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[O] THE NTN-SNR GROUP PARTNERS' MAGAZINE

N°13

PRODUCTS AND SERVICES 02

LINEAR MOTION: THE WIDEST RANGE ON THE MARKET

INNOVATION 07

THE ELECTRIC WHEEL MOTOR SYSTEM GAINING SPEED

MARKET 10

SUSPENSION OFFER: SAFETY AND ADDITIONAL SERVICES



INVENTING FOR THE FUTURE



Making the bearing socially responsible

Several articles in this edition touch upon NTN-SNR's capacity to innovate. This strategy, focussed on R&D, is one of the company's driving forces of development. Today, we're preparing for what will do the best on our markets in the next 20 years.

When we imagine our future products, intangible objectives remain: quality, performance, and the bearing's intelligence (with mechatronics). However – and it must be emphasised – we are also looking at how to adjust to changes in society: new means of transportation, “green” energies, reduction of the carbon footprint of industrial activities, more energy-efficient vehicles, etc.

Some of the innovations presented here fall within the scope of this vision: blade root bearings adapted to future fuel-efficient aircraft engines, inverted tapered roller bearings in automobiles to improve energy efficiency, electric wheel motors for clean and efficient vehicles, etc.

By exercising our multidisciplinary expertise over the years, in fields such as tribology (the study of contacts), lubricants, calculations, and mechatronics, we have developed bearings that practically eliminate friction in mechanical assemblies. Designed to reduce energy consumption at the heart of contemporary rotating solutions, they stand out as essential components in applications responding to current environmental challenges – wind turbines, electric vehicles, etc. Thanks to these innovations, we are able to apply the notion of social responsibility to bearings.

HERVÉ BRELAUD,
Deputy CEO, Europe and Africa
Vice President, NTN-SNR Industry



LINEAR MOTION A winning com for automated production lin

NTN-SNR's linear guide range offers a full range of solutions for designing automated, rugged and reliable tools and production lines in a variety of industrial sectors.



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Created nearly 30 years ago with a series of guide rails and ball screws, NTN-SNR's Linear Motion range has never ceased to grow. Starting in 1992, SNR began producing compact linear modules that combine several assemblies. “We were pioneers in this sector,” pointed out Ulrich Gimpel, Director of NTN-SNR's Linear Motion Department, Europe. In 2001, NTN-SNR also created an engineering centre and a dedicated production site in Bielefeld, Germany.

AUTOMOBILE ASSEMBLY LINES

Updated and extended in 2009, the range consists of four product families: rails-guides, linear modules, ball bushings and ball screw drives. “A rich and attractive offer for numerous industrial sectors”, said Ulrich Gimpel. Notably, NTN-SNR's linear systems are used in the automobile industry's automated and

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robotic assembly lines. "We collaborate with the ThyssenKrupp Engineering Branch, which designs the production installations for major manufacturers", emphasised Mr Gimpel.

MEDICAL INSTRUMENTS, ELECTRONIC COMPONENTS

More generally, the breadth of the Linear Motion range and the precision of its components can be used to design a wealth of load displacement and handling solutions. They can be found in packing machines, machine tools (wood or metal), as well as in medical instruments such as scanners (for platform displacement), and in solar panel and electronic component production lines.

NTN-SNR is constantly innovating to adapt its range to the specificities of industrial applications. The company again demonstrated this in 2016 at the Automatica Trade Exhibition by presenting a compact telescopic lifting module that can reach 10 m/s (AXS280TV), and variations of its shaft systems that are specially treated to meet the hygiene requirements of the food-processing industry (AXF100).

Outstanding achievements

Since 2011, Kugel Architekten, a Stuttgart-based (Germany) architectural firm, has used NTN-SNR linear guidance systems to produce retractable membrane roof systems. In 2014, it used such a system to cover a shopping street in Buchs, Switzerland. "The NTN-SNR linear range, discovered during a trade show, provides enough references, precision and ruggedness to manufacture a structure based on standard components, without any specific development," said Nicolai Kugel, architectural engineer. For the project in Buchs, the 50 x 11-m membrane roof remains in place throughout the year. The rails used are protected with an anti-corrosion treatment, specially designed for outdoor exposure. They are pre-assembled at the factory, notably in order to respect expansion forces.



