



Type test report no. V V 2D 001e

Switching tests

Test department
16.04.2003

Type test for on-load tap-changer types:

V V III 250/400/600 Y - 40/76 - 10/12 .. 0/W/G,
V V III 250/400/600 D - 40/76 - 10/12 .. 0/W/G,
V V III 250/400 D - 145 - 10/12 .. 0/W/G.

Test specification:

IEC 60214-1:2003, sub-clause 5.2.2: "Switching tests".

Test sample:

V V III 600 D - 76 - 12 12 0.

Manufacturer:

Maschinenfabrik Reinhausen GmbH, Regensburg, Germany.

Tests performed:

Service duty test: 50,000 operations at 750 A through-current and 1115 V step voltage

Breaking capacity test at
max. rated through-current: 200 operations at 1460 A through-current and 1570 V step voltage

Breaking capacity test at
max. rated step voltage: 200 operations at 1040 A through-current and 2350 V step voltage

Note: The same type of vacuum interrupter is used as main switching contact and as transition contact for all tap-changers of type V V. Therefore these tests are applicable to all on-load tap-changers type V V.

Test arrangement:

Mounting and mechanism: OLTC mounted in a test frame with motor drive mechanism

Transition resistor: Value and design of transition resistor as used in normal service

OLTC oil filling: Transformer oil Shell Diala D

Servicing during tests: Contacts and oil were not renewed during the tests

Test results:

The requirements of IEC 60214-1:2003 were met, i.e.:

- The oscillograms taken at the beginning and at the end of the service duty test did not show a significant alteration in the characteristics of the tap-changer.
- During all switching operations the arcing times were less than the maximum permissible duration of 11 ms.
- The inspection of the tap-changer after the tests did not leave any doubts as to the suitability of the tap-changer for service.

This report contains 10 sheets.

MASCHINENFABRIK REINHAUSEN GMBH
- TEST DEPARTMENT -

1. Test specification

The type test was performed in accordance with IEC 60214-1:2003 "Tap-changers - Part 1: Performance requirements and test methods", sub-clause 5.2.2 "Switching tests".

2. Data of test samples

Test sample:	V V III 600 D - 76 - 12 12 0.
Serial no.:	161384
Year of manufacture:	2002
Maximum rated through-current:	600 A
Relevant rated step voltage at maximum rated through-current:	1000 V
Maximum rated step voltage:	2000 V
Relevant rated through-current at maximum rated step voltage:	350 A

3. Scope of application

The same type of vacuum interrupter is used as main switching contact and as transition contact for all tap-changers of type V V. The mechanism for opening and closing the vacuum interrupters is adapted to the rotation of the tap-changer insert during one operation. The tap-changer insert rotates through an angle per operation of:

- 36° between each contact of the 10 pitch tap selector,
- 36° between contacts 11 to 12 and 1 to 12 and 29° between the other contacts of the 12 pitch tap selector

Due to the 12 pitch tap selector operating with both angles per operation, the test of a 12 pitch tap selector is representative for 10 pitch tap selectors, too.

The mechanism for opening and closing the vacuum interrupters as well as the switching behaviour of the vacuum interrupters does not depend on:

- insulating levels
- type of change-over selector (coarse or reversing or without)

Therefore this type test report is valid for all types of "V V":

- V V III 250/400/600 Y - 40 - 10 .. 0/W/G
- V V III 250/400/600 D - 40 - 10 .. 0/W/G
- V V III 250/400/600 Y - 76 - 10 .. 0/W/G
- V V III 250/400/600 D - 76 - 10 .. 0/W/G
- V V III 250/400/600 Y - 40 - 12 .. 0/W/G
- V V III 250/400/600 D - 40 - 12 .. 0/W/G
- V V III 250/400/600 Y - 76 - 12 .. 0/W/G
- V V III 250/400/600 D - 76 - 12 .. 0/W/G
- V V III 250/400 D - 145 - 10 .. 0/W/G
- V V III 250/400 D - 145 - 12 .. 0/W/G

4. Test arrangement

Mounting and mechanism:	OLTC mounted in a test frame with motor drive mechanism
Tap-changer setup:	Complete tap-changer as used in normal service
Transition resistor:	Value and design of transition resistor as used in normal service, see tables 1..3.
Oil filling:	Transformer oil Shell Diala D.
Oil cooling:	During the service duty test the heat produced by the transition resistors was drained by a cooling system to enable switching intervals of 5.4 s. The oil was maintained at about 80°C.
Servicing during tests:	Contacts and oil were not renewed during the tests.
Test circuit:	A resonance circuit was used as test circuit to minimize the effects of the tests on the supply system. Two phases (V and W) of one on-load tap-changer were used for the tests, see fig. 2.
Measurement:	By means of voltage transformers and current transformers.
Recording:	Each test was recorded and evaluated by a transient recorder, examples see fig. 3..5.

