

# ESTONIAN CALIBRATION LABORATORIES CAPABILITIES

***E. Kulderknap***

Institute of Instrument Engineering, Tallinn Technical University  
Ehitajate tee 5, Tallinn, 12618, Estonia

*Abstract. In this work are analysed capabilities and position of the Estonian calibration laboratories. During last 10 years had Estonia changed completely and this involve also the actievity on metrology area. Basic change was this, that on the socialist time was verification mandatory for almost all measuring instruments, now shall it be replaced greatly by voluntary calibration. Huge problem for Estonian calibration laboratories was the reference standards traceability. On the previous time it came from the Soviet Union metrological institutes. Now the main laboratory reference standards are mostly traceable to the western countries reference standards.*

*In this work are analysed the traceability assurance and the influence of changes to the laboratories and to the metrological infrastructure. In a summary is given conclusion of actions which can be used for restructuration of metrological infrastructure of the post socialist counties.*

*Keywords: calibration, calibration laboratories, metrological infrastructure*

## 1 INTRODUCTION

Achievement of high quality of industrial production and everyday services involve, as important part, the control procedures and the testing. The control and testing operations contain large amount of measurements. These measurements shall be reliable, i.e. shall have required accuracy parameters and traceable measurement unit. The traceable measurement unit shall go through the competent measuring instrument calibration laboratory whose measurement standards shall have compliance with the widely accepted requirements.

The Estonian infastructure and especially industry was reconstructed during post Soviet time. To assure the quality of required measurements there was primary task to built up the metrological laboratories and the measurement standards system taking account World wide principles. This task demand to tie up the reference standards traceability scheme with the competent calibration laboratories standards in Western countries and set up the competent calibrations of the measuring instruments in the Estonian calibration laboratories.

In given work are analysed the Estonian calibration laboratories capabilities and given recommendation to work up the required metrological infrastructure in the post socialist country. Also are given calibration system Estonian clients short review and its needs overlook for calibration services.

This work results were used in practical activity for reconstruction of the calibration laboratories system in Estonia. Nowadays situation permits better quality of the measurements by control and testing operations.

## 2 PREVIOUS SITUATION OF CALIBRATION/METROLOGICAL LABORATORIES

On the end of 1989 in Estonia were 4 main regional verification laboratories and about 100 - 110 metrological laboratories dealing with so called in-house verification, i.e. they completed verification for its own factories or firms need. Practically each measuring instrument should to be verified. Also all laboratory standards were verified, mainly in the regional metrological institutes. Traceability was achieved through these institutes and Soviet Union reference standards up to the international primary standards.

In the table 1 are given main data for metrological laboratories in Estonia on the end of 1989.

Weaknesses for such system were high cost, very high centralisation which do not allowed personal initiative, standards were only verified and all measuring instruments were under metrological control even these which do not need this.

Positive factors were: good personnel training, no great financial problems for laboratory with verification of the standards and procedures good professional level by reason that they were issued and validated by metrological institutes.

**Table 1.** Metrological laboratories main data in Estonia (up to 1989)

Laboratories quantities	Involved personnel	Procedures	Traceability	Measuring instrument quantity to be verified
110 - 115	250 - 300 persons	Verification based on GOST standards	To Soviet Union main standards (in Moscow, Leningrad, Kiev, Riga)	About 1 - 1,2 million exemplars

Up to the end of 1993 when market economy was during 2 years introduced in Estonia the quantity of metrological laboratories was declined up to 45. Verification stays as main control form.

### 3 NOWADAYS SITUATION OF CALIBRATION LABORATORIES

The more closed co-operation with Western European infrastructure demands the modernisation of Estonian metrological activity. The basic change was this that the calibration raised as metrological control procedure. For assuring the competence of metrological laboratory accreditation took position as main tool. Firms' quality systems certification by ISO 9000 demands also measuring instrument calibration.

On the end of 1999 in Estonia were 2 accredited calibration laboratories and exists 23 licensed verification laboratories from which 7 - 10 performed also calibrations as third party. In the factories performed simplified calibrations 6 - 8 laboratories.

