Type Tests on a Triple-Single
27 kV, 16 kA Recloser

IEC 62271-111(Ed.2.0) / IEEE Std C37.60-2012
Clauses 6.2, 6.5, 6.6, 6.101, 6.103, 6.106, 6.109, 6.111
REPORT OF PERFORMANCE

CLIENT/MANUFACTURER  Togami Electric Mfg. Co., Ltd.
1-1 Ohtakara-Kitamachi
Saga 840-0802, Japan

TEST OBJECTS

**Recloser**
Manufacturer: Togami Electric Mfg. Co., Ltd.
Type: VBN20-A3-Y
Rated Max. Voltage: 27 kVrms, 150 kV BIL
Rated Current: 800 A_rms continuous,
16 kA_rms interrupting, 16 kA_rms 3 s short-time
Mfg. Date: 07/2018
Unit (Serial) №’s: #1 (E000018), #2 (E000019),
#3(E000020), #4 (E000021),

**Recloser Control**
Manufacturer: Schweitzer Engineering Laboratories
Type: SEL-651R
Unit (Serial) №’s: #1 (1172190162), #2 (1172190163),
#3(1172190164)
Firmware Version №: R406-V0
Mfg. Date: 08/2017

TESTED BY  Powertech Labs Inc.
12388 - 88th Ave, Surrey, BC
Canada V3W 7R7
www.powertechlabs.com

TEST DATES  2018-08-20 to 2018-09-07

TEST SPECIFICATIONS  IEC 62271-111(Ed.2.0) / IEEE Std C37.60-2012
Clauses 6.2, 6.5, 6.6, 6.101, 6.103, 6.106, 6.109, 6.111.2, 6.111.3

TEST RESULT  PASS

Powertech Labs Inc. does not accept any liability for any damages resulting from the use of this report. The results relate only to the item tested, and it is the responsibility of the manufacturer to maintain conformity of any object having the same designations.
Information regarding the estimated measurement uncertainty is available upon request. The test report shall not be reproduced except in full, without written approval of Powertech Labs Inc.

Prepared by:  Reviewed by:

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Powertech Labs Inc.

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Specialist Engineer, High Power Lab
Powertech Labs Inc.
13 OSCILLATORY AND FAST TRANSIENT SURGE TESTS

General Information:
Standard: IEEE C37.60-2012, Clause 6.111.2
Test Date: August 23, 24, 2018
Test Leader: Meiru Du

Environmental Conditions:
Date: 23 August 2018 24 August 2018
Temperature: 20.8 °C 19.8 °C
Relative humidity: 55.1 % 57.4 %
Barometric pressure: 752.8 mmHg 750.0 mmHg

Test Conditions:
The tests were in accordance with IEEE C37.90.1-2012. The controller and recloser were tested while connected to 120 Volts, 60 Hz supply for all tests. Test surges were applied to the AC power cord and control cable using a capacitive clamp and an external coupling/decoupling network in common and transverse mode, in accordance with Table 3 and 4 of IEEE C37.90.1.

Oscillatory Test Voltage: 2.5 kV_\text{peak}
Fast Transient Test Voltage: 4.0 kV_\text{peak}

Recloser Unit No: #1
Controller Unit No: #2

Oscillatory Waveform Validity Tests

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator output voltage: 2.5 kV</td>
<td>2.5 kV</td>
<td>(pass if ≤ 1%)</td>
</tr>
<tr>
<td>Feed through voltage test: 22 V</td>
<td>19.2 V</td>
<td></td>
</tr>
</tbody>
</table>

Test Generator performance verification:

<table>
<thead>
<tr>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test duration: 2.1 s</td>
<td>2.1 s</td>
<td>(2.0 to 2.2 s)</td>
</tr>
<tr>
<td>Repetition rate: 8 bursts / 16.7 ms</td>
<td>7 bursts / 16.7 ms</td>
<td>(6 to 10 bursts per 16.7 ms)</td>
</tr>
<tr>
<td>Oscillation frequency: 0.92 MHz</td>
<td>0.92 MHz</td>
<td>(0.9 to 1.1 MHz)</td>
</tr>
<tr>
<td>Waveform envelope decay: 4.4 μs</td>
<td>5.0 μs</td>
<td>(4 to 6 μs to 50%)</td>
</tr>
<tr>
<td>Rise time of the first peak: 84 ns</td>
<td>60 ns</td>
<td>(60 to 90 ns – 10% to 90%)</td>
</tr>
<tr>
<td>Peak voltage level (no load): 2.4 kV</td>
<td>2.48 kV</td>
<td>(2.25 to 2.5 kV when set to 2.5 kV)</td>
</tr>
<tr>
<td>Output impedance: 230 Ω</td>
<td>236 Ω</td>
<td>(160 to 240 Ω)</td>
</tr>
</tbody>
</table>

Open circuit voltage waveform test:

![Figure 1: Open circuit voltage burst waveform](image1)

![Figure 2: First few cycles of oscillatory waveform](image2)
Fast Transient Waveform Validity Tests

