METROLOGICAL ASSURANCE, CONFIGURATION AND LAUNCH OF A NEW SPECTRI TECHNICAL FIELD – "SPECTRI-LAB" CALIBRATION LABORATORY FOR NOISE METERS, CALIBRATORS AND NOISE DOSIMETERS. ESTABLISHING ITS OWN METHODOLOGIES AND APPLYING THE RELEVANT INTERNATIONAL STANDARDS

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Abstract: This paper presents the used concept, technical support and metrological reference regarding the unique laboratory for calibration of noise meters, calibrators, noise dosimeters - SPECTRI - LAB in the Republic of Bulgaria.

Key-Words: - calibration, calibration systems for sound Meters, calibrators, noise dosimeters

1. Introduction

As a natural continuation of more than 18 years of successful commitment in the field of measurement and management of noise and vibrations, SPECTRI Ltd. has launched its new field - Spectrometer, Calibrators and Noise Measuring Laboratory SPECTRI-LAB.

The company invested in the latest generation of measuring and software equipment from the world's highest class (Brūel & Kjær) to provide its Bulgarian partners and customers with a reliable, fast and flexible service to support their ambition to work accurately and deliver quality business .

Calibration is a fundamental step in the measurement process. It ensures that the instrument used for testing shows exactly the required parameter and that the instrument meets its specification.

SPECTRI-LAB will use the following calibration system (main plan):

SPECTRI-LAB will use the international standards for the calibration of noise meters as follows:

BDS EN 60942: 2003
Calibration Method for Acoustic Calibrator
BDS EN 60651: 1999;
BDS EN 60804: 2003;
BDS EN 61672-1, 2, 3: 2013
Method for Calibration of Sound Meter
BDS EN 61252: 2000
Method of calibration of a personal dosimeter
SPECTRI-LAB will calibrate in the following ranges:

Acoustic Calibrator - sound pressure level: 90 ÷ 130 dB (resolution 20 µPa), rated frequency 250Hz,
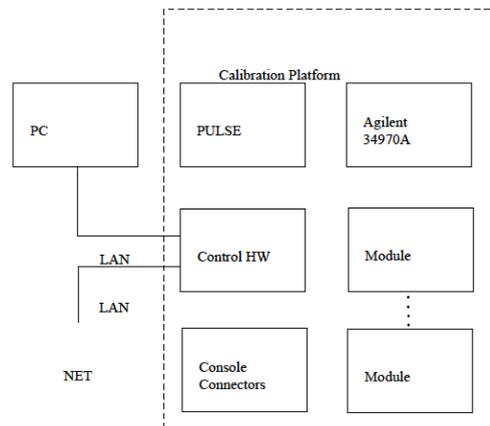

Fig.1 Elements of the calibration system

1 kHz. CMC: 0.15 dB

Acoustic multifunction calibrator - sound pressure level: 90 ÷ 115 dB (resolution 20 µPa), nominal frequencies 31.55 Hz ÷ 12.5 kHz. CMS: 0.2 dB: 31.5 Hz ÷ 4 kHz, 0.3 dB: 8 kHz ÷ 12.5 kHz

Sound meter - response from an acoustic calibrator signal: 94 ÷ 124 dB (20 µPa), nominal frequencies 31.55 Hz ÷ 12.5 kHz. CMC: 0.3 dB: 31.5 Hz ÷ 12.5 kHz

Sound meter - Response to electrical measuring signals: 20 ÷ 140 dB (20 µPa) nominal frequencies 20 Hz ÷ 20 kHz. CMC: 0.4 dB: 20 Hz ÷ 20 kHz

Personal dosimeters - response of acoustic calibrator signal: sound pressure level of the calibrator 90 ÷ 115 dB; Measuring time 60 s ÷ 120 s. CMC: 4%

Personal dosimeters - Response to Electrical Measurement Signals: 0.3 Pa2h ÷ 105 Pa2h. CMC: 4%

