

ROV-Serviceable, Submarine Cable-Connected Wellheads for IODP Borehole Observatories

Jon Erickson, William Ussler III, Gene Massion, Larry Bird, and Charles K. Paull

Abstract

A new wellhead design that is easily ROV/HOV serviceable has been developed for installation at Integrated Ocean Drilling Program (IODP) borehole observatories. The original impetus for this development was the need for an ROV-serviceable, submarine cable-connected wellhead design for the Monterey Bay Borehole Observatory IODP drilling expedition once scheduled for late 2005. This expedition was removed from the active schedule because of permitting issues, but the design has been completed.

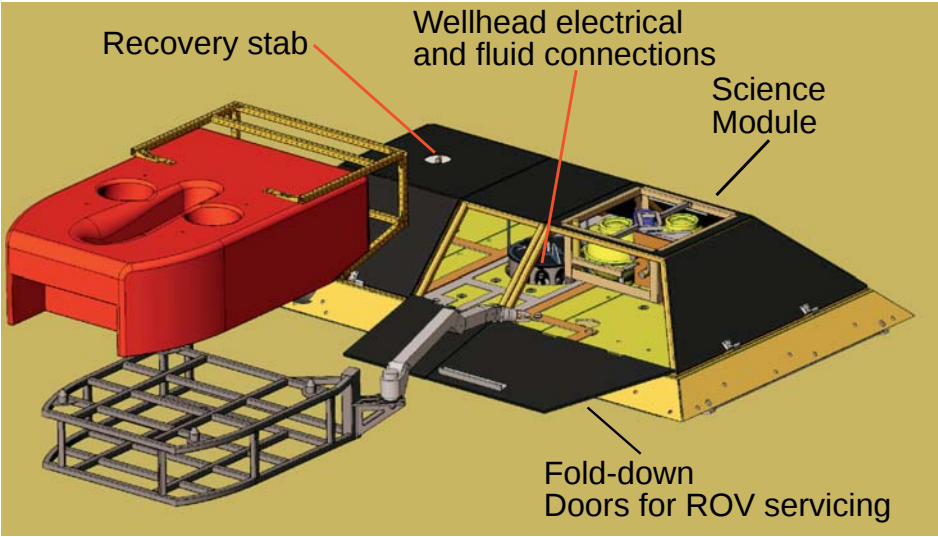
The evolution of cased holes that could be re-entered started during the Deep Sea Drilling Project (DSDP) with the initial objective of replacing drill bits and re-entering the existing hole to achieve greater total depth. This was achieved with the installation of seafloor re-entry cones with casing extending down into the borehole. However, over the next decade the potential of using cased legacy holes for subsurface monitoring was realized and has been increasingly utilized by either CORK (Circulation Obviation Retrofit Kit) or seismometer installations. Modifications to the initial designs of the re-entry structures were incremental, and ROV/HOV servicing of borehole monitoring experiments was achieved by placing a metal platform on top of the re-entry cone to provide a place for the ROV/HOV to land. One result of this configuration is that the monitoring equipment rises several meters above the re-entry cone into the water column. Because most previous Ocean Drilling Program (ODP) and IODP observatory installations have been in remote deepwater locations, this exposure of the monitoring equipment and the upper part of the borehole CORK body or instrument hangers has not been a major design consideration. However, several developments are occurring that require a substantial redesign of the current seafloor expression of the re-entry cone and completion equipment. First, drilling operations involving cased re-entry structures are increasingly being proposed for shallower water depths (<2 km) on continental margins. Second, the increasingly sophisticated observatory deployments and experiments conducted during the IODP will increase the dependence on ROV/HOVs to service these facilities. Finally, there is the intention to be able to connect instruments on the seafloor to submarine cables. To ensure the long-term viability and science return of these observatories, newly designed wellheads will be deployed that are intended to protect the scientific instrument, facilitate servicing by ROV/HOV, and be able to accommodate seafloor cable connections.

The surface expression of the new wellhead design is a radical departure from traditional re-entry cone designs used by the ODP and IODP. However, the design dimensions of the mud skirt have not changed, nor has the interface with the Drill Quip casing hanger assemblies been modified. The mud skirt has been modified to accept modular assemblies, which includes a substantially smaller re-entry cone module, which are indexed and bolted onto the mud skirt.

