

X-Rings & Quad Rings (4-Lobe Seals)

Bi-directional sealing with lower friction and longer life than conventional O-rings in reciprocating dynamic service

Overview

X-Rings-also marketed under the trade name Quad Rings-represent an advanced sealing geometry that addresses the most common failure modes of conventional round O-rings in dynamic reciprocating applications. The distinctive four-lobed cross-section provides two independent sealing lips on each side of the groove, creating a sealing interface that delivers measurably superior performance in friction reduction, spiral failure resistance, and bi-directional pressure retention compared to traditional circular profiles.

The fundamental engineering innovation of the X-Ring geometry lies in its optimized contact stress distribution. A standard round O-ring makes continuous circumferential contact with the groove walls, creating a relatively large frictional interface. In contrast, the four-lobe profile of an X-Ring contacts the groove surface at four discrete high-pressure points-two on each side-reducing the total contact area by 15-30% under equivalent squeeze conditions. This reduction in contact area directly translates to lower frictional drag, which in reciprocating dynamic service means reduced actuator energy consumption, less heat generation at the seal interface, and extended service life for both the seal and the counter-surface. The valleys between the lobes also act as lubricant reservoirs, retaining hydraulic or pneumatic fluid at the sealing interface to further reduce dry-running friction during startup and low-speed operation.

Spiral failure represents the most prevalent seal failure mode in reciprocating cylinders with long stroke lengths. This phenomenon occurs when a round O-ring rolls and twists within the groove during the reciprocating motion, progressively winding the seal into a helical configuration. Once twisted, the O-ring develops circumferential shear stresses that manifest as characteristic helical cracks running diagonally around the seal circumference at approximately 45 degrees. The root cause is the round cross-section's inherent tendency to roll under the tangential forces generated by reciprocating motion, a failure mode that becomes increasingly probable as the stroke-to-bore-diameter (L/D) ratio exceeds 10:1 and cycle frequency increases above 5 cycles per minute. The four-lobe geometry of the X-Ring fundamentally eliminates this failure mechanism because the lobes mechanically key into the groove surfaces, preventing the rotational displacement that initiates spiral twisting. Documented field data demonstrates X-Ring stability at L/D ratios exceeding 50:1 under conditions where round O-rings fail within 100,000 cycles.

From a design integration perspective, X-Rings offer a significant practical advantage: they occupy the same groove width and depth as standard round O-rings manufactured to the same nominal cross-section. This dimensional interchangeability means that X-Rings can often be deployed as drop-in replacements to improve seal life without requiring any modification to existing gland geometry, tooling, or assembly procedures. Engineers evaluating seal upgrades for spiral-failure-prone applications can specify X-Rings with confidence that the existing groove design remains valid. It is important to verify groove width against the specific X-Ring supplier's size chart, as the lobe geometry may require marginally more groove width than a round O-ring at the minimum tolerance end-standard AS568 groove widths are generally compatible, but verification is recommended for high-squeeze or minimum-tolerance groove designs.

Material options for X-Rings mirror the standard elastomer portfolio available for O-rings, with compound formulations optimized for the four-lobe molding process. Nitrile butadiene rubber (NBR) in 70 Shore A hardness remains the workhorse material for general hydraulic and pneumatic service, offering excellent petroleum fluid resistance at the most economical price point. Fluorocarbon (FKM) extends operating temperature to +200 C with superior chemical resistance for synthetic hydraulic fluids, aggressive fuels, and high-temperature pneumatic systems. Ethylene propylene diene monomer (EPDM) provides outstanding water, steam, and ozone resistance for outdoor and plumbing applications where petroleum oil compatibility is not required. Silicone (VMQ) delivers the broadest

temperature range, from -60 C cryogenic service to +230 C static seals, with FDA-compliant grades available for food and medical device applications.

Hardness selection for X-Rings follows the same engineering principles as O-rings, with 70 Shore A representing the standard for most dynamic applications. Softer compounds at 50-60 Shore A are specified for low-pressure pneumatic systems or fragile housings where compression force must be minimized. Harder grades at 80-90 Shore A improve extrusion resistance for high-pressure hydraulic service above 100 bar, though backup rings should be considered for pressures exceeding 150 bar regardless of X-Ring hardness. The four-lobe geometry itself provides slightly better extrusion resistance than a round O-ring of the same hardness because the lobes distribute extrusion stress across two contact points rather than concentrating it at a single edge.

