ESTABLISHMENT OF THE MEXICAN NATIONAL STANDARD IN DENSITY

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Abstract: *Nowadays CENAM is developing the national standard of density, standard that will offer traceability on density measurements to all our country.*
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1 INTRODUCTION

Nowadays there is a density lab at CENAM whose measurements and calibrations are based on water density according to the Kell´s equation, where water is a function of the temperature, of course water must be pure (free of solids and solved gasses), water class I ASTM, near to 18 MΩ of resistivity to 1 cm of length, see fig. 1. The goal of the national density lab is to offer best uncertainty to the calibration of devices that are being used on different productive sectors of the country.

CURRENT DENSITY'S TRACEABILITY

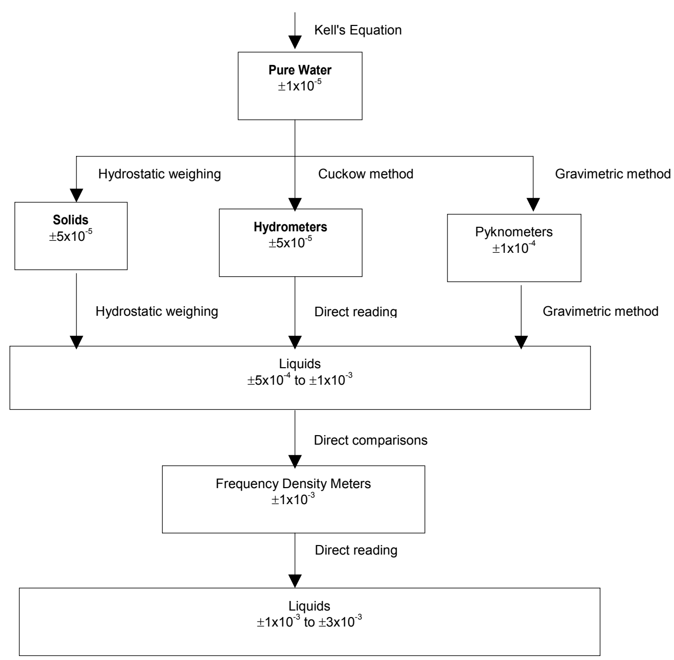

figure1. Measurement density's traceability chart based on water's density

2 DEVELOPMENT

Density is a derived quantity of mass and length, a primary standard of density implies to have a standard of best metrological quality in its quantity, and haven't been calibrated by other density standard.

In the future it would be excellent that Mexico would have a solid density standard (fig 2), a sphere made on zerodur or silicon with relative uncertainty of its radius around $\pm 2{,}7 \times 10^{-7}$ (±12,5 nm on approx. 4,672 cm) that length in volume means relative uncertainty about $\pm 8 \times 10^{-7}$ ($\pm 3{,}4 \times 10^{-4}$ cm^3 on approx. 427,075 cm^3), mass could be measured with relative uncertainty of $\pm 2 \times 10^{-7}$ (±200 µg en approx. 1006,709 g) and both volume and mass combined would offer relative uncertainty near to $\pm 8{,}3 \times 10^{-7}$ (±0,000 019 5 g/cm^3 on approx. 2,357 221 3 g/cm^3). All uncertainties to 1 σ.

figure 2. Solid density standard

To obtain that uncertainty of the radius of a sphere is not a problem of measurement, it is a problem of manufacture. Nowadays CSIRO of Australia offer spheres with these characteristics.

For economy reasons, CENAM decided to acquire a secondary density standard, a couple of zerodur spheres named as Z-01 and Z-02. These spheres were manufactured at Research Center of Optics (CIO) placed in León Guanajuato, Mexico, spheres have uncertainty of radius about 120 nm, such uncertainty is not enough for primary standard, but its characteristics of surface finished and spherically are enough to expect a good behavior as secondary density standard. These spheres were calibrated by PTB of Germany, using primary density standards of this country, (ZK1 and ZK2) made of same material.

Results of calibration are the following,

Z-01		
Volume	393,592 8 cm^3	± 0,000 4 cm^3 (k=1)
Mass	998,147 83 g	±0,000 075 g (k=1)
Density	2,535 991 08 g/cm^3	±0,000 002 58 g/cm^3 (k=1)
Z-02		
Volume	394,850 9 cm^3	± 0,000 4 cm^3 (k=1)
Mass	1001,334 29 g	±0,000 075 g (k=1)
Density	2,535 980 77 g/cm^3	±0,000 002 58 g/cm^3 (k=1)

The relative uncertainty of these standards is approximate to $\pm 1 \times 10^{-6}$, that is one level less than relative uncertainty of pure water (approximate $\pm 1 \times 10^{-5}$).

To have density standards with relative uncertainty better than the water's density, we'll get solids and liquids with relative uncertainty similar than water's equation offer. This situation is very important especially for frequency density meter calibration (density meters of the oscillating type).

Density meter of oscillating type being came replacing to hydrometer and pycnometers on density measurements on industrial task, nowadays its relative uncertainty of calibration of density meter type oscillating usually couldn't be better than $1x10^{-3}$, with the new scheme of trazabillity based on solid density standards (spheres) this uncertainty of calibration could reach to $5x10^{-5}$, this would happen because they come up to two levels of trazabillity chart.

It is the same with uncertainty of solids and liquids, because we hope to reach uncertainties around to $5x10^{-5}$ for liquids and solids instead of $5x10^{-5}$ y $1x10^{-4}$ respectively, see fig 3.

