



BISHOP'S ACTIVRAK™ VR RACK:

VARIABLE RATIO RACK FOR COST EFFICIENT ACTIVE STEERING FEEL

50 years following Bishop's first Variable Ratio (VR) rack & pinion patent, Bishop introduces another first into the automotive steering market – ActivRak™ VR Rack.

Conventional VR rack applications offer the opportunity to have a steering rack that provides relaxed on-centre driving as well as reduced turns lock to lock (TLTL) for ease of parking and low speed manoeuvring compared to constant ratio (CR) rack applications. Bishop's ActivRak™ VR steering racks offer all this as well as a fast response to steering inputs from the driver, allowing significant benefits to the vehicle's dynamic behaviour.

An ActivRak™ VR Rack is a unique form of Bishop Variable Ratio, where the rack gain characteristic is tuned to achieve a particular yaw gain target. This yaw gain target is consistent with what might be achieved using an angle overlay active steering system. Typically there will be a significant increase in rack gain, greater than 25%. This increase will occur within a small absolute pinion rotation from on-centre - typically the maximum rack gain will have been achieved in less than 170° pinion rotation from the on-centre position and often in 90° or less.

Is this product concept new? Not at all! Arthur Bishop, founder of Bishop Steering Technology, first published such a steering ratio proposal in 1953. However excessive compliance in the steering and suspension systems of the day and the lack of a suitably accurate manufacturing technology meant that this remained just a concept until the 21st century.

Continuous improvement in vehicle suspension systems as well as Bishop's own warm rack forging process mean that the ActivRak™ concept is fully feasible and entered production in 2008. The inherently high rates of change in rack gain call for a combination of higher levels of tooth accuracy and meshing

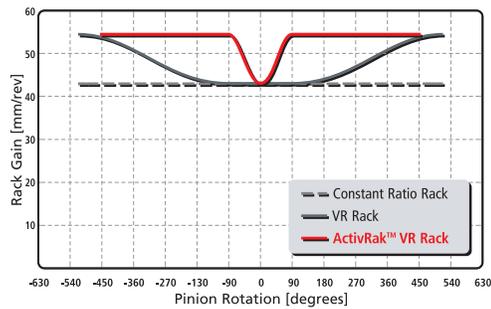


Figure 1: Typical rack gain characteristics including constant and VR racks Pinion Rotation [degrees]

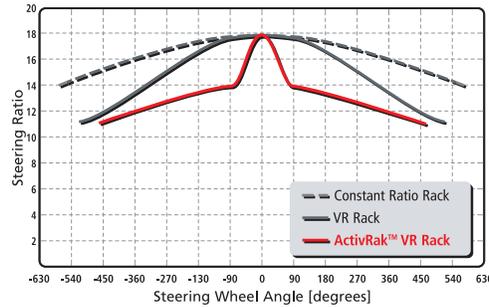


Figure 2: Result of applying the VR characteristics from Figure 1 to overall steering ratio

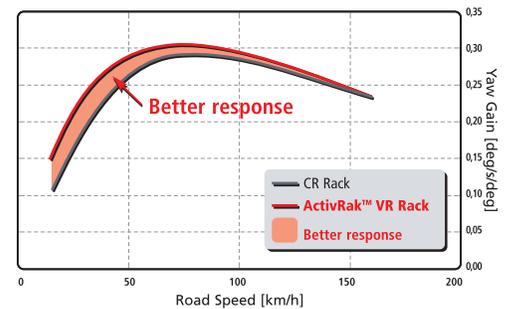


Figure 3: Comparison of yaw gain for the ActivRak™ and the CR rack from Figure 1

contact ratio to ensure that the VR transition is smooth and stable – ensuring that the driver can feel the steering performance of the vehicle without actually feeling the rack and pinion teeth of the steering gear through the steering wheel.

Warm forged steering racks from Bishop offer the highest accuracy commercially available in the market and the process can be used to forge all materials currently used for steering racks.

Bishop offers two basic types of rack shape – the Y rack and D rack. Bishop's Y form racks offer the widest teeth available - up to 115% of the rack shaft diameter, independent of the position of the pinion relative to the rack. Variability in proportions and tooling concepts means that there is a rack shape available to meet the requirements of the plethora of steering systems available on the market today.