In the table 2 are given main data for third party calibration/metrological laboratories in Estonia on the end of 1999. In the table 3 is given calibration laboratories metrological area of activity.

**Table 2.** Estonian third-party calibration/metrological laboratories main data up to 1999

Laboratories quantity	Involved personnel	Procedures	Traceability	Measuring instrument quantity to be controlled
25	80 - 100 persons	Verification based on OIML documents. Calibrations based on well-known principles	As rule through Finland, Sweden reference standards	About 0,2 - 0,3 million exemplars

**Table 3.** Estonian calibration laboratories metrological area of activity

Area of activity	Labs quantity	Measurement range	Best measurement capability
Mass measuring instrument calibration: - labs with estimated quality system; - machinery/apparatus plants labs	8 ca 5	1 mg - 200 t 1 mg - 5 t	1 kg, $U=\pm 0,2$ mg
Length measuring instrument calibration: - labs with estimated quality system - machinery plants laboratories	4 ca 10	0 - 100 m 0 - 1 m	1 mm, $U=0,07$ $\mu$ m 1 m, $U=0,1$ $\mu$ m 1 mm, $U=0,1$ $\mu$ m
Temperature measuring instrument cal.: - labs with estimated quality system - laboratories in various areas	4 ca 80	0 - 1200 °C 0 - 1000 °C	100 °C, $U=0,05$ °C 100 °C, $U=0,1$ °C
Pressure measuring instrument calibr.: - labs with estimated quality system - machinery plants laboratories	10 ca 8	(-0,1-60) MPa (-0,1-60) MPa	100 kPa, $U=0,1$ kPa 100 kPa, $U=0,2$ kPa
Force measuring instrument calibration: - labs with estimated quality system	2	0,05 - 1 MN	50 kN, $U=0,6$ kN

The relation of performed verifications and calibrations is ca 95/5. This relation show that very hard is to change existing situation, verification stays strongly as main metrological control form.

Users of metrologically controlled (verified or calibrated) measuring instruments in Estonia are shown in Figure 1. Shown quantities based on the author expert opinion.

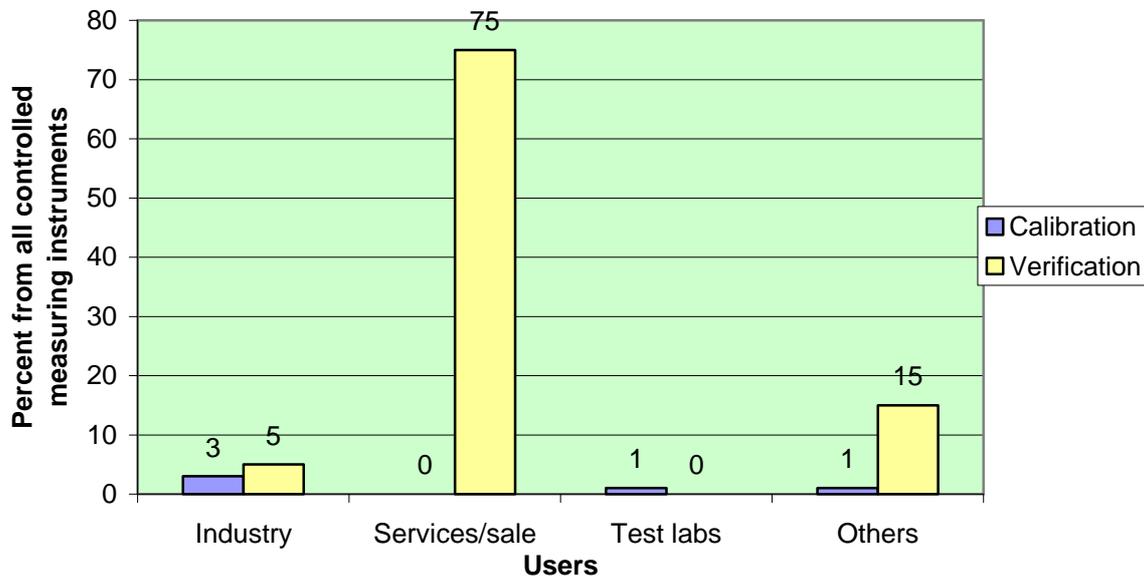


Figure 1. Users of metrologically controlled measuring instruments

#### 4 FOREIGN AID

For the modernisation of Estonian metrological infrastructure was given expert and economical aid by various founds (PHARE) and countries (Sweden, Switzerland, Finland).

