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

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## Abstract

A new wellhead design that is easily ROV/HOV serviceable has been developed for installation at IODP borehole obsevatories. The origianl 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 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 Integrated Ocean Drilling Program (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 reentry cone and completion equipment. First, drilling operations involving cased reentry 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 able to accommodate seafloor cable connections.

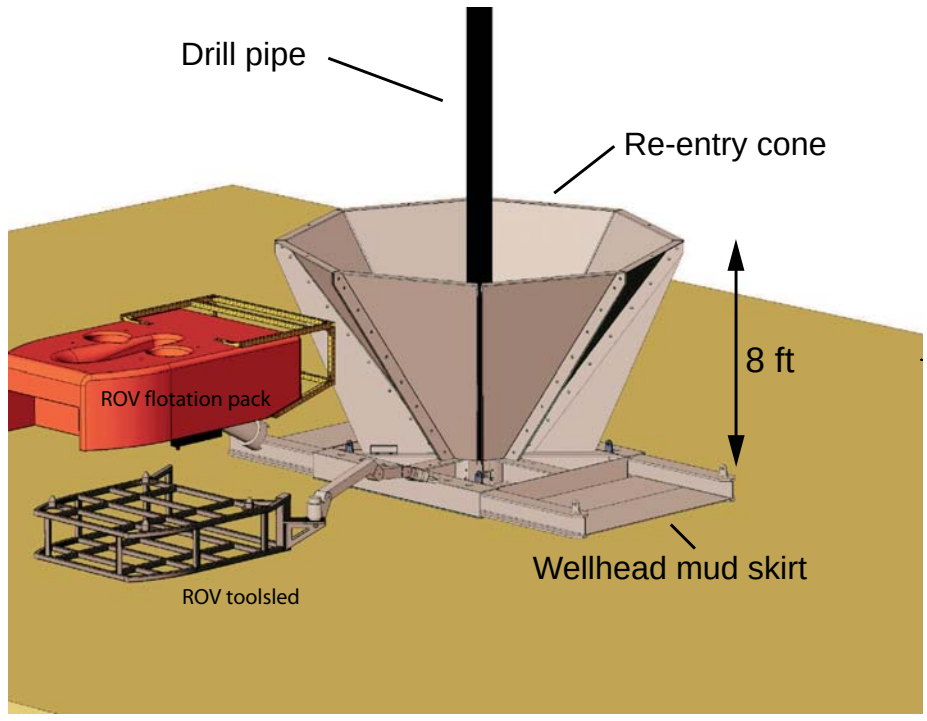
The surface expression of the new wellhead design is a radical departure from traditional re-entry cone designs used by the ODP and IODP. However, the design dimensions of the mud skirt have not changed, nor has the interface with the Drill Quip casing hanger assemblies been modified. The mud skirt has 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 drillpipe 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.

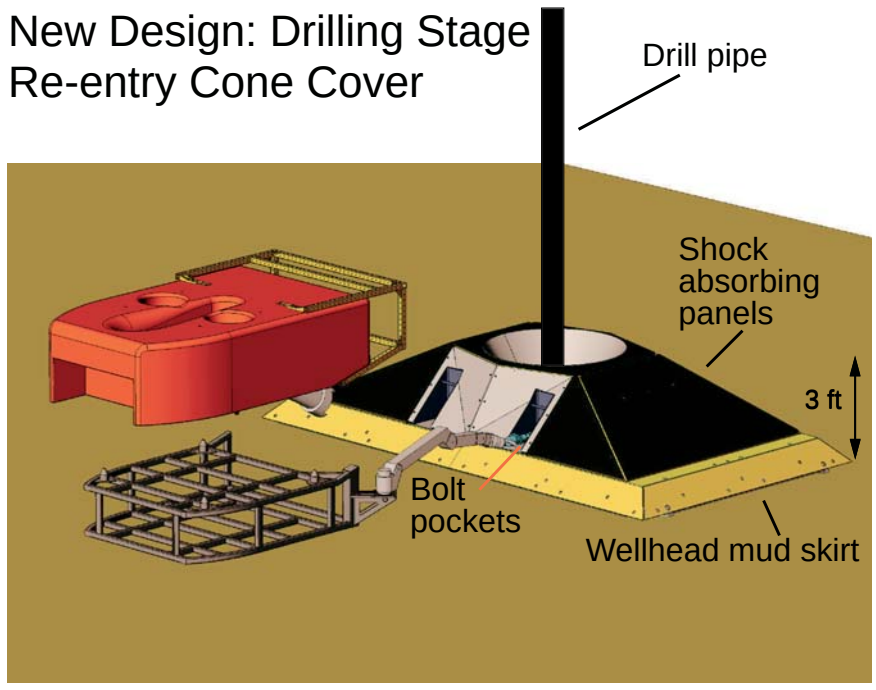
These designs are available for implementation on future IODP borehole observatorys and will be posted on an IODP website in the near future.