5. Tests performed

The most onerous switching conditions occur, if the through-current and the circulating current are in phase, because the breaking current of the main switching contact for switching direction 1 to n is the result of the vectorial addition of these currents, see switching sequence of type V V in fig. 1. The values of breaking current and recovery voltage for this "heavy" switching direction are given in the tables 1..3 as "rated values".

In normal service only "heavy" or only "light" switching operations occur for switching direction 1 to n, depending on the direction of power-flow. Due to the characteristics of the test circuit (s. fig. 2), a "heavy" switching operation is always followed by a "light" switching operation for switching direction 1 to n, if the test circuit is used without the auxiliary switch. Therefore the connections of the step voltage to the tested tap-changer were interchanged after every switching operation with an additional tap-changer as auxiliary switch and thus the switching conditions in normal service were simulated by the test circuit. Phase "W" of the tested tap-changer was loaded with "heavy" switching conditions, phase "V" was loaded with "light" switching conditions.

The test values of "step voltage" and "through-current" were higher than required by IEC 60214-1:2003, due to the restricted adjustment possibilities of the test equipment.

5.1 Service duty test at rated step voltage

	Rated values for switching direction		Tested values for switching direction	
	1 to n	n to 1	1 to n	n to 1
Step voltage	1000 V		1115 V	
Through-current	600 A		750 A	
Number of operations	25,000	25,000	25,000	25,000
Main switching contact				
- breaking current	1188 A	600 A	1375 A	745 A
- recovery voltage	2020 V	1020 V	2089 V	1070 V
- arcing times	< 11 ms	< 11 ms	< 11 ms	< 11 ms
Transition contact				
- breaking current	-	588 A	-	630 A
- recovery voltage	-	1000 V	-	1115 V
- arcing times	-	< 11 ms	-	<11 ms
Switching sequence from contact to contact			9...12...3	3...12...9
Transition resistor				
- value	1.7 Ω		1.7 Ω	
- cross section	6 x 1.2 mm ²		6 x 1.2 mm ²	
Example of oscillogram			See fig. 3	-

Table 1: Tested values of currents and voltages during the service duty test compared with requirements of IEC 60214-1:2003

5.2 Breaking capacity test at twice the maximum rated through-current

	Rated values for switching direction		Tested values for switching direction	
	1 to n	n to 1	1 to n	n to 1
Step voltage	1000 V		1570 V	
Through-current	1200 A		1460 A	
Number of operations	20	20	100	100
Main switching contact				
- breaking current	1788 A	1200 A	2360 A	1460 A
- recovery voltage	3040 V	2040 V	3085 V	1780 V
- arcing times	< 11 ms	< 11 ms	< 11 ms	< 11 ms
Transition contact				
- breaking current	-	588 A	-	880 A
- recovery voltage	-	1000 V	-	1570 V
- arcing times	-	< 11 ms	-	<11 ms
Switching sequence from contact to contact			9...12...3	3...12...9
Transition resistor				
- value	1.7 Ω		1.7 Ω	
- cross section	6 x 1.2 mm ²		6 x 1.2 mm ²	
Example of oscillogram			See fig. 4	-

Table 2: Tested values of currents and voltages during the breaking capacity test at twice the maximum rated through-current and at the relevant rated step voltage compared with requirements of IEC 60214-1:2003

