Factory and Field Verification Tests of Controlled Switching System (CSS)

according to CIGRE WG13.07

H. Ito, H. Kohyama, K. Kamei, T. Yonezawa
TM T&D Corporation, Japan

H. Wilson, S. Billings
Mitsubishi Electric Power Products, Inc. USA

TM T&D
TM T&D Corporation

MITSUBISHI ELECTRIC

Factory and Field Verification Tests of CSS

Outlines

1. CIGRE Testing Requirements
2. Individual Component Testing
3. Integrated System Testing
4. Field Verification
5. Conclusions

TM T&D Corporation

MITSUBISHI ELECTRIC

1. CIGRE WG13.07 Documents for Testing

- CIGRE proposed the testing requirements and their procedures for CSS.
- The guide emphasizes importance of compensation for operating time variations.
- Some mechanisms showed a significant delay after idle times of breakers for only a few hours.
- The method of determining the optimum close target is proposed by pre-strike characteristic.

2. Individual Component Testing

145kV independent-operated GCB with spring mechanisms

Controller

TM T&D Corporation

MITSUBISHI ELECTRIC

Factory Tests for Circuit Breakers

Electrical performance tests

- Dielectric characteristics (RDDS / RRDS)
- Minimum arcing time for reignition-free window

Mechanical performance tests

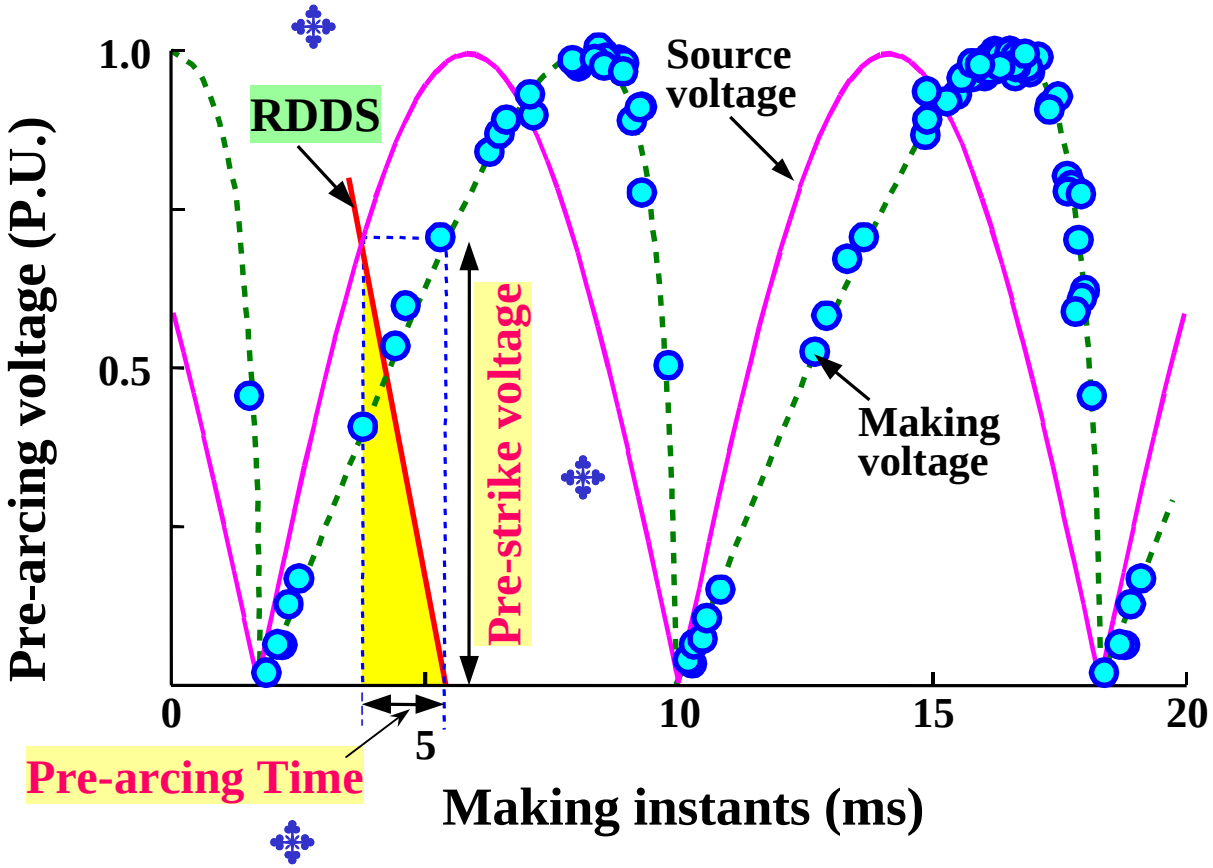
- Variations of operating time on operating conditions
- Delay of operating time after an “idle time”

RDDS: Rate of Decrease of Dielectric Strength
RRDS: Rate of Rise of Dielectric Strength

