Liquid Silicone Rubber Capabilities
Advanced Liquid Silicone Rubber (LSR) technology is seeing exponential growth, particularly into high-tech fields of applications. In life sciences, it is driven by an increasing trend toward self-treatment of chronic ailments such as autoimmune diseases, blood conditions and hormone deficiencies. While in areas such as food processing and potable water, more stringent environmental, as well as health and safety scrutiny, are the catalysts to the move to LSR. In automotive, the vision of the fully autonomous car means vehicles have more and more electronic features; prompting the demand for super clean and integrated LSR components. The rising demand for LSR is also related to urbanization, demographic and social changes as a growing affluent population has a greater buying power for electronics and other lifestyle products and consumables.
INTRODUCTION

Increasingly the world is becoming one and this trend is evident in manufacturing. Products are based on global platforms and manufacturers are demanding that their components are produced in the same way consistently, wherever they are supplied from. Trelleborg Sealing Solutions can help facilitate this through a network of over 50 marketing companies, regional R&D facilities, strategically placed manufacturing sites and centers of excellence globally.

In the still rather new field of high precision LSR technology, Trelleborg Sealing Solutions is a world leading player. What distinguishes Trelleborg as a leader are:

- Ability to develop and produce components at the highest level of complexity and accuracy
- Swiss precision tooling, process and automation technology
- Global manufacturing presence
- State-of-the-art and unique manufacturing set-up including cleanrooms
- Quality mindset throughout
- Development partner from first concept stage to serial production

LOCAL PRESENCE, GLOBAL REACH

- Shanghai, China
- Stein am Rhein, Switzerland
- Pernik, Bulgaria
- Northborough, Massachusetts, US

Trelleborg’s LSR processing technology was born in Switzerland and the original manufacturing facility in Stein am Rhein is now the global center of excellence. The same processes and regimes founded there are replicated exactly in worldwide manufacturing facilities located in North America, Europe and Asia, with quality systems including ISO 9001, ISO 13485, ISO 14001 and TS 16949.
Liquid silicone rubber: solutions through advanced technology

LSR and two-component injection technology can be applied to any industry. The components Trelleborg aims to produce are the result of your and our designers’ imagination plus the quest for innovative solutions of our toolmakers and process engineers.
Benefits of silicone

Silicone is an extremely versatile material that lends itself to a broad range of application conditions. As a liquid raw material, silicone offers advantages in processing that render it a premier choice of material for technical components in high volumes.

- Available in hardnesses from 10 – 80 Shore A
- Platinum curing gives the highest purity material
- Excellent low and high temperature resistance
- Offers excellent resistance to ozone, weather and UV rays
- Water repellent
- Offers excellent mechanical damping properties
- Possesses outstanding electrical properties:
  - Availability of UL94 listed types
- Specific to food contact applications:
  - Compliant with FDA, BFR, NSF
  - Neutral in taste and odor
- Specific to potable water applications:
  - Compliant with WRAS, KTW, ACS, NSF
- Specific to biomedical and pharmaceutical applications:
  - Highest purity
  - Biocompatibility to ISO 10993 and USP Class VI
  - Compliant with European Pharmacopeia 3.2.9
  - Withstands common sterilization methods such as steam, γ-radiation, ETO
Trelleborg Sealing Solutions

Liquid Silicone Rubber Capabilities

**LSR multi-component solutions**

- **General advantages of LSR**:
  - Flexible in terms of shape, size and thickness
  - Can be produced with complex geometries
  - High dimensional stability in finished products
  - Favorable chemical resistance
  - Outstanding aging properties
  - Outstanding service temperature

- **Advantages of 2C LSR technology**:
  - Offers the lowest TCQ (Total Cost of Quality)
  - Enables highest level of design solutions
  - Can integrate multiple components into one solution
  - Provides the highest level of quality in product development, process, and overall quality due to lean manufacturing
  - Provides the highest consistency in product dimension, precision, and overall quality due to lean manufacturing