## Existing Re-entry Cone Wellhead Design



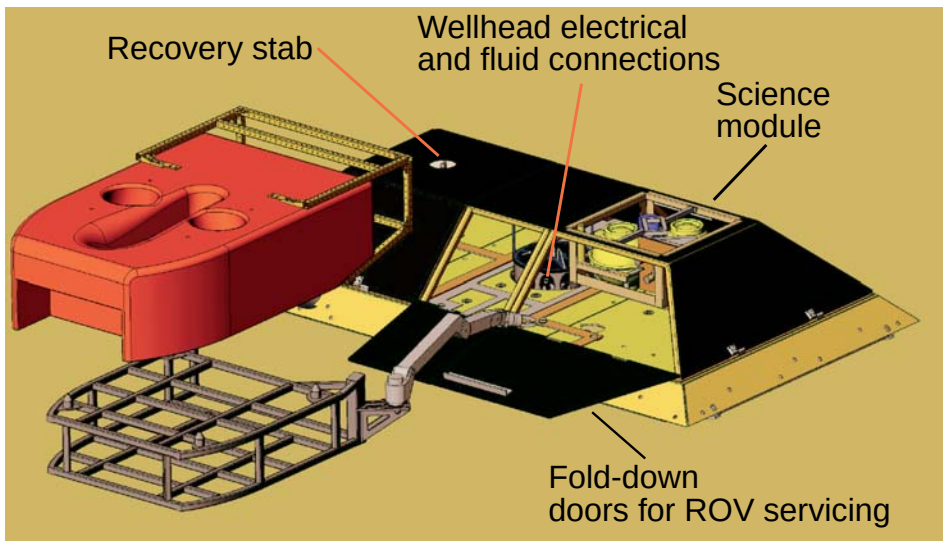

*This schematic diagram shows the existing re-entry cone wellhead design used by the ODP and IODP. A full-scale mockup of MBARI's ROV Ventana is shown without its mid-section to reveal more of the wellhead. This re-entry cone is not ROV friendly or trawl-resistant. The mudskirt supports standard IODP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

## New Design: Drilling Stage Re-entry Cone Cover



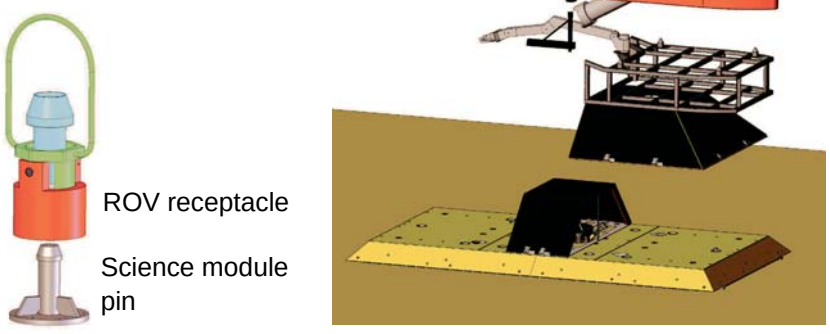

*The new re-entry cone is modular and can be removed by an ROV after drilling is completed. Modules can be reinstalled at a later date if re-entry is required to remove/install downhole instrument strings or to clean or deepen the borehole. The re-entry cone module and side panel frames are secured with 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.*