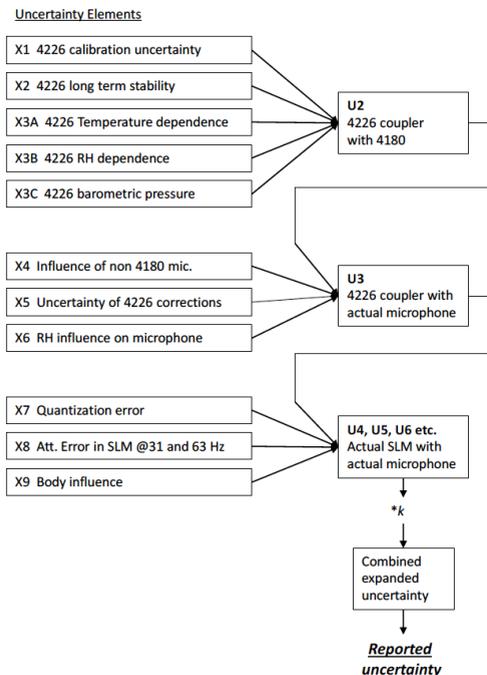The model we use to determine the uncertainty budget is as follows (items to be included):

Figure 2 Uncertainty model

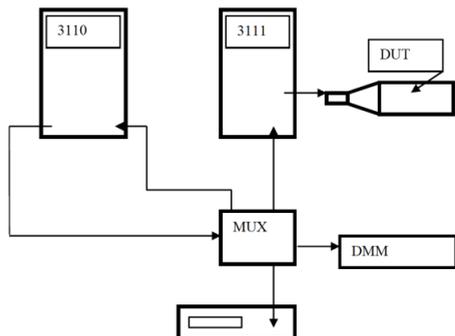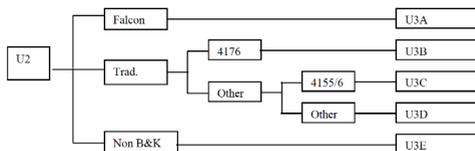## 2. Calibration principle used - noise meters

Fig.3 Check analogue signal

Fig. 4 Automatic acoustic calibration - sound level meter 2238

3. Principle of determination of the uncertainty for the calibration of noise meters:

f [Hz]	X1 4226 cal	X2 Long term	X3A temp.	X3C pres.	NF1	NF2	NF3A	NF3C	u1	u2	u3A	u3C	U2 Comb Unc.
									standard uncertainties				
31,5	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
63	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
125	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
250	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
500	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
1k	1,27	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,635	0,350	0,046	0,115	0,736
2 k	1,04	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,520	0,350	0,046	0,115	0,639
4 k	1,15	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,575	0,350	0,046	0,115	0,685
8 k	1,5	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,750	0,350	0,046	0,115	0,837
12,5 k	1,74	0,7	0,08	0,2	0,5	0,5	0,577	0,577	0,870	0,350	0,046	0,115	0,946

Fig.5 Uncertainty in the calibration of noise meters

4. Calibration Acoustic Measurement Model - Using the Direct Measurement Method with Standard Multifunctional Sound Calibrator:

The deviation from the actual sound level "ΔLsp", dB of 20 µPa is derived from the equation:

$$\Delta Lsp = \Delta Lspm + \delta Lspe + \delta Le,$$

$$Such\ as\ \Delta Lspm = Lspm - Lspe \qquad (2)$$

Where:

ΔLspm - the difference between the readings of the measured sound level meter and the set level of the reference multifunctional sound calibrator dB;

Lspm - Measurement sounder reading, dB about

20 µPa;

Lspe - set level of reference multifunctional sound calibrator, dB about 20 µPa;

δLspe - deviations from the actual sound level value, dB

(From the Calibration Certificate of the Reference Sound Calibrator);

δLe - correction of the measured value due to the sound meter resolution.

The reference multifunctional sound calibrator type 4226 - Brūel & Kjær has feedback for equalizing atmospheric pressure. Therefore, the correction of the change in atmospheric pressure in the specified calibration conditions is negligible. This is reflected in the calibrator's technical documentation.

5. Acoustic Calibrators Principle Used

Calibration principle

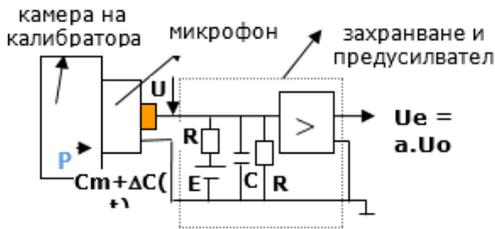The devices and auxiliaries are connected according to fig.6

Fig.6 Automatic acoustic calibration

$P = Uo / So;$

$Lp = 20.lg (P / Po);$

Where:

P - sound pressure (Pa);

Po - Rated value 20µPa (2.10 Pa);

So - sensitivity of the open microphone reference (V / Pa) expressed in calibration cards as *Mo*, dB for 1v / Pa.

