

ABB solutions meeting deepwater drilling challenges

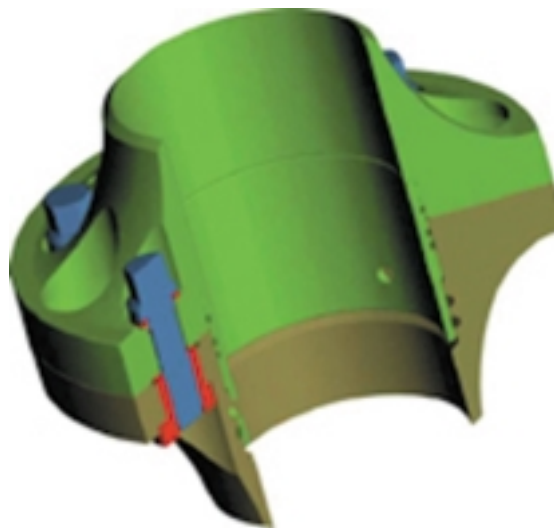
By Ian Calder

ABB Vetco Gray is meeting current deepwater drilling challenges with a range of solutions that include significantly improved load-carrying structures between the floating vessel and sea floor. Newly developed drilling risers and subsea wellhead systems offer greatly increased performance capacities for deepwater applications.

A surge of innovation is currently sweeping the offshore industry. New dual-derrick drillships are being built with load performance capacities up to double those of previous systems. At the same time, applications in water depths of as much as 10,000 feet, riser joints with individual lengths of up to 90 feet, and tensioner handling capacity exceeding 3 million pounds, are all making extra load capacity demands on the system components.

To address these needs, ABB has designed, built and function-tested solutions for:

- Drilling risers, 16" to 21" OD HMF, class F, G and H style flanged risers and 21" MR-10, class H dog style risers
- SHD-H4 drilling connectors for use with the BOP stack
- 18-3/4" SMS-700 subsea wellhead systems and 13" MS-700 subsea slender wellhead systems
- Composite risers and choke/kill line tubes – so-called VastyDeep™ solutions



1 HMF flanged drilling riser connection. Working loads for these new connections range from 2000 to 3500 kips.

HMF flanged drilling riser connections for working loads of 2000 to 3500 kips (2 to 3.5 x 10⁶ lbf)

Increased tension loads for deepwater drilling risers call for designs capable of handling a capacity increase from 2000 to 3500 kips **1**, **2**. At the same time, water

depths for applications have increased from 4000 to 10,000 feet, with joint lengths growing from 75 to 90 feet. The design of the HMF flanged connection provides for guided stabbing for all lines. A simplified hydraulic wrench makeup system for the 6 individual bolts ensures



2 HMF riser flange being tension-tested (API class F rating to 2500 kips tension)

ABB Vetco Gray's Aberdeen R&D test center has verified the structural integrity of the connector by means of 2D and 3D finite element analysis. The results were compared with those recorded for a fully strain-gauged test fixture manufactured at ABB Vetco Gray's Montrose facility.

