SHORT-CIRCUIT INTERRUPTING PERFORMANCE OF DEAD-TANK TYPE GAS CIRCUIT BREAKER RATED ON 1100KV 50KA 50HZ

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Abstract: In-case of dead-tank circuit breaker with the earthed metal enclosure, the dielectric performance between live part and enclosure during current interruption is very important and should be verified by the appropriate testing procedures. As the voltage class of transmission power system is being upgraded up to 1100 and 1200kV, high-power testing laboratories have the limitation of the testing facilities in testing the dead-tank GCB. KERI has developed new unit-testing circuits and procedures that have the equivalence with the full-pole test for short-circuit and capacitive current switching tests.

1 INTRODUCTION

In case of dead-tank circuit breaker with the earthed metal enclosure, standard requires the dielectric performance between live part and enclosure during current interruption process and these capabilities shall be verified by the appropriate tests. According to IEC 62271-100: Annex O, the full-insulation performance test under the hot-gas condition is required to verify the interrupting capability of short-circuit current with high frequency TRV. In addition, the full-insulation performance test under the cold-gas condition is also required to verify the interrupting capability of capacitive current.

As the voltage class of transmission power system is being upgraded up to 1100kV and 1200kV, high-power testing laboratories have the limitation of the testing facilities in making the full-pole testing of the dead-tank GCB. In order to overcome this limitation and provide the appropriate testing services, KERI has developed new unit-testing circuits and procedures that have the equivalence with the full-pole testing procedure.

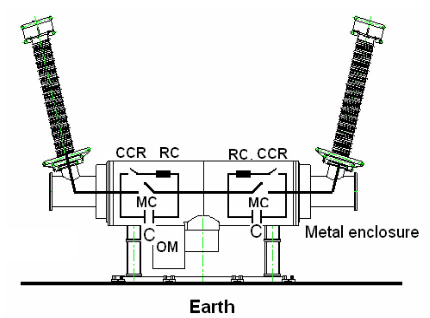
This paper introduces the synthetic unit-test circuit made up of two separated sources and the procedures for UHV(≥800kV) dead-tank circuit breaker. Short-circuit generator is used for current source and L-C resonance circuit for voltage source.

2 TEST BREAKER CHARACTERISTICS

The technical data of tested breakers reported in the next Table 1. The tests were conducted on 800kV and 1100kV breakers and Table 1 shows the Layout of the circuit breaker also.

Table 1: Technical information of test breaker

Rated voltage	1100 / 800kV
Rated short-circuit breaking current	50 kA
Rated frequency	50 / 60 Hz
Enclosure	Dead-tank
Number of break per phase	2
k_{pp}(1st-pole-to-clear factor)	1.3
k_c (capacitive voltage factor)	1.2
Operating mechanism	Hydraulic
Number of mechanism	One common
Closing resister	Equipped
Breaking resister	Not equipped



MC : Main Contact	
RC : Resister for Closing	
CCR: Contact for Closing Resister	
OM: Operating Mechanism	
C : Grading Capacitor	
1100kV Transient Recovery Voltage	
u1	876kV
t1	438us
uc	1634kV
t2	1752us
RRRV	2.0kV/us
Distribution factor	0.55

3 SHORT-CIRCUIT INTERRUPPITING TEST

In the past, KERI performed a full-pole test method of an 800kV circuit breaker. Recently, KERI developed new unit test procedures which can be applied for ≥ 800kV rating's breaker.

During general unit testing of dead-tank circuit breaker, the insulation to earth is not fully stressed. It is therefore necessary to prove whether the insulation to earth is capable of withstanding this full voltage during interrupting process.

For the verification of breaking and insulation performance in metal enclosures, the following multi-part testing procedure was proposed:

a. Breaking performance: For verifying the breaking performance between contacts, the test shall be carried out with the condition of for test duties T100s and T100a. And, test voltage shall be equal to the value of the most highly stressed unit.

b. Insulation performance: For verifying the insulation performance between live parts and enclosures, the tests shall be performed with the rated short-circuit current interrupted by all units with maximum arcing time and full voltage applied between the terminal and enclosure for both duties T100s and T100a. A single breaking operation is carried out to demonstrate this performance.