5.3 Breaking capacity test at maximum rated step voltage

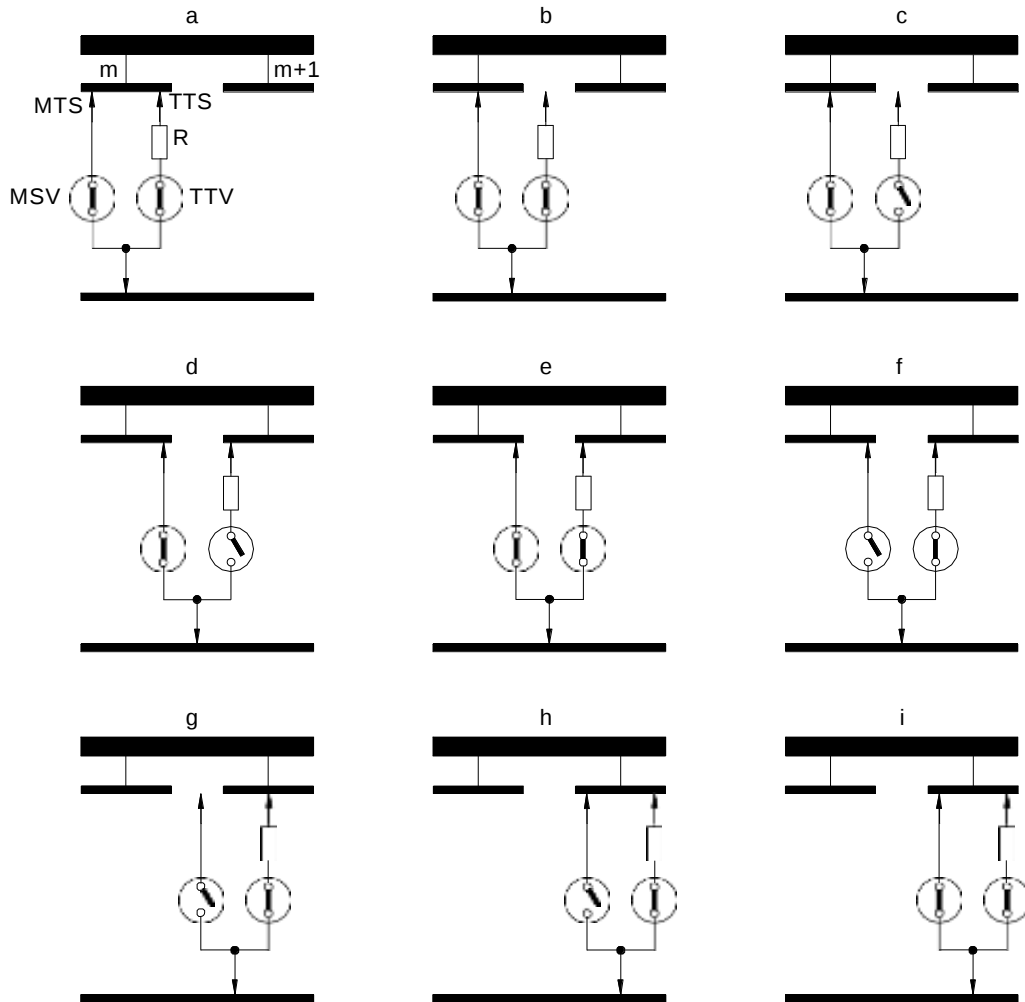
	Rated values for switching direction		Tested values for switching direction	
	1 to n	n to 1	1 to n	n to 1
Step voltage	2000 V		2350 V	
Through-current	700 A		1040 A	
Number of operations	20	20	100	100
Main switching contact				
- breaking current	1306 A	700 A	1705 A	1025 A
- recovery voltage	4310 V	2310 V	4300 V	2235 V
- arcing times	< 11 ms	< 11 ms	< 11 ms	< 11 ms
Transition contact				
- breaking current	-	606 A	-	655 A
- recovery voltage	-	2000 V	-	2350 V
- arcing times	-	< 11 ms	-	< 11 ms
Switching sequence from contact to contact			9...12...3	3...12...9
Transition resistor				
- value	3.3 Ω		3.3 Ω	
- cross section	6 x 0.8 mm ²		6 x 0.8 mm ²	
Example of oscillogram			See fig. 5	-

Table 3: Tested values of currents and voltages during the breaking capacity test at maximum rated step voltage and at twice the relevant rated through-current compared with requirements of IEC 60214-1:2003

6. Test result

The requirements of IEC 60214-1:2003 were met, i.e.:

