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Measurement Methods for Laboratory Instruments

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Executive Summary

When buying a new refrigerator or dishwasher for our homes, we usually look for a device that uses energy and water efficiently. Energy labels like the EU-labels [1] or, in the US, the ENERGY STAR® label [2] help us to make a good choice and to compare different suppliers in terms of energy efficiency. But what if you would like to buy a new instrument for your lab? How could you differentiate between the performance of instruments from different suppliers beyond energy efficiency? What standards or certifications are available that facilitate the comparison of different devices? What about sustainable procurement, a topic that is becoming increasingly important?

Legal requirements and standards for laboratory equipment

First of all, there are legal requirements for every instrument placed in the market. These requirements may vary based on specific regulations in a particular country or region. In the European Union, every product has to fulfill comprehensive requirements regarding risk and safety, environmental, and consumer protection [3]. The consumer can verify this by the CE marking and the CE declaration of conformity [4]. There are different directives, depending on the product group, with which suppliers must comply in order to obtain the CE marking and the approval for the European market. Devices are subject to the Machinery Directive (2006/42/EC), which describes the guidelines for marking and the special health and safety requirements that need to be met. A CE marking shows that the manufacturer assures that these requirements are fulfilled [5].

A second European guideline, which is especially important for instruments and devices used in the lab environment, is the ATEX Product Directive (2014/34/EU) [6]. This directive summarizes the essential health and safety requirements which must be observed by the manufacturer and which they are obliged to demonstrate by the corresponding conformity assessment procedures [7]. It applies, for example, to laboratory refrigerators (+4°C): if chemicals or highly flammable liquids are stored at lower temperatures, an explosion-proof refrigerator that complies with the ATEX guidelines is required.

Besides these legal regulations, there are further standards in the world of laboratory instruments. If working with incubators or heating ovens, it is mandatory to have a constant temperature and homogeneous temperature distribution. Especially when working with cells, the temperature should be the same on the shelf at the bottom and the one on the top – after opening and closing the door, it should not take too long to reach the nominal temperature again inside the incubator [8]. The same is for refrigerators and freezers. Further important parameters include humidity regulation, CO_2, and, depending on the application, oxygen regulation. The comparison of the performance of different instruments is possible due to DIN 12880:2007-05. This standard describes, inter alia, measurement procedures for the determination of heat distribution in heating ovens and cell incubators.