The four pillars of the Linear Motion range

LINEAR MODULES

Compact and parallel modules, linear tables, multi-axis systems, and more. NTN-SNR offers the broadest range of modules on the market: cross sections from 40 to 460 mm, with rack, toothed belt or ball screw drive systems and roller guide or ball rail guide systems. These modules are able to move loads ranging from just a few grams to 2 tonnes.



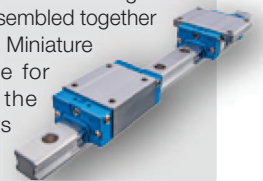
BALL SCREW DRIVES

NTN-SNR proposes rolled ball screw drives in tolerance grade T7, ground screws up to tolerance grade T3, in diameters ranging from 4 to 120 mm, as well as standard and special nuts.



BALL RAILS-ROLLER GUIDES

The guide rails are available in both the standard version and with caged ball technology. These rails limit contact between the balls, which reduces maintenance requirements. Having a standard length of 4 m, the rails can be assembled together up to 200 m in length. Miniature versions are available for the requirements of the electronic components industry.



BALL BUSHINGS

NTN-SNR supplies ISO-standard ball bushings of different shapes (closed, open, tandem, with flange), with diameters ranging from 3 to 80 mm (available in mm or in inches), and equipped with plastic or steel cages. The high performance "super ball bushings" have a load capacity that is three times greater and have an extended service life.



Wireless linear position measurement

NTN-SNR has developed a wireless position measurement solution for its linear guidance systems. Greater compactness and flexibility for the designers of industrial systems.

Beyond its broad product range, NTN-SNR proposes innovative functional systems in the field of Linear Motion. In this context, the company has developed a mobile wireless position measurement system, fully integrated in the guide rail.

REDUCED OVERALL DIMENSIONS

This innovative system provides manufacturers a highly accurate and repeatable measuring system (+/- 15 µm/m), with fewer mobile parts (cables, guide chain). The reduced overall dimensions of this assembly make it easier to integrate and it is able to reach greater travel speeds (up to 5 m/s). It also enables the mobile portion to be electrically insulated from the fixed rail. "Significant simplification of assembly, use and maintenance for additive manufacturing machines, electronic production lines, laser-cutting machines and certain machine tools,"

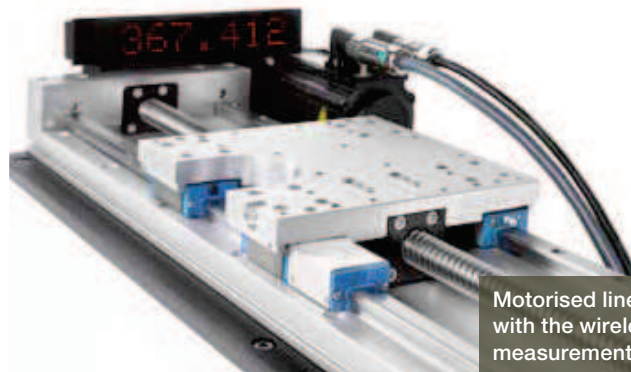
stipulated Jérôme Mathieu, Mechatronics Project Manager at NTN-SNR.

SUPERIOR TECHNOLOGY

Technologically speaking, this product is classified as a magnetic measurement solution built into guide rails. It is based on a wireless sensor-cell, powered through the rail by inductive coupling that reads and transmits its readings via a high-speed fibre-optic link. The guide rail incorporates the magnetic measuring gauge, the fibre optics for transmitting data and the

power transfer system. "An adapted 'plug & play' assembly that does not require calibration," added Mathieu.

