



The Muttsee lake is the main reservoir of the pumped storage plant with a capacity of 23 million cubic metres of water.

Image: Axpo Power

Tube forming

Energy generation without leakage in the Swiss Alps

Only two years after commissioning, leaks were detected on hydraulic stainless steel tubes at one of Europe's largest pumped storage plants in the Swiss Alps. In some areas, conventional stainless steel cutting ring fittings had been unable to withstand the strong vibrations at exposed locations of the power plant. Kraftwerke Linth-Limmern AG now relies on the tube forming system from STAUFF.

The principle is simple: The main task of a pumped storage plant is to store energy. When there is excess energy in the power grid, for example during the night, water is pumped from a lower reservoir to a storage reservoir at a much higher altitude. The water acts as a storage medium and in a way takes on the role of a battery: When energy is needed, for example during periods of peak demand during the day, the water is drained and drives turbines. Electricity can be generated and fed into the power grid within a matter of seconds.

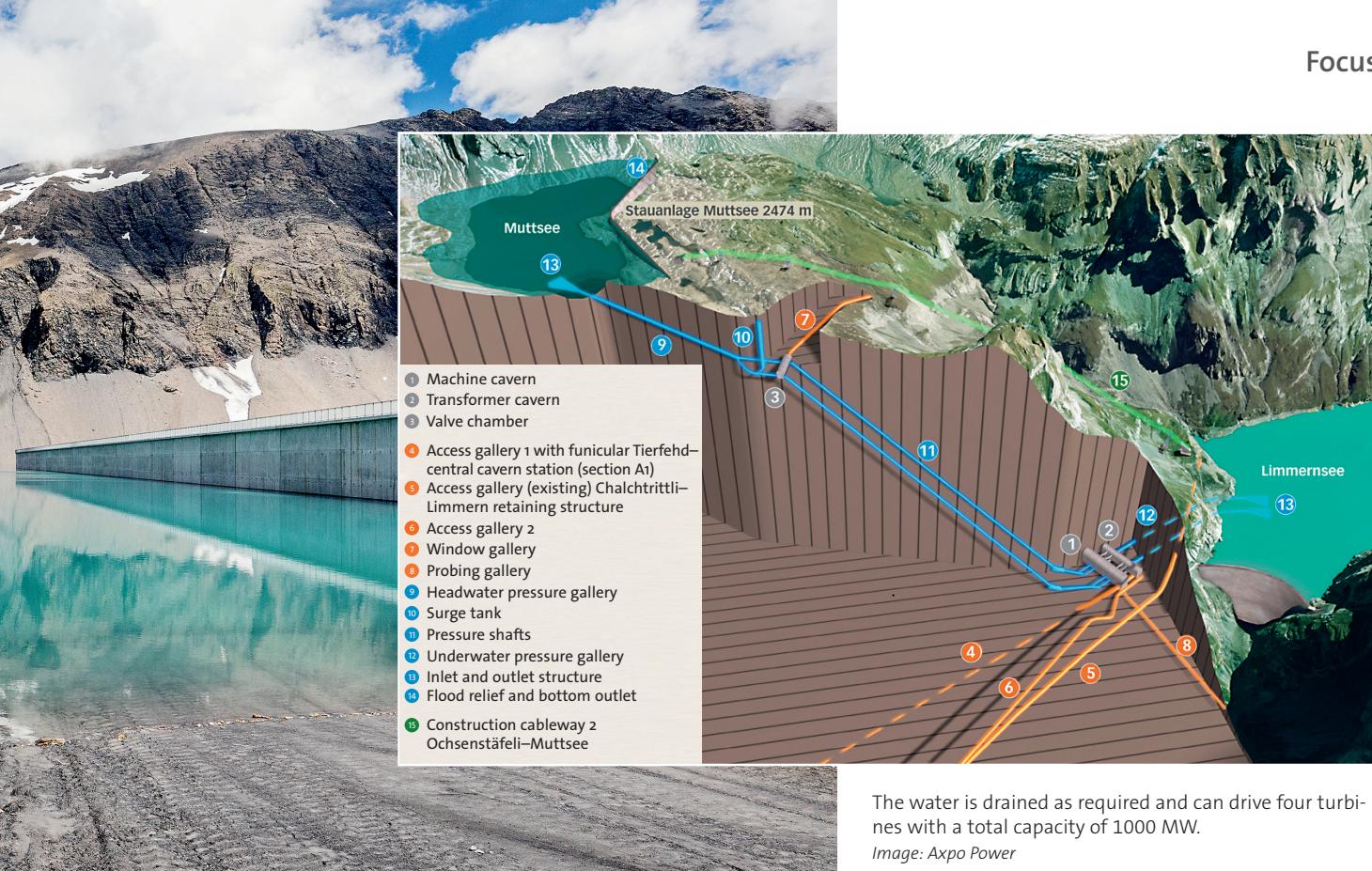
This principle means that pumped storage plants are often referred to as "trump cards" for the energy revolution. While power generation through wind power and photovoltaic systems fluctuates and cannot be controlled, hydropower in a pumped storage plant can be accessed flexibly and at short notice. The challenge of compensating for phases of low power generation from sustainable sources or periods of peak demand can be overcome by integrating pumped storage