TM T&D Corporation

MITSUBISHI ELECTRIC

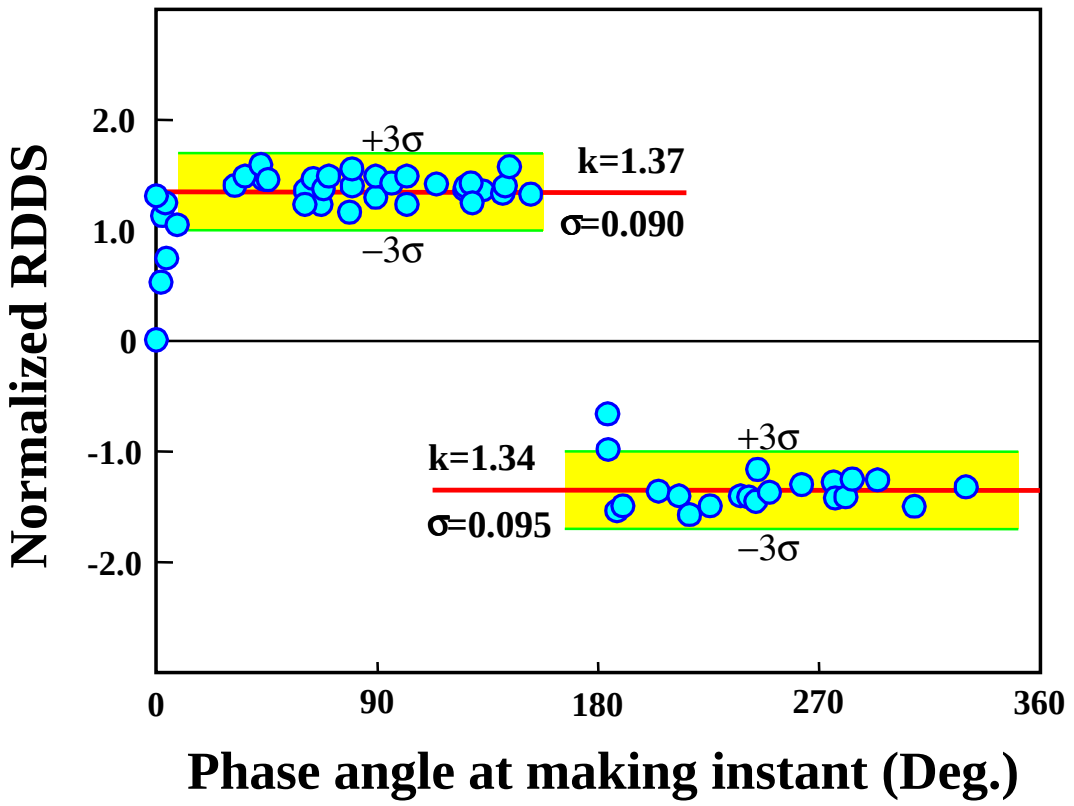
Pre-strike voltage for a cycle of power frequency