- The oscillograms recorded at the beginning and at the end of the service duty test did not show a significant alteration in the characteristics of the tap-changer. All switching times of the main switching contacts (open-close of MSV), as relevant switching time for transition resistor loading, were in the range of 41...56 ms, depending on the oil temperature and the rotation angle per operation, see clause 3.
- During all switching operations the arcing times were less than the maximum permissible duration of 11 ms. The time interval between opening of the vacuum interrupters (MSV, TTV) and opening of the tap selector contacts (MTS, TTS) was more than 13 ms during all operations and no arcing at the tap selector contacts could occur. The switching tests proved that no arcing takes place outside of the vacuum interrupters and therefore the tightness test during the service duty test is not required by IEC 60214-1:2003.
- The inspection of the tap-changer after the tests did not leave any doubts as to the suitability of the tap-changer for service.



MTS: Tap selector contacts, main path
TTS: Tap selector contacts, transition path
MSV: Main switching contact
TTV: Transition contact
R: Transition resistor

Figure 1: Switching sequence of on-load tap-changer type V V

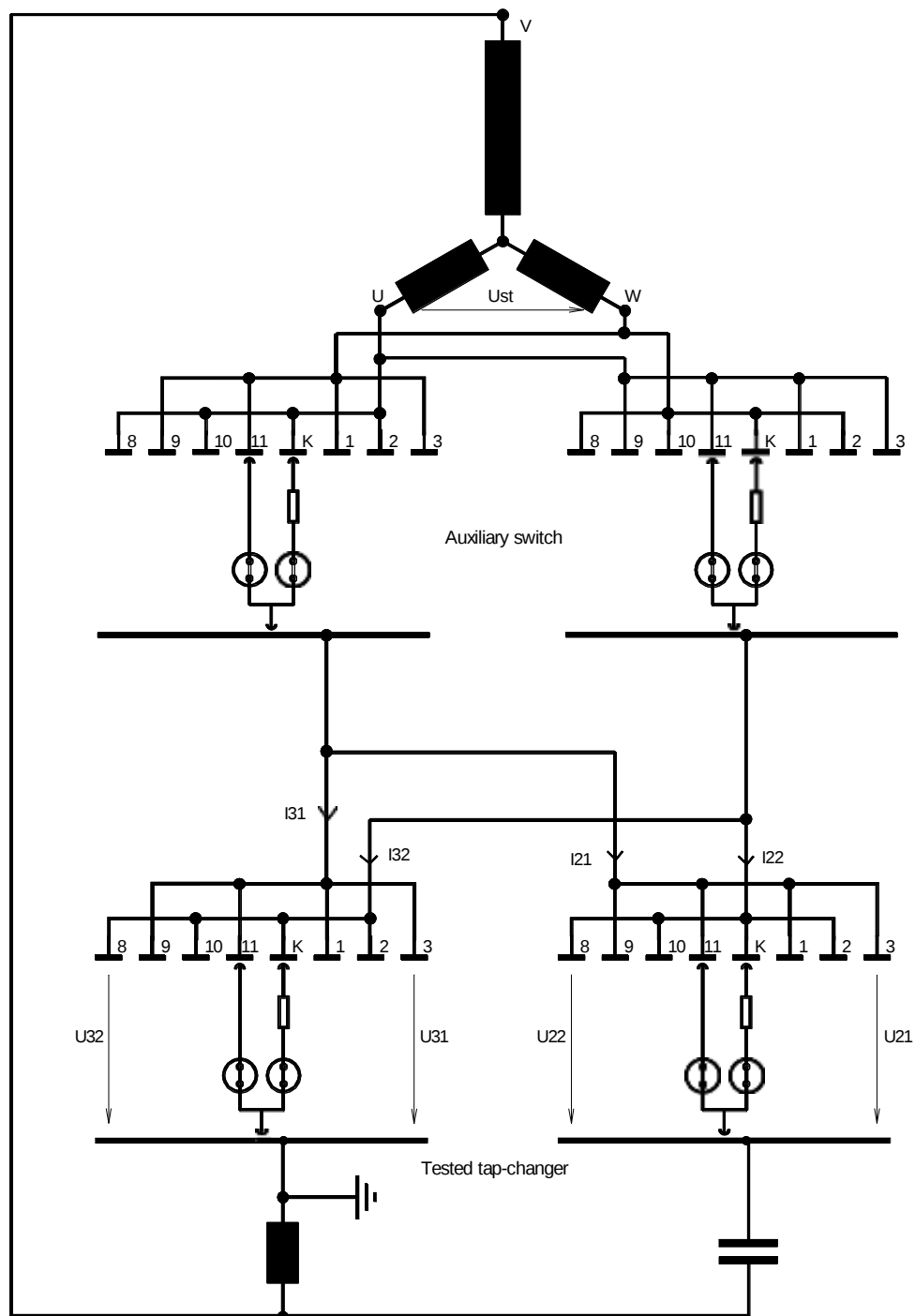


Figure 2: Test circuit

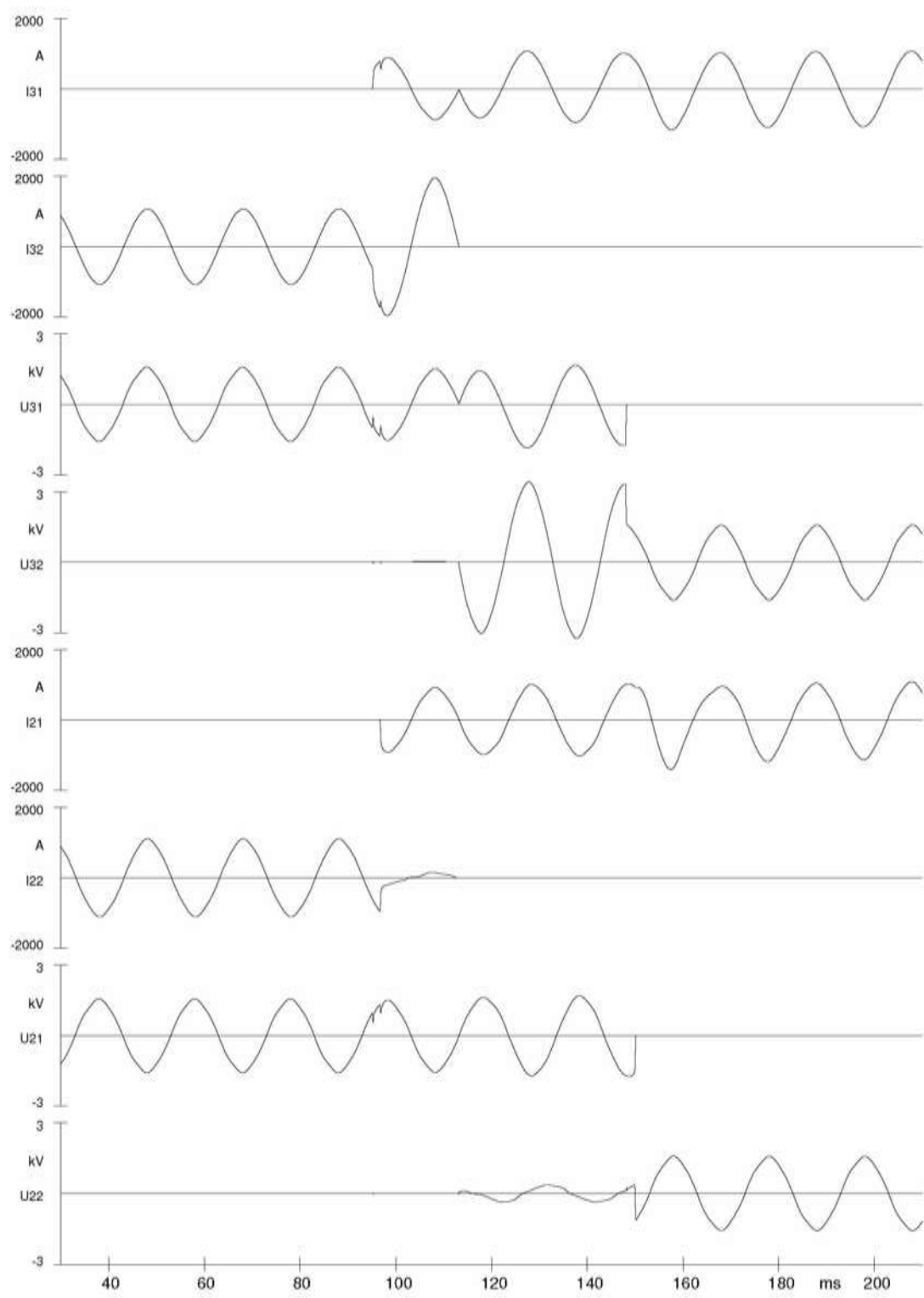


Figure 3: Example of oscillogram for service duty test, switching direction1 to n.