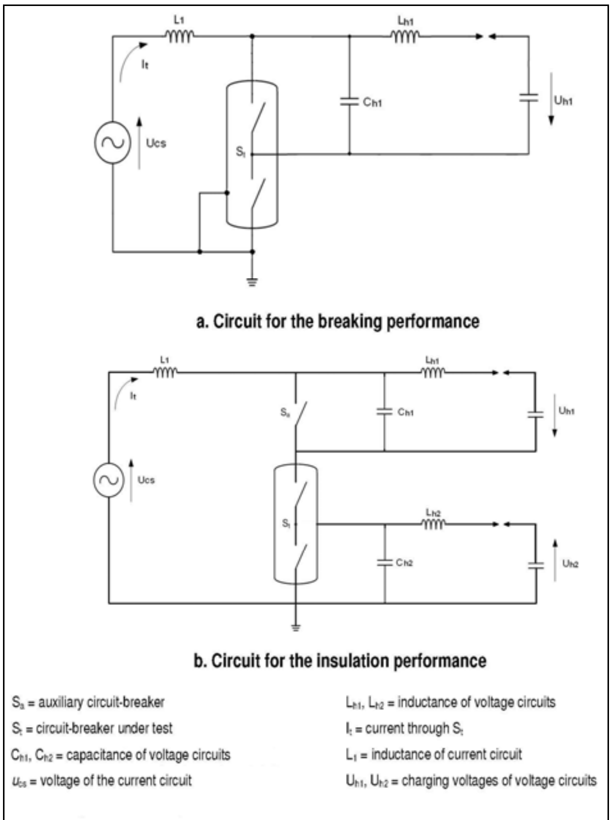


Figure 1: Separated unit test circuits for short-circuit performance of dead tank circuit breaker

Circuit-a of Figure 1 is voltage injection circuit for the breaking performance. In this stage, the interrupting capability between contacts is verified with the rated short-circuit current and TRV corresponding with the value determined by voltage distribution rate. This test shall be performed under the conditions of test duty T100s that consists of symmetrical current and rated operating sequence of circuit breaker, and test duty T100a that consists of asymmetrical current and maximum arcing energy. As seen in Figure 2, the insulating support is not needed for this test, because the enclosure is earthed during the test.

Circuit-b of Figure 1 shows also two voltage injection circuit, one is applied to primary bushing, the other to the metal enclosure. During full-units interrupt the current, full voltage is applied between terminal and the isolated enclosure. To achieve this circuit, the insulating support is needed as seen in Figure 3.

Figure 2: Test breaker rated on 1100kV

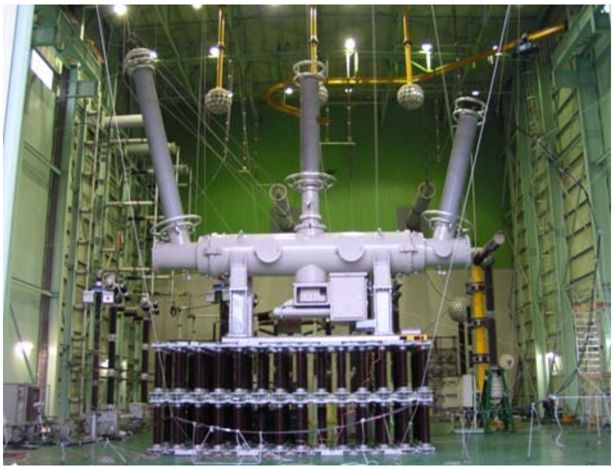


Figure 3: Test breaker rated on 800kV

The advantage of this multi-part testing procedure is that full-voltage can be applied to phase to enclosure, even if the testing facilities have lower voltage strength than that of the test breaker. Moreover, it is possible to reduce the distortion of last loop current wave, because the number and ratings of auxiliary circuit breaker can be reduced to approximately half of the full-pole testing.

The disadvantage is that additional test is needed for verifying phase to enclosure characteristics and isolated supporting structure is also needed. And the isolated power supply for breaker operation and the isolated measurement system is essential.

4 CAPCITIVE CURRENT SWITCHING TEST

Figure 4 is half pole test circuit for capacitive switching tests. The operation of this circuit is following.

The main voltage circuit of capacitance (C_{M1}, C_V) and inductance (L_{pf}) may be chosen to give the injected current (i_V) with approximately the same frequency with current source. The frequency (fi) of the injected current which is used to synchronize the instant of current zero can be written

$$f_i = \frac{1}{2\pi\sqrt{(C_{M1}+C_V)\cdot L_{Pf}}} \quad \text{.................. (1)}$$

After the current source (ic) is interrupted by the auxiliary breaker (Sa1) and the injected current (iv) is interrupted by the test breaker, DC voltage remains trapped in capacitance (C_V). Also, oscillating voltage occurs through the circuit of C_{M1} and Lpf and its frequency (fv) is given by

$$f_v = \frac{1}{2\pi\sqrt{C_{M1}\cdot L_{Pf}}} \quad \text{............................. (2)}$$

Therefore, sum of these two voltages are applied to the test breaker (St) via C_T.

