Contents

Scope

This Technical Reference covers the use, design and specifications of the Sartorius-Scale-30 kg scale used in the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Fire Research Laboratory (FRL).

Instrument Description

GENERAL

The Sartorius-Scale-30 kg weighing device is used primarily for mass measurements up to a capacity of 60 lb_m. This scale offers a modular design incorporating the use of a load cell, a weighing platform, and an indicator unit. The components of Sartorius-Scale-30 kg weighing device are calibrated as one unit in accordance with manufacturer and ATF specifications.

Load Cell

The Sartorius-Scale-30 kg uses one model Sartorius 03167124 60 lb_m capacity load cell. The load cell responds to an applied load positioned on a weighing platform and relays an electrical response to a junction box with amplifier. The electrical signal is then transmitted to the indicator unit.

Weighing Platform

The Sartorius-Scale-30 kg uses a Sartorius model CAPP1U-50DD-LU weighing platform with a 45.72 cm x 45.72 cm (18” x 18”) stainless steel load plate. The platform is NEM4/IP65 designed to withstand everyday wash down environments. The platform must be leveled manually by the user prior to testing to reduce measurement errors caused by the angular orientation of the scale. Adjusting the supports on each of the corners of the weighing platform raises or lowers each corner if the scale is used on an unlevel surface.

Indicator

The Sartorius-Scale-30 kg uses a Sartorius Combics 2 Model CAISL2-U indicator unit to provide a digital display of the analog electrical output signal from the load cell. The indicator offers a maximum readability of 0.002 lb_m (0.0005 kg) at a 60 lb_m (30 kg) capacity. The indicator also contains functions that zero, tare, and offset mass measurements to the full capacity defined by the indicator.

CONNECTING TO THE DATA ACQUISITION

The Sartorius Combics 2 indicator allows for transmitting data to the data acquisition (DAQ) system by means of a network cable connected to a FireTOSS jack.

Uncertainty

The uncertainty of the mass measurements was estimated using the guidelines of the National Institute of Standards and Technology (NIST) Technical Note 1297 [1], Special Publication 1007 [2], and the NIST Uncertainty Workshop [3]. The combined standard uncertainty of the mass measurements is a combination of the uncertainty of the allowable tolerances noted in the manufacturer's specifications, the allowable tolerances outlined in NIST Handbook 44[4], and uncertainty due to random errors that occur naturally during an experiment.

Manufacturer specifications for the characteristics of the Sartorius-Scale-30 kg lists;

- the linearity as ±0.022 lb_m
- the repeatability as ±0.0661 lb_m

Additional tolerance requirements for the weighing device provided by NIST Handbook 44 defines;

- the tolerance as ±0.0055 lb_m
- the zero balance as ±0.0331 lb_m
- the sensitivity as ±0.0022 lb_m
- the temperature effect on the minimum dead load output as ±0.0011 lb_m over a temperature change of 5°C [4]

It can be assumed that these errors have a rectangular probability distribution and the standard uncertainty can be estimated by dividing each component by $\sqrt{3}$ [1]. The combined standard uncertainty for Sartorius-Scale-30 kg characteristics is ± 4.467 x 10^{-2} lb_m or ± 7.444 x 10^{-2} % of a 60 lb_m capacity.

The uncertainty for the weighing device must also account for random errors in measurement values that occur naturally during an experiment. This uncertainty is determined using sample measurements taken during typical test conditions. The standard uncertainty for the device measurements is calculated by Equation (1.1) [3].

$$u = \frac{S}{\sqrt{n}} \quad (1.1)$$

where:

S = Standard deviation of the measurements in a sample
n = Number of measurements in the sample

The standard uncertainty for the measurements, based on a sample containing 600 measurements of 50 lb_m, is ± 1.8710 x 10^{-4} lb_m or 3.118 x 10^{-4} % of a 60 lb_m capacity.

The standard uncertainty for the Sartorius-Scale-30 kg characteristics and the measurement values are combined in quadrature to obtain a combined standard uncertainty using Equation 1.2 [1].

$$u_c(x) = \sqrt{\sum u(x_i)^2} \quad (1.2)$$

where:
$u_c(x)$ = Combined standard uncertainty
$u(x_i)$ = Standard uncertainty component

The combined standard uncertainty for the Sartorius-Scale-30 kg ± 4.467 x 10^{-2} lb_m or ± 7.444 x 10^{-2} % of a 60 lb_m capacity.

References

1. Taylor, B. N., & Kuyatt, C. E., "NIST Technical Note 1297: Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," National Institute of Standards and Technology, Gaithersburg, MD, 1993.
2. Bryant, A.R., Ohlemiller, T.J., Johnsson, E.L, Hamins, A., Grove, B.S., Guthrie, W.F., Maranghides, A., Mulholland, G.W., "Special Publication 1007," National Institute of Standards and Technology, Gaithersburg, MD, 2003.
3. Guthrie, W. & Liu, H., "Hands-on Workshop on Estimating and Reporting Measurement Uncertainty," National Institute of Standards and Technology, Presentation given to CPSC, 2007.
4. "Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing Devices," National Institute of Standards and Technology, Gaithersburg, MD, 2010.
5. "Operating Instructions Sartorius Combics Series Indicator Models CAISL1, CAISL2, CAIS1, CAIS2" Sartorius Industrial Scales GmbH & Co. KG, Goettingen, Germany, September, 2013.
6. "ATF-LS-FRL-LI019 Weighing Devices" Bureau of Alcohol, Tobacco, Firearms, and Explosives – Fire Research Laboratory, Beltsville, MD.