THE TRACEABILITY SYSTEM OF FORCE MEASUREMENTS IN ROMANIA

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ABSTRACT

The paper presents some technical aspects about the Romanian system built-up to ensure the traceability of force measurements to the SI units. The regulations of the traceability schemes and the steps to be followed are presented. The Force Laboratory Timisoara, pending of Romanian Bureau of Legal Metrology proposed and implemented the national traceability of force measurements. The paper presents the best measurements capabilities, which the Romanian calibration laboratories offer for force measurements. In order to perform a national and international validation of the force measurements in Romania, the traceability system must be in accordance with the national and international standards. One of the major parameters of the traceability system is the uncertainty associated with calibration or measurement results. This trend is based on the explosive implementation of the ISO 9000 series and ISO 17025 requirements in industry and other fields. The Romanian Government putted forward some regulations in order to provide for the necessary conditions to report the results to the acknowledged standards.

1. INTRODUCTION

In metrology, the traceability is known as the property of a measurement result or of a standard attributed value to be reported to determinate values, generally to national or international standards, through an uninterrupted chain of comparisons, all having determinate uncertainties [1].
The uninterrupted comparison chain includes the necessary series of calibration in order to ensure that all the results of measurements are connected to the adequate national or international standards. Through this successive comparisons, the traceability of the measurements results to International System of measures (SI) is ensured.
The Romanian Government putted forward some regulations in order to provide for the necessary conditions to report the results of measurements to the acknowledged standards. So, the Romanian settlements in the field of metrology [2] stipulates that the national standards represent public goods. The standards utilized for the verification and calibration of the measuring devices must be in accordance not only with the Romanian national standards, but also with the international standards.
Romania posses a metrological traceability system, which includes the national standards and the reference and working standards in the testing and calibration laboratories.
The primary goal of metrological infrastructure in Romania consists in assuring the correctness, uniformity and traceability of measurements. In view of this, the laboratories of Romanian National Institute of Metrology carries out a systematic activity for maintaining the appropriate accuracy level of the national standards in relation with the international standards. On the other side, Romanian National Institute of Metrology provides for dissemination of the measurement units from the national standards, through successive levels of accuracy, down to the working standards and ordinary measuring instruments [3].
In the force field, the high accuracy measurements, on the basis of traceability system to SI units become in Romania a problem of a great importance for assessment of mechanical properties of material and products. This trend is based also on the explosive implementation of the series of standards ISO 9000 and ISO 17025 in the activities of various organizations.

In order to perform a national and international validation of force measurements the traceability system must be in accordance with national and international force standards.
The Romanian Bureau of Legal Metrology, through the Force Laboratory Timisoara, keeps the national force standards in Romania.
The general scheme implemented in Romania for the traceability to the SI of measurement results is shown in figure 1:

