

# THE TORQUE NATIONAL STANDARD FOR 20 kN·m in MEXICO

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## ABSTRACT

This paper presents the needs in Mexico for larger ranges in torque calibration. The design of a torque standard to meet, and surpass, those needs are here included. The general design considerations, the layout of the system and the subsystems designed for the torque national standard for 20 kN·m in Mexico are discussed and included in this paper.

## 1. INTRODUCTION

CENAM, the national metrology laboratory in Mexico, has established a torque metrology laboratory for some years now. In 1996 a 2 kN·m reference standard was design, constructed and put into operation [1]. A few years later (2001) [2], a primary standard for the same range was designed, constructed and started operations at the end of 2003. Recently (2004) [3], another torque comparison standard was also developed (designed, constructed and in operation) for low torque ranges (0,1 N·m to 10 N·m, can be operated up to 100 N·m).

At the present time, industry in Mexico is in need of higher ranges to measure torque and the measurements are required with higher accuracy day by day. Although, there is one high ranges torque secondary calibration laboratory in Mexico, this laboratory has to send its reference transducers aboard for calibration and the calibration queue may take months. Yet more, the customs paper work and the transportation cost involved in the calibration of the reference standards makes it difficult for other torque laboratories to establish a facility for ranges above 2 kN·m.

In the whole American Continent, no facilities are available for such needs, INMETRO (the national metrology laboratory in Brazil) has a standard with a measuring range up to 3 kN·m. Due to these requirements, the Centro Nacional de Metrología (CENAM) in Mexico has carried out a project to establish a new torque national standard for a range up to 20 kN·m.

## 2. SCOPE

The requirements for the design of the torque national standard for measurements and calibrations in the range of up to 20 kN·m are presented in Table 1.

Table 1. Mexican torque national standard requirements.

<b>Measurement range</b>	2 kN·m up to 20 kN·m
<b>Instruments to be calibrated</b>	Torque transducers
<b>Torque application direction</b>	Clockwise and anticlockwise
<b>Torque application mode</b>	Ascending and descending
<b>Maximum relative uncertainty (<math>k=2</math>)</b>	$8 \cdot 10^{-4}$

### 3. DESIGN CONSIDERATIONS

The design of the system was based in a secondary reference torque standard using a high accuracy torque transducer with which, by direct comparison, calibrations could be performed. With this type of system a relative uncertainty ( $k=2$ ) as good as  $4 \cdot 10^{-4}$  can be achieved, hence no primary standard is necessary for the required calibrations.

To optimize the space used for installation and operation, the arrangement of the system has been considered in the vertical position. Also, in order to have the possibility of increasing the maximum torque measurement capability for the standard, its design has been performed with maximum stiffness for torque load. Other considerations related to ergonomic operation and cost efficiency had been added to the design.

### 4. SUBSYSTEMS OF THE STANDARD

The torque national standard is divided in 7 main subsystems:

- a) Torque generation system.
- b) Torque transmission system.
- c) Reference standard system.
- d) Main structure system.
- e) Counter reaction system.
- f) Anchorage system.
- g) Coupling accessories.

#### 4.1 Torque Generation System

This system is made by a servomotor and a planetary gearbox. This equipment are coupled to generate the torque required for the calibration having some special features such as immediate stop, zero backlash and no return or backwards movement when in the stop position. The system is placed in the bottom of the standard arrangement and has its own separate support. In order to have an adequate overall height of the standard, the motor is placed in a cavity below ground level. See Figure 1.

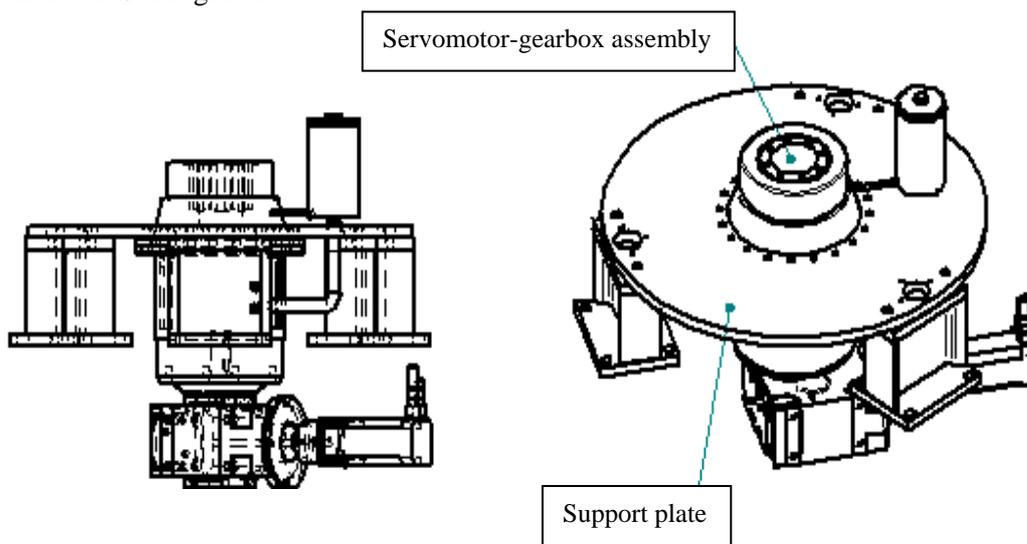


Figure 1: Torque generation system.

