

Study Committee B3

Substations and electrical installations

10735_2022

Life management and improvement of reliability, maintainability and operability of 500 kV substations

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Motivation

- Concerns on 500 kV substation reliability as first equipment are now reaching 50 years old.
- Resilience of power equipment needs to be strengthened against natural disasters.
- Maintenance personnel are declining due to a decreasing birth rate and ageing population.
- Life management of power equipment needs to be considered.

⇒ Upgrade 500 kV substation applying GIS, transformer and LAN-type monitoring system with latest technologies.



Approach for life management of 500 kV substation

Goals of life management

Securing of electricity supply with lower fee

- Maintaining equipment reliability
- Minimum de-energization period
- Higher resilience
- Economical equipment

Efficient operation and maintenance

- Reduction of maintenance work
- Minimum de-energization in replacement and inspection work

Replacement

Replacement of ageing equipment

- GIS
- Retrofit of circuit breaker, bushing
- Maintenance-free
- Improving seismic performance
- Transformer
- Compact equipment
- Minimum work period and de-energization

Remote monitoring and control

- Unmanned substation
- Reduced control cables

Applied technologies

- Deterioration diagnosis
- Risk assessment

Effective use of existing equipment

- Retrofit
- Reuse of foundation

Application of new technology and new construction method

- Spring-operated CB
- Polymer gas-insulated bushing
- Elimination of soundproof wall of transformer
- Simplified fire fighting equipment
- LAN-type monitoring and control system
- Improvement in method of on-site assembly of transformer

Implementations

- Old double-pressure circuit-breakers and oil-impregnated paper (OIP) bushings of 500 kV GIS were replaced with spring-operated CBs and polymer gas-insulated bushings.
- 500 kV transformers were upgraded to new ones with polymer gas-insulated bushings and vacuum valve on-load tap changer (OLTC). Site assembling work period was minimized, which contributed to short de-energization duration.
- LAN-type monitoring & control system was applied, which made substations unmanned and reduced amount of control cables and their construction costs.

Polymer gas-insulated bushing Porcelain OIP bushing



Overview of existing and replaced bushings

▶▶ [Details in the following slides](#)

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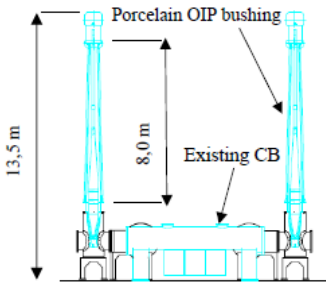
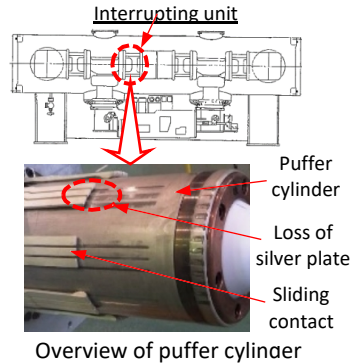
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Replacement of GIS

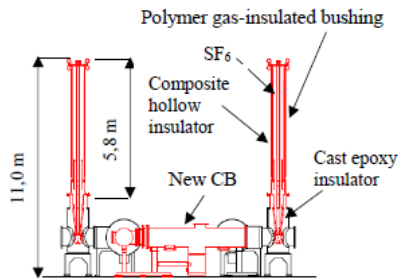
- First generation 500 kV GIS have been aged 40 – 50 years.
- Renewal priorities was set based on:
 - age, number of operations
 - gas pressure conditions
 - contact conditions of the main circuit
 - depletion of maintenance personnel
 - discontinuation of GIS components and maintenance parts
 - maintenance costs and failure risks
- Replaced components

GCB: hydraulic, 4 break \Rightarrow spring, 2 break

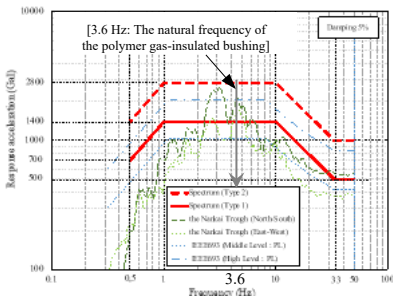
Bushing: Oil impregnated paper type \Rightarrow Polymer gas-insulated type



