

# **C A T A L O G U E**

**of products from elastomeric and polymeric materials  
and from compressed wire mesh for oil and gas equipment,  
gas transport, gas pumping, automotive, aerospace  
and shipbuilding industries.**

**Critical special-purpose units and assemblies**

**ESTABLISHED in 1991**

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# THE REAM GROUP

The REAM Group founded in 1991 continues its dynamic development as a company with class leading production of critical technical rubber products and filtration elements and also as an innovation engineering company "REAM-RTI", LLC, which designs and manufactures assemblies and components for modern artificial lift equipment, automotive, railway, aerospace and many other industries.

All products of the REAM Group are manufactured using a management system certified to ISO 9001:2011, the international Quality standard.

The REAM Group facilities include:

- own preproduction site of elastomeric composites;
- testing-engineering laboratory for technical rubber products;
- quality control laboratory for testing and control of polymeric raw materials and compound products;
- laboratory for polymeric coatings;
- modern equipment for production and control of all kinds of manufactured products;
- assemblies and components production site;
- engineering complex that uses Pro/ENGINEER and T-Flex programs.

The effective performance of REAM's products complies with the best alternative products in the world due to thorough control and manufacturing of orders from receipt of the order, considering its use, operating conditions and maintenance.

The result of our professionals' work is:

- specialist elastomeric compounds, manufacturing techniques of elastomer products and commercial manufacturing of elastomeric and polymeric products and products from compressed wire mesh;



- application technologies of polymeric composite coatings with special properties;
- cutting edge engineering developments;
- quality testing techniques and technical specifications for products;
- safeguarding of intellectual property through patents and "know-how" registrations.

Highly experienced professionals: production engineers, technical specialists, designers, equipment service staff and others work in the REAM Group.

The REAM Group has long-term technical relations with global raw material suppliers and compounding ingredient distributors and can get their input when formulating new elastomeric and polymeric compounds or improving production technologies.







Company professionals participate in international seminars, conferences and exhibitions to share experience and get information about new market developments and requirements for products and to discuss results of their own research that enables them to widely

use current technological and engineering solutions in the production process.

The REAM Group constantly participates in international exhibitions held in Moscow ("Oil and Gas", "MIMS", "Tires and Rubber") and abroad with the support of Government and Department of Science and Technology of Russian Federation.

REAM's achievements in the sphere of technology and development of new materials are recognized by a gold medal for elastomeric compounds with required swelling, a gold medal for elastomeric compound RS-26ch (seal components from this compound have a guaranteed operation period in units for over 15,5 years), a gold medal for manufacturing of components for the oil production industry from the material Aflas™, a silver medal for elastomeric compound Ter-10, a gold medal for seal bags from the elastomeric compound Ter-10.



A silver medal was awarded for the formulation of elastomeric compounds of the "RS" Series (uncured elastomeric compounds for assemblies operating in the automotive industry, agricultural and transport machine building industry, oil,

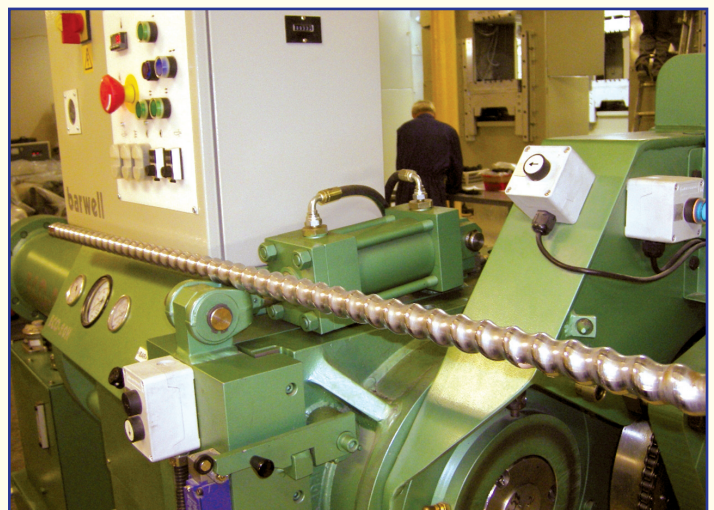
gas and fuel equipment sectors and also in hydraulic and pneumatic devices); a bronze medal was awarded for elastomeric wear-resistant compounds with low friction coefficient. In 2011 REAM won a prize for the compound RS-3 and for the production of seal bags from RS-3. In 2012 REAM took a

prize for O-rings from a new elastomeric compound Af-15-1. A diploma of Russian and Moscow funds of protection of consumer rights confirmed active participation of the REAM Group in creation of the cultured consumer market in Russia.

The REAM Group is a recognized supplier of essential, critical products for both Russian and export markets. The REAM

Group's customers include leading domestic and foreign producers of equipment and oilfield service companies.

The catalogue includes the majority of the commercialized and permanently supplied products, a description of the properties and application details of the elastomer products, the engineering polymeric materials and coatings. In addition there is a comprehensive troubleshooting and failure analysis of selected elastomer products, results of engineering research in the field of filtration, low friction elastomeric seals and water swellable elastomers.



# I. PRODUCTS FROM ELASTOMERIC MATERIALS

## I.1. Applied Materials

### I.1.1. I. Elastomeric Compounds, Their Characteristics and Properties Used in Manufacturing

Table 1

Elastomeric compound grade and standards	Technical rubber product application	Technical rubber product application conditions		Elastomeric compound properties
		Medium	Temperature, °C	
1	2	3	4	5
<b>NBR-based elastomeric compounds</b>				
RS-26ch Russian Technical Requirements TU 2512-013-46521402-2003	Moulded seals for fixed joints with 15,5-year operation period. Technical rubber products for ESP units (seal bags, mechanical seal bellows, sealing rings). Seal elements for packers. Technical rubber products for fuel feed systems	Mineral and semi-synthetic oils. Well fluids. Fuels	-50...+180	- oil and petrol resistance - cold resistance - resistance to 6 % H <sub>2</sub> S - ED resistance of the 1 <sup>st</sup> -2 <sup>nd</sup> class, NACE TM 0192-98 - resistance to 10 % acid and alkali solutions - black colour
RS-26ch-2 Russian Technical Requirements TU 2512-023-46521402-2007	Moulded seals for fixed joints. Technical rubber products for vehicle shock-absorbing systems. Seals and lip seals	Hydraulic fluids. Oils	-60...+150	- oil and petrol resistance - cold resistance - wear resistance - black colour
RS-26ch-5 Russian Technical Requirements TU 2512-009-46521402-2003	Moulded seals for movable joints. Rubber bearings. Marine bearings. PCP pump and drill motor stators. Technical rubber products for vehicle shock-absorbing systems. Seals and lip seals	Mineral and semi-synthetic oils. Well fluids. Water. Lithol. Synthetic fluids	-50...+170	- anti-friction properties - dry friction resistance - oil and petrol resistance - cold resistance - ED resistance of the 1 <sup>st</sup> -2 <sup>nd</sup> class, NACE TM 0192-98 - black colour
RS-26ch-65 Russian Technical Requirements TU 2512-009-46521402-2003	Moulded seals for movable joints. Rubber bearings. Marine bearings. Thrust washers	Mineral and semi-synthetic oils. Well fluids. Fuels. Water. Lithol. Synthetic fluids	-40...+170	- wear and abrasive resistance - anti-friction properties - dry friction resistance - oil and petrol resistance - ED resistance of the 1 <sup>st</sup> -2 <sup>nd</sup> class, NACE TM 0192-98 - resistance to 10 % acid and alkali solutions - black colour
RS-3 Russian Technical requirements TU 2512-028-46521402-2009	Moulded seals for fixed joints with 15,5-year operation period. Technical rubber products for ESP units (seal bags, mechanical seal bellows, sealing rings). Seal elements for packers. Technical rubber products for fuel feed systems	Synthetic oils. Well fluids. Fuels	-60...+200	- oil and petrol resistance - cold resistance - resistance to 6 % H <sub>2</sub> S - ED resistance of the 1 <sup>st</sup> -2 <sup>nd</sup> class, NACE TM 0192-98 - resistance to 10 % acid and alkali solutions - black and green colours
RS-OP New formulations	Cold cure un moulded seals for strengthening of cable joints	Air. Well fluids	-50...+130	- oil and petrol resistance - cold resistance - black colour
RS-N New formulations	Water swellable moulded and un moulded technical rubber products for well isolation. Isolation of interlayer cross-flows and other works. Swellable packer elements	Tap water	-30...+100	- high water absorption capacity - $\Delta m$ (24 hours, STP) $\geq 300$ % - oil and petrol resistance - grey and beige colours
RS-NP New formulations	Water swellable moulded and un moulded technical rubber products for well isolation. Isolation of interlayer cross-flows and other works. Swellable packer elements	Highly mineralized water	-30...+100	- high water absorption capacity - $\Delta m$ (24 hours, STP) $\geq 70$ % - oil and petrol resistance - grey and beige colours

Items in the catalogue are examples of mass production but we produce more products than are shown here

1	2	3	4	5
<b>HNBR-/HSN-based elastomeric compounds</b>				
Ter-10 Russian Technical Requirements TU 2512-017-46521402-2005	Critical moulded products for fixed joints operating under high loads. Technical rubber products for ESP units (seal bags, mechanical seal bellows, sealing rings). Seal elements for packers	Aggressive additive-rich synthetic oils. Well fluids. Fuels	-50...+200	- oil and petrol resistance - resistance to 15 % H <sub>2</sub> S - ED resistance of the 1 <sup>st</sup> class, NACE TM 0192-98 - weathering resistance - black and green colours
Ter-19 Russian Technical Requirements TU 2512-017-46521402-2005	Critical moulded products for movable joints operating under high loads. PCP pump and drill motor stators. Rubber bearings. Marine bearings	Mineral and semi-synthetic oils. Well fluids. Fuels. Water. Lithol. Synthetic fluids	-50...+200	- anti-friction properties - dry friction resistance - oil and petrol resistance - weathering resistance - black and green colours
<b>EPDM-based elastomeric compound</b>				
RS-EP-T Russian Technical Requirements TU 2512-019-46521402-2009	Moulded seals with required swelling for fixed joints. ESP motor electric cable connector seals	Air. Ozone. Steam. Acid and alkali solutions	-50...+150 short-time up to +170	- weathering resistance - dielectric properties - beige colour
<b>FFK-based elastomeric compound</b>				
RS-VA Russian Technical Requirements TU 2512-019-46521402-2009	Moulded seals for fixed and semi-movable joints	Air with fuel vapor. Oils. Lubricants. Acid and alkali solutions	-20...+250	- chemical resistance - heat resistance - dielectric properties - brick-red colour
<b>FEP-/TFE/P-based elastomeric compound</b>				
Af-15 Russian Technical Requirements TU 2512-016-46521402-2004	Moulded seals for movable and fixed joints. Technical rubber products for ESP units (seal bags, mechanical seal bellows, sealing rings). Seal elements for packers	Mineral and synthetic oils. Well fluids. Fuels. Direct steam. Mercaptan	-50...+250 short-time up to +300	- aggressive medium resistance - resistance to 25 % H <sub>2</sub> S - ED resistance of the 1 <sup>st</sup> -2 <sup>nd</sup> class, NACE TM 0192-98 - vapor resistance - dielectric properties - brittle temperature down to -48 °C - black and blue colours
<b>TFE/P-/EPDM-based elastomeric compound</b>				
RS-66 Russian Technical Requirements TU 2512-026-46521402-2008	Moulded seals for movable and fixed joints. Technical rubber products for ESP units (seal bags, sealing rings)	Mineral and synthetic oils. Well fluids. Fuels	-50...+230	- improved cold resistance - heat resistance - black colour
<b>PVMQ-/VMQ-based elastomeric compounds</b>				
RS-SIL Russian Technical Requirements TU 2512-019-46521402-2009	Moulded and unmoulded seals. Breathing equipment diaphragms. Protective covers	Air with high ozone concentrations. Electrostatic field. Lubricants. Oxygen. Water	-60...+250 short-time up to +300	- ozone resistance - heat resistance - dielectric properties - colour choice - by agreement with the Customer
MBF-8 Russian Technical Requirements TU 2512-025-46521402-2008	Moulded seals for fixed and semi-movable joints. Technical rubber products for ESP units	Synthetic oils. Air	-60...+250	- heat resistance - oil resistance - lilac colour

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### I.1.2. Explosive Decompression Resistant Elastomeric Compounds

ED resistance of elastomeric compounds is of great importance for providing long-life and reliable performance of various units and assemblies operating under high pressure conditions in liquid and gas media.

Elastomeric compounds formulated by REAM's experts

are ED resistant and correspond to the 1<sup>st</sup> and 2<sup>nd</sup> classes of ED resistance in accordance with NACE TM 0192-98 "Evaluating Elastomeric Materials in Carbon Dioxide Decompression Environments".

#### Damage-Based ED Resistance Class Rating System

ED resistance class	NACE TM 0192-98	Elastomeric compound			
		RS-26ch (NBR)	RS-3 (NBR)	Ter-10 (HNBR, HSN)	Af-15 (TFE/P)
1	No visual damages	+	+	+	+
2	Minimal surface blisters and cracks	+	+	-	+
3	Many visible and internal damages	-	-	-	-
4	Heavy damages, sample breaking	-	-	-	-

### I.1.3. Low Friction Elastomeric Compounds (Slippery Elastomeric Compositions) (Elastomeric compounds with a dynamic friction coefficient of less than 0,2 against hard surfaces without any lubricant)

Low friction and wear resistant elastomeric compounds are recommended when application suggests harsh wear conditions and minimum breakout torque. REAM-RTI commercialized a range of wear and abrasion resistant elastomeric compounds RS-26ch-5/-65 and developed a new elastomeric compound K-38. The dry friction coefficient of the compounds against hardened carbon steel is below 0,2. The compounds are able to sustain dry friction conditions under severe mechanical load for at least 40 minutes.

The use of the low friction elastomeric compounds as the materials for impeller thrust washers resulted in significant (tens times) decrease of total wear. Testing of low friction elastomers performed by ZAO "NOVOMET-Perm" (a test bench for ESP units) revealed advantages of REAM's low friction elastomers over traditional materials

textolite, flubon and the latest wear resistant material carbonite used for production of impeller thrust washers (Appendices 1, 2).

Being a promising alternative for such traditional materials as textolite, novolone (PTFE + carbon) and carbonite the low friction elastomeric compounds are used for production of marine bearings. Low friction elastomeric compounds are also recommended for application in PCP pump and drill motor stators. For harsh operation conditions a number of specialist HNBR-/HSN- and FEP-based low friction elastomeric compounds are formulated.

Elastomeric compounds RS-26ch-5/-65 correspond to the 1<sup>st</sup> class of ED resistance in accordance with NACE TM 0192-98 "Evaluating Elastomeric Materials in Carbon Dioxide Decompression Environments".

## I.1.4. Swelling Elastomeric Materials

### I.1.4.1. Elastomeric Materials that Swell in Oils and Hydrocarbon Media

Products made from elastomers that swell in liquid media can help to solve a number of engineering problems connected with:

- guaranteed sealing of fixed joints in difficult installation conditions (hermetic cable heads) and at high (of up to 50 MPa) differential pressures of liquid media (packing seals for well isolation and servicing);
- precision assembling of critical units such as "hole - bearing bush" when heavy-shrink fitting is unacceptable (e.g. when a bearing bush is made from brittle materials like ceramics or from hard alloy metals);
- tight (with zero backlash) movable fit in spline joints;
- vibration reduction in bearing and other assemblies.

Fixing elastomer seals with required swelling (e.g. 30...100 %) are applied in special designs. For example, sealing O- and T-rings from the specialist elastomeric compound RS-EP-T (EPDM) are used to fix the housings of down-hole electric motor bearings. The sealing rings help to reduce vibration rate in the zone of the sealed (fixed) assembly down to 15 times.

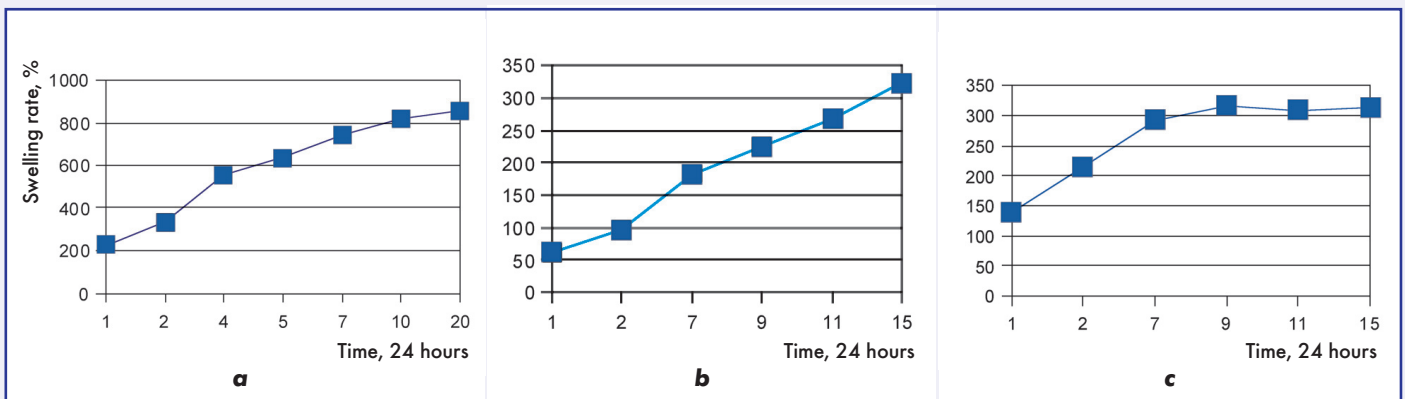
Elastomeric compound formulations are taken according to application conditions like required value of volume swelling in the given medium (up to 400 % and more), swelling rate, service temperatures, product physical properties and other criteria.

### I.1.4.2. Tap and Well Water Swellable Elastomers

Water swellable elastomeric materials operating in tap (pH = 6-9) and well (pH = 2-3) water are successfully applied in the oil production industry. These "self-sealing" elastomers find applications in "squeeze jobs" in the oil wells and are used for waterproofing in various other fields. Well water has high mineral levels and contains up to 25 % of chlorides.

The REAM Group's experts formulated elastomeric compounds that can swell both in tap and well water.

The formulation of elastomeric compounds allows variation of both swelling value in an aqueous medium (tap water - up to 850 %, mineralized water - up to 200 %) and water absorption dynamics depending on operation conditions of water swellable elastomers.



**Swelling rate of the N-RS compound sample after exposure to tap water, STP (a), of the NP-RS compound sample after exposure to well water, STP (b), of the NP-RS compound sample after exposure to well water at 90 °C (c)**

## I.1.5. Dielectric Elastomers

Specialist dielectric elastomers are widely used in the manufacturing of cable connector seals for ESP motors.

**Table 2**

Electric strength at 50 Hz frequency, kV/mm, min					
RS-SIL	MBF-8	RS-VA	RS-EP-T	Af-15-1	RS-3-1
PVMQ-/VMQ-based elastomeric compound	PVMQ-/VMQ-based elastomeric compound	FFK-based elastomeric compound	EPDM-based elastomeric compound	FEP-/TFE/P-based elastomeric compound	NBR-based elastomeric compound
22,0	29,4	22,0	26,7	31,5	30,2

Items in the catalogue are examples of mass production but we produce more products than are shown here

## I.2. Main Requirements for Elastomers Used in Production of High-Tech Components for Oil and Gas Equipment

Requirements for elastomeric materials for oil and gas equipment depend on the product position in assemblies and units and on the media where the product operates. Unfortunately, these requirements for elastomer seals are not complete as every assembly or unit differs by its design and operation.

Additionally, with correct method of matching equipment with down-hole conditions and service, modern oil and gas equipment should have a useful life time for

1000 days minimum.

Our company follows the requirements and recommendations of international standards and the ones of the leading global oil and gas equipment manufacturers and other customers.

Tables 3, 4 and 5 show summarized requirements for elastomers applied in ESP units. The data is taken from Technical requirements of TNK-BP, NK "Rosneft", API 11S7 (RP 11S7) recommendations.

### Summarized technical requirements for elastomers applied in ESP units of TNK-BP

Table 3

Groups of the equipment according to categories of complicating factors	Requirements for elastomers	Recommended elastomers
1	Service temperature range from -45 to +150 °C. Resistance to well fluids, mineral and semi-synthetic oils. Maximum ED resistance	RS-3
2	Service temperature range from -45 to +150 °C. Resistance to well fluids, mineral and semi-synthetic oils. Maximum ED resistance	RS-26ch
3	Service temperature range from -45 to +170 °C. Resistance to well fluids, mineral and semi-synthetic oils. Maximum ED resistance	Ter-10
4	Service temperature range from -45 to +170 °C. Resistance to well fluids, mineral and semi-synthetic oils. Maximum ED resistance	Af-15
5	Service temperature range from -45 to +200 °C. Resistance to well fluids, mineral and semi-synthetic oils. Maximum ED resistance	RS-66

Generally, sulphur cured elastomers are not recommended for submersible oil and gas applications, since the interaction of the elastomer with H<sub>2</sub>S and other sulphur substances causes overcuring (cracks) and loss of sealing, elastic and physical properties. As a rule, sulphur cured elastomers have shorter life time and less heat and chemical resistance than peroxide cured elastomers.

ED resistance is an important technical requirement for elastomers applied in oil and gas equipment. Historically, technical norms for ED resistance evaluation of elastomer and polymer oil and gas products were not developed in the former USSR.

However, there are international technical norms like NACE (National Association of Corrosion Engineers) Standards: standard TM 0192-98 "Evaluating Elastomeric Materials in Carbon Dioxide Decompression Environments", standard TM 0297-97 "Standard Test Method Effects of High-Temperature, High-Pressure Carbon Dioxide Decompression on Elastomeric Materials" and standard ISO 23936 "Petroleum, petrochemical and natural gas industries - Non-metallic materials in contact with media related to oil and gas production". Part 2 of ISO 23936 describes requirements and testing operations of elastomeric materials utilized in oil and gas equipment, including ED resistance tests. ISO 23936-2 comes from the requirements of national standard of Norway NORSOK

M-710 "Qualification of Non-Metallic Sealing Materials and Manufacturers". Unfortunately, these standards are little known and are not applied in Russia.

It is important to note that ED resistance can be significantly different for the elastomeric compounds of the same base elastomer. To provide ED resistance of the products one requires a special compound formulation.

REAM-RTI implemented testing of elastomers in accordance with NACE TM 0192-98 (the USA) and NORSOK M-710 (Norway). All elastomeric compounds (formulated and then commercialized) are regularly qualified to evaluate the rating values of ED resistance (Appendix 3).

It is important to distinguish failures of elastomer products caused by dynamic stresses from the ones caused by ED (Appendix 4).

The problem of "elastomer vs motor oil" compatibility is also vital in ESP motors. Incompatibility of elastomeric compound and motor oil causes the failure of seals easily. For example, standard mineral dielectric oil starts its destruction at +137 °C, what is not regulated in the corresponding technical norms. Products of thermal destruction of the oil being aggressive chemical radicals cause the extraction of compound components (namely plasticizers) in many traditional "cheap" elastomers. This makes elastomers hard and brittle and they finally lose their elastic properties.

*Items in the catalogue are examples of mass production but we produce more products than are shown here*

## Technical requirements for elastomers applied in ESP units of NK "Rosneft"

Table 4

The down-hole electric motor and seal section designs	Elastomer requirements	Recommended elastomers
D1	Elastomers must retain their properties while being stored at temperature from -50 °C and while operating up to +150 °C. Resistance to mineral dielectric oil	RS-3, RS-26ch
D2	Elastomers must retain their properties while being stored at temperature from -50 °C and while operating up to +150 °C. Resistance to synthetic oils	RS-3, Ter-10
D3, D4	Elastomers must retain their properties while being stored at temperature from -40 °C and while operating up to +220 °C. Resistance to synthetic oils	Af-15, RS-66

### API 11S7 (RP 11 S7) Recommendations

Table 5

	Service temperature, °C	Groups of elastomers	Recommended elastomers
No groups division	> +121	NBR, non-sulphur cure	RS-3, RS-26ch
	> +135	HNBR (HSN), non-sulphur cure	Ter-10
	> +163	FKM-based elastomers	RS-VA
	> +177	TFE/P fluoroelastomers (Aflas™, Viton Extreme)	Af-15, RS-66

Chemistry of elastomers has been rapidly advancing in recent decades and enables to choose or formulate elastomeric compounds, life time of which is equal to the life time of the assembly. Such elastomeric compounds meet the most severe technical requirements of advanced submersible oil and gas equipment. Some of these elastomers are able to perform at temperatures of over +300 °C or at very low temperatures and keep their chemical resistance.

In Appendix 7 there is given a comparative price analysis of various base elastomers. NBR is a unit of measurement. The base elastomers are ranked depending on their performance. Product prices can differ greatly as high performance materials are manufactured from more expensive raw materials and require additional technical procedures.

### 1.3. Main Requirements for Elastomers in the Automotive Industry

In the automotive industry technical rubber products are applied in more than 500 units. Their functional application may be connected with sealing of critical units, engine components, transmission, fluid feed, braking and cooling systems, noise reduction and car body vibration, etc.

None of polymeric materials can perform all required functions itself. As each elastomeric compound exhibits its own properties a wide range of compounds is used in the industry. Technical rubber products must operate under the following service conditions:

- low (from -50 °C) and high (up to +200 °C and higher) temperatures;
- exposure to various aggressive chemical agents;
- exposure to various liquid and gas fuels, lubricants, cooling media;
- exposure to hydraulic or brake fluids;
- exposure to ozone;
- periodic or permanent dynamic loads;
- service life period of 40 000 hours minimum;
- exposure to dust or other abrasive media

and must protect the environment from harmful influence of chemicals, fuels, lubricants, anti-freezing agents, etc. present in quantity in automotive systems.

In production of technical rubber products for the automotive industry NBR-based elastomeric compounds

with different content of acrylonitrile are widely used. Main advantages of NBR are:

1. Resistance to solvents, fuels and oils.
2. Good physical properties, wear resistance, compression set, elasticity and resistance to thermal destruction.

Another widely used in the automotive industry elastomer is EPDM. Its advantages are atmospheric, ozone and heat resistance.

