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High-voltage switchgear and controlgear –
Part 37-082: Standard practice for the measurement of sound pressure levels on alternating current circuit-breakers

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 37-082: Standard practice for the measurement of sound pressure levels on alternating current circuit-breakers

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International Standard IEC/IEEE 62271-37-082 has been prepared by subcommittee 17A: High-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear, in cooperation with the Switchgear Committee of the IEEE Power & Energy Society[1], under the IEC/IEEE Dual Logo Agreement between IEC and IEEE.

This publication is published as an IEC/IEEE Dual Logo standard.

The text of this standard is based on the following IEC documents:

FDIS	Report on voting
17A/1014/FDIS	17A/1023/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

International standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62271 series can be found, under the general title *High-voltage switchgear and controlgear*, on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this standard may be issued at a later date.

The contents of the corrigendum of January 2014 have been included in this copy.

[1] A list of IEEE participants can be found at the following URL: http://standards.ieee.org/downloads/62271-37-082/62271-37-082-2012/62271-37-082_wg-participants.pdf

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 37-082: Standard practice for the measurement of sound pressure levels on alternating current circuit-breakers

1 Scope

This part of International Standard 62271 provides methods for the measurement of sound pressure level produced by outdoor alternating current circuit-breakers in a free-field environment. These methods may also be used indoors or in restricted field, provided that precautions are observed in the measurement and interpretation of the results.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
A-weighted sound level
sound level as measured on a sound level meter using a setting that emphasizes the middle frequency components similar to the frequency response of the human ear at levels typical of rural backgrounds in mid frequencies

2.2
ambient noise
all noises that exist in an area that are not related to a facility or equipment under consideration

Note 1 to entry: Ambient noise includes sound from other industrial noise, transportation sources, animals, and nature, etc.

2.3
ambient sound level
ASL
sound level that is a composite of different airborne sounds from many sources far away from and near the point of measurement

Note 1 to entry: The ASL does not include any sound from the facility or equipment under consideration and is measured without it.

Note 2 to entry: The ASL is measured under representative conditions.

Note 3 to entry: As with comprehensive sound levels, representative conditions do not constitute absolute worst-case conditions but conditions that portray typical conditions for the area

2.4
bands
octave
1/3 octave
series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency

Note 1 to entry: Each octave band has a centre frequency that is double the centre frequency of the octave band preceding it. The 1/3 octave band analysis provides a finer breakdown of sound distribution as a function of frequency.

2.5
C-weighted sound level
approximation of the sensitivity of human hearing at industrial noise levels (above about 85 dBA)

Note 1 to entry: The C-weighted sound level (i.e., measured with the C-weighting) is more sensitive to sounds at low frequencies than the A-weighted sound level and is sometimes used to assess the low-frequency content of complex sound environments.

2.6
calibration
procedure used for the adjustment of a sound level meter using a reference source of a known sound pressure level and frequency

2.7
dB
decibel
unit of measure of sound pressure that compresses a large range of numbers into a more meaningful scale

Note 1 to entry: Hearing tests indicate that the lowest audible pressure is about 2×10^{-5} Pa (0 dB), while the sensation of pain is about 2×10^{2} Pa (140 dB). Generally, an increase of 10 dB is perceived as twice as loud.

$$\text{Sound pressure level (dB)} = 10 \log\left(\frac{p^2}{p_0^2}\right) = 20 \log\left(\frac{p}{p_0}\right)$$

where

p is the root-mean-square of the sound pressure (in Pa);

p_0 is the reference root-mean-square-sound of the sound pressure, generally 2×10^{-5} Pa.

The decibel is a linear weighting and can also be used when referring to differences in weightings.

2.8
dB(A)
the decibel (dB) sound pressure level filtered through the A filtering network to approximate human hearing response at low intensities

Note 1 to entry: Also see dB and A-weighted sound level.

2.9
far field
area far enough from the noise source that the noise emissions can be treated as if they come from a single point or line source and the individual components of the noise source are not apparent as separate sources

Note 1 to entry: This is typically at a distance of at least three to five times the major dimensions of the noise source.

Note 2 to entry: The far field may consist of two parts, the free part and the reverberant part. In the free part, the sound pressure level obeys the inverse-square law (6 dB loss per doubling of distance for a point source). The reverberant part exists for enclosed or semi-enclosed situations where there are many reflected sound waves from all directions. An example of a reverberant field is industrial equipment enclosed in a room.

