Rhino
Integrated borehole enlargement system
Customizable, rugged, precision-engineered Rhino system reamers improve drilling performance and deliver high-quality, concentric boreholes. They can be configured for a wide range of borehole sizes and any borehole enlargement application.
Rhino borehole enlargement system

Applications
- Deepwater wells
- Extended intervals drilled with rotary steerable systems
- Extended-reach-drilling (ERD) wells
- Loosely consolidated formations
- Highly abrasive formations

Benefits
- Improves hole-enlargement-while-drilling (HEWD) efficiency by reducing drillstring vibration
- Enhances wellbore assurance through larger ID production strings, control of equivalent circulating density (ECD), and improved casing running

Features
- Integrated jet nozzles and flow paths
- Tungsten carbide hardfacing and diamond-enhanced inserts
- Configurations for a wide range of borehole sizes and any HEWD application
- Optional Predator* cutter blocks equipped with ONYX* PDC cutters

Hydraulically actuated reamers
HEWD improves well construction by reducing the number of drilling trips and improving wellbore quality. The Rhino* integrated borehole enlargement system is designed to efficiently enlarge boreholes while drilling, maintain better control of ECD, optimize tubular programs that increase production rates at less cost, and improve casing running.

The Rhino borehole enlargement system comprises a family of hydraulically actuated reamers, including
- Rhino XS* hydraulically expandable reamer for reliable single-trip borehole enlargement
- Rhino XS2* full-cycle expandable reamer for full circulation at TD, pulling out of hole, and above the casing shoe.
- Rhino XC* on-demand hydraulically actuated reamer for complete control of reamer activation
- Rhino RHE* dual-reamer rathole elimination system for elimination of dedicated rathole cleanout runs.

Field-proven reamers in 5,000 runs with 7 million ft reamed worldwide
Rhino system reamers can be customized for a variety of challenging applications. Field-proven in more than 5,000 runs and with 7 million ft reamed worldwide, Rhino system reamers save time and bring production online faster.
Optimized cutting structure for bit and reamer dynamics

The design of the Rhino system reamers’ cutting structure is optimized for bit dynamics, formation lithology, and the entire BHA. Each cutter is in a unique location on the cutting profile for a more stable and durable reamer cutting structure. Reamer placement and operating parameters are optimized for maximum performance with the rest of the BHA components.

To enhance wear resistance and improve thermal stability in hard, abrasive formations, Rhino system reamers can be equipped with Predator cutter blocks, which use ONYX PDC cutters. IDEAS* integrated design platform is used to create application-specific cutter blocks that avoid damaging vibrational loading of the cutters. Three cutter blocks help improve ROP without sacrificing durability.

The i-DRILL* engineered drilling system design provides insight into the interaction of the cutting structure with the drilling system. The one-piece balanced design increases torque and load-carrying capacity while reducing drilling-generated vibrations.

The i-DRILL drilling system design uses predictive modeling to match the drill bit with the reamer. The cutting structure design is optimized to increase durability and maximize ROP. Cutters stay sharp longer to drill more footage at faster ROP in a range of applications.
Modeling processes for operational efficiency

**Optimized system design**
The Rhino borehole enlargement system uses sophisticated dynamic modeling to efficiently enlarge the borehole and improve wellbore quality. Matching the cutting structure with the bit and reamer provides a balanced drilling assembly and helps maintain BHA stability. BHA instability can cause excessive vibration and stick/slip as well as failure of the BHA components.

Using 4D simulation, the IDEAS integrated design platform provides a full virtual world view of the elements that impact drilling for a complete simulation of the rock-cutting process. The design minimizes the likelihood of undergauge and irregular boreholes.

Once the cutting structures are matched, the i-DRILL engineered drilling system design uses predictive modeling to pair drill bit and reamer design and identify solutions to minimize vibrations and stick/slip. It also models the drilling system and directional response of the PowerDrive* rotary steerable system (RSS). Modeling helps determine optimal reamer placement and surface operating parameters and ensures that placement of the reamer does not interfere with the directional steering capabilities of the RSS.