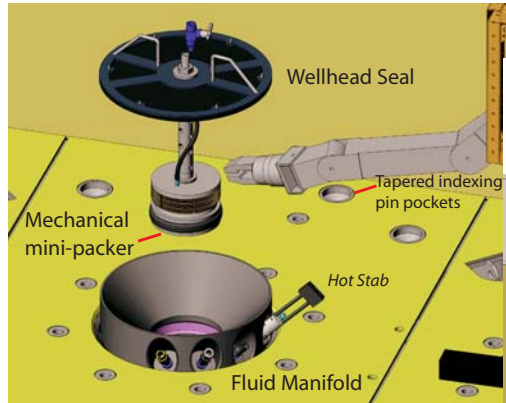
- Highlights of the design changes include:
- A shape that is trawl-resistant, limiting liability.
 - A modular design that allows reconfiguration by an ROV or HOV.
 - A re-entry cone that has been reduced from 8-ft vertical height to a 3-ft height and integrated into a removable central module.
 - A re-entry cone module that can be removed and replaced by an ROV or HOV.
 - Side modules adjacent to the central re-entry cone module that form a shock absorbing structure that is designed to withstand and deflect drill pipe hits.
 - ROV-serviceable science and submarine-cable communications modules that replace the drilling modules after borehole completion.
 - A wellhead designed to accept an ROV-serviceable mini-packer for sealing the well opening.
 - ROV-serviceable fluid and electrical connections to a casing manifold.
 - A non-corrosive ROV hot stab for making downhole fluid connections.

These designs are available for implementation on future IODP borehole observatories and will be posted on an IODP website in the near future.

New Design: Post-Drilling Removable Science Modules

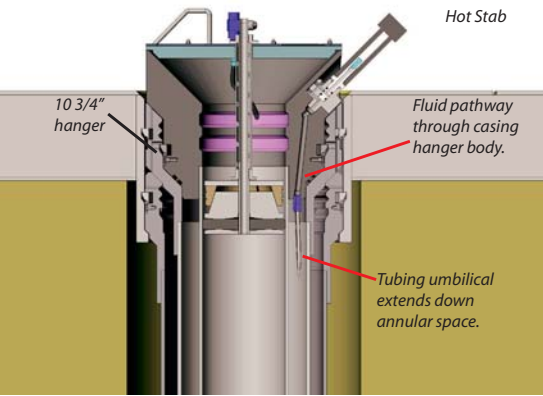


A completed wellhead is shown. The re-entry cone and side panel frames have been removed and replaced with a protective cover consisting of a central wellhead cover and two science modules. Fold-down doors provide access for ROV/HOV servicing. The geometry of the mudskirt allows full access to the central wellhead by a standard ROV manipulator for servicing wellhead electrical and fluid connections. A recessed Recovery Stab pin is centrally-located on the top of each module. This allows heavier and larger payloads than can be carried by an ROV manipulator. Payload is limited by vehicle thrust and variable buoyancy capacity.



Perspective view of the top of the wellhead mudskirt shows pockets for tapered indexing pins attached to the underside of all cover modules. The wellhead seal is installed by an ROV/HOV and the mechanical mini-packer is expanded by rotating a large nut with an ROV torque tool. Hot Stab connections can be made with an ROV manipulator.

Wellhead Seal and Fluid Manifold



Cross-section of wellhead seal with mechanical mini-packer installed. A tubing umbilical in the space between the 16\"/>

Schematic cross-section of wellhead with mini-packer installed. This sealing system provides feedthroughs for basic borehole measurements, including temperature and pressure.