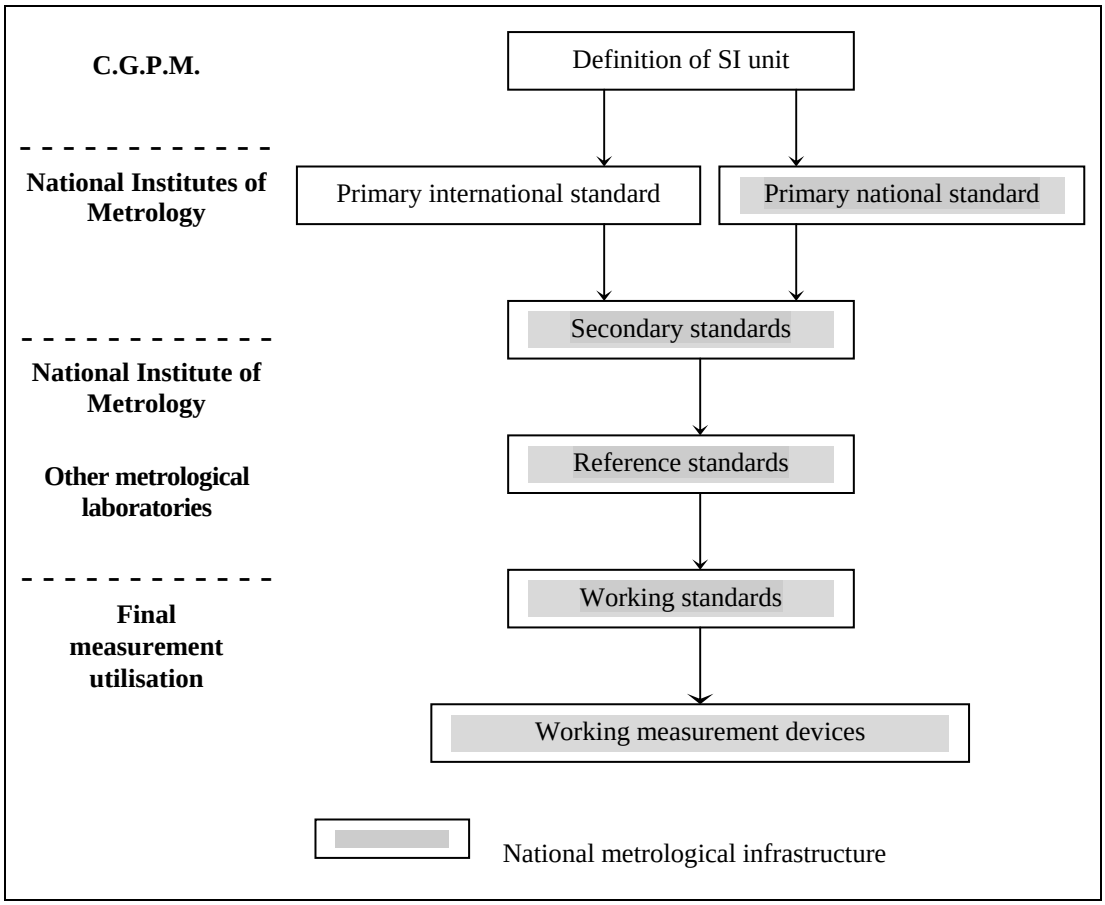

Figure 1: General scheme of traceability

2. GENERAL VIEW OF THE TRACEABILITY SYSTEM OF FORCE MEASUREMENTS

The dissemination of the force unit in Romania proceeds from the following main elements:

a) *definition of the force unit*: description of the principle and the method for reproducing the force unit, the relevant quantities involved (mass, length, time) and the limiting ambient conditions;
b) *national force standards*: primary implementation of SI force unit. Three deadweight machines having maximum ranges of 10 kN, 50 kN and 100 kN represent the Romanian national force standards;
c) *secondary and reference force standards:* standards having the best technical and metrological characteristics, available in an organization or in a place, from which starts the traceability for all force measurements in that place. Generally, the reference force standards are constituted from deadweight and lever or hydraulic amplifier, or comparison force machines;
d) *reference and working standards:* the calibration laboratories establish oneself the traceability of their standards and measuring devices to the SI units, relating to the

secondary and reference standards. These standards are used for the verification and calibration of working measurement devices for force.

It is important to notice that the dissemination of force unit starts from the definition of SI unit, going to the final measurement utilization, while the chain of traceability of measurement results starts from the working measurement devices, going to the reverse way.

The structure of the Romanian metrological traceability chain for the force measurements is presented in figure 2:

