

**AL 15-lea CONGRES INTERNAȚIONAL DE METROLOGIE
„Valoare adăugată prin intermediul unei măsurări mai bune”
03 - 06 Octombrie 2011, Paris, Franța**

***The 15TH INTERNATIONAL CONGRESS OF METROLOGY
“Added value through better measurement”
03 - 06 October 2011, Paris, France***

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Colegiul Francez de Metrologie (CFM) organizează, la fiecare doi ani, Congresul Internațional de Metrologie în orașe diferite din Franța.

Obiectivul principal al CFM este diseminarea cunoștințelor privind controlul proceselor de măsurare în domeniul industrial și economic.

Sunt implicate toate sectoarele de activitate și toate mărimile fizice.

CFM este, de asemenea, un loc pentru schimbul de experiență între experți din metrologie din laboratoare și centre tehnice, și utilizatori de mijloace de măsurare în aplicații industriale de zi cu zi.

Membrii fondatori ai CFM sunt: institutul național de metrologie - Laboratoire National de Métrologie et d'Essais (LNE), Biroul Național de Metrologie (BNM), a cărui activitate este acum integrată în LNE, Technical Center for Heating, Ventilation and Air Conditioning Industries și Peugeot Citroen Automobile (PSA - producător de automobile).

Astăzi, CFM numără 250 de membri.

CFM lucrează în cooperare cu Ministerul Francez al Industriei, COFRAC (Comitetul Francez pentru Acreditare) și toate asociațiile regionale din Franța implicate în domeniul metrologiei.

La nivel internațional, OIML, BIPM, EURAMET, EA și NCSLI sunt partenerii CFM.

CFM reprezintă Franța în cadrul IMEKO

Evenimentul este unic în Europa în acest domeniu prin temele tratate (toate mărimile fizice) și numărul de participanți.

Primul congres s-a desfășurat în anul 1983 la Bordeaux și a reunit 80 de participanți.

Ultimele ediții ale congresului s-au desfășurat la Lyon (2005), Lille (2007) și Paris (2009). În anul 2011, cea de a 15 ediție a congresului, a avut loc în perioada 3-6 octombrie, tot la Paris (Porte de Versailles) și a fost organizată în colaborare cu:

The French College of Metrology organises every two years The International Metrology Congress in different cities from France.

The objectives of CFM: to disseminate knowledge about the control of measurement processes in the industrial and economical field.

All sectors and all physical quantities are concerned.

The CFM is also a place for exchanges between metrology experts, from laboratories and technical centers, and metrology and measurement means users in industry daily applications.

The founding members of CFM are: the national metrology institute - Laboratoire National de Métrologie et d'Essais (LNE), Bureau National de Métrologie (BNM) whose activities are now integrated into the LNE, Centre Technique des Industries aérauliques et thermiques (Technical Center for Heating, Ventilation and Air Conditioning Industries) and Peugeot Citroen Automobile (PSA – car manufacturer).

Today CFM counts 250 members.

The CFM works in cooperation with the French Ministry of Industry, COFRAC (French Committee for Accreditation) and all regional associations from France involved in metrology.

On international level, OIML, BIPM, EA EURAMET, and NCSLI are the partners of CFM.

The CFM represents France within IMEKO.

The event is unique in Europe in this sector by the themes covered (all physical quantities) and the volume of participants.

The first congress took place in 1983 in Bordeaux, and gathered 80 participants.

The last editions of the congress took place in Lyon (2005), Lille (2007) and Paris (2009). In 2011, the 15th International Congress of Metrology was held from 3 to 6 October also in Paris (Porte de Versailles) and

- utilizatori importanți ai metrologiei: Dassault, EdF, GSK Biologicals, Hôpitaux de Paris, Renault, SNCF, Total;
- centre tehnice, furnizori și fabricanți: Acac, BEA Métrologie, Cetiati, Hexagon Metrology, IMQ, Stork Intermed;
- institute naționale de metrologie: LNE (Fr), NPL (GB);
- universități reprezentative: Université de la Méditerranée;
- organisme internaționale de referință: BIPM, Euramet, NCSLI, OIML.