Four patent applications have been filed regarding this new concept. It is the result of a collaborative project financed by the German Ministry of Education and Research, in association with the company Sensitec GmbH, a specialist in magnetic measurement, and the Institute of Production Techniques and Machine Tools (IFW) at Leibniz University in Hanover (Germany).



Motorised linear table equipped with the wireless position measurement system.

The club of "Linear Centers" expands northward

In May 2016, Internordic (Sweden) joined the network of NTN-SNR Linear Center-approved partners.

NTN-SNR now has a Linear Center in Scandinavia. In May 2016, Internordic, based in Sweden, joined this network of added-value partners on which the bearing manufacturer relies to market its linear product ranges. "Our role is to provide locally based expert support: fast deliveries, configuration of solutions, and technical support," explained Tony Atlebris, Internordic's General Manager.

In order to be granted approval, Internordic's teams took a certification course at NTN-SNR's Linear Motion European Engineering Centre in Bielefeld (Germany) that included training in technical subjects and configuration and computational tools. Finally, Internordic acquired cutting systems to adjust products to

customers' requirements. The Linear Centers network now includes thirty or so partners located throughout Central and Western Europe and in South America.



Left to right: Björn Sundin (NTN-SNR), Mikael Sigfridsson (Product Manager, Internordic) and Tony Atlebris (Managing Director, Internordic).

1 Number of "Linear Centers" per country, in Northern Europe



AERONAUTICS

NTN-SNR ranked in the top 10 of the Clean Sky programme innovations

The blade root bearing developed by NTN-SNR for SNECMA's Open-Rotor "engine of the future" was among the 10 best projects of the European Clean Sky research programme.

NTN-SNR developed a new blade root bearing for SNECMA's Open-Rotor engine demonstrator – considered to be “the engine of the future” – as part of the European Clean Sky aeronautic research programme. In April 2016, a committee of European experts ranked this project among the 10 best projects out of the 482 projects in the programme. *“This demonstrates our ability to anticipate the needs of the aeronautics industry and to develop innovative solutions,”* said Guillaume Lefort, Aeronautics Project Manager at NTN-SNR.

TECHNICAL CHALLENGES

The Open Rotor, which foreshadows the engines foreseen for 2030-2040, aims to combine the advantages of turbojet and turboprop engines. It features two rows of unshrouded blades, whose orientation varies according to the phase of flight. The blade root bearing sets this angle and transmits the forces to the engine, all within a thermal environment in which temperatures can reach 180°C.

“Compared to those that we produce for contemporary turboprop engines, the Open Rotor's bearings must withstand 15% more stress loading, temperatures two times higher... within half the space with an integrated seal!”, said Guillaume Lefort.

WORLD LEADER

Leveraging its position as a world leader in blade root bearings, NTN-SNR – chosen by the European Union to meet the technical challenge – has designed an angular contact double row ball bearing. The main innovations concerned the tribological system (study of friction and contacts to determine appropriate surface treatments and lubrication) as well as the seal of the bearing when subjected to high centrifugal forces. Specific calculations were needed to ensure the proper operation of the blade incidence controls, as well as their return to the neutral position, in the maximum torque connections.

SHORT-TERM IMPACTS

In December 2015, after 34 months of development, NTN-SNR delivered a complete set of several bearings to SNECMA for use in an Open-Rotor engine, as well as replacement bearings. *“We have met all of SNECMA's and the European Union's requirements,”* added Guillaume Lefort.