## New Design: Post-Drilling Removable Science Modules

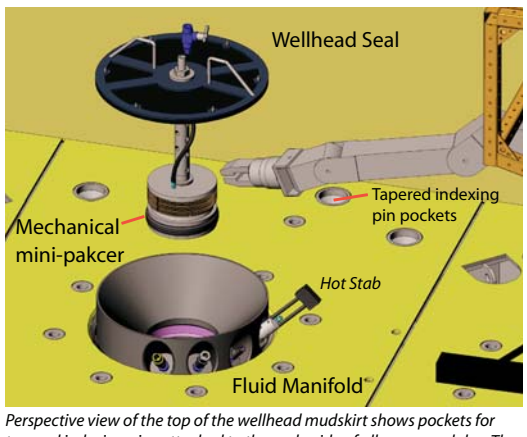



*A completed wellhead is shown. The re-entry cone and side panel frames have been removed and replaced with a protective cover consisting of a central wellhead cover and two science modules. Fold-down doors provide access for ROV/HOV servicing. The geometry of the mudskirt allows full access to the central 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.*

## Recovery Stab

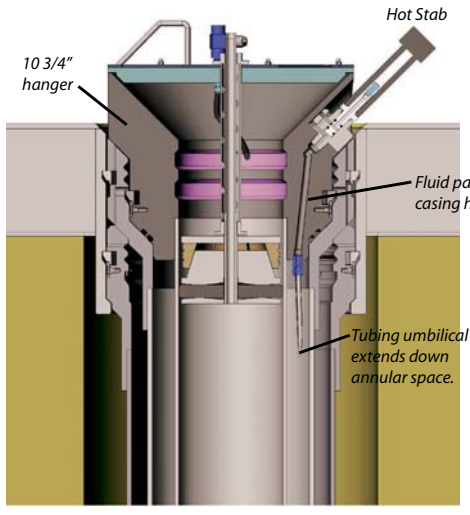



*A mockup illustrates the use of the Recovery Stab and an ROV to lift a science module off the wellhead template. A small hydraulic winch installed in the ROV's toolsled is used to secure the science module against the underside of the toolsled. This Recovery Stab was originally designed for the MARS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

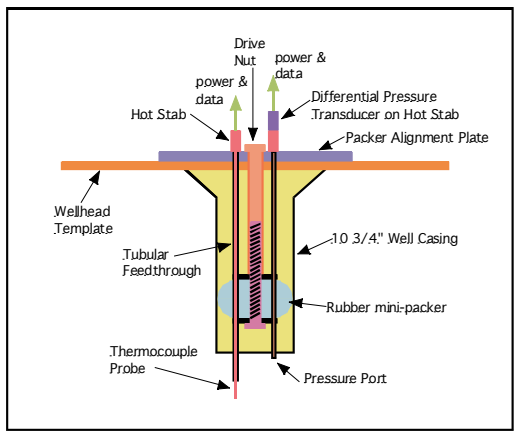



*Perspective view of the top of the wellhead mudskirt shows pockets for tapered indexing pins attached to the underside of all cover modules. The wellhead seal is installed by an ROV/HOV and the mechanical mini-packer is expanded by rotating a large nut with an ROV torque tool. Hot Stab connections can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

## Wellhead Seal and Fluid Manifold



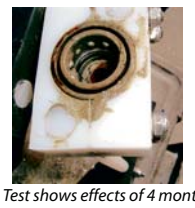

*Cross-section of wellhead seal with mechanical mini-packer installed. A tubing umbilical in the space between the 16" and 10 3/4" casing terminates at the wellhead into a fluid manifold. The mechanism for hanging and sealing the 10 3/4" casing to the 16" casing with an internal tubing umbilical has been developed by IODP drilling engineers. A Hot Stab is shown connected to the fluid manifold.*




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

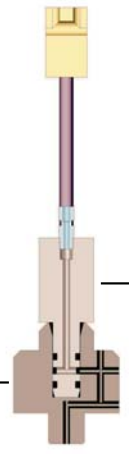
## Hot Stab for Fluid Connections

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



*Test shows effects of 4 month exposure of an off-the-shelf quick connector to seawater. Non-corrosive materials are required for a 10-year useful life.*

Isometric View




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