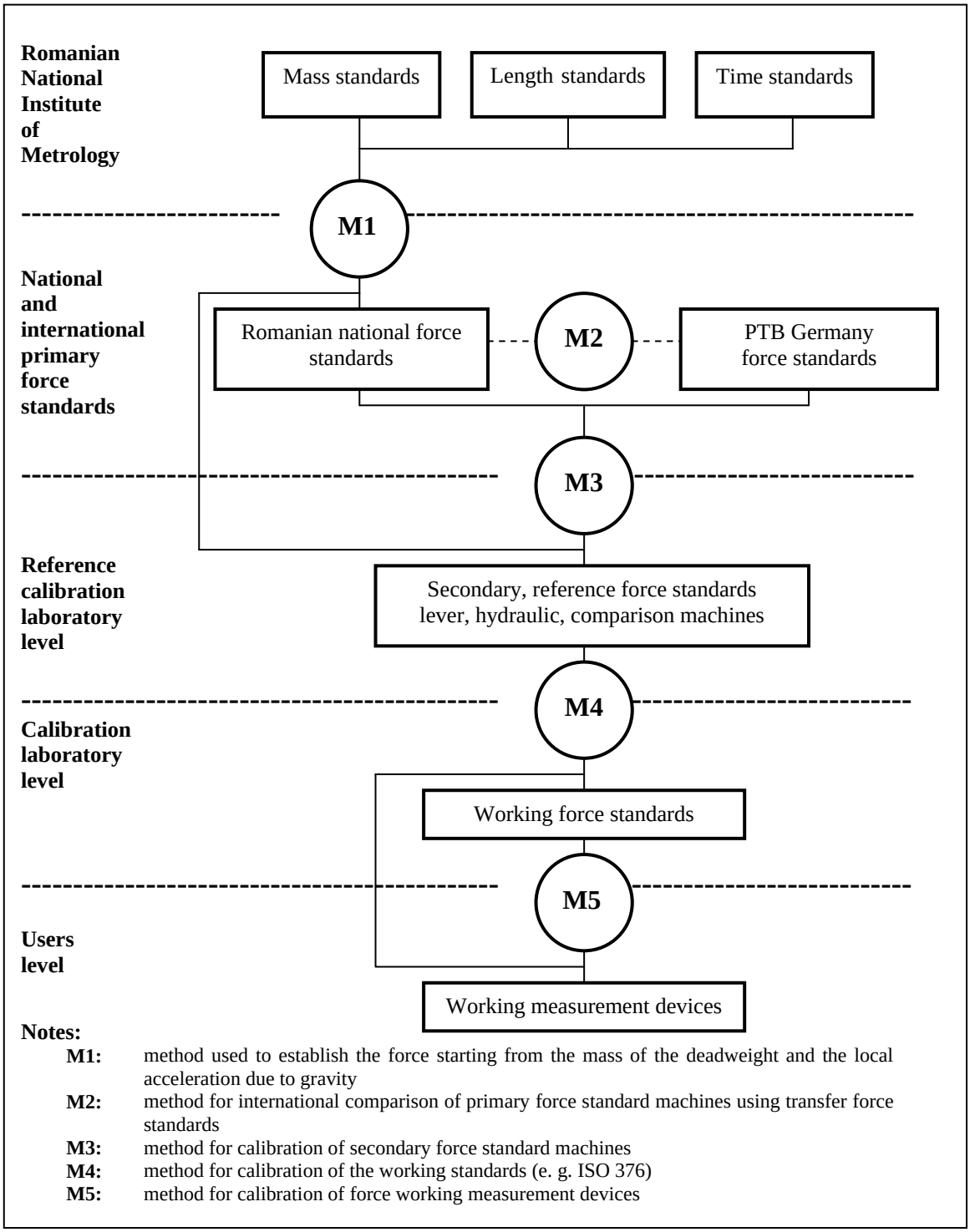

Figure 2: Force traceability chain in Romania

Four levels of the traceability chain are emphasized: international level, national level, calibration laboratory level and user level for the force measurement devices. For each level an uncertainty range of measurements is typical.

a) *International level* . On this level, the international definition of the force units are established and the international comparisons are performed.