Determination of *Uo* by measuring the effective value of the output voltage "*Ue*" and reading the coefficient "a", which depends on the degree of loading of the microphone output (Figure 6)

$Ue = a.Uo$ or $Uo = Ue / a, a = b.Cm/(Cm+C);$

Where:

Ue - voltage at the output of the preamplifier;

Cm - the capacity of the microphone capsule;

C - input preamplifier capacity;

b - voltage factor for the pre-amplifier kit with power supply unit.

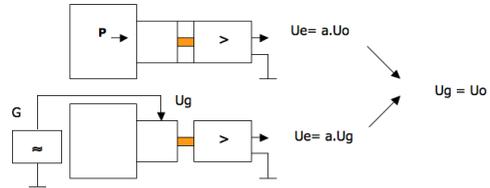Determination of Uo by direct measurement by the substitution voltage method (Fig.2)

Fig.6 Determination of Uo

Ug - a sinusoidal substitution voltage fed by a generator in series to the microphone capsule

6. Measurement model for determining Lp by a reference microphone with a normalized sound pressure transducer in an electrical signal:

The sound pressure level "Lp" in the chamber of the measured sound calibrator is derived from the equation:

$$Lp = Lo - Mo - Lpo - δLpa + δLv +$$
$$+ δLa + δLe + δLs + δLt \qquad (1)$$

Where:

Lo - value of the measured open-circuit level at the output of the reference microphone, dB vs. 1v;

Lpo - reference level corresponding to 20 µPa, Lpo = 20.lg (2.10), dB;

Mo - open loop sensitivity of the reference microphone, dB relative to 1v / Pa;

δLpa - correction of the atmospheric pressure barometer;

δLv - correction, depending on the equivalent volume of the microphone used;

δLa - correction of the coefficient "a". When measured by the replacement voltage method, this correction is not counted;

δLe - correction of the measured value due to the resolution of the sound metering system;

δLs - correction of the measured value, depending on the polarization voltage tolerance for the microphone;

δLt - change the sensitivity of the reference microphone from a change in temperature.

7. Values Xj of input quantities:

Measured value (Lo)

For repeated measurements, Lo is calculated by the formula:

$$Lo = \frac{\sum_{i=1}^{n} Lio}{n} \qquad (3)$$

Where:

Lio - the value of the level recorded in the i-th measurement;

N - number of measurements.

Lone level (Lpo) - Constant value

$$Lpo = 20.lg\ (2.10) = -93.98\ dB \qquad (4)$$

The evaluation of the open circuit sensitivity level of the reference microphone under point 3.1 is "Mo" dB. 1v / Pa of the certificate of its last calibration for the relevant frequency.

The assessment of the barometric correction (δLp) depends on the atmospheric pressure at the moment of measurement and is read by the corresponding barometer. In some types of sound calibrators, there is a pressure equalization feedback input, and the estimate of this correction is zero and the contribution to uncertainty is increased. This is detailed in the technical documentation of the respective calibrator.

Correction depending on the equivalent volume of the used microphone (δLv). There are advanced sound calibrators with volume feedback, so it is important that the fixation (δLv) be in accordance with the technical documentation.

Resolution of resolution (δLe)

This input parameter has a zero expectancy and an error equal to half the value of the smallest significant digit of the voltmeter.

Since all input quantities are uncorrelated, the Lp level equation is equal to the square root of the sum of the dispersions (squares of the uncertainty inputs) of the input quantities

$$u(Lp) = \sqrt{\sum u^2(Xi)}$$

Extended uncertainty, U (Lp)

The expanded uncertainty of the U measurements is obtained by multiplying the quadratic uncertainty of the estimate u(Lp) by the confidence interval k, U=k.u(Lp)

For normal (Gaussian) distribution of the measured magnitude and probability of the confidence interval, approximately 95%, k = 2.

8. Presentation of SPECTRI-LAB calibration system

The Calibration Platform of the Brüel & Kjær 3630 is a universal platform for the calibration of instruments and transducers in the field of noise and vibration.

The applications used by SPECTRI are as follows:

Calibration of noise meters (SLM) - calibration software Type 7763

Calibration of noise meters is extremely governed by legislation. As the number of instruments requiring calibration increases, the need for an efficient calibration system is present.