2.10
fast response
fast response has a time constant of 125 ms or less on a sound level meter

2.11
impulsive noise
noise characterized by brief excursions of sound pressure (acoustic impulses) which significantly exceed the ambient noise

Note 1 to entry: The duration of a single impulse is usually less than one second (see ANSI S1.13-2005).

Note 2 to entry: For the purpose of this standard, the noise produced by the closing or opening of a circuit-breaker, or their combination, is classified as impulsive noise. Other components, such as compressor unloader exhausts, may be sources of impulsive noise.

2.12
impulse r.m.s. sound level
Unit: decibel (dB, dB(A), dB(B), or dB(C))

maximum r.m.s. value reached by a sound wave, with the mean (or average) taken over a short, specified time interval

Note 1 to entry: For the purposes of this standard, the averaging time is that given by a resistance-capacitance charging circuit with a 35 ms time constant.

2.13
parallelepiped
a body "having parallel planes"; a three-dimensional figure formed by six parallelograms

2.14
peak instantaneous sound pressure level
Unit: decibel (dB)

maximum unweighted positive or negative pressure peak value reached by an impulsive sound wave at any time during the period of observation

Note 1 to entry: For the purpose of this standard, readings can be considered as peak instantaneous sound pressure level if the C-weighting is used and the response time of the instrument is 50 ms or less. Peak instantaneous sound pressure level is sometimes referred to as impact noise.

2.15
sound level
Unit: decibel (dB, dB(A), dB(B), or dB(C))
weighted sound pressure level obtained by the use of a metering characteristic and the weightings A, B, C (or other) as specified

Note 1 to entry: The weighting used is indicated. For the purpose of this standard, C weighted sound level is the same as sound pressure level (SPL).

2.16
sound pressure level
SPL
Unit: decibel (dB)
twenty times the logarithm to the base 10 of the ratio of the pressure of a sound to the reference sound pressure

Note 1 to entry: Unless otherwise specified, the effective (r.m.s.) pressure is to be used. The reference sound pressure is 2×10^{-5} Pa.

2.17
type tests
tests that are made to determine the sound level produced by a particular size, type, style, or model of circuit-breaker

Note 1 to entry: Type tests include a complete series of sound level measurements under all normal operating conditions of the circuit-breaker. These tests are usually made only on representative circuit-breakers to substantiate the values assigned to all circuit-breakers of the same design, and are not intended to be used for normal production testing.

Note 2 to entry: Applicable portions of these tests may be used to evaluate modifications of design or to verify that performance limits are being met.

2.18
field tests
tests that are made to determine the sound levels produced by circuit-breakers operating in their normal installed location

Note 1 to entry: The kind, number, and locations of measurements made in field tests are determined by the particular objectives of the tests.

Note 2 to entry: Results of field tests may not be applicable to other circuit-breakers of the same type or class.

2.19
free field
when a point source (or any source that radiates equally in all directions) radiates into free space

2.20
restricted field
when a point source (or any source that radiates equally in all directions) radiates into a non-free space where reflections will occur

3 Acoustical environment

3.1 Ambient noise

Ambient noise can sometimes be a factor for intermittent and especially continuous noise measurements, and for locations remote from the circuit-breaker. Correction for ambient sound pressure levels can be made to intermittent and continuous noise readings when the total sound measurement exceeds the ambient measurement by 4 dB to 15 dB. Impulsive noise measurements cannot be corrected satisfactorily for ambient sound pressure on the pressure-squared basis, therefore, impulsive noise measurements shall be made only when the total sound measurement is expected to exceed the ambient measurement by 15 dB or more, which is almost always the case unless significant hammering or other impulsive type noise is present in the test area.

3.2 Wind conditions

Wind conditions may result in measurement errors, especially for unweighted (flat) measurements and for low frequency components of sound. A wind screen will be useful in many cases, however, it is recommended that measurements not be made when wind speed exceeds the values listed in Table 1. (These numbers are intended as a guide only, and are based on actual measurement experience. Great care should be exercised to avoid measurement errors due to wind.)

Table 1 – Wind conditions for sound measurements

Peak instantaneous dB	**R.m.s. impulse** dB	**Maximum wind speed** m/s
< 100	< 90	2,2 (5 mph)
< 120	< 110	4,5 (10 mph)
< 140	< 130	6,7 (15 mph)

3.3 Air condition

Temperature and humidity are not significant factors in measuring sound pressure levels of circuit-breakers, however, they can have an effect on the measuring equipment, and the manufacturer's recommendations should be observed. Extremes of ambient air temperature should be avoided as should extremely humid or fog conditions.