Obiectivele principale ale congresului din anul 2011 au fost:

- evoluția tehnicilor de măsurare și implicațiile lor pentru industrie, cercetare - dezvoltare și societate;
- valoarea adăugată a măsurării ca un instrument pentru calitatea produselor și proceselor;
- participarea la dezvoltarea tehnologiilor inovatoare.

Ca o noutate, în acest an, organizatorii, CFM și GL Events Exhibitions au decis să-și unească eforturile pentru a crea, la scară europeană un eveniment complet și coerent, într-un singur loc și în aceeași perioadă. Astfel, au decis ca lucrările Congresului să se desfășoare împreună cu MESUREXPOVISION, care este un forum de referință pentru profesioniștii din domeniile de măsurare și testare din Franța.

Un "sat," al congresului de Metrologie a fost înființat în cadrul expoziției MESUREXPOVISION, avantajul expozanților în această zonă fiind acela că beneficiau de tarife privilegiate și acces la lucrările conferinței.

Congresul a reprezentat un loc de întâlnire pentru specialiști în domeniul metrologiei din industrie și al laboratoarelor științifice prin:

- 6 mese rotunde și aproximativ 180 de prezentări;
- 70 standuri cu expoziție care prezintă cele mai recente noutăți tehnice ale producătorilor de echipamente de măsurare, ale furnizorilor de servicii și organizațiilor oficiale;
- vizite tehnice la diverse companii.

Cele 6 mese rotunde, cu sesiuni de discuții pentru industrie, au avut următoarele subiecte:

- Controlul temperaturii în domeniul sănătății;
- Cariera de mâine în metrologie?
- Biologia medicală și acreditarea: cheia succesului;
- R & D, producție și Metrologie: aptitudini necesare pentru a concilia;
- Controlul și economisirea energiei în industrie;
- Măsurări mai bune cu costuri mai mici.

was organised by CFM in partnership with :

- big industrial users of metrology: Dassault, EdF, GSK Biologicals, Hôpitaux de Paris, Renault, SNCF, Total;
- technical centres and providers : Acac, BEA Métrologie, Cetiati, Hexagon Metrology, IMQ, Stork Intermed;
- the following national institutes of metrology: LNE (Fr), NPL (GB);
- representatives from universities: Université de la Méditerranée;
- european and international metrology key organisations : BIPM, Euramet, NCSLI, OIML

The fundamental objectives of the congress from this year were:

- the evolution of measurement techniques and their implications for industry, research and development and society;
- the added value of measurement as a tool for quality of products and processes;
- the participation in the development of innovative technologies.

As a new, this year, the organisers, the Collège Français de Métrologie and GL Events Exhibitions, have decided to unite their efforts to create, on the European scale, a complete and coherent event in one place and on the same dates. Thus, they decided that the congress run together with MESUREXPOVISION which is the reference forum for measurement and testing professionals in France.

A Metrology Congress "village" has been set up inside the MESUREXPOVISION exhibition, in which exhibitors were offered special discounts and the possibilities to attend the sessions of the Congress.

The Congress was a meeting place for specialists in metrology from industry and scientific laboratories through :

- 6 industrial round table sessions, and about 180 presentations;
- 70 booths exhibition of equipment and services, (an exhibition showing the latest technical improvements by manufacturers of measurement equipments, providers of services and the official organizations);
- technical visits to companies.

The six round table discussions sessions for industry were scheduled on the following topics:

- Temperature control in the health field;
- Medical biology and accreditation: the keys to success;
- Tomorrow's careers in metrology?
- R&D, production and metrology: skills to conciliate;
- Controlling and saving energy in industry;
- Better measurement for lower costs.