Using offset well data, surface and downhole measurements, and a thorough knowledge of products and applications, the i-DRILL design process creates a virtual drilling environment. A bit-underreamer balance analysis helps determine the combination that will result in the highest ROP under stable conditions. The final design improves drilling performance over a wide range of applications.

The IDEAS design platform calculates individual cutter loading to predict the dynamic behavior of the cutting structure.
Rhino XS hydraulically expandable reamer

**Reliable hydraulic actuation**
The Rhino XS hydraulically expandable reamer provides reliable hydraulic actuation for single-trip borehole enlargement with an activation ball that is dropped from surface.

Hydraulic actuation is provided by the Z-Drive* reamer cutter block deployment system. When activated by the ball drop, the Z-Drive system pushes the cutter blocks upward and radially outward to the fully open position, facilitating rapid cutout and ensuring a full-gauge, concentric borehole. When pumping stops, the cutter blocks retract. Dependable retraction of the cutter blocks helps avoid stuck BHAs.

**Applications**
- Shoe-track drilling when cement must be cleared from casing
- Post-shoe-track drilling in formations that require enhanced stabilization
- Hole enlargement while drilling

**Advantages**
- Hydraulic activation
- Cutter block design that eliminates PDC cutter contact with casing ID
- Optional cement cleanout blocks for removal of the cement sheath that forms in the casing ID when drilling out the shoe track
First Two-Phase Nitrogen Mud System Well Underreamed in One Run

Hydraulically expandable reamer saves 3 days on Iraq underbalanced well

Using the Rhino XS hydraulically expandable reamer, an operator in northern Iraq saved 3 days on an underreaming run in a well with a two-phase nitrogen mud system. The unstable formation had caused boreholes to collapse, and those that were completed were out of gauge. In addition, low fracture gradient created severe mud losses.

The Rhino XS reamer increased wellbore quality and casing running efficiency while using an underbalanced drilling method with a nitrogen-charged mud system. In one run, the 615-m section was enlarged from 14 in to 17 in — the first successful underbalanced HEWD operation in a two-phase nitrogen mud system well.
Rhino XS2 full-cycle expandable reamer

Applications
- Underreaming while drilling
  - tight holes
  - swelling formations
  - abrasive formations
  - wells with ECD or casing clearance issues

Advantages
- Enables effective hole cleaning at TD with full drilling circulation rates
- Enables full circulation while tripping out into the casing or above casing shoe
- Prevents new cuttings generation when pulling out of hole
- Reduces risk with moving parts away from critical flow ports
- Allows custom borehole enlargement solutions including
  - enlarging a portion of wellbore
  - cement cleanout
  - use as an expandable stabilizer
  - use as a Rhino RHE system upper reamer

Effective reaming with full-cycle actuation
The Rhino XS2 full-cycle expandable reamer is the latest addition to the integrated Rhino system. The tool enables effective hole cleaning at TD with full circulation rates. Additionally, the Rhino XS2 reamer eliminates cuttings from being generated when POOH or performing other borehole enlargement strategies.

Broad applications
The reamer is ideal for use with rotary steerable systems and is particularly well suited for challenging applications, including extended-reach drilling, operations in highly abrasive formations, and backreaming in loosely consolidated formations.
**Activation and deactivation mechanisms**

Beginning full-cycle actuation involves pumping an activation ball downhole, which shears the sleeve and exposes the fluid ports. The reamer’s unique design positions moving parts farther from critical flow ports.

Drilling fluid flows through the fluid ports, opening the cutter blocks. The hole is then drilled and enlarged. The tool has three ports, facilitating cuttings removal.

Once drilling and underreaming is performed, the cycle is completed by pumping another ball down. The deactivation pins shear, releasing the sleeve and ball to the catcher, and closing fluid ports to the cutter blocks.