Angular contact double row ball bearing

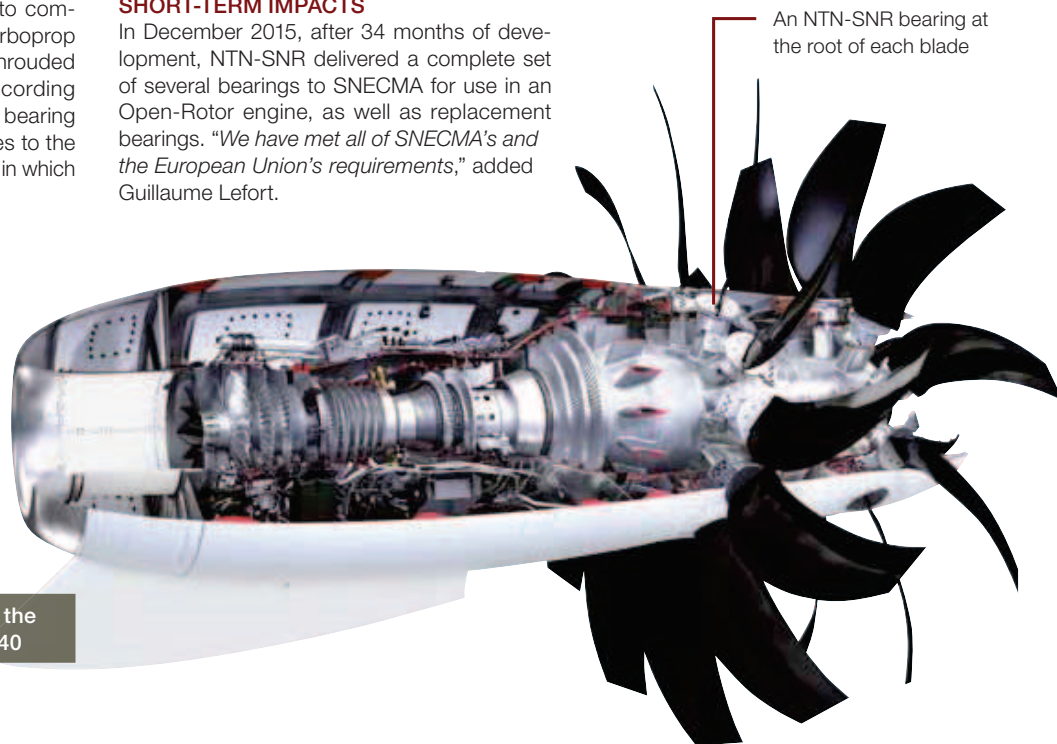


The Open Rotor is expected to enter commercial service in 2035. However, engine manufacturers are already studying the possibility to introduce this controllable-pitch fan blade concept on conventional shrouded engines. The developments undertaken by NTN-SNR may thus have implications in the near future.

CLEAN SKY: REDUCING THE ENVIRONMENTAL FOOTPRINT OF FUTURE AIRCRAFT

With the support of the European Union, the Clean Sky programme has mobilised universities and manufacturers around research projects aiming to reduce fuel consumption and noise levels of air traffic.

An NTN-SNR bearing at the root of each blade



The Open Rotor foreshadows the engines of aircraft in 2030-2040

COBOTICS

Weight reduction welcomed with open arms

The Lightweight bi-material bearing lightens the jointing of an automated arm without reducing load-bearing capacity or accuracy. An ideal compromise in cobotics*.

NTN-SNR is developing a new generation of bearings for the drive of high-precision systems that are two times lighter than current standard bearings. “We can reduce weight by up to 57% on certain references without losing load capacity,” said Vivien Pollier, Industry Project Manager.

BI-MATERIAL DESIGN

The weight reduction results from the bi-material design of the bearing rings: their most highly stressed areas, made of steel, provide excellent mechanical strength, while the least sensitive zones are made of aluminium, which results in the reduced weight. “Our expertise in machining and

assembly allows the expected rotation precision for this type of bearing to be retained,” he stated.

Following several years of development, the first prototypes have already undergone functional validation. Presented at the last Hanover Exposition in 2015 and more recently at the 2016 Automatica Trade Fair, the Lightweight bearing is aimed at cobotic applications – where robotics interact with a human operator.

*Cobotics, or collaborative robotics, uses robotics, mechanics, electronics and the cognitive sciences to assist humans in their daily tasks.

A bi-material bearing to lighten cobotic applications.



A sensor that is easy to integrate.