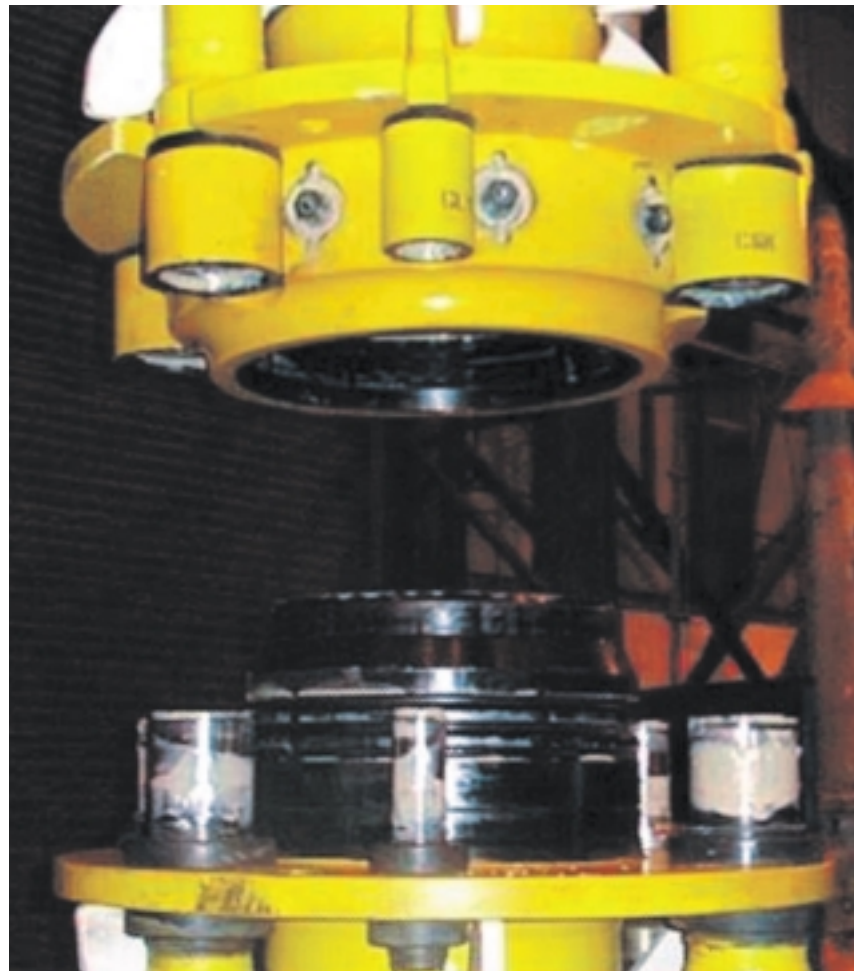
Confidence in the connector has been substantiated by two drilling contractors who have placed orders for five riser systems utilizing the MR-10 'H' for their new rig builds.

ease of assembly during field makeup, even with the riser moving due to the ship's motion.

This field-proven design was chosen by drilling contractors during its recent expansion into much deeper waters. Applications are in excess of 130,000 feet, requiring roughly 1600 individual riser joints.

MR-10 class H riser performance verified by FE analysis

Ever-increasing demands for a high-strength, fast makeup dog style drilling riser able to cope with the harshest of operating environments has led to ABB Vetco Gray's development of the MR-10 Class 'H' drilling riser 3. The design features 360° dog-to-mandrel engagement with a larger bearing area between the dog-to-box window. Increased performance and reliability in the field is provided by a simple yet robust design that facilitates easier strip down during overhaul and maintenance.



3 Performance evaluation testing an MR-10 Class H 3.5 million pound deepwater riser



4 SHD-H4 drilling connectors for use with subsea BOP stacks and wellheads.

Delivery of these systems was completed in the first quarter of 2000. Ocean Rig ordered two systems for its Bingo 9000-1 and 9000-2 rigs; Sedco Forex ordered three systems for the rigs Cajun Express, Sedco Energy and Sedco Express. These rigs all target applications at water depths down to 10,000 ft.

SHD-H4 drilling connectors used with subsea BOP stacks and wellheads

Verification testing of the SHD-H4 connector was conducted in accordance with API 16R, utilizing the full-scale test fixture. The connector was subjected to various axial loads, including an internal pressure of 5000 psi x 3.5 million lb-ft tension, thus allowing verification of the seal integrity. The test program concluded with a 5.2 million ft-lb tensile induced load, after which the connector was stripped down and inspected for any adverse effects. No adverse deformation or signs of failure due to the final 5.2 million ft-lb tensile load test could be observed.