plants – without having to resort to nuclear power or fossil fuels.

The Limmern pumped storage plant is located in the Swiss Alps, around 100 km from Zurich. During the latest expansion stage, the Muttsee lake 2474 m higher up was integrated in the power plant: The 1054 m long retaining structure allows the lake to store 23 million cubic metres of water. The Limmernsee lake 630 m lower down acts as the lower reservoir. The water drained from the Muttsee lake can drive four turbines with a capacity of 250 MW each. In total, Kraftwerke Linth-Limmern have a capacity of 1520 MW after integration of the Muttsee lake.

An exceptional pumped storage plant

The Limmern pumped storage plant was commissioned in stages in 2016/17. Only two years later, leaks were detected on hydraulic lines during maintenance work. Uwe Brölls is the Key Account Manager at Fluidtec AG in Kreuzlingen, the authorised STAUFF partner for



The water is drained as required and can drive four turbines with a total capacity of 1000 MW.

Image: Axpo Power

Switzerland. "When leaks were found at the Limmern pumped storage plant in 2019, I was consulted as an expert for hydraulic line systems. The damage analyses showed that cracks had formed in some of the cutting ring tube fittings." This was caused by the permanent vibrations acting on the hydraulic lines in the power plant.

Leak-free under extreme conditions

24° tube connectors with cutting ring are generally very durable and are regarded as the universal standard for connecting metric tubes with outside diameters between 4 and 42 mm in hydraulic systems reliably and without leaks. "For the application with the extreme conditions at the Limmern pumped storage plant, however, it would have been better to use a different joining solution – tube forming – from the outset," summarises Uwe Brölls. He recommends STAUFF Form, which was specially developed for high-pressure applications and strong vibrations by STAUFF, the German manufacturer and developer of all components for hydraulic line systems. The principle: The STAUFF Form machine is used to reshape the tube end so that a positive connection is created during installation with a conventional fitting body and a union nut. The only conceivable leakage path is additionally secured with a Viton seal. So while STAUFF Form only changes the