MECHATRONICS

An absolutely revolutionary angle sensor

NTN-SNR's new Absolute Angle Sensor prototype is minimally invasive and can be fitted seamlessly to an existing shaft line without design or maintenance constraints.

NTN-SNR has fulfilled the wishes of design offices and maintenance crews with its latest mechatronic innovation, the Absolute Angle Sensor prototype, an angle sensor encapsulated on a kinematic chain.

TWO COMPACT COMPONENTS

Unlike contemporary monoblock measuring devices, it separates the encoding and magnetic reading components: there is a measuring ring fitted on the rotating shaft on one side, and a

reading sensor mounted on the chassis of the application on the other. “This separation results in a minimally invasive assembly, adapted to all shaft dimensions,” said NTN-SNR Industry Innovation Manager Sébastien Brisson.

Featuring NTN-SNR's TMR (Tunnel Magneto-Resistive) technology, the sensor reads the pole phase shift between the ring's two tracks and determines the absolute angle of the shaft with a tolerance less than 0.1°. Currently undergoing testing on capital goods and in the aeronautical sector, the Absolute Angle Sensor has incorporated the rotation speed sensor of an ASB® (Active Sensor Bearing), another flagship product of NTN-SNR's mechatronic product range.

E-WAZUMA

The electric wheel motor system gaining speed

NTN-SNR is further demonstrating the capacities of its wheel motors by equipping a 100% electric prototype of the Wazuma, the sports tricycle produced by Lazareth.

Presented at the Lyon (France) Bike Expo in March 2016, the E-Wazuma did not go unnoticed. Recognisable by its futuristic design, this sports tricycle is a 100% electric version of the Wazuma LR1 produced by Lazareth, a French manufacturer of exceptional vehicles. Its propulsion is provided by two NTN-SNR 30 kW wheel motors, built into the twin rear wheels. *"Thanks to the efficiency of its motors in excess of 90%, E-Wazuma offers performance comparable to the internal combustion version"*, explained Vincent Pourroy-Solari, NTN-SNR's Automotive Innovation Manager.

RANGE OF POSSIBILITIES

With its distinctive sporty character, the E-Wazuma again demonstrates the possibilities afforded by electric wheel motors. In 2014, during their first joint project, NTN-SNR and Lazareth adapted and approved the Too'In, a microcar equipped with two 4-kW wheel motors and reserved for urban use. NTN-SNR also demonstrated that its technology could power "Joe Bloggs" car by equipping a stock Honda Civic.

These examples underscore the benefits of electric wheel motors. In particular, their small

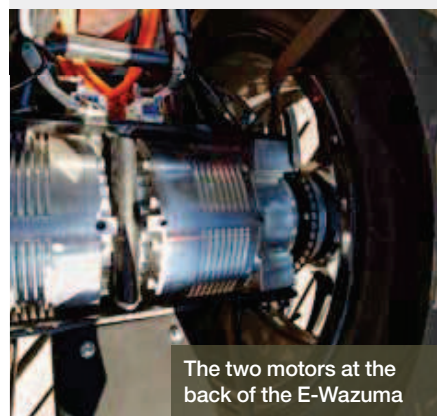
overall dimensions allow them to be housed inside the wheel rim. NTN-SNR has chosen a technology using a cycloid reducer, more compact and lighter than direct drives. It requires less torque as the power is transmitted by the rotation speed. Most of all, it is compatible with the suspension and braking systems that currently exist on vehicles.

OPPORTUNITIES IN VARIOUS MARKETS

The wheel motor thus offers a variety of attractive features to appeal to markets beyond the automotive sector, for which the conversion to electric propulsion remains very gradual. Among these other sectors, NTN-SNR has made contacts with manufacturers and transformers regarding the electrification of airport equipment, and technical and utility vehicles. The wheel motor could notably be used to equip transit vans to perform "last-mile" inter-city package deliveries by defying the traffic restrictions to which vehicles with naturally-aspirated engines are increasingly subjected. *"In terms of its fun factor", the E-Wazuma tells a story: that of adapting a small-series produced vehicle to electric propulsion, with minimum transformation and while maintaining performance,"* concluded Vincent Pourroy-Solari.

