DECLARATION AND VERIFICATION OF NOISE EMISSION VALUES OF MACHINERY AND EQUIPMENT IN RUSSIA

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ABSTRACT
Original positions of the inter-state standard GOST 30691-2001 are considered, in which the requirements are established to declaration and verification of noise emission values of machinery and equipment, being manufactured in Russia and imported there from different countries. The comparison of the standard with the international standard ISO 4871:1996 is conducted. The main differences are marked. The suggestions for standards revision are made.

INTRODUCTION

Since July 1, 2002 GOST 30691 [1] has been introduced in Russia setting requirements for certification of machine-building industry products as sources of noise, for format and content of noise emission values declaration in the normative and covering machinery documentation, for methods of verifying the declared noise emission values. The standard has been adopted at the 19th session of the Eurasian Council for Standardization, Metrology and Certification (EACC) and shall be introduced as an inter-state standard. In the part of the methods for determination and verification of declared noise emission values the standard further develops and augments GOST 27408 [2] providing opportunities to declare and verify not only values of the main noise emission parameters (sound power level) but also values of the emission sound pressure levels at a work station and at other specified positions. As stated in introduction to the standard, information on the acoustic noise emitted by machinery and equipment is needed for users, designers, manufacturers and official bodies. This information is required for comparison of the noise emitted by various devices, for matching the measured noise level with set limits, for forecasting noise levels at a work station, for assessing effectiveness of noise abatement measures. With enacting of the standard the restrictive principle of setting noise emission values in normative and technical documentation for machine-building industry products actually becomes invalid. Preference is given to the declarative principle – currently in force in most countries, according to which the machinery manufacturer is granted the right to declare actual noise emission values for its machinery and equipment while responsibly guaranteeing the performance. Such approach also allows to regulate certification tests of the machine-building industry products and to assess the acoustic parameters of the machine under test as such and not the conditions under which it has to operate, as was the case on many previous occasions. The declared noise emission values should also be used for comparison with the normative values determined as per GOST 27409 [3], GOST 30530 [4].

The standard means introduction of the international standard ISO 4871 [5] in Russia and other CIS countries adopting it. At the same time it contains additional requirements differentiating it from the international standard. This paper deals with comparative analysis of the main provisions of both standards and detailed review of the additional requirements.

NOISE EMISSION VALUES SUBJECT TO DECLARATION

Sound power level is taken as the main noise emission parameter whose values are subject to declaration in normative and technical covering documentation for machinery and equipment. This characteristic describes the noise emitted by the machine into the ambient space and its values depend only on the design specifics, operating mode and mounting conditions of the sound source. At the same time, in practice other parameters are used in specific situations. In the international standard ISO 4871 [5], in addition to the sound power level, the machinery noise emission parameter whose values should be stated in the covering documentation is stated as the sound pressure level at given positions which characterizes the intrinsic noise emitted by the machine and is determined in the same way as the sound power level. Because to the possible confusion in terminology with respect to sound pressure levels used to define noise immission the term "emission sound pressure level" is used in the standard. Methods for determining emission sound pressure levels at specified positions are set by the ISO 11200 series [6] two of which have been introduced CIS countries as GOST 30683 [7] and GOST 30720 [8]. For a complete presentation of declared noise emission values it is necessary to state the both noise emission parameters.

According to GOST 30691 subject to declaration are values of one or several quantities from among the number of the following noise emission characteristics:

- the A-weighted sound power level, L_{WA};
- the sound power level in octave frequency bands, L_W;
- the A-weighted emission sound pressure level, L_{pA};
- the C-weighted peak emission sound pressure level, $L_{pC,peak}$.

As distinct from ISO 4871, the list of noise emission characteristics whose values are subject to declaration includes the sound power level in octave frequency bands L_W. This is done due to the following reasons. Sound power levels in octave frequency bands are the main noise characteristics for which normative values are set for stationary machinery [3]. The norms of permitted noise at work stations are set not only for the frequency weighted quantities but also for the octave spectrum, and it is impossible to make relevant calculations and assess the expected levels for their full conformity with the norms without inclusion of the declared L_W values in technical machinery documentation. Basic standards for precision and engineering methods of determining sound power levels set values of standard deviation s_R for frequency weighted quantity only in the case of a source with relatively "flat" spectrum. s_R values for other noise sources are set only for levels in octave or 1/3-octave frequency bands. L_W values as per precision and engineering methods are always determined together with L_{WA} and the requirement for their inclusion in technical documentation for the machinery does not entail any additional expenses for testing. It is even more relevant, since L_{WA} values for most technical methods are calculated from previously determined L_W values.