b) *National level* . A number of primary force standard machines materialize the force SI unit. These machines are directly traceable to mass, length and time national standards. However, some factors not yet completely defined (e. g. displacements of the mechanical parts during the calibration process, axis alignment, elastic and plastic deformations) may influence the reproduction of the force unit. In order to minimize this influences, comparisons like international comparisons for the Primary Force Standard Machines, using transfer standards, have to be carry out. For performing a suitable comparison, some force transducers having high metrological characteristics (e. g. stability, repeatability, reproducibility and sensitivity) used as transfer standards became necessary. For this purpose, the Force Laboratory Timisoara uses a series of transfer standards, having appropriate metrological performances, as follows: HBM Z4A 5 kN, 20 kN, 50 kN and 100 kN force transducers together with a HBM DMP 40S amplifier. The force transducers used as transfer standards are calibrated in the Force Laboratory of PTB Germany. Table 1 shows the Romanian national force standards:

Table 1: The national force standards in Romania

Standard type	Maximum force	Description	Expanded uncertainty
Deadweight force calibration machine	10 kN	9 steps of 1 kN; 10 steps of 0,1 kN Traction/ Compression	5×10^{-5}
Deadweight force calibration machine	50 kN	19 steps of 2,5 kN; 5 steps of 0,5 kN Traction/ Compression	2×10^{-5}
Deadweight force calibration machine	100 kN	20 steps of 5 kN Traction/ Compression	2×10^{-5}

c) *Calibration laboratory level*. Reference force laboratories keep secondary and reference force calibration machines. Generally, these laboratories ensure the traceability of working standards and working measurement devices to the national or international force standards. The Romanian legislation of metrology stipulates that the national standards are used only for the reproduction of the SI measurement units as well for their dissemination to the immediate inferior standards. These circumstances conduce to the necessity to enlarge the force standard machine basis. In Romania, two reference force laboratories are available: Force Laboratory Timisoara, belonging to Romanian Bureau of Legal Metrology, and Force Laboratory Craiova, belonging to I.C.M.E.T. organization (research institute). Table 2 shows the reference force standards available in Romania:

Table 2: The secondary and reference force standards in Romania

Standard type	Maximum force	Localization	Expanded uncertainty
Deadweight and hydraulic amplifier force standard machine	1000 kN Traction/ Compression	Force Laboratory Timisoara	1×10^{-4}
Deadweight and lever amplifier force standard machine	1000 kN Traction/ Compression	Force Laboratory Craiova	1×10^{-3}
Comparison force standard machine using one reference transducer	1000 kN Traction/ Compression	Force Laboratory Timisoara	5×10^{-4}
Comparison force standard machine using one reference transducer	3000 kN Compression	Force Laboratory Timisoara	1×10^{-3}
Comparison force standard machine built-up system	32 MN Compression	Force Laboratory Craiova	1×10^{-3}

The force transducers calibration is usually performed in accordance with the requirements of ISO 376:1999 [4]. The evaluation of the uncertainty of calibration results is in accordance with the requirements of EA-10/04 (EAL-G22) [5].
Ordinary calibration laboratories perform verification and calibration for the working measurement devices. The calibration and verification of the force measuring system of the uniaxial testing machines constitute the most important part of the related activities.

d) *Final user level.* This level is constituted of different force measuring devices. The entire built-up traceability system of the force measurements in Romania starts from the necessities to ensure an appropriate level of uncertainty of the force measurements at this level.

3. CONCLUSIONS

Romania possesses a national system able to ensure the traceability of force measurements to International System of measures (SI). The chain of traceability of the force measurements is based on the national and reference standards. The national force standards are constituted from three deadweight machines of 10 kN, 50 kN and 100 kN, with the *bmc* of 5 x 10^{-5}, 2 x 10^{-5} respectively 2 x 10^{-5}. The following reference force standard machines are also available: a deadweight and hydraulic amplifier machine of 1 MN, a deadweight and lever amplifier machine of 1 MN, two comparison force machines of 1 MN and 3 MN, and a built-up force comparison machine of 32 MN. The *bmc* of these force machines is situate in the range 1 x 10^{-4} ... 1 x 10^{-3}. The international traceability of force measurements is ensured to P.T.B. Germany. The Romanian system of traceability of force measurements, part of the national quality infrastructure, can fulfill the requirements of the international applicable standards.

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