Circulating fluid can then be pumped at maximum flow rates for optimal hole cleaning at TD without activating the cutter blocks. Multiple bottom-up cycles can be pumped as required. When the tool is inside the casing, additional cycles can be pumped without the risk of damaging the casing. The deactivated tool trips out without generating new cuttings.
Rhino XS2 Reamer Enables Talisman to Circulate More Than 25 h After Deactivation and Drills to TD

Reamer offers flexibility and extended circulating time with no tool erosion

Talisman was drilling into a depleted zone in the Bunga Seroja field of western Malaysia. The operator needed to keep cuttings generation and equivalent circulating density (ECD) low to avoid circulation losses. Talisman also needed to circulate for longer hours after deactivation.

Schlumberger recommended using the Rhino XS2 reamer, which successfully drilled and enlarged the 877-m section while maintaining ECD at 12.6–12.8 ppg. After drilling to TD, Talisman circulated for 25 additional hours after deactivation. After completing the operation, the Rhino XS2 reamer was POOH and without generating new cuttings.
Custom BHA expands an average of 1,100 m per section with 18-m/h ROP

While drilling in deepwater Brazil, an operator wanted to overcome wellbore instability problems in its horizontal wells by enlarging the horizontal section from 8½ in to 9½ in.

Schlumberger recommended the Rhino XS2 reamer, which would help prevent damage to the formation and deter the creation of ledges and washouts during cleanup cycles.

While deactivated after enlarging all the horizontal sections an average of 1,100 m per run, the three bottom-up cycles were achieved in open hole, and one bottom-up cycle was achieved inside the 9¾-in casing. The average ROP of these seven runs was 18 m/h, and all hole enlargements were completed with a 100% success rate.
Rhino XC on-demand hydraulically expandable reamer

**Complete control of reamer activation and deactivation**
When borehole enlargement requires multiple reaming intervals, the Rhino XC on-demand reamer provides complete control of reamer activation. It eliminates time-consuming pumpdown activation devices and can be placed anywhere in the drillstring for increased operational flexibility.

The reamer’s one-piece, balanced design increases torque and load-carrying capacity while reducing drilling-generated vibrations, producing in-gauge wellbores for improved casing running and cementing clearance. Three integrated jet nozzles can be changed to ensure optimum borehole cleaning and cuttings evacuation in a variety of formations. The reamer’s large-ID bore handles high fluid volumes with optimized distribution between the bit and cutter blocks. This high-fluid capability accommodates the flow rate requirements of other downhole tools.

**Applications**
- Boreholes requiring multiple reaming and nonreaming intervals
- Close-tolerance and expandable casing programs
- ERD wells and other well profiles with inclinations greater than 65° where conventional pumpdown activation is technically limited

**Advantages**
- On-demand wellbore enlargement with unlimited activations
- Full flow capability in reaming and nonreaming modes
- Deployment and retraction of PDC cutter blocks in minutes for improved casing running, cementing clearance, and ECD control
- Borehole stability

*The Rhino XC reamer’s reaming mode can be changed in minutes to effectively enlarge boreholes regardless of the well’s inclination angle.*
Unlimited on-demand reamer activation and deactivation

**Fast activation sequence with surface confirmation**

The Rhino XC reamer uses a flow-activation system that enables a faster activation sequence. It is indexed by cycling flow into a predetermined flow range, which changes the reamer status. In normal operations, as flow increases or decreases through the index range without stopping, the reamer status does not change.

To activate the reamer, the flow rate is brought into the index range, which is a band of flow rates determined by the reamer size. Once entered into the index range, flow is decreased again, and the reamer is indexed, changing its status from off to on. Then flow is brought up to the full drilling flow rate, and a drop in standpipe pressure indicates activation at surface. For subsequent drillpipe connections made at surface, the activation state does not change as long as the flow transverses the index range.