## 4.2 Torque Transmission System

The torque transmission system has as its main part an air bearing. This air bearing is supported by a double arrangement of plates that allows dismounting of the air bearing and/or the torque reference standard. Also, has a three column alignment system to maintain the torque axis in line with the rest of the parts of the standard. The use of the air bearing reduces significantly friction during the calibration process and gives stability and easy of mounting as it is placed between the torque reference standard and the instrument to be calibrated. Figure 2 shows the system.

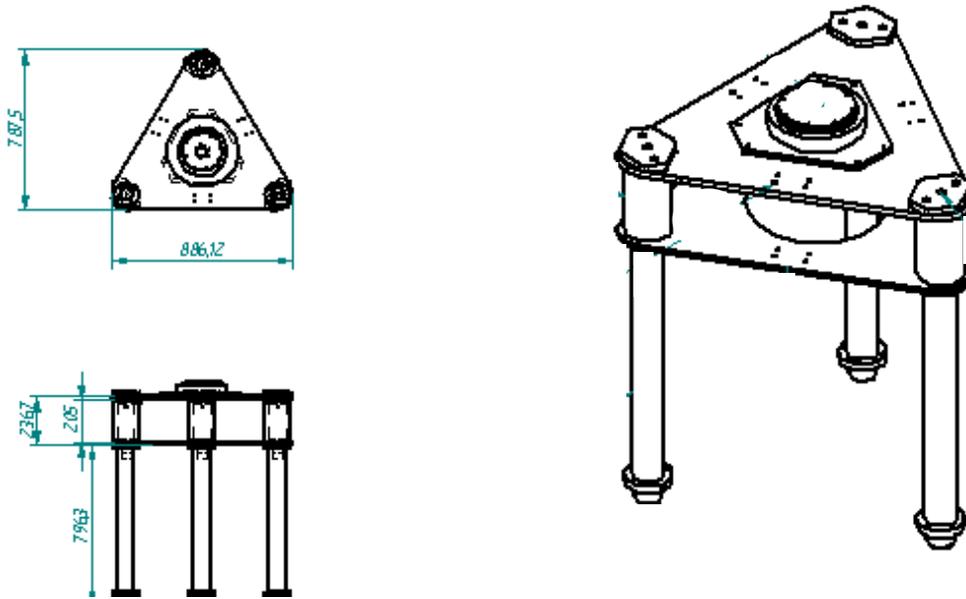


Figure 2: Torque transmission system.

## 4.3 Reference Standard System

The reference standard system has the reference torque transducer (high accuracy) and the couplings needed to install the standard, hydraulic and flexible couplings. These couplings are used to reduce to a minimum the parasitic components that may occur [4], such as flexion moments and forces.

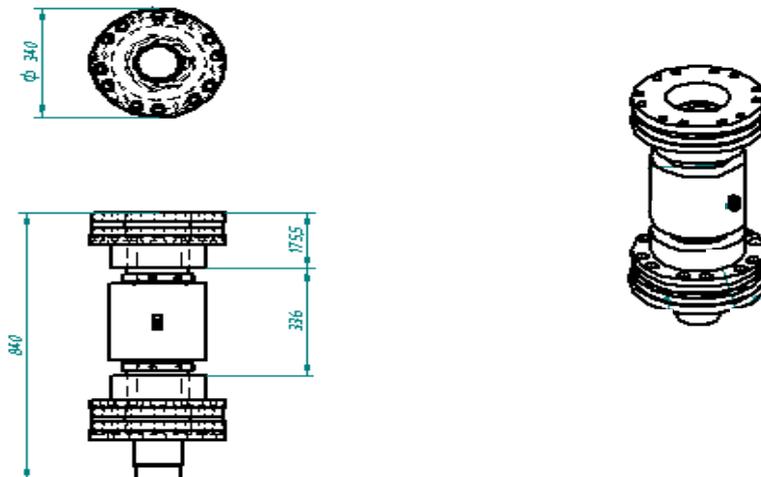


Figure 3: Reference standard system.

#### 4.4 Main Structure System

The main structure system is made by a hollow steel cylinder of 2 540 mm diameter. This cylinder is fixed to the floor by external and internal L-shape plates. This type of structure has a high torsional stiffness and gives a vertical reference axis for the movement of parts and load application.