Whereas in 1958 Arthur Bishop was confronted with the options of hydraulic power steering or manual steering, today the automotive engineer can choose from manual steering, hydraulic and electro-hydraulic power steering, column and pinion driven electric power steering through to rack driven electric power steering, where the rack is driven by either a second pinion drive or a ball screw drive. Bishop is unique in the market in that they are not confined to only one rack type, but can offer a rack type suitable for each of these applications. This is in addition to the capacity to assist in the development of the VR gain curve to meet the vehicle dynamics requirement. ActivRak™ can be used with all types of power steering.

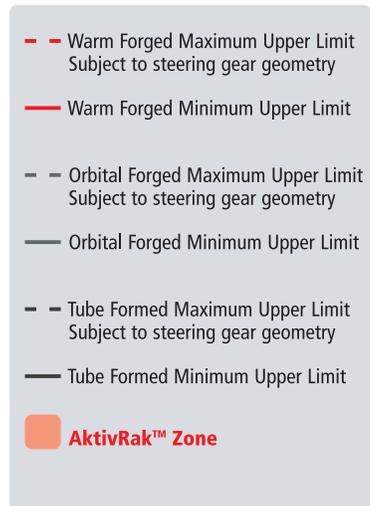
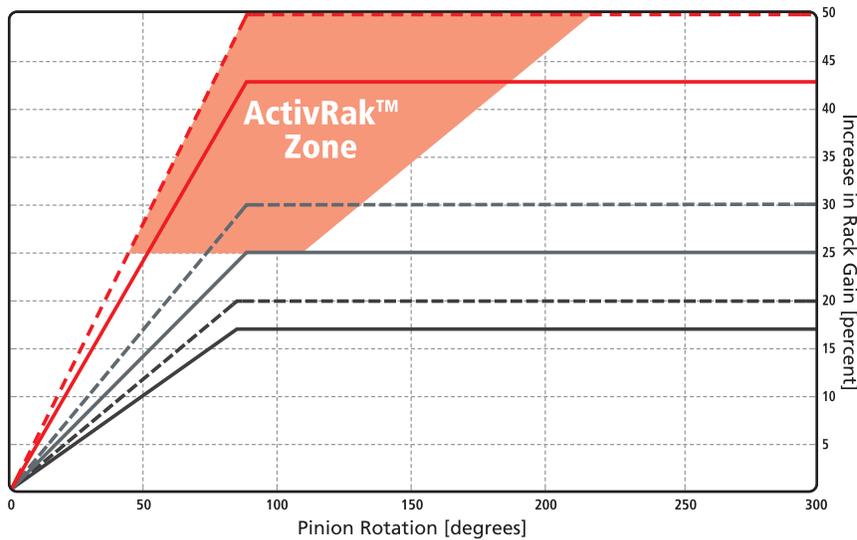


Figure 4: The ActivRak™ characteristic vs. the characteristic of other VR racks

ACTIVRAK™ – A BETTER MOUSETRAP?

Changes to the types of power steering and the additional functionality that is now available in a steering system have resulted in more demands on the steering rack. These demands have led to many new possibilities in how VR racks are applied to these systems which has resulted in some very dynamic VR characteristics – this new range of variable ratio racks is referred to as ActivRak™.

Most power assisted steering systems are fundamentally torque modulating (or force amplifying) systems. The relationship between vehicle speed and maximum front wheel angle is governed by physics of the moving car and the kinematics of suspension geometry. Recently, 'angle over-lay' active steering systems have been developed to offer an elegant but complicated and expensive solution to the need for speed dependent steering ratio functionality. The ActivRak™ uses an angle-dependent kinematic relationship in the meshing between the rack and the pinion to effectively provide a speed dependent steering ratio without the need for a complex and expensive servomotor actuation system. Active torque overlay systems are a recent innovation that offer enhanced steering system capability for little extra cost, at least in electric steering applications. The combination of such active torque overlay systems with an ActivRak™ offers the potential to deliver all of the functionality of a torque overlay system plus provide the yaw response tuning as described above. The result is a system for nominal extra cost that has the key benefits of both the angle and torque overlay systems.

