform better with less core jamming when the AHC is used.

Benefit: With improved WOB control and reduced frequency of lift off of the bit, PDC cutter and diamond bits can be used, and the ADCB system can be deployed to improve recovery in fractured basement rocks. This should also improve the recovery and data from downhole sampling tools, including the Pressure Core Sampler (PCS).

Specifications

Maximum Heave (PHC stroke)
6.1 m (±10 ft)

Maximum AHC Dynamic Force
50,000 lb (222,400 newtons)

Maximum AHC Power
500 hp (compensates for friction [PHC + AHC + guide horn])

AHC Operating Range

Maximum Ship Vertical Velocity
4.3 ft/s (1.3 m/s)

Operational Stroke (PHC)
4.9 m (±8 ft)

Limitations

The heave compensators cannot be used when coring with the Advanced Piston Corer (APC).