Aproximativ 180 de lucrări au fost prezentate, cu subiecte variate, cum ar fi:

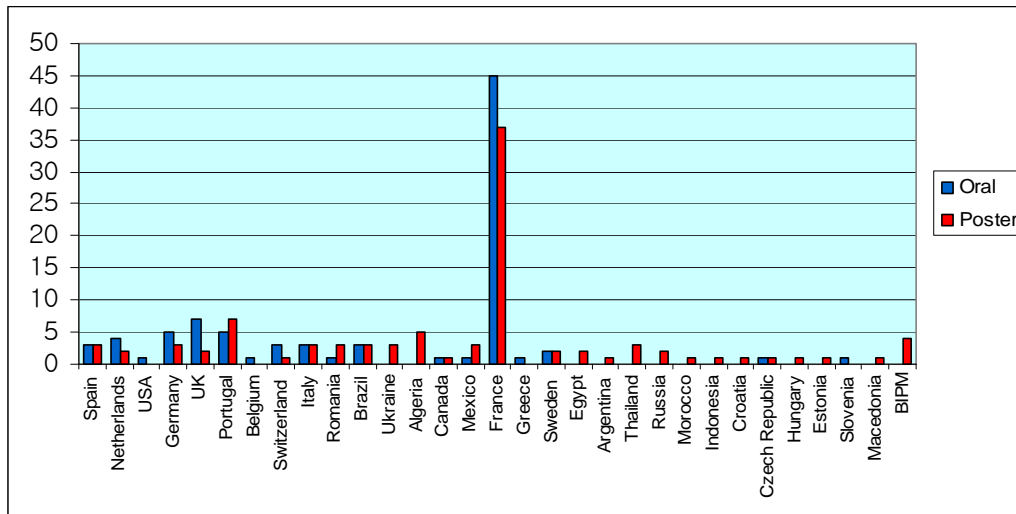
- măsurarea debitului de lichid și gaz;
- nano și micro-tehnologie;
- măsurări electrice extreme;
- surse de energie și metrologie, metrologie și mediu;
- programe europene de cercetare în metrologie și aplicațiile lor industriale;
- metrologia în sănătate, protecția împotriva radiațiilor;
- mărimi mecanice, temperaturi industriale;
- incertitudini și capacități, etc.

Graficul 1 ne arată numărul de lucrări și forma de prezentare a acestora (orală sau poster) pentru fiecare țară.

Nearly 180 live talks were presented on various subjects, including:

- liquid and gas flow measurement;
- nano and micro-technologies;
- extreme electrical measurement;
- energy sources & metrology, and metrology & environment;
- european metrology research programmes and their industrial applications;
- metrology in health, radiation protection and dosimetry;
- mechanical quantities, industrial temperature;
- uncertainties and capabilities, etc.

The Graphic 1 presents the number of the papers and their presentation form (oral or poster) for each country.



Grafic 1: număr de lucrări și forma de prezentare/**Graphic 1:** number of the papers and presentation form

Cum se vede din graficul 1, pentru România au fost acceptate 4 lucrări: una pentru prezentare orală și 3 pentru sesiunile de postere, după cum urmează:

- din partea IFIN HH:

- „Calibration facility for low-level dose-rate calibration” (sesiunea orală);
- „Electrical characterisation of an ionisation chamber for absolute measurement of the absorbed dose for beta ray” (sesiunea de postere);

- din partea INM, a fost prezentată lucrarea:

- “Use of regression to determine the errors of indication and associated uncertainty, starting from a calibration certificate of “NAWI” (sesiunea de postere), autor: Adriana Vâlcu;

- din partea BRML - INM, în colaborare cu Dräger Safety: „Uncertainty budget for mass concentration of exhaled breath alcohol”

As it is shown in the Graphic 1, for Romania were accepted 4 papers: one for oral presentation and 3 for poster session, as following:

- from IFIN HH:

- „Calibration facility for low-level dose-rate calibration” (oral presentation);
- „Electrical characterisation of an ionisation chamber for absolute measurement of the absorbed dose for beta ray” (poster session).

- from INM was presented the following contribution:

- “Use of regression to determine the errors of indication and associated uncertainty, starting from a calibration certificate of “NAWI” (poster session), author: Adriana Vâlcu;

- from BRML- INM, in collaboration with Dräger Safety: „Uncertainty budget for mass

(sesiunea de postere), autori: Mirela Anghel - National Institute of Metrology, Fănel Iacobescu - Bureau of Legal Metrology, Sorin Anghel - Dräger Safety.