Having analyzed the performance of units and assemblies operating under harsh service conditions REAM-RTI's professionals realize new design solutions, formulate new elastomeric compounds, invent new technological concepts for manufacturing of technical rubber products. Company innovation solutions are as follows:

- low friction elastomers for movable joints - the friction coefficient of elastomer/carbon steel under dry friction is 0,2 max (minimum value is 0,12...0,15);
- elastomers with required swelling for fixed joints;
- elastomers with high dielectric properties;
- specially treated elastomer products with improved shelf life (compared to traditional elastomer products).

The unique solution of REAM-RTI is specialist sealing products for the dream vehicle running on environ-



mentally safe fuel dimethyl ether (DME). DME being a motor fuel belongs to renewable alternative fuels.

The samples of sealing components were laboratory and field tested in the research centres of AMO ZIL and FGUP "NIID" and are recommended for application in the engine fuel systems of ZiL-5301 refrigerated truck. RS-26ch- and RS-26ch-5-made products showed as much as a 5 % growth in sizes in DME and

diesel oil.

Such product as a filling valve made from a tear resistant elastomer was designed and produced in small batches for suspension absorbers of sport cars. In car races gaseous nitrogen is needle-pumped into the shock absorber through the filling valve. The first results of REAM's filling valve application showed that the domestic product successfully replaced a high-priced imported one.

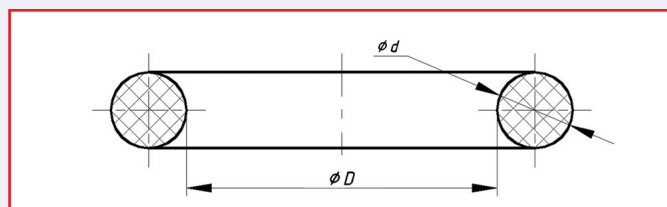
## I.4. The List of Technical Rubber Products Applied in Oil and Gas Equipment

### I.4.1. O-Rings

#### I.4.1.1. O-Rings According To Russian Standard GOST 9833-73

O-rings are manufactured from elastomeric compounds RS-26ch, RS-3, RS-3-1, RS-EP-T, Ter-10, Af-15 and Af-15-1. For movable joints elastomeric com-

pounds RS-26ch-5 and Ter-19 are used. O-rings can be manufactured according to Customer's requirements (drawings and prototypes of the Customer).



O-ring 004-006-14-2	O-ring 014-018-25-2	O-ring 020-025-30-2	O-ring 035-041-36-2	O-ring 102-108-36-2
O-ring 005-007-14-2	O-ring 015-019-25-2	O-ring 022-027-30-2	O-ring 036-042-36-2	O-ring 104-110-36-2
O-ring 008-010-14-2	O-ring 016-020-25-2	O-ring 023-028-30-2	O-ring 038-044-36-2	O-ring 115-121-36-2
O-ring 003-006-19-2	O-ring 017-021-25-2	O-ring 025-030-30-2	O-ring 039-045-36-2	O-ring 118-124-36-2
O-ring 004-007-19-2	O-ring 018-022-25-2	O-ring 027-032-30-2	O-ring 042-048-36-1	O-ring 125-130-36-2
O-ring 005-008-19-2	O-ring 019-023-25-2	O-ring 028-033-30-2	O-ring 042-048-36-2	O-ring 130-135-36-2
O-ring 006-009-19-2	O-ring 020-024-25-2	O-ring 030-035-30-1	O-ring 044-050-36-2	O-ring 135-140-36-2
O-ring 007-010-19-2	O-ring 021-025-25-2	O-ring 030-035-30-2	O-ring 045-051-36-2	O-ring 140-145-36-2
O-ring 008-011-19-2	O-ring 022-026-25-2	O-ring 032-037-30-2	O-ring 046-052-36-2	O-ring 150-155-36-2
O-ring 009-012-19-2	O-ring 023-027-25-2	O-ring 033-038-30-2	O-ring 048-054-36-2	O-ring 155-160-36-2
O-ring 010-013-19-2	O-ring 024-028-25-2	O-ring 034-039-30-2	O-ring 049-055-36-2	O-ring 170-175-36-2
O-ring 011-014-19-2	O-ring 025-029-25-2	O-ring 035-040-30-2	O-ring 050-056-36-2	O-ring 185-190-36-2
O-ring 012-015-19-2	O-ring 026-030-25-2	O-ring 038-042-30-2	O-ring 052-058-36-2	O-ring 210-215-36-2
O-ring 013-016-19-2	O-ring 027-031-25-2	O-ring 040-045-30-2	O-ring 054-060-36-2	
O-ring 014-017-19-2	O-ring 028-032-25-2	O-ring 042-048-30-2	O-ring 055-061-36-2	O-ring 032-040-46-2
O-ring 015-018-19-2	O-ring 029-033-25-2	O-ring 045-050-30-2	O-ring 056-062-36-2	O-ring 036-044-46-2
O-ring 017-020-19-2	O-ring 030-034-25-2	O-ring 050-055-30-2	O-ring 057-063-36-2	O-ring 044-052-46-2
O-ring 018-021-19-2	O-ring 032-036-25-2	O-ring 051-056-30-2	O-ring 058-064-36-2	O-ring 048-056-46-2
O-ring 019-022-19-2	O-ring 034-038-25-2	O-ring 055-060-30-2	O-ring 059-065-36-2	O-ring 050-058-46-2
O-ring 020-023-19-2	O-ring 036-040-25-2	O-ring 056-061-30-2	O-ring 064-070-36-1	O-ring 060-068-46-2
O-ring 022-025-19-2	O-ring 038-042-25-2	O-ring 060-065-30-2	O-ring 064-070-36-2	O-ring 070-078-46-2
O-ring 023-026-19-2	O-ring 040-044-25-2	O-ring 063-068-30-2	O-ring 066-072-36-2	O-ring 077-085-46-2
O-ring 024-027-19-2	O-ring 041-045-25-1	O-ring 065-070-30-2	O-ring 068-074-36-2	O-ring 095-102-46-2
O-ring 026-029-19-2	O-ring 041-045-25-2	O-ring 066-071-30-2	O-ring 069-075-36-2	O-ring 145-155-46-2
O-ring 027-030-19-2	O-ring 042-046-25-2	O-ring 070-075-30-2	O-ring 070-076-36-2	
O-ring 028-031-19-2	O-ring 043-047-25-2	O-ring 071-076-30-2	O-ring 072-078-36-2	O-ring 050-060-58-2
O-ring 030-033-19-2	O-ring 044-048-25-2	O-ring 075-080-30-2	O-ring 074-080-36-2	O-ring 060-070-58-2
O-ring 032-035-19-2	O-ring 048-052-25-2	O-ring 080-085-30-2	O-ring 075-081-36-2	O-ring 063-073-58-2
O-ring 033-036-19-2	O-ring 051-055-25-2	O-ring 085-090-30-2	O-ring 076-082-36-2	O-ring 065-075-58-2
O-ring 034-037-19-2	O-ring 052-056-25-2	O-ring 090-095-30-2	O-ring 078-084-36-2	O-ring 085-095-58-2
O-ring 040-043-19-2	O-ring 054-058-25-2	O-ring 095-100-30-2	O-ring 079-085-36-2	O-ring 090-100-58-2
O-ring 050-053-19-2	O-ring 060-064-25-2	O-ring 100-105-30-2	O-ring 080-086-36-2	O-ring 110-120-58-2
	O-ring 062-066-25-2	O-ring 110-115-30-2	O-ring 084-090-36-2	O-ring 115-125-58-2
O-ring 003-006-25-2	O-ring 065-070-25-2	O-ring 125-130-30-2	O-ring 085-091-36-2	O-ring 140-150-58-2
O-ring 004-006-25-2	O-ring 070-075-25-2	O-ring 150-155-30-2	O-ring 086-092-36-2	O-ring 155-165-58-2
O-ring 006-010-25-2	O-ring 075-080-25-2		O-ring 088-094-36-2	O-ring 160-170-58-2
O-ring 007-011-25-2	O-ring 078-082-25-2	O-ring 018-024-36-2	O-ring 089-095-36-2	O-ring 170-180-58-2
O-ring 008-012-25-2	O-ring 080-085-25-2	O-ring 026-032-36-2	O-ring 090-096-36-2	O-ring 180-190-58-2
O-ring 009-013-25-2	O-ring 085-090-25-2	O-ring 028-034-36-2	O-ring 092-098-36-2	O-ring 210-220-58-2
O-ring 010-014-25-2	O-ring 090-095-25-2	O-ring 029-035-36-2	O-ring 094-100-36-2	O-ring 225-235-58-2
O-ring 011-015-25-2	O-ring 100-105-25-2	O-ring 030-036-36-2	O-ring 098-104-36-2	O-ring 260-270-58-2
O-ring 012-016-25-2	O-ring 102-108-25-2	O-ring 032-038-36-2	O-ring 099-105-36-2	O-ring 290-300-58-2
O-ring 013-017-25-2	O-ring 018-023-30-2	O-ring 034-040-36-2	O-ring 100-106-36-2	

Items in the catalogue are examples of mass production but we produce more products than are shown here

### 1.4.1.2. O-Rings, AS 568A

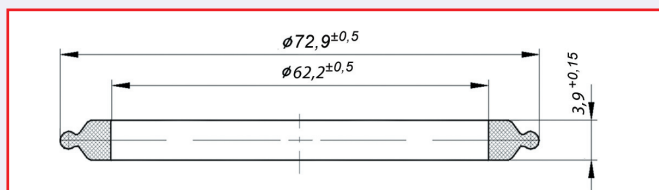
O-ring N° 010 6,07 x 1,78	O-ring N° 149 71,12 x 2,62	O-ring N° 233 72,62 x 3,53
O-ring N° 012 9,25 x 1,78	O-ring N° 150 72,69 x 2,62	O-ring N° 234 75,79 x 3,53
O-ring N° 021 23,52 x 1,78	O-ring N° 151 75,37 x 2,62	O-ring N° 235 78,97 x 3,53
O-ring N° 022 25,12 x 1,78	O-ring N° 152 82,22 x 2,62	O-ring N° 236 82,12 x 3,53
O-ring N° 023 26,70 x 1,78	O-ring N° 153 88,57 2,62	O-ring N° 237 85,32 x 3,53
O-ring N° 024 28,30 x 1,78	O-ring N° 154 94,92 x 2,62	O-ring N° 238 88,49 x 3,53
O-ring N° 026 31,47 x 1,78	O-ring N° 155 101,27 x 2,62	O-ring N° 239 91,67 x 3,53
O-ring N° 029 37,82 x 1,78	O-ring N° 214 25,00 x 3,53	O-ring N° 240 94,84 x 3,53
O-ring N° 040 72,75 x 1,78	O-ring N° 216 28,17 x 3,53	O-ring N° 241 98,02 x 3,53
O-ring N° 041 75,92 x 1,78	O-ring N° 218 31,34 x 3,53	O-ring N° 243 104,37 x 3,53
O-ring N° 042 82,27 x 1,78	O-ring N° 221 36,09 x 3,53	O-ring N° 244 107,54 x 3,53
O-ring N° 109 7,59 x 2,62	O-ring N° 222 37,69 x 3,53	O-ring N° 245 110,72 x 3,53
O-ring N° 118 21,89 x 2,62	O-ring N° 225 47,22 x 3,53	O-ring N° 249 123,42 x 3,53
O-ring N° 122 28,24 x 2,62	O-ring N° 227 53,57 x 3,53	O-ring N° 253 136,12 x 3,53
O-ring N° 123 29,82 x 2,62	O-ring N° 228 56,74 x 3,53	O-ring N° 258 151,99 x 3,53
O-ring N° 124 31,42 x 2,62	O-ring N° 229 59,92 x 3,53	O-ring N° 259 158,34 x 3,53
O-ring N° 129 39,34 x 2,62	O-ring N° 230 63,09 x 3,53	O-ring N° 361 151,77 x 5,33
O-ring N° 130 40,94 x 2,62	O-ring N° 231 66,27 x 3,53	
O-ring N° 131 42,52 x 2,62	O-ring N° 232 69,44 x 3,53	



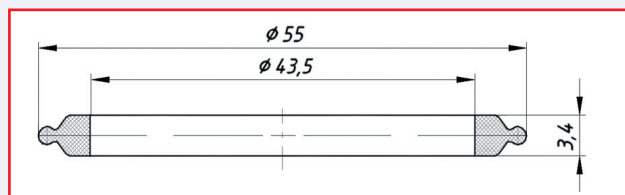
Items in the catalogue are examples of mass production but we produce more products than are shown here

### 1.4.1.3. T-Shaped Rings

T-shaped rings are produced from elastomeric compound RS-EP-T.



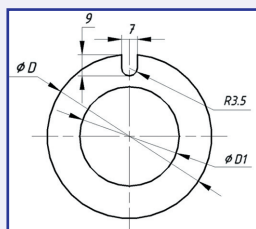
T-ring RR.041A.04.63 for 544 Series bearing



T-ring 46521402-450-43969

### 1.4.1.4. ED-Rings

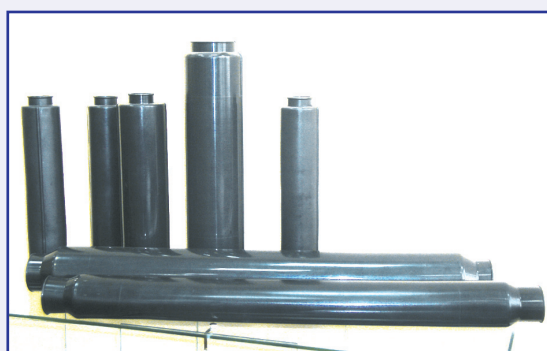
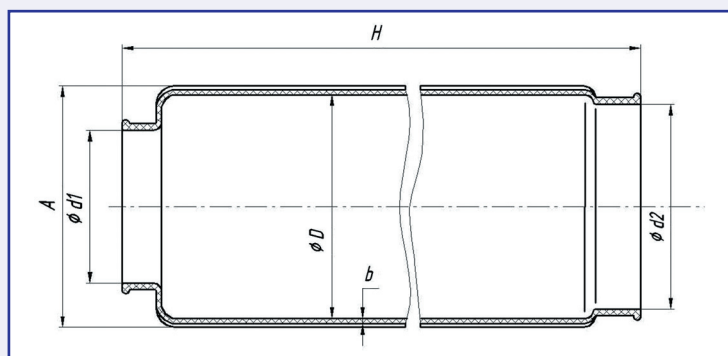
Product number	D, mm	D1, mm	Elastomeric compound
ED 139.006/RR.033.206.126	60 <sup>-2</sup>	35 <sup>+2</sup>	RS-26ch, Af-15, Ter-10
ED 139.006-03/RR.033.206.126-R	60 <sup>-2</sup>	35 <sup>+2</sup>	RS-26ch
ED 001.00.016/RR.033.206.126	60 <sup>-2</sup>	35 <sup>+2</sup>	RS-VA



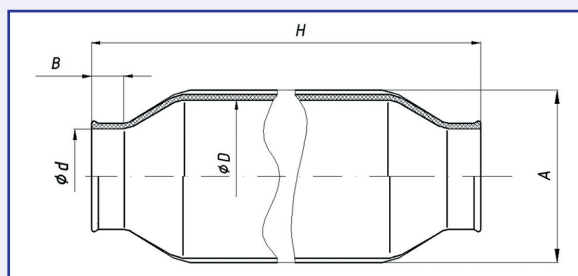
### 1.4.2. Seal Bags

#### 1.4.2.1. Seal Bags for CIS Equipment

REAM-RTI, LLC manufactures seal bags for ESP motors commercialized by OOO "Borets", ZAO "NOVOMET-Perm", OAO "ALNAS", OOO "ALMAZ" and by other domestic manufacturers. Seal bags are manufactured in accordance with Russian Technical Requirements TU 2539-008-4652-1402-03 from both sulphur and nonsulphur cured elastomers (four groups of elastomers) (Appendix 8).

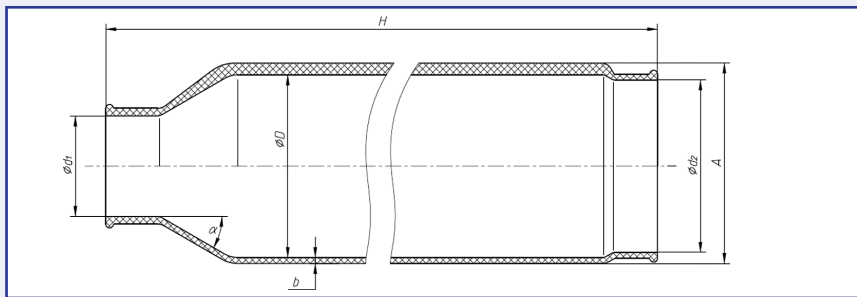


Product number	H, mm	d1, mm	d2, mm	D, mm	b, mm	A, mm
NM-600.001	357,0	40,0	69,8	73,0	2,3	82,2
GN-838.06.02 (103.001.0107)	360,0	39,0	77,0	81,0	2,3	90,2
GN-838.06.02 (103.001.0107)	359,0	39,0	61,0	66,4	2,3	75,0
GN-817.06.03 (102.001.0112)	359,0	39,0	67,0	71,0	2,3	80,2
106.001.0113	560,0	109,0	138,0	147,0	2,5	156,6
GN-845.00.21	456,0	77,0	98,0	103,4	2,3	112,0
PB 92T.01.001	357,0	39,0	61,0	66,4	2,3	75,0

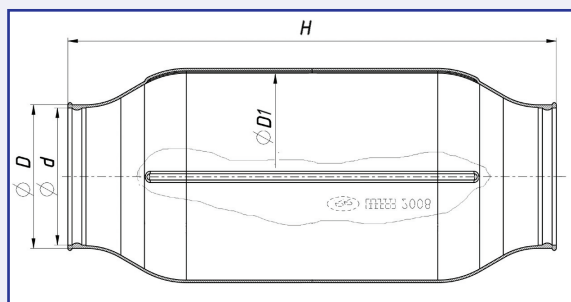


Product number	H, mm	A, mm	B, mm	D, mm	d, mm
8TShch 456.040-R (GB 5.02.021-R)	800	99,6	24	92	60
8TShch 456.039-R	800	79,6	37,2	72	53
GB 5.01.026-R	82	77,6	14	70	50
RR.5.400.001.01-R (EYuTI.G.391.701 analogue)	400	79	29,5	72	53

Items in the catalogue are examples of mass production but we produce more products than are shown here

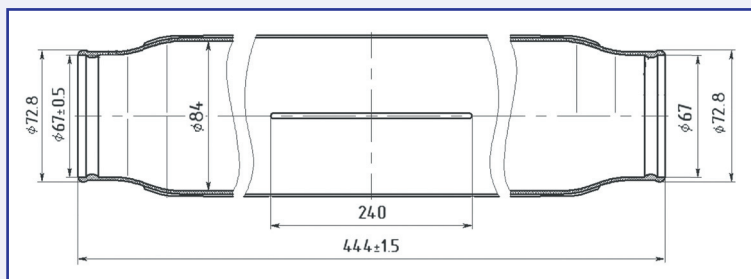


Product number	H, mm	d1, mm	d2, mm	D, mm	b, mm	A, mm	$\alpha$ , °
RR.5.360.001.01-01R (102.001.0008)	359,0	39,0	67,0	71,6	2,3	80,2	30
RR.041.006.05.360-10R	359,0	40,0	61,0	65,6	2,3	75,0	30
RR.041.006.5A.360-10R (103.001.0008)	360,0	39,0	77,0	81,6	2,3	90,2	40

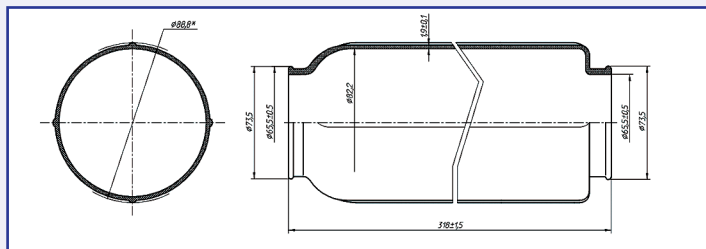


Product number	H, mm	D, mm	d, mm	D1, mm	A, mm
102.000.0002 (RR.031.006.140)	440	49	44	71	75
102.000.0004 (RR.031.006.145)	440	49	44	71	75
103.000.0002 (RR.031.006.142)	440	49	44	82	86
103.000.0004 (RR.031.006.146)	440	49	44	82	86
106.000.0001	350	103	98	148	152
108.000.0002	605	38	33	51	54

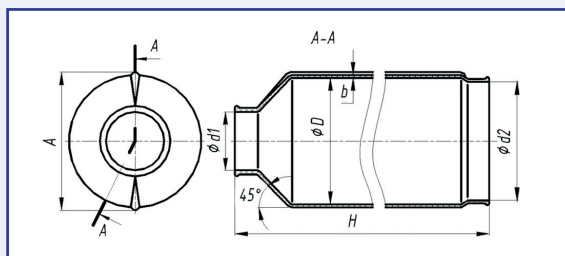
#### 1.4.2.2. Replacement Parts for Imported Equipment. Seal Bags



Seal bag for REDA ESP unit RR.043.006.5A.444

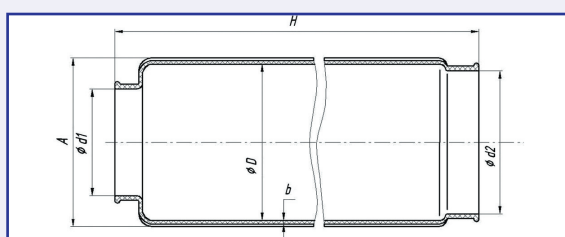


Seal bag for ODI ESP unit RR.41.06.0001 (400 Series)



Seal bags for CENTRILIFT ESP units

Product number	H, mm	d1, mm	d2, mm	D, mm	b, mm	A, mm
RR.041.006.07.454 (513 Series)	454,0	46,0	93,7	100,8	2,3	109,2
RR.041.006.05.357 (400 Series)	356,0	40,0	70	73,2	2,3	82,2



Seal bag for CENTRILIFT ESP unit  
RR.041.006.05.357-01

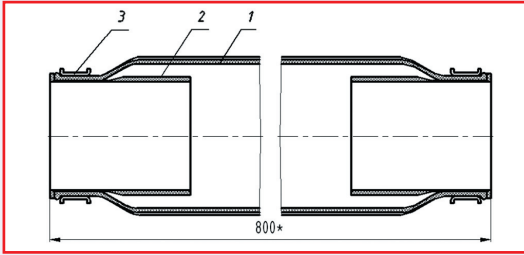
Product number	H, mm	d1, mm	d2, mm	D, mm	b, mm	A, mm
RR.041.006.05.357-01 (400 Series)	357,0	40,0	69,8	73,0	2,3	82,2

Items in the catalogue are examples of mass production but we produce more products than are shown here



### 1.4.2.3. Elastomer Seal Bag Kit Recommended for G51 Class Seal Section

The kit ensures the reliability of seal bags in conditions of incidental operational factors: extremely high running/lifting speed of pumping equipment and motor oil instantaneous release. It is manufactured from elastomeric compounds according to Customer's requirements (Appendix 9).



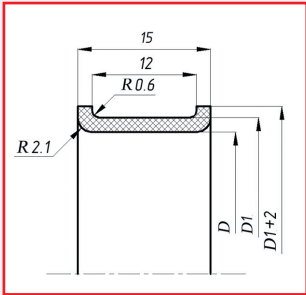
The complete kit with protective elements



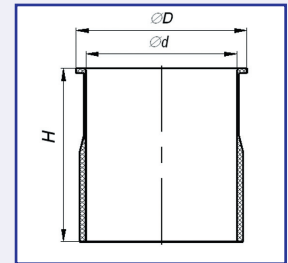
The complete kit for seal bags  
RR.033.202.034, RR.033.202.035:  
1 - seal bag;  
2 - damper ring;  
3 - bandage ring

Product number	Seal bag	Bandage ring	Damper ring
RR.033.202.034	8TShch 456.039-R	GZ.020	RR.033.010.0026
RR.033.202.035	8TShch 456.040-R	GZ.020-01	RR.033.010.0027

A bandage ring is used to prevent seal bag throat failures in G51 class seal section.  
Note: bandage rings can be also manufactured for other seal sections.



Product number	D, mm	D1, mm	Elastomeric compound	Seal bag
GZ.020	60	63	RS-26ch	8TShch 456.039-R
GZ.020-01	67	70	RS-26ch	8TShch 456.040-R



Damper ring is used to prevent seal bag failures in G51 class seal section.  
Note: damper rings can be manufactured for other seal sections.

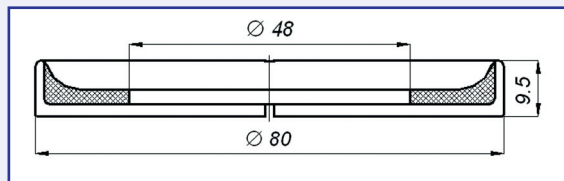
Product number	D, mm	d, mm	H, mm	Elastomeric compound	Seal bag
RR.033.010.0026	62	54	39	RS-26ch	8TShch 456.039-R
RR.033.010.0027	69	61	27	RS-26ch	8TShch 456.040-R

### 1.4.2.4. Washers

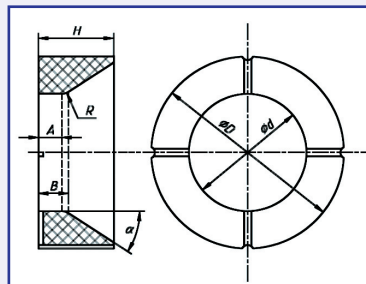
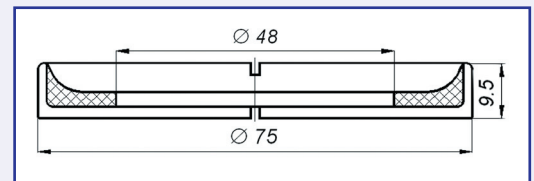
Elastomeric compounds RS-26ch, Ter-10, Af-15



Washer GN - 817.06.04



Washer GN - 836.06.04



Washers for conical seal section bags

Product number	D, mm	d, mm	H, mm	A, mm	B, mm	$\alpha$ , °
RR-032-204-88-r (for the seal bag RR.5.360.001.01-01R)	79,5	48,5	31	9,5	12,5	33

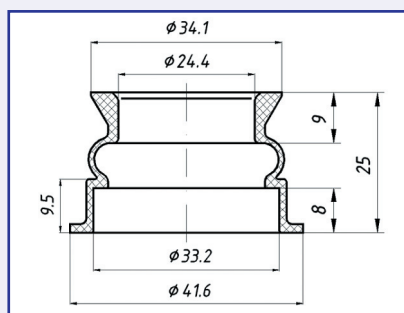
Items in the catalogue are examples of mass production but we produce more products than are shown here

### I.4.3. Mechanical Seal Bellows

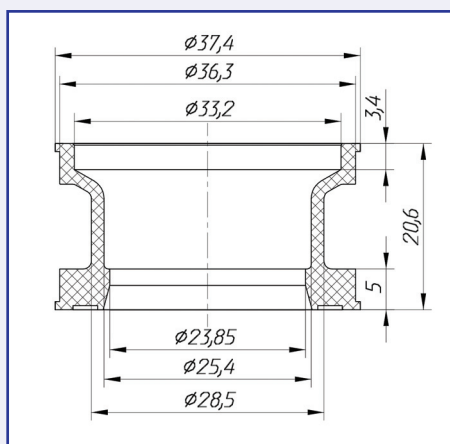
REAM-RTI, LLC manufactures mechanical seal bellows for protector shafts. Bellows are produced from elastomeric compounds RS-26ch, RS-3, Ter-10 and Af-15. These

compounds ensure enhanced heat resistance, resistance to mineral, semi-synthetic and synthetic oils, well fluids, high ED resistance and low friction coefficient.