TM T&D Corporation

MITSUBISHI ELECTRIC

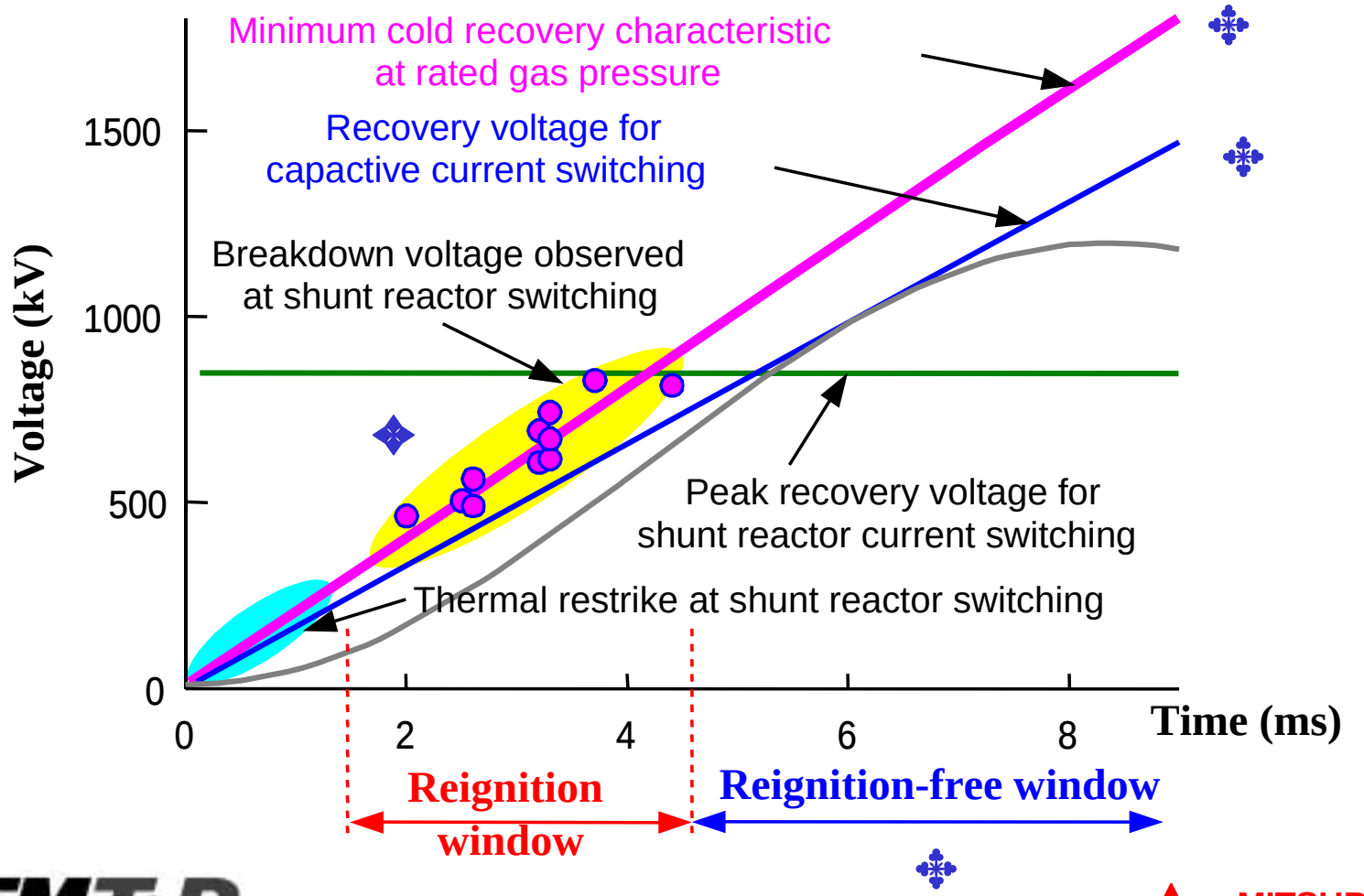
RDDS measured by pre-strike test



TM T&D Corporation

MITSUBISHI ELECTRIC

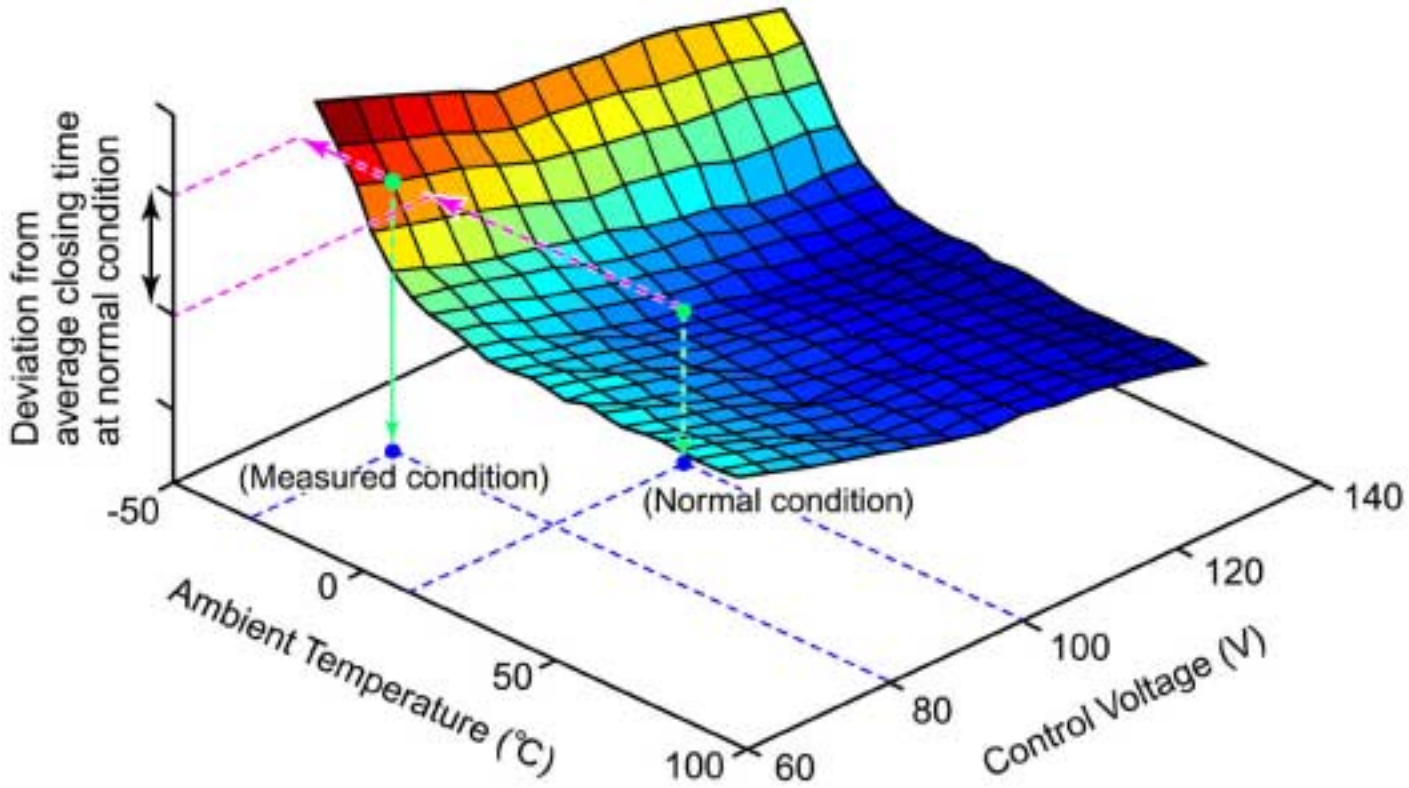
Dielectric recovery characteristic of 550kV 1-break GCB



TM T&D Corporation

MITSUBISHI ELECTRIC

Conditional Compensation

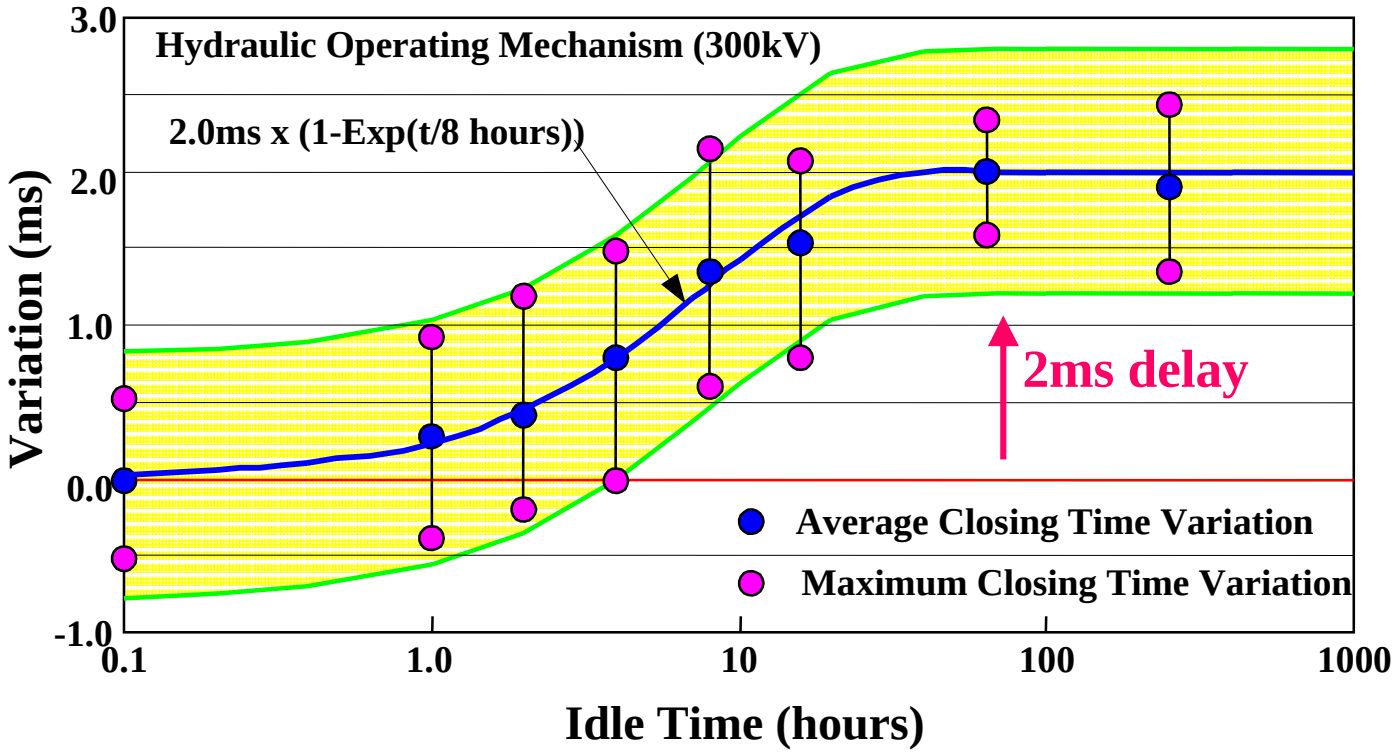


Deviation from average closing time plotted as functions of temperature and control voltage