Manufacturing X-Rings requires precision mold tooling with carefully controlled lobe geometry to ensure consistent sealing performance. Our molds are engineered with flashless or minimal-flash cavity designs, and every production lot undergoes dimensional inspection of lobe height, lobe width, and cross-section symmetry to verify conformance to geometric tolerances. Custom sizes are manufactured without tooling fees for diameters within our existing mold range; non-standard cross-sections requiring new mold tooling can be developed with lead times of 3-4 weeks. All compounds are mixed in-house under ISO 9001 quality systems with full batch traceability.

Advantages

The practical significance of this friction reduction extends across multiple performance dimensions: pneumatic actuators achieve faster response times and lower air consumption; rotating shafts maintain consistent torque output without requiring back-to-back O-ring arrangements or complex gland designs. In contrast, a single round O-ring in a double-acting cylinder may experience significant wear and leakage during reciprocation. Field data from injection molding machine tie-bar seals, hydraulic press rams, and pneumatic cylinder rods consistently demonstrates that X-Rings maintain effective sealing in the same groove often lasts 2-3 years before replacement is needed. When evaluating the total cost of ownership, the 10-40% unit price premium of X-Rings is almost always offset by reduced maintenance and downtime. For new equipment designs, specifying X-Rings from the outset provides long-term reliability benefits without the need for equipment modifications. This lubrication retention is particularly valuable during system startup, after extended shutdown periods, and in low-speed applications where seal and bore surface wear.

Materials

	Properties	Best For
Standard X-Rings	-40 C to +120 C, excellent petroleum oil and fuel resistance, lowest cost	General hydraulics, pneumatics, fuel systems, standard industrial service
High-Temp X-Rings	-20 C to +200 C, superior chemical and heat resistance, brown color standard	High-temperature hydraulics, chemical processing, aerospace, aggressive media
Food Grade X-Rings	-50 C to +150 C, excellent water, steam and ozone resistance	Water systems, HVAC, food and beverage processing, outdoor equipment
Medical (EPDM) X-Rings	-60 C to +230 C, FDA grades available, extreme temperature flexibility	Medical devices, food equipment, cryogenic and high-heat static seals

Sizing

X-Rings are dimensioned by inside diameter and cross-sectional width, designed for the same groove geometry as standard O-rings. Supply standard sizes to match AS568 and ISO 3601 series, plus custom dimensions to drawing.

Available Size Ranges

Series	Coverage
AS568 Series	1.78 mm (CS), 2.62 mm (CS), 3.53 mm (CS), 5.33 mm (CS), 6.99 mm (CS)
ISO 3601 / Metric	1.80 mm, 2.65 mm, 3.55 mm, 5.30 mm, 7.00 mm
Custom	Any ID and CS manufactured to drawing

FAQ

What is the difference between an X-Ring and a Quad Ring?

They are the same product. X-Ring is a generic industry descriptor for a four-lobed seal; Quad Ring is a registered trade name for the same geometry. Both terms describe a seal with four lobes-two sealing lips per side-and are used interchangeably in the sealing industry. The functional performance is identical regardless of which term the supplier uses.

Can I use an X-Ring in a standard O-ring groove?

Yes-X-Rings are designed to fit in standard O-ring grooves without changing gland dimensions. However, always verify the groove width and depth against the X-Ring supplier's size chart for the specific cross-section. X-Rings require slightly more groove width than the O-ring nominal CS due to the lobe geometry. Standard AS568 groove widths are compatible with most X-Ring sizes in the same CS series. If groove width is at the minimum tolerance, confirm fit before committing to production volumes.

When should I choose an X-Ring over a round O-ring?

Choose an X-Ring for dynamic reciprocating applications where: (1) spiral failure has been observed or documented in service; (2) stroke-to-bore diameter (L/D) ratio exceeds 10:1; (3) duty cycle exceeds 5 cycles per minute continuously; (4) lower actuator friction is required for efficiency or control response; or (5) pressure alternates direction in a double-acting cylinder. For static seals, round O-rings perform equally well and cost less-X-Rings add value primarily in dynamic service.