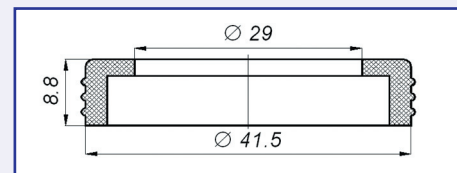
**Bellows EYuTI.G.566.001-R for mechanical seal 2R25**



**Bellows GZ 2552.004 for mechanical seal JOHN CRANE INT-0250-S-EPO**



**Lip seal 1N-21756 (GZ 2552.005) for mechanical seal JOHN CRANE INT-0250-S-EPO**



### I.4.4. Thrust Washers

#### I.4.4.1. Thrust Washers for ESP Impellers

Thrust washers for ESP impellers are manufactured from the abrasive resistant elastomeric compound K-38 (the low friction elastomeric compound).

The low friction elastomer replaces textolite as the material used in the production of the thrust washers. The thrust washers exhibit enhanced wear and abrasion resistance and anti-friction properties.

Operating conditions:

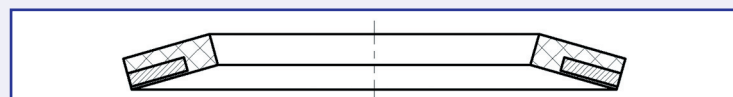
- well fluid, 10 % HCl and H<sub>2</sub>SO<sub>4</sub> and 6 % H<sub>2</sub>S solutions,
  - service temperature range - from 0 °C up to +150 °C;
  - mineral dielectric oil (Russian Technical Requirements TU 38.401.177-96), mineral oils, well fluids;
  - pressure of up to 40 MPa.
- (Appendices 1, 2, 12).

Product number	D, mm	d, mm	H, mm
<b>NM - 018 Sh</b>	40,1 <sup>+0,3</sup>	29,9 <sup>-0,2</sup>	2 <sup>+10,1/- 0,2</sup>
<b>UE 155 - 057</b>	46,1 <sup>+0,3</sup>	35,7 <sup>-0,2</sup>	2 <sup>+0,1/-0,2</sup>
<b>UE 155 - 022</b>	44,1 <sup>+0,3</sup>	34,7 <sup>-0,2</sup>	2 <sup>+0,1/-0,2</sup>
<b>NM - 008 Sh</b>	39,2 <sup>+0,2</sup>	31,9 <sup>-0,2</sup>	1,5 <sup>+0,25</sup>
<b>NM - 028 ShR</b>	50,2 <sup>-0,3</sup>	39 <sup>+0,3</sup>	2 <sup>±0,1</sup>
<b>NM - 020 ShR</b>	45,7 <sup>-0,3</sup>	34 <sup>+0,3</sup>	2 <sup>±0,1</sup>
<b>NM - 019 ShR</b>	42,1 <sup>+0,3</sup>	31,7 <sup>-0,2</sup>	2 <sup>±0,1</sup>
<b>NM - 033 ShR</b>	52,2 <sup>-0,3</sup>	41 <sup>+0,3</sup>	2 <sup>±0,1</sup>
<b>1a/o VNNK - 250.22</b>	59,2 <sup>-0,3</sup>	47 <sup>+0,3</sup>	2
<b>NM - 033.003</b>	26 <sup>-0,21</sup>	19 <sup>+0,21</sup>	2 <sup>±0,1</sup>
<b>NM - 031.042</b>	42,5 <sup>-0,3</sup>	31,5 <sup>+0,3</sup>	2 <sup>±0,1</sup>



Elastomeric compound RS-26ch

Product number	D, mm	d, mm	H, mm
<b>MNGB 00.001</b>	44 <sup>±0,5</sup>	34 <sup>±0,5</sup>	3 <sup>±0,2</sup>
<b>UE 102 - 018</b>	20 <sup>±0,5</sup>	12 <sup>±0,5</sup>	2 <sup>±0,2</sup>
<b>UE 102 - 027</b>	50 <sup>-0,62</sup>	34,2 <sup>+0,62</sup>	3 <sup>-0,25</sup>



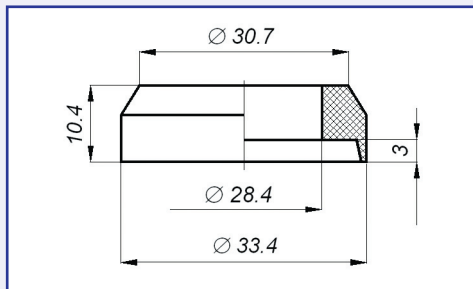
**Metal mesh reinforced thrust washers**

Items in the catalogue are examples of mass production but we produce more products than are shown here

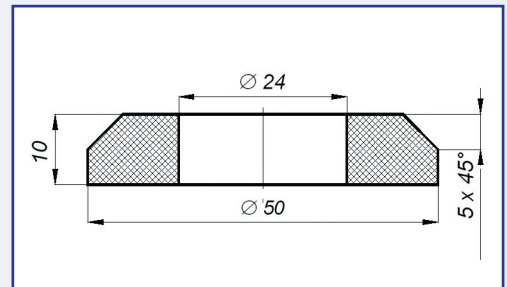
## I.4.5. Shock Dampers

Elastomeric compound RS-26ch

**Shock damper for shaft 7/8" GZ.004  
class seal section**



**Shock damper for shaft 2PB 92.00.004**



## I.4.6. Elastomer Products for ESP Motors

### I.4.6.1. Low Friction Elastomer Products (with improved frictional properties)

Low friction elastomeric compounds (slippery elastomeric compositions) are characterized by enhanced wear and abrasion resistance and ability to retain high performance under dry friction conditions. The selection of suitable contact materials is vital for submersible equipment for use in crude oil with high hard particle concentrations (of more than 500 mg/l).

Low friction elastomeric compounds have a dry friction coefficient against hardened steel of max 0,2 and are able to perform well even under dry friction conditions. This property makes low friction elastomeric compounds especially suitable for submersible oil and gas applications such as marine bearings, thrust washers, PCP pump and down-hole motor stators (equipment life time is 400 days min).

To improve working efficiency of products in movable joints that are exposed to sliding friction against smooth metal surfaces is possible if one uses not only compound (volume treatment) but surface finishing methods of already finished elastomeric materials as well.

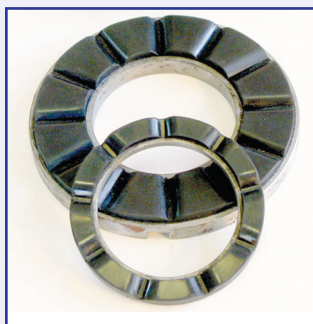
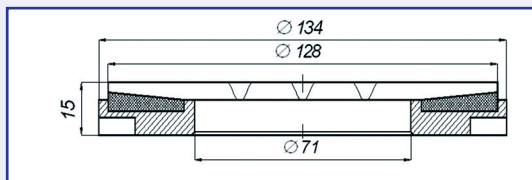
Adsorptive-absorption treatment (AAT) method was devised and patented by REAM's experts. This method provides such increased product performance as follows:

- low dry friction coefficient (static and dynamic) - 0,2 max;
- ozone resistance;
- no need for special lubricant for unit assembly;
- contact temperature decrease of moving seal lips.

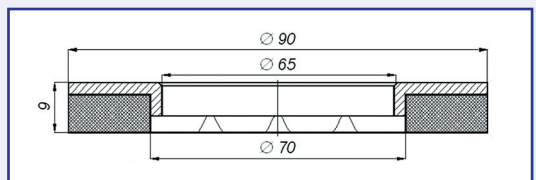
Appendix 13: Comparison of methods to reduce dry friction of technical rubber products.

Elastomeric compound RS-26ch-65

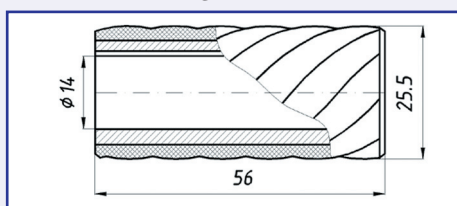
**Thrust bearing BEP 01.240SB**



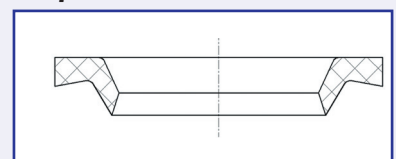
**Reversible thrust bearing BEP 01.250**



**Bushing EP 028.03.03.000-01SB**



**Scraper**



Items in the catalogue are examples of mass production but we produce more products than are shown here



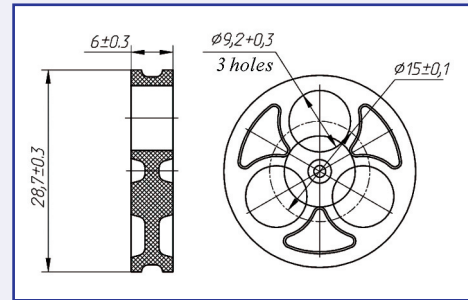
#### 1.4.6.2. Cable Connector Seals for ESP Motors

Cable connector seals are manufactured in accordance with Customer's technical requirements from elastomeric compounds RS-26ch or RS-EP-T (Table 1).

Operating conditions:

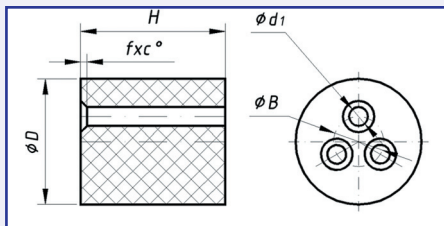
- service temperature range - from -45 °C up to +170 °C;
- mineral dielectric oil (Russian Technical Requirements TU 38.401.177-96), mineral oils, well fluids;
- pressure of up to 25,0 MPa.

According to Customer's requirements seals can be produced from other elastomeric compounds.

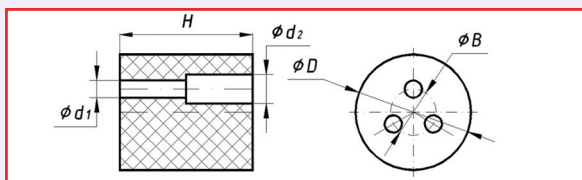


Seal RR-035.011.0028

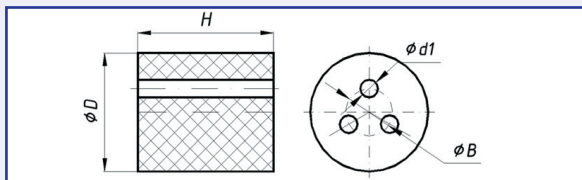
#### Seals from elastomeric compound RS-26ch



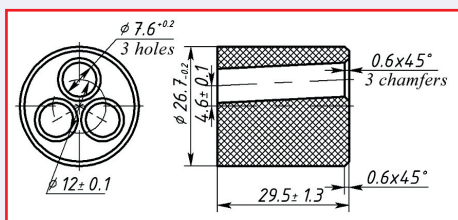
Product number	H, mm	D, mm	d1, mm	B, mm	Chamfers fxc°
EYUTL.K.485.004	22 ±0,5	28 -0,5	6,5 ±0,1	15 ±0,1	0,5x45
NPO039.011.001-01	22	28 -0,3/-0,5	9,5 +0,4	15 ±0,1	-
NPO039.011.001-02	22	27,8 -0,52	9 +0,36	15 ±0,1	1,5x45
NPO039.011.001-03	15	28 -0,3	9 +0,3	15 ±0,1	1,25x45



Product number	H, mm	D, mm	d1, mm	d2, mm	B, mm
UB-ODI 002.005	20	28,3 -0,21	7,8 +0,22	9 +0,22	14 ±0,1
UB 001.005	20	28,3 -0,21	7 +0,22	9 +0,22	15 ±0,1



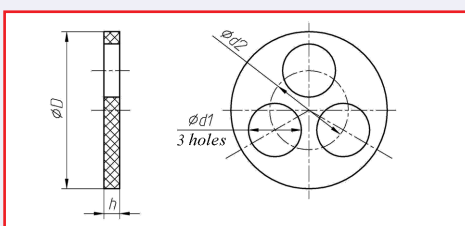
Product number	H, mm	D, mm	d1, mm	B, mm
UB 001.011	20	28,3 -0,52	8,3 +0,4	15 ±0,1
K46.022-01	22 ±1	27,8 -0,1	9 -0,2	15 ±0,2



Seal KAB.009



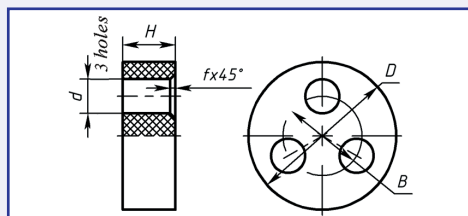
#### Seals from elastomeric compound Ter-10



Product number	h, mm	D, mm	d1, mm	d2, mm
RR.033.014.113	2,6 -0,15	26 ±0,2	8,8 +0,1	13,1 ±0,1
RR.035.203.0029	2,5 ±0,2	23,5 ±0,3	8,75	12,45

Items in the catalogue are examples of mass production but we produce more products than are shown here

### I.4.6.3. Elastomer Cable Connector Thrust Washers

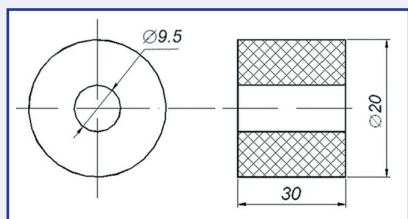


Product number	H, mm	D, mm	d, mm	B, mm	Chamfers fxc°
EYU TI.K.485.002	10	28,3 <sup>-0,2</sup>	6,5 <sup>±0,18</sup>	15 <sup>±0,1</sup>	-
EYU TI.K.485.003	5	28 <sup>-0,1</sup>	6,5 <sup>±0,18</sup>	15 <sup>±0,1</sup>	1x45

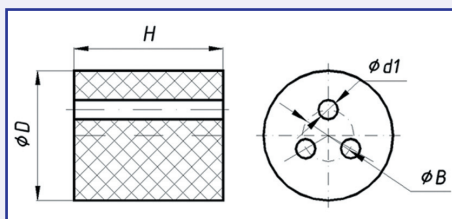
### I.4.6.4. Seals for Bottom-Hole Apparatuses to Measure Temperature and Pressure in Oil Wells (designed by AOZT "ELNA")

Seals are produced from elastomeric compounds that enable operation:

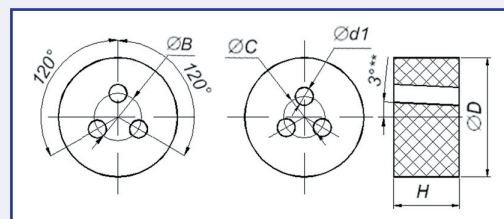
- in well fluid;
- at temperatures from - 45 °C up to + 120 °C;
- under pressure of up to 40 MPa.



**Bush TMG DM 03.04**



**Inserted piece TMG DM 03.05**

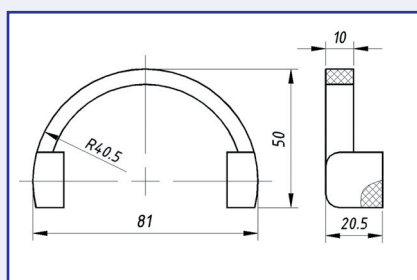


**T-joint TMG DM 03.06**

Product number	H, mm	D, mm	d1, mm	B, mm	C, mm
<b>Bush TMG DM 03.04</b>	30 <sup>±0,3</sup>	20 <sup>±0,2</sup>	9,5	-	-
<b>Inserted piece TMG DM 03.05</b>	28 <sup>±0,3</sup>	20 <sup>±0,2</sup>	3	8	-
<b>T-joint TMG DM 03.06</b>	11 <sup>±0,2</sup>	20 <sup>±0,2</sup>	3	8	7

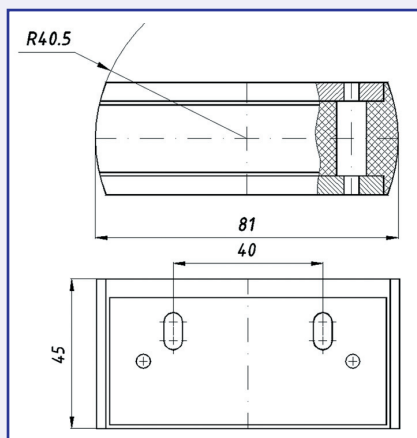
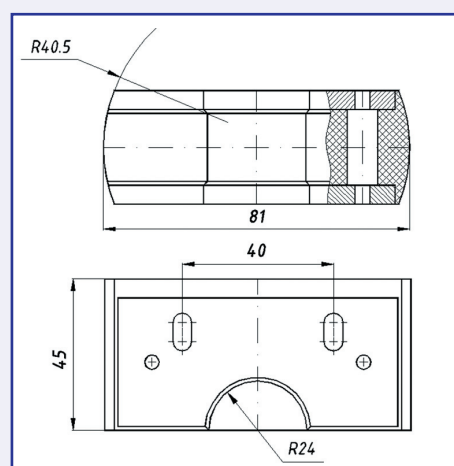
### I.4.7. Elastomer Products for Drilling Equipment

#### I.4.7.1. Preventer Seals (designed by OOO "Promspetsmash")



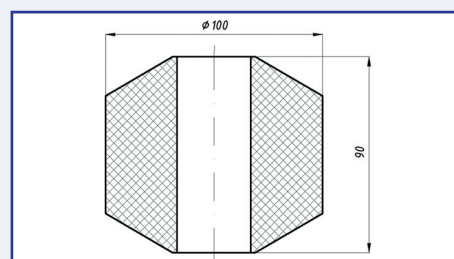
**Seal ART  
1.10.03.085**

**Seal ART  
1.10.03.090**



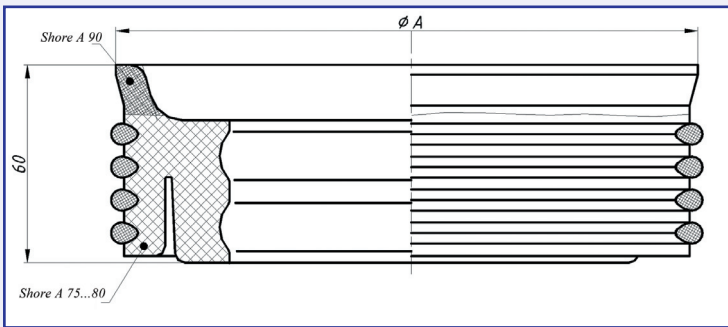
**Seal ART  
1.10.03.060**

**Seal 1 MK  
2.01.02.020**



Items in the catalogue are examples of mass production but we produce more products than are shown here

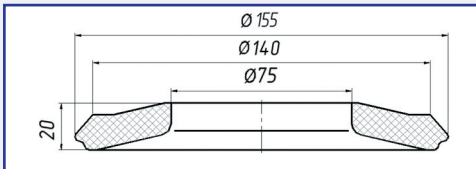
### 1.4.7.2. Piston Seal



The piston seal designed for mud pump piston heads with diameters of 160 and 170 mm is manufactured from elastomeric compounds of the "RS" Series. Sections with movable joints require low friction elastomers (slippery elastomeric compositions).



### 1.4.7.3. Valve Seal



The valve seal K7 is designed for mud pumps NBT 475, NBT 600, NBT 950 and UNBT 600. It is a co-design of REAM-RTI, LLC and Spetstekhnika, LLC (the town of Izhevsk).

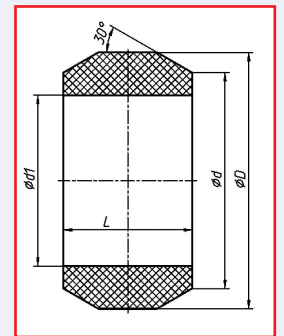
## 1.4.8. Elastomeric Seal Elements For Packers

### 1.4.8.1. Packer Seal Elements for Hydro-Fracturing

Packer seal elements are applied in packer sealing assemblies for hydro-fracturing, squeeze jobs, drill casing pipe pressure tests, leakage look-up and other technological works in oil wells. The packer is equipped with a kit of seal elements of different hardness (Shore A 70 and 90). The seal elements are manufactured according to our own specialist technology from elastomeric compounds RS-26ch-70

and RS-26ch-90. They are solid and exhibit high performance and reliability under the following operating conditions:

- well fluid;
- 6 % H<sub>2</sub>S environment;
- service temperature range - from -45 °C up to +125 °C;
- pressure of up to 70 MPa.



Product number	D, mm	d, mm	d1, mm	l, mm	Drill casing pipe ID, mm
RR.031.012.150	119,5 <sup>±1,25</sup>	102 <sup>±1,25</sup>	80 <sup>±1,0</sup>	66 <sup>±0,8</sup>	124,7...133,1
RR.031.012.162	82 <sup>±1,0</sup>	73 <sup>±1,0</sup>	59,5 <sup>±0,8</sup>	60 <sup>±0,8</sup>	87,6...90,6
RR.031.012.163	120,7 <sup>±1,25</sup>	109 <sup>±1,25</sup>	91 <sup>±1,0</sup>	66 <sup>±1,0</sup>	124,7...133,1
RR.031.012.164	139,7 <sup>±1,25</sup>	125 <sup>±1,25</sup>	105 <sup>±1,0</sup>	66 <sup>±1,0</sup>	144,1...147,1
RR.031.012.165	150,5 <sup>±1,25</sup>	145 <sup>±1,25</sup>	105 <sup>±1,0</sup>	66 <sup>±1,0</sup>	159,4...161,6
RR.031.012.187	121,5 <sup>±1,25</sup>	104 <sup>±1,25</sup>	60 <sup>±1,0</sup>	82 <sup>±1,1</sup>	



### 1.4.8.2. Packer Seal Elements for Dual Oil Production and for Oil Well Filtration System Separators

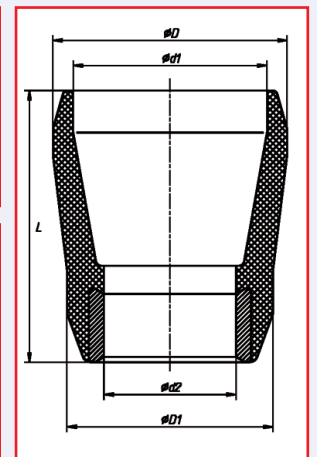
Metal reinforced seal elements are manufactured from low friction elastomeric compound RS-26ch-5.

Seal elements operate:

- in the mixture of oil, well water and oil well gas;
- in mineral and semi-synthetic oils;
- at temperatures of up to +150 °C.

