

At high speed through the heart of Europe

## Gotthard base tunnel with participation by Leister

Construction of the NEAT (German acronym for New Rail Alpine Crossing) project represents a further step in regard to Switzerland's integration in the growing European high-speed network. The core is the Gotthard base tunnel, which at 57 km will be the longest rail tunnel in the world. It will comprise two single-track tunnel tubes. Construction is simultaneously in progress on five partial sections of different lengths, so as to optimise the construction time and costs. The costs for this gargantuan project are estimated to be around 9.8 billion Swiss francs (approx. 6.5 billion euros). The construction time will total 20 years. The historic breakthrough of the tunnel occurred on 15<sup>th</sup> October 2010 and the grand opening is planned for 2016.

### Future-oriented project

"AlpTransit" passenger trains will one day travel through the tunnel at 200 to 250 km/h. Even with the travelling speed of 160 km/h that is currently possible, the journey between Milan and Zurich will be reduced by an hour to 2 hours 40 minutes. Besides the familiar high-speed trains (TGV, ICE), modern tilting trains will be able to travel over the new sections at speeds of over 200 km/h. 20 million people who live in the direct catchment area of the "AlpTransit" line will benefit



*Finished tunnel seal. The individual sheets are welded in parallel.*

from the shorter journey time. The entire project sets new standards in terms of planning, logistics, technology, ecology and financing. Following construction of the flat rail route, fewer locomotives, less personnel and energy will be required for the same amount of transport. This means that rail will once again represent a real alternative to road and air transportation.



*Overhead welding work with the TWINNY S.*

### **A coordinated workflow is necessary**

The heading is created with a tunnel boring machine or traditionally, with drilling and blasting. Afterwards, an external safeguarding shell is applied with shotcrete. This must fulfil the highest requirements for roughness and flatness. The drainage layer is applied onto the shotcrete. It is fastened onto the concrete with setting bolts. The exact spacing of the fastening points was determined in tests. Discs backed with Velcro are fastened during the same work stage. These will later support the plastic sealing sheeting which is laminated with special felt.

### **The «worm» has got what it takes**

The plastic sealing sheets are welded by a giant, 2 x 250 metre long monster, the so-called “worm”. It works around 24 metres a day through the tunnel. Running through its lower part are the supply lines for electricity, water and fresh air for the tunnel boring machine which is situated further ahead. The entire construction site traffic including excavated material and personnel also runs on rails below it. The “worm” is also

the location for testing the roughness and flatness of the shotcrete, applying the drainage layer and fastening the Velcro-backed discs. Afterwards, the plastic sealing sheets are unrolled with a special device and pressed onto the Velcro-backed discs.

### **Overhead welding made easy**

The overlaps of the sheets are then welded tightly and permanently using the TWINNY S welding machines from Leister. This compact combination wedge device has proven its merits once more. Even overhead welding is possible as a result: the TWINNY S presses the two sheets together and thus rises easily and safely during welding. The welding progresses almost by itself. If required, the welding direction can be corrected simply and without interruption. The contact pressure, welding speed and temperature can be adapted to the relevant requirements. Despite its small dimensions, welding speeds of up to two metres per minute are possible with the TWINNY S, depending on the contact pressure. This is a crucial advantage when you consider the size of this project.



*The TWINNY S can be easily guided, even in the case of vertical weld seams.*

*Fiddly welding work on the base seal is no problem for the lightweight and practical TRIAC DRIVE.*



*“Double” pressure roller and welding nozzle of the TWINNY S.*

The tightness is the most important criterion when evaluating the weld quality. To guarantee the greatest possible safety here, a test channel is installed for each overlap weld. This is realised with the pressure roller on the TWINNY S which was specially designed for this purpose. This ensures two parallel weld seams of 15 mm each. The test channel that results between these seams is 20 mm wide. The watertightness can be reliably monitored via compressed air using this channel.

### **Working in a confined space**

The structural sealing acts as a shield protecting against penetration by mountain water. Drainage pipes collect the diverted moisture on both sides. This is held in the large, central collecting pipe and routed to the tunnel exits. Waterstop profiles set in concrete on both sides in the kicker area (concrete base) complete the „rain shield“. The rain shield seal is joined to the back of the waterstop here. This fiddly work in a very confined space and on hard substrate is

performed with the lightweight and practical semiautomatic welding machine TRIAC DRIVE from Leister. Where necessary, a protection rail is mounted afterwards and finally a reinforcement installed. As a final step, the concrete inner shell of the tunnel is installed.