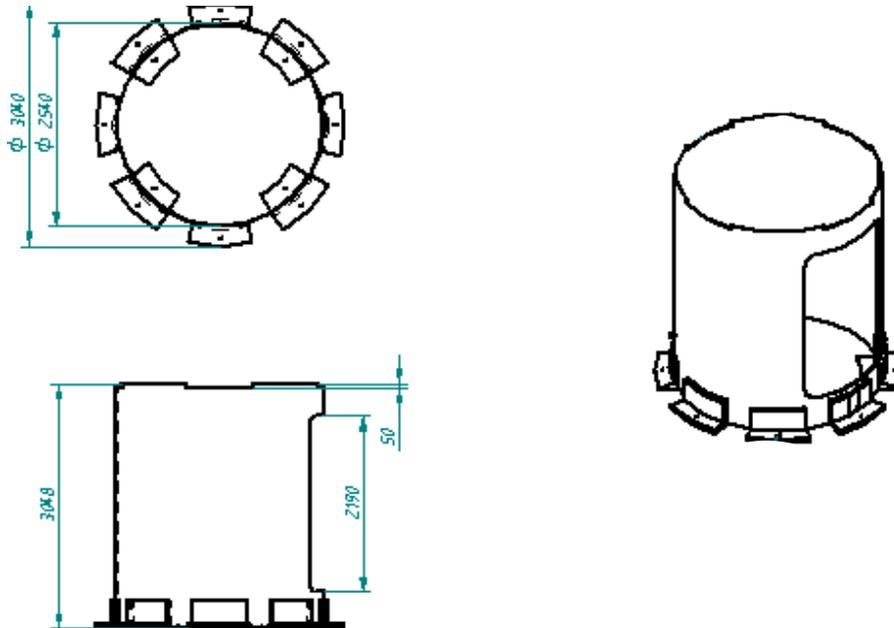


Figure 4: Main structure system.

#### 4.5 Counter Reaction System

This system has two parts, a plate (serving as lid of the hollow cylinder or main structure) and a vertical rigid moving system to adapt the torque instrument to be calibrated. This system withstands the torque load and transmits it to the main structure.

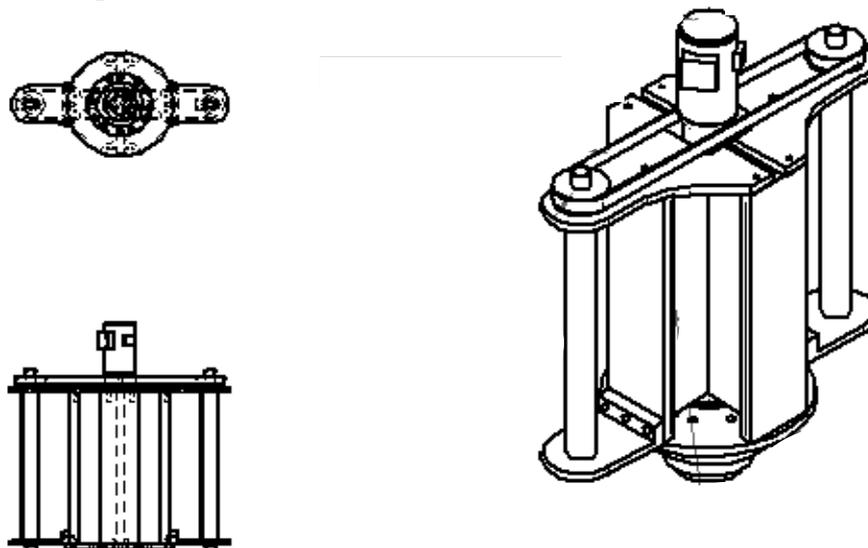


Figure 5: Counter reaction system.

#### 4.6 Anchorage System

The system consists of the bolts anchorage, affixed to the floor at ground level, and the cavity (with sliding rails) for the servomotor-gearbox assembly, see Figure 6.