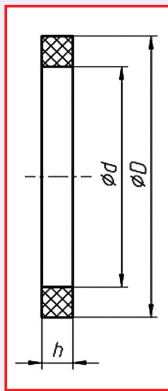


Product number	D, mm	D1, mm	d1, mm	d2, mm	L, mm	Drill casing pipe nominal diameter, mm
415.631.0010	133 <sup>±0,5</sup>	117 <sup>±1,25</sup>	110 <sup>±1,25</sup>	75 <sup>+1,0</sup>	155 <sup>±1,6</sup>	146
415.632.0010	102 <sup>±0,5</sup>	90 <sup>±1,0</sup>	85 <sup>±1,0</sup>	58 <sup>+1,0</sup>	120 <sup>±1,6</sup>	114
415.633.0010	93 <sup>±0,5</sup>	80 <sup>±1,0</sup>	77 <sup>±1,0</sup>	52 <sup>+1,0</sup>	108 <sup>±1,6</sup>	102
415.634.0010	153 <sup>±1,25</sup>	135 <sup>±1,25</sup>	126 <sup>±1,25</sup>	86 <sup>+0,63</sup>	178 <sup>±1,8</sup>	168
415.635.0010	164 <sup>±1,25</sup>	145 <sup>±1,25</sup>	134 <sup>±1,25</sup>	90 <sup>±1,0</sup>	188 <sup>±1,8</sup>	178

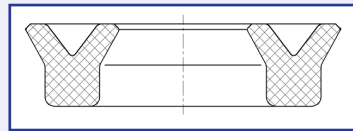


Items in the catalogue are examples of mass production but we produce more products than are shown here

## 1.4.9. Other Elastomer Products

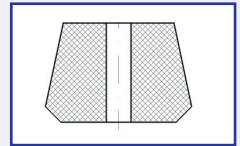


**Quad ring seal**

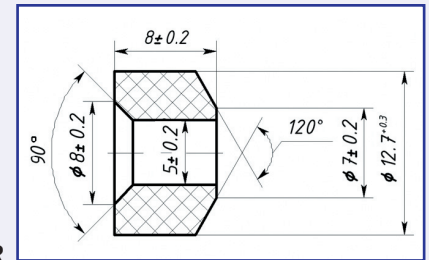


**Leap seal,  
GOST 14896-84**

**Spacer  
PE-2489.00.013**

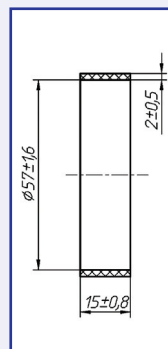
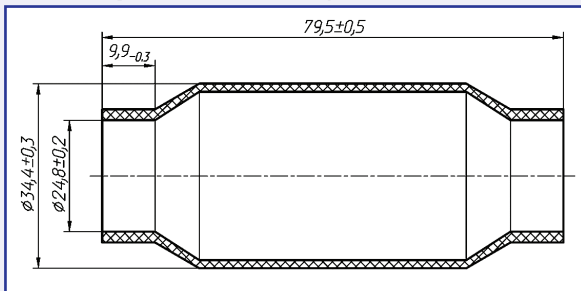


Product number	D, mm	d, mm	h, mm
<b>RR.031.105.168 (18934607)</b>	65,9 $\pm$ 0,5	63 $\pm$ 0,5	3,2 $\pm$ 0,1
<b>85119525</b>	89,5 $\pm$ 0,5	81 $\pm$ 0,5	6 $\pm$ 0,1
<b>RR.031.105.136</b>	86,4 $\pm$ 0,5	67,5 $\pm$ 0,5	9,5 $\pm$ 0,2
<b>RR.031.012.166-01</b>	66 $\pm$ 0,63	46 $\pm$ 0,5	9,5 $\pm$ 0,2
<b>RR.031.012.166-02</b>	101 $\pm$ 0,8	82,5 $\pm$ 0,63	9,5 $\pm$ 0,2



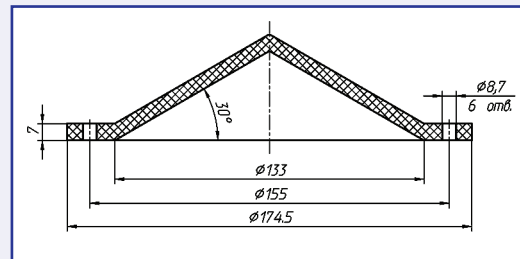
**Seal EYuTI.G.390.144-R**

**Compensator AKSh-43/RR.033.006-110**

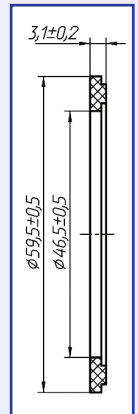


**Rectangular cross-section ring 8VZh.214.99**

**Seal RR.031.013.116**



**Seal RR.031.011.117**



### 1.4.9.1. Bearings for Motor Boats

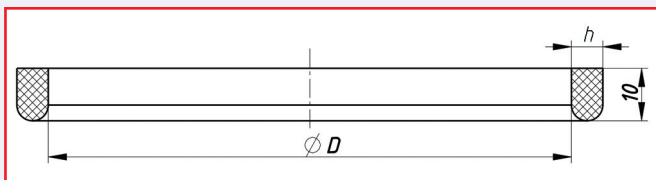


Marine bearings for water-jet motors of the "VDD" Series are used in modern motor boats, yachts and small vessels.

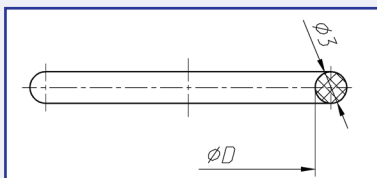
The bearings are custom-made from low lubrication elastomeric compounds of the "RS" Series by our own specialist technology.

The bearings are resistant to abrasive wear and aggressive medium (sea water) and exhibit low vibration.

### 1.4.9.2. O-Rings for Condensing Apparatuses



Product number	D, mm	h, mm	Elastomeric compound
<b>DAIF.757764.104</b>	283	6	Af-15
<b>DAIF.757764.104-01</b>	143	6	Af-15
<b>DAIF.757764.104-02</b>	295	6	MBF-8
<b>DAIF.757764.104-03</b>	155	6	MBF-8
<b>DAIF.757764.109</b>	119	5	Af-15
<b>DAIF.757764.109-01</b>	227	5	Af-15
<b>DAIF.757764.109-02</b>	129	5	MBF-8
<b>DAIF.757764.109-03</b>	237	5	MBF-8

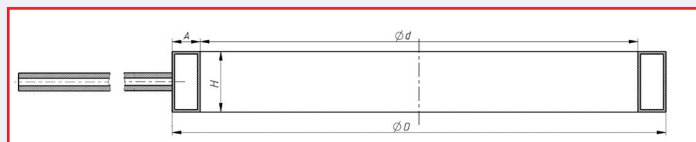


Product number	D, mm	Elastomeric compound
<b>DAIF.757764.107</b>	23,5	Af-15
<b>DAIF.757764.107-01</b>	31	MBF-8

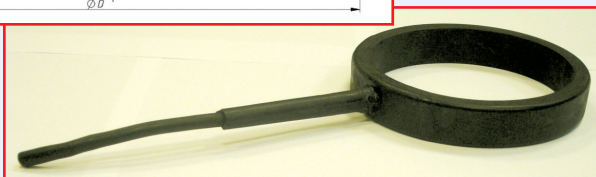
Items in the catalogue are examples of mass production but we produce more products than are shown here



### 1.4.9.3. Lip Seals for the Test Bench



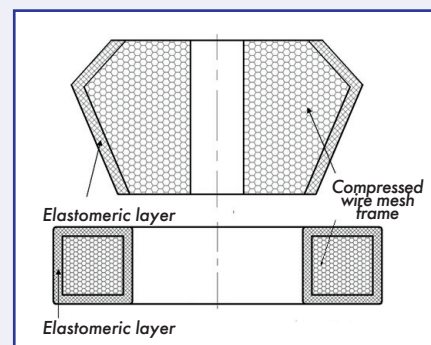
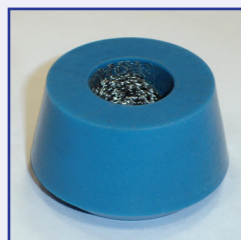
(Appendix 14)



Product number	D, mm	d, mm	H, mm	A, mm
D100	125	100	24,4	12,5
D109	125	109	24,4	8
D115	135	115	24,4	10
D125	145	125	24	10
D137	153	137	24,3	8
D172	194	172	23,8	11

### 1.4.9.4. Dampers from Compressed Wire Mesh

Movable and fixed joint seals maintain the required contact pressure over a wide temperature range (from -100 °C up to +250...300 °C) despite considerable vibrational and torsional loads that arise due to equipment and machine operation. The dampers are made from compressed wire mesh frame filled with the elastomeric polymer. The applied elastomeric polymer is selected to meet service of both temperature and media requirements.



The compressed wire mesh frame provides a long guaranteed compression of the sealing surfaces to the mating surface. The compression applied is independent of the elastomeric polymer relaxation properties.

## 1.5. Unmoulded Technical Rubber Products

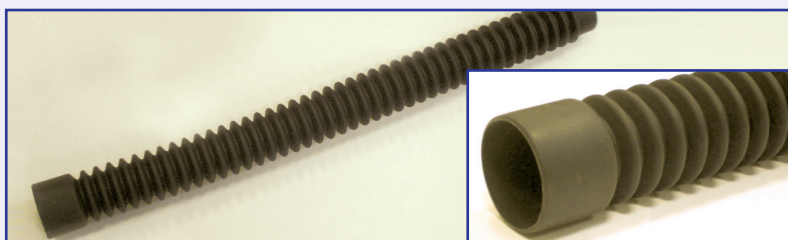
### 1.5.1. Rubber Cords, GOST 6467-75

Round rubber cords are used for sealing fixed and movable joints (operating environment pressure is up to 1,0 MPa (10 kgf/cm<sup>2</sup>) and for chamber dust and mud protection. The cord diameter is 1,5...5,0 mm.



### 1.5.2. Elastomer Tubes, GOST 5496-78

Elastomer tubes are used for water, air and gas supply. They are used in various manufacturing sectors.



Items in the catalogue are examples of mass production but we produce more products than are shown here

## II. PRODUCTS MADE FROM HEAT-RESISTANT ENGINEERING THERMOPLASTIC COMPOSITES

### II.1. Main Materials and Their Properties

#### II.1.1. Engineering Thermoplastic Composites

The REAM Group commercialized critical parts for oil and gas equipment from heat-resistant engineering thermoplastic materials. These are ESP impellers, rotor components for gas separators, connecting blocks for ESP motors, cable connector thrust washers, polymer-coated diffusers, impeller washers.

The purpose of the engineering thermoplastic composites is to replace high-quality steel and other metals to minimize wear and to reduce noise regardless of operating conditions. Such composites combine high heat and wear resistance, mechanical characteristics, high permissible loads, dimensional stability, chemical resistance over a wide temperature range (of up to +260 °C), and low water absorption.

Main heat-resistant engineering thermoplastic materials are:

- **polyphenylene sulphide (PPS)**, a crystallizing material obtained by oil resin polymerization due to which benzene rings and sulphur atoms form giant molecules that give some nonstandard properties to the material.

PPS is one of the most heat-resistant engineering thermoplastic composites (long-term operation at temperatures of up to +240 °C is possible); it has high resistance to impact loads, it is nontoxic and chemically resistant to various oils and automobile fuel. The material demonstrates high cracking resistance, high dimensional stability, low water absorption. It is self-damping without any additives.

- **polyetheretherketone (PEEK)**, a linear, aromatic, partially crystal engineering thermoplastic composite.

PEEK exhibits low friction coefficient and excellent wear resistance at different load pressure ranges, various velocities and temperatures at variable roughness of contacting surfaces. The material is high resistant to various organic and non organic fluids despite high temperatures and pressure. Unique combinations of hardness, impact elasticity and tribological behaviour enable to produce components with long lifetime.

The REAM Group cooperates with leading manufacturers of the engineering thermoplastic composites such as Ticona and Chevron Phillips Chemicals (PPS), Victrex (PEEK) and others.

Application of heat-resistant engineering thermoplastic composites in critical components of oil and gas equipment gives a number of advantages, such as:

- low density, and consequently low weight of the product;
- corrosive resistance;
- hydro-abrasive wear resistance;
- wear resistance;
- low vibration of the product;
- chemical resistance;
- low friction factor;
- performance at dry friction;
- enhanced heat resistance;
- dimensional stability.

#### II.1.2. Engineering and Technical Purpose Polymers

**Tekhnamid** (glass-filled Polyamide-66) is the engineering glass-filled thermoplastic polymer that combines high mechanical strength, elasticity over a wide temperature range, anti-friction properties, high fatigue resistance and low strain relaxation. The material has excellent resistance to oil and gas and hydrocarbon products.

Tekhnamid exhibits the highest strength properties, good hardness level, excellent wear resistance, the highest heat resistance among polyamides, resistance to atmospheric factors, heat and moisture resistance, and chemical resistance.

Tekhnamid is used for production of critical parts operating under extreme mechanical load conditions (gear wheels, bushings, various housings).

ZAO "SPAZ "Plaza" (St. Petersburg) and the REAM Group co-designed the unique dividing piston for automotive gas-liquid (hydropneumatic) shock absorbers manufactured by OAO "GAZ".

The important functional purpose of the piston is to separate liquid and gas operating media. The piston consists of polymer "Tekhnamid" and the company specialist low friction elastomer seal which operates over a wide tempe-



**Dividing piston AV.32.09.00-01**

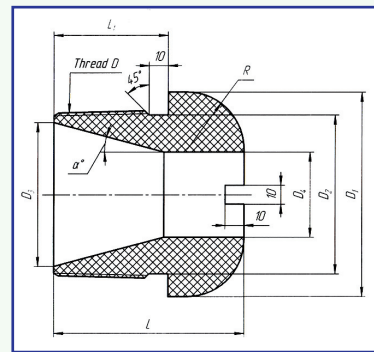
perature range.

The piston design prevents the cross migration of liquid and gas in single-tube shock absorbers that remarkably

increases the operational life of the absorbers and improves ride comfort.

**Polyoxymethylene resin (POM)** - is a high crystal thermoplastic self-lubricating polymer that combines high elasticity modulus at elongation and bend, rather high impact value, good anti-friction properties and high resistance to organic solvents. Long-term service temperature ranges from -60 °C up to +100...135 °C.

Polyoxymethylene resin combines high hardness level and impact resistance (also at low temperatures). It exhibits excellent spring properties, high fatigue life at dynamic loads and alternating impacts, low strain relaxation at high temperatures, good wear resistance and low friction coefficient, high dimensional stability including at high humidity, chemical resistance to automotive fuel, oils, organic solvents, weak acids and alkalies. Polyoxymethy-



**Drillable shoe nose**

Product number	Dimension, mm				
	D1	D2	L	L1	R
<b>BK-P 102-01</b>	110 ±0,5	98	110	69	30
<b>BK-P 114-02</b>	127 ±0,5	110	124	74	40

lene resin is resistant to mineral oils at temperatures of up to +100 °C. At higher temperatures the polymer swells and dissolves. It does not crack. It is not resistant to radiation. It has excellent shiny and hard surface.

The REAM Group jointly with OOO NTTs "ZERS" mastered production of the drillable shoe nose. The POM-made drillable shoe nose was successfully tested.

### Main properties of polymeric materials

**Table 5**

Parameters	Tekhnamid A-SV30-T-AF	Zytel HTN	PBT Crastin	POM Kepital	PPS	PEEK Victrex
<b>Strength at break, MPa</b>	170	200	130	62	195	190
<b>Tensile strength modulus, MPa</b>	10 000	10 000	10 000	8 200	14 700	12 000
<b>Elongation at break, %</b>	3,0	3,0	2,5	2,65	1,9	2,7
<b>Service temperature:</b>						
- long-time (up to 7 years)	150	150	150	100	240	260
- short-time (up to 24 hours)	200	200	170	135	270	315
<b>Moisture absorption, %</b>	1,9	1,5	0,2	0,2	0,02	0,1
<b>Hydrolysis resistance</b>	Good	Good	Medium	Excellent	Excellent	Excellent
<b>Chemical resistance</b>	Excellent	Good	Good	Excellent	Excellent	Excellent
<b>Electric strength, kV/mm</b>	24	25	36	19	28	30

## II.2. Products Made from Heat-Resistant Engineering Thermoplastic Composites for ESP Pumps

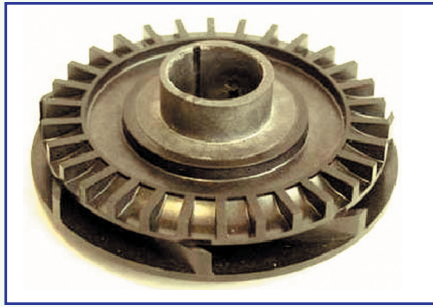
### II.2.1. Impellers

Two-hub design impellers of size 5 with the capacity of 50 m<sup>3</sup>/day and impellers of size 5A with the capacity of 124 m<sup>3</sup>/day (for ZAO "NOVOMET-Perm") have been currently commercialized. According to the design, the impeller centre zone can be manufactured from various anti-friction materials. Currently, impeller centre zones are manufactured from PPS or PEEK - the materials that exhibit enhanced tribological behaviour.

In case of insufficient heat resistance of PPS, PEEK can be used for impellers.

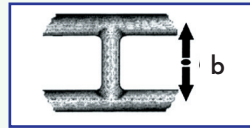
Such composite-made products replace Ni-resist cast iron impellers in wells where enhanced resistance to corrosion, scaling and chemical resistance are required.

To enhance the reliability of impellers the unique monolith impeller was designed.

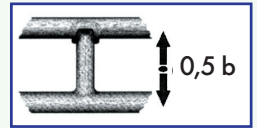


**Solid impeller  
from polymeric material**

Solid structure



**Weld design**

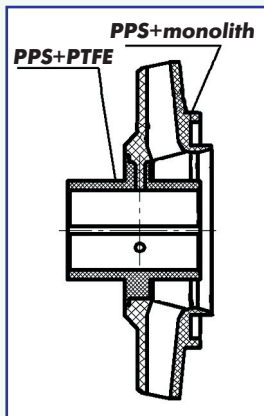


Strength differences

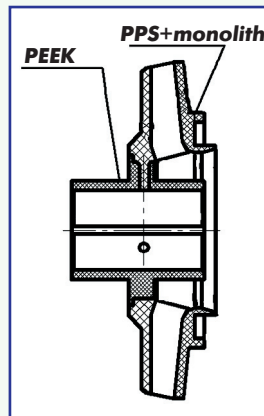
Polymer composite impellers versus Ni-resist cast iron impellers:

- scaling decrease;
- weight decrease;
- corrosion resistance.

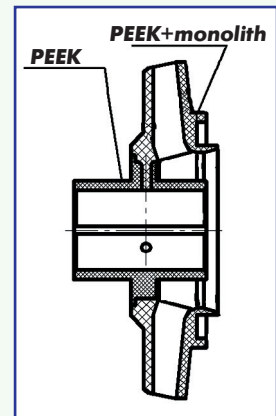
**"Monolith standard"  
Series**



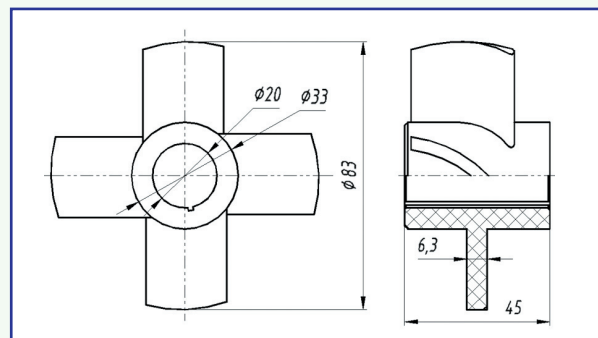
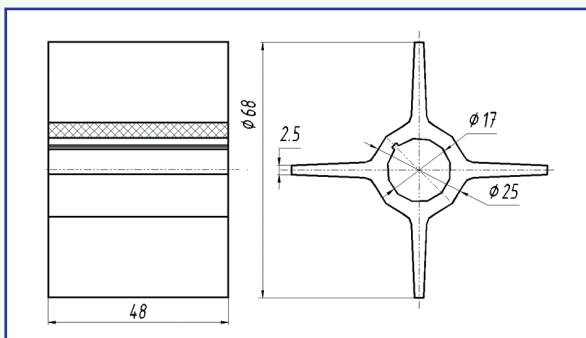
**"Monolith super"  
Series**



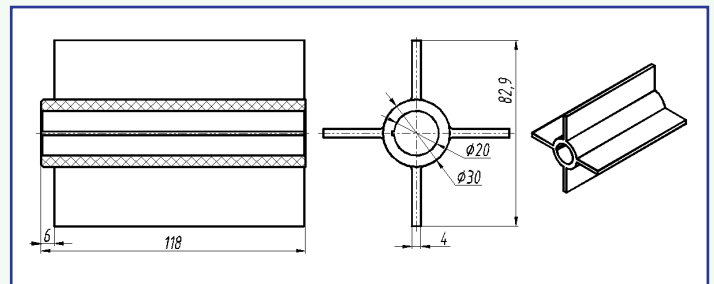
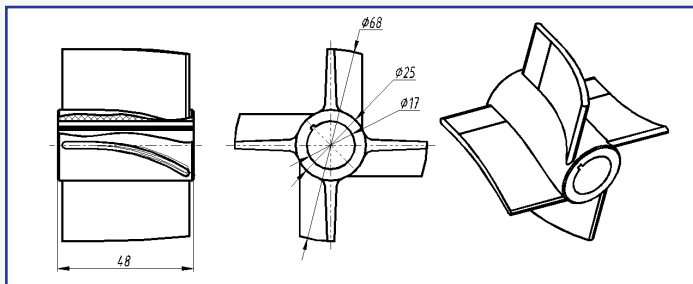
**"PEEK super+ "  
Series**



## II.2.2. Gas Separator Flow Rectifiers



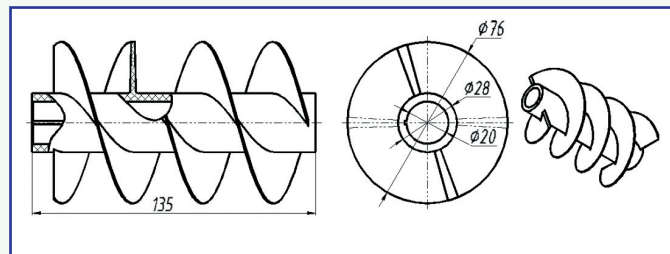
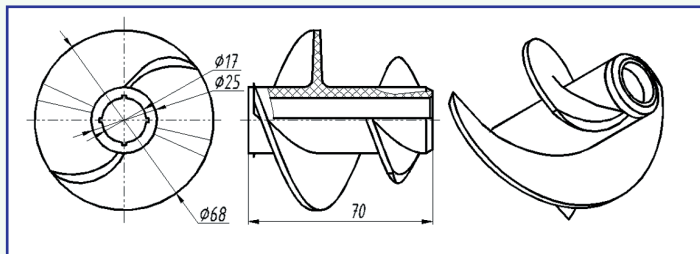
## II.2.3. Gas Separator Drums



Items in the catalogue are examples of mass production but we produce more products than are shown here



## II.2.4. Gas Separator Screw Types



Gas separator screw types

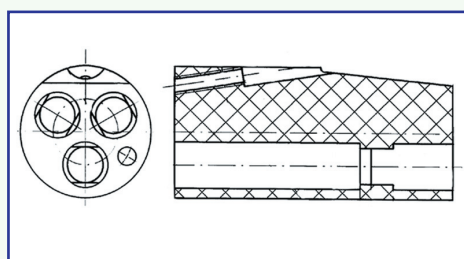


Polymer products

## II.2.5. Connecting Blocks for ESP Motors

### Technical features:

- operating temperature of up to +315 °C;
- high corrosion resistance;
- high chemical resistance.

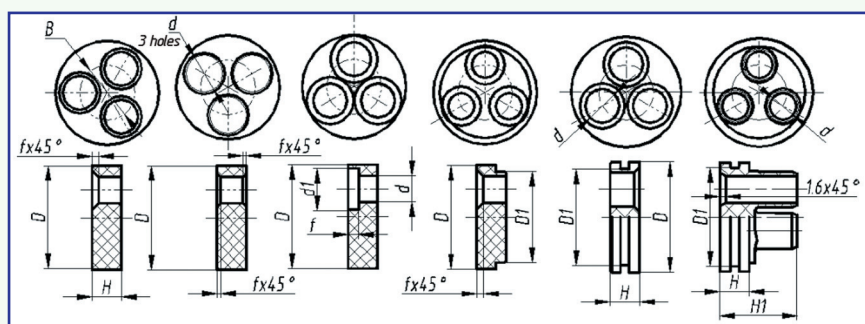


### Design

The design of the products enables to use the connecting blocks in ESP motors of the main Russian manufacturers such as OOO "Borets", OAO "ALNAS", ZAO "NOVOMET-Perm".

## II.2.6. Extension Cable Connector Thrust Washers

The list of the thrust washers produced by REAM-RTI, LLC:



Items in the catalogue are examples of mass production but we produce more products than are shown here

Table 6

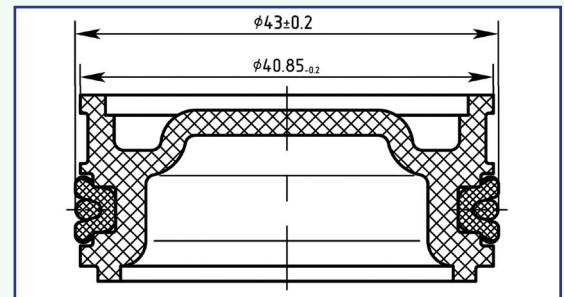
Product number	H, mm	D, mm	d1, mm	d2, mm	d3, mm	B, mm	Chamfers fxc°	Chamfers fxc°II
UB 001.006	8 <sup>-0,2</sup>	28,2 <sup>-0,21</sup>	10 <sup>-0,5</sup>	11,2	-	15 <sup>±0,1</sup>	-	-
UB 005.001	8 <sup>-0,2</sup>	28,2 <sup>-0,21</sup>	7,1 <sup>+0,15</sup>	-	24,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 005.002	8 <sup>-0,2</sup>	28,2 <sup>-0,21</sup>	9,2 <sup>+0,15</sup>	-	-	15 <sup>±0,1</sup>	1,8x45	-
UB 005.003	8 <sup>-0,2</sup>	28,2 <sup>-0,21</sup>	9,2 <sup>+0,15</sup>	-	-	15 <sup>±0,1</sup>	2 chamfers 1x45	-
UB 009.007	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	10,2 <sup>+0,18</sup>	11,5 <sup>+0,43</sup>	-	15 <sup>±0,1</sup>	-	-
UB 009.007-01	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	11,2 <sup>+0,18</sup>	12,3 <sup>+0,43</sup>	-	15 <sup>±0,1</sup>	-	-
UB 009.011	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	7,5 <sup>+0,15</sup>	-	26 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 009.011-01	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	8,8 <sup>+0,15</sup>	-	26 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 009.011-02	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	8,2 <sup>+0,15</sup>	-	26 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 009.012	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	9,5 <sup>+0,15</sup>	-	26,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 009.012-01	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	10,8 <sup>+0,18</sup>	-	26,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 009.012-02	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	10,2 <sup>+0,18</sup>	-	26,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 017.001	21	29,5 <sup>-0,21</sup>	7,2 <sup>+0,06</sup>	-	26,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,6x30	-
UB 017.002	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	7,3 <sup>+0,15</sup>	-	26 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45
UB 017.003	8 <sup>-0,09</sup>	29,5 <sup>-0,21</sup>	9,2 <sup>+0,15</sup>	-	26,7 <sup>-0,05</sup>	15 <sup>±0,1</sup>	1,8x45	0,5x45

### II.2.7. The Dividing Piston for Hydro- and Pneumatic Systems and Gas Shock Absorbers

Teknamid A-SV30-T-AF (piston)  
RS-26ch-5 (O-rings)

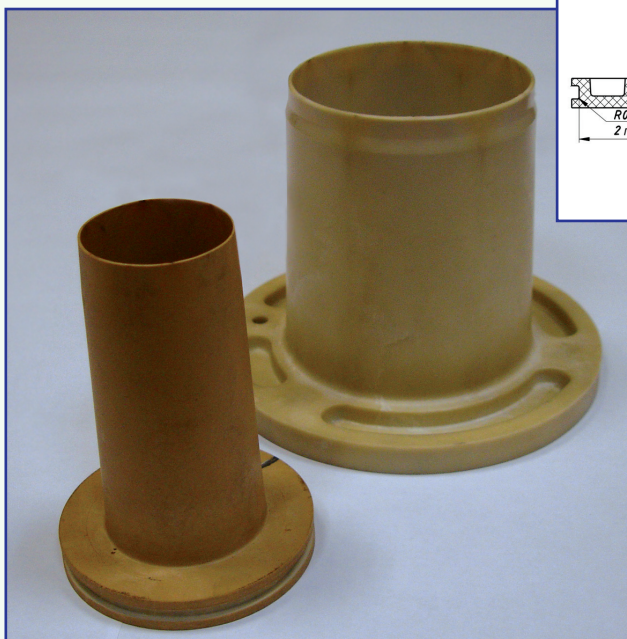
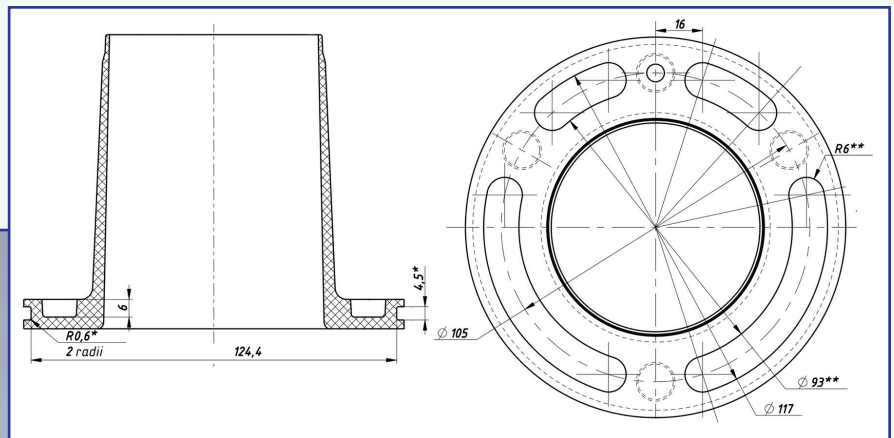
The unique specialist low friction sealing O-rings and the light polymeric piston from engineering polymer "Teknamid" enable to use the product in various hydro- and pneumatic systems, in gas shock absorbers as well as in critical highly sensitive devices.

