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TECHNICAL SPECIFICATION

colour inside

High voltage direct current (HVDC) substation audible noise

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CONTENTS

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 61973, which is a technical specification, has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment, with the participation of IEC technical committee 115: High voltage direct current (HVDC) transmission for DC voltages above 100 kV.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
22F/243/DTS	22F/260/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has 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

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- withdrawn,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

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HIGH VOLTAGE DIRECT CURRENT (HVDC) SUBSTATION AUDIBLE NOISE

1 Scope

This technical specification applies to the specification and evaluation of outdoor audible noise from high voltage direct current (HVDC) substations. It is intended to be primarily for the use of the utilities and consultants who are responsible for issuing technical specifications for new HVDC projects with and evaluating designs proposed by prospective contractors. It is primarily intended for HVDC projects with line-commutated converters. Part of this technical specification can also be used for the same purpose for HVDC projects using voltage sourced converters, and for flexible a.c. transmission systems (FACTS) devices such as static Var compensators (SVCs) and static synchronous compensators (STATCOMs).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

ISO 1996-2, *Acoustics – Description, assessment and measurement of environmental noise – Part 2: Determination of environmental noise levels*

ISO 266:1997, *Acoustics – Preferred frequencies*

ISO 3740, *Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards*

ISO 3743-2, *Acoustics – Determination of sound power levels of noise sources; engineering methods for small, movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for anechoic and hemi-anechoic rooms*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 8297, *Acoustics – Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment – Engineering method*

ISO 9613-1, *Acoustics – Attenuation of sound during propagation outdoors – Part 1: Calculation of the absorption of sound by the atmosphere*

ISO 9613-2, *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

ISO 9614-1, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

ISO 9614-2, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning*

3 Terms and definitions

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

3.1 Sound and noise terms

3.1.1
sound
any pressure variation in air, water or other elastic medium

Note 1 to entry: Sound is expressed as sound pressure, sound intensity or sound power (see 3.1.3).

Note 2 to entry: In this technical specification, the medium is assumed to be air.

3.1.2
sound waves in air
traveling sound pressure fluctuations

3.1.3
sound pressure
p
fluctuating pressure superimposed on the static pressure

Note 1 to entry: Sound pressure is expressed in pascal.

Note 2 to entry: Sound pressure is usually expressed through the use of a decibel scale, as sound pressure level (see 3.1.4).

3.1.4
sound pressure level
L_p
logarithm of the ratio of the r.m.s. value of a given sound pressure to the reference sound pressure

$$L_p = 10 \lg\left(\frac{(p)^2}{(p_0)^2}\right) = 20 \lg\left(\frac{p}{p_0}\right)$$

where:

p is the measured r.m.s. sound pressure in pascal;

p_0 is the reference r.m.s. pressure of 2×10^{-5} pascal, which corresponds to the 0 dB as threshold of audibility.

Note 1 to entry: $\lg(x)$ means the 10th logarithm of x; this convention is used throughout the document.

Note 2 to entry: The sound pressure level (L_p) is expressed in decibels (dB).

Note 3 to entry: Sound pressure level is measured with sound level meters, which normally incorporate a frequency-weighting filter. For further details see 3.2.3.

Note 4 to entry: Since the sound level distribution measured around sound emitting objects is usually non-uniform it is normally necessary to assess sound levels on spatial average figures gained from several measuring positions rather than on one single discrete position.

3.1.5
average sound pressure level
$\overline{L}_{pA}$

$$\overline{L}_{pA} = 10 \lg\left(\frac{1}{N}\sum_{i=1}^{N} 10^{0,1 L_{pAi}}\right)$$

where:

$\overline{L}_{pA}$ is the average sound pressure level in dB(A);

L_{pAi} is the measured sound pressure level at location i in dB(A), if required corrected for the influence of background noise;

N is the total number of measurement locations.