Primarily aid was given:

- to work up the Estonian mass reference standard (Switzerland help), the mass standard was set up but the competence of laboratory is up to now not assured;
- for foreign experts visits to the Estonian metrological laboratories;
- for Estonian metrological personnel training;
- for calibration of the laboratories reference standards in the leading calibration laboratories of Sweden and Finland to assure the competent traceability;
- for intercalibrations.

Practice shows that the second case was useful in the initial stage of modernisation and last three case were more useful for the ripen infrastructure development. The case to establish the mass reference standard was less successful. The reference standard laboratory does not give practical calibrations up to now. One reason for this was, that in the initial contract was not set up the exact goal.

#### 5 TRACEABILITY AND MAIN STANDARDS

Reliable and acceptable result of the calibration shall have an unbroken traceability chain to the highest international reference standard. Such traceability shall be obtained through the competent calibration laboratory of the reference standards. During last few years was great effort made in Estonia to tied up the traceability scheme with the Western competent calibration laboratories standards. Foreign aid programs gave big help for this actievity.

For Estonian infrastructure have more importance mass, length, time and temperature measurements and main task was to assure the traceability of calibrations in these fields.

The mass measurement traceability scheme for Estonia is given in the table 3. Practical users need mainly the II or III OIML class balances, very few the I class balances.

The length measurement traceability scheme for Estonia is given in the table 4. Practical users need mainly the II OIML classes length measures, required most accuracy in some laboratories is on the level of  $U=10^{-6}$  (relative).

The temperature measurement traceability scheme for Estonia is given in the table 5.

Similar way, as shown in tables 3 – 5, have traceability DC electrical (traceability from VTT, Finland), pressure ((0,04 ... 60) MPa, MIKES, Finland) and time measuring instruments calibrations (GPS).

**Table 3.** Traceability scheme by calibrations of mass measuring instruments in Estonia

Standard	Place	Accuracy parameters
International kilogram standard	BIMP (Bureau International Measures and Weights)	1 kg, has trift in values (difference from 1889 until 1954 -0,0034 mg [1])
Kilogram prototype copy	No 40, Sweden, SP [2]	1 kg
Leading calibration laboratories reference standards	Metrosert Ltd, accred. by FINAS in 1999	1 kg ±0,1 mg
Calibration laboratories standards	10 laboratories	Various values: 1 kg ±0,5 mg or less accurate
Practical users	Up to 250 test laboratories and medium size firms	Various values: Weights F1, F2, M1 and mainly M2 (1 kg 150 mg), balances II and mainly III class

**Table 4.** Traceability scheme by calibrations of length measuring instruments in Estonia

Standard	Place	Accuracy parameters
International length standard - meter, Cs reper. Also as national reference standards	In leading industrial countries: USA, Germany, Russia etc.	Not stabilised by time $S_0=5 \cdot 10^{-10}$ m
He-Ne/ $I_2$ laser	Finland, MIKES [3]	$\lambda=0,632,991 \mu\text{m}$ , $U=5 \cdot 10^{-11}$ (relative)
Gauge blocks. Comparison by Fabry-Pero interferometer	Finland, MIKES [3]	(10 – 1000) mm, $U=(0,03+0,08L) \mu\text{m}$
Leading calibration laboratories reference standards. Gauge blocks. Length measures	Metrosert Ltd, accred. by Estonian Accred. Body in 1999	(0,5...100) mm, $U= (0,03+0,3L) \mu\text{m}$ (1...1,009) mm, $U= (0,03+0,3L) \mu\text{m}$ (50...500) mm, $U= (0,03+0,3L) \mu\text{m}$
Calibration laboratories standards. Gauge blocks, rulers	Up to 10 laboratories	$U=10^{-5}$ (relative) and lower
Practical users	Up to 250 - 300 firms	$U=10^{-4}$ (relative) and lower

