

TORQUE METROLOGY IN MEXICO, TWENTY YEARS

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Abstract - The Physikalisch Technische Bundesanstalt - PTB in Germany was the pioneer of torque primary metrology, Dr. Diedert Peschel was the first torque laboratory Head. The Centro Nacional de Metrología in México, CENAM, began operations in 1994. The torque laboratory was installed in 1995 at CENAM. This paper presents the most important activities during the last two decades and the action plans for the coming years in torque metrology in Mexico.

Keywords: metrology, torque, Mexico.

1. INTRODUCTION

Torque is commonly used in industry. It is widely used in assembly processes which involve threaded parts, as helicopter rotors, in testing automobile clutch pedals, engine manufacturing, among many other applications. Tolerance limits in many cases, use specified accuracies. Sometimes, the instruments which are used for measurements on this quantity are not properly maintained (in metrological terms), so that the measurements obtained are not consistent for the required specifications, producing negative effects which are difficult to control on the product or process. To minimize these negative effects, due to the traceability of measurements with instruments (industry, testing laboratories, secondary laboratories), the Physikalisch Technische Bundesanstalt, PTB in Germany, started with the quantity of torque at primary level by installing its laboratory, and Dr. Diedert Peschel as the pioneer of primary metrology of torque. CENAM - Mexico was one of the first institutes to establish a Torque National Laboratory in 1995 [1].

2. TORQUE STANDARDS AT CENAM

In these 20 years, CENAM has established and maintained operational the metrology laboratory of torque. For the establishment of this laboratory the international standards of quality and metrology were applied [2]. Its development has been gradual and according to the needs of the secondary laboratories and industry, in compliance with the Mexican Federal Law on Metrology and Standardization – LFMN [3]. In 1996 the services started in the laboratory, mainly calibrating torque measurement tools, known as "torque wrenches" and the calibration of some low accuracy torque transducers. The first standard was a transfer torque machine with a range up to 2 kN·m.

2.1 Torque measurement standards

The first national standard of torque, is based on a transfer system which comprises a set of torque transducers of high accuracy; an electric engine and a speed reducer which are coupled for the generation of torque; a system of alignment, an against-reaction plate, a pneumatic system which is used as support of low friction; and the control system; all mounted in a steel frame. This standard was the first of its kind worldwide and was developed in collaboration with the PTB of Germany, in a measuring range up to 2 kN·m.

The dissemination of the quantity is performed by calibrations to standard reference transducers of secondary laboratories and industry.

A torque primary standard, according to the definition of the quantity [4 and 5], consists of a lever arm, a support system, a leveling system, a system for application of mass loading and a manual-automatic control. At CENAM there are four standards for this quantity, shown in Table 1 [6].

Table 1. Torque measurement standards at CENAM.

ID	Range		Measurement uncertainty ($k = 2$)
	Min	Max	
PNPT-20 N·m	0.2 N·m a 20 N·m		$\pm 5 \cdot 10^{-4}$
PNPT-2 kN·m	1 N·m a 2 kN·m		$\pm 5 \cdot 10^{-4}$
PNPT-20 kN·m	500 N·m a 20 kN·m		$\pm 5 \cdot 10^{-4}$
PPPT-2 kN·m	1 N·m a 2 kN·m		$\pm 3 \cdot 10^{-5}$

3. SECONDARY TORQUE CALIBRATION LABORATORIES IN MEXICO

Specialists in torque at CENAM have worked closely with companies and secondary laboratories of other quantities, with the purpose of establishing torque laboratories which enable the dissemination of this quantity properly and to support the development of technical and legal metrology in torque.

Close cooperation with the National Calibration System, SNC, has been established (in accordance with the Mexican Metrology Law). Since 1996, the collaboration with the SNC was promoted and various activities were started, such as meetings of a working group in force and torque, technical assistance, individual projects (to laboratories), advanced teaching courses in torque (exclusive to SNC), proficiency tests for secondary laboratories (being CENAM the organizer and pilot laboratory).

The number of secondary laboratories for torque has increased significantly since CENAM started operations in 1994. A comparative of the existing laboratories throughout the last two decades is shown below.

Table 2. Secondary torque calibration laboratories in Mexico.

Quantity	1995	2005	2015	In progress
Torque	0	11	27	5

The following figure shows the distribution of accredited and non-accredited torque laboratories in Mexico.



Figure 1. Distribution of secondary torque calibration laboratories in Mexico, 2015.

4. TORQUE STANDARDIZATION

The SNC working group for force and torque is formed by the secondary laboratories and CENAM, and it has taken the important task of reviewing the existing written standards in the field of torque.