3.4 Local topography

Local topography can affect measurements and care should be taken to avoid measurements being influenced by noise reflection, focus, or amplification from walls, buildings, or any

surfaces other than the floor or ground. i.e. ensure that the circuit-breaker is not located parallel or at right angles to reflective walls.

4 Instrumentation

4.1 Sound level meter

4.1.1 General

In general, this will consist of a microphone, an amplifier, a calibrated attenuator, an indicating instrument, weighting networks, and an output connection to accommodate additional equipment.

4.1.2 Preferred sound level meter

The preferred sound level meter is the Type 1 (precision), with a response time of 50 ms or less. It shall be capable of measuring peak instantaneous sound pressure levels up to 150 dB. The sound level meter shall also be capable of measuring impulse r.m.s. sound levels as defined in Clause 2. A meter decay time constant of three seconds or more is required for either measurement. A hold feature, which greatly increases the decay time constant, may be used if the sound level meter is so equipped.

NOTE The preferred sound meter conforms to type Class 1 (precision) according to IEC 61672-1.

4.1.3 Peak and time average

A Type 2 (general purpose) sound level meter may be used if equipped with an impact noise analyzer capable of making both peak instantaneous sound pressure level readings up to 150 dB and time average readings.

4.2 Calibration capability

Microphone calibration shall be performed before and after each test series. If the sound meter is found to be out of calibration, then a) if before the test series, the test shall not be preformed or b) if after the test series, the test series shall be considered invalid.

4.3 Supplemental instrumentation

A wide selection of additional equipment such as storage oscilloscopes, tape recorders, sound analyzers, etc. is generally available and, when used, can result in more complete data and permanent records.

5 Type test methods

5.1 General test requirements

5.1.1 General

A type test consists of a complete series of tests made in a minimum of nine locations, of which four shall be preferred, as described in 5.2 and 5.3, for impulsive noise caused by circuit-breaker operations, and additional tests for continuous and intermittent noise, if applicable.

5.1.2 Sound pressure level measurements

Sound pressure level measurements shall be made under conditions of rated filling pressure for operation and rated control voltage.

5.1.3 No load conditions

Measurements shall be made under no-load conditions.

5.1.4 Impulse noise measurement

Impulsive noise measurements shall include opening operations and closing operations.

NOTE These conditions are intended for normal type tests.

5.1.5 Location of microphone

Microphones shall be placed 1,5 m (5 ft) above ground level.

5.1.6 Orientation of microphone

The microphone shall be oriented with respect to the source so that sound strikes the diaphragm at the angle for which the microphone was calibrated to have the flattest frequency response characteristic. In most cases, for measurement of impulsive noise from a circuit-breaker, the microphone can be oriented to point straight up and will give satisfactory results. It is preferable to mount the microphone on a stand or tripod with the sound level meter connected by a remote cable. The operator, if present at the microphone location, shall stand facing perpendicular to a line between the microphone and the circuit-breaker, so that his body does not act as a shield or reflector for the noise.

