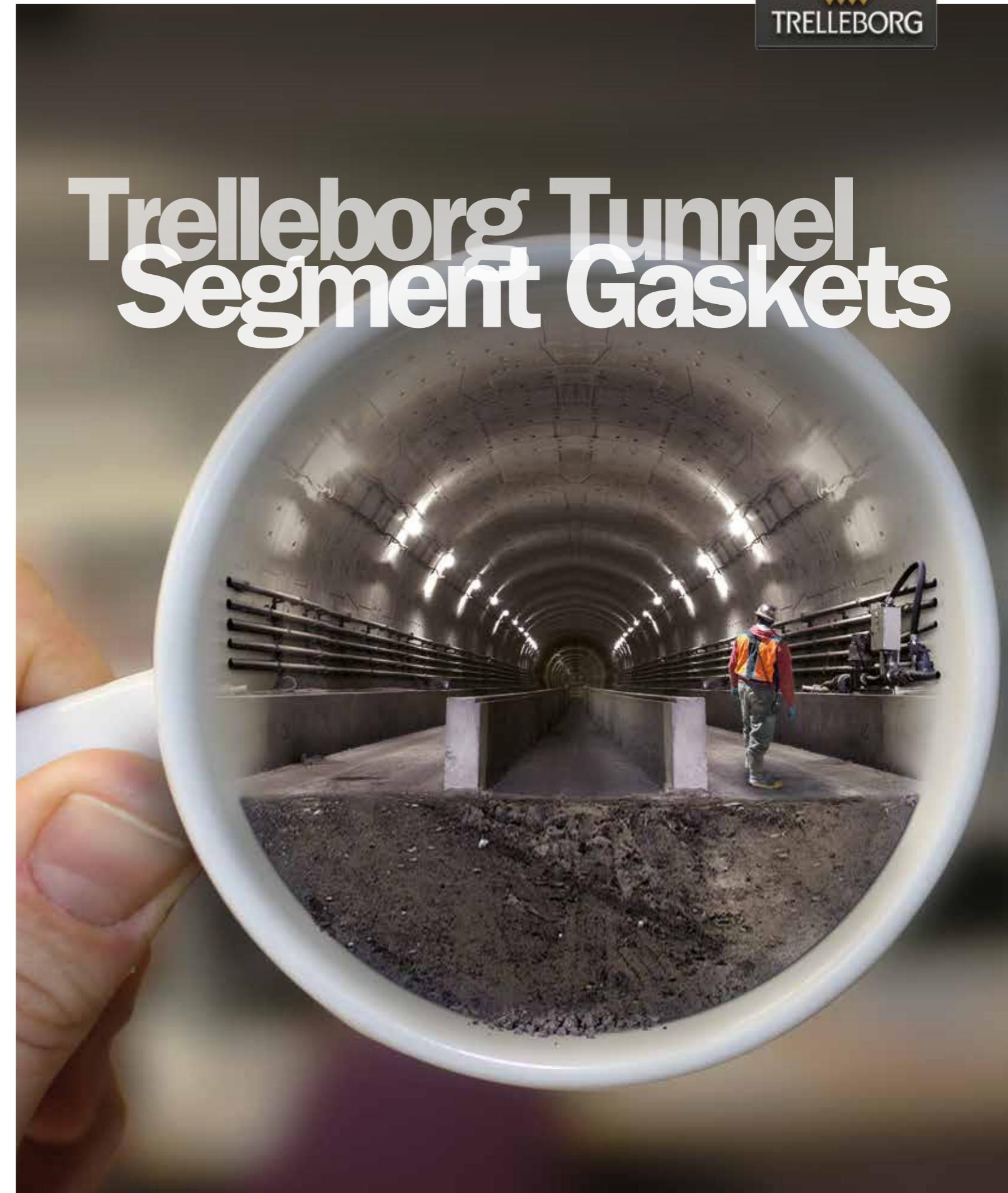




Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative engineered solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has local presence in over 40 countries around the world.

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Trelleborg Tunnel Segment Gaskets



Trelleborg The Company

Trelleborg Engineered Products is your partner in the design and production of engineered rubber products. Our focus is on the markets of civil engineering, offshore oil and gas, dredging, sewage, building and industry. Trelleborg Engineered Products is a member of the Trelleborg group – a global industrial group offering leading-edge expertise in polymer technology combined

with advanced industrial know-how of functional solutions and systems to meet our customers' requirements. The Group has approximately 15,000 employees in some 40 countries and 90 manufacturing plants. The Group's Headquarters are located in Trelleborg, Sweden. Trelleborg AB was founded in 1905 and the Trelleborg share has been included in the Stockholm Exchange A-list since 1964.

Introduction

Trelleborg Engineered Products has unrivalled expertise in seal design and elastomer technology, and is the world's leading manufacturer of elastomeric gaskets for immersed tunnels, cut & cover tunnels and bored tunnels. For the segmental lining of bored tunnels Trelleborg Engineered Products supplies tunnel segment gaskets (TSGs) under

the trade name Trelleborg. Since 1985, Trelleborg TSGs have been successfully supplied to major segmentally lined tunnel projects around the world. The TSGs, which are located in precast grooves encircling the mating faces of each segment, give a secure rubber-to-rubber waterproof seal as soon as the segments are bolted together.



Benefits of elastomeric TSGs

Trelleborg Tunnel Segment Gaskets:

- are easy to install;
- create an effective seal when bolts are tightened, immediately creating dry joints;
- assure an effective seal despite ground movement and alternating wet and dry conditions;
- have a proven reliability, eliminating the need for a costly remedial work to seal leaks after construction;
- and have a proven record of durability, being resistant to chemical attack and microbiological degradation.