The E-Wazuma, specification sheet

- Wazuma concept (Lazareth)
- Two 30-kW wheel motors, 90% efficiency, 490 N/m torque (NTN-SNR)
- 500-V/10-kWh Li-ion battery (TYVA Énergie)
- Specific control electronics (Viveris Technologies)
- Approval expected in late 2016



The two motors at the back of the E-Wazuma

AUTOMOBILE

The new 'raison d'être' of the reversed tapered bearing

NTN-SNR launches reversed tapered bearings to improve the energy performance of vehicles.

After having long been limited to applications specific to the aeronautics sector, the reversed tapered bearing could soon contribute to lowering vehicle CO₂ emissions. NTN-SNR is currently conducting several tests with manufacturers to study its use in gearboxes and rear differentials. "The increase in energy efficiency reaches 5% to 10%", explained Sylvain Todeschini, NTN-SNR Project Engineer. Other applications are currently being studied: wheels of automobiles and utility vehicles, railcar axle boxes, and agricultural tractor transaxles/axles.

PATENTED IMPROVEMENTS

The concept of reversed tapered bearings has been around for a long time; it involves reversing the position of the functional thrust collar holding the rollers in place by putting it on the outer ring rather than on the inner ring. This design limits parasitic friction between the collar and rollers, thereby reducing drag torque. It also allows for increased load-bearing capacity while maintaining constant overall dimensions. And finally, the bearing's geometry facilitates heat dissipation and improves lubricant retention. NTN-SNR has made several (patented) improvements – groove geometries, cage design – in order to optimise performance and mass produce it.

The functional thrust collar on the outside ring improves energy efficiency.



ISO 50001 CERTIFICATION

The mark of a responsible manufacturer

In January 2016, NTN-SNR sites in France were granted ISO 50001 certification. This attests to their ability to control and reduce their energy consumption.



Certified ISO 14001 since 1999, NTN-SNR continues its industrial commitment focussed on reducing its carbon footprint. Over the last few months, the Group's French sites have developed an organisational structure and obtained tools designed to control and improve their energy consumption. In January 2016, the approach culminated in their ISO 50001 certification. "Our customers are becoming increasingly aware of this commitment," highlighted Alexandra Boucher, Environmental Manager at NTN-SNR.

COMMON INDICATORS

For the past 10 years, NTN-SNR teams have continually increased targeted initiatives:

continuous monitoring of consumption at the Seynod 3 production unit, speed variation on energy-intensive equipment, etc. Certification exemplifies the approach and incorporates it into the long-term perspective with common objectives. NTN-SNR now has an energy performance indicator that is consolidated every quarter based on data provided by the sites. The Group is aiming to improve its energy performance by 3% by late 2017. The approach will also be extended to production units located in Italy, Romania and Brazil.

MACHINE TOOLS

The ULTAGE super precision bearing range soon to be produced in Europe

NTN-SNR is investing nearly 7.6 million euros in its plant in Mettmann (Germany) to manufacture its first premium range of spindle bearings for machine tools, starting in 2017. A first in Europe.

Japan will no longer be the only country producing the ULTAGE Super Precision range. NTN-SNR is adapting its plant in Mettmann, Germany, to produce its premium range of spindle bearings for machine tools starting in 2017. These bearings are the fruit of NTN's historic expertise (see text box). *"Setting up industrial facilities in Europe will allow us to handle the demands of the local market more efficiently,"* said Francis Travostino, Head of NTN-SNR's Spindle 2017 Project.

The plant will produce the entire range of universal bearing models and NTN-SNR will be able to deliver specific assemblies with a maximum of two to three weeks. *"By reducing our importation times from Japan, we will be able to offer the responsiveness expected by aftermarket players – distributors or repair services – and OEM – spindle, machine-tool or rotary tool manufacturers,"* he added.

