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IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

CT2M LE PARTENAIRE À VOTRE MESURE

METHODOLOGY AND SOFTWARE DEVELOPMENT FOR NUCLEAR MATERIAL CHARACTERIZATION USING WEIGHING SCALES

INTERNATIONAL METROLOGY CONGRESS

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Context

- In collaboration with the Nuclear material metrology laboratory (L2MN) of the Institut de Radioprotection et de Sureté Nucléaire (IRSN), the Centre Technologique Méditerranéen de Métrologie (CT2M) has developed a methodology for weighing the true and conventional mass of an object (gross weight) and the mass of nuclear material in a container (net weight) for masses up to 300 kg. Such methodology is applicable within the laboratory, as part of the nuclear material annual inventory, and during inspections as part of national control. It guarantees the correct use of the scales, the weighing result and the associated uncertainty. A spreadsheet in Excel format is used to control scales and temperature probes, and to process and format the collected data.

1- DEFINITION OF PREPACKED PRODUCTS & TOLERANCES

Weighing of nuclear materials (noble material U, Pu, Th or waste):

- as part of the **control of nuclear materials** on behalf of the Ministry of Ecological and Inclusive Transition (Defence Code) on French territory (inspection)

→ Measurements of the **gross and/or net mass** carried out at the operator's premises in France in an industrial environment

→ Environmental conditions not always controlled.

- Held by the L2MN (inventory)

→ Measurements of the **gross mass** carried out at the laboratory

→ Need to master the measurement process.

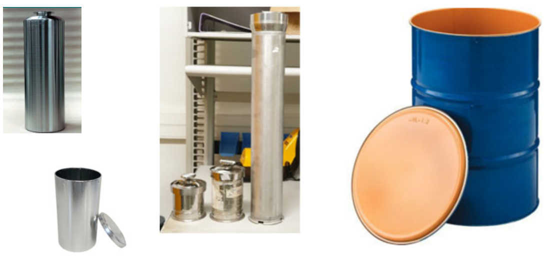

Fig. 1. Containers encountered during inspection

	Waste	Noble material	Empty container
Weight	~ 10 – 200 kg	~ 300 kg for uranium drums	10 – 20 kg
Volumic mass	0 – 19 000 kg/m³	2000 – 20 000 kg/m³	8000 - 9000 kg/m³

Fig. 2. Characteristics of weighed materials

2 - WEIGHING CONDITIONS

Different weighing operation are carried out:

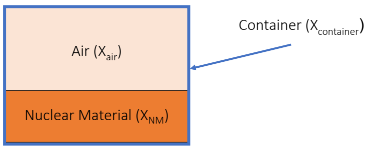

Fig. 3. Weighing scheme

Gross mass	X_{brut} correspond to ($X_{container} + X_{air} + X_{NM}$)
Nett mass	$X_{net} = X_{NM} = X_{brut} - X_{container} - X_{air}$

Calculation :

- in conventional mass : no correction done, taken into account in the uncertainty (Cf. LAB GTA 95)
- In true mass (air lift correction) C = $a \times \left(\frac{1}{r} - \frac{1}{r_0}\right) \times x$

a = air density during weighing operation (in kg/m³)

r = density of the weighed object (in kg/m³)

r_0 = density of standard weights (8000 kg/m³)

Assumptions taken into account:

- Mass value of the containers ($X_{container}$) provided by the manufacturer or measured by the L2MN
- Mass of air (X_{air}) calculated from the volume of container, the mass and volume of nuclear material and the density of the air
- Density of the weighed object (r) : value of 10 000 kg/m³ and possible range of value between 0 et 20 000 kg/m³ to take into account all the weighed materials.

Weighing of empty containers (to determine the tare associated with a type of container) :

- Determined from the weighing of n containers of the same type (n ≥ 5 ideally)
- Each of the n containers is weighed once
- Standard uncertainty linked to the variability of the containers determined from a sample of containers of the same type

$$u_{DM} = 1/2 \times t_{0.975\ (\upsilon = n-1)} \times S$$

With :

- S standard deviation obtained on the sample of n containers
- t Student factor (to correct the standard deviation obtained on a small population of samples)

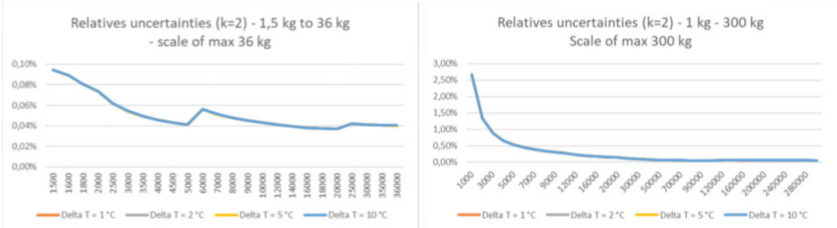

Fig. 4. Example of weighing uncertainties on 2 different scales

3 – UNCERTAINTY BUDGET

	Scale					Containers		Air density		Nuclear Material
	Resolution	Precision	Temperature effect	Trueness	Eccentricity	Variability	Volume	No air buoyancy correction (if calculation in **conventional** mass)	Air lift correction (if calculation in **true** mass)	Density of nuclear material
Xbrut	X_{brut}	X_{brut}	X_{brut}	X_{brut}	X_{brut}			X_{brut}	X_{brut}	
X net	X_{brut} and $X_{container}$	X_{brut} and $X_{container}$	X_{brut} and $X_{container}$	X_{brut} and $X_{container}$	X_{brut} and $X_{container}$	$X_{container}$	X_{air}	X_{net}	X_{net}	X_{air}

Fig. 5. Summary of the influencing factors taken into account in the uncertainty calculation