

9. Tests to verify the sound level of high-voltage/low-voltage transformer prefabricated substation**9.1. Reference standards**

Clause	Test item	Standard	
	Content	Title	Nr.
Annex B	Test to verify the sound level of a prefabricated substation	AC prefabricated substations for rated voltages above 1kV and up to and including 52kV	IEC 62271-202
-	-	Power transformers - Part 10: Determination of sound levels	IEC 60076-10

9.2. Measurement

	AC prefabricated substation as per IEC 62271-202		
Annex B	Requirements	Remark	Verdict
	The purpose of the test is to calculate the difference between the non-load sound level of a given power transformer alone (see IEC 60076-10:2016) and the non-load sound level of the high-voltage/low-voltage prefabricated substation containing the same power transformer		P
	NOTE 1 Full-load noise level can be considered under special requirement		N/A
	Comparison of the two values is an evaluation of the sound behaviour of the enclosure of the prefabricated substation. It is expected that the enclosure will not increase the sound level of the power transformer		P
	NOTE 2 The enclosure might increase the sound level of the power transformer by resonance phenomena		N/A
	The test values are only valid for the tested assembly at the rated voltage and frequency. If the prefabricated substation to be used contains different components, parts and/or is connected to a network with different supply voltage or frequency, the behaviour of the enclosure may differ		P
	The prefabricated substation tested shall be fully assembled, comprising all fittings and equipment		P
	The test shall be carried out according to IEC 60076-10:2016, which defines the method of test and calculation of an A-weighted sound level along a prescribed contour around the power transformer		P

	AC prefabricated substation as per IEC 62271-202		
Annex B	Requirements	Remark	Verdict
	The same method shall be used for measurements on the prefabricated substation where the enclosure is the sound-emitting boundary		P
	The method of measurement shall comply with IEC 60076-10:2016 with the exception of the requirement for the measuring device, which shall be at 1,5 m above ground level as defined for the prefabricated substation	The height of measured point is 1.5m	P
	These shall be in accordance with IEC 60076-10:2016. For the purpose of positioning the measuring instruments, the enclosure shall be considered as the principal radiating surface of the prefabricated substations		P
B.5	Presentation and calculation of the results		P
	The sound level shall be calculated in accordance with IEC 60076-10: 2016		P
	The report of the test shall include all applicable information as given in IEC 60076-10: 2016 for both configurations: transformer alone and fully assembled prefabricated substation		P
	In addition, for the prefabricated substation configuration, the following information shall also be included:		P
	a) main design characteristics of the enclosure, doors, covers and ventilation grids, including material used	Refer to technical drawings and user manual	P
	b) dimensioned drawing of the internal arrangement of the components inside the enclosure, position and size of doors and ventilation openings, and any other part that may significantly influence the sound propagation	Refer to technical drawings	P
	c) position of the transformer with respect to the enclosure, doors, covers, and ventilation openings	Refer to technical drawings	P

Power transformers - Part 10: Determination of sound levels as per IEC 60076-10			
	Requirements	Remark	Verdict
	The test object shall be on no-load and excited at rated voltage of sinusoidal and rated frequency.	On no-load Rated frequency: 50Hz and 60Hz	P
	If a transformer is fitted with on-load tap-changer equipment, the measurements shall be made with the transformer on a tapping which involves this condition and which is as near to the principal tapping as possible.	Without OLTC	N/A
	The excitation voltage shall be appropriate to the tapping in use.		P
	For measurements made with forced air cooling auxiliaries out of service, the prescribed contour shall be spaced 0.3m away from the principal radiating surface.	Spaced distance: 0.3m	P
	For measurements made with forced air cooling auxiliaries in service, the prescribed contour shall be spaced 2m away from the principal radiating surface.		N/A
	For transformer with a tank height $\geq 2.5\text{m}$, two prescribed contours shall be used which are on horizontal planes at one-third and two-thirds of the tank height.		N/A
	The microphone positions shall be on the prescribed contours, approximately equally spaced and not more than 1m apart.	The microphones are equally spaced on the prescribed contours Spacing: 0.970m	P
	There shall be a minimum of six microphone positions.	Measuring points: 20	P
	Sound pressure method measurement		P
	Environmental correction K	5.55dB (Transformer outside the substation) 1.80dB (Transformer inside the substation)	-
	The measurements shall be taken when the background noise is approximately constant.		P
	The A-weighted sound pressure level shall be recorded for each measuring position.		-
	Uncorrected average A-weighted sound pressure level determined from the measured value :		P

Power transformers - Part 10: Determination of sound levels as per IEC 60076-10			
	Requirements	Remark	Verdict
	$\overline{L_{pA0}} = 10 \lg \left\{ \frac{1}{N} \sum_{i=1}^N 10^{0.1 L_{pAi}} \right\}$		-
	N the total number of the measuring positions		-
	Average A-weighted background noise pressure level determined from the measured value before and after the test sequence:		P
	$\overline{L_{bgA}} = 10 \lg \left\{ \frac{1}{M} \sum_{i=1}^M 10^{0.1 L_{bgAi}} \right\}$	For detail refer to 9.6	-
	M the total number of the measuring positions		-
	L_{bgAi} measured A-weighted background noise pressure level at i_{th} measuring position		-
	The corrected average A-weighted sound pressure level calculated by using the following equation:		P
	$\overline{L_{pA}} = 10 \lg \left(10^{0.1 \overline{L_{pA0}}} - 10^{0.1 \overline{L_{bgA}}} \right) - K$	For detail refer to 9.6	-
	$\overline{L_{bgA}}$ the lower of the two calculated average A-weighted background noise pressure levels		-
	A-weighted sound power level calculated from the following equation:		P
	$L_{WA} = \overline{L_{pA}} + 10 \lg \frac{S}{S_0}$		-