FOUR THOUSAND REFERENCES PRODUCED IN GERMANY

The ULTAGE production unit, currently under construction, will cover 1,500 m² within the Mettmann plant. Upon completion, two production lines will be deployed: the first will be dedicated to small bearings – with a maximum outside diameter of 110 mm, and the second will be for large-size bearings – with a maximum outside diameter of 280 mm. All of the references will be assembled on a single assembly and inspection line. As with the ULTAGE facility in Japan, production crews will operate in three air-conditioned and pressure-controlled areas depending on the operation – production, measurement, assembly or inspection of rings and bearings. *"An ultra-modern production environment for the laboratory clean rooms,"* stated Francis Travostino. NTN-SNR is investing 7.6 million euros in the construction of this jewel of industrial technology.

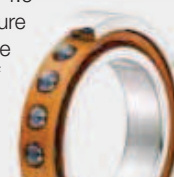


Shorter delivery lead times for spindle, machine-tool and rotary tool manufacturers.

Once launched, the unit will produce over a hundred basic references. In the long term, the progressive increase in production will ultimately allow the unit to manufacture the 340 basic references covering the entire range of ULTAGE Super Precision bearings. The product range includes more than 4,000 "variants", depending on the combinations chosen.

The key advantages of ULTAGE Super Precision

The products in the range – angular-contact ball bearings – bring together all the characteristics of NTN's ULTAGE quality label: steel cleanliness, heat treatment, optimised design, production environment with a high degree of cleanliness, and strict control of suppliers. They offer a high axial load capacity and withstand high rotation speeds (up to 1.9 million N.Dm). They feature an innovative polyamide cage, the profile of which optimises lubricant circulation and retention.



AUTOMOTIVE AFTERMARKET

Suspension Offer: additional safety and services



A leader on the OEM market, NTN-SNR also markets a complete suspension range for the automobile aftermarket. Front and rear kits, bump stops, unitary filtering units and suspension arms: our premium offer consists of more than 400 references and stands out due to the safety of the components and the associated services.

Consolidating its position as a leader in both OEM and distribution: in order to reach the objective that it set for itself in the suspension market starting in 2017, NTN-SNR has increased its development of the range that it markets for players of the automobile aftermarket – purchasing groups, wholesalers, distributors, etc. “We’ve added 20% more references in 2015 and plan to expand the range in the same proportions over the next two years,” stated Amélie Paviet, Suspension Product Line Manager. NTN-SNR’s Suspension range for the automobile aftermarket features more than 400 references, distributed among four product

families: bump stop kits, bump stops and unitary filtering units, suspension arm kits and rear suspension kits (see opposite). In addition to excellent coverage – nearly 90% of the market in Western Europe – the range stands out owing to the quality of the products and services proposed

EACH COMPONENT IS TESTED

The qualities of each reference directly contribute to the safety of the suspension system. As a leading manufacturer of bump stops – the Seynod production unit in France produces 20 million units every year! – NTN-SNR asserts the original quality of its parts and expertise promoting innovation (see box pg. 11). And if a kit component can be supplied by a partner, it systematically undergoes bench testing and validation by a Quality team at NTN-SNR’s Cran-Gevrier and Annecy facilities, located in France’s Haute-Savoie region.

For example, the filtering unit – a part that is indispensable for driving comfort and roadhandling – undergoes strict inspection: mechanical strength, stiffness, material analysis, etc. “The Suspension range fully assumes the safety guarantee, #SecurityInside, of the Chassis division of which it is a part,” said Amélie Paviet.

CONNECTED SERVICES AND ADAPTED INSTRUCTIONS

NTN-SNR adapts its services to the needs of its customers. Distributors and garage owners can now use the TechScaN’R application on their smartphones to consult information regarding the installation, adjustment or replacement frequency of Suspension range products. Contrary to certain preconceived ideas... The bump stop must be replaced at the same time as a pair of shock absorbers: approximately every 75,000 to 100,000 km. “This is done only a third of the time, on average, which is reason for concern since a worn suspension system can increase braking distance by 15%,” pointed out Paviet. It is through this educational approach that NTN-SNR exhibits the expertise of a OEM technical leader, which affirms its ambition to become a leader in the automobile aftermarket sector.