Patent for the invention is № 2300680 (Dividing piston seal).

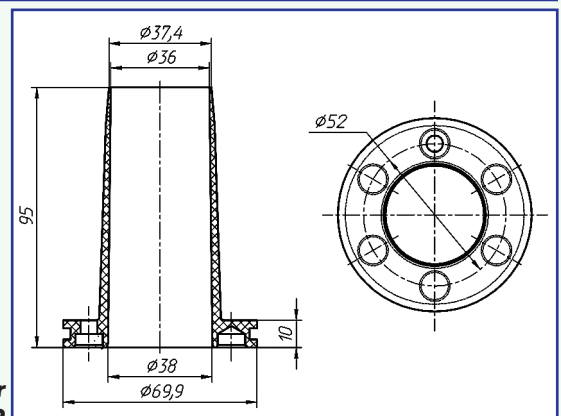


### II.2.8. Protective Cover for the Down-Hole Electric Motor

Protective cover RR.201.204.0090



Protective cover  
RR.201.204.0112



Items in the catalogue are examples of mass production but we produce more products than are shown here



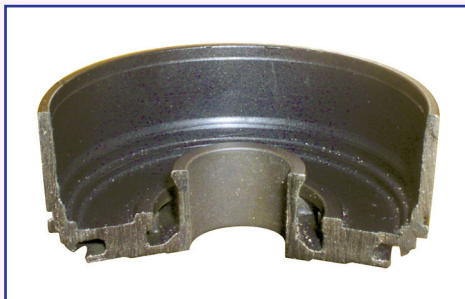
### III. POLYPHENYLENE SULPHIDE- AND POLYETHERETHERKETONE-BASED PROTECTIVE POLYMERIC COATINGS

In the REAM Group there was formulated a family of specialist liquid and powder polymeric compositions and there were mastered technologies of polymeric coating application on parts of submersible oil production equipment. The formulated polymeric composite coatings protect the equipment from all kinds of corrosion, scaling and paraffinic deposits, abrasive wear at service temperatures of up to +260 °C (PPS) and +310 °C (PEEK). The coatings exhibit high heat conduction, dielectric strength, high wear resistance, low scaling, hydrophobic, oleophobicity and unique chemical resistance.

*Products for oil production equipment  
with protective polymeric coating*



#### III.1. Pumping Stages (ESP Submersible Centrifugal Pumps, etc.) with Multilayer Anti-Scaling and Abrasion-Resistant Coating ("PPK-S", "PPK-SI")



*Polymer-coated diffuser  
(cut-away view)*

Our specialists formulated and successfully introduce the PPS-based polymeric coating. The coating safely protects ESP unit pumping stages from scaling, solids and corrosion. The multilayer protective coating consists of:

- binary cross-linking corrosion-resistant primer that provides a bond between the matrix and the polymer;
- 2 types of main PPS-based coatings:
  - a polymer composition "PPK-S" that provides resistance to scaling, paraffins and all kinds of corrosion;
  - a polymer composition "PPK-SI" filled with e.g. TiC and other fluoropolymeric additives that enhance abrasion resistant properties of the coating and provide resistance to scaling, paraffins and all kinds of corrosion.
- hydrophobic primer that provides hydro- and oleophobic properties of the base coating.

##### **Coating "PPK-S" (anti-scaling), its characteristics:**

- thickness of one coating layer - 35...50 µm;
- pH - 3...8 (0 pH - short-time);
- specific density -  $1,43 \pm 0,05$  g/cm<sup>3</sup>;
- matrix - steel, iron, aluminum, etc.;
- thermal resistance - up to +260 °C;
- pencil hardness - 2 H.

*Diffuser  
with anti-scaling  
coating*



##### **Coating "PPK-SI" (abrasion-resistant), its characteristics:**

- thickness of one coating layer - 50...65 µm;
- pH - 3...8 (0 pH - short-time);
- specific density -  $1,43 \pm 0,05$  g/cm<sup>3</sup>;
- matrix - steel, iron, aluminum, etc.;
- thermal resistance - up to +260 °C;
- pencil hardness - 4...5 H.

*Diffuser  
with abrasion-resistant  
coating*



Inside abrasion-resistant coating "PPK-SI" for tubes provides effective protection against scaling, paraffins, abrasion wear at service temperatures of up to +260 °C.

*Items in the catalogue are examples of mass production but we produce more products than are shown here*

### III.2. The Coating for Bodies and End Connecting Parts of Oil Production Equipment and Filters

**Protective scratch resistant coating "PPK-SZ"** for outside surfaces of oil production equipment body parts protects efficiently from scaling, mechanical impurities, corrosion (including electrocorrosion); it provides abrasion resistance of oil and gas equipment during reciprocal movements in down-hole columns. This enhanced abrasion resistance is due to the filler system of the polymeric composition, e.g.  $\text{Al}_2\text{O}_3$  in  $\alpha$ -form and fluoropolymer additives that increase hydrophobic and oleophobicity.



**Tube with inside abrasion-resistant and outside scratch resistant coating**

#### **Coating "PPK-SZ" (anti-scratching), its characteristics:**

- thickness of one coating layer - 100...150  $\mu\text{m}$ ;
- pH - 3...8 (0 pH - short-time);
- matrix - steel, iron, aluminum, etc.;
- thermal resistance - up to +260  $^{\circ}\text{C}$ ;
- pencil hardness - 5...6 H;
- enhanced abrasion resistance.



**Filter housing with protective coating**

### III.3. Protective Coating for Coupling Connector Threads

The coating effectively protects threads from corrosion. It provides more than 30 cycles of makeups-breakouts and cathode protection. Its protective features are similar to the ones of the material Coupling Guard (the USA).



**Coupling connector with the protective coating**

### III.4. Coating for Bearings

PEEK-based abrasion-resistant coating for bearings and contacting parts with anti-scaling properties at service temperatures of up to +310  $^{\circ}\text{C}$  in hydrogen sulphide-rich media.



**Bearing with the protective coating**



## IV. COMPRESSED WIRE MESH AND ITS PROPERTIES. EQUIPMENT WHERE COMPRESSED WIRE MESH IS USED

The REAM Group manufactures a variety of products from compressed wire mesh, including filtration elements and filters for cleaning liquid and gaseous media from solid particles.

The structure of compressed wire mesh is purposely oriented wire spirals which form an open porosity system as a result



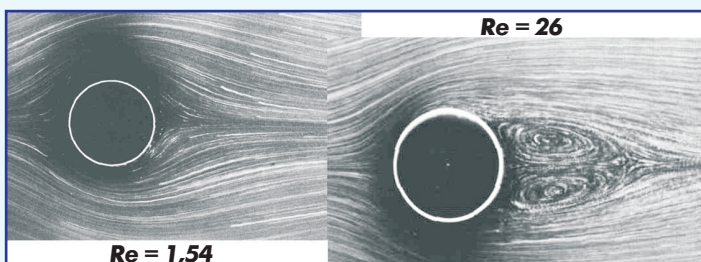
**Surface of compressed wire mesh**

of cold plastic deformation. The open porosity system provides all mechanical, physical and hydrodynamic parameters required.

The most important properties of compressed wire mesh are erosion resistance, strength, elasticity, damping ability and ability to recover.

The channel of the filtration element made from compressed wire mesh is a slot of variable cross-section between adjacent wire loops. Due to the eye-like shape of the filtration element channels, it is virtually impossible for solid particles to become lodged in the channel.

Laminar flow around the cylindrical section wire provides



**Cylindric body flow-around picture**  
(Sadatoshi Taneda)

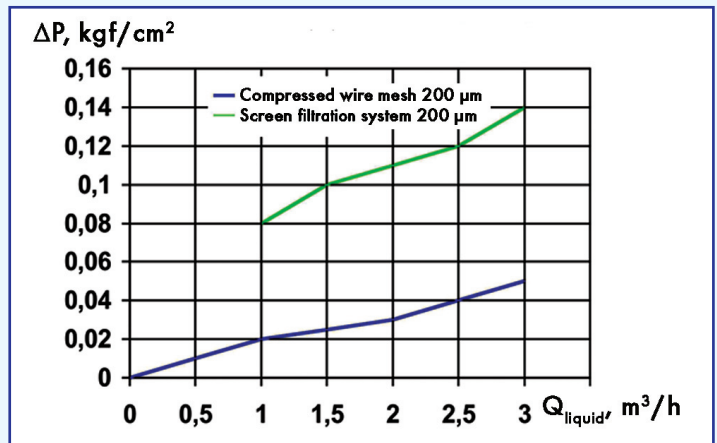
uniquely low hydraulic resistance of compressed wire mesh. Low hydraulic resistance enables the reduction of the active area of the filtration system by 1,5...2 times when compared to other filtration systems, while filter efficiency remains the same.

High erosion resistance of filtration elements from compressed wire mesh makes them a promising alternative to filters produced by powder metallurgy or screen technology, foam metal and screen filters.

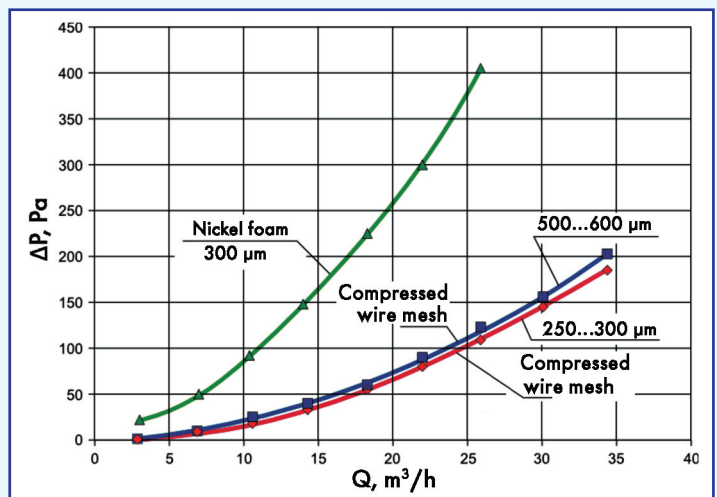
Due to their high strength, elasticity, corrosion and erosion resistance filtration elements from compressed wire mesh can be refurbished and users can get up to 90 % recovery of the initial filtration capacity.

Filtration elements from compressed wire mesh can be easily adapted to Customer's requirements in terms of shape, dimensions and efficient filtration surface. They can also have desired cutoff rating. The material for filters is metal wire of the required grade (stainless steel, nickel, tungsten, aluminum, copper, brass, nichrome, molybdenum, etc.) and diameter (0,03...1,2 mm). The wire material is chosen depending on the technical requirements of particular application and cost-functionality ratio. E.g., stainless steel or nichrome provides aggressive chemical media filtration, in particular filtration of polymeric solutions at temperatures of up to +800 °C.

REAM-RTI is able to produce multilayer anisotropic filtration elements of complex shapes, where the cutoff rating and wire material in each layer vary as required by the Customer.



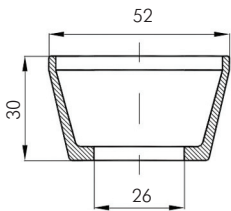
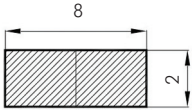
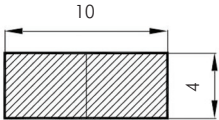
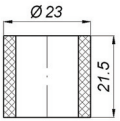
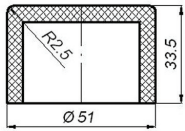
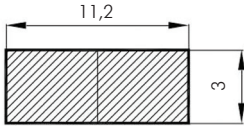
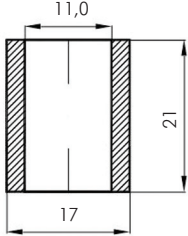
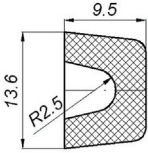
**Pressure/flow characteristic curves**



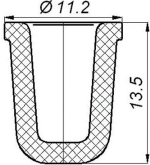
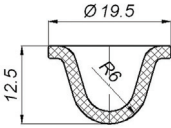
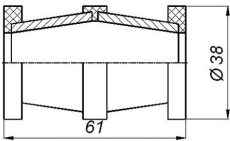
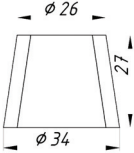
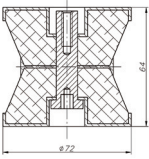
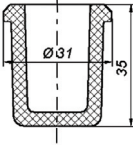
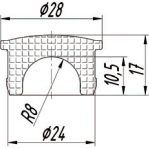
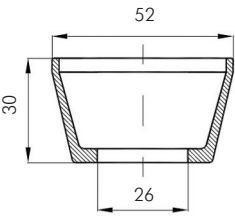
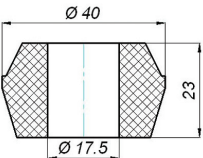
**Characteristic curves of Nickel foam and Compressed wire mesh in air**

Items in the catalogue are examples of mass production but we produce more products than are shown here

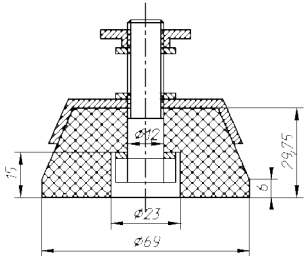
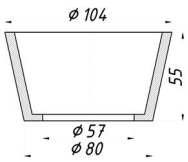
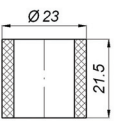
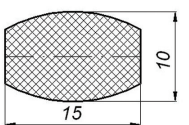
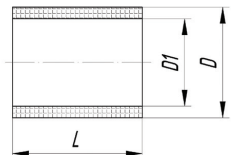
## IV.1. Products from Compressed Wire Mesh

<b>№</b>	<b>Drawing, dimensional specifications, mm</b>	<b>Product number</b>	<b>Product name</b>	<b>Application</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>1</b>		<b>100-3512035-01</b>	<b>Car air brake system pressure regulator valve filter</b>	<b>KamAZ, MAZ, ZiL, etc.</b>
<b>2</b>		<b>100-3521135-01</b>	<b>Car air brake system coupling head filter</b>	<b>KamAZ, MAZ, ZiL, etc.</b>
<b>3</b>		<b>100-3533025-01</b>	<b>Car air brake system brake force regulator filter</b>	<b>KamAZ, MAZ, ZiL, etc.</b>
<b>4</b>		<b>25.3519296</b>	<b>Brake chamber filter</b>	<b>KamAZ, MAZ, ZiL, etc.</b>
<b>5</b>		<b>ShG-51x34</b>	<b>Sound attenuating chamber</b>	<b>KamAZ, MAZ, ZiL, etc.</b>
<b>6</b>		<b>42837723-98-04 (FO-11,2x3)</b>	<b>Pneumatic cylinder filter of the actuator of bus/trolley-bus doors</b>	<b>Buses, trolley-buses</b>
<b>7</b>		<b>FO-21x17</b>	<b>Pneumatic circuit filter of bus/trolley-bus doors</b>	<b>Buses, trolley-buses</b>
<b>8</b>		<b>FO-13,6x9,5</b>	<b>Valve filter</b>	<b>Automotive fuel injection system, bus/trolley-bus liquid phase heaters</b>

Items in the catalogue are examples of mass production but we produce more products than are shown here

1	2	3	4	5
9		FO-14x11	Liquid phase heater injector filter	Automotive fuel injection system, bus/trolley-bus liquid phase heaters
10		FO-19,5x12,5	Breather filter	Vehicle hydraulic system tanks
			Brake system air dispenser filter	Railway transport
11		FO-2-34x27SB	Brake system air dispenser filter	Railway transport
12		FO-34x27	Rolling stock brake system air dispenser filtration element	Railway transport
13		KShMS.19.02.01.610SB	Shock absorber	Railway transport
14		100-3511330-01	Car air brake system line haul filter	All motor-vehicle trains
15		FSV-24x17	Inserted filtration element	Gas and liquid filters
16		100-3512035-01	Gas and liquid filtration element	Liquid and gas filtration units
17		V-1027-10	Damping bush	Units and equipment anti-vibration mountings

Items in the catalogue are examples of mass production but we produce more products than are shown here

1	2	3	4	5																																
18		VPM-1	Shock mount bush	Units and equipment anti-vibration mountings																																
19		FO-104x55	Filtration element of the cartridge filter	Production equipment																																
20		25.3519296-01	Gas-analyzer filter	Gas analysis equipment																																
21		RR-056.013.0029	Damper	Oil production devices																																
22	 <table><thead><tr><th>Product number</th><th>D, mm</th><th>d, mm</th><th>L, mm</th></tr></thead><tbody><tr><td>FSN-94x84x35</td><td>94</td><td>84</td><td>35</td></tr><tr><td>FSN-94x84x70</td><td>94</td><td>84</td><td>70</td></tr><tr><td>FSN-105x95x35</td><td>105</td><td>95</td><td>35</td></tr><tr><td>FSN-105x95x70</td><td>105</td><td>95</td><td>70</td></tr><tr><td>FSR-94x84x35</td><td>94</td><td>84</td><td>35</td></tr><tr><td>FSR-105x95x35</td><td>105</td><td>95</td><td>35</td></tr><tr><td>FSR-123x113x35</td><td>123</td><td>113</td><td>35</td></tr></tbody></table>	Product number	D, mm	d, mm	L, mm	FSN-94x84x35	94	84	35	FSN-94x84x70	94	84	70	FSN-105x95x35	105	95	35	FSN-105x95x70	105	95	70	FSR-94x84x35	94	84	35	FSR-105x95x35	105	95	35	FSR-123x113x35	123	113	35	FSN-94x84x35 FSN-94x84x70 FSN-105x95x35 FSN-105x95x70 FSR-94x84x35 FSR-105x95x35 FSR-123x113x35	Filtration element of the oil well filter	Oil production equipment
Product number	D, mm	d, mm	L, mm																																	
FSN-94x84x35	94	84	35																																	
FSN-94x84x70	94	84	70																																	
FSN-105x95x35	105	95	35																																	
FSN-105x95x70	105	95	70																																	
FSR-94x84x35	94	84	35																																	
FSR-105x95x35	105	95	35																																	
FSR-123x113x35	123	113	35																																	

## IV.2. Main Technical Characteristics of Filters

Cutoff rating - 5...600  $\mu\text{m}$ .

Differential pressure across the filter wall - up to 25 MPa.

Operating pressure - up to 200 MPa.

Operating media temperature range - from -60 °C up to +800 (3000) °C.

Repetitive cleaning of filters can be performed mechanically, by the reverse flow, ultrasonic vibration, burning of organic depositions, etc.

Unique properties of filters from compressed wire mesh promise wider applications in various manufacturing sectors and in oil and gas equipment.

## IV.3. Filter Intake Module FVPR with Compressed Wire Mesh Filtration Elements

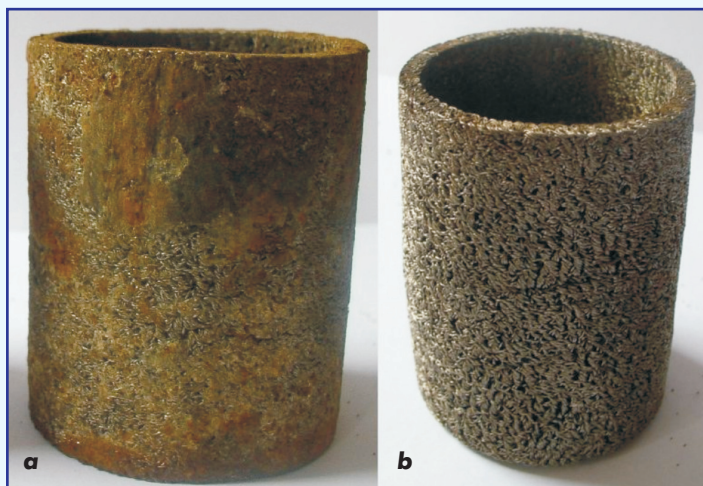
### Application

Filter intake module of the REAM Group FVPR, with externally positioned compressed wire mesh filtration elements, has been designed for application in ESP units 5, 5A

and 7A with nominal outputs of 15...600  $\text{m}^3/\text{day}$  to prevent penetration of solids such as sand, proppant, etc. with particle sizes exceeding 200 (100)  $\mu\text{m}$  into the pumping units.

*Items in the catalogue are examples of mass production but we produce more products than are shown here*





**Filtration element:**  
a) before recovery, b) after recovery



**Filtration elements of FVP filter**

### Advantages

1. ESP pump offers enhanced reliability, effective operation and run life increase.
2. High filter capacity due to modular structure of the compressed wire mesh filtration system and filter section design.
3. Crevice effect of the compressed wire mesh and ability of filtration elements to remain clear of solids.
4. 1,5...2 times reduction in total filter length due to high porous surface of the compressed wire mesh and low hydraulic resistance of the filter as compared to slotted and screen filtration systems.
5. ESP unit long-term operation without output decrease.
6. Possibility to alter cutoff rating by force of controlled pre-press of filtration elements.
7. Insensitivity to shock loads and hole curvature due to elastic properties of compressed wire mesh.
8. High corrosion and erosion resistance of filtration elements from compressed wire mesh and possibility of their recovery during servicing operations.

### Design Philosophy of the Filters

To prevent decrease of ESP units flow rate due to filtration element blinding bypass valves are utilized in the filter.

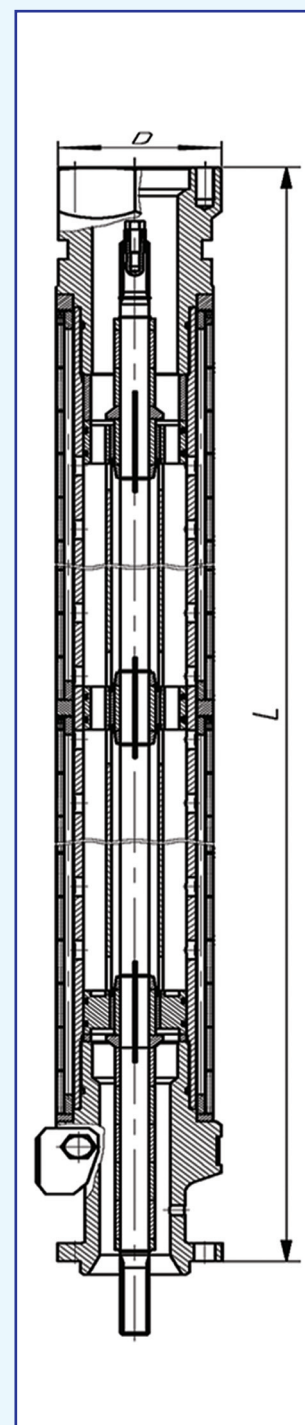
Filtration elements have protective ends from stainless steel to protect edges of filtration elements and to make them rigid.

Production process and the design of filtration elements enable to get desired channel size and filtration rating of 50...600  $\mu\text{m}$ . Filtration rating of 200  $\mu\text{m}$  is in high-demand for filters of ESP units.

### FVPR Filters Sections

Filters FVPR size of 5, 5A and 7A with externally positioned filtration elements and rating 100 and 200  $\mu\text{m}$  are manufactured according to Russian Technical Requirements TU 3665-030-46521402-2010.

