TEST REPORT Routine Tests

Customer	
PO No.	
Trench Austria Ref.	

TA Item	Designation	Type	Qty.	Equipment No.
01	Neutral Earthing Aggregate	ELK 10/50/315	1	

Following tests have been carried out according to test standard IEC 60076-6 with satisfactory results:

- Measurement of winding resistance
- Check of voltage ratio and voltage vector relationship
- Measurement of no-load loss and no-load current
- Measurement of current over the whole adjustment range and of no-load voltages of the auxiliary and secondary windings
- Measurement of current, loss and zero-sequence impedance at rated voltage
- Measurement of short-circuit impedance, short-circuit voltage and load loss at secondary winding short-circuited
- Separate source a.c. withstand voltage test
- Induced a.c. withstand voltage test
- Operation test of core air-gap mechanism

End of testing:	03.07.2020
Place of testing:	Linz-Leonding, Austria

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Equipment no.:

1. Measurement of winding resistance

Position of tap-changer: 3

Measured values			Calculated values					
Terminals	θ_{amb} in °C	R_{dcamb} in mΩ	θ in °C	θ_{ref} in °C	c	R_{dcref} in mΩ	I_r in A	P_{dc} in W
1U -1V	22	5842.0	235	75	1.20623	7046.8	2.624	24
1U-1W	22	5846.3	235	75	1.20623	7052.0	2.624	24
1V-1W	22	5843.1	235	75	1.20623	7048.1	2.624	24
1U,1V,1W-1.2	22	3182.4	235	75	1.20623	3838.6	50	9597
2U -2V	22	76.985	235	75	1.20623	92.86	68.73	219
2U-2W	22	77.210	235	75	1.20623	93.13	68.73	220
2V-2W	22	77.326	235	75	1.20623	93.27	68.73	220

2. Check of voltage ratio and voltage vector relationship

Voltage ratio tolerance on all tappings: < ±0.5 %
Voltage vector raltionship : ZNyn11(d)

3. Measurement of no-load loss and no-load current

Position of tap-changer: 1

f_t =	50	Hz			θ_{amb} =	22 °C			
Terminals	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U - Y	33.328	200	6665.6	0.0476	1	0.0476	1.069	200	213.8
1V - Y	33.859	200	6771.8	0.0498	1	0.0498	0.561	200	112.2
1W - Y	32.950	200	6590.0	0.0656	1	0.0656	1.257	200	251.3
			6675.8			0.0543			577.3

Position of tap-changer: 2

f_t =	50	Hz			θ_{amb} =	22 °C			
Terminals	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U - Y	32.551	200	6510.2	0.0491	1	0.0491	1.081	200	216.2
1V - Y	33.061	200	6612.2	0.0506	1	0.0506	0.559	200	111.8
1W - Y	32.175	200	6435.0	0.0672	1	0.0672	1.248	200	249.5
			6519.1			0.0556			577.5

Position of tap-changer: 3

f_t =	50	Hz			θ_{amb} =	22 °C			
Terminals	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U - Y	31.750	200	6350.0	0.0495	1	0.0495	1.059	200	211.8
1V - Y	32.243	200	6448.6	0.0521	1	0.0521	0.563	200	112.7
1W - Y	31.365	200	6273.0	0.0684	1	0.0684	1.254	200	250.8
			6357.2			0.0566			575.2

Position of tap-changer: 4

f_t =	50	Hz			θ_{amb} =	22 °C			
Terminals	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U - Y	30.978	200	6195.6	0.0513	1	0.0513	1.073	200	214.6
1V - Y	31.449	200	6289.8	0.0531	1	0.0531	0.556	200	111.2
1W - Y	30.607	200	6121.4	0.0703	1	0.0703	1.243	200	248.6
			6202.3			0.0583			574.4

Position of tap-changer: 5

f_t =	50	Hz			θ_{amb} =	22 °C			
Terminals	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U - Y	30.177	200	6035.4	0.0520	1	0.0520	1.057	200	211.4
1V - Y	30.646	200	6129.2	0.0549	1	0.0549	0.559	200	111.7
1W - Y	29.809	200	5961.8	0.0720	1	0.0720	1.251	200	250.2
			6042.1			0.0596			573.3

4. Measurement of current over the whole adjustment range and of no-load voltages of the auxiliary and secondary windings

Position of tap-changer: 3

Measured values						
f_t = 50 Hz			θ_{amb} = 22 °C			
	Main winding			Secondary winding	Auxiliary winding	Current transformer
Terminals	1U,1V,1W-1.2			X8.1-X8.2	X6.3-X6.4	-
I_p in A	U in V	I in A	P in W	U_s in V	U_a in V	I_s in A
5.0	504.7	0.409	8.60	39.70	8.713	-
10.0	504.5	0.794	-	40.17	8.820	-
20.0	504.0	1.588	-	40.48	8.871	-
30.0	503.9	2.380	-	40.44	8.829	-
40.0	503.5	3.170	-	40.88	8.921	-
50.0	503.2	3.963	64.8	41.86	9.150	-