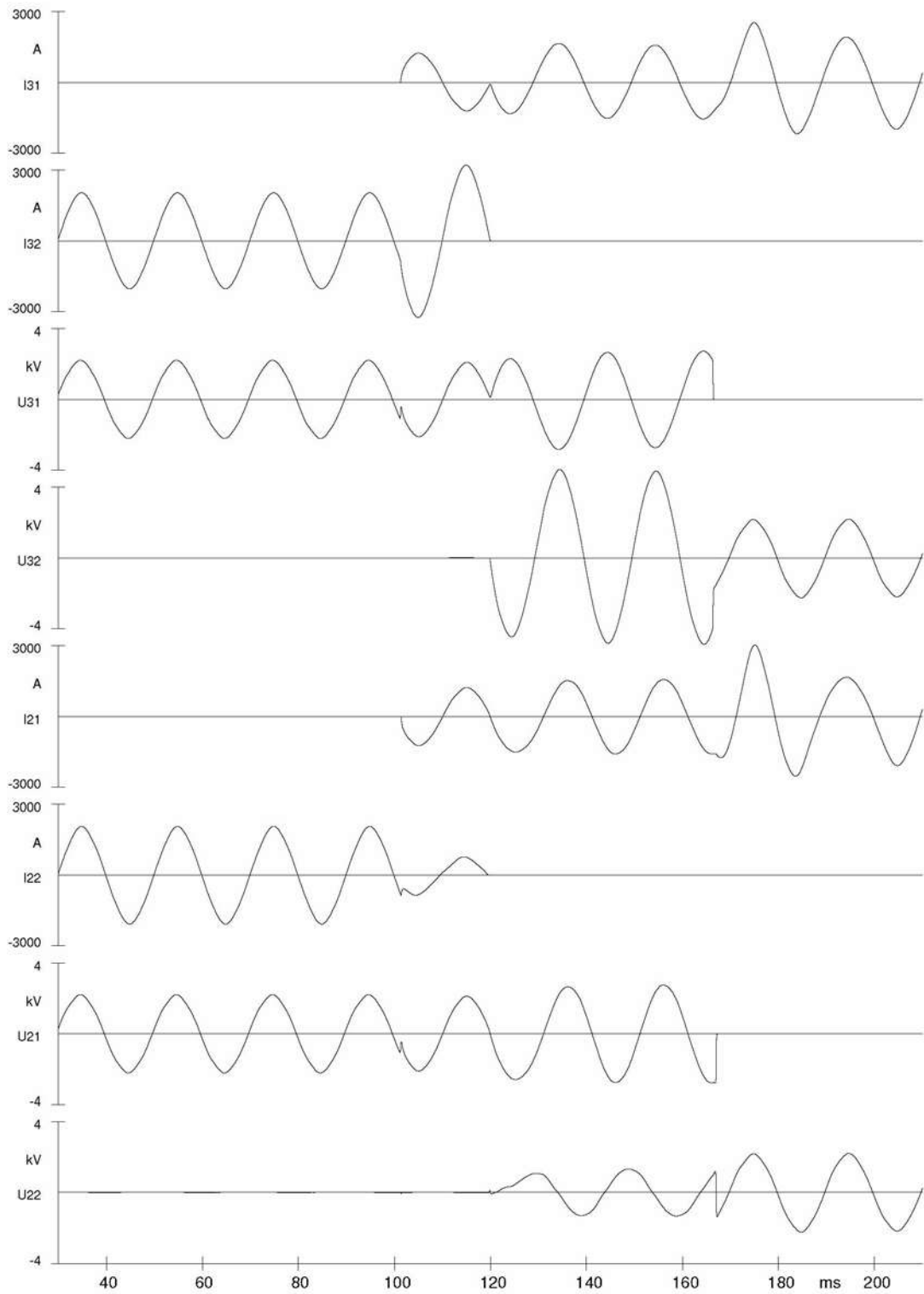


Figure 4: Example of oscillogram for breaking capacity test at twice the maximum rated through-current and at the relevant rated step voltage, switching direction 1 to n.