TM T&D Corporation

MITSUBISHI ELECTRIC

Idle Time Compensation

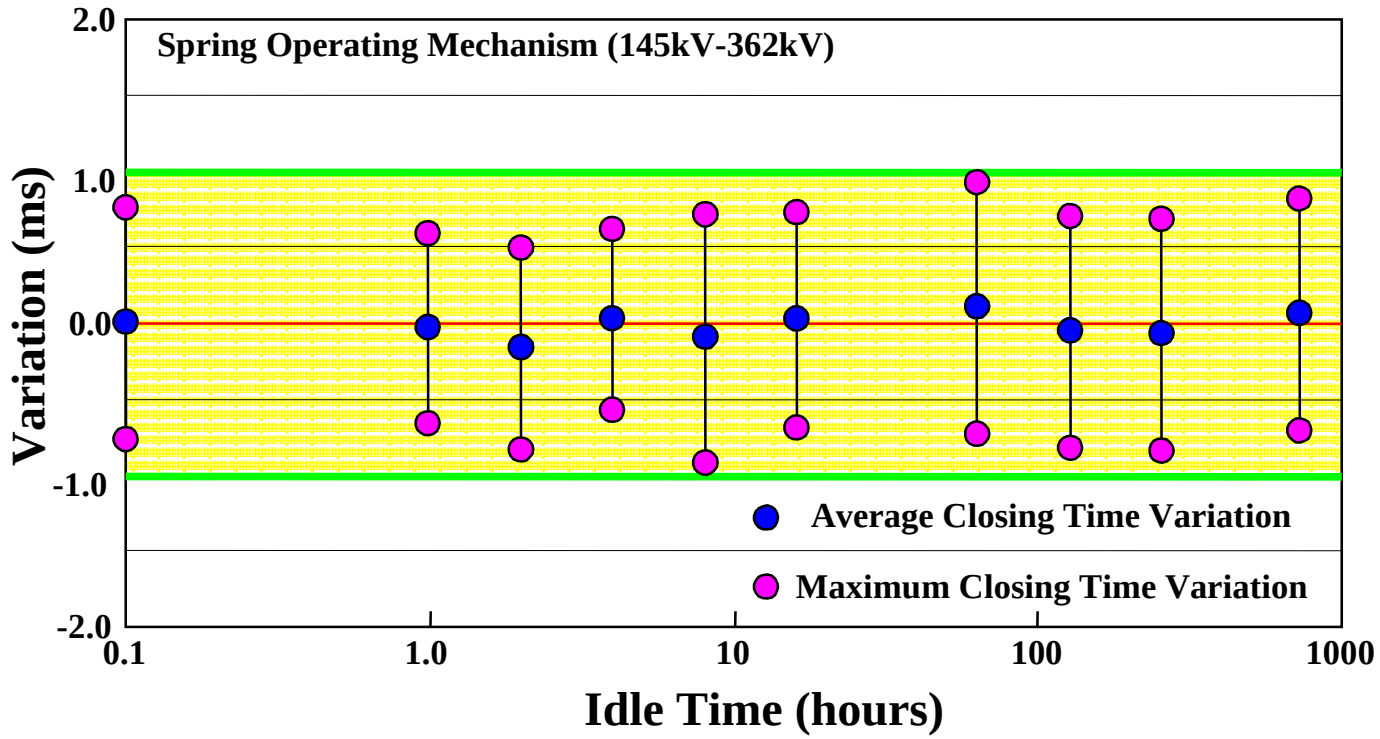


Idle time dependence of circuit breaker with a conventional hydraulic operating mechanism