Note 1 to entry: The summation of several frequency bands (1/1-octave, 1/3-octave etc.) is performed in a similar fashion:

$$\overline{L}_{pA} = 10 \lg\left(\frac{1}{N}\sum_{i=1}^{N} 10^{0,1 L_{p(f_j)}}\right)$$

where:

$\overline{L}_{pA,TOT}$ is the total sound pressure level in dB(A);

$L_P(f_j)$ is the sound pressure level in frequency band f_j in dB(A), if required, corrected for the influence of background noise;

N is the total number of frequency components.

Note 2 to entry: See 3.2.2 for more information on 1/3-octave and 1/1-octave bands.

3.1.6
sound intensity
I_I

for a plane propagating sound wave, the sound intensity, I_I at a given point is defined as

$$I_I = \frac{p^2}{\rho \times c}$$

where:

p is the r.m.s. value of the measured sound pressure in pascal;

ρ is the constant density of air in equilibrium in kg/m^3;

c is the speed of sound in air in m/s.

3.1.7
normal sound intensity
I_{In}

for a plane propagating sound wave, the sound intensity, I_I at a given point in the normal direction n is defined as

$$I_{In} = \frac{p^2}{\rho \times c}$$

where:

p is the r.m.s. value of the measured sound pressure in pascal;

ρ is the constant density of air in equilibrium in kg/m^3;

c is the speed of sound in air in m/s.

3.1.8
sound intensity level
L_I

expressed in decibels ratio of the sound intensity to the reference sound intensity

$$L_I = 10 \lg\left(\frac{|I|}{I_0}\right)$$

where, $I_0 = 1 \times 10^{-12}\,\mathrm{Wm}^{-2}$

3.1.9
normal sound intensity level
L_{In}

ratio of the normal sound intensity to the reference sound intensity

$$L_{In} = 10 \lg\left(\frac{|I_n|}{I_0}\right)$$

where, $I_0 = 1 \times 10^{-12}\,\mathrm{Wm}^{-2}$

Note 1 to entry: Normal sound intensity level is expressed in decibel.

Note 2 to entry: I_n may be negative if there is a sound wave into the enclosing surface, which may happen in the acoustical near-field. The level is then expressed as – "xx" dB. The equation in 3.1.6 however assumes a plane propagating wave in the far-field of a sound source, in the direction defined as positive.

3.1.10
sound power
W

rate at which sound energy is radiated by a source

Note 1 to entry: Sound power is a scalar quantity and is expressed in watt.

Note 2 to entry: The total sound power is defined as:

$$W = \oint_A \overline{I}\, d\overline{A}$$

where:

A is a closed surface of integration;

$\overline{I}$ is the vector of sound intensity on an elementary surface $d\overline{A}$.

3.1.11
sound power level
L_W

$$L_W = 10 \lg \left(\frac{W}{W_0} \right)$$

where:

W is the emitted sound power in watt;

W_0 is a reference sound power of 1×10^{-12} W and corresponding to 0 dB as the threshold of audibility.

Note 1 to entry: The sound power level is expressed in decibel.

Note 2 to entry: The A-weighted sound power level (L_{WA}) of an object may be determined from the surface sound pressure level (L_{pA}) according to ISO 3744.

$$L_{WA} = L_{pA} + 10 \lg \left(\frac{S}{S_0} \right)$$

where:

S is the area of the "measurement surface" enclosing the object (in m^2);

S_0 is a reference area of 1 m^2.

Note 3 to entry: The sound power within an enclosing surface is independent of the distance to the sound source, but the sound pressure depends on the distance, reflections etc.

3.1.12
sound propagation
for hemispherical propagation over a reflecting plane, the sound pressure level at a given point depends on the distance from the source, the source sound power and the geometry involved as expressed by the following equations

$$L_p = L_W - 10 \lg (2\pi r^2)$$

or alternatively

$$L_p = L_W - 10 \lg (2\pi) - 20 \lg (r)$$

Note 1 to entry: This expression is sometimes called "the law of distance" in acoustics, when dealing with sound propagation from stationary sources. The law of distance implies that the sound pressure level decreases by six decibels (6 dB) for each doubling of distance from the sound source, provided that the measurements are performed in the *far-field* of the sound source. The boundary of the far-field depends among other things on the size of the sound source, the spatial complexity of the sound field and on the radiated frequency. For example; for