CENAM had the initiative of preparing a written standard for the calibration of measurement tools of torque, compatible with the ISO-6789 standard, so it was proposed to the Mexican Institute for Standardization and Quality, IMNC. The result of this work was the first Mexican standard for torque identified as NMX-CH-6789-IMNC-2006. CENAM has also conducted updating courses in the field of uncertainty estimation in torque.

5. NATIONAL PROFICIENCY TESTS AND INTERNATIONAL COMPARISONS

To standardize the results obtained by secondary laboratories from measurements and calibrations, since 2001 there have been organized national proficiency tests among secondary laboratories [7]. Some results of these proficiency tests were presented at national or international conferences.

Some secondary laboratories from other countries have chosen to undertake proficiency tests (among other

activities) with CENAM as the pilot laboratory; such is the case of Colombia, Chile and Peru.

5.1 Proficiency tests (PTs)

Table 3 presents the range, number of participating secondary laboratories and year when the PT was concluded. In this table bilateral proficiency tests are not included; to date, there have been conducted more than 20 bilateral proficiency tests. In column "Participating laboratories" it is included, in brackets, the pilot laboratory and the PT organizer.

Table 3. Torque proficiency tests in Mexico.

Torque	Participating laboratories	Year
EA 320 N·m	8 (CENAM)	2001
EA 500 N·m	10 (CENAM)	2005
EA 100 N·m	4 (CENAM/ema)	2008
EA 500 N·m	4 (CENAM/ema)	2008
EA 300 N·m	9 (CENAM/ema)	2009
EA 300 N·m	11 (CENAM/ema)	2010
EA 300 N·m	6 (CENAM/ema)	2010
EA 1kN·m	12 (CENAM/ema)	2012
EA 500 N·m	9 (CENAM/ema)	2012
EA 1 kN·m	8 (CENAM/ema)	2014
EA 100 N·m	12 (CENAM/ema)	2015
EA 50 N·m	10 (CENAM/ema)	2015

5.2 International Comparisons

In the column "Number of participating laboratories" the pilot laboratory is included in brackets [8, 9 and 10].

Table 4. International torque comparisons in which Mexico has participated.

Torque	No. of Labs.	Year
PTB/CENAM 2 kN·m (comparison exercises)	2 (PTB)	1996 1998
SIM.7.27 BK CENAM (MEXICO) / INMETRO (BRAZIL) 100 N·m	2 (CENAM)	2004
SIM. BK CENAM (MEXICO) / INM (COLOMBIA) 1 kN·m	2 (CENAM)	2014

6. PERSPECTIVES ON TORQUE

6.1 National level

The standards of a measuring range of up to 20 N·m and the one of up to 20 kN·m (Table 1) are in the process to be formalized by the Mexican government as national standards. Also, work is in progress to increase the measuring interval of the standard for 20 kN·m, possibly up to 40 kN·m.

As for written standards, the Mexican standard NMX-CH-6789-IMNC-2006 is under review and update, and in due time an initiative will be presented to establish a program to develop Mexican standards for calibration of transducers and one for the verification of dynamic torque tools known as "power assembly tools".

6.2 International level

It has been established the first program of CIPM key comparisons. From this program the first 2 global comparisons of up to 1 kN·m and up to 20 kN·m have been completed. In the 2 comparisons participated Mexico - CENAM.

Table 5. International torque comparisons organized by the CIPM.

Torque	No. of Labs.	Year
Torque Key Comparison CCM.T-K1 Torque: 0 N·m, 500 N·m, 1 kN·m	10 (PTB)	2009
Torque Key Comparison CCM.T-K2 Torque: 0 N·m, 10 kN·m, 20 kN·m	6 (PTB)	2011

7. CONCLUSIONS

The foundations of torque metrology in the world are firm and the work done up to now have consolidated the quantity and established the dissemination lines to ensure the quality of measurements at an industrial level in a quantity that is highly dependent on parasitic loads and effects of installation, operation and use. Metrology torque worldwide is taking steps to establish standards of dynamic torque and torque impact.

In Mexico, CENAM, the SNC and the Mexican Accreditation Entity, EMA, are working together on the strategic planning to reach a leading place internationally. However, it is necessary to accelerate the efforts in standardization and conformity assessment towards an international development. It is also necessary to continue with the proficiency tests among the secondary laboratories to ensure uniformity and compatibility which is aimed to reach the optimal conditions for international competitiveness and recognition of Mexican metrology in torque. Another area of opportunity is to support the development of national manufacturers of torque measurement instruments, through research and technological development in this field [11, 12 and 13]. The development of industrial or technical metrology in torque is a scope for quality assurance measurements and efficient use of measurements and instruments in strength of materials and industrial applications.

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