

Underground substation transformer for a megacity

Shanghai operates high-capacity single-phase autotransformers

The challenge

Shanghai, located on China’s central coast, is the country’s biggest city and a global financial hub. With a population of around 23 million, space becomes very limited.

Power supply utilities are therefore faced with the challenge of producing large high-capacity transformers in limited spaces. The Shanghai Hongyang project presented many of these exciting challenges to which Siemens Transformers readily rose.

The customer, State Grid Corporation of China, planned to install a 500-kV underground substation which needed two banks of three single-phase autotransformers with a total capacity of 3,000 MVA – including some extremely demanding requirements in dielectrics and heat dissipation.



500-kV single-phase autotransformer in the test bay

“Siemens offers a ‘slimmed down’ power transmission solution for Shanghai, the golden megacity, with the satisfactory capacity.”

Jiang Jinhua, SGCC Shanghai Research Institute

The task for the Siemens Transformers plant in Jinan was to deliver an autotransformer which was specially designed and built for underground use. The space limitation set fixed conditions from the very beginning – from the bidding stage and throughout the entire production process.

What is more, the specification set very high standards for the quality of the units as well as their ability to withstand severe conditions, controlling the hot spot and excessive losses.

The solution

To meet the high customer demands, an exceptional transformer design was created, which included an optimized insulation design, and magnetic leakage and loss control – a challenging task. A particularly targeted cooling mode, equipped with an advanced water-cooling system, was introduced to ensure safe operation of such a high-capacity transformer.

A series of Lean Production workshops were organized with the aim of increasing the efficiency as well as ensuring the highest quality for the project at all times. Considering the lead connection for example, an interdisciplinary Business Excellence workshop specifically reorganized the production process to reduce lead connection times and man hours by approximately 50 percent each. Even more importantly: just as planned in the initial target, quality assurance was maximized.

The mission was accomplished in April 2016 when the six brand-new 500-MVA/500-kV single-phase autotransformer units successfully passed the tests.

This project is a true example of ingenuity, as despite challenging circumstances Siemens Transformers designed an underground transformer for their customer which is set to become the highest-capacity single-phase autotransformer of 500 kV worldwide.



Technical features

1. Advanced water-cooling system

Operation of a transformer in an underground cavern always increases the demand for its cooling capabilities. For these transformers, that withstand increased levels of voltage and load, traditional air-cooling was not sufficient. As a solution, an advanced water-cooling system was designed and built.

2. Powerful and compact go well together

When installing a transformer bank of three 500-kV autotransformers, size is always an issue. This is even more important when the transformer is located under the streets of a megacity. The overall size of the units, however, is considerably compact, measuring just 9 x 5.6 x 7.3 meters (L x W x H) each.

4. Control of hot spot and excessive losses

High impedance presented challenges for hot spot and stray loss control. Fully supported by a 3D magnetic model tool, the shielding structure design, especially on the tank and clamping frame, increases overall efficiency.

3. Impedance reach losses

Not only were the specifications in terms of voltage level extraordinary, the requirements for short-circuit strengths were also more demanding than usual. Each transformer should withstand a certain amount of short-circuit load. However, the autotransformers for the underground substation in Shanghai can stand impedance of up to 22 percent. This means that the units will operate as usual even when exposed to a load 22 percent higher than their rated current.

Local customer approach with global quality standards

Siemens Transformers has a global setup of manufacturing locations and produces their products in Northern, Central, and Southern America as well as in Asia and Europe.

This global manufacturing network allows for relatively short transportation routes and ensures that customers get local support. Furthermore, our comprehensive factory network ensures that quality standards are upheld in all Siemens Transformer plants worldwide.

“The Shanghai Hongyang project really means a lot to us, and we are exceptionally proud to have built the highest-capacity 500-kV single-phase underground autotransformer in the world.”

Ouyang Tao, General Manager of
Siemens Transformers plant in Jinan

Specifications to consider for underground operation of transformers

There are several reasons why a transformer needs to be operated underground. It can be due to space limitations or restrictions set in place to meet environmental requirements. Special considerations need to be taken into account:

- Space limitations: units need to be transported and installed in the limited space available
- Safety considerations: use of ester fluid and/or special capabilities such as short-circuit strength and high impedance might be necessary
- Quality requirements: to minimize operational risks and maximize the economic benefit of underground units, nothing but the highest quality can be used

With our global network of plants and experienced, dedicated staff, we are happy to assist you in designing and manufacturing the transformer that best fits your needs.

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