În figura 1 este arătat unul dintre posterele prezentate de reprezentanții BRML - INM la al 15-lea Congres Internațional de Metrologie.

În timpul prezentării, au fost discuții interesante și constructive cu specialiști interesați de subiectele abordate în articol.

Schimbul de idei din timpul discuțiilor au fost marcate de un puternic simț de colegialitate și de împărtășire a experiențelor proprii.

Majoritatea acestor discuții au fost binevenite și, fără nici o urmă de îndoială, ele trebuie luate în calcul pentru îmbunătățirea activității științifice în domeniul metrologiei.

INM a fost prezent cu lucrări și în edițiile anterioare ale Congresului, după cum urmează:

- în anul 2005 a fost prezentată (în sesiunea orală a congresului) lucrarea: " Calibration of nonautomatic weighing instruments used in pharmaceutical laboratories", autor: Adriana Vâlcu;

- în anul 2007 au fost prezentate următoarele lucrări (în sesiunile poster):

1) "A review of calibration of mechanical analytical balances", autor: Adriana Valcu;

2) "Interlaboratory comparison of seven weights standards in several Romanian laboratories", autori: Adriana Vâlcu, G. Popa, S. Baicu;

3) "An efficient use of the balance calibration certificate in order to minimize measurement uncertainty in mass determinations performed in physico-chemical laboratories", autor: Andrei Hoiescu.;

4) "Testing/calibrating electrical measuring instruments under non-sinusoidal conditions", autor: Ioana Odor.

- în anul 2009 au fost prezentate lucrările:

1) „Mass measurement and uncertainty evaluation of standard weights, autori: Adriana Vâlcu, George Popa, Sterică Baicu;

2) „Uncertainty evaluation of mass concentration of exhaled breath alcohol”, autor: Mirela Anghel;

3) „Traceability and uncertainty: metrological notions defining the quality of measurements”, autor: Elvira Buzac.

Concluzii

Congresul Internațional de Metrologie organizat de CFM este unul dintre cele mai importante evenimente din domeniul Metrologiei și este sigur că toate persoanele

concentration of exhaled breath alcohol” (poster session), authors: Mirela Anghel - National Institute of Metrology, Fănel Iacobescu - Bureau of Legal Metrology, Sorin Anghel - Dräger Safety.

In the figure 1, is shown one of the poster presented by the BRML-INM representatives, in the 15th International Congress of Metrology.

During the presentation, the author had interesting and constructive discussions with specialists interested in the topic of the articles.

The exchange of ideas in the discussions were marked by a sense of collegiality and mutual sharing of experiences.

Most of their remarks were welcomed and without a shadow of doubt they must be taken into account for improving the scientific activity in the metrology field.

INM was present with works in the previous editions of the Congress, as follows:

- in 2005 was presented (in the oral session of the congress) the paper: „Calibration of nonautomatic weighing instruments used in pharmaceutical laboratories”, autor: Adriana Vâlcu;

- in 2007 was presented the next papers (in the poster sessions):

1)“A review of calibration of mechanical analytical balances”, autor: Adriana Valcu;

2)“Interlaboratory comparison of seven weights standards in several Romanian laboratories”, authors : Adriana Vâlcu, George Popa, Sterică Baicu ;

3) “An efficient use of the balance calibration certificate in order to minimize measurement uncertainty in mass determinations performed in physico-chemical laboratories”, autor: Andrei Hoiescu;

4) “Testing/calibrating electrical measuring instruments under non-sinusoidal conditions”, autor: Ioana Odor.

- in 2009 were presented the next papers:

1) „Mass measurement and uncertainty evaluation of standard weights, authors: Adriana Vâlcu, George Popa, Sterică Baicu;

2) „Uncertainty evaluation of mass concentration of exhaled breath alcohol”, autor: Mirela Anghel;

3) „Traceability and uncertainty: metrological notions defining the quality of measurements, autor: Elvira Buzac.