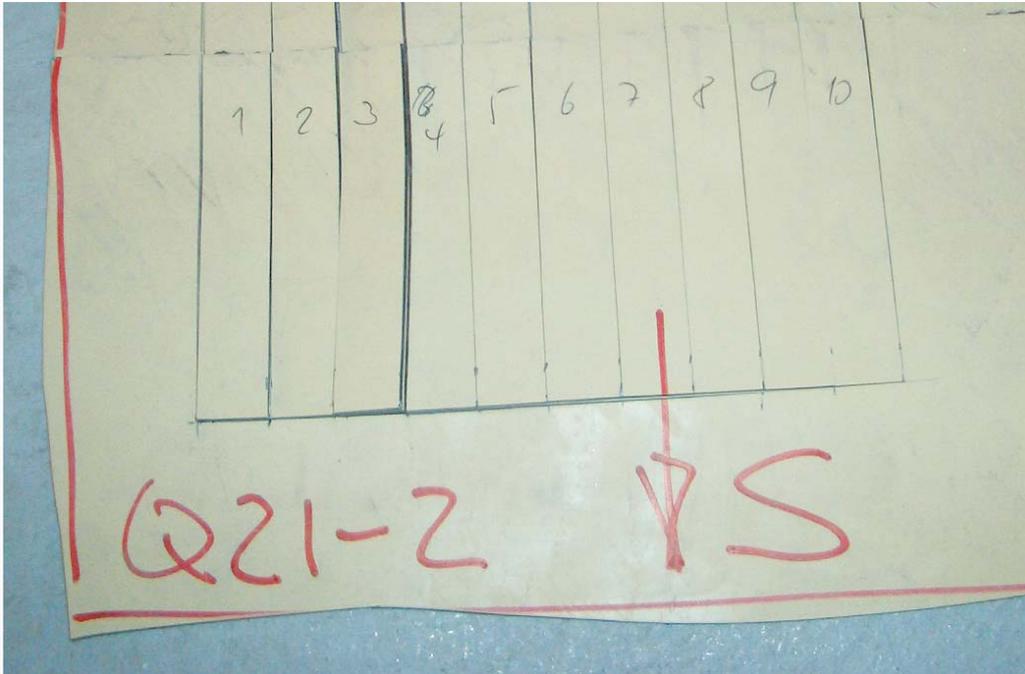
### **1000 km weld seams**

For NEAT south side and centre the plastic sealing sheets are produced in the Sika plant in Duedingen, Switzerland with a width of 2.20 metres. Two overlapping sheets are prefabricated here. As a result, a circumferential weld seam of 24 running metres is only necessary approx. every 4.30 metres for processing in the tunnel. This includes the two-sided weld seams on the base seal and the weld seams for the countless cross connections of the two tunnel tubes. In total, this corresponds to a weld seam length of around 1000 kilometres for the entire, 57 kilometre long Gotthard tunnel! The sheet fabrication, cutting-to length and delivery of the plastic sealing sheets are each adapted to the construction section.

### Quality is crucial

On account of the permanent shift operation and the special parameters, a high level of dust, heat and air humidity arises in the tunnel. Only the best quality of material, processing and machine enables fault-free and hence efficient work. With a planned service life of over 100 years, there are different requirements in play than those typical of standard structures. All products used for the sealing system therefore had to prove their suitability for this extraordinary project during long tests. The selection of the materials was also accompanied by regular monitoring. This thereby ensures that the quality and processing remain within a defined tolerance

range. The specialists at the accredited test institute, Tecnotest AG in Rueschlikon, Switzerland are relied on for this process. Control inspections concerning the drainage and sealing are conducted in the laboratory. In addition, the company inspects the quality of the weld seam and the substrate on site. Regular peel tests to check the weld quality are carried out directly in the tunnel using the EXAMO test device from Leister, a device highly suitable for construction sites. The plastic sealing sheets and the drainage layer undergo further tests in the laboratory in order to test the various material properties.



*Welding samples taken directly in the tunnel.*



*Peel tests are conducted in the laboratory, but also on site with the EXAMO test device from Leister.*



*Mechanical application of the prefabricated, 4.30 m wide plastic sealing sheets onto the Velcro-backed discs located below. Welding is then carried out.*

### Long-term project

The flat rail route opens up new dimensions in passenger and goods transportation. Economic centres on both sides of the Alps will be brought closer together. The railway will become a modern and powerful instrument of transportation on the North-South axis thanks to “AlpTransit”. It will be able to provide greater transport capacity with shorter travelling times. Furthermore, it will guarantee an environmentally-friendly, sustainable solution for issues of mobility and the continually growing volume of traffic. An incredible amount of work has gone into this project for the future. The quality of this construction of the century is therefore extremely important. Not only is the processing and the material crucial, but also the machinery used. Leister shares the responsibility for this thanks to the use of its welding machines and hot-air hand tools. Even under these exceptional conditions in the tunnel, the equipment of the long-established Swiss company is once again proving its merit. After all, the sealing system must continue to fulfil its purpose in 100 years’ time!