- **Multi-component solutions**
  - Provides the highest level of design solutions
  - Can integrate multiple components into one solution
  - Provides the highest level of consistency in product development, process, and overall quality due to lean manufacturing

- **Process**:
  - 2C LSR technology
  - In-process quality control
  - Flashless and wasteless
  - Robust APQP process
  - Lean culture
  - Continuous improvement experience

- **Case study**:
  - Trelleborg’s unique capabilities
  - Provides the highest level of design solutions
  - Can integrate multiple components into one solution

- **Process**:
  - 2C LSR technology
  - In-process quality control
  - Flashless and wasteless
  - Robust APQP process
  - Lean culture
  - Continuous improvement experience

- **Material**:
  - Custom-designed systems and ready-to-use solutions
  - Satisfaction guaranteed
  - Best quality and performance in the shortest time

- **Design**:
  - To customer specification or
  - Best fit, form and function 'black box' design
  - Quality in mind
  - Robustness in performance

- **Process**:
  - 2C LSR technology
  - In-process quality control
  - Flashless and wasteless
  - Robust APQP process
  - Lean culture
  - Continuous improvement experience

- **Checks**
  - Process and operational control
  - All processes and systems are certified
  - Procedure documentation

- **Characteristics**
  - Liquid Silicone Rubber Capabilities
  - Specialized systems and ready-to-use solutions
  - Satisfaction guaranteed
  - Best quality and performance in the shortest time

- **Process**:
  - 2C LSR technology
  - In-process quality control
  - Flashless and wasteless
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Providing the right solution for an application can be challenging. At Trelleborg Sealing Solutions we employ a complete toolbox of skills and expertise to make sure that the best result is achieved every time.

**The complete toolbox**

**DESIGN OF PRODUCT**
- To customer specification or ‘black box’ design
- Best fit, form and function
  - Robustness in manufacturability
  - Quality in mind

**MATERIAL**
- Partnering with the world’s leading material developers
- Application and processing experts

**CLEANROOMS**
- Class 7 and 8 to ISO 14644-1
- Ultra lean and clean

**Quality by Design**
TOOLING
• From prototype to complete multi-cavity production tools
• Quick prototyping and sampling service
• Proprietary designs
• Innovation-driven

AUTOMATION
• State-of-the-art equipment
• Customized, fit-for-purpose solutions for the highest efficiency and quality

ADVANCED LIQUID INJECTION MOLDING
• Leading edge technology
• Closed loop manufacturing cells including handling, cleaning, inspection and packing

PROCESS
• Lean
• Flashless and wasteless principles
• Robust APQP process
• In-process quality control
• Zero-Defect quality culture

TECHNICAL SKILLS
• Our biggest asset
• Tradition of apprenticeship, training and continuous improvement
• Outstanding skill levels based on extensive technical experience
Shoulder-to-shoulder engineering

Full-integrated solutions – from first concept through to serial production. Less than thousands to every millions of parts, we will align our customer’s vision to deliver development partner and dependable manufacturer of high quality, high precision LSR and 2C LSR components.

Quality by Design

01 CONCEPT DEVELOPMENT
Concept & Development     Value engineering of a unique solution     Commercial offering     Contracting     IP (Intellectual Property)

02 PRODUCT SPECIFICATION
Specifications     CAD models     Critical criteria     Cleanliness     Special surface finish or treatments

03 SCALING & PRODUCTION
Process simulation     Tooling optimization     Tool design readiness     Materials     Production concepts

04 CONCEPT VALIDATION
Concept validation     Product engineering     Value engineering     Conceptual design

05 TESTING & VALIDATION
Testing     Functional test     Material evaluation     Quality control

06 PRODUCT OPTIMIZATION AND DESIGN FREEZE
0.1 (Design of Experiment)

07 REALIZATION
Design realization     Machining     Prototyping     Numerical control

08 SERIAL VALIDATION
Production          Validation     Dimensional capability     In-line inspection

09 SCALE & PRODUCTION
Production scale     Tooling     Supply systems

PRODUCT ENGINEERING PROCESS
Fully integrated solutions – from first concept through to serial production. From tons of thousands to many millions of parts, we work alongside our customers as a reliable development partner and dependable manufacturer of high-quality high-performance LSR and 2C LSR components.