Conclusions

The International Metrology Congress organised by CFM it is one of the most important events in the Metrology domain and it is sure that all the people involved

implicare în organizarea lui vor continua să păstreze și chiar să ridice calitatea unor astfel de manifestări științifice.

in its organization will continue to maintain or even improve the quality of such scientific events.

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USE OF REGRESSION TO DETERMINE THE ERRORS OF INDICATION AND ASSOCIATED UNCERTAINTY, STARTING FROM A CALIBRATION CERTIFICATE OF "NAWI"

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Abstract
Based on the reference document [1], the article proposes the way to calculate the errors of indication and associated measurement uncertainties, by resorting to the general information provided by the calibration certificate of a balance (non automatic weighing instruments, shortly NAWI). The paper may be also considered a useful guideline for:

- operators working in calibration laboratories accredited in various fields where the weighing operations are part of their testing activities;
- test houses, laboratories, or manufacturers using calibrated non-automatic weighing instruments for measurements relevant for the quality of production subject to GM requirements (e.g. ISO 9000 series, ISO 10012/ISO/IEC 17025);
- bodies accrediting laboratories;
- accredited laboratories for the calibration of NAWI.

3. The error of indication and associated measurement uncertainty for any indication within the weighing range

A) continuous approximation (interpolation). In this case, the approximation function *must* pass through the known points. In interpolation, it is assumed that the interpolation nodes are exactly known, being not affected by errors.

B) direct approximation, when the approximation function *must not* pass through the points known, but approximate better the known values (this is a typical situation of approximation of experimental data affected by inherent errors).

A. Continuous approximation (interpolation)
A.1 Interpolation by polynomials
The most common type, Lagrange polynomials:
$$P_n(x) = \sum_{i=0}^n y_i \cdot L_i(x)$$

$$L_i(x) = \frac{(x-x_0)\dots(x-x_{i-1})(x-x_{i+1})\dots(x-x_n)}{(x_i-x_0)\dots(x_i-x_{i-1})(x_i-x_{i+1})\dots(x_i-x_n)}$$

A.2 Linear interpolation between two adjacent points
For a reading R with $I_k < R < I_{k+1}$, the error of indication and the measurement uncertainty are:
$$E(R) = E(I_k) + (R - I_k)(E_{k+1} - E_k) / (I_{k+1} - I_k)$$

$$U(R) = U(I_k) + (R - I_k)(U_{k+1} - U_k) / (I_{k+1} - I_k)$$

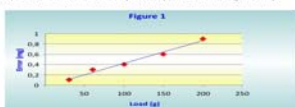
B) Direct approximation
For approximations, the "min χ^2 " approach (similar to the least squares approach) is proposed:
$$\chi^2 = \sum_{i=1}^n w_i^2 (f_i - E_i)^2 = \text{minimum}$$

where:
 w_i are the residuals;
 f approximation function containing n_{par} parameters ($n_{par} < n$);
 E_i error of indication;
 $w_i = \frac{1}{\sigma_i^2}$ the weighting factor.

To check the validity of the approximation, the following condition should be met:
$$\left| \min \chi^2 - \nu \right| \leq \beta \sqrt{2\nu}$$

with:
 $\nu = n - n_{par}$ the degrees of freedom
 β a factor chosen to be 1, 2 or 3

Approximation by a straight line
A preliminary estimation of the polynomial can be made, using the graphic representation XY (scatter plot) of the data sheet (Example in the Figure 1)



If a polynomial is written for a NAWI, we can write:
$$E(R) = f(R) = a_0 + a_1 R + a_2 R^2 + \dots + a_n R^n$$

 n_p , the degree of the polynomial; $n_p = n_{par} - 1$
For $n_p = 1$, the polynomial becomes a linear function:
$$E(R) = f(R) = a_0 + a_1 R$$