Filter	Filter section installed length, mm	Filter section net weight	Carrying capacity of the filter section at filtration rating of, $\text{m}^3/\text{day}$	
			200 $\mu\text{m}$	100 $\mu\text{m}$
<b>FVPR5-12-030-150 (60)</b>	3230	90	150	60
<b>FVPR5-12-040-200 (80)</b>	4230	110	200	80
<b>FVPR5-12-050-250 (100)</b>	5230	130	250	100
<b>FVPR5A-12-030-180 (75)</b>	3230	95	180	75
<b>FVPR5A-12-040-240 (100)</b>	4230	125	240	100
<b>FVPR5A-12-050-300 (125)</b>	5230	150	300	125
<b>FVPR5A-16-050-400</b>	5230	150	400	-
<b>FVPR7A-16-030-200</b>	3250	125	200	-
<b>FVPR7A-16-040-300</b>	4250	160	300	-
<b>FVPR7A-16-050-400</b>	5250	190	400	-

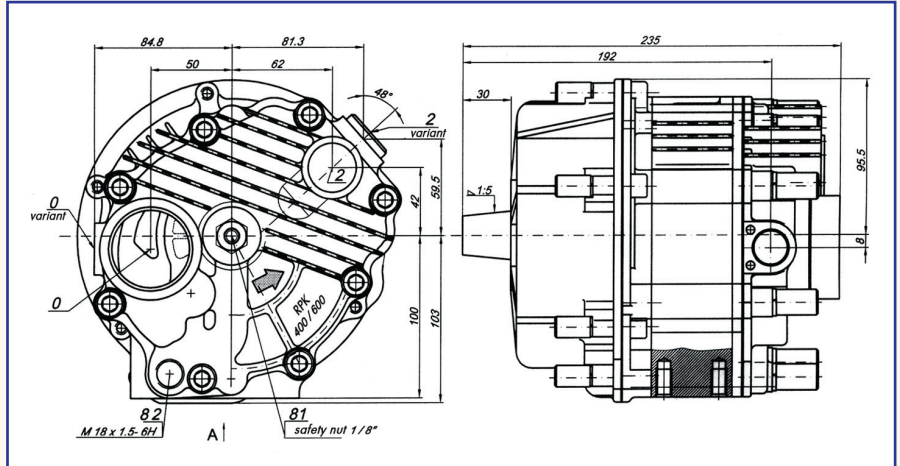
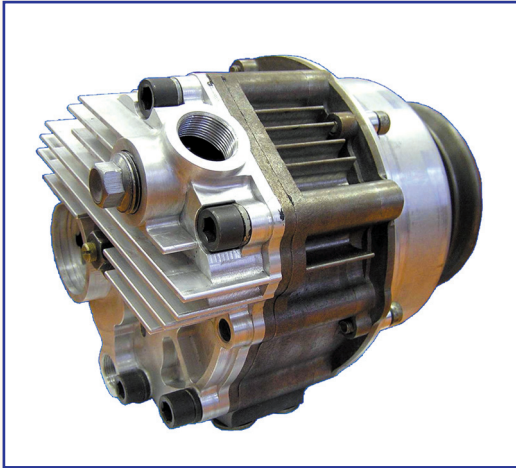


Items in the catalogue are examples of mass production but we produce more products than are shown here

## V. R&D WORKS

R&D group of the company works on design and prototype production of new pumping and compressor equipment, in addition work is done to optimize machine assemblies and mechanisms.

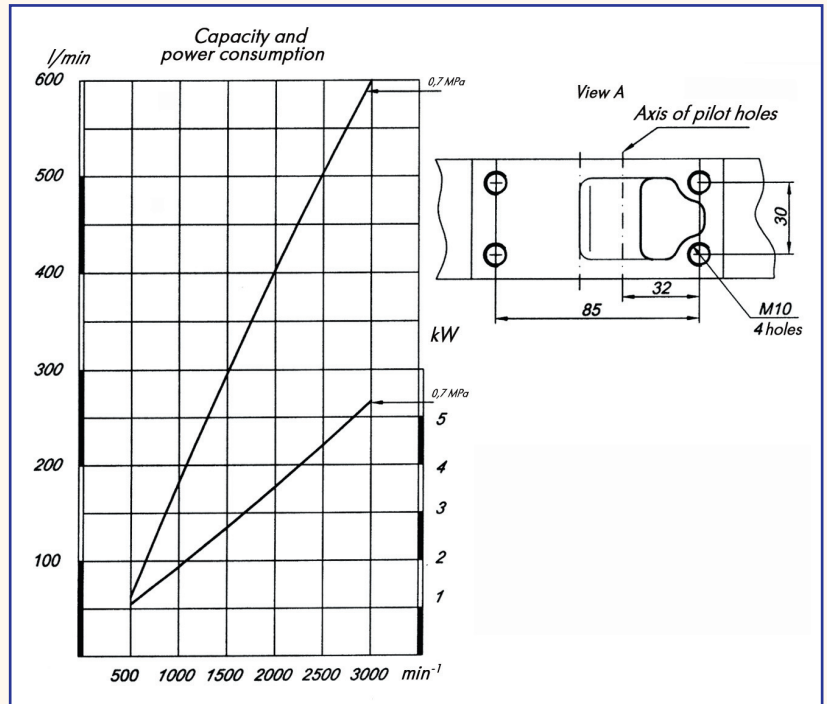
### V.1. Trochoid Rotary-Piston Compressor RPK 400/600



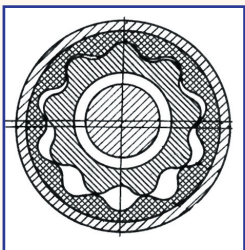
At present a trochoid rotary-piston compressor RPK 400/600 is one of the objects for the automotive industry designed by REAM's engineers and designers.

#### Technical characteristics:

- Number of sections - 1;
- Working volume per revolution -  $316 \text{ cm}^3$ ;
- Nominal pressure -  $0,7 \text{ MPa}$ ;
- Maximum pressure -  $1 \text{ MPa}$ ;
- Nominal speed, rpm -  $2200 \text{ min}^{-1}$ ;
- Maximum speed, rpm -  $4000 \text{ min}^{-1}$ ;
- Cooling - air;
- Lubrication - forced, motor oil;
- Capacity -  $24 \text{ m}^3/\text{h}$  ( $400 \text{ l/min}$ ) at  $n = 2000 \text{ min}^{-1}$ .



### V.2. Stators of PCP Pump Screw Pairs



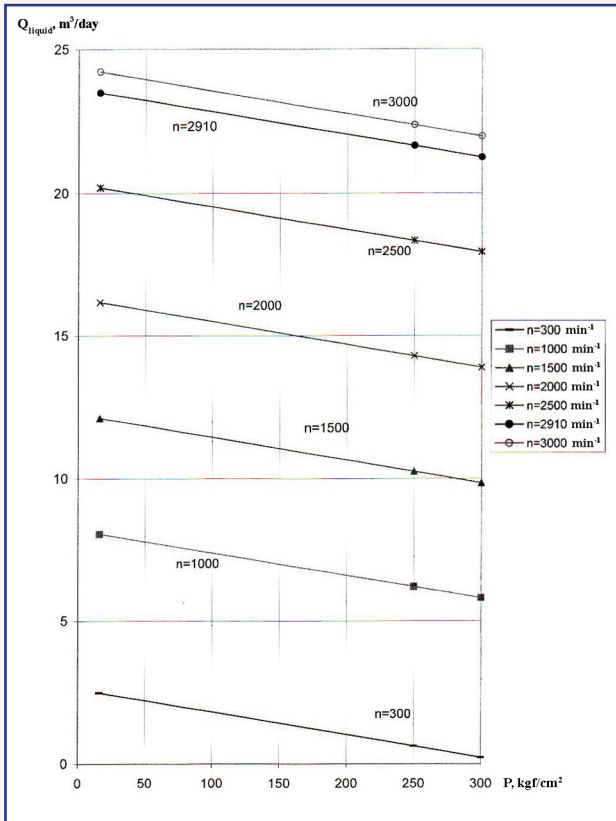
Company professionals formulated an elastomeric NBR-based compound with low friction coefficient for priming of down-hole drilling motors of up to 2,5 m long for drilling of oil and gas wells. The elastomeric compound, made by injection moulding, fully meets the requirements for priming of down-hole drilling motors.



### V.3. Gerotor Pump

A family of submersible gerotor pumps GPN was designed in the REAM group. The pump can be actuated both by the submersible electric motor and by the surface motor. The pump design is based on the original, patented in Russia engineering solutions. New materials and advanced technologies are used in pump production.

Bench gerotor multiphase pump (the pilot gerotor multiphase pump model) operating in well gas liquid fluid medium proved its efficiency at differential pressure of the pump of 1,5 MPa; taking leakage, friction and hydraulic losses into the account the pump efficiency is 0,7 MPa.



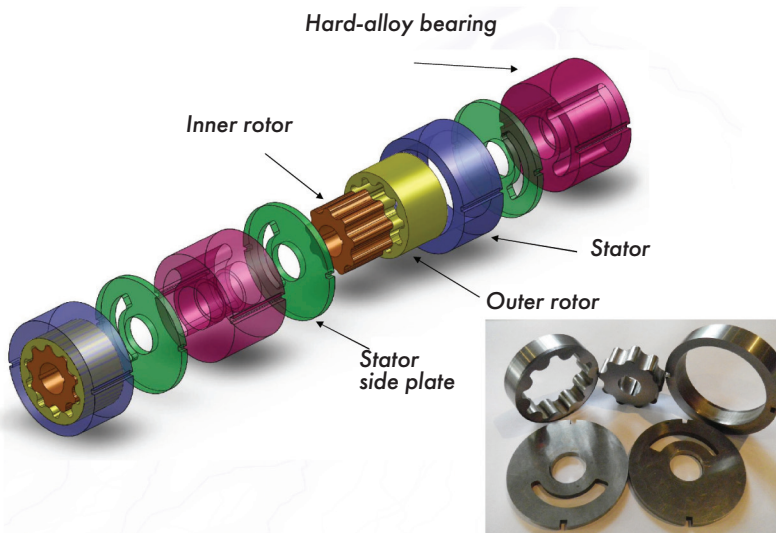
**Pump GPN4-50-2000.**  
 $Q_{\text{liquid}}$  versus  $P$  at different fixed values of  $n$   
 and at efficiency coefficient = 0,7

#### Advantages:

- Positive-displacement type of the pump;
- Operating pressure per one pumping stage - 3 MPa;
- Modularity;
- Diameter - 2 inches min;
- Short specific length of the pumping unit;
- Low central load;
- Capacity is regulated by the rate speed;
- Operation in high-temperature media (of up to +300 °C);
- Operation in viscous fluid;
- Minimal vibration.



#### The submersible gerotor pump



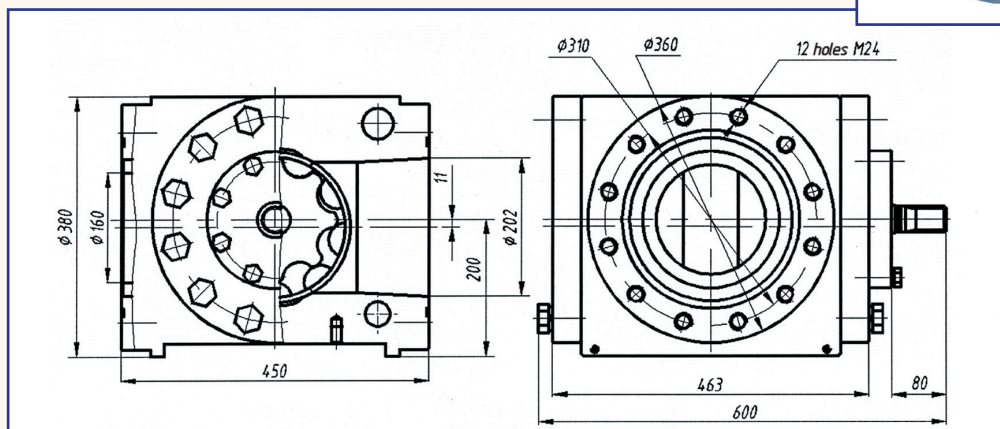
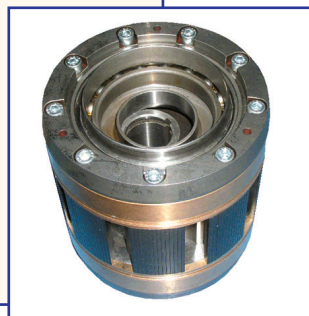
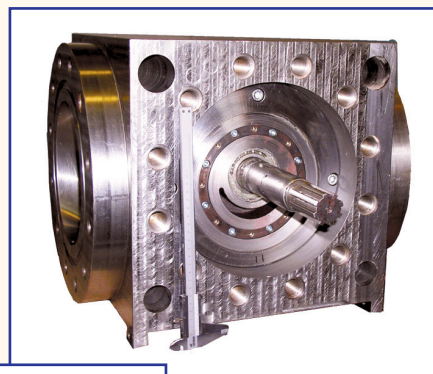
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## V.4. Multiphase Pump NPM 200/600

Multiphase transfer pump NPM 200/600 was designed for oil and gas industry. Its pilot model bench development is underway.

### Technical characteristics:

- Pump design type - gerotor;
- Number of sections - 1;
- Working volume per revolution - 0,81 l;
- Operating medium - well gas liquid fluid (GLF);
- Pump inlet GLF temperature - up to 80 °C;
- Pump inlet GLF pressure - up to 6 MPa;
- Pump differential pressure - up to 7 MPa;
- Maximum speed, rpm - 3000 min<sup>-1</sup>;
- Capacity in GLF - up to 130 m<sup>3</sup>/h;
- Pump inlet gas content - up to 100 % during 1 hour;
- Power consumption - up to 125 kW;
- Cooling - liquid;
- Lubrication of bearings - motor oil.



## V.5. Piston Module of the Down-Hole Motor Seal Section

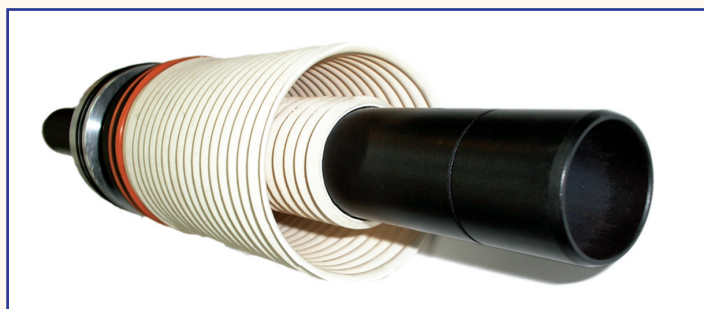
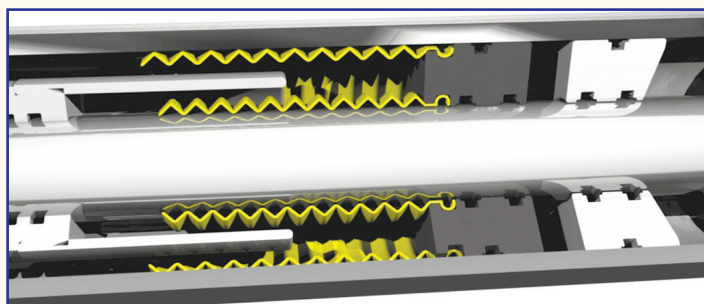
The REAM Group company experts designed the piston module of the ESP unit protector for the oil and gas industry.

### Intended Purpose

The piston module is designed to be installed in seal sections of down-hole oil-filled electric motors to separate the operating medium (oil) and the well fluid, to compensate for oil leakage and temperature variations of the oil volume while the down-hole electric motor operates. The piston module can be installed in the seal sections of the ESP unit in sizes from 3 to 9.

### Piston module specifications

- Operating surfaces of the piston module are protected by hydrophobic grease/buffer fluids from the well fluid.
- Corrugated protective elements prevent mechanical impurities penetrating into the grease and into the vicinity of the seals of the pistons.
- Two independent, free moving pistons applied provide:
  - enhanced sensitivity to pressure change due to the gas spring effect;



**The piston-type system of the module**

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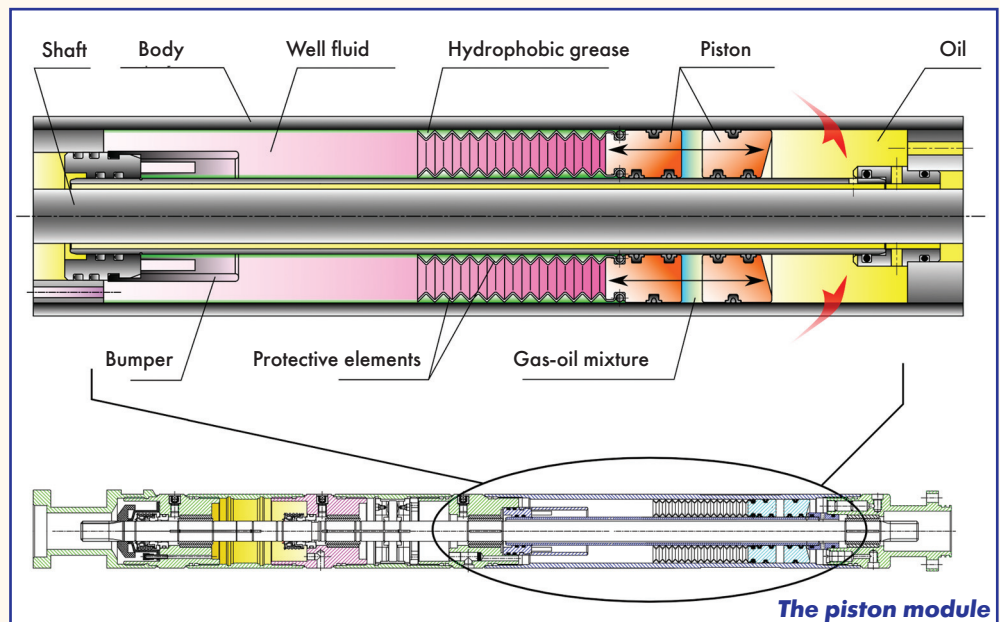


- high protection of the electric motor oil well chamber from gas and liquid oil well medium penetration;
- high reliability of the system due to doubling of the separator of the operating medium (oil) and the well fluid.

- Pistons and seals are not sensitive to bending deformation of the pump body.

- Pistons and their seals prevent gas migration from the well fluid into the operating medium.

- Pistons and their seals are made from materials resistant to aggressive media and high temperatures (of up to +300 °C for seal sections).



#### **Use of the protector with the piston module**

- Harsh operating conditions in directional-horizontal production wells.
- Wells with high gas content.
- High temperatures of the well fluid at the bottom of the electric motor (of over +140 °C):
  - when using the technology of superheated steam injection into wells (SAGD technology);
  - in geothermal environments.

- Corrosive well media that contain  $H_2S$  and chemical agents (pH 2...12).
- High content of the mechanical impurities in the well fluid.

#### **Advantages of the use of the protector with the piston module**

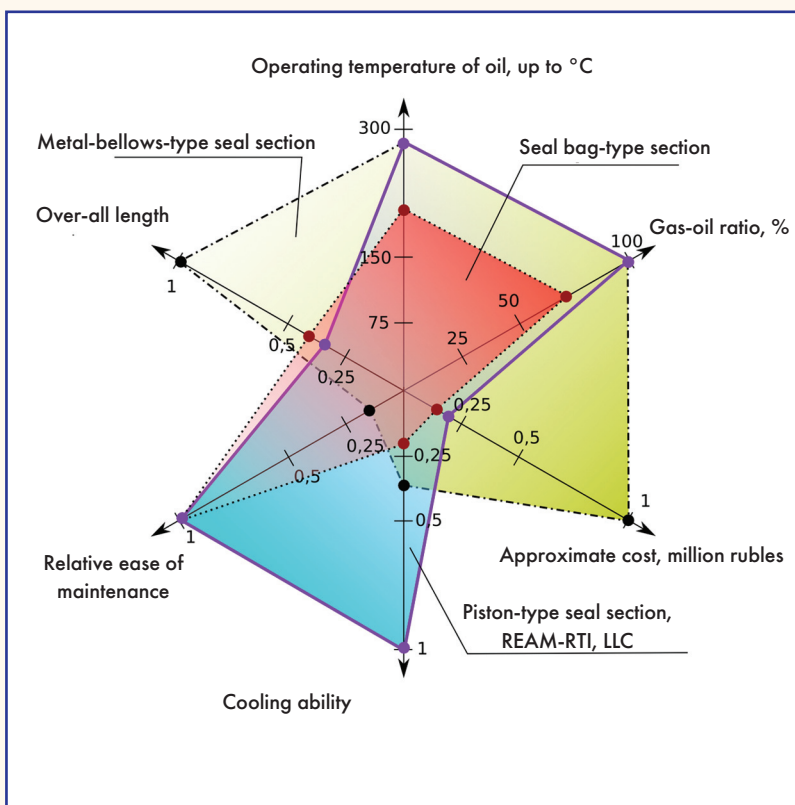
- Operating temperatures of down-hole oil-filled electric motors are reduced due to efficient cooling of the motor oil through the housing walls. (Distinct from the seal bag-type and metal-bellows-type protectors, the piston module has no additional heat-transfer resistance, thus thermal build-up is eliminated).

The protector with the piston module may be applied in wells with extremely high gas-oil ratio.

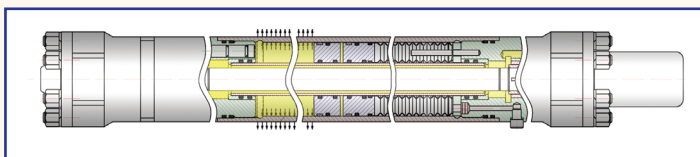
- Due to presence of two free pistons damping sharp volume changes in the system, there is a minimal risk of the shaft face seal failure and of instantaneous oil release.
- The protector operates efficiently in any position or orientation.
- Shortened length of the protector reduces the risks of the equipment trips in directional well sites.
- Piston-type protectors for high temperature operating media (of up to +300 °C) enable mastering thermal technologies for viscous and super-viscous oil production as well as for geothermal springs exploitation.
- Good maintainability.

#### **Test results**

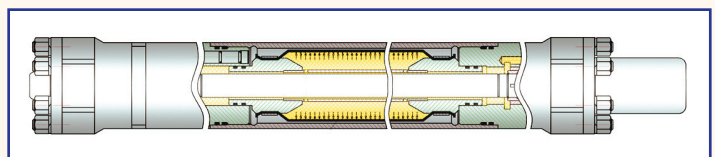
The piston-type protectors PBP92 underwent operating tests in wells of Tomskneft-VNK, Samaraneftegaz, Surgutneftegaz and Rosneft, the protector GZNP-92/5-00 - in Tatneft (Ashalchinskoe field of bituminic oils).



**Comparative analysis of parameters of heat resistant protectors of different types**



**Heat transfer of the piston-type protector**



**Heat transfer of the seal bag-type protector**

Items in the catalogue are examples of mass production but we produce more products than are shown here

***Piston module application according to ESP unit sizes***

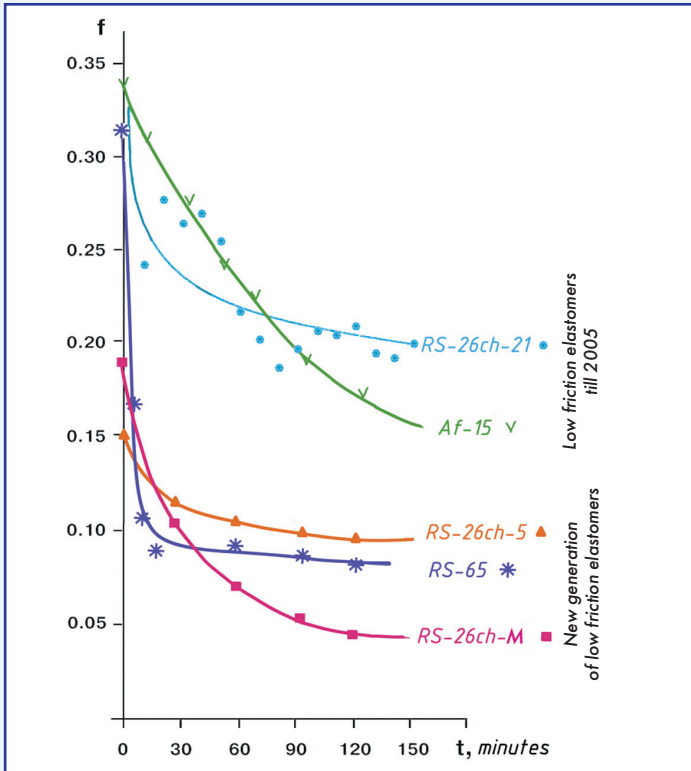
<b>ESP unit, size</b>	<b>Minimum inner diameter of the casing string, mm</b>	<b>Maximum diameter of the motor body, mm</b>	<b>Maximum diameter of the protector body, mm</b>	<b>Volume of the compensation chamber, l</b>	<b>Maximum compensable oil volume of the down-hole electric motor at <math>\Delta T = 200\text{ }^{\circ}\text{C}</math>, l</b>	<b>Approximate capacity of the down-hole electric motor, kW</b>
<b>3</b>	100	81	81	1,0...3,3	17	100
<b>4</b>	112	96	86	1,1...3,8	20	125
<b>5</b>	121,7	117 (103)	92	1,2...4,1	22	150
<b>5A</b>	130	117 (103)	103	1,6...5,3	28	250
<b>6</b>	143	130	114	1,9...6,2	33	300
<b>6A</b>	154	130	123	2,2...7,5	39	400
<b>7</b>	159	130	130	2,5...8,6	45	500
<b>7A</b>	165	143	136	2,8...9,3	49	600
<b>8</b>	213	189	172	4,1...15,3	80	1100
<b>9</b>	225	189	185	5,5...18,3	96	1500

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## VI. Appendix

### Appendix 1

#### Evaluation of Friction Coefficient $f$ Versus Test Duration $t$ for "Elastomer Thrust Washer/Carbon Steel Ring (high carbon steel)" Test Samples

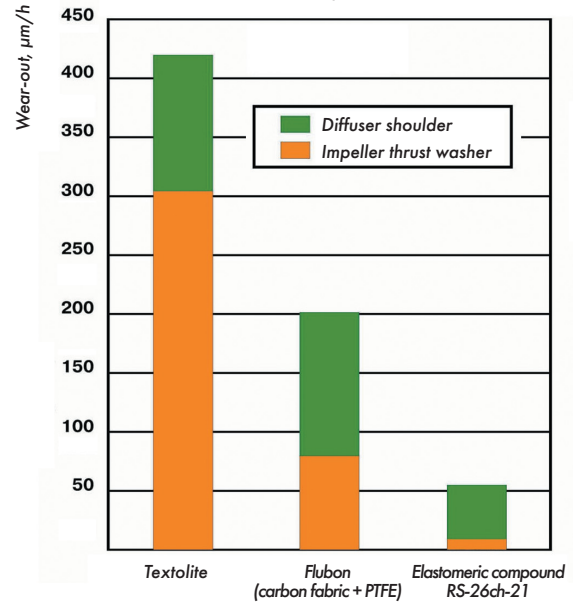


### Appendix 2

#### Abrasion Resistance Comparison Bar Graph for "Elastomer Thrust Washer/Carbon Steel Ring"

Influence of thrust washer material on the wear ratio of ESP pump stage contact surfaces (diffuser material - NOVOMET-Perm's abrasion-resistant metal powder alloy)

Test environment: mono corundum particle-rich water - 10g/10l  
Liquid flow - 2,08 m<sup>3</sup>/h  
Average size of abrasion particles - 15  $\mu$ m



### Appendix 3

#### Test Parameters According to Requirements of NACE TM 0192-98 and ISO 23936-2 Standards

Testing parameter	NACE TM 0192-98	ISO 23936-2
Gaseous medium composition	100 % CO <sub>2</sub>	10 % CO <sub>2</sub> + 90 % CH <sub>4</sub> 10 % CO <sub>2</sub> + 90 % N <sub>2</sub>
Temperature, °C	20...30	100 $\pm$ 2
Pressure, MPa	5,2 $\pm$ 0,3	15,2 $\pm$ 1/-0,5
Exposure time.	24 $\pm$ 1 hrs x 1	68 hrs x 1
Number of cycles		Total cycles - 8
Pressure release time to the norm (decompression)	< 1 min	2 $\pm$ 0,2 MPa/min
Shape of the sample	O-ring 37,47 x 5,33	O-ring 37,47 x 5,33
Number of samples	3 at least	4 at least
Classification of damages	External examination; examination of the cut; photographing; class rating system 1 - 4	External examination; examination of the cut; photographing; class rating system 0 - 5

Items in the catalogue are examples of mass production but we produce more products than are shown here

## Appendix 4

### O-Ring Troubleshooting and Failure Analysis

#### Abrasion



**Description:** The seal or parts of the seal exhibit a single flat surface parallel to the direction of motion. Loose particles and scrapes may be found on the seal surface.