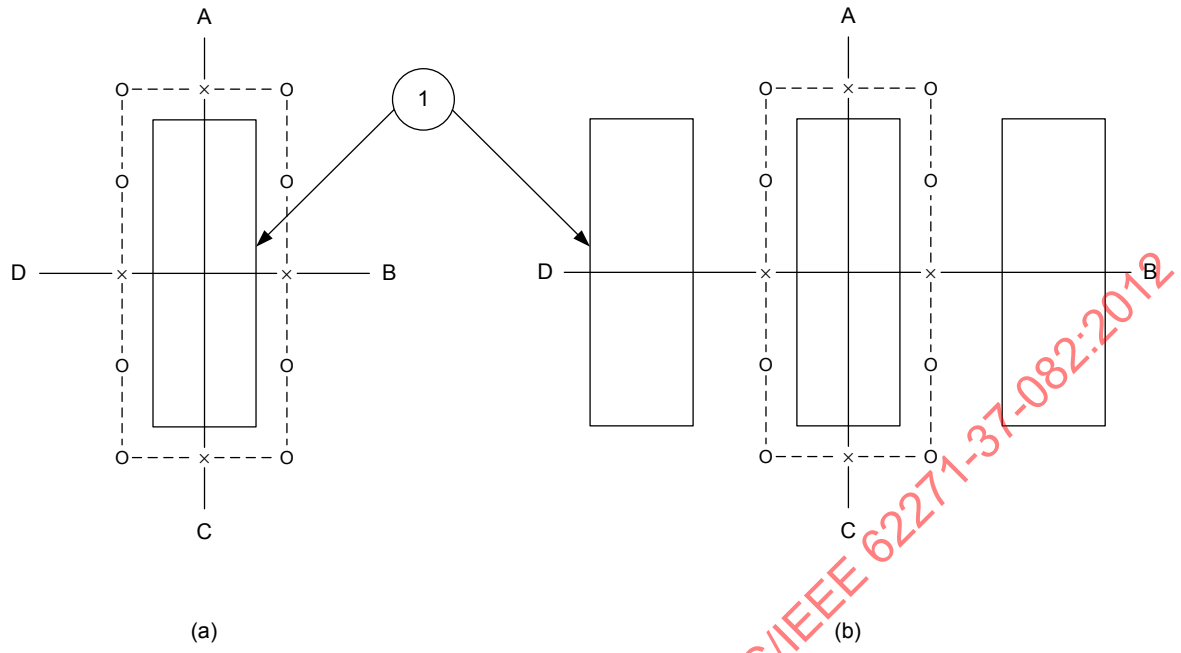
5.2 Near-field measurements

5.2.1 Type of noise measurements

Measurements shall be taken for each type of noise (continuous, intermittent, and impulsive) at the main control cabinet and at four locations around the circuit-breaker as shown in Figure 1. Additional measurements shall be taken 0,9 m (3 ft) from other noise sources, such as compressor unloader exhausts, if located separately from the above locations.

Continuous and intermittent noise measurements shall be taken using A-weighting or octave band as required by the objectives of the test.

Impulsive noise measurements shall be taken of the peak instantaneous sound pressure level without weighting or using C-weighting.



(a) Single frame circuit-breaker

(b) Multiple frame circuit-breaker

Key

(1) Reference parallelepiped (circuit-breaker outline)

× Preferred measurement points

o Additional measurement points

Figure 1 – Location of measurement points with respect to the reference parallelepiped for near field measurements

5.2.2 Near field measurement with fully opened doors

Measurements shall be taken 0,6 m (2 ft) in front of the circuit-breaker control switch with the main control cabinet doors in the fully opened position.

5.2.3 Near field measurement with fully closed doors

Measurements of the circuit-breaker shall be taken a distance of 0,9 m (3 ft) from the outline parallelepiped of the circuit-breaker with cabinet doors fully closed. See Figure 1(a) for locations on single frame circuit-breakers and Figure 1(b) for locations on multiple frame circuit-breakers.

5.3 Far-field measurements

5.3.1 Type of noise measurements

Measurements shall be taken for each type of noise (continuous, intermittent, and impulsive) at a minimum of four locations as shown in Figure 2.

Continuous and intermittent noise measurements shall be taken using A-weighting or octave band as required by the objectives of the test.

Impulsive noise measurements shall be taken without weighting, or using C-weighting, as follows:

a) for a Type 1 sound level meter, record impulse r.m.s. readings;

b) for a Type 2 sound level meter and impact noise analyzer, record readings using the time average setting with 10 ms time constant. Positive pressure readings are recommended.