Products from the Suspension range

Two in front, two in back. The NTN-SNR range for the automobile aftermarket sector consists of four product families, distributed between the front and rear suspension.

FRONT SUSPENSION

Bump stop kits

Each NTN-SNR suspension kit contains all the elements needed for a quality overhaul and to guarantee safety: a filtering unit, a stop and its mounting elements. The references marketed – currently 250 kits – undergo prior testing and validation by the Quality team. The central role played by the filtering unit should be mentioned: it is positioned on the upper part of the strut and is designed to absorb impacts while driving and secures the kit to the chassis.



Individually packed bump stops and filtering units

The bump stop is located at the top of the strut on MacPherson-type shock absorbers – the most widespread model in Europe, installed on 90% of vehicles. It provides a steering pivot point, which directly contributes to good roadhandling. As an OEM leader, NTN-SNR proposes more than sixty bump stop references for the automobile aftermarket for nearly 200 vehicle models. 50 filtering unit references are also available in the individually packaged format.



Mobile seal: a “made in NTN-SNR” patent

NTN-SNR has developed a special seal that protects the bump stop from the throes of its operating environment – water, dust, etc. Patented in 2007, this mobile seal is an excellent compromise between performance and comfort: it ensures stop sealing, while limiting friction torque.

REAR SUSPENSION

Suspension arm kits

NTN-SNR markets more than twenty suspension arm kits, thus covering 100% of the existing applications. Each reference contains all the components needed for quick and efficient installation: bearings, seals, nuts, deflectors, spacer, etc.



Rear suspension kits

These kits – representing 70 references at NTN-SNR – are designed to absorb rear suspension vibrations. The kit contains no bearings and is mounted with a single filtering unit. The kit's simplicity makes the unit extremely easy to replace, ideally each time the shock absorber is replaced.



«A worn suspension system can increase braking distance by 15%»

Amélie Paviet,
Suspension Products Line Manager



How many bearings are there in a car?

This obviously depends on the model! We've nevertheless undertaken to give a rough count of the minimum number of bearings in a car. We counted 36.

Here's how we came up with that number:

- 10 bearings on the steering column: 8 needle bearings (4 per universal joint) and 2 needle bearings on the column
- 6 gearbox bearings: 2 on the primary shaft, 2 on the secondary shaft and 2 on the differential
- 6 engine accessory bearings: 2 on the starter, 2 on the alternator, and 2 on the power steering motor
- 4 wheel bearings
- 3 engine distribution bearings: 1 bearing for each of the 2 idler rollers, 1 for the water pump
- 2 bump stops-suspension bearings (MacPherson)
- 2 seat adjustment bearings (roller freewheels for height adjustment)
- 1 bearing-clutch bearing
- 1 engine flywheel pilot bearing
- 1 transmission shaft bearing (intermediate bearing)



Front wheel bearing, one of the 36 bearings in an automobile.

This number increases rapidly with certain widespread technologies: 2 bearings are added for the air-conditioning compressor, for example. Regarding shafts, there are 6 units on an entire transmission system (2 main bearings on the longitudinal shaft, 4 bearing in the rear differential). For the engine, 2 bearings are regularly seen at the end of the cam shaft (distribution end).

The sophistication of certain functions tends to drive up the number of bearings. Recent automatic dual-clutch transmissions (DCT) require an additional 3 bearings: 2 on the gearbox's second primary shaft, and 1 for the double clutch. Certain high-end engines feature one bearing per valve, i.e. 4 per cylinder and thus 48 on a 12-cylinder engine!

The list is not exhaustive: bearings are also sometimes found in surprising locations, such as in Citroën's fixed-centre steering wheel.