*The finished welded sealing layer before concreting the inner shell of the tunnel.*

Questions about the NEAT construction site directed to the project manager responsible at Sika Bau AG, Urs Streuli

**The NEAT construction site is dominated by difficult climatic conditions. – What does this mean for the machinery and equipment used?**

Temperatures of up to 28 °C and an air humidity of over 90 % predominate in the tunnel. A clean weld seam preparation is therefore essential. It is also important to store all machinery cleanly after use in order to prevent unnecessary corrosion.

**What are the most important measures for complying with the processing quality?**

Clean work in general, as well as clean weld seam preparation. What is more, the welding must not be too fast and must never be performed in water.

**How do you monitor the processing quality?**

Every weld seam is subject to a visual inspection with the screwdriver; dual seams with a test channel are "inflated". Peel tensile tests are also carried out regularly. The latter either in the Sika laboratory or by Tecnotest AG. A control weld is also conducted when starting work.

**What are the most important advantages of Leister devices from your point of view?**

We work exclusively with Leister devices and depend on their reliability. They correspond exactly to our requirements. We have been working with Leister equipment for as long as I can remember...

**Sometimes the spaces are very confined on a tunnel construction site like the one here with NEAT. How effective does the Leister machinery prove to be?**

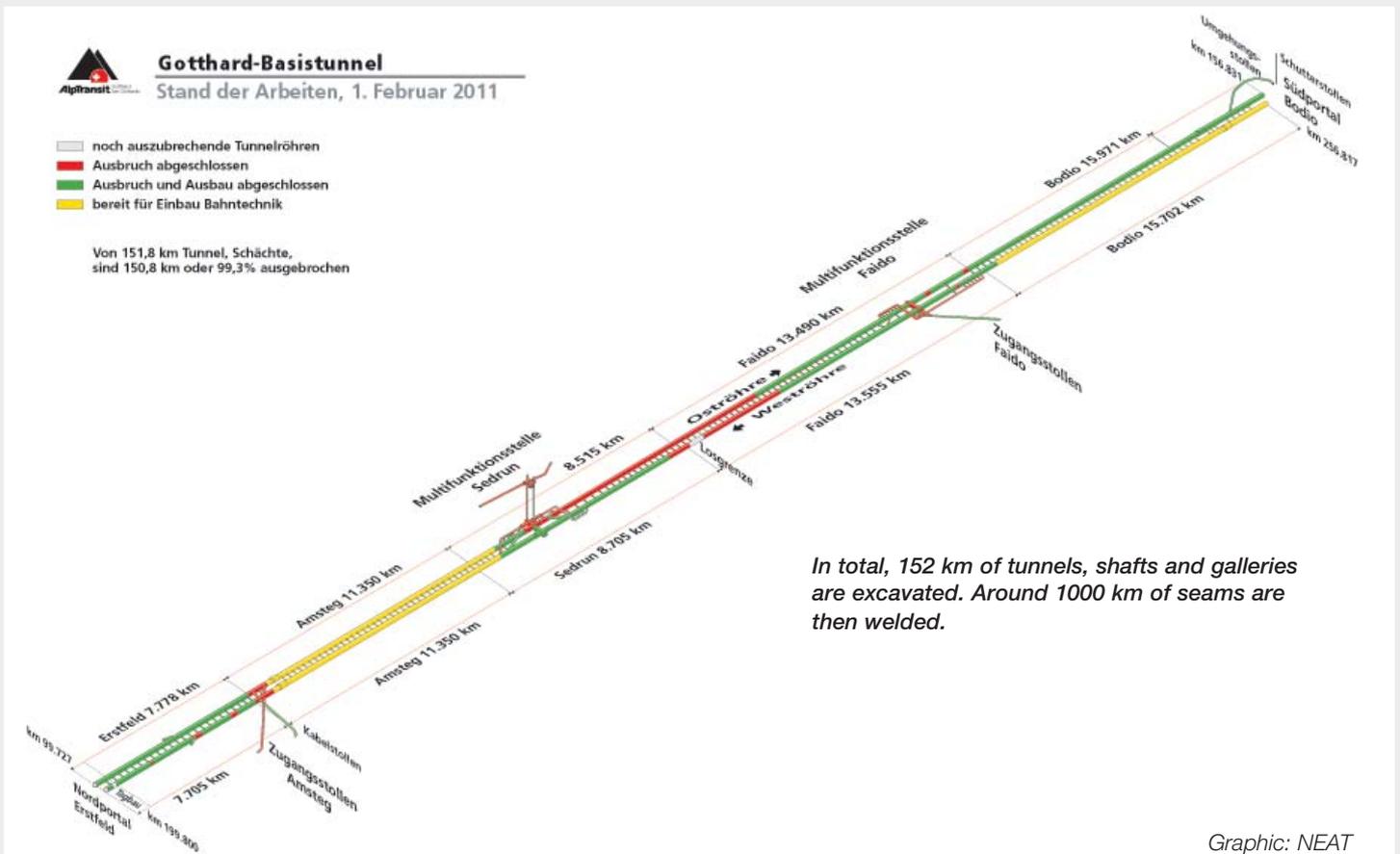
TRIAC Drive and TWINNY S are practical and lightweight welding machines. That makes them ideally suited for use even in very confined spaces like here. Even overhead welding work does not pose any problems.