1. The reamer is not activated.
2. The activation process begins.
3. Flow is brought into the indexed range.
4. The reamer is indexed, changing its status.
5. A decrease in surface pressure indicates reamer activation.
Case Study

Deepwater GOM Well Section Enlarged in One Trip and 62 Hours

On-demand reamer provides extended rathole for coring BHA stabilization

While drilling a deepwater well in the Gulf of Mexico (GOM), an operator ran the Rhino XC on-demand reamer to drill a 2,188-ft interval in one trip and 62 hours. The Rhino XC reamer was chosen to reduce the time for HEWD and provide an extended rathole section for coring BHA stabilization.

When the cutter blocks were activated, the reamer enlarged the 12 1/4-in section to 13 1/2 in—a total of 1,551 ft. The cutter block was then deactivated at the top of the coring section, and a 12 1/4-in borehole was drilled an additional 583 ft, providing the required stabilization for the subsequent coring assembly.

The Rhino XC on-demand reamer enlarged the 12 1/4-in section to 13 1/2 in without the need for a contingency liner, cutter blocks were deactivated at 27,000 ft, and the 12 1/4-in borehole was drilled an additional 583 ft to provide an extended rathole.
Case Study

High-Inclination Well in Brunei Underreamed Below MWD Tool Placement

Rhino XC reamer enlarges upward-inclined horizontal section in one trip

Brunei Shell Petroleum ran the Rhino XC on-demand reamer to enlarge a 1,039-m horizontal section—from 8 ½ in to 9 ¼ in—in a well with a fish-hook profile. The on-demand reamer was activated at 2,093.3-m MD at a borehole angle of 107°.

In a single run, the Rhino XC reamer successfully underreamed the high-inclination well, from 2,030-m MD to 3,069.6-m MD, below the MWD tool. At the targeted TD, the reamer was deactivated, and a pressure increase confirmed that the cutter blocks had retracted. The Rhino XC reamer eliminated the need for pumpdown device activation, which would not have been possible at the 107° angle.

In a single run, the Rhino XC reamer underreamed 1,039.3 m of a fish-hook profile well with an upward-inclined horizontal section that increased from 35° to 107°.
Rhino RHE dual-reamer rathole elimination system

Elimination of rathole cleanout runs
The Rhino RHE rathole elimination system is designed to eliminate dedicated rathole cleanout runs and avoid costly trips back to surface. The integrated dual-reamer system comprises an active Rhino XS reamer, a passive Rhino XC on-demand reamer, a PowerDrive RSS, and a customized PDC drill bit from Smith Bits, a Schlumberger company. The system enlarges the borehole and reduces rathole length, all in one run, providing on-demand activation with surface confirmation.

Conventional borehole enlargement
In deepwater HEWD, the reamer is positioned above the long, complex LWD string so that the enlarged borehole will not degrade the accuracy of formation evaluation measurements. This results in a rathole of more than 100 ft at TD. Enlarging the rathole to TD requires tripping the drilling BHA back to surface to perform a dedicated cleanout run, which averages 24 hours of extra time.

Rathole enlargement while drilling
The Rhino XS reamer—positioned above the MLWD tools—is operated as an active borehole enlargement system to open the pilot hole during HEWD. The near-bit Rhino XC on-demand reamer is operated in passive mode during the drilling phase. Its cutter blocks are passive when retracted during normal drilling mode and locked undergauge from the bit size to avoid interference with the drilling operation. The Rhino XC reamer can be equipped with optional cement cleanout cutter blocks that have a minimum number of cutters on the gauge surface.

Upon reaching TD, the BHA is tripped back to position the Rhino XC reamer above the pilot hole. An indexing sequence activates the reamer, and once the passive blocks are activated, the rathole enlargement-while-drilling process begins.