TM T&D Corporation

MITSUBISHI ELECTRIC

Idle Time Compensation



Idle time dependence of circuit breaker with the spring operating mechanisms

TM T&D Corporation

MITSUBISHI ELECTRIC

3. Integrated System Testing

245kV independent-operated GCB with spring mechanisms

TM T&D Corporation

MITSUBISHI ELECTRIC

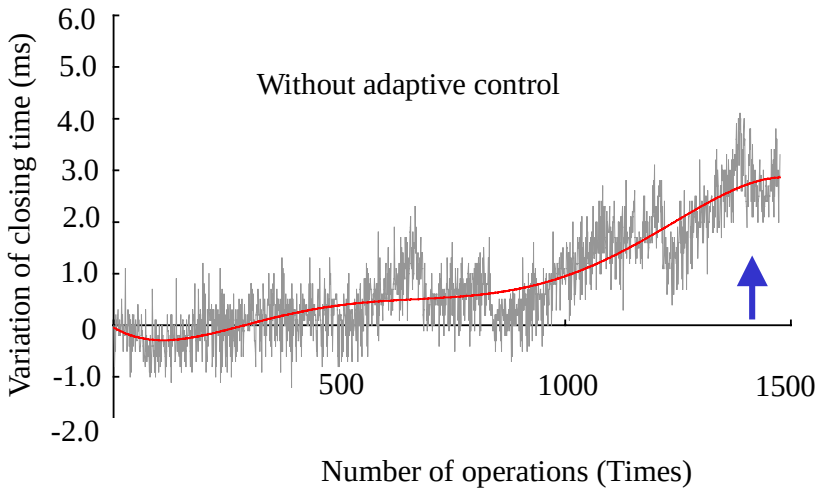
Factory Tests for Integrated System

Complete performance tests

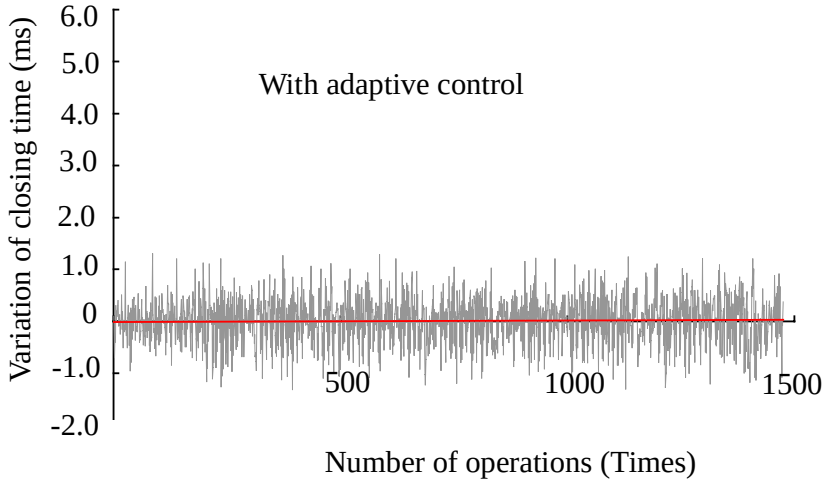
- Compatibility of circuit breaker, controller & sensor
- Age related “drift” of operating time
- Distribution of switching instant
- Maximum making voltage for voltage zero target
- Verification of reignition-free