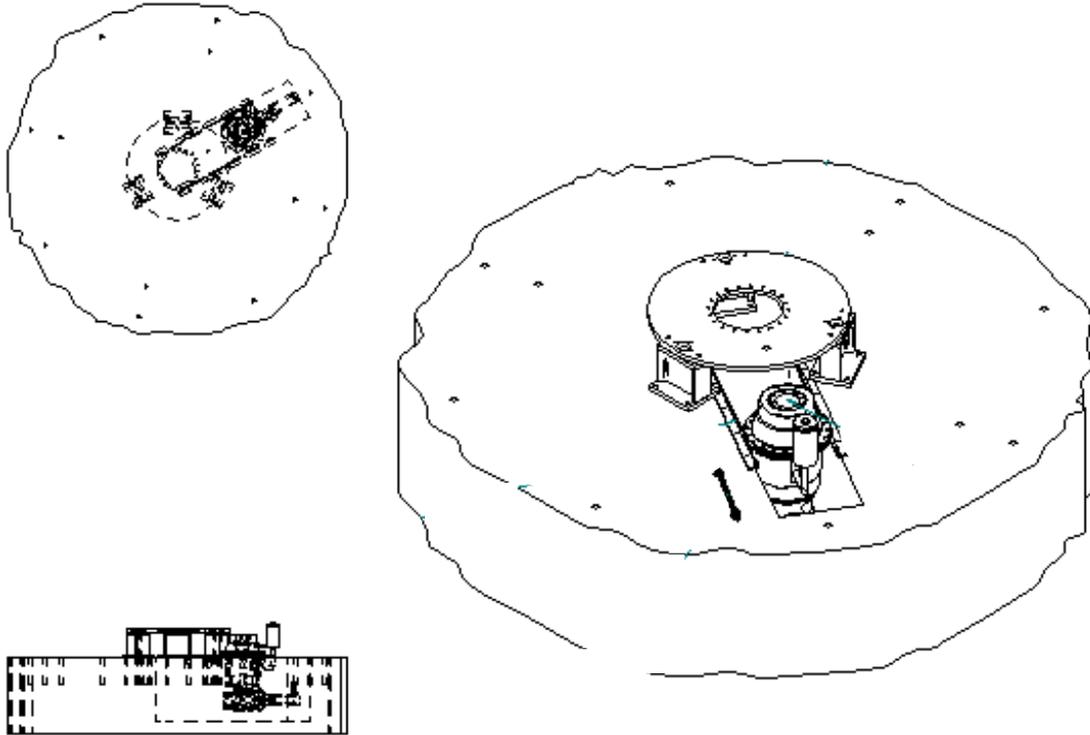


Figure 6: Anchorage system.

#### 4.7 Coupling Accessories

In any measurement system there are non wanted force components, in torque this parasitic components (flexion moments, axial forces, transversal forces, etc.) generate a non desired influence in the measurement results [4]. For this reason, the use of hydraulic and flexible couplings has been included. These couplings transmit the torque and help to reduce to a minimum the parasitic components.

As it is well known, the hydraulic couplings transmit efficiently the torque, at the same time that helps to joint parts in the torque standard system. On the other hand, the flexible couplings help to absorb misalignment, axial and angular.

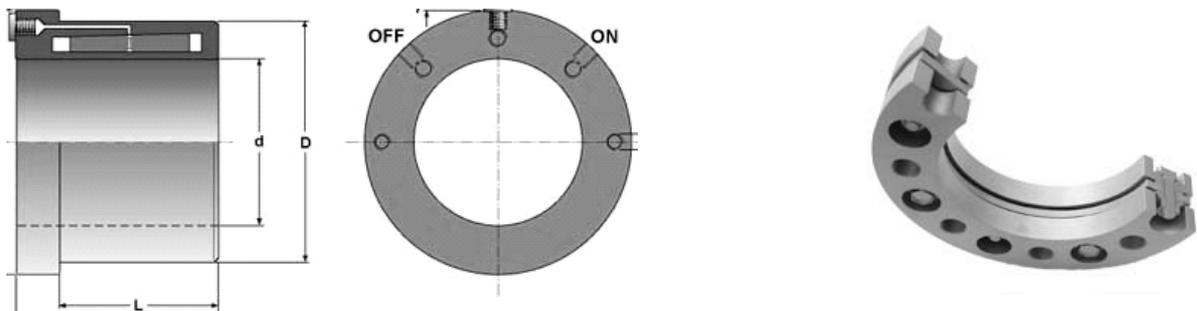


Figure 7: Hydraulic and flexible couplings.

## 5. RESULTS AND CONCLUSIONS

The design of the torque national standard for 20 kN·m is expected to surpass the required characteristics. The expected characteristics for the system are presented in Table 2.

**Table 2:** Mexican torque national standard expected characteristics

<b>Measurement range</b>	0,3 kN·m up to 20 kN·m
<b>Instruments to be calibrated</b>	Torque transducers
<b>Torque application direction</b>	Clockwise and anticlockwise
<b>Torque application mode</b>	Ascending and descending
<b>Expected maximum relative uncertainty (<math>k=2</math>)</b>	$4 \cdot 10^{-4}$

This paper presents the design of the standard at the time of its writing. The Mexican national reference standard for 20 kN·m for torque calibrations is under construction. When presenting this paper at the 19th IMEKO TC3 conference "Force, Mass and Torque, Theory and Practice in Laboratories and Industry", up to date information on the advance in the construction of the standard is going to be included.

## ACKNOWLEDGEMENTS

The authors wish to express their appreciation for the work performed by Héctor Antonio Barrera Domínguez, a student at CENAM, who used a computer design program to draw the parts of the standard.

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