The number and choice of the declared noise emission values depend on the time nature of the noise emitted by the machinery of a specific type and shall be set in the relevant standard for noise testing which are called noise test codes in international normative documents to emphasize the fact that they cover machinery of a specific type only. For the machines emitting steady noise subject to mandatory declaration are values of the main noise characteristics as per GOST 12.1.023 [9] and GOST 27409 [3]: the sound power levels in octave frequency bands, L_W, the A-weighted sound power level, L_{WA}, and the A-weighted emission sound pressure level, L_{pA}, at specified positions. For the machines emitting non-steady noise these are the values of the A-weighted time-averaged sound power level, L_{WA}, and the A-weighted time-averaged emission sound pressure level, L_{pA}, at specified positions. The value of C-weigted peak emission sound pressure level, $L_{pC,peak}$, is subject to mandatory declaration only when it exceeds 130 dB. Values of sound power level in octave frequency bands are to be declared for the bands with geometrical mean frequencies of 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz.

Noise emission declaration shall consist of either declared single-number noise emission values L_d or declared dual-number noise emission values L and K.

GUIDELINES FOR DETERMINATION OF DECLARED NOISE EMISSION VALUES

Relevant guidelines in GOST 30691 as in the international standard are given in informative annex A, based on GOST 27408 [2] and do no vary in principle from provisions of ISO 4871.

Two instances are considered: determination of declared noise emission values for a single machine and for a batch of similar machines. The declared single-number noise emission value L_d is calculated by equation

$$L_d = L+K, \tag{1}$$

where L is the measured noise emission value for a single machine or the arithmetic mean of the measured noise emission values of three machines in a sample from the batch under certification determined under the same conditions, in dB; K is the L associated uncertainty, in dB, calculated in the instance of a single machine by equation

$$K=1{,}645\, s_R, \tag{2}$$

at certification of a batch of similar machines by equation

$$K=1{,}5 s_t + 0{,}564(s_M - s_t). \tag{3}$$

In the equations for K s_R is the standard deviation of reproducibility, in dB, whose values are given in the measurement method; s_t is the estimated value of the total standard deviation, in dB, determined on the measurement results; s_M is the reference standard deviation, in dB, corresponding to the total standard deviation specified for the machine model, which is considered typical for batches of machines of the given model. The values of s_M should be provided in the relevant noise test code. The methods of determining s_M values for specific machine models are given in GOST 27408 [2] and require testing samples from various batches of machines of the given model. When the values of s_M and s_t are not given in the test code, the standard recommends to use the estimated values of s_M from Table 1. The estimated values of s_t in this case taken as 0.5 dB lower than the relevant values of s_M given in Table 1.

Table 1

Measurement method (accuracy grade)	Estimated value of s_M, dB									
	for L_W in octave band with geometrical mean frequency, Hz								for L_{WA}	for L_{pA}
	63	125	250	500	1,000	2,000	4,000	8,000		
Precision (grade 1)	-	3,5	2,5	2,0	2,0	2,0	2,0	3,0	2,0	-
Engineering (grade 2)	5,5	5,5	3,5	2,5	2,5	2,5	2,5	2,5	2,5	3,0

The declared noise emission value determined in this way is the upper confidence limit with probability of acceptance of 95% while K value calculated by Eq. (3) corresponds to the producer's (supplier's) risk of rejection of 5% for a three-machine sample inspection. At the same time the standard allows using samples of a larger size but does not specify that in such case instead of the 0,564 constant in the second addend of Eq. (3) another multiplier should be used whose value corresponds to the acceptability constant at single sampling inspection which should be determined, depending on the sample size, by Table 1, from [2, 10]. There is no relevant indication in ISO 4871 either.

Pursuant to requirements of both standards, the noise emission values to be declared should be determined from measurements of highest practicable grade of accuracy i. e. using precision or engineering methods. At the same time, ISO 4871 provides the estimated values of s_M and s_t only for the engineering and survey methods. It contains no relevant values for sound power levels in octave frequency bands either.

VERIFICATION OF NOISE EMISSION DECLARATION

There are significant differences in requirements for verification of declared noise emission values in the standards. According to the both standards the quantity to be verified is either the declared single number noise emission value L_d or the sum of the measured noise emission value L and the uncertainty K depending on the form of noise emission declaration. Verification shall be effected by means of noise measurements made according to the same noise test code or, if there is no noise test code, according to a basic measurement standard with the same or better grade of accuracy, and under the same machinery and equipment operating conditions as those to which the declared noise emission values refer. At the same time, it is permitted, to effect verification using a basic test method with a lower grade of accuracy by agreement between manufacturer and user, providing allowance is made for the lower accuracy. Unlike the international standard, in GOST 30691 this position is specified as follows: in the case of single-number declaration the value L_d under verification is to be increased by the difference between values of the uncertainty K corresponding to the methods to be used when determining and verifying the declared noise emission value, while at verification of the double-number noise emission value instead of the declared K value its value relevant to the method with a lower grade of accuracy is used. Actually, this provision of the standards comes to the requirement for uniformity in the applied statistical parameters at verification and declaration of the noise emission values.