**Table 5.** Traceability scheme by calibrations of temperature measuring instruments in Estonia

Standard	Place	Accuracy parameters
International thermodynamic temperature standard - Kelvin	In leading industrial countries: USA, Germany, Russia	$S_0=10^{-3}$ K 0,01 °C, $U=0,0002$ °C 0,01 °C, $U=0,0002$ °C
12 fixed points from 13,81 to 1337,58 K. Ge resistance thermometers, Pt resistance th, various triple point equipment	Sweden, SP	
Leading calibration laboratories reference standards. Pt resistance thermometers, glass bulb thermometers	Metrosert Ltd, accred. by Estonian Accred. Body in 1999	(-50 ... 420) °C; $U=0,01$ °C (0 ... 1100) °C; $U=0,3$ °C
Calibration laboratories standards. Platinum resistance thermometers, glass thermometers	5 laboratories	$U=0,05$ °C and lower
Practical users	Up to 200 test laboratories and firms	$U=0,1$ °C and lower

The traceability is problematic in the areas where the summary quantity of used measuring instruments is small like high force, noise and vibrations measurements.

## 6 COMPETENCE OF CALIBRATION LABORATORIES

### 6.1 Accreditation

The calibration laboratory is recognised as competent when it is accredited according to the requirements of the standard EN-ISO 17025. In Estonia exists accreditation body which has conformity with the standard EN 45003 requirements. It had accredited 2 calibration laboratories and by Finnish accreditation body FINAS had accredited 1 calibration laboratory (mass and DC measuring instrument calibration). These calibration laboratories guarantee main calibrations required by testing and industry.

### 6.2 Intercalibrations

Up to some extent competence can be shown by the interlaboratory comparisons between existing calibration laboratories in Estonia. The reference laboratory of such comparison shall tie up its calibrations with the international comparison schemes which help avoid possible systematic deviation of the area. Estonian three leading calibration laboratories were taken part in the intercalibrations between European calibration laboratories for mass, length and temperature measurements. The results were satisfactory. In 1997 was carried out comparison between the Estonian calibration laboratories of balances.

### 6.3 Uncertainty of measurement

The uncertainty of measurement is calculated in the Estonian calibration laboratories according basic requirements of the document EA 4/02 [4]. Uncertainty is expressed as the combined uncertainty  $u$ , which consists of the combined uncertainty  $u_A$  calculated by using statistical methods and of the combined uncertainty  $u_B$  found by using other methods. Components of  $u_B$  are estimated by laboratories themselves taking account existing knowledge and practical experience.

Expanded uncertainty  $U$  is given by equation

$$U = k \cdot u \quad (1)$$

where coverage factor  $k = 2$  which gives probability level 95 % assuming normal distribution.

### 6.4 Correlation influence

Calibration input quantities are often correlated i.e. they are dependent on each other in one way or other. In small area like Estonia the correlation by calibrations exists in laboratories especially due to:

- the calibrations are performed using the same method and the same surrounding conditions, and;
- laboratory standards are used, which are calibrated by one laboratory which use the same reference standards and the same personnel and the same method.

Up to now, no study works were made to find concrete values of correlation in Estonian calibration laboratories.

## 7 CONCLUSIONS

During 9 years was modernised the metrological structure in Estonia. Results were as follows:

- verification converts to calibration but very slowly;
- traceability is mainly assured but in some fields exists problem with assuring;
- quantity of controlled measuring instruments get lower which cause strong competition between survived laboratories;
- foreign aid is needed for intercalibrations, for reference standards calibration in foreign countries laboratories, for the training of personnel in specific areas (uncertainty, traceability) and for practical exchange of calibration laboratories leading personnel and experts;
- some foreign aid project failed, especially if there was not fixed exact goals and surveillance.

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**AUTHOR:** Edi KULDERKNUP, Institute of Instrument Engineering, Tallinn Technical University, Ehitajate tee 5, 12618, Tallinn, Estonia. Phone int. +372 2 498 890; Fax int. +372 6 519 220  
E-mail: [edi@evs.ee](mailto:edi@evs.ee)