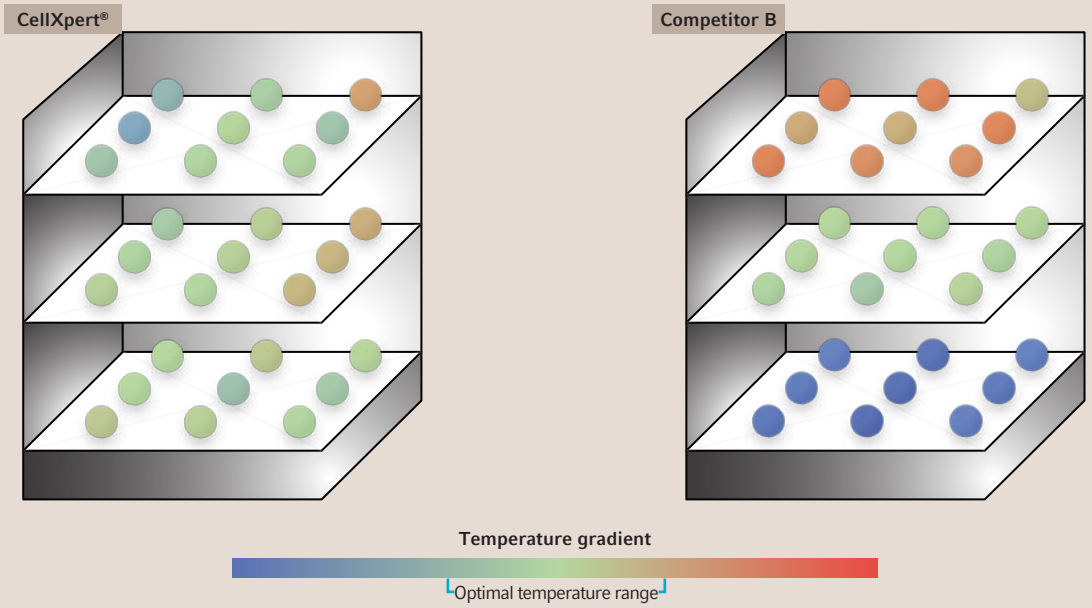


Fig. 1: Spatial temperature distribution in different CO_2 incubators verified by measurement according to DIN 12880:2007-05 [8].

Other well-known standards in the world of laboratory instruments are DIN 58951-2:2018-01 for autoclaves or the DIN EN 14175 standards series for fume cupboards.

The latter are not only tested in the test room under standardized conditions, but also on site to ensure that they meet the requirements in practice. In addition to EN 14175, which describes the various test methods, specifications of the national authorities apply, which specify certain threshold values.

In the US the ASHRAE standard 110-2016 describes the "method of Testing Performance of laboratory fume hoods" [9].

All these standards define measurement methods under clearly specified conditions for the testing of devices and mandate further requirements for equipment to fulfill.

If there are several devices from different suppliers which are all tested according to a common standard, the results can be compared and one can make an informed decision.

But there aren't standards for every lab device. For quite a few instruments, manufacturers have to develop and establish their own test protocols and generate data to prove instrument performance and quality.

If there is no standard, which requirements are important for device tests and measurements?

Factors which apply for tests based on external standards also apply for test methods developed in-house. These tests can be done by instrument suppliers or by users who need to check and validate equipment.

Defined measurement protocols and testing carried out with validated and certified test equipment is a prerequisite. Conditions and equipment (e.g. serial numbers) need to be documented, results should be confirmed by date and signature of the person in charge. All environmental variables (e.g. humidity, air velocity, light, status of instrument, etc.) should be taken into consideration.

In respect to the measurement conditions (test set-up), there are two different viewpoints which need to be considered. On the one hand, the test should reflect as closely as possible the field conditions under which the device is used. On the other hand, real field conditions contain many variables which make comparability of test results challenging. Some conditions may need to be artificial to ensure that two (or more) test runs at different locations can be accurately compared. This should be analyzed and discussed before the tests are performed to save costs and test capacities.

Testing of equipment by an external test house provides the manufacturer an external cross-check of existing in-house data. For customers, this independent testing provides additional confidence in a product.

The results can be found together with the manufacturers' test conditions in the data sheets, the technical information in the operating manual or the device specifications on the website. For example, if you look into the manual of the "CryoCube® F740hi ULT freezer", you will find the following measurement conditions:

"The device is empty. The interior temperature is -80 °C. The ambient temperature is 20 °C." [10].

In summary, even without an external standard, which in some cases simply does not (yet) exist, manufacturers' specifications should be based on test methods and protocols whose conditions are documented, clearly described, and thus, in principle, comparable.

For reliable and efficient operation in your day-to-day work, pay attention to the manufacturers' specifications which concern, for example, maintaining a certain room temperature. In doing so, it can be ensured that the devices also perform as desired in everyday practice.

Sustainability aspects are becoming more important

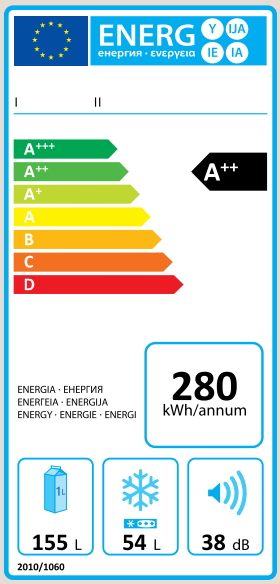
Standards and test methods describe the performance of your instrument. But further criteria, like energy and water consumption, gain prominence as sustainable procurement becomes more important. But how can you find a resource-efficient laboratory device? Coming back to the well-known energy labels for household devices, these labels provide a good orientation at home (Figure 3A) – but these European labels do not apply to laboratory instruments [11,12].