An ActivRak™ can achieve the functionality of an angle overlay steering system without the requirement for any additional components, hence the cost is low and it does not add any mechanisms that might filter out vital road feel feedback to the driver.



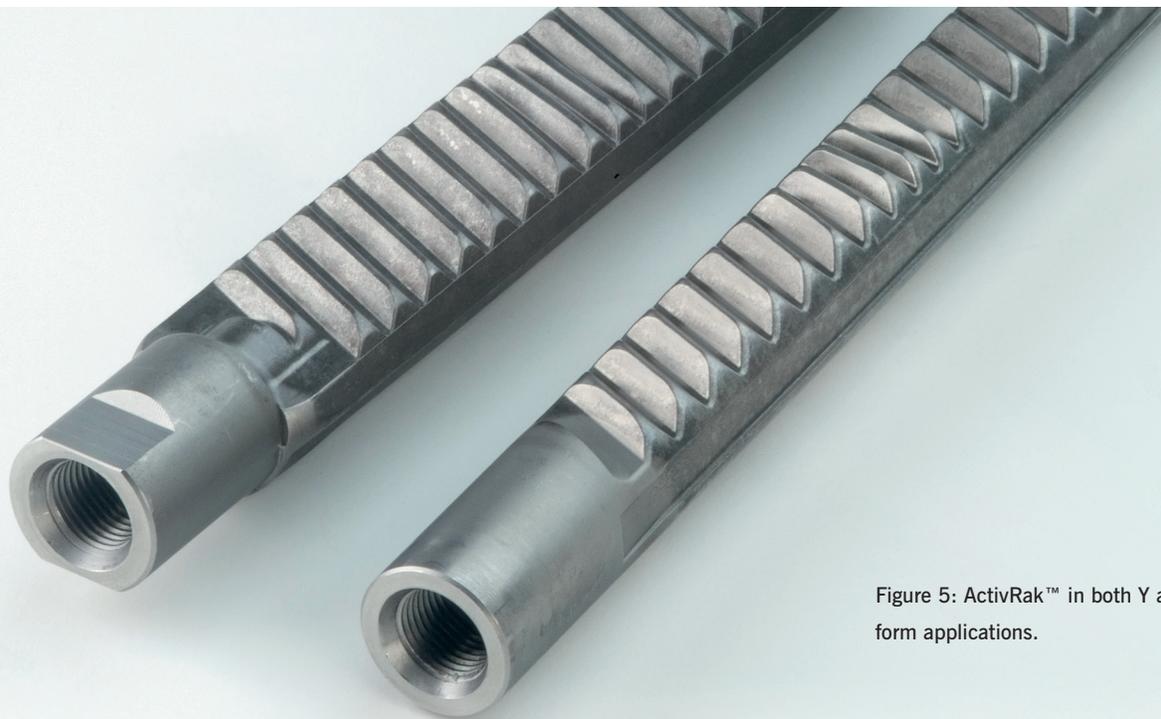


Figure 5: ActivRak™ in both Y and D form applications.

ABOUT BISHOP STEERING

Bishop Steering Technology is a world leader in the development of automotive steering systems and their production techniques. As the inventor of variable ratio racks for use with conventional helical pinion, Bishop specializes in the design and supply of leading edge rack and pinion steering technologies. More than 23% of all vehicles produced globally each year contain components based on Bishop technology. Also the recent acquisition of Bishop by the GMH Group has further strengthened its technical and manufacturing capabilities.

ABOUT VARIABLE RATIO (VR) RACK & PINION STEERING

Bishop is synonymous with VR steering. Arthur Bishop, founder of Bishop Steering Technology, invented VR steering first for aircraft nose wheels, then for motor vehicles and was granted the first variable ratio rack and pinion patent for cars in 1958. Bishop VR was used in the first variable ratio rack & pinion application to go into production in 1981. Since then VR steering has become increasingly common in a range of motor vehicle applications around the world, ranging from Formula 1 race cars to standard passenger cars through to SUV and light van applications where increased safety is required.