Also, approximately quarter cycle later after current interruption, secondary voltage injection circuit (C_{M2}, R_T, C_T) is activated and its voltage (U_{C2}) contributes in escalating TRV peak voltage. Generally, the injected current with somewhat lower value than power frequency is recommended for producing the AC voltage same with that of current source. This can reduce the severity of voltage wave appearing after the secondary voltage injection.

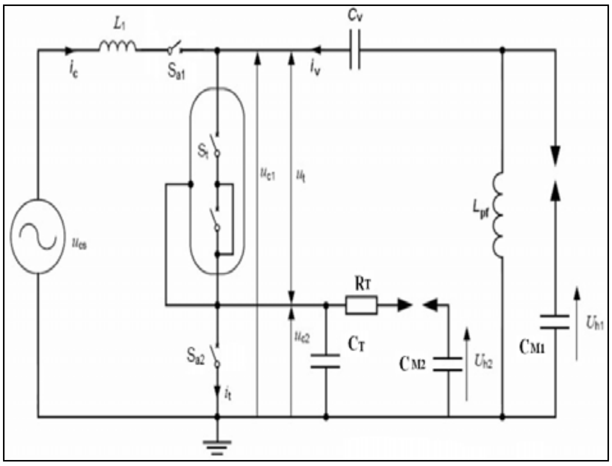


Figure 4: Half pole test circuit for capacitive current switching tests on metal enclosure

According to STL guide, even though the amplitude of the injected current and the di/dt at current zero have normally no influence on the interruption of capacitive currents up to a level equal to the rated normal current, lower value is suggested in this method.

The injected timing of voltage circuit should be controlled to minimize the difference time difference of the interrupting point from current source to injected current of voltage source. With these adjustments, it is possible to decrease the reduction of TRV peak by the current chopping.

The advantage of the method is using two different sources, which reduce the insulation stress of test facility.

The disadvantage is that severer condition occurs in the range of re-ignition, because the TRV until quarter cycle is lower than the condition of actual system. Lower TRV during quarter cycle gives the chance to interrupt the current with the short arcing time during re-ignition period. On the other hand, it means that circuit breaker shall withstand the TRV between shorter contact gap without re-strike. And additional recovery voltage test is needed due to not-sustained voltage during 0.3s duration after current interruption.

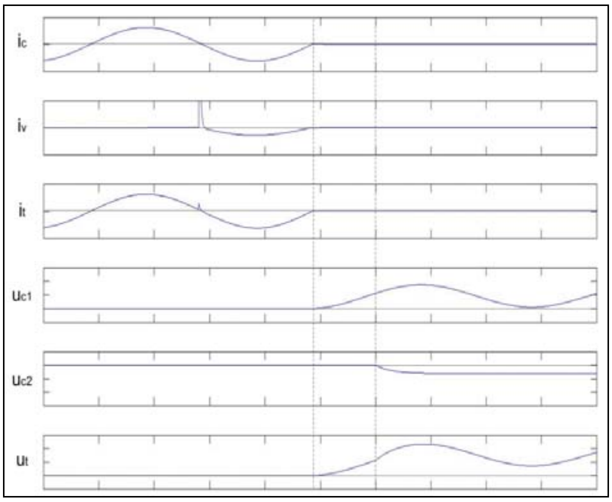


Figure 5: Simulation results for capacitive current switching tests related Figure 4

5 CONCLUSION

By using the testing methods introduced in this paper, short-circuit interrupting performance and capacitive current switching performance have been completed on dead tank circuit breaker for 800kV / 1100kV 50kA 50Hz GCB which is being upgraded.

The most special feature of suggested method is that it is possible to verify full-insulation properties for interrupting unit and phase to enclosure by using the testing facilities with lower voltage strength.

The testing method suggested in this paper has been reported in STL Guide:2009.

6 REFERENCES

[1] IEC 62271-100(2008), High-voltage switchgear and control gear – Part 100: High-voltage alternating –current circuit-breakers

[2] IEC 62271-101(2010), High-voltage switchgear and control gear – Part 101: Synthetic testing

[3] STL Guide, IEC 62271-101:2006, Issue 1, June 2009