Drift of the closing time measured with and without adaptive control

Without Adaptive Control



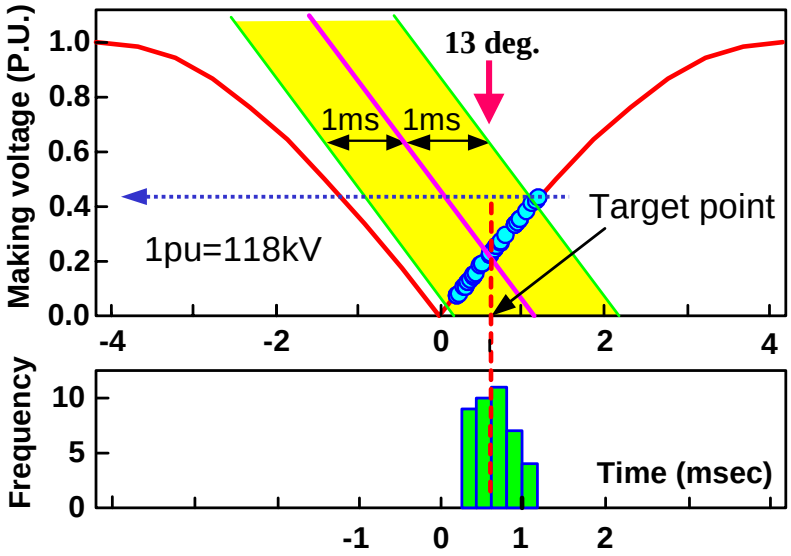
With Adaptive Control

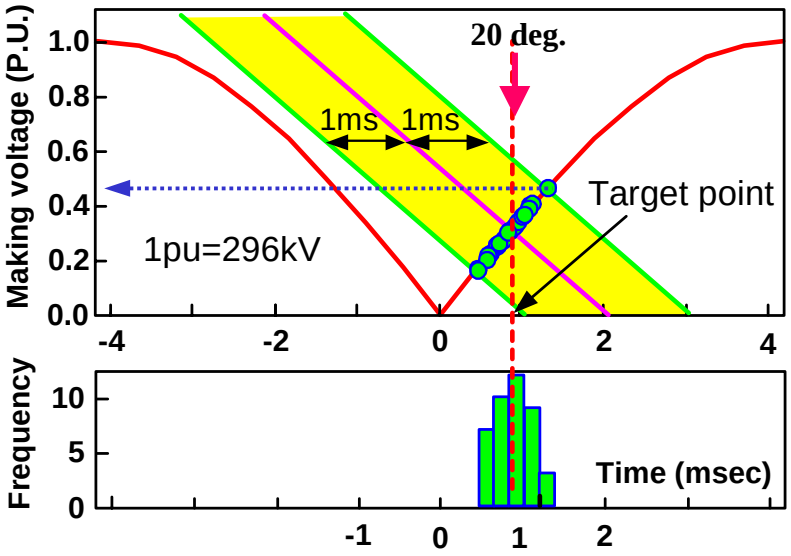


TM T&D Corporation

MITSUBISHI ELECTRIC

Controlled Switching Tests for voltage zero





Distribution of making voltages and closing instants using 145kV and 362kV GCB

TM T&D Corporation

MITSUBISHI ELECTRIC

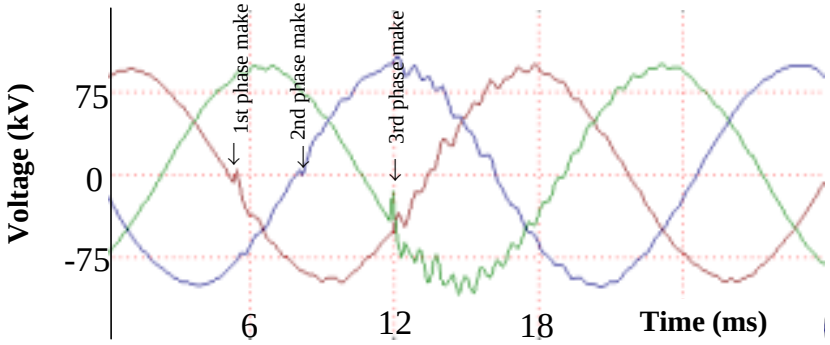
Commissioning Tests at Site

Commissioning tests of 145kV spring operated GCB

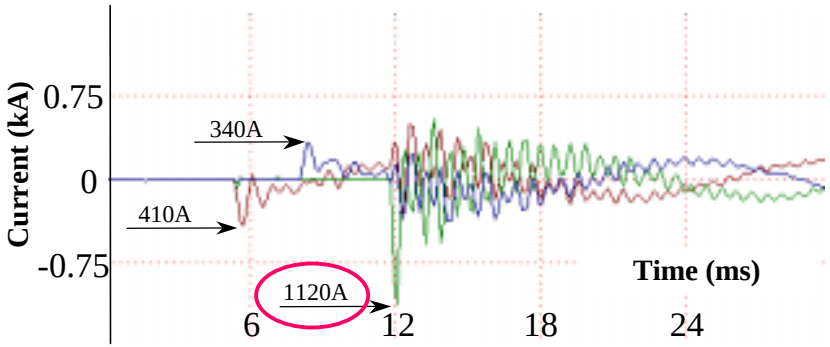
TM T&D Corporation

MITSUBISHI ELECTRIC

Waveforms of 2nd making test



(a) Voltage waveform of 2nd making test

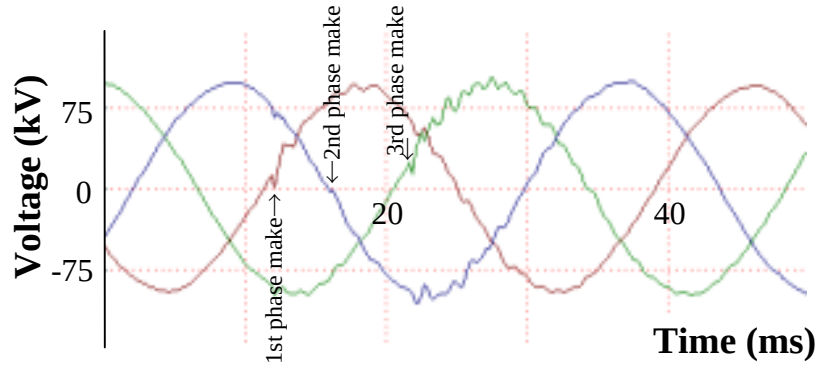


(b) Current waveform of 2nd making test

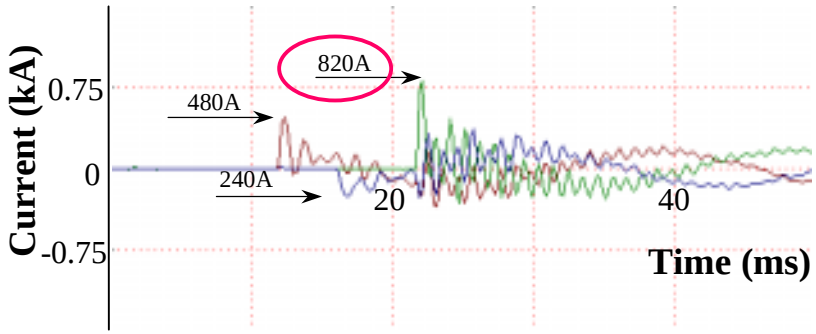