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator output voltage:</td>
<td>4.0 kV</td>
<td>4.2 kV</td>
<td>(pass if ≤ 1% of generator output)</td>
</tr>
<tr>
<td>Feed through voltage test:</td>
<td>38 V</td>
<td>1.6 V</td>
<td></td>
</tr>
</tbody>
</table>

Test Generator performance verification:

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test duration:</td>
<td>60 s</td>
<td>60 s</td>
<td>(≥60 s)</td>
</tr>
<tr>
<td>Burst period:</td>
<td>300 ms</td>
<td>344 ms</td>
<td>(240 to 360 ms)</td>
</tr>
<tr>
<td>Burst duration:</td>
<td>14.7 ms</td>
<td>14.8 ms</td>
<td>(12 to 18 ms)</td>
</tr>
<tr>
<td>Repetition rate:</td>
<td>2.5 kHz</td>
<td>2.5 kHz</td>
<td>(2 to 3 kHz)</td>
</tr>
<tr>
<td>Impulse duration:</td>
<td>58 ns</td>
<td>60 ns</td>
<td>(35 to 65 ns to 50% value)</td>
</tr>
<tr>
<td>Rise time:</td>
<td>5.3 ns</td>
<td>5.0 ns</td>
<td>(3.5 to 6.5 ns – 10% to 90%)</td>
</tr>
<tr>
<td>Peak voltage level (no load):</td>
<td>4.2 kV</td>
<td>4.2 kV</td>
<td>(3.6 to 4.4 kV when set to 4 kV)</td>
</tr>
<tr>
<td>Output impedance:</td>
<td>58.3 Ω</td>
<td>56.3 Ω</td>
<td>(40 to 60 Ω)</td>
</tr>
</tbody>
</table>

Open circuit voltage waveform test:

![Figure 3: Open circuit voltage burst waveform](image)

![Figure 4: One fast transient peak](image)

Requirements:
The recloser/FI and controller shall be considered to have passed the tests if – during, or as a result of the tests – all of the conditions below are met for the recloser/FI and controller:

- The specified performance of the recloser/FI and controller does not change beyond specified tolerances;
- No hardware damage occurs;
- No change in calibration beyond normal tolerances result;
- No loss or corruption of stored memory occurs;
- System resets do not occur and manual resetting is not required;
- If disrupted, established communications not affecting protection functions recover within the manufacturer’s time period;
- Communication errors, if they occur, do not affect the protective functions of the recloser/FI and controller
- Where the loss of digital pulse synchronization occurs, it does not produce an out of tolerance condition.
- No changes in the electrical, mechanical, or communication status error outputs occur. This includes alarms, status outputs, or targets.
- No erroneous, permanent change of state of the visual, audio or message output results.
- No error outside normal tolerances of the data communication signals (SCADA analogs) occur

Result:
PASS
14 RECLOSEER-CONTROLLER SIMULATED SURGE ARRESTER OPERATION TEST

General Information:
Standard: IEEE C37.60-2012, Clause 6.111.3
Test Date August 20, 21, 22, 2018
Test Leader Meiru Du

Environmental Conditions:
Date: 20 August 2018 21 August 2018 22 August 2018
Temperature 25.9 °C 23.7 °C 25.4 °C
Relative humidity 45.0 % 41.9% 44.2%
Barometric pressure 750.0 mmHg 752.2 mmHg 747.5 mmHg

Test Conditions:
The tests was in accordance with the test set-up requirements outlined in section 6.111.3.2 of the test standard. The control was energized and operational during the tests with settings as follows:
  a) Value of trip point (pick up setting) not to exceed the rated load current of the device;
  b) Reclosers set for the maximum number of operations to lock-out;
  c) Other settings for normal operation consistent with a) and b) above.

The surges were applied using the following test levels and configurations:

Test Voltage: 108 to 132 kV_{peak}
Surge Current: 5.4 to 6.6 kA_{peak}
Recloser Unit No: #1
Controller Unit No: #2

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Switch</th>
<th>HV Applied</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open</td>
<td>Source Terminals</td>
<td>15 positive and 15 negative surges</td>
</tr>
<tr>
<td>2</td>
<td>Closed</td>
<td>Source Terminals</td>
<td>15 positive and 15 negative surges</td>
</tr>
<tr>
<td>3</td>
<td>Closed</td>
<td>Load Terminals</td>
<td>15 positive and 15 negative surges</td>
</tr>
<tr>
<td>4</td>
<td>Open</td>
<td>Properly Rated Transformer</td>
<td>15 positive and 15 negative surges</td>
</tr>
<tr>
<td>5</td>
<td>Closed</td>
<td>Properly Rated Transformer</td>
<td>15 positive and 15 negative surges</td>
</tr>
</tbody>
</table>

Requirements:
During the application of surges, the control shall neither close the recloser/FI from an open position nor open (trip) the recloser/FI from a closed position. No change of state shall occur or be reported.

Following the tests, the recloser/FI and control apparatus shall be capable of performing all normal functions without impairment. The following verifications shall be made following the test if supported by the control apparatus:
  • Communicate with an external computer;
  • Open and close the recloser;
  • Upload event(s) or oscillography captured;
  • Receive a firmware download;
  • Receive a program download;
  • Perform the maximum number of sequence operations for which it is rated at any convenient pick up level.

Result:
PASS