This simple linear model and its least squares estimates in matrix notation:
$$N \cdot a = Y$$

where:
 N is a column vector whose components are the errors E_i ; a a column vector with the coefficients of the approximation (a_0, a_1); X a matrix with two columns, whose first row is $(1, I_k)$; I is the indication of the weighing instrument (considered to be equal to nominal mass applied);
 $U(Y)$ the variance-covariance matrix of Y .
The coefficients a (a_0 and a_1) can be determined as follows [1]:
$$a = (X^T W X)^{-1} X^T W Y$$

with
$$W = U(Y)^{-1}$$

To check the validity of the approximation, the "minimum χ^2 " is calculated, with ν the residual:
$$\min \chi^2 = \nu^T W \nu \quad \nu = Xa - Y$$

The variance-covariance matrix of the coefficients a can be calculated:
$$U(a) = (X^T W X)^{-1}$$

The error and associated uncertainty for any reading R [1]:
$$E_{appr}(R) = r^T a$$

$$U(E_{appr}) = 2\sqrt{r^T U(a) r}$$

with:
 r a column vector whose elements are $(1, R)^T$;
 a a column vector whose elements are the derivatives of f : $(0, 1)^T$;
 $U(E_{appr})$ represents the expanded uncertainty of the reading calculated according to the formula:
$$U(R) = 2\sqrt{r^T U(a) r} + s^2(I)$$

 s is the resolution of NAWI at no-load indication;
 s_f the resolution of NAWI at load;
 $s(I)$ the standard deviation associated to the repeatability.
If the coefficient a_0 can be considered zero, (taking into account that, due to zero-setting of the weighing instrument), the error
$$E_{appr}(R) = f(R) = a_1 R$$

The coefficient a_1 and associated expanded uncertainty can be calculated as follows:
$$a_1 = \sum w_i E_i / \sum w_i^2; \quad U(a_1) = 2\sqrt{U(a_1)} = 2\sqrt{\sum w_i^{-1}}$$

The "minimum χ^2 " is calculated using the next formula:
$$\min \chi^2 = \sum w_i (a_1 I - E_i)^2$$

The expanded uncertainty of the approximation $U(E_{appr})$ can be obtained:
$$U(E_{appr}) = 2\sqrt{a_1^2 (E_{appr})^2 + R^2 U(a_1)^2}$$

1. Introduction
The calibration certificate of a weighing instrument provides only generic information. This turns over to the laboratory the responsibility of estimating weighing uncertainty for specific applications. Since the implementation of quality management systems, measurement uncertainty became a key element in demonstrating the laboratory's capability to provide reliable services and products that would meet the customer's demands. The paper is intended for operators of laboratories accredited for relevant measurements, and shows how errors and assigned uncertainties can be obtained from the discrete values resulted at calibration and/or presented in a calibration certificate, for any other reading within the calibrated weighing range.

2. Calibration certificate
The basic information provided by a certificate, elaborated according to [1], contains:

- general information (identification of the calibration laboratory, identification of the certificate, reference to the accreditation, signature(s), identification of the client, information regarding the weighing instrument etc);
- information about the calibration procedure;
- results of measurement (errors of indications, repeatability of indications, effect of eccentric application of a load, on the indication).

4. Conclusions
Starting from a calibration certificate of a NAWI, the article proposes the way to calculate the errors of indication and associated measurement uncertainties within the calibrated weighing range, for other readings, different from those stated in the calibration certificate. The paper described only the approximation by a straight line. When an approximating polynomial of higher degree is used, the same calculations (adapted according to the degree of the polynomial), are performed.

References

- [1] EURAMET. cg -18 Guidelines on the Calibration of Non-automatic Weighing Instruments, version 3.0 (03/2011)
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- [3] J. P. Clark, Evaluation of Methods for Estimating the Uncertainty of Electronic Balance Measurements, Report WSRC-MS-99-00958 Westinghouse Savannah River Company.
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Fig. 1: Poster la Sesiunea Mărimi Mecanice/Poster in Mechanical Quantities Session: „Use of regression to determine the errors of indication and associated uncertainty, starting from a calibration certificate of NAWI” (author: A. Vălcu)