Applications
- Casing operations to ensure the casing shoe and cement are set at TD
- Rathole enlargement at TD

Advantages
- On-demand activation of enlargement system with surface confirmation
- Elimination of dedicated rathole cleanout runs, reducing well construction time
- Assurance of a secure casing shoe and cement job
- Real-time data extenders enable reamer placement between MLWD and RSS tools
Case Study

Dedicated Trip for Rathole Cleanout Avoided in Deepwater Gulf of Mexico

**Dual-reamer rathole elimination system saves Noble Energy 16 hours of rig time**

Schlumberger designed the Rhino RHE system to minimize the time required to enlarge the rathole in a deepwater well Noble Energy was drilling in the Gulf of Mexico. The integrated system drilled the 1,221-ft section in 14.5 hours at average ROP of 84.5 ft/h. The Rhino XS reamer—operating in active mode—opened the 12 1/4-in pilot hole to 14 1/2 in. During drilling, the passive Rhino XC reamer’s blocks were locked to avoid interfering with the drilling operation. After reaching TD, the near-bit Rhino XC on-demand reamer was activated, enlarging the rathole in less than 3 hours. The dual-reamer system eliminated a trip back to surface to perform a dedicated rathole cleanout run, saving Noble Energy an estimated 16 hours.

**Rhino XS reamer**

**Rhino XS2 reamer**

**Rhino XC reamer**

**Rhino RHE system lower reamer**

**Rhino RHE system upper reamer**

**LWD**

**MWD**

**RSS**

**Drill bit**

**Drill collar**

**Rathole with conventional BHA**

**Rathole with Rhino RHE system BHA**

**The Rhino RHE system comprises a Rhino XS reamer and a Rhino XC reamer. The Rhino XS hydraulically activated reamer is positioned above the MLWD tools to open the pilot hole. The Rhino XC on-demand reamer is positioned near the bit and operates in passive mode during drilling. After reaching TD and tripping back to position the on-demand reamer above the pilot hole, an indexing sequence activates the reamer to enlarge the rathole.**
Stabilization in enlarged hole sections

Reducing drillstring vibration is important in building a quality borehole. Vibration shortens the life of downhole tools and surface equipment, slows drilling, results in an irregular borehole, and, in severe cases, causes the entire BHA to become lost in hole.

When run above a Rhino system reamer, the Rhino system stabilizer provides concentric, stable points of contact in the enlarged hole section, which increases lateral support. The stabilizer reduces drillstring vibration in HEWD operations to improve drilling efficiency and performance.

The stabilizer uses three abrasion-resistant stabilizer blocks with the Z-Drive reamer cutter block deployment system. Tungsten carbide hardfacing and diamond-enhanced inserts are available to provide additional wear resistance.

To open the long rathole to the larger borehole size, the drilling BHA is usually tripped back to surface, and a dedicated cleanout run is performed. Eliminating the cleanout trips in wells with multiple casing sections requiring HEWD results in significant time savings.
Cement cleanout blocks

Cement cleanout blocks are designed to remove the cement sheath that forms in casing. Typically run in tandem with standard Rhino system reamers, cement cleanout blocks are designed for shoe-track drilling and post-shoe-track drilling in formations that require enhanced stabilization.

Cement cleanout blocks increase stability when drilling a new formation after the shoe track has been drilled out.

Rhino system reamers equipped with cement cleanout blocks reduce the risk of stuck BHAs through dependable cutter block retraction. The cutter block design eliminates PDC cutter contact with casing ID.

Example of BHA using a Rhino XS reamer with cement cleanout blocks.
Find out more about the Rhino system family of hydraulically expandable reamers at slb.com/Rhino.

**Animation**
Watch animations that illustrate how Rhino system reamers work.

**Case Studies**
Read more about how Rhino system reamers have helped operators save time and bring production online faster.

- Rhino XS2 reamers enlarge seven horizontal sections in deepwater wells offshore Brazil
- On a deepwater GOM well, the Rhino XC reamer drilled a 2,188-ft interval in one run and 62.5 hours.
- The Rhino RHE system saved 16 hours of rig time by eliminating a dedicated rathole cleanout run in the Gulf of Mexico.

**IDEAS**
Integrated design platform
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**i-DRILL**
Engineered drilling system design
slb.com/i-DRILL

**PowerDrive**
Rotary steerable system
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