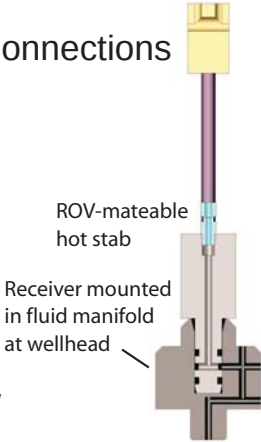
Hot Stab for Fluid Connections

- Traditional Quick-Connectors
- corrode
 - moving parts and springs
 - not easily ROV-mateable

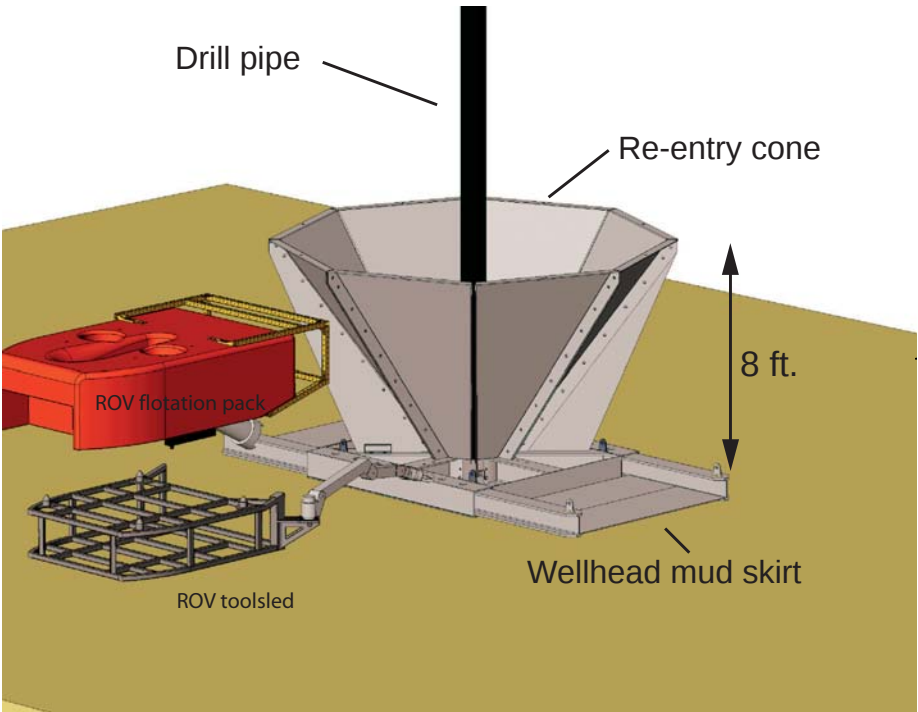
- Hot Stab Features
- non-latching
 - no moving parts
 - ROV-mateable
 - low internal volume
 - non-corrosive, suitable for trace metal chemistry and microbiology