Shoulder-to-shoulder engineering

**PRODUCT ENGINEERING PROCESS**

**01 CONCEPT DEVELOPMENT**
- Concept development
- Value engineering at customer side
- Conception and drawing
- Conceptual design

**02 PRODUCT SPECIFICATION**
- Drawings
- 3D models
- Critical criteria
- Simplicity
- Special surface finish
- Special packaging
- Product testing

**03 PROTOTYPE MACHINING**
- Prototype machining
- Test design models
- Test production prototypes

**04 CONCEPT VALIDATION**
- Flow simulation
- Quick prototyping
- Quick sampling
- Material evaluation

**05 TESTING AND VALIDATION**
- Dimensions
- Material properties
- Functional product testing
- Surface cleanliness
- Special testing, e.g. bioburden

**06 PROTOTYPE OPTIMIZATION AND DESIGN FREEZE**
- Pre-serial trials
- DOE (Design of Experiment)

**07 INDUSTRIALIZATION**
- Construction of molding and demolding tools and automated handling units
- Closed loop fully automated cells for high volumes
- Finalization of serial process in suitable environment: Cleanroom, White room, Gray room, Food safe cells

**08 SERIAL VALIDATION**
- Part and material validation package to suit customer requirements
- Run@Rate studies
- Dimensional capability
- In-line inspection
- Process audit

**09 SCALE-UP PRODUCTION**
- Feasibility analysis
- FEA simulation
- Manufacturing feasibility
- Tool design models
- Supply chain considerations
- Feed-to-line concepts

**Quality by Design**
Shoulder-to-shoulder engineering

Fully integrated solutions – from first concept through to serial production. Two lines of thousands to many millions of parts, all we need are your customer requirements. Shoulder-to-shoulder innovation and dependable manufacture of high quality, high precision LSR and 2C LSR components.

PRODUCT ENGINEERING PROCESS

01 CONCEPT DEVELOPMENT

• Concept development
• Value engineering of customer concept
• Concept drawing
• Design sheet
• Value analysis

02 PROJECT SPECIFICATION

• Spec sheets
• Bill of parts
• Technical drawings
• Technical notes
• QA planning and costing

03 TOLERANCE ANALYSIS

• FEA simulation
• Tooling design
• GD&T analysis
• Tool design verification

04 CONCEPT VALIDATION

• Pre-validation
• Value engineering of customer concept
• Concept validation
• Gate reviews
• Value assessment

05 TESTING AND VALIDATION

• Functional testing
• Miniature product testing
• Process equipment
• Quality control

06 PRODUCT OPTIMIZATION AND DESIGN FREEZE

• DOE (Design of Experiment)
• Pre-action trials

07 PRODUCTION

• Prefabrication of injection molds
• Pre-action trials
• Production trials
• Quality control

08 SERIAL VALIDATION

• Production trials
• Full scale trials
• Finalization of serial process

09 FEASIBILITY ANALYSIS

• Manufacturing feasibility
• Tool design models
• Supply chain considerations
• Cost to build
• Tooling models

Quality by Design
Shoulder-to-shoulder engineering

Fully integrated solutions - from first concept through to serial production, tens of thousands to many millions of parts are 맞이 개발도를 통한 정확적인 제품 개발 과정에서의 가늘기 및 정밀도를 높이 고도화한 LSR 및 2C LSR 구성품.