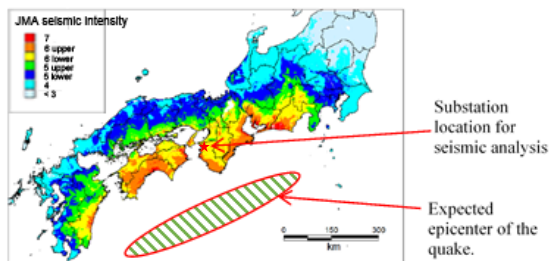
(a) Before replacement



(b) After replacement



The stresses by the Spectrum Type 2 were all below the whole GIS allowable stresses



Expected area of the Nankai Trough Earthquake. The Nankai Trough earthquake is expected to be one of the largest earthquakes (magnitude 9 class)

Construction

- Existing foundation for the disconnector, the current transformer (CT) and the CB were reused.
- Only the CB was upgraded in order to avoid the de-energization of the main busbar and to use the existing equipment effectively.

Benefits

- Spring CB reduces failure rate, requires less regular inspection.
- Polymer gas-insulated bushing improves the whole GIS seismic performance whose response acceleration is more than 1.3 times of high level specified in IEEE 693-2018.

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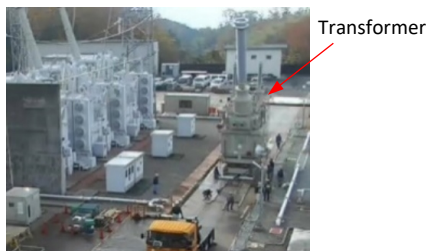
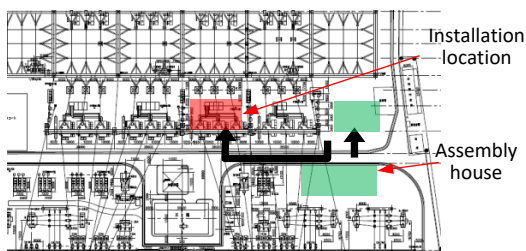
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Replacement of transformer

- Comprehensive evaluation was made on the existing aged transformers based on:
 - age
 - static electrification evaluation
 - dissolved gas analysis in oil
 - average degree of polymerization
 - oil leakage
- Improvement in replaced transformer
 - Polymer gas-insulated bushing
 - Elimination of soundproof tanks
 - Simplification of fire extinguishing system
 - Vacuum valve OLTC

Reduction of de-energization duration

- To minimize the de-energization duration for replacing transformers,
 - Re-use of existing foundation
 - Assembling new transformer at another place
 - The new transformer was moved to the installation location with bushings equipped



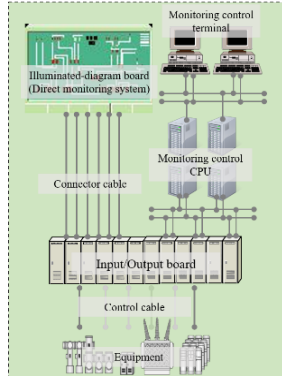
⇒ Shortening of outage duration by 15 months

LAN-type monitoring & control system

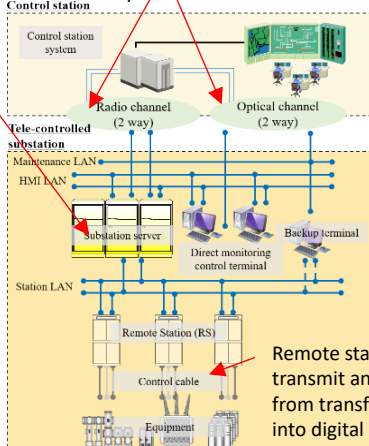
- The existing direct monitoring and control panels (illuminated panels) were replaced with LAN-type monitoring and control systems.
- The system transmit large amount of information with less control cables.
- All the seventeen 500 kV substations have been unmanned by 2019.

Servers realize remote and direct monitoring.

Substation directly controlled by resident personnel



The system has double networks to be redundant



Renewal of monitoring and control system in 500 kV substation