**Contributing Factors:** Rough sealing surfaces. Too high temperatures. Process environment containing abrasive particles. Inadmissible dynamics of reciprocal motion of sealing parts. Sealing surfaces too smooth to allow for adequate.

**Suggested Solutions:** Use recommended gland surface finishes. Use elastomers with antifriction volume modification. Eliminate abrasive components or protect seal from exposure to them.

#### Compression set



**Description:** The seal cross-section looks flattened. The flattened sides correspond to the shape of contact surfaces of the seal.

**Contributing Factors:** Incompatibility with chemical environment and/or heat application conditions and excessive squeeze. Incomplete cure of the elastomer seal. Application of elastomer with high compression set. Excessive volume swelling of elastomer in chemical medium.

**Suggested Solutions:** Apply elastomer with low compression set. Use correct geometrical dimensions of the groove.

#### Chemical Degradation

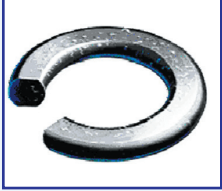


**Description:** The seal may exhibit signs of degradation including blisters, cracks, voids or discoloration. However, in some cases the degradation is only detectable by measurement of physical properties.

**Contributing Factors:** Incompatibility with chemical environment.

**Suggested Solutions:** Use more chemically resistant elastomer.

#### Contaminating impurity



**Description:** Surface impurities can be seen on the seal surface and also embedded into the seal section.

**Contributing Factors:** Contamination from the service/application environment. Elastomer is exposed to aggressive media or it has been degraded (e.g. under excess temperature).

**Suggested Solutions:** Eliminate elastomer impurity level while manufacturing and packing seals.

#### Explosive Decompression



**Description:** Explosive decompression results when high-pressure gases are absorbed by the seal, and then, as the pressure is rapidly dropped, the expanding gases are trapped in the micropores of the elastomer, causing surface blisters and ruptures as they escape. The effected seals will exhibit random short splits or ruptures deep into the seal cross-section. When first removed the surface may also be covered with small blisters.

**Contributing Factors:** Rapid pressure drop from high pressure. Low-hardness/low-modulus elastomer.

**Suggested Solutions:** Specify a higher-modulus/higher-hardness material. Specify a decompression-resistant material. Slow the release of system pressure.

#### Extrusion or Nibbling



**Description:** The seal develops ragged edges, generally on the low pressure side, which appear tattered. This condition is more common with high pressure systems.

**Contributing Factors:** Excessive clearances. Excessive system pressure. Low-hardness/low-modulus elastomer. Irregular clearance gaps due to eccentricity. Sharp groove edges. Excessive gland fill. Expansion of cylinder wall due to pressure.

**Suggested Solutions:** Decrease clearances. Decrease system pressure if possible. Use higher-hardness/higher-modulus elastomer. Use back-up ring. Increase rigidity and concentricity of metal components. Use more chemically compatible elastomer. Increase groove width or change O-ring size. Stiffen cylinder wall to limit expansion.





#### **Installation Damage**

**Description:** The seal or parts of the seal may exhibit small cuts, nicks or gashes.

**Contributing Factors:** Sharp surfaces on glands or components. Inadequate lead-in chamfer. O-ring too large for gland. Low-hardness/low-modulus elastomer. Seal surface contamination.

**Suggested Solutions:** Break all sharp metal edges and cover threads with tubes or tape for installation. Provide a 15° lead-in chamfer of adequate length so O-ring sees only chamfer. Review gland and O-ring design per recommended design standards. Specify a higher-hardness/higher-modulus material.



#### **Plasticizer Extraction**

**Description:** It is often difficult to detect with only a visual inspection. The seal may look like the seal with undersize cross-section.

**Contributing Factors:** Incorrect elastomer or incorrect elastomer curing process. High vacuum. Low hardness/modulus. Low- molecular-weight plasticizer.

**Suggested Solutions:** Switch to elastomer with low-temperature properties so plasticizers aren't needed. Change plasticizers used to ones less compatible with process fluids. Use the second curing cycle to minimize gas release.



#### **Over-Compression**

**Description:** The seal exhibits parallel flat surfaces corresponding to the sealing surfaces. May also develop circumferential splits within the flattened surfaces.

**Contributing Factors:** Excessive compression squeeze. Elastomer with poor compression set properties. Elastomer with inadequate heat resistance. Elastomer that swells excessively in system fluid. Improperly cured part used.

**Suggested Solutions:** Use smaller O-ring or adjust gland dimensions. Use material with better compression set resistance. Use more heat resistant elastomer. Use more chemically resistant elastomer. Check cure state of parts prior to installation.



#### **Degradation in plasma medium**

**Description:** Discoloration is often detected on the seal. Erosion of the elastomer part is possible in areas exposed to the plasma. Some powdering of the surface is possible.

**Contributing Factors:** Chemical reaction capacity of plasma. Ion bombardment of the surface. Electron bombardment (overheating). Incorrect groove design. Incompatibility of sealing material and plasma medium.

**Suggested Solutions:** Eliminate plasma influence.



#### **Spiral Failure**

**Description:** The seal surface exhibits a series of deep or spiral cuts. This failure is often seen with long-stroke, hydraulic piston seals.

**Contributing Factors:** Mounting technique problems. Eccentric components. Wide clearances in combination with side loads. Elastomer is too soft. Low-hardness/low-modulus elastomer. Stroke speed too slow - dynamic reciprocating. Uneven surface finishes. Inadequate lubrication.

**Suggested Solutions:** Revise mounting technique of the seal. Use elastomer with higher hardness/modulus. Use elastomer with antifriction volume modification. Specify an external lubricant or use an internally lubricated material. Use a higher durometer material. Increase stroke speed or use D-ring instead of O-ring.



#### **Heat Hardening/Thermal Degradation**

**Description:** The seal may exhibit radial cracking on the highest temperature surfaces, often accompanied by the flattening of the seal characteristic of over-compression. Certain elastomers may exhibit signs of softening, such as a shiny surface.

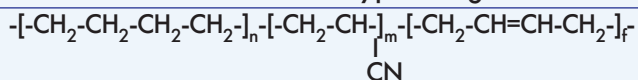
**Contributing Factors:** Thermal properties of elastomer. Excessive temperatures, temperature excursions or temperature cycling.

**Suggested Solutions:** Select more heat-resistant elastomer. Consider possibility of cooling sealing surfaces. Increase thermal mass to dampen temperature cycling or excursions.

## Appendix 5

### The Use of HNBR in Manufacturing of Technical Rubber Products

Hydrogenated nitrile-butadiene rubber is a new type of high-saturated elastomer with the structure as follows:



Regarding heat resistance HNBR is found in between NBR and FKM. Service temperature range of products based on HNBR is from -50 °C up to +200 °C.

Compared to fluoroelastomers hydrogenated rubbers show good resistance to amines, spirit- and sulphur-rich fuels and oils. Elastic-strength figures of HNBR are 1,5...2,0 as high as FKM. Additionally, HNBR-based elastomers have better processability compared to elastomeric compounds based on fluoroelastomers. HNBR elastomers do not require special cross-linking agents and vulcanization accelerators.

The use of new oils and fuels with more aggressive additives for longer service life and improved performance, increased automotive "under bonnet" temperatures, longer warranties, less maintenance time tolerated etc. have resulted in higher technical demands and requirements placed on elastomer products for both aerospace and automotive applications. These new fluids and higher service temperature requirements have led to a growing demand in elastomers with enhanced properties.

Elastomeric parts designed for oil and gas field applications must be resistant to mechanical wear as well as chemical attack from the aggressive drilling and cutting fluids (for example - synthetic oils, methane, carbon dioxide, hydrogen sulphide, acids, amines, etc). The influence of these aggressive media is increased at high pressure and high temperatures.

HNBR-based elastomers show a well balanced performance in fuel, oil, heat, ozone, at low temperatures ensuring their use in a wide range of products and applications.

HNBR-based elastomers exhibit the following properties:

- good physical properties also at high service temperature in synthetic oils and in air;
- good wear resistance at normal and high temperatures;
- resistance to ozone and weathering;
- high resistance to oils with aggressive additives, including oils with added amines;
- high resistance to hydrogen sulphide (20 % max);
- high ED resistance.

Due to its inherent properties HNBR is the promising elastomer for use in various fields such as oil production, oil transport, automotive industry, mechanical engineering, aircraft industry, power generation sector, construction engineering - wherein technical rubber products operate under extreme load conditions.

Elastomeric compound Ter-10 shows excellent ED resistance - physical property test results show a continued performance even after the influence of gas.

Tests were performed in accordance with NACE TM 0192-98 requirements.

## Appendix 6

### Products Made From AFLAS™ Fluoroelastomers

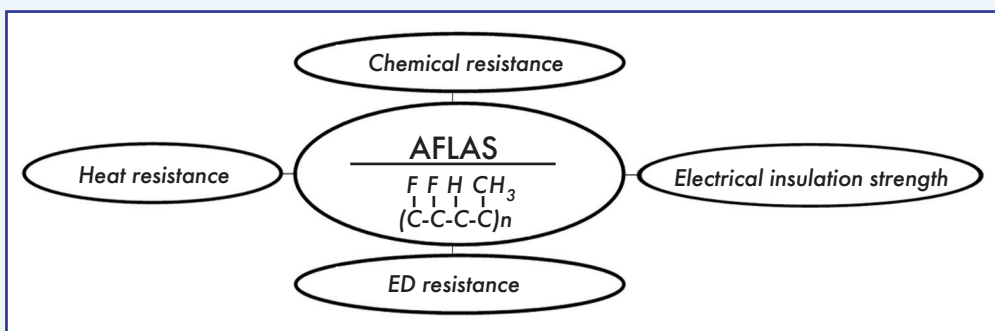
REAM-RTI, LLC produces ED resistant elastomer products from a specialist compound Af-15.

Aflas™ is a unique alternating copolymer of tetrafluoroethylene (C<sub>2</sub>F<sub>4</sub>) and propylene (C<sub>3</sub>H<sub>6</sub>). Products made from AFLAS™ fluoroelastomers give an excellent combination of high temperature performance, chemical resistance, electrical insulation, (ED) Explosive Decompression resistance at a competitive price.

#### Heat resistance

Mechanical properties, including high tear resistance, are maintained even after long-term exposure to elevated temperatures of up to +200 °C. Products can operate long-term at temperatures of + 230 °C (for up to three months) and + 250 °C (for up to thirty days). Short-term operation of Aflas™ seals is even possible at temperatures of +300 °C.

Products DO NOT LOSE their functional properties even after exposure to very low temperatures of down to -50 °C



without imposing dynamic load. On exposure to cold temperatures Aflas™ hardens without embrittlement.

#### Chemical resistance

Products made from Aflas™ fluoroelastomer compounds have excellent chemical resistance when exposed to corrosive fluids, gases and steam; in particular, aqueous solutions of amines, alkalies, bases, chlorine and hydrogen/fluoride acids, high temperature direct steam, synthetic and mineral oils, and also 25 % hydrogen sulphide.

The resistance of Aflas™ products to acids (sulphuric,

*Items in the catalogue are examples of mass production but we produce more products than are shown here*

nitric, hydrogen/fluoride, hydrochloric), synthetic oil, alkalis, direct steam at temperatures of up to +200 °C, spirits and mineral oils is much higher than the resistance of other traditional fluoroelastomers.

#### ED resistance

Products made from Aflas™ type fluoroelastomers show good ED resistance, therefore they can be applied in high-gas content environments at speed pressure drops. Due to ED resistance (in contrast to traditional fluoroelastomers) Aflas™-made products are widely applied in the international oil and gas market.

#### Electrical strength

Due to excellent electrical insulation properties Aflas™-made products retain their dielectric properties even at high service temperatures. Aflas™ is a perfect material for

wire and cable insulation and other insulating products operating at high temperatures. Volume electrical resistance is  $> 10^{13}$  Ohm·cm. Electric strength is 31 kV/mm.

There are formulated special semi-conducting compounds that exhibit volume electrical resistance of  $\sim 10^6$  Ohm·cm and electric strength of 3 kV/mm.

#### Resistance to direct steam and hot air

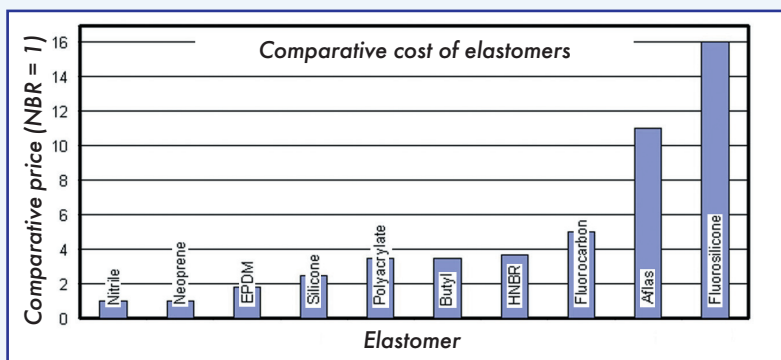
Aflas™-made seals show enhanced resistance to direct steam and hot air even in the presence of aggressive fluids.

Due to the above properties products made from fluoroelastomers can be used in very harsh operation conditions - in oil and gas production, chemical industry, electrical applications, power generation and other industries.

We produce the following technical rubber products - fittings, lip seals, gaskets, O-rings, seal bags, packers, journal bearings and others.

### Appendix 7 Characteristics of Elastomers

The company professionals have durable business relations with world leading rubbers and compounding materials manufacturers and get informational, technical and technological support of such polymer chemistry leaders as DOW CORNING, DU PONT, WACKER CHEMIE, GREEN TWEED, HENKEL, 3M, BAYER, ASAHI GLASS, SOLVEY, PARKER, TICONA, CHEVRON PHILLIPS CHEMICALS and others.



Elastomer Masterbatch type	Operation in the media	Not applicable in the media
<b>Nitrile, NBR</b>	Hydrocarbons, oils, lubricants, fuels, weak solutions of acids and alkalis of up to 20 %	Ozone, ketones, ethers, aldehydes, chlorinated hydrocarbons, nitro compounds
<b>Neoprene, CR</b>	Weak solutions of acids and alkalis, ozone, greases, lubricants, fuels and solvents	Strong acids, ketones, ethers, chlorinated aromatic hydrocarbons, nitro compounds
<b>EPDM</b>	Water, steam, brake fluids, weak solutions of acids and alkalis	Mineral oils, solvents, aromatic hydrocarbons
<b>Silicone, VMQ</b>	Diluted acids and bases, ozone, sodium hydroxide, water, steam, some mineral oils	Solvents, oil, concentrated acids, ambiance surges
<b>Polyacrylate, ACM</b>	Ozone, heavy pressure, lubricants, hot oil, greases	Water, spirits, glycols, alkali, ethers, aromatic hydrocarbons
<b>Butyl, HR</b>	Hot water, steam, gaseous medium, acids and alkalis, oils, spirits, ketones, ethers	Solvents, aromatic hydrocarbons
<b>HNBR</b>	Hydrocarbons, oils, lubricants, fuels, weak solutions of acids and alkalis of up to 20 %; improved chemical resistance, enhanced temperature, light and ozone resistance	Ozone, ketones, ethers, aldehydes, chlorinated hydrocarbons, nitro compounds
<b>Fluorosilicone, FVMQ</b>	Ozone, chlorinated solvents, oils, hydrocarbons and fuels	Brake fluids, ketones
<b>Fluorocarbon, FKM</b>	Aliphatic, aromatic hydrocarbons, acids, greases, various chemically aggressive media	Ketones, low-molecular ethers and spirits, nitro compounds, ambiance surges
<b>Aflas™, TFE/P</b>	Acids, alkalis, fuels, amines, synthetic and mineral oils, pressure surges	Freon, dimethyl ketone, methyl-butyl-ethane, butyl acetate, tetrachloride carbon

Items in the catalogue are examples of mass production but we produce more products than are shown here

## Appendix 8

### Elastomeric Compounds According to Technical Requirements TU 2539-008-46521402-03

According to REAM's Technical Requirements TU 2539-008-46521402-03 for seal bags for down-hole electric motors the elastomers are grouped by the following performance: heat resistance and resistance in

various operating media. Customers now can choose the elastomeric group that meets the definite operating requirements of the seal section.

Group of the elastomeric compound		Operation conditions		Inadvisable media	Recommended elastomeric compound
Group (according to curing method)	Subgroup number	Service temperature, °C	Operating medium		
<b>A</b> (sulphur)	<b>I</b>	-30 до +120	Mineral hydrocarbon oils, standard mineral dielectric oil, fuels, petrol, water, well fluid	Acid and alkaline solutions with concentration of 20 % min, aromatic hydrocarbons, H <sub>2</sub> S-rich (0,12 % min) well fluid	3826s black colour
<b>B</b> (nonsulphur)	<b>IIa</b>	-50 до +180	Mineral hydrocarbon oils, standard mineral dielectric oil, fuels, petrol, water, well fluid	Acid and alkaline solutions with concentration of 20 % min, aromatic hydrocarbons, H <sub>2</sub> S-rich (6 % min) well fluid	RS-26ch black colour
	<b>IIб</b>	-50 до +180	Synthetic oils, standard mineral dielectric oil, well fluid		RS-3 black colour
<b>B</b> (nonsulphur)	<b>III</b>	-50 до +200	Aggressive additive-rich oils, synthetic and semi-synthetic oils, fuels, well fluid	Chloroform, ketones, H <sub>2</sub> S-rich (15 % min) well fluid	Ter-10 black and green colours
<b>B</b> (nonsulphur)	<b>IV</b>	-50 до +250	Mineral and synthetic oils, standard mineral dielectric oil, spirits, acids, alkalies, well fluid	Benzol, chlorinated hydrocarbons, H <sub>2</sub> S-rich (25 % min) well fluid	Af-15 black and blue colours

Sulphur cured elastomeric compounds such as 3826s belong to the first subgroup of elastomers according to REAM's Technical Requirements TU 2539-008-46521402-03.

NBR-based elastomeric compounds RS-26ch and RS-3 belong to the second subgroup of elastomers.

HNBR-based elastomeric compound Ter-10 belongs to the third elastomeric subgroup.

According to the mentioned above Technical Requirements Af-15 based on fluoroelastomer Aflas™ (TFE/P) belongs to the fourth subgroup.

## Appendix 9

### Seal Bags of G51 Class Seal Section Problems and Their Solutions (CIS Equipment)

Among oil production equipment with ESP motors some of the equipment failures fall on such component as seal section. Failure diagnostics reveals tears of bellows of shaft face seals and tears of seal bags. Most frequent are failures in G51 class sections and the share of these failures still remains high in the repairable fleet of the equipment.

There are some seal bag failures typical of G51 class seal sections. They are 1. punching shear of the seal bag wall into the aperture of the seal bag base; 2. circular tear of the seal bag throat; 3. longitudinal failures of the seal bag. One of the main factors that causes the above-mentioned failures is the replacement of oil, which cools the electric motor, with gas. The problem is aggravated by the existing seal bag design that is the cylindrical shape of the seal bag that ends in tapered-cylindrical throats. With this design the seal bag chamber must be completely filled with oil.

If the oil volume is insufficient to completely fill the seal bag chamber the seal bag is compressed. In case the external reservoir liquid contains gas, this gas fills the remaining vol-

ume of the seal bag chamber due to its active diffusion through the seal bag elastic wall.

Leading manufacturers of ESP units take into account the necessity to "degas" oil and develop new designs of seal sections, such as MG54, PB92 and GZN. To prevent longitudinal failures of seal bags they introduced vent ports and doubling of face seals. When oil leaves the seal section the seal bag slowly collapses but stays whole taking the shape of a three-edged prism due to the compression set (Fig. 4).

Due to the current design, it is difficult to introduce innovations such as vent ports and cascade (multilayer) systems of face seals in the available equipment fleet with G51 class seal sections being repaired. As such, in

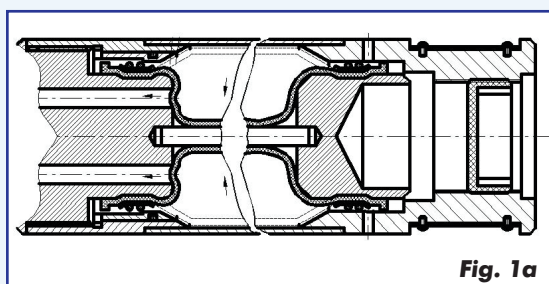


Fig. 1a

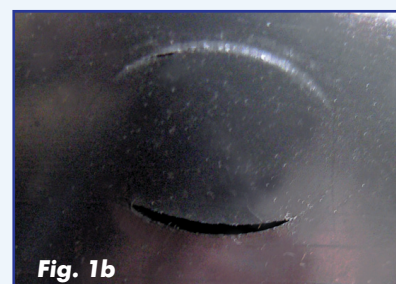


Fig. 1b

**The first type of seal bag failure**

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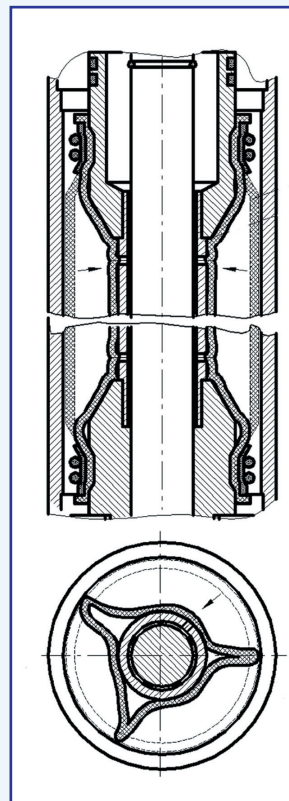
**Fig. 2. The second type of seal bag failure**

wells with high GOR seal bags of G51 class seal sections will inevitably suffer a high risk of the third type of seal bag failure.

It is possible to partly reduce the frequency of the third type failure by changing the construction of the main seal bag in order to give it a new geometric shape with the least internal volume possible. In this case the maximal fill volume could be reached due to "seal bag expansion". Such construction has been designed by REAM-RTI. Also, the work is underway on the original moulding technology developed for this design, and the technology needs field-testing.

To eliminate the first and the second types of seal bag failures in G51 class seal sections REAM's specialists jointly with their colleagues from Surgutneftegaz developed a new construction of composite seal bags, that has been successfully tested for over two years. This engineering solution has been patented (Fig. 5).

The new design consists of the main seal bag into the throat of which damper rings 2, 2' are inserted. The function of the rings is both to prevent a fast collapse of the seal bag wall at oil release and punching shear of the seal bag wall into the aperture between the seal bag base and the seal bag (the first type of seal bag failure). On the throats of the seal bag under a clamp or wire lock-up bandage rings 3 provided with rims are installed. The rims should prevent both extrusion of the seal bag wall into the gap between the seal bag and the protector case and circular tear of the seal bag



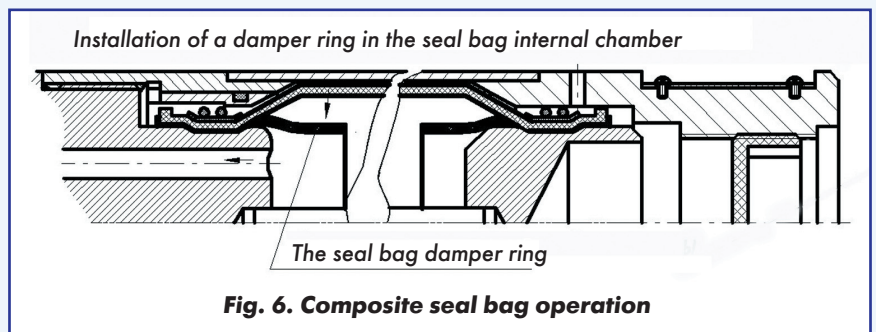
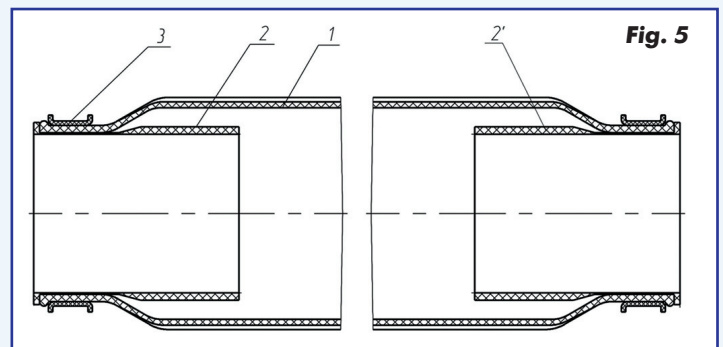
**Fig. 3. The third type of seal bag failure**



**Fig. 4. MG54 seal bag (manufactured by ALNAS) from the lifted seal section**

(the second type of seal bag failure). The use of bandage rings gives another positive effect. The rings reduce the stress in the elastomer wall of the seal bag throat caused by tightening of the clamps, thus enhancing the reliability of the system.