Sound level meters calibration complies with all relevant international standards and recommendations and is equally well suited for use in national calibration laboratories and calibration centers.

The system combines state-of-the-art information technology with Brüel & Kjær's proven expertise in calibration of noise and vibration tools.

Calibration of sound meters (SLM) with Type 7763 Calibration Software is not just an effective tool, it is actually a globally-supported, easy-to-read system with uncertainty budgets needed for accreditation purposes.

Used for acoustic and electrical calibration of noise meters, calibrators, dosimeters, octave filters - according to international standards.

The Calibration Platform of the Brüel & Kjær 3630 uses the portable 100 kHz PULSE ™ multi-analyzer as the core element of the system. Portable PULSE ™ is an extremely versatile multi-analyzer that can analyze signal level, FFT, 1 / n-octave filters and the overall range of measurement parameters. PULSE ™ also generates the test signals needed to meet the requirements of international standards.

The Type 3630 Calibration System is designed to calibrate Brüel & Kjær instruments as well as other manufacturers' sound level meters in accordance with IEC 60651, IEC 60804, IEC 61672 as well as all other relevant standards. The system comes with Genuine Type 7762 Sound Level Measurement Software and Type 7763 Test Option, performing different tests manually, semi-automatically or in automatic modes. Tests are performed both acoustically and electrically.

Here is a functionality for tracking and control-

ling calibration intervals by standard and the tools used by the system are facilitated by the calibration manager software, including client and tool database. The measurement circuit is guaranteed by an integrated digital voltmeter DMM Agilent 34970 and Brüel & Kjær Type. Used as a 4226 multi-frequency calibrator (a), as well as the 4180 microphone laboratory standard.

Fig.7 Calibration system Type 3630.

Calibration platform Type 3630 with calibration software Type 7792 for noise dosimeters

Noise Dose Meter Calibration Type Type 7792 for Type 3630 Calibration platform is an automated tool designed to perform periodic noise dosimeter tests in accordance with IEC 61252. The software automatically starts a variety of predetermined tests according to selected references. The system includes a database of the current Brüel & Kjær types of noise meters, including sound level measurement and noise exposure. New types of dosimeters are entered with a range of parameters required for their definition. Uncertainty budgets are provided to facilitate laboratory accreditation (ISO 17025) and calibration reports are automatically generated to reduce the risk of human error.

Calibration platform Type 3630 with calibration software Type 7794 for calibrators.

Platform Type 3630 with Calibration Software **Type 7794** is a tool for performing automated periodic calibrator tests in accordance with IEC 60942. The system performs calibration of acoustic calibrators and speech recorders with one frequency (250 Hz / 1000 Hz) as well as multifunction calibrators With different calibration frequencies and amplitudes). Calibration procedures for Brüel & Kjær Acoustic Calibrators Types 4220, 4228, 4230 and 4231 are pre-defined in the software, which also allows the

addition of new types of calibration tools and procedures. Uncertainty budgets are provided to facilitate laboratory accreditation (ISO 17025) and calibration reports are generated automatically.

Available option for upgrading to type 9699 for Reciprocal Microphone Calibration

(Primary Calibration)

Figure 7 Recoil Calibration System for Microphones

Used calibration system for calibrators, noise meters, noise dosimeters: Type 3630-Brüel & Kjær

Fig.8 Real working visualization

9. Conclusions

Since 2016, SPECTRI, through its testing and calibration laboratory, SPECTRI-LAB provides a new type of services on the Bulgarian market, namely:

- testing and monitoring of noise in industrial locations
- Calibration of acoustic calibrators
- Calibration of noise meters
- Calibration of noise dosimeters

With this initiative, SPECTRI Ltd. aims to

strengthen its portfolio of services in the field of measurement, evaluation and calibration of noise and vibrations, to increase its expertise potential and, last but not least, to provide its clients with additional facilities and support in their tasks Metrological assurance and quality control of the equipment used by them.

4. References

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[3] Multifunctional system "Pulse"

[4] BDS EN 60942: 2003 Electroacoustics. Sound calibrators;

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[6] BDS EN 60804: 2003 Integral instrument for measuring the average sound level;

[7] BDS EN 61672-1,2,3: 2013 Electroacoustics. Apparatus for measuring sound level

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