TM T&D Corporation

MITSUBISHI ELECTRIC

Waveforms of 3rd making test



(a) Voltage waveform

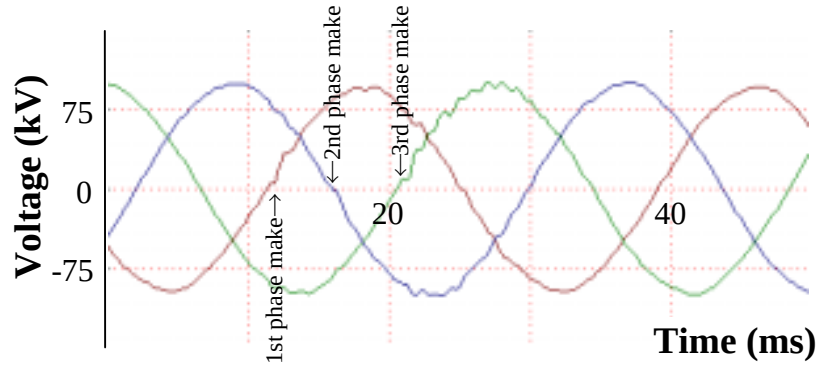


(b) Current waveform

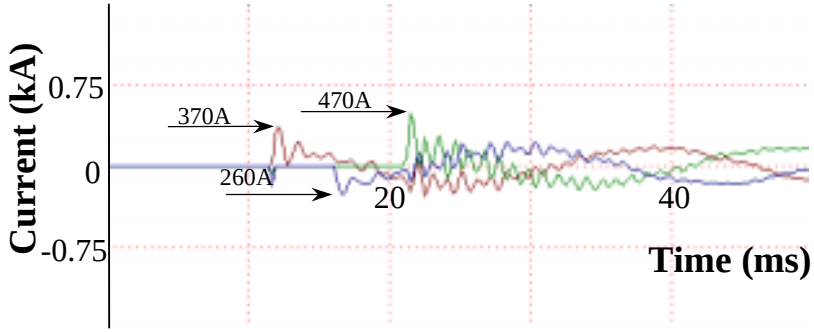
TM T&D Corporation

MITSUBISHI ELECTRIC

Waveforms of 6th making test



(a) Voltage waveform

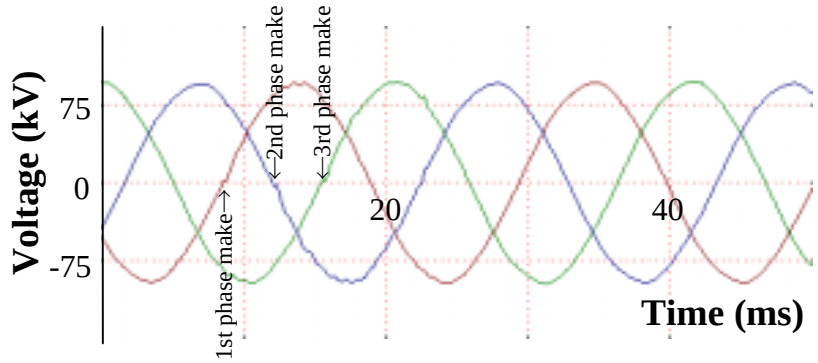


(b) Current waveform

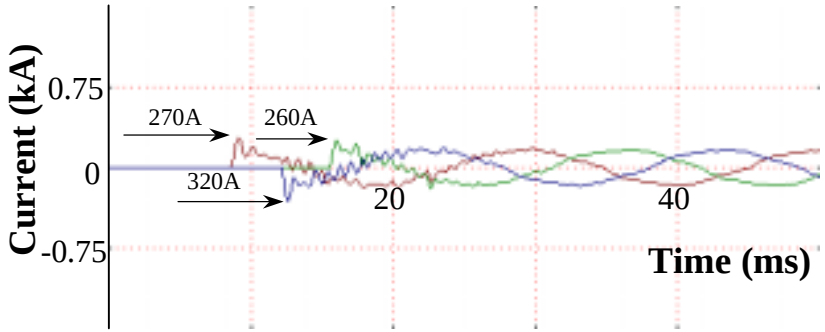
TM T&D Corporation

MITSUBISHI ELECTRIC

Waveforms of 10th making test



(a) Voltage waveform



(b) Current waveform

TM T&D Corporation

MITSUBISHI ELECTRIC

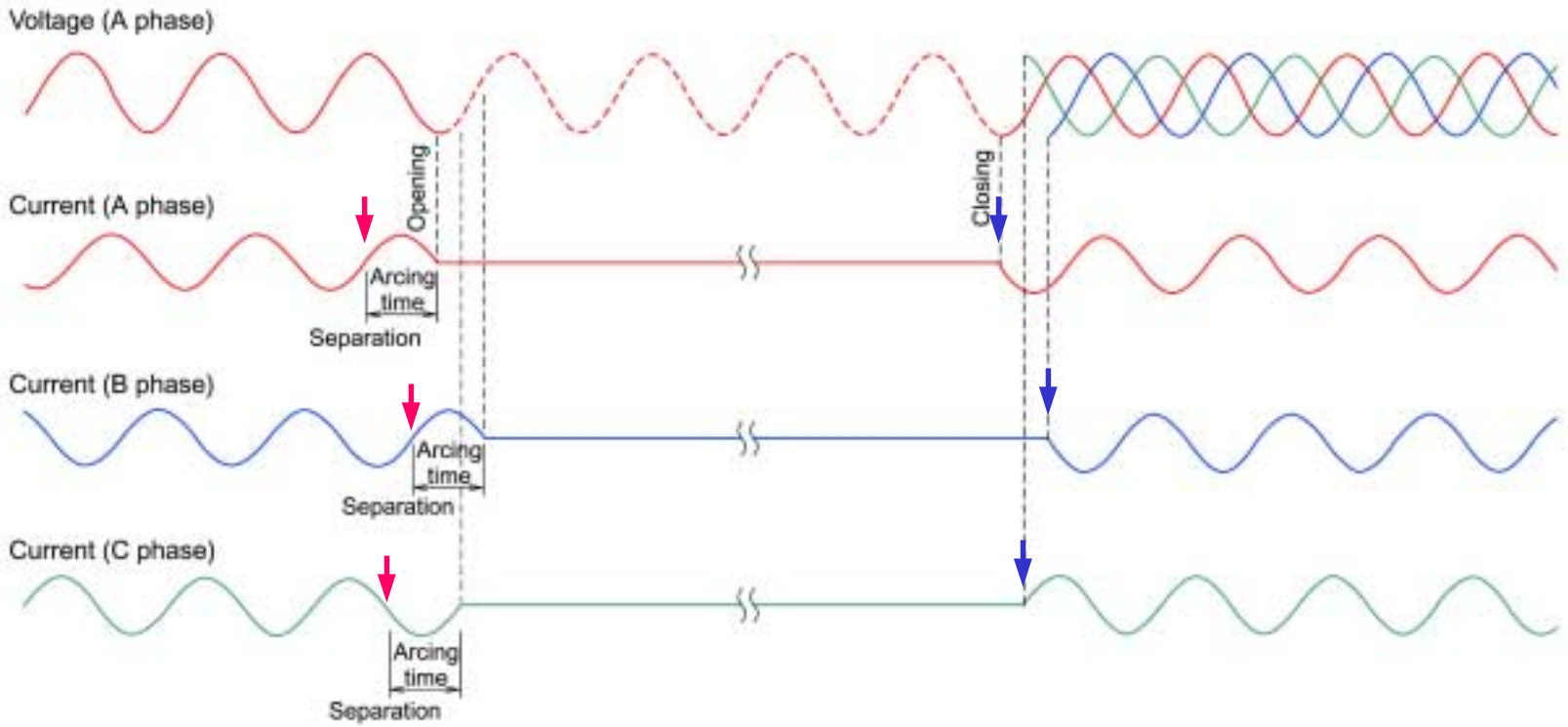
4. Field Verification Test

Commissioning tests of 204kV hydraulic operated GIS

TM T&D Corporation

MITSUBISHI ELECTRIC

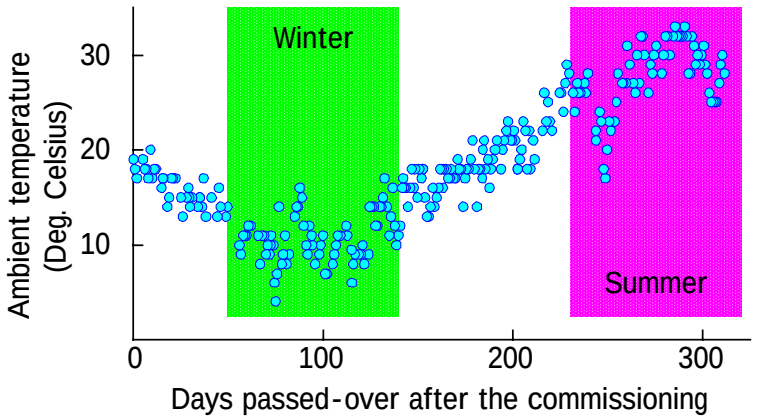
Controlled shunt reactor de-energization and energization