Quality, environmental and health and safety policy

The policy at Trelleborg Engineered Products is to design, produce and supply rubber products to match the desires, requirements and expectations of the customer. The basis of our policy is the Trelleborg Group 'Code of Conduct' policy statement on our web site www.trelleborg.com. During the design of products and processes, the environment and health and safety comprise key aspects of the process.

Trelleborg Engineered Products uses an integrated management system in line with international standards such as ISO 9001, ISO 14001 and SCC** 2008/05 Petrochemical



The low compression set and stress relaxation values of the elastomeric compound used in their manufacture enable elastomeric TSGs to recover under reduced applied load thereby maintaining a positive seal between segments despite ground movements.

Trelleborg Engineered Products manufactures a range of Trelleborg TSGs designed for precast concrete, steel and cast iron segments used in the lining of tunnels or shafts and large mains sewers. All are precision engineered to meet the precise requirements of individual projects.

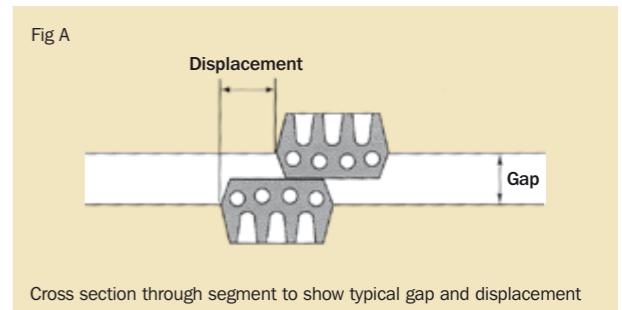
Design

When specifying TSGs for segmented tunnel applications, there are a number of factors which need to be taken into account. It is the particular combination of factors in each case which determines the eventual choice of gasket, which in turn ensures an efficient, watertight seal over the projected service life of the tunnel. Upon request we can forward a Specification Guide which lists these factors.

On the basis of information provided, Trelleborg Engineered Products will be able to specify the most suitable and economical Trelleborg TSG for a particular application. To ease the selection process, customers are invited to consult Trelleborg Engineered Products who will identify, test and demonstrate the appropriate gasket for a particular project.

Gaps and displacements

Gaps and displacements occur between segments, either as an allowance for building tolerances or to help steerage, line and level during the construction of the tunnel (see Fig A). The purpose of the TSG is to seal to the required pressure at the maximum expected gap and displacement. As the size of the gap and/or displacement increases, the ability for a given TSG to withstand water pressure decreases.



Cross section through segment to show typical gap and displacement



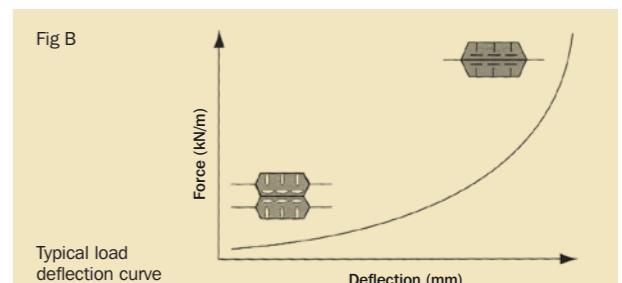
Working and test pressures

Segmental linings require gaskets to ensure a watertight seal. Ground water is normally under pressure and the chosen gasket must therefore be tested for its ability to withstand the pressures involved. This can be done by using specially designed test rings. These are built to simulate the worst conditions which can be expected

during construction and service life of the tunnel. Hydrostatic pressure is built up within the rig to the required test pressure and maintained for a prolonged period of time. The test pressure is always higher than the highest working pressure to ensure a margin of safety.

Closure force

It is important to know the forces required to compress the gasket as these dictate the force required to bring two segments completely together. Trelleborg Engineered Products can provide this information by using one of its compression testing facilities which plots the force against closure for a given gasket, see Fig B.



Groove dimensions

The groove is required to locate the gasket in the segment and is of a size that when the segments are closed, (ie no gap), the volume of rubber is housed within the groove. The size of the groove therefore has a major effect on the choice of TSG and its subsequent performance.

Trelleborg Engineered Products' gaskets are designed such that the elastomeric material can be compressed to fit within a given groove. The size of the groove therefore has a major effect on the choice of TSG and its subsequent performance.



Spray adhesive

Trelleborg Engineered Products will recommend and supply a spray adhesive appropriate for bonding its Trelleborg TSGs to concrete or cast iron segments. Data sheets relating to the spray adhesive are available and Trelleborg Engineered Products can give further advice on storage and application.

Engineering

Trelleborg Engineered Products' Engineering Department specializes in the design of high-performance seals. We apply FEM analysis in the design process to decrease development times and increase the quality of the design. All designs are verified by testing the seals for compression stiffness and water-tightness.

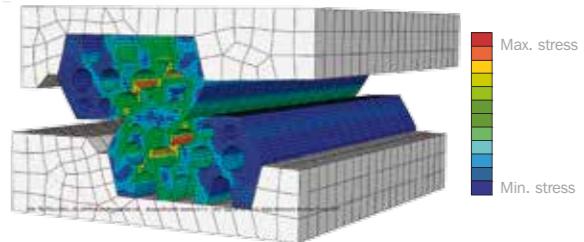


Fig C: Stress analysis by FEM



Tunnel boring machine

In addition to tunnel segment seals, Trelleborg Engineered Products manufactures and supplies seals for Tunnel Boring Machines, such as inflatable emergency seals.