Verification tests were performed on both the Super HD-H4 wellhead connector 4 and the Super MS-700

wellhead housings under full rated loads. The Super MS-700 housings consisted of an 18-3/4" high-pressure housing and a 38" low-pressure housing. The drilling

connector and high-pressure wellhead housing both have internal pressure ratings of 15,000 psi. The entire system, consisting of the wellhead connector, high-pressure housing and low-pressure housing, has been rated for isolated loads of 3 million lbs tension and 7 million ft-lbs bending moment. Under combined loads, the Super HD-H4 is rated to 15,000 psi internal pressure, 1.5 million lbs tension and 7 million ft-lbs bending moment. Testing followed test procedure HTS980059 Rev A and was conducted on 10 February, 1999.

The system was subjected to 3 cycles



5 Super MS-700 subsea wellhead and guidelineless re-entry assembly (GRA)



6 Conoco successfully spudded the first SMS-700 system in the Gulf of Mexico in late January 1999 with the 'Deepwater Pathfinder'. The 'Deepwater Frontier' spudded the second SMS-700 system off the coast of New Zealand in March 1999. The 'Deepwater Frontier' has since moved to another location off Congo and has started drilling its third well.

each of the isolated loads (15,000 psi internal pressure, 3 million lbs tension and 7 million ft-lbs bending) and then two 2 cycles of combined loads (15,000 psi internal pressure with 1.5 million lbs tension and 7 million ft-lbs bending moment).

The strain-gauge readings remained stable during all load test phases, and returned to within +/- 5% of their pretest values after the loads were removed. At no time was the maximum strain observed to exceed 80% of the design value. Also, during none of the internal pressure time hold periods did the pressure drop more than 40 psi, which is less than 10% of the allowed figure.

The Super HD-H4 wellhead connector /Super MS-700 wellhead system successfully met all the rated load verification test acceptance criteria.

Customer acceptance has been exceptional, with orders for 13 Super HD-H4 drilling connectors received from 6 of the major deepwater drilling contractors.

These same drilling contractors also acquired over 130,000 feet of drilling riser.

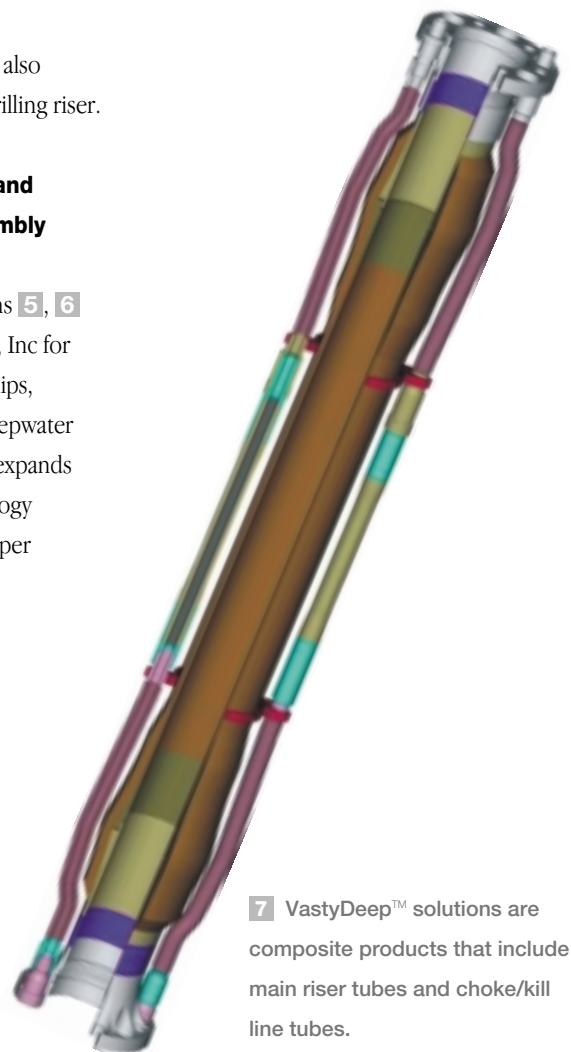
SMS-700 subsea wellhead and guidelineless re-entry assembly (GRA)

Three SMS-700 wellhead systems **5**, **6** have been delivered to Conoco, Inc for use on its new deepwater drillships, 'Deepwater Pathfinder' and 'Deepwater Frontier'. The SMS-700 system expands on field-proven MS-700 technology and incorporates the 18-3/4" super wellheads with the SHD-H4" connector profile on the high-pressure housing. The system is rated at 15,000 psi working pressure and has a bending capacity of 7,000,000 ft-lbs.