At the same time it is permitted in GOST 30691 to apply the batch of machinery and equipment verification method as per ISO 4871 only for the products to be exported to the countries in which this international standard is in force or for accepting the products imported from such countries. For other products intended for use in the CIS countries methods of statistical check should be applied as per GOST 27408 [2] or GOST 20736 [11]. It is also stated that, at the user's request, methods of these standards should also be applied to verification of noise emission values of imported products. The main difference is that GOST 27408 allows three equivalent procedures for verifying the declared noise emission value (simple sampling inspection, double sampling inspection and sequential sampling inspection) and variance in the sample size for the batch to be inspected. GOST 20736 permits also to vary the producer's risk grade and the acceptance defect level. The verification method set by ISO 4871 and introduced by GOST 30691 provides only for the double sampling inspection procedure for a three-machine sample with supplier's risk of 5% (probability of acceptance of 95%) and the acceptance defect level of 6.5%. Thus, the standard introduces, without any justification, the twofold procedure of inspection of the machine-building industry products used in the country and, by allowing variances of the producer's risk values at inspection, contravenes the above-mentioned requirement for ensuring uniformity in the applied statistical parameters at verification and declaration of the noise emission values. At determination of the declared values the standard allows only one value of the probability of acceptance (95%). The same value is used in verification and declaration methods for noise emission values as per GOST 27408, and the contradiction with the value of the producer's risk other than 5% is not eliminated at application of inspection methods as per GOST 20736. In order to ensure said correlation of the statistical parameters the variation of the producer's risk values at verification should entail modification of the uncertainty K by appropriate change of the multiplier in the first addend of Eq. (3) [10]. In addition the opportunity, provided in GOST 20736, to use at verification the acceptance defect level lower than 6.5% can cause unjustified inspection strengthening and should be by all means agreed to the producer as well it stipulated for the case of applying method of lower accuracy. Finally, methods of GOST 20736 require operating with values of the sound power or the square sound emission pressure and not with their levels. This circumstance is also omitted in the standard under review. In other words, the reference to GOST 20736 introduces contradictions in the requirements set by the standard and should be augmented by the proper limitations.

In its turn, only one value of 2,5 dB is taken in ISO 4871 for the reference standard deviation s_M at verifying a batch of machines. As a result, the criterial values are strictly fixed in the inequalities in accordance with which decisions are made on conformity or non-conformity of the batch on the results of testing. Such approach is also in conflict with the above-mentioned requirement for uniformity of the statistical parameters at declaration and verification, since it does not reflect the practically possible scatter of values of s_M, which is mentioned in Annex A of the international standard. Thus, for determination of the declared noise emission value it is recommended to use estimated values of s_M equaling 2,0 dB or 4,0 dB, depending on the accuracy grade of the measurement method applied. A simple calculation shows that the possible discrepancy in the criterial values exceeds the estimate error allowed by the standard which is linked to rounding-up of the sound power level values measured at inspection to 0,5 dB. In fact, with s_M = 4,0 dB instead of critial value of 3 dB (1,194×2,5) used in the standard for verification based on measurements on one machine from a batch we will get 5 dB (1,194×4), and instead of criterial value 1,5 dB (0,564×2,5) used for verification based on measurements on three machine from a batch we will get 2 dB (0,564×4). Such discrepancy causes distortions in the verification results. It will be even larger when using s_M values from Table 1 for low-frequency octave bands. In order to prevent said conflict in GOST 30691 is used, instead of rigidly fixed criterial values in the inequalities under verification, product $k\,s_M$ with multiplier k corresponding to the acceptability constants $k_{à}$=1.194, k_r=-0.201 and k_d=0.533 for double sampling inspection procedure with the sample size n=3 used as per GOST 27408 [2] (ISO 7574-4 [10]) depending on the relevant inspection stage.

CONCLUSIONS

The above comparative analysis shows that, according to the definitions contained in GOST-R 1.12 [12] and ISO/IEC Guide 2 [13], the standards can not be accepted as harmonized, since the noise emission declaration made as per ISO 4871 for the machines emitting constant noise will not conform with requirements of GOST 30691, and the batch of machines acceptable under the method set by the international standard can be faulted as a result of verification as per GOST 30691 due to selection of other statistical parameters or incorrect use of the distribution law for the noise emission values to be verified.

Both standards need elaboration of positions, especially as concerns reciprocal harmonization of the requirements for determination of noise emission values at declaration and verification procedures.

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