Quality by Design

PRODUCT ENGINEERING PROCESS

01 CONCEPT DEVELOPMENT
- Concept & feasibility
- Value engineering of customer concept
- Initial engineering
- Design
- Business planning

02 PRODUCT SPECIFICATION
- Drawings
- 3D models
- Critical criteria
- Cleanliness
- Special surface finish or treatments
- Special packaging
- Product testing

03 PROTOTYPE MASTERS
- FEA simulation
- Manufacturing feasibility
- Tool design
- Tooling
- Prototype

04 CONCEPT VALIDATION
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- Critical materials
- Special packaging
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09 SCALE-UP PRODUCTION
- Rapid tools
- Direct Line Feed (DLF) programs
- Ready-to-use product packaging and supply systems

Feasibility analysis
- FEA simulation
- Manufacturing feasibility
- Tool design models
- Production concepts
ELASTOMER WITH UNIQUE CAPABILITIES

**Injection Molding**

- Flexible, cost-efficient production process
- Capable of producing parts for high-volume applications
- High precision and repeatability

**Advanced Liquid Silicone Rubber (LSR)**

- Superior dimensional stability and mechanical properties
- Excellent clarity and transparency

**Characteristics**

- **Silicone**
  - Best fit, form, and function
  - Best-in-class material properties

- **Multi-Component Solutions**
  - Enhances overall design freedom
  - Enables customization of part geometries and technical requirements

- **In-Process Quality Control**
  - Robust APQP process
  - Zero-Defect quality culture

- **Lowest Total Cost of Ownership (TCO)**
  - Much greater design latitude for the developer
  - Eliminates need for secondary seal/gasket assembly

- **Risks and costs associated with secondary assemblies**
  - Lower total cost of ownership (TCO) for the customer

- **Secondary Components**
  - Can integrate multiple components into one fully-bonded solution

- **Optimizes Solutions**
  - Enables production of part geometries and technical requirements
  - Enables highest volume production as a result of high production volumes

- **Process Efficiency and Quality**
  - Enables highest quality production as a result of innovation

**Process Capabilities**

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  - Much greater design latitude for the developer
  - Eliminates need for secondary seal/gasket assembly

- **Robust and most efficient way of providing**
  - Multiple components into one fully-bonded solution

- **Can integrate multiple components into one**
  - Offers the lowest TCQ (Total Cost of Quality)

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**Trelleborg Solutions**

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MULTI-COMPONENT

LSR OVERMOLDING
- Combination of LSR with mostly plastic or metallic substrates
- Robust and most efficient manufacturing process for lower to medium volumes
- Fully-bonded custom solutions produced in two steps
- Available in a variety of hard-soft combinations

SIMULTANEOUS 2C LSR PROCESS
- Our most outstanding capability otherwise referred to as 2K, 2shot, co-injection or rubber-to-plastic bonding
- Available in many hard-soft and soft-soft combinations including multi-color and multi-hardness options
- Robust and most efficient way of providing fully fit to purpose product in high volumes

MULTI-COMPONENT OPTIONS
- LSR in combination with other substrates, completed in a combination of injection molding, assembly and other process steps
- Customized systems and ready-to-use solutions
Using our advanced LSR design and production capabilities, Trelleborg Sealing Solutions offers a wealth of custom solutions.
MICRO AND NANO TECHNOLOGY

- Components below 10 milligrams in weight
- Flashless production made possible with Trelleborg’s needlepoint injection technology and fully automated parts handling

THIN SECTIONS

- 0.10 mm / 0.004 inch or less
- Ideal for thin membranes
- Perfect consistency in thickness and quality
- No pin holes

DELICATE PARTS

- Formed reliably every time
- Flashless production made possible with special tool construction and automation
**Liquid Silicone Rubber Capabilities**

**VIRTUALLY FLASH-FREE**
- No need for secondary deflashing
- High dimensional stability directly from mold
- Flashless, wasteless design principles
- Highest efficiency

**BLIND SECTIONS**
- Through holes perfectly formed every time
- Long tube sections reliably formed
- Made possible with special tool construction

**HIGHEST PRECISION**
- Surfaces from high polish to textured
- Consistent manufacturing over millions of parts
UNDER CUTS

- Common feature in bellows, for example
- Made possible with LSR and special tool construction for molding and de-molding
Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative engineered solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has local presence in over 40 countries around the world.

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