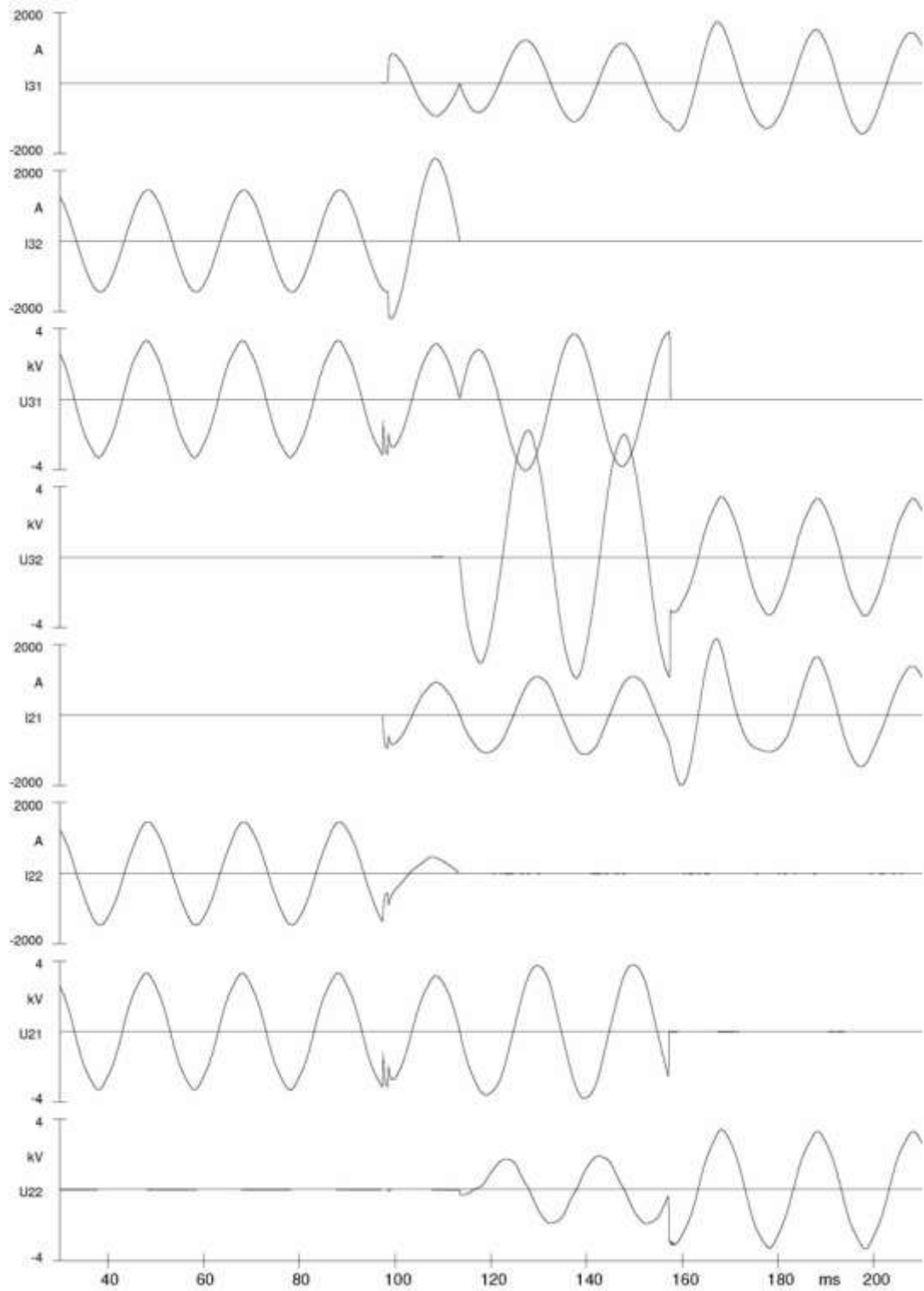


Figure 5: Example of oscillogram for breaking capacity test at maximum rated step voltage and at twice the relevant rated through-current, switching direction 1 to n.