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Services

IN AUSTRALIA:

Bishop Steering Technology Pty Ltd

Unit 6 148 James Ruse Drive
Rosehill NSW 2142
Australia

Tel. +61 2 8836 2500

Fax +61 2 8836 2599

steering@bishopsteering.com.au
www.bishopsteering.com

IN USA:

Bishop Steering Technology Inc.

8802 Bash Street, Suite A
Indianapolis IN 46256
USA

Tel. +1 317 585 5785

Fax +1 317 585 5780

info@bishopsteering.com
www.bishopsteering.com

IN EUROPE:

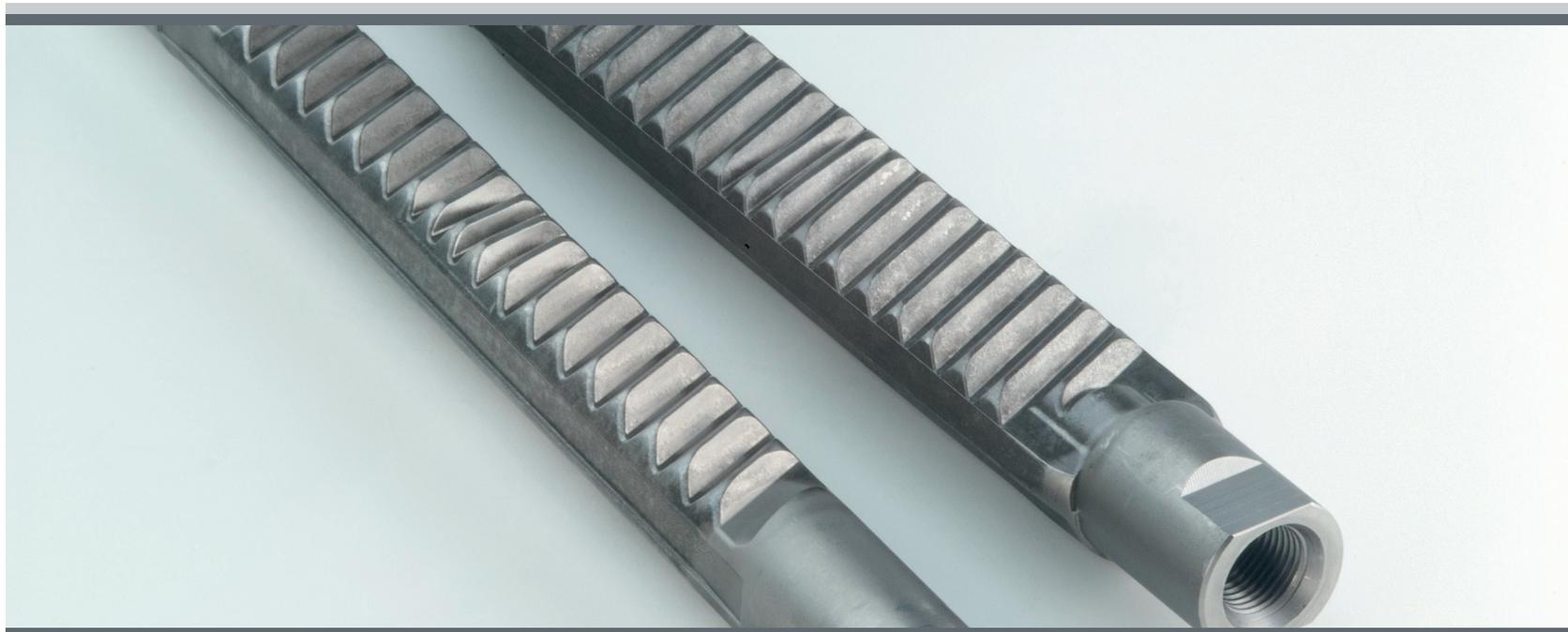
MVO GmbH Metallverarbeitung Ostalb

Nikolaus-Otto-Straße 1
73529 Schwäbisch Gmünd
Germany

Tel. +49 (0) 7171 10424-0

www.mvo-g.de

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 **BISHOP**
Steering Technology Pty Ltd

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