9.3. Measurement condition of test day

Test day	
Measurement date	25 th May., 2023
Ambient condition	23.3 °C
Related humidity	56%
Air pressure	101.2kPa

9.4. Test instrument

Equipment	Type	Serial number	Scope/accuracy	Next calibration date
Sound level meter	AWA5661	E7095	Class 1	2024-05-15
Voltage transformer or high voltage measuring system	SYBS-3312	E6758	Transformer: Class 0.05 Power analyzer: Class 0.1	2023-09-07
Steel tape measure	5m	LJ3044	Class 2	2023-11-21

9.5. Measured value

9.5.1. Measured value of sound level (transformer without enclosure) at 50Hz				
Total area of the surface of the test room	Average acoustic absorption coefficient	The sound absorption area of the test room	The area of the measuring surface	The measuring distance
Sv [m²]	α [-]	A [m²]	S [m²]	[m]
298	0.15	44.7	28.91	0.3
Sound pressure level of background noise [dB]	Before test	42.8		
	After test	45.4		
Background noise correction factor: K [dB]		5.55		
Average sound pressure level : $\overline{L_{PAO}}$ [dB]		57.67		
Corrected average A-weighted sound level $\overline{L_{pA}}$ [dB]		51.88		
A-weighted sound power level: L_{WA} [dB]		-		
Supplement information: * Tap position: rated tapping				
* Acceptance criteria is given by agreement between purchaser and manufacturer				
* $\overline{L_{PAO}}$: Uncorrected average A-weighted sound level				

9.5.2. Measured value of sound level (transformer without enclosure) at 60Hz					
Total area of the surface of the test room	Average acoustic absorption coefficient		The sound absorption area of the test room	The area of the measuring surface	The measuring distance
Sv [m²]	α [-]		A [m²]	S [m²]	[m]
298	0.15		44.7	28.91	0.3
Sound pressure level of background noise [dB]	Before test		43.3		
	After test		45.0		
Background noise correction factor: K [dB]			5.55		
Average sound pressure level : $\overline{L_{PAO}}$ [dB]			57.35		
Corrected average A-weighted sound level $\overline{L_{pA}}$ [dB]			51.57		
A-weighted sound power level: L_{WA} [dB]			-		
Supplement information: * Tap position: rated tapping * Acceptance criteria is given by agreement between purchaser and manufacturer * $\overline{L_{PAO}}$: Uncorrected average A-weighted sound level					

9.5.3. Measured value of sound level (prefabricated sustation with transformer inside) at 50Hz					
Total area of the surface of the test room	Average acoustic absorption coefficient		The sound absorption area of the test room	The area of the measuring surface	The measuring distance
Sv [m²]	α [-]		A [m²]	S [m²]	[m]
1562.8	0.35		546.98	70.20	0.3
Sound pressure level of background noise [dB]	Before test		28.0		
	After test		27.9		
Background noise correction factor: K [dB]			1.80		
Average sound pressure level : $\overline{L_{PAO}}$ [dB]			43.8		
Corrected average A-weighted sound level $\overline{L_{pA}}$ [dB]			41.9		
A-weighted sound power level: L_{WA} [dB]			60.4		
Supplement information: * Tap position: rated tapping					
* Acceptance criteria is given by agreement between purchaser and manufacturer					
* $\overline{L_{PAO}}$: Uncorrected average A-weighted sound level					

9.5.4. Measured value of sound level (prefabricated sustation with transformer inside) at 60Hz					
Total area of the surface of the test room	Average acoustic absorption coefficient		The sound absorption area of the test room	The area of the measuring surface	The measuring distance
Sv [m²]	α [-]		A [m²]	S [m²]	[m]
1562.8	0.35		546.98	70.20	0.3
Sound pressure level of background noise [dB]	Before test		27.9		
	After test		28.0		
Background noise correction factor: K [dB]			1.80		
Average sound pressure level : $\overline{L_{PAO}}$ [dB]			41.6		
Corrected average A-weighted sound level $\overline{L_{pA}}$ [dB]			39.6		
A-weighted sound power level: L_{WA} [dB]			58.1		
Supplement information: * Tap position: rated tapping					
* Acceptance criteria is given by agreement between purchaser and manufacturer					
* $\overline{L_{PAO}}$: Uncorrected average A-weighted sound level					

9.7. Conclusion

The enclosure of the prefabricated substation does not increase the sound level of the transformer.

The prefabricated substation has passed the tests.

10. Conclusion

This prefabricated substation has been successfully tested, the test procedure and test results are in conformity with standards and specification.