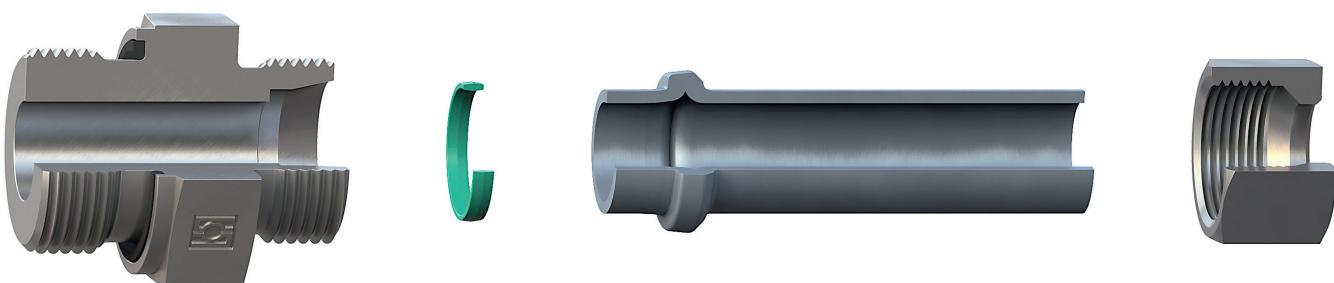
shape of the tube material, a cutting ring connection is achieved when a metal ring with two edges cuts into the tube surface. This incision into the material limits the vibration resistance. In contrast to this, the forming system has a higher tear-out strength, which offers a safety benefit under extreme conditions – like the strong pressure surges and vibrations as at the Limmern pumped storage plant. This is a crucial aspect for mechanical engineering and plant engineering manufacturers in safety-critical fields, such as ship building, offshore plants or cranes and lifting devices.

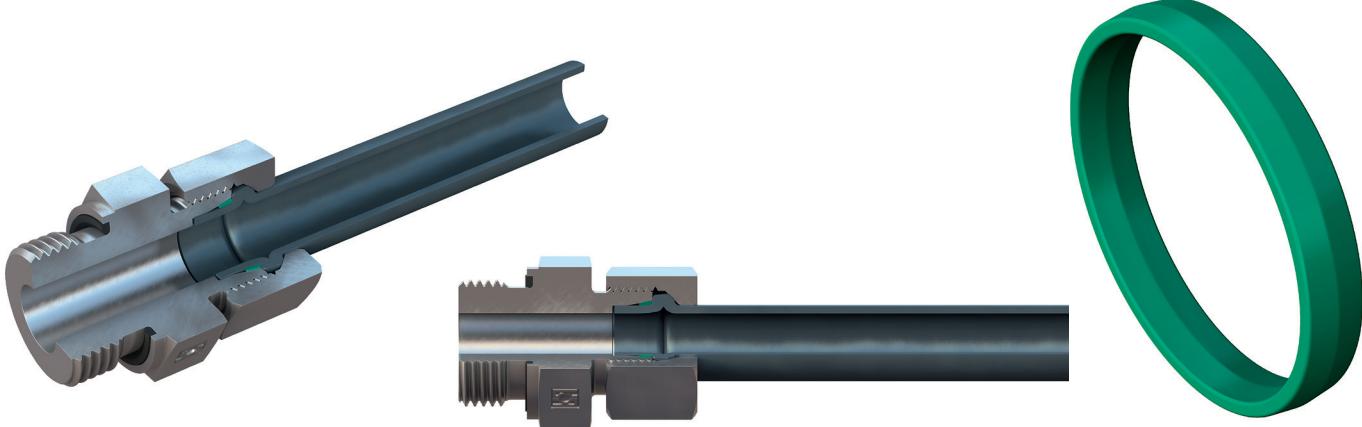
Operational safety and environmental protection

Oswald Hauser, Head of the Mechanical Engineering division at Kraftwerke Linth-Limmern AG, chose STAUFF Form together with his maintenance team in 2020. Since then, the stainless-steel cutting ring fittings have gradually been replaced with formed connections. "Our focus is on operational safety, leak protection and prevention of environmental damage. The stainless-steel lines carry up to 18,000 litres of oil that must not leak into the plant or nature." The use of highly durable tube connections also substantially reduces the service and maintenance costs. After all, several dozen kilometres of lines have to be checked at the Limmern pumped storage plant in tightly spaced maintenance intervals.

The STAUFF Form Evo is completely based on standard components.

Image: STAUFF





The forming system is also available with a simple Viton seal.