**Are you happy with the support provided by the Leister Sales and Service Centre?**

Yes, we are satisfied with the service of the Leister partner responsible. If one of the devices needs a service, it is soon ready for use again afterwards.

**Does Sika Bau AG also work with Leister equipment for other major projects? – If yes, which ones?**

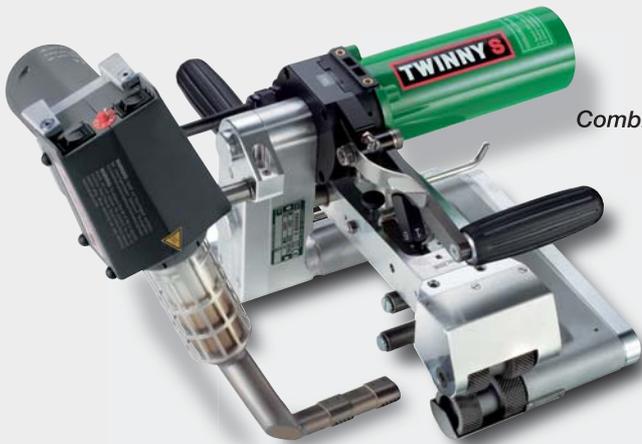
We only work in Switzerland. Sika Bau AG uses Leister devices exclusively in all tunnel projects here, for example on the bypass tunnels in Zurich, Lungern and Olten, and in the Ceneri base tunnel (part of the new flat rail route through the Alps).



In total, 152 km of tunnels, shafts and galleries are excavated. Around 1000 km of seams are then welded.

Graphic: NEAT

Leister equipment used on the NEAT construction site:



Combi-wedge welder TWINNY S



Semiautomatic welding machine TRIAC Drive



Hot-air hand tool TRIAC PID



Hot-air hand tool TRIAC S



Test device EXAMO

**Construction customer:**

**Sealing system for the south side and centre:**

**Sealing sheets for the south side and centre:**

**Laying company for the south side:**

**Laying company for the centre:**

**Sealing system for the north side:**

**Sealing sheets for the north side:**

**Laying company for the north side:**

**Laboratory and tunnel inspection tests:**

**Equipment supplier for sealing work:**

AlpTransit Gotthard AG, 6003 Lucerne, Switzerland, [www.alptransit.ch](http://www.alptransit.ch)

Sika, 8048 Zurich, Switzerland, [www.sika.com](http://www.sika.com)

PVC-P from Sikaplan, thickness 2.0 mm

Consortio IGS (SikaBau AG and Tecton AG)

Sika Bau AG, 8952 Schlieren, Switzerland, [www.sikabau.ch](http://www.sikabau.ch)

Sarnafil AG, 6060 Sarnen, Switzerland, [www.sarnafil.ch](http://www.sarnafil.ch)

PE-Copolymer from Sarnafil, thickness 2.2 mm

Gunimperm SA, 6532 Castione, Switzerland

Tecnotest AG, 8803 Rüschlikon, Switzerland, [www.tecnotest.ch](http://www.tecnotest.ch)

Leister Process Technologies, 6056 Kägiswil, Switzerland, [www.leister.com](http://www.leister.com)

**Text:**

**Photos:**

Norbert Tholl, Tecnotest AG / Christophe von Arx, Leister / NEAT

Norbert Tholl, Tecnotest AG

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