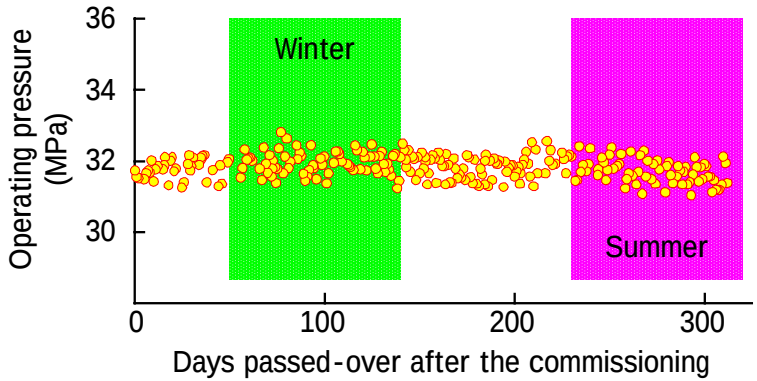


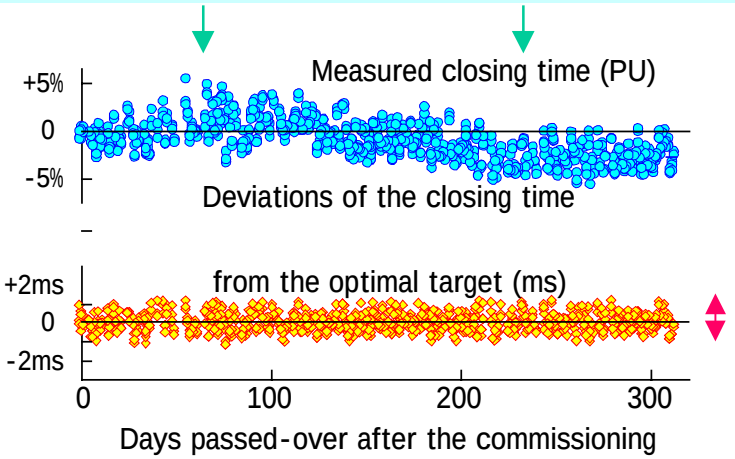
TM T&D Corporation

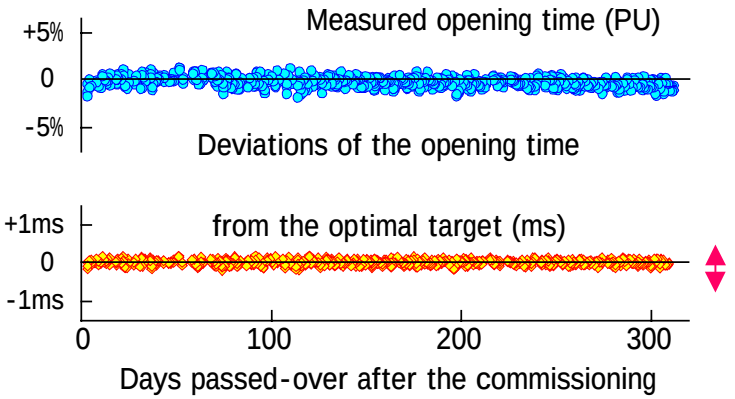
MITSUBISHI ELECTRIC

Operating records of temperature, hydraulic pressure, closing and opening times over one year





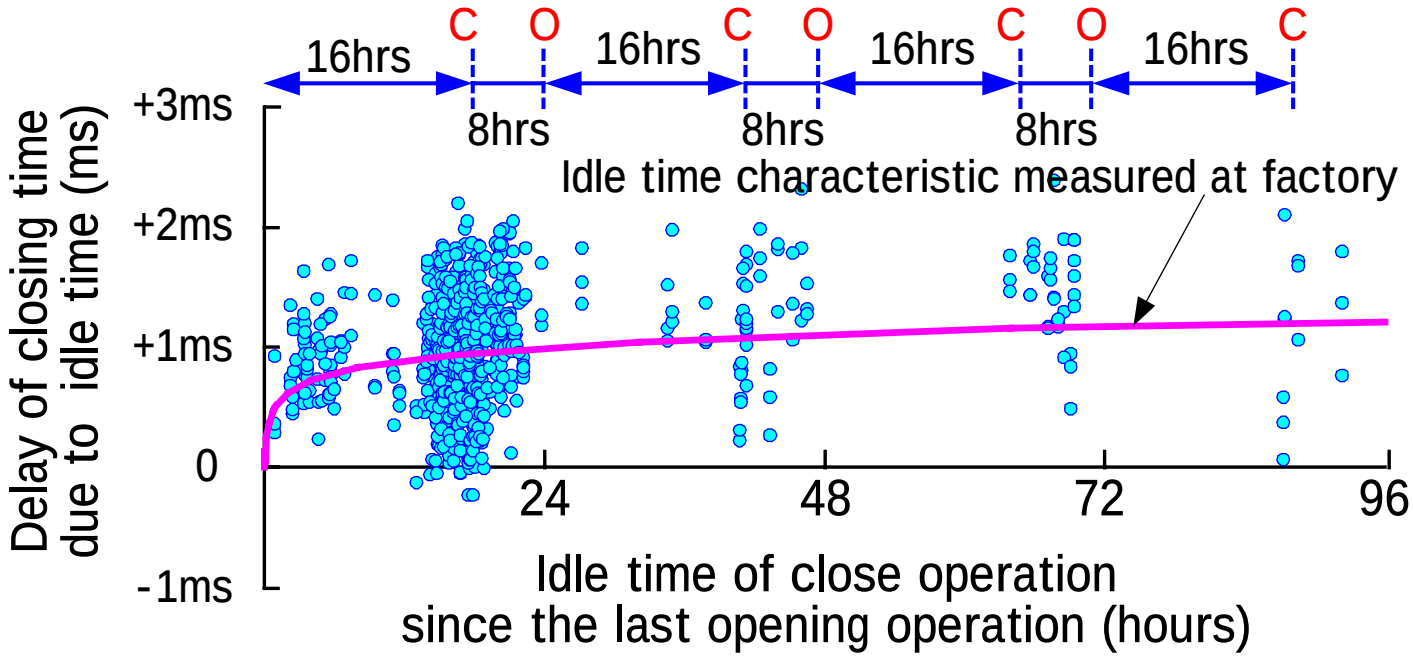




TM T&D Corporation

MITSUBISHI ELECTRIC

Idle time characteristic of 204kVGIS with hydraulic drives



TM T&D Corporation

MITSUBISHI ELECTRIC

Summary of Results

- Effective compensation for deviations of operating time associated with past operations has been demonstrated.
- The requirement of idle time compensation can be judged from the measurement up to 100 hours.
- Innovative operating mechanisms do not show any delay of the operating times for idle time up to 1000 hours.
- Controlled shunt capacitor switching in the field showed more successful results due to the adaptive control.
- Commissioning test demonstrates successful reactor opening without any reignition.

5. Conclusions

- **CIGRE WG13.07 recommendation successfully covers all the testing requirements and their procedures.**
- **CSS verified according to the CIGRE recommendation demonstrates successful results in the field.**

Thank you very much for your attention

TM T&D Corporation

MITSUBISHI ELECTRIC