Do X-Rings cost more than O-rings?

X-Rings typically cost 10-40% more than equivalent round O-rings due to the more complex mold geometry and lower production volumes. The unit price premium is almost always justified in spiral-failure-prone applications: if a round O-ring lasts 50,000 cycles and an X-Ring lasts 200,000+ cycles in the same application, the annual seal cost drops by 50-75% even at 40% higher unit price. Request a lifecycle cost comparison when evaluating the switch-the break-even point is usually within 3-6 months of operation.

What hardness is standard for X-Rings?

70 Shore A (ASTM D2240) is the most common hardness for dynamic X-Rings in hydraulic and pneumatic service. 50-60 Shore A is used for low-pressure applications (<10 bar) or fragile housings where excessive compression force is a concern. 80-90 Shore A provides better extrusion resistance for high-pressure reciprocating seals above 100 bar. For very high pressure (>200 bar), consider adding PTFE backup rings alongside the X-Ring to prevent extrusion.

At what L/D ratio should I switch from O-rings to X-Rings?

L/D ratio (stroke length divided by bore diameter) is the key indicator for spiral failure risk. At $L/D > 10$, round O-rings typically begin showing spiral failure before 500,000 cycles at reciprocating speeds of 0.1-0.3 m/s. At $L/D > 20$, spiral failure often occurs within 100,000-200,000 cycles. X-Rings remain stable to $L/D > 50$ under the same conditions. If your application has $L/D > 10$ and cycle frequency above 3-5 cycles/min, X-Rings are the recommended seal profile. Request spiral failure analysis data for your specific bore diameter and stroke when evaluating seal selection.

How do I identify whether a failed O-ring experienced spiral failure?

Spiral failure produces a distinctive helical crack pattern on the O-ring surface-cuts running diagonally around the circumference at approximately 45°, like a twisted barber pole. This differs from extrusion failure (nibbling damage on one edge, flat spots where the gap is), compression set failure (flat cross-section with no cracking), and chemical attack (surface crazing, tackiness, or uniform swelling). If you see helical cracks, switch to X-Rings or investigate groove surface finish and lubrication before assuming a material problem.

Can X-Rings be used with PTFE backup rings?

Yes. X-Rings can and should be paired with PTFE backup rings in high-pressure dynamic applications exceeding 100-150 bar. The backup ring prevents extrusion of the X-Ring material into the diametral clearance gap, while the X-Ring provides the primary sealing function with its low-friction, spiral-failure-resistant geometry. The combination of an X-Ring with PTFE backup rings delivers the optimal solution for high-pressure, long-stroke hydraulic cylinders

where both extrusion and spiral failure are potential concerns. Specify the backup ring material (virgin, glass-filled, or bronze-filled PTFE) based on pressure level and chemical environment.

What surface finish is recommended for X-Ring grooves?

For optimal performance, X-Ring grooves should be machined to a surface finish of Ra 0.4-1.6 μm (16-63 μin) on dynamic surfaces. Rougher finishes increase friction and accelerate seal wear; smoother finishes below Ra 0.2 μm may cause stick-slip behavior due to inadequate lubricant retention at the interface. Groove corners should have a minimum radius of 0.1 mm to prevent cutting the seal during installation. Lead-in chamfers of 15-20° with a minimum length of 1.5 x the seal cross-section should be provided on all sharp edges to prevent damage during assembly.

What is the lead time and MOQ for custom X-Ring sizes?

Standard AS568 and ISO 3601 X-Ring sizes in NBR 70 Shore A ship within 7-15 business days with an MOQ of 1 piece. FKM, EPDM, and VMQ compounds require 10-20 business days due to material scheduling. Custom sizes within our existing mold range are manufactured without tooling fees; non-standard cross-sections requiring new mold tooling can be developed with 3-4 week mold fabrication lead times. For large-volume OEM programs, we offer scheduled production with blanket purchase agreements and consignment inventory arrangements. Contact our engineering team with your bore diameter, groove dimensions, stroke length, and operating conditions for a formal recommendation and quotation.