Isometric View

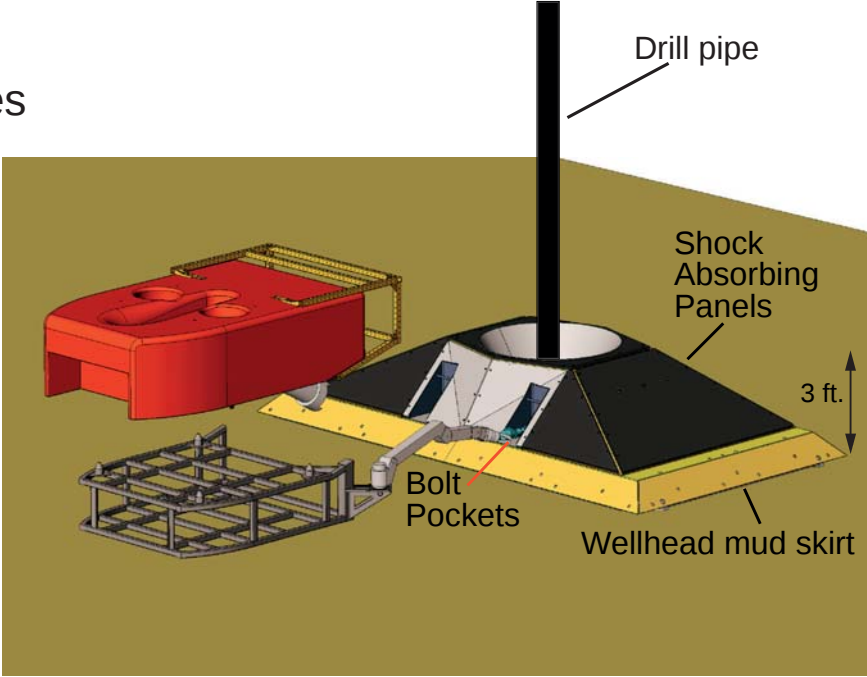


Existing Re-entry Cone Wellhead Design

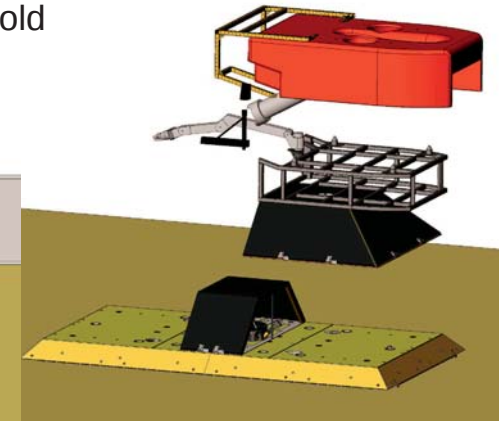


This schematic diagram shows the existing re-entry cone wellhead design used by the ODP and IODP. A full-scale mockup of MBARI's ROV Ventura is shown without its mid-section to reveal more of the wellhead. This re-entry cone is not ROV friendly or trawl-resistant. The mudskirt supports standard IODP casing hanger assemblies (3 or 4 Drill Quip casing hangers).

New Design: Drilling Stage Re-entry Cone Cover

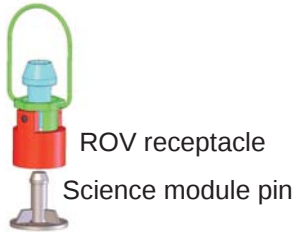


The new re-entry cone is modular and can be removed by an ROV after drilling is completed. Modules can be reinstalled at a later date if re-entry is required to remove/install downhole instrument strings or to clean or deepen the borehole. The re-entry cone module and side panel frames are secured with a few strategically placed bolts that can be removed or reinstalled using a commercial ROV-operated hydraulic torque tool. The side panel frames are covered with thick plastic panels that form a shock absorbing structure designed to withstand and deflect drillpipe impacts. These expendable side panels and re-entry cone are removed by an ROV after drilling is completed.



A mockup illustrates the use of the Recovery Stab and an ROV to lift a science module off the wellhead template. A small hydraulic winch installed in the ROV's toolsled is used to secure the science module against the underside of the toolsled. This Recovery Stab was originally designed for the MARS (Monterey Accelerated Research System) submarine cable installed in Monterey Bay in 2007.

Recovery Stab



MBARI-designed wellhead systems satisfy four critical technological needs identified in the IODP Technology Roadmap (www.iodp.org/eng-dev)

- ✓ **ROV-serviceable wellheads and submarine cable connections**
 - o ROV access to the wellhead is required for periodic maintenance of borehole observatories:
 - Change batteries
 - Collect samples
 - Download data
 - Exchange science modules
 - Make submarine cable connections
 - Repair monitoring systems
 - o Standardization of interfaces between wellheads and ROVs is needed
 - o A borehole test facility for test and validation of instruments, and training of ROV pilots would reduce operational costs, and improve efficiency and reliability of actual deployments
- ✓ **Electric, optical fiber and fluid feed-throughs at wellheads and in subsurface casing completions**
 - o Feed-throughs are necessary for installing long-term borehole monitoring systems:
 - Electrical cables
 - Telemetry cables
 - Optical fibers
 - Fluid and microbiological sampling tubes
 - o Any design needs to be compatible with existing shipboard deployment procedures and casing hanger geometries
- ✓ **Reliable wellhead hanger seals**
 - o Previous ODP designs did not seal properly for hydrologic experiments
 - o Hanger seals are needed to create and maintain the integrity of hydrologic seals between each casing string
- ✓ **Borehole instrument deployment, re-entry and servicing systems**
 - o Borehole observatories need re-entry capability:
 - Deploy, recover, and re-deploy borehole instruments
 - Perform short-duration borehole experiments
 - Maintain long-term borehole experiments
 - Modify borehole casing infrastructure
 - o Re-use existing ODP/DSDP boreholes