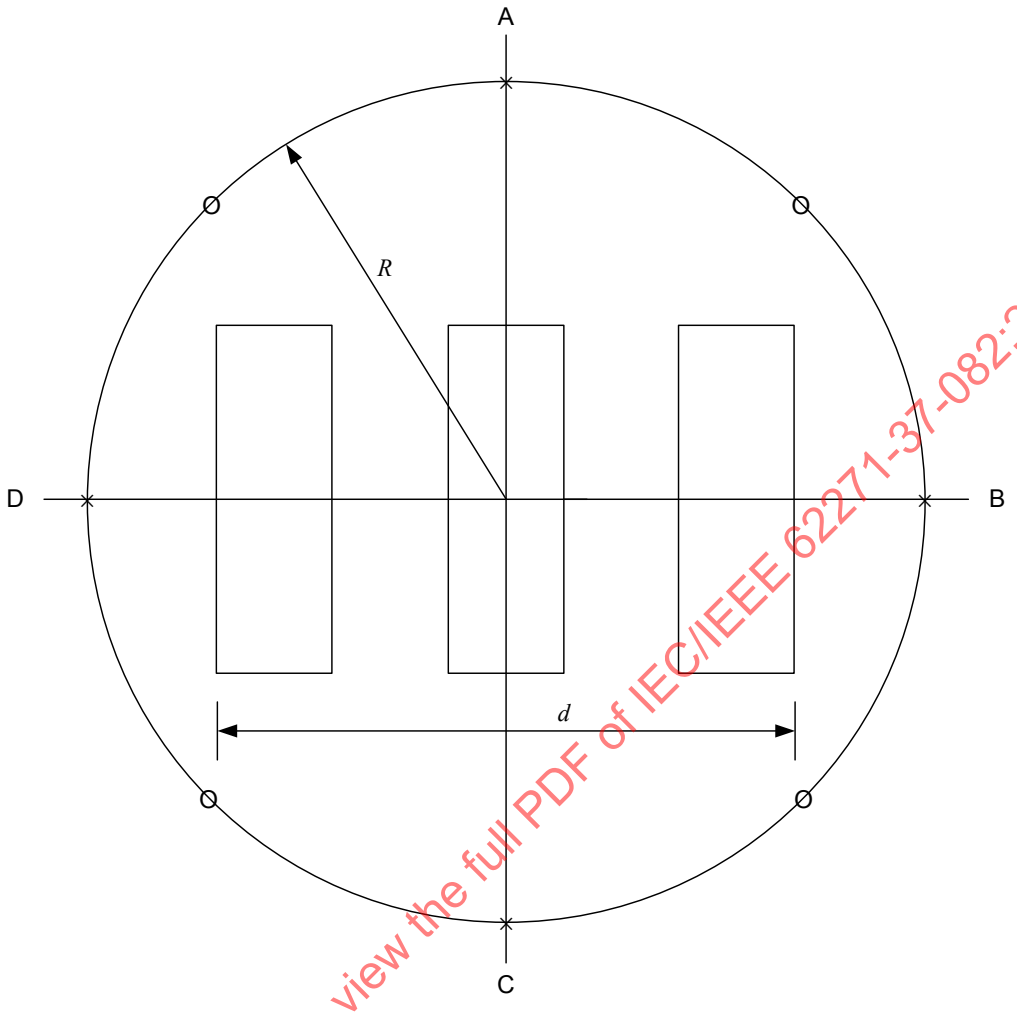
5.3.2 Far field measurement

Far-field measurement distances (radius R) shall be a minimum of two times the maximum circuit-breaker horizontal dimension (d). The following standard distances shall be used wherever possible:

a) circuit-breakers up to and including 52 kV: R = 15,2 m (50 ft);

b) circuit-breakers higher than 52 kV and up to and including 362 kV: R = 45,7 m (150 ft);

c) circuit-breakers above 362 kV: R = 91,4 m (300 ft).



Key

× Preferred measuring points (A, B, C and D)

o Alternate measurement points

Figure 2 – Location of measurement points with respect to circuit-breaker outline for far field measurements

5.3.3 Equivalent data

Circumstances such as obstructions, property boundaries, specific data requirements, etc, may make it impossible or undesirable to take measurements at the standard distances. In such cases, measurements taken at other distances can be converted to equivalent data at the standard distances specified in 5.3.2. Refer to 5.5.2 and Figure 3 for methods of converting data to the standard reference distances.

5.4 Data

5.4.1 General

The following data shall be recorded for type tests that are made according to the requirements of this standard. Standard form (Figure 3) is recommended for recording data.

5.4.2 Circuit-breaker being tested

a) Description (manufacturer, type, rating, serial number or identification number);

b) Operating conditions (closing or opening, plus any exceptions to 5.1).

5.4.3 Environment

a) Acoustic environment (use sketch if necessary);

b) Location of circuit-breaker and microphone locations;

c) Location of any obstructions in the test area;

d) Wind speed and direction immediately before and after tests.

5.4.4 Instrumentation

a) Equipment used (manufacturer, type, name);

b) Weighting used;

c) Data on calibration.

5.4.5 Acoustical data

a) Sound pressure level measurements obtained;

b) Corrections applied, if any, and reason;

c) Corrected sound pressure level or sound level;

d) Ambient sound pressure level before and after test.