Calculated values at rated voltage						
U_r = 11000 /√3 = 6350.85 V (50 Hz)						
	Main winding	Secondary winding	Auxiliary winding	Current transformer	Potentio-meter	Potentio-meter
Terminals	1U,1V,1W-1.2	X8.1-X8.2	X6.3-X6.4	-	-	-
I_p in A	I_{pr} in A	U_{sr} in V	U_{ar} in V	I_{sr} in A	R_1 in Ω	R_2 in Ω
5.0	5.1	499.6	109.6	-	-	-
10.0	10.0	505.7	111.0	-	-	-
20.0	20.0	510.1	111.8	-	-	-
30.0	30.0	509.7	111.3	-	-	-
40.0	40.0	515.6	112.5	-	-	-
50.0	50.0	528.3	115.5	-	-	-
				R_{tot} in Ω:	-	-

5. Measurement of current, loss and zero-sequence impedance at rated voltage

Position of tap-changer: 3 U_r = 11000 /√3 = 6350.9 V f_r = 50 Hz

Measured values							f_t = 50 Hz			
Terminals	θ_{amb} in °C	U_i in V	c_U	U in V	I_i in A	c_I	I in A	P_i in W	c_P	P in W
1U,1V,1W-1.2	22	63.62	100	6362.0	0.0471	100	4.71	0.125	10000	1251
	22	63.53	100	6353.0	0.5095	100	50.95	1.104	10000	11040

Calculated values			θ_{ref} = 75 °C			θ = 235 °C		
Terminals	I_p in A	I_m in A	ΔI_m in %	Z_s in Ω	Z_m in Ω	ΔZ_m in %	P_{dc} in W	P_m in W
1U,1V,1W-1.2	5.0	4.70	-6.02	-	1351.60	-	96	1263
	50	50.93	1.87	-	124.69	-	9597	12673

6. Measurement of short-circuit impedance, short-circuit voltage and load loss
at secondary winding short-circuited

Position of tap-changer: 3 U_r = 11000 / 420 V S_r = 50 kVA

Measured values						Calculated values		
f_t = 50 Hz			θ_{amb} = 22 °C			θ_{ref} = 75 °C		
Terminals	U in V		I in A		P in W	$P_{k\,ref}$ in W	Z_k in Ω	u_k in %
1U - 1V	356		2.23		148.5			
1V - 1W	356		2.20		139.1			
1W - 1U	355		2.19		149.8			
U_m =	356	I_m =	2.21	P_m =	437.4			
U_k =	423.0	$I_{r\,prim}$ =	2.62	$P_{k\,amb}$ =	618.6	742	95.14	3.93
				$I_{r\,sec}$ =	68.73			

7. Separate source a.c. withstand voltage test

Frequency of the test voltage :	50	Hz	Remark :
Duration of the test :	60	s	During the test no flashover
Test voltage prim. winding and arc-suppression reactor :	28	kV	or puncture occurred.
Test voltage sec. winding of earthing transformer :	3	kV	
Test voltage sec. winding of arc-suppression reactor :	3	kV	
Test voltage auxiliary winding of arc-suppression reactor :	3	kV	
Test voltage current transformer :	-	kV	
Test voltage auxiliary wiring :	2	kV	

8. Induced a.c. withstand voltage test

Position of tap-changer: 3

Frequency of the test voltage :	100	Hz	Remark :
Duration of the test :	60	s	During the test no flashover
Test voltage prim. winding 3ph. line-to-line :	22	kV	or puncture occurred.
Test voltage prim. winding and arc-suppression reactor 1ph. :	12.7	kV	
Position of arc-suppression reactor :	5	A	

9. Operation test of core air-gap mechanism

8 complete cycles of operation were performed with reactor un-energized.	Remark : During the test on the air-gap mechanism no failure occurred.

Legend:

ad 1. Measurement of winding resistance

θ_{amb} ...	Ambient temperature	
θ_{ref} ...	Reference temperature	
θ ...	Temperature constant	
c ...	Temperature factor	$c = (\theta+\theta_{ref}) / (\theta+\theta_{amb})$
R_{dcamb} ...	Measured DC winding resistance at ambient temperature	
R_{dcref} ...	DC winding resistance at reference temperature	$R_{dcref} = R_{dcamb} . c$
I_r ...	Rated current	
P_{dc} ...	DC loss at rated current and reference temperature	$P_{dc} = I_r^2 . R_{dcref}$

ad 3. Measurement of no-load loss and no-load current

f_t ...	Test frequency	
θ_{amb} ...	Ambient temperature	
U_i ...	Voltage reading	
c_U ...	Ratio of voltage transformer	
U ...	Test voltage	$U = U_i . c_U$
I_i ...	Current reading	
c_I ...	Ratio of current transformer	
I ...	Current at test voltage	$I = I_i . c_I$
P_i ...	Loss reading	
c_P ...	Wattmeter constant	$c_P = c_U . c_I$
P ...	Loss at test voltage	$P = P_i . c_P$