FUTURE DENSITY’S TRACEABILITY

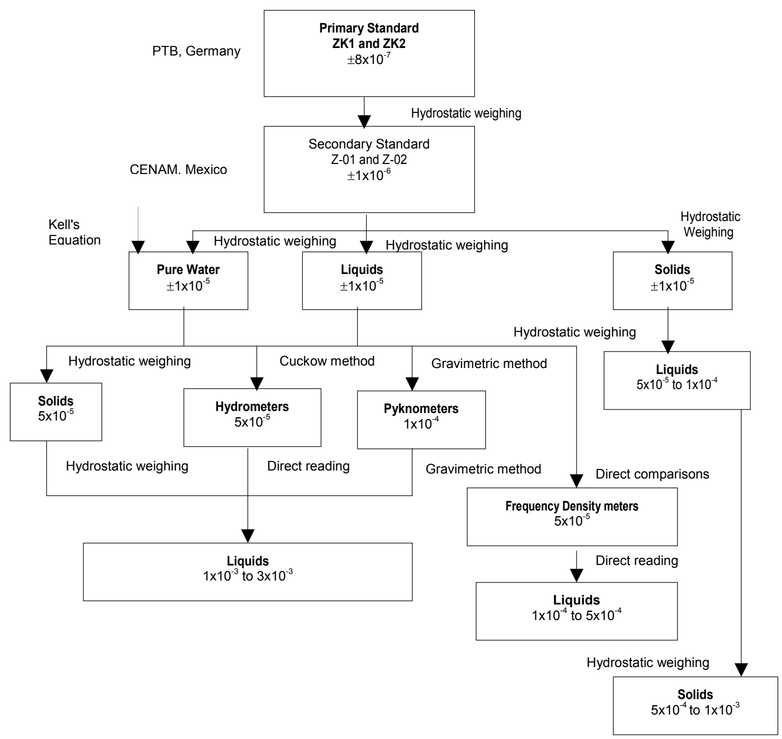

figure 3. Measurement density’s traceability based on solid density standards

3 SYSTEM

To transfer density’s accuracy from spheres to other solids or liquids a vertical hydrostatic weighing system is being developed.

The system consists in weighing spheres below balance in a liquid, that liquid sometimes works as a transfer liquid and other times as a measurand.

By using an automatic mechanism, spheres will be placed one by one in a suspension that will be directly connected to the pan of balance. Balance will be placed on a tall table especially available to weight below balance, see fig. 4. To get the levels of uncertainty pretended a mass comparator of capability of 1 kg and readability of 10 μg, a thermostatic bath to keep liquid temperature and spheres temperature about 5 milikelvins will be used.

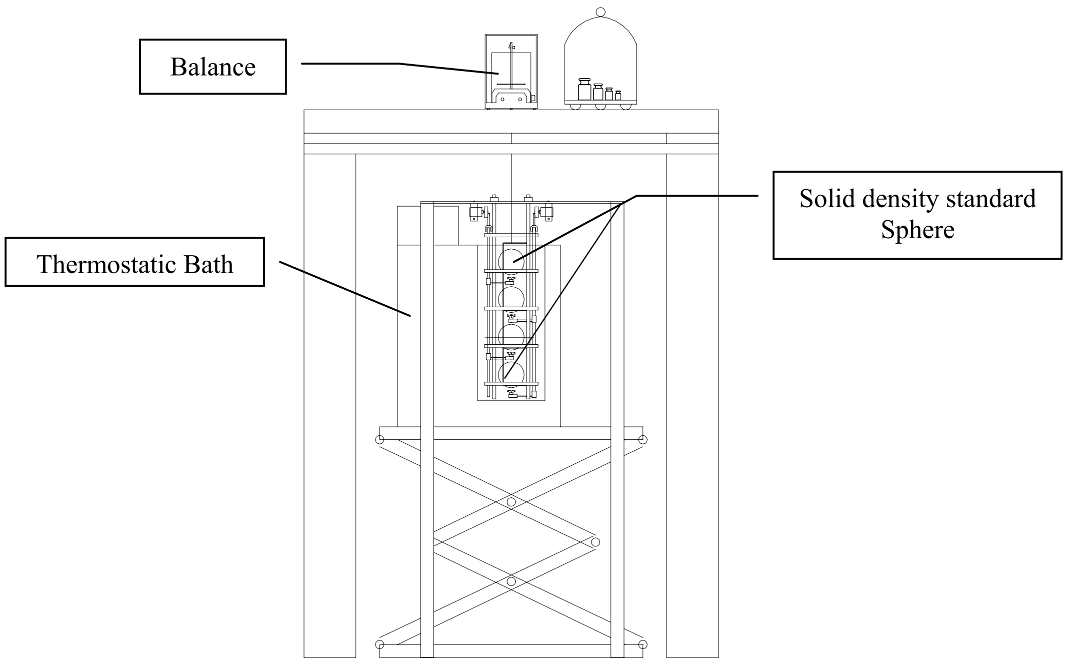

figure 4. System of hydrostatic weighing for solid density standards

Measurement of spheres (solids)

For the measurement of solids, a series of comparisons between spheres on air and lately in a transfer liquid will be made, by differences of air and liquid buoyancy read on balance, it will calculate the volume of the spheres.

Measurements of liquids

By the measurements of apparent mass of spheres in a liquid (to determine its density), we'll measure its liquid's buoyancy and, with the volume of the spheres and buoyancy value we'll calculate liquid density.

4 CONCLUSIONS

A secondary density standard will work appropriately due mainly to two raisons, first, we will get liquids with the same uncertainty of water's density but with low surface tension coefficient and with different density value for calibrations of devices and, second, we'll get better uncertainty of calibration of devices for industrial purposes.

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