5.4.6 Miscellaneous

a) Persons responsible for tests;

b) Date, place, and time of tests.

5.5 Report

5.5.1 Completeness of the report

The report shall consist of the data listed in 5.4 together with such calculations, analysis, conversions, comparisons, etc, as are appropriate to the purpose of obtaining the measurements.

5.5.2 Conversion

Each far-field reading, if made at other than the standard measurement distances, as per 5.3.2, shall be converted to equivalent data at the standard distances, using the following equation:

dB (to be added to reading) = 20 log x/R

Where x is the distance from the centre of the circuit-breaker to the microphone location, and R is the standard distance (see 5.3.2 and Figure 2).

This conversion shall not be attempted for distances smaller than 10,7 m (35 ft) or greater than 304,8 m (1 000 ft) because significant errors may result.

Type of tests _____(Design, Conformance, Field Test Report No._____) Made by_____ Location _____ Date _____ Time _____ *Circuit-breaker nameplate* Manufacturer _____ Type _____ Serial no. _____ Interrupter rating (kA) _____ Time _____ Rated operating press._____ Mufflers (Yes/No) _____ *Sound Level Meter*: *Manufacturer* _____ Type _____ Serial number ____ Microphone used _____ Calibration _____ Date _____	Calibration method used ___ Calibration equipment used ___ Mfg* ___ Type _____ S/N _____ Environment: Ambient noise, before _____dB(A), _____ dB(C) _____ After _____ dB(A) _____ dB(C) Wind direction/speed _____ Other data _____ Far field measurement radii: Locations (see Figure 2) _____ A _____ B _____ C _____ D *Sketches and notes* (Distance to be included – Use reverse side) *Mfg= manufacturer

Microphone Location		Continuous	Intermittent	Impulse – As read			Impulse – Corrected			Circuit-breaker operating conditions		
				Close	Open	Close-Open	Close	Open	Close-Open	Pressure for insulation	Pressure for operation	Notes
NEAR FIELD	**Weighting used**											
	Cont cab											
	(A)											
	(B)											
	(C)											
	(D)											
FAR FIELD	**Weighting used**											
	(A)											
	(B)											
	(C)											
	(D)											
	Average											

Figure 3 – Measurement of sound pressure levels of a.c. circuit-breakers – Record form

Far-field readings, as measured or converted as described above, shall be averaged using the power-average method, and reported as a single average number along with the individual readings.

$$\overline{L_{\mathrm{p}}} = 10\log\frac{1}{n}\left[\mathrm{Antilog}\frac{L_{\mathrm{p1}}}{10} + \mathrm{Antilog}\frac{L_{\mathrm{p2}}}{10} + \ldots\ldots + \mathrm{Antilog}\frac{L_{\mathrm{p}n}}{10}\right]$$

where $\overline{L_{\mathrm{p}}}$ is the average sound level in dB; L_{p1}, L_{p2}, ... $L_{\mathrm{p}n}$ are the individual sound levels in dB, and n is the total number of sound recordings made for any individual test.

6 Field test methods

6.1 General

Field tests are made on circuit-breakers installed in their operating environment. Data taken on a particular circuit-breaker may not be applicable to other circuit-breakers of the same type in different field environments.

6.2 Wind conditions

In locations where it is difficult to obtain measurements with wind speeds within limits given in 4.2, measurements may be made with due regard for the effects of wind on the readings. Measurements shall not be attempted when the reading due to the combined effects of wind and ambient noise is within 10 dB of the expected sound level.

6.3 Circuit-breaker operating conditions

6.3.1 Operating conditions

Measurements shall be made for circuit-breaker operating conditions expected to be encountered in service. Conditions may include operation while energized and carrying current within circuit-breaker ratings, or unusual service conditions as specified.

6.3.2 Specific conditions

When field test data is to be compared to data obtained in type tests, conditions specified in 6.2 shall be observed. (Some field tests may be made to determine the effects on circuit-breaker sound levels due to unusual service conditions).

6.3.3 Measurements

Measurements shall be made on opening and closing operations.

6.4 Microphone locations

Microphones shall be located 1,5 m (5 ft) above ground, and shall be oriented as described in 6.3.

Microphone locations for field tests will depend upon the purpose of the test. When possible, microphones shall be located at the same positions as described for type tests, per Clause 6 and Figures 1 and 2, so that a direct comparison of results can be made.