ad 4. Measurement of current over the whole adjustment range and of no-load voltages of the auxiliary and secondary windings

f_t ...	Test frequency	
θ_{amb} ...	Ambient temperature	
I_p ...	Current position	
U ...	Test voltage	
I ...	Current of the main winding at test voltage	
P ...	Loss at test voltage	
U_s ...	Voltage of secondary winding at test voltage	
U_a ...	Voltage of auxiliary winding at test voltage	
I_s ...	Current of current transformer at test voltage	
U_r ...	Rated voltage	
I_{pr} ...	Current of the main winding at rated voltage	$I_{pr} = I \,.\, U_r/U$
U_{sr} ...	Voltage of secondary winding at rated voltage	$U_{sr} = U_s \,.\, U_r/U$
U_{ar} ...	Voltage of auxiliary winding at rated voltage	$U_{ar} = U_a \,.\, U_r/U$
I_{sr} ...	Current of current transformer at rated voltage	$I_{sr} = I_s \,.\, U_r/U$
R_1 ...	Resistance of Potentiometer 1	
R_2 ...	Resistance of Potentiometer 2	

ad 5. Measurement of current, loss and zero-sequence impedance at rated voltage

U_r ...	Rated voltage	
f_r ...	Rated frequency	
f_t ...	Test frequency	
θ_{amb} ...	Ambient temperature	
θ_{ref} ...	Reference temperature	
θ ...	Temperature constant	
c ...	Temperature factor	$c = (\theta+\theta_{ref}) / (\theta+\theta_{amb})$
U_i ...	Voltage reading	
c_U ...	Ratio of voltage transformer	
U ...	Test voltage	$U = U_i \, . \, c_U$
I_i ...	Current reading	
c_I ...	Ratio of current transformer	
I ...	Current at test voltage	$I = I_i \, . \, c_I$
P_i ...	Loss reading	
c_P ...	Wattmeter constant	$c_P = c_U \, . \, c_I$
P ...	Loss at test voltage	$P = P_i \, . \, c_P$
I_p ...	Current position	
I_m ...	Measured current at rated voltage	$I_m = I \, . \, U_r / U$
ΔI_m ...	Tolerance of measured current at rated voltage to the current setting	$\Delta I_m = (I_m / I_s - 1) \, . \, 100$
Z_s ...	Impedance setting	
Z_m ...	Measured impedance	$Z_m = U / I$
ΔZ_m ...	Tolerance of measured impedance to the impedance setting	$\Delta Z_m = (Z_m / Z_s - 1) \, . \, 100$
P_{dc} ...	DC loss at current setting and reference temperature	$P_{dc} = I_s^2 \, . \, R_{dcref}$
P_m ...	Total loss at rated voltage and reference temperature	$P_m = P . (U_r / U)^2 - P_{dc} / c + P_{dc}$

ad 6. Measurement of short-circuit impedance, short-circuit voltage and load loss at secondary winding short-circuited

U_r ...	Rated voltage	
S_r ...	Rated power	
f_t ...	Test frequency	
θ_{amb} ...	Ambient temperature	
θ_{ref} ...	Reference temperature	
θ ...	Temperature constant	
c ...	Temperature factor	$c = (\theta+\theta_{ref}) / (\theta+\theta_{amb})$
U ...	Test voltage line to line	
I ...	Current at test voltage per phase	
P ...	Load loss at test voltage per phase	
U_m ...	Average test voltage	$U_m = \Sigma U / 3$
I_m ...	Average current at test voltage	$I_m = \Sigma I / 3$
P_m ...	Load loss at test voltage	$P_m = \Sigma P$
U_k ...	Short-circuit voltage at rated current	$U_k = U_m \,.\, I_{r\,prim} / I_m$
$I_{r\,prim}$ ...	Rated primery current	$I_{r\,prim} = S_r / U_{r\,prim} / \sqrt{3}$
$I_{r\,sec}$ ...	Rated secondary current	$I_{r\,sec} = S_r / U_{r\,sec} / \sqrt{3}$
$P_{k\,amb}$ ...	Load loss at rated current and ambient temperature	$P_{k\,amb} = P_m \,.\, (I_{r\,prim} / I_m)^2$
$P_{k\,ref}$ ...	Load loss at rated current and reference temperature	$P_{k\,ref} = (P_{k\,amb} - P_{dc} / c) / c + P_{dc}$
Z_k ...	Short-circuit impedance at reference temperature	$Z_k = \sqrt{[(U_k/\sqrt{3} / I_r)^2 - (P_{k\,amb} / 3 / I_r^2)^2 + (P_{k\,ref} / 3 / I_r^2)^2]}$
u_k ...	Related short-circuit voltage	$u_k = Z_k \,.\, I_{r\,prim} / (U_{r\,prim} / \sqrt{3}) \,.\, 100$