Image: STAUFF

Personal introduction to operation

The support from Fluidtec played an important role in the decision for STAUFF Form. "We are in very good hands with Mr Bröllös. We have been working together in other areas for many years. He has helped us out of a fix many times, for example when we needed spare parts at short notice." Oswald Hauser particularly wants to highlight the introduction to the forming machine, the heart of STAUFF Form. STAUFF employees travelled from the headquarters in the German Sauerland region to train the installation personnel. These highlighted additional benefits of the forming system: Another design feature of STAUFF Form is that excessive or incomplete tightening is virtually impossible. The forming machine is easy to operate and changing tools for different tube diameters is easy. The introduction to the cloud connection and use of the remote service function were also convincing. Users benefit

from the close cooperation with the project manager at the STAUFF headquarters in Germany. Oswald Hauser: "The change to STAUFF Form is an important technical step for us and also an advantage with regard to work processes, reliable installation and maintenance effort."

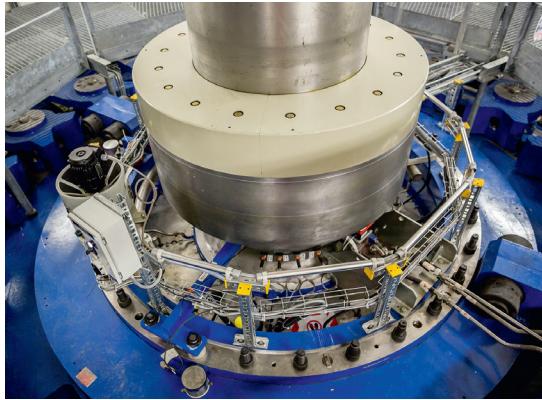
Uncomplicated software updates

In 2021, STAUFF updated its forming system that had been successfully used in international mechanical and plant engineering since 2015: The previously used metallic adapter ring with a permanently bonded elastomeric seal was replaced with a "simple" FKM (Viton®) seal. This is less expensive and therefore of particular interest for applications involving larger quantities, without compromising safety. Both systems are still available and are formed with the same machines. The changeover to STAUFF Form EVO only requires a tool change and a



Power underground:
Housing the machine systems in caverns – here a view of the transformers – contributes to preserving the landscape.

Image: Axpo Power



Each of the four pump turbines has a capacity of 250 MW.

Image: Axpo Power



The machine cavern is 150 m long, 30 m wide and 53 m high.

Image: Axpo Power

software update. With the latest generation of machines, software updates are very straightforward: They can be transmitted online. This is made possible by a communication module with SIM card integrated into the machine. The communication features offer additional benefits for users. The machine history and parameters, for example, can be viewed via an online service and analysed together with the account manager. The cause of a malfunction can be quickly identified, and the quality of the forming process can be maintained at a high level. Customers can use the detailed documentation of the completed forming processes as proof of correct assembly. The data exchange with STAUFF's own cloud is encrypted in both directions, reliably protecting data against third-party access, misuse and manipulation.

Controversial pumped storage

Conventional pumped storage plants have been technically established for decades. The overall efficiency of 75 to 80% is clearly above other storage methods, for example compressed-air energy storage. The construction of a new pumped storage plant, however, is always a substan-

tial intrusion on the natural environment, for example when previously free streams or rivers are dammed, or large reservoirs are built. Environmental associations therefore demand that environmental protection is treated as the most important target parameter from the outset, rather than just being an afterthought during the planning process. Disused mining sites are potential locations that require no or only little interference with nature. Concepts for integrating these in sustainable energy solutions are being examined in some mining regions.

Respecting nature

At the Linth-Limmern pumped storage plant, natural lakes are used as the lower reservoir and main reservoir. Damming the Muttsee lake has only little impact on the flora and fauna in the barren mountain landscape. The greatest impact on nature occurred during the construction phase, which is why the removal of any required installation was part of the environmental restrictions. The container cluster and the two transport cableways have now been removed and the areas used during construction have been restored.

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