While reviewing the manufacturers' datasheets can be helpful when standard protocols do not exist, there are standard labels available to compare the energy efficiency and environmental impact of one device over another.

The ENERGY STAR label (Figure 2) is awarded to energy-efficient freezers and laboratory refrigerators. By following a precisely prescribed test procedure, the results are determined and compared with specified standard values. If a device is equal to or below the specified energy consumption, the standard is met. The ENERGY STAR label is provided by the EPA, the United States Environmental Protection Agency.

The ACT label (Figure 3B) goes even further [13]: As eco-friendliness is not limited to energy consumption, a sustainability check includes resource efficiency, but also considers the entire lifecycle from resource procurement, production, and development, to use and disposal. A sustainability label should also evaluate these aspects. The ACT label, provided by the International My Green Lab organization, includes information about the environmental impact of manufacturing, usage, and disposal of a product and its packaging. By rating these points on a scale of 1 (least environmental impact) to 10 (most environmental impact), a user can choose the most environmentally friendly product. The scoring is based on supplier data and – for ULT freezers – on test data of ENERGY STAR with the North American voltage of 115 V.

Fig. 2: An ENERGY STAR certified CryoCube® F740hi ULT freezer



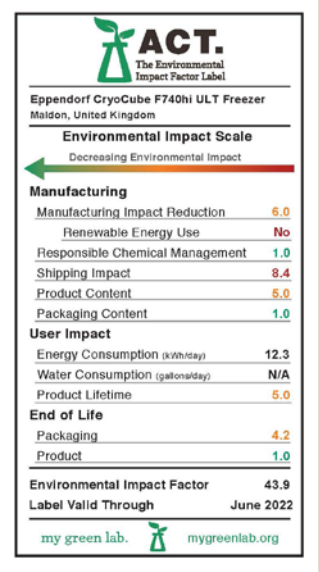


Fig. 3:
A: Sample of an EU Energy Label established by European Union Directive.
A: Sample ACT Environmental Impact Factor Label

"Just like a nutrition label on the back of a cereal box, the first-of-its-kind ACT label provides the necessary information for scientists and procurement officials to make informed environmental choices for laboratory products," said James Connelly, CEO of My Green Lab. "By putting information in the hands of scientists we can empower better decision-making and catalyze market transformation across the Life Science Industry."

EGNATON CERT is a certification standard in Europe especially for large devices which rates its performance regarding technical and process quality, as well as ecologic, economic, and socio-cultural aspects regarding human factors, which include, among other things, OHS and product safety. The technical performance criteria are based, if available, on international standards and their test specifications; in all other cases, separate specifications are developed. In the case of fume cupboards, the thermal load is evaluated in a further test in addition to the specifications of EN 14175. Threshold values are specified for the evaluation of the test results, which are defined on the basis of national limit values.

The rating scheme is based upon the BNB/DGNB system for sustainable laboratory buildings with bronze, silver, gold, or platinum level [14].

Summary

It can be said that one gets proven results about an instrument's performance through standards. Nowadays, these standards include ratings regarding sustainability performance which provide greater transparency for customers looking to evaluate a particular instrument. Even without an external standard, the manufacturer's data are obtained through defined protocols and methods, which can be found in its data sheets, operating instructions, and manuals.

About Eppendorf

Eppendorf is a leading life science company that develops and sells instruments, consumables, and services for liquid-, sample-, and cell handling in laboratories worldwide. Its product range includes pipettes and automated pipetting systems, dispensers, centrifuges, mixers, spectrometers, and DNA amplification equipment as well as ultra-low temperature freezers, fermentors, bioreactors, CO_2 incubators, shakers, and cell manipulation systems. Consumables such as pipette tips, test tubes, microtiter plates, and single-use bioreactora vessels complement the range of highest-quality premium products.

Eppendorf was founded in Hamburg, Germany in 1945 and has more than 3,300 employees worldwide. The company has subsidiaries in 26 countries and is represented in all other markets by distributors.

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