The operation principles of the composite seal bag are shown in Fig. 6.



**Fig. 6. Composite seal bag operation**

**Table 1**

Fig.	Failures of seal bags	Main causes	Assembly type: compensator / protector
1	Punching shear of the seal bag wall into the aperture of the seal bag base	Oil release at lower speeds (pressure drop speed is 0,2 MPa/sec max)	Compensator
2	Circular tear of the seal bag throat	High speed extraction of the equipment from the oil well with considerable gas content in the oil chamber	Compensator and protector
3	Longitudinal failure of the seal bag	Oil release at high speeds (pressure drop speed is 0,2 MPa/sec min)	Protector

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materials engineering research  
laboratory

## TEST CERTIFICATE

This document confirms that MERL (Materials Engineering Research Laboratory Ltd) has tested a set of rubber compounds for OOO "REAM-RTI" in accordance with the requirements of NORSOK M-710 standard "Qualification of Non-Metallic Sealing Materials and Manufacturers".

The compounds tested were:

1. RS-26ch – a general purpose NBR compound.
2. RS-26ch -5 – an internal lubrication NBR compound with low friction.
3. Ter-10 – a general purpose HNBR compound.
4. Af-15 – a general purpose Aflas™ compound.

The O-rings (37,47mm x 5,33mm) of the compounds above have been tested under conditions as following:

Pressure: 150 bar (15MPa).

Temperature: +100°C.

Exposure time: 10 cycles of 24 hours each.

Medium: 97 % CH<sub>4</sub> + 3 % CO<sub>2</sub>.

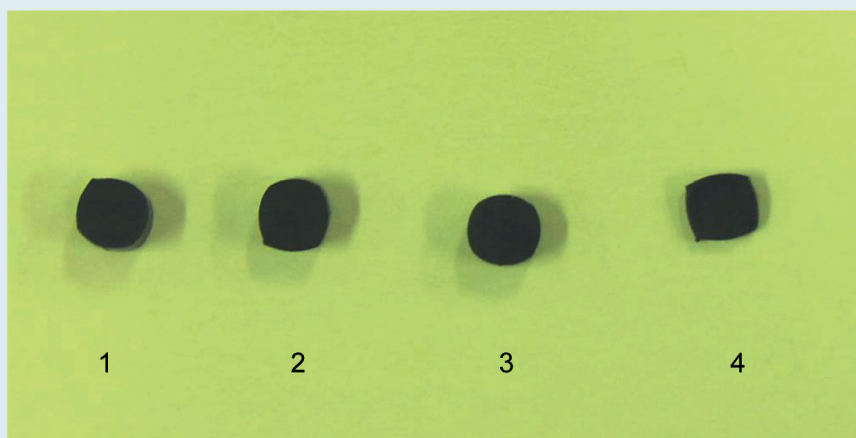
Decompression rate: 20 bar per minute.

No cracks, blisters or any other imperfections were caused in the O-rings tested.

The resistance against Rapid Gas Decompression of the compounds tested is assessed as 0000, i.e. all compounds tested successfully passed the qualification test.

Passed by : G J Morgan (BSc. Hons.)  
Date: 18/4/2006

*G.J. Morgan*



### MATERIALS ENGINEERING RESEARCH LABORATORY LTD

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## **Appendix 11**

### **Unique Solutions of Kalsi Seals for Drilling and Oil Production Equipment**

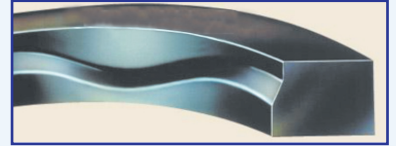
The Kalsi Bearing is a relatively thin disk that has a number of repetitive bearing segments that define flexing regions and support regions. The bearing dynamic surface, which is initially flat, deflects elastically under thrust load.

The deflection creates regions of gradual convergence

between the bearing and the mating surface that act as efficient hydrodynamic inlets. During rotation, these inlets force lubricant into the dynamic interface, creating a load supporting interfacial lubricant film that significantly reduces bearing friction, wear, and heat.

#### **Radial Elastomeric Self-Lubricating Seals of High Pressure for Abrasive Media**

The unique Kalsi Seal design provides hydrodynamic seal lubrication even under high differential pressure. This reduces seal friction, and provides long life.



#### **Application:**

Down-hole drilling mud motors.  
Rotary steerable drilling tools.  
High speed drilling and coring swivels.  
Rotary Control Devices (RCD's).  
Rotary valve actuators.  
Rock drilling machines.  
Slant hole drilling swivels.  
Underwater vehicles.  
Submerged dredge pumps.  
Oilfield cement pumps.  
Construction swivels.  
Oilfield vacuum truck agitators.

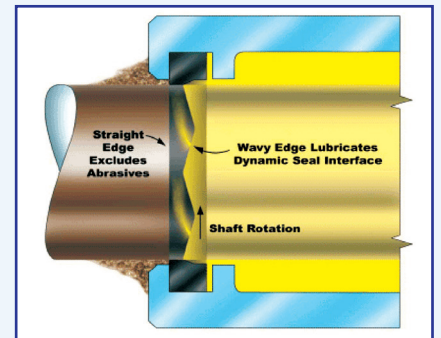
Industrial slurry mixers.  
Oilfield roller reamers.  
Machine tools.  
Hydraulic swivels.  
Blast hole drilling.  
Other abrasive service rotary equipment.  
Gun drills.  
Drilling tool spindles.  
Down-hole propelling engines.  
Rotary swivels.  
Centrifugal pumps for waste waters.  
Multiphase pumps.

#### **How Kalsi Seals Work**

Kalsi Seals are installed in a housing groove and compressed against a shaft, and seal statically in the same manner as other interference-type seals, such as O-rings.

The dynamic sealing lip incorporates a wavy hydrodynamic edge on the lubricant side, and an abrupt circular exclusionary edge the environment side. When rotation occurs, a thin lubricant film is hydrodynamically wedged into the dynamic sealing interface by the waves. This hydroplaning effect lubricates the seal and shaft, preventing the typical dry rubbing wear, high running friction and heat associated with conventional seals, allowing higher pressure and speed combinations and providing long life.

When rotation stops, the hydrodynamic lubricating action stops, and static sealing is reestablished.



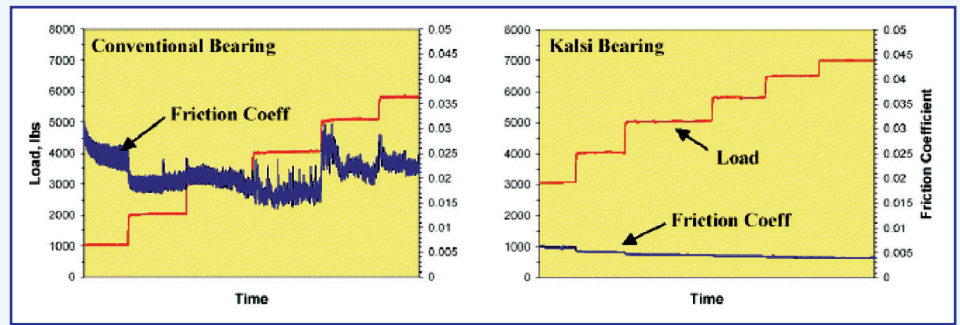
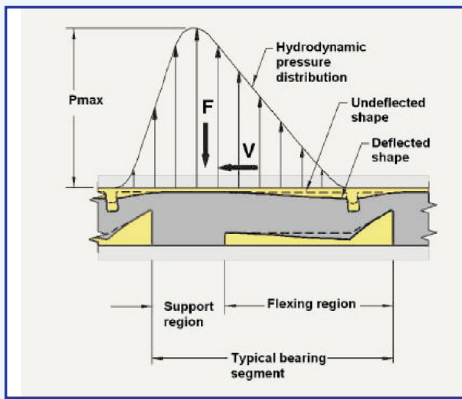
#### **Thrust Hydrodynamic Bearings with High Load-bearing Capacity**

##### **Features and Benefits**

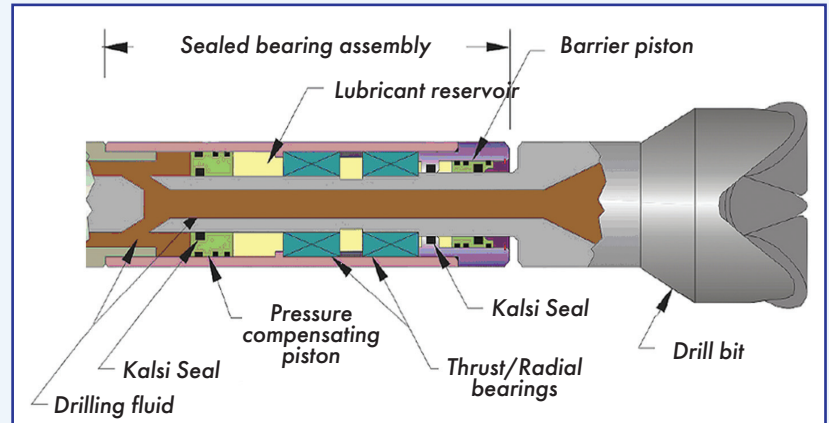
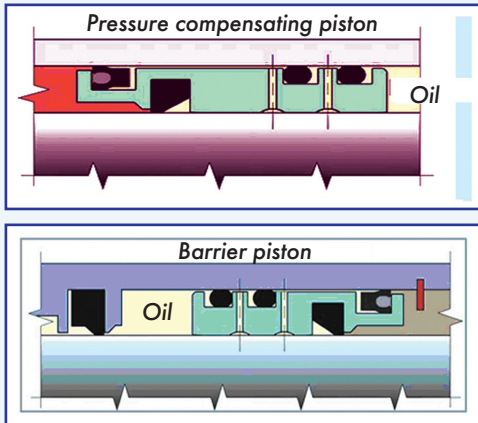
- Hydrodynamic lubrication reduces seal and shaft wear, running torque, and seal-generated heat, and permits higher pressure and speed combinations.
- Lip design excludes environmental abrasives.
- Suitable for transient conditions that cause mechanical face seals to fail or leak excessively, such as frequent starts/stops, pressure fluctuations, shock and vibration, and temperature changes.
- Compact, one-piece seal design is installed in a simple O-ring type groove.







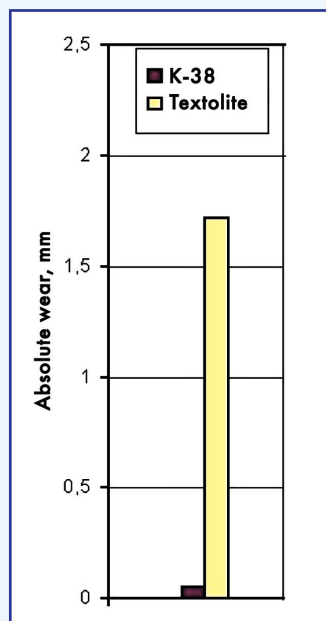
### Drilling Spindle



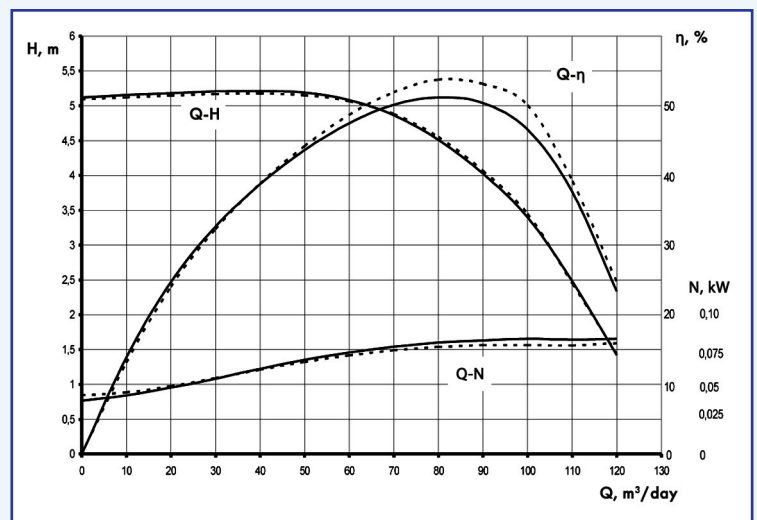
## Appendix 12 Elastomer Support Washer



The elastomer support washer made from elastomeric material K-38 formulated by REAM-RTI, LLC increases the efficiency coefficient of ESP unit working stages 3 % or more and reduces wear at least 10 times. The unique properties of the material K-38 are proven by numerous tests.



ESP unit

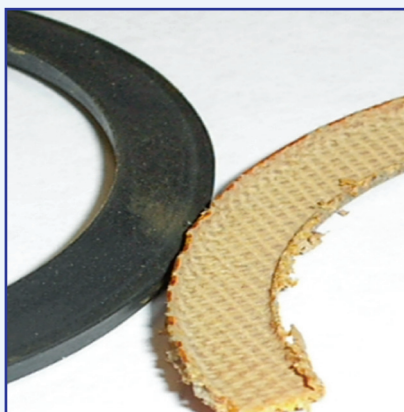


**The results of comparison tests performed by OAO "OKB BN KONNAS" of flow head capacity characteristics of a VNN5A-50 stage with impeller support washers from the material textolite (—) and elastomer K-38 (---),  $n = 2910 \text{ min}^{-1}$**

**The results of comparison tests performed by ZAO "NOVOMET-Perm" of wear on impeller support washers made from REAM's elastomeric material K-38 and from textolite. Wear on the impeller support washers made from the elastomeric composite K-38 after bench tests under feed of  $50 \text{ m}^3/\text{day}$  with abrasive concentration of  $2 \text{ g/l}$  after 5-hour testing according to the data of geometric measurement of the centrifugal pump VNN5A-50, ZAO "NOVOMET-Perm"**

Items in the catalogue are examples of mass production but we produce more products than are shown here





**Support washers  
from the elastomeric composite K-38 (left)  
and textolite (right)  
after the above-noted tests**

The designs of support washers:

- a design for heat resistance of up to  $+200\text{ }^{\circ}\text{C}$ ;
- a design for chemical resistance (of up to  $20\text{ }\%$   $\text{H}_2\text{S}$ );
- a design for multiphase media (gas content of up to  $80\text{ }\%$ ).

REAM-RTI mastered the technology of bulk production of impeller support washers from abrasion-resistant elastomeric materials for the primary Russian ESP product manufacturers. REAM-RTI will supply support washers for tests in extremely harsh operation conditions to reduce ESP unit energy consumption.

### **Appendix 13 Comparison of Methods to Reduce Dry Friction of Technical Rubber Products**

Elastomeric compounds used for production of seals, marine bearings, PCP pump/drill motor stators and other heavy duty components that are exposed to sliding friction against smooth metal surfaces must have high resistance and exhibit low friction coefficient and minimal breakout torque.

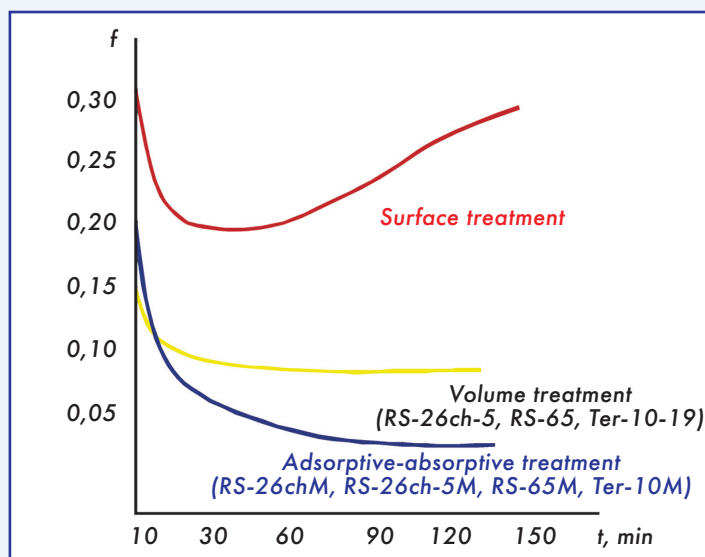


**Examples of elastomer products  
with low dry friction coefficient**

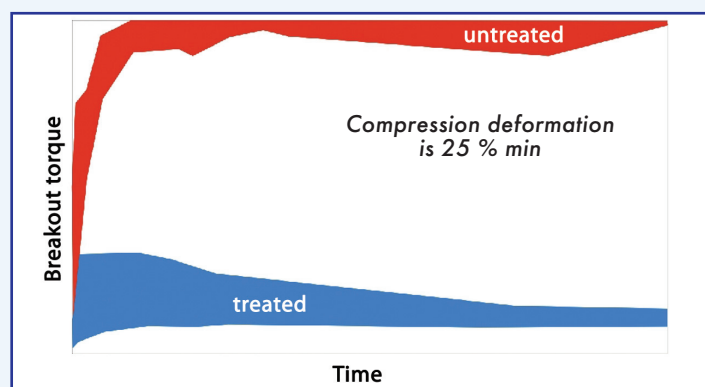
Improving the features of widely-used elastomeric compositions is possible by modifying (treating) working characteristics of the existing elastomeric materials.

A number of different treatment methods can be used: the volume treatment - modifiers are added at the elastomer formulation stage, the surface treatment - treatment of the finished product surface by modifiers and the combined treatment - combination of volume and surface treatments.

REAM-RTI specialists invented and patented a method of adsorptive-absorptive treatment (AAT) that uses non-



**Friction coefficient  $f$  versus test duration  $t$  for elastomeric compounds treated by different methods. Friction couple: elastomer thrust washer/carbon steel ring test samples (high-carbon steel),  $R_z = 0,5...0,65\text{ }\mu\text{m}$**



**The results of bench tests of untreated and treated leap seals in the liquid medium (the material - HNBR compound, 87 Shore A)**

ionic surfactants as modifiers. The AAT requires the finished products to be dipped into the modifier medium

and this results in the modifier being absorbed on the product surface and then it penetrates into the material matrix. The modifier migrates on to the surface of the modifier and creates a functional layer, e.g. a low friction layer or/and anti-corrosive highly resistant layer.

This technology is successfully used for cured products as it does not change their geometry.

AAT application is sometimes restricted. Care is needed in selecting media and AAT regimes for products which operate in vacuum and at high temperatures.

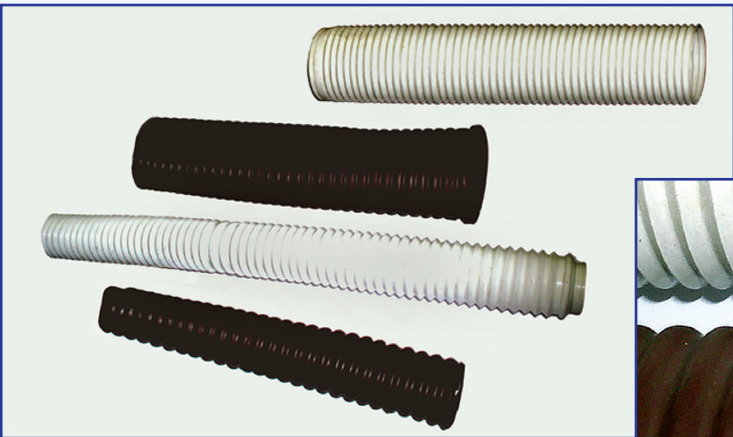
This method of product treatment is applied in the production of reliable, heavy duty oil production equipment seals and can improve efficiency as it increases the operation of PCP pump and drill motor stator elastomeric coatings.

**Comparison of "dry" friction reduction methods of technical rubber products made from NBR- and HNBR-based elastomers**

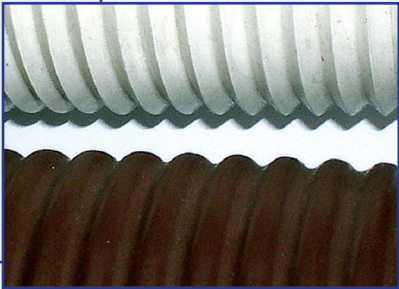
"Dry" friction reduction method	Restrictions for the use of friction reduction method	Minimum dynamic friction coefficient (f)
Surface treatment	Wear of the treated reduced friction layer in the abrasive medium	0,20...0,30
Volume treatment	Technical problems due to compound mix and product combination. Non compatibility or agglomeration of anti-friction additive agents	0,15...0,25
Adsorptive-absorptive treatment	Evaporation or out-washing of the modifier in the medium and/or in the operating conditions	0,09...0,20

**Appendix 14**

**Blow Moulding Technology in Modern Production of Technical Rubber Products**



Comparison of corrugated products manufactured by:  
- dipping;  
- blow moulding (the blank is the uncured silicone tube)



**Blow moulding (silicone)**

**Dipping (liquid rubber)**



**ESP seal section seal bag**

Material - RS-26ch (NBR).



**Parison tube**

Material - TFE/P (Aflas™).

Items in the catalogue are examples of mass production but we produce more products than are shown here

**Lip seals for the test bench of electric submersible motors (blow moulding method)**

The blank is an extruded tube, the material is rubber NO-68.



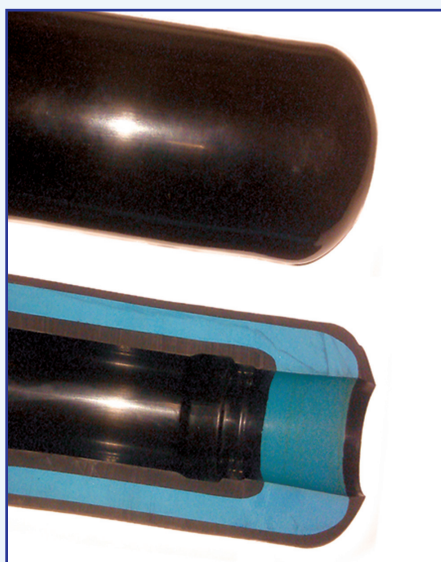
**Characteristics of the blow moulding technology:**

1. The use of strained parison tubes.
2. Valid thickness variation of blanks is 0,1 mm max.
3. Forming medium pressure is 0,5 MPa min.
4. Parison tubes shelf life is 2 days.
5. Complete and full leak resistance while the product is being cured.
6. Forming medium needs to be free from any impurities (such as moisture, oil, etc.).

**Advantages of the blow moulding technology:**

1. Possibility to manufacture hollow moulded products of high precision with wall thickness of 0,5...8,0 mm.
2. Possibility to manufacture overall products. The product length is restricted by the tool set.
3. Possibility to produce hollow products from elastomers with Mooney viscosity of up to 100.
4. Curing cycle cutting.
5. Low cost of the tool set.

**Appendix 15**  
**Multilayer Aflas-100H-based Elastomer Products**



The REAM Group has mastered a technology for manufacturing multilayer Aflas-100H-based products without any adhesives.

**Appendix 16**  
**Main Customers of the REAM Group**

**Oil and Gas Sector, Oilfield Service Companies**

OOO "PK "Borets"	OOO "RIMERA-Servis"
OOO "SK Borets"	OOO "Samara-Elektro-Servis"
OOO "Lysvaneftemash"	OOO "Servis Tsentr EPU"
ZAO "NOVOMET-Perm"	ZAO "LUKOIL EPU Servis"
OOO "ALMAZ" "	OOO "Ritek ITTs"
OAO "OKB BN KONNAS"	OOO "RINPO"
OAO ANK "Bashneft"	OOO "Permenergokomplekt"
OAO "ALNAS"	OOO "Nasosy PPD"
OOO NPF "Bitek"	OOO "Consolidated Services"
OAO NPO "Burovaya tekhnika"	OOO "NPF Zavod "Izmeron"
ZAO "Gidromashservis"	OOO "Ttriol-Neft"
OAO "Livgidromash"	OAO "SKZ "KVAR"
OOO "TD "Chapaevskii zavod metalloizdelii"	OOO "Samaraneftgaz-Servis"
ZAO "ELEKTON"	TOO "STEELMASTER"
ZAO "Geophysymash"	OAO "Slavneft-Megionneftgaz"
ZAO NPP "GEOMETR"	OOO "YuNG-Servis"
OOO "Kurganskii kabelnyi zavod"	OOO "RN-Krasnodarneftgaz"
OAO "Surgutneftgaz" STsBPO EPU	Kalsi Engineering, Inc. (the USA)
OOO "Oilpump Service"	OOO "Shlumberge" (the USA)
OOO "RIMERA"	"PetroAlyans Services Company Ltd." (Cyprus)

**Vehicle manufacturers, ship builders, manufacturers of power plant and hydraulic equipment,  
and specialty equipment manufacturers**

ZAO "SPAZ "Plaza"	OOO "Gazpriboravtomatika"
OAO "Zavod "AVTOPRIBOR"	OOO "Gazprom transgaz Tomsk"
OAO "Volchanskii agregatnyi zavod"	OOO "TekhnoTEK"
OAO "Tutaevsky motornyi zavod"	OAO "Serpukhovskii kondensatornyi zavod "KVAR"
OAO "BelOMO-MMZ named after S.I. Vavilov"	ZAO "Firma SOYuZ-01"
OAO "Kaluzhskii zavod of electronic products	OOO "Baza komplektatsii "Tyazhpromarmatura"
"Avtoelektronika"	OAO "Mekhinstrument"
OAO "PENZMASH"	OOO "Ekolit-D"
OOO "Gruzovik"	OOO "PROMYSHLENNYE VAKUUMNYE SYSTEMY"
OOO "TD GRUZOVIK-AVTO"	OOO "Tsytkon-Servis"
OAO "Research Studies Institute of engines"	OOO NPP "Tsytkon-Servis"
OAO "NPP "Zvezda"	ZAO "AVIAL"
OAO "Ship repair centre "Zvyozdochka"	OAO "KAMPO"
OOO "Gidroreaktivnaya tekhnika"	ZAO "Ingersoll Rand CIS"
FGUP "176th sudoremontnyi zavod of MO RF"	OOO "PENTA YuNIOR"
OOO "Predpriyatie "Gidrotekhnika"	ZAO "VKh-Taifun"
OOO "ELSTER Gazelektronika"	ZAO NPF "META"

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