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# Advanced Compaction Design for 500kV Substation

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## Abstract

Substations are now being constructed in various locations such as mountainous areas, inside buildings and underground in city centers because of the severe space restrictions in Japan. In particular, trunk transmission substations are required to have compaction design to satisfy the increasing electricity demand and to reduce construction cost.

This paper describes the state of compaction design, focusing on large 500kV capacity substations that are installed in small restricted areas such as mountainous areas, city centres and underground.

First, the 500kV Shin-Toyosu underground GIS substation, which has been operated since 2000 by Tokyo Electric Power Co., Inc. (TEPCO), supplying electricity to the Tokyo Area in Japan, was constructed with advanced compaction design including economy, reduction of construction period and substation building cost. The equipment specifications were reviewed by applying the latest technologies.

(1) The world's first circular building was employed. As for equipment layout, the equipment is composed of three units and each unit is located in one of the 120-degree sectors making use of the circular form. (2) In order to achieve miniaturization of the equipment, the Lightning Impulse Withstand Voltage (LIWV) was reduced from 1300kV to 1050kV by installing a surge arrester near equipment such as transformers and shunt reactors. (3) Regarding the transportation of a transformer, the body can be divided into four sections （Per single phase） to satisfy the strict transportation regulations in the Tokyo area. (4) Regarding the 500kV equipment, the bus is a three phase enclosure type, the circuit-breakers are of the vertical single phase enclosure type and have one-break point in terms of reduction of equipment height.

Next, TEPCO completed the construction of 500kV outdoor GIS substations. TEPCO developed a couple of technologies to minimize the substation area as follows.
(1) Large three-phase transformers were transported as single-phase units due to the road traffic limitations. However, at present, the transformers are disassembled into the windings, cores, and tanks at a factory for transporting to a site after the factory tests. Then they are reassembled at the site. This transportation method is adopted for transformer installation. (2) Vertical single break point circuit breakers are employed at the Shin-Toyosu substation. (3) The distance of air-insulation of the transmission line between GIS bays is reduced from 34m to 27m because of the reduction in the lightning surge and switching surge with high performance surge arresters. (4) The diameter of the GIS tank is downsized because the allowance temperature of the tank was upgraded with the application of higher stress spacers and heat resistant seal materials.

As a result, these technological improvements have led to a reduction in the area required by about 80% compared with a conventional air insulated substation that was constructed in the 1970s.