ABB Vetco Gray's super wellheads are designed to meet drilling requirements at water

depths down to 10,000 ft. The new design also incorporates trip-saving features such as the stack-retrievable GRA (Guidelineless Re-entry Assembly). The super GRA, based on our standard GRA, can be pulled off the conductor housing and retrieved with the BOP stack.

Another trip-saving feature designed into the SMS-700 wellhead system is a bit guide which can be retrieved at any time during the drilling process. This is accomplished



7 VastyDeep™ solutions are composite products that include main riser tubes and choke/kill line tubes.

by having the remotely operated vehicle place a tool on the drill pipe at a tool joint connection and attaching hooks mounted in the bit guide.

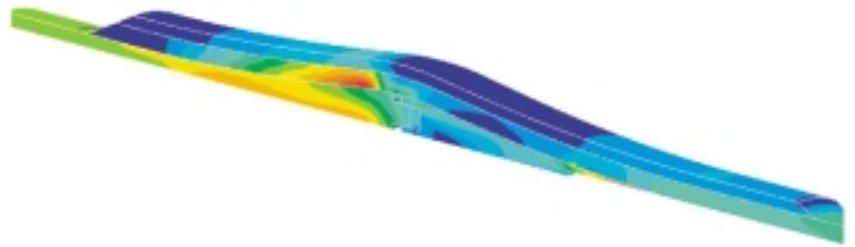
Other features include the open construction of the GRA, which allows free flow of the cuttings during the drilling process, a gimballed mudmat with hydrate deflector, and an automatic mudmat latch for easy hands-off operation during moonpool operations.

VastyDeep™ solutions – composite developments in main riser tubes and choke/kill line tubes

Drilling and production of oil and gas is taking place in increasingly deeper water. The greater water depths, however, are making conventional materials impractical as total system weights exceed the limits of current vessel and production system designs. By using advanced, lightweight materials, such as composites **7**, a given vessel design can be used at increased water depths. ABB Vetco Gray is in the process of commercializing composite products that include choke and kill lines, drilling risers and production risers.

Extensive design and testing activity is aimed at developing a new line of composite products to meet the industry's deepwater needs. Laboratory testing has included tests on a 21" all-composite drilling riser made of carbon fiber and epoxy.

The riser has undergone static loading up to 2 million pounds as well as cyclic bending and tension spectra simulating approximately half of its field-service life. It is planned to ready the riser for offshore field trials where it will be placed in a con-



8 Finite element model of the fully preloaded composite-to-metal interface design used in composite drilling and production risers

ventional steel riser string for a 3- month tour of duty. After the field trials, it will be returned to Houston for further testing.

Both the drilling and production risers feature a special interface connection called the Geometric Trap™ that attaches the standard metallic riser end-fittings to the all-composite main body.

The patented Geometric Trap very efficiently and reliably transfers the tension and bending loads to the tube structure by means of a preloaded geodesic-isotensoid dome arrangement.

Design and testing activity has also been directed at choke and kill lines. Both 3" and 4 1/2" lines have been designed and analyzed.

Testing of the choke and kill lines has included hydrotesting to 22,500 psi, 15,000 psi cyclic testing for an equivalent of 100 years of service, and gas testing to 15,000 psi.

Due to the complex nature of

composites, the increased benefit that comes from optimization and the need for a short design cycle, it has become necessary to automate the design and analysis process wherever possible.

New analytical methods and tools have therefore been developed that make use of state-of-the-art expert systems and knowledge-based technology **8**. As a result, design cycles that previously lasted two to three months can be reduced to just two or three hours.

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