OPERATION AND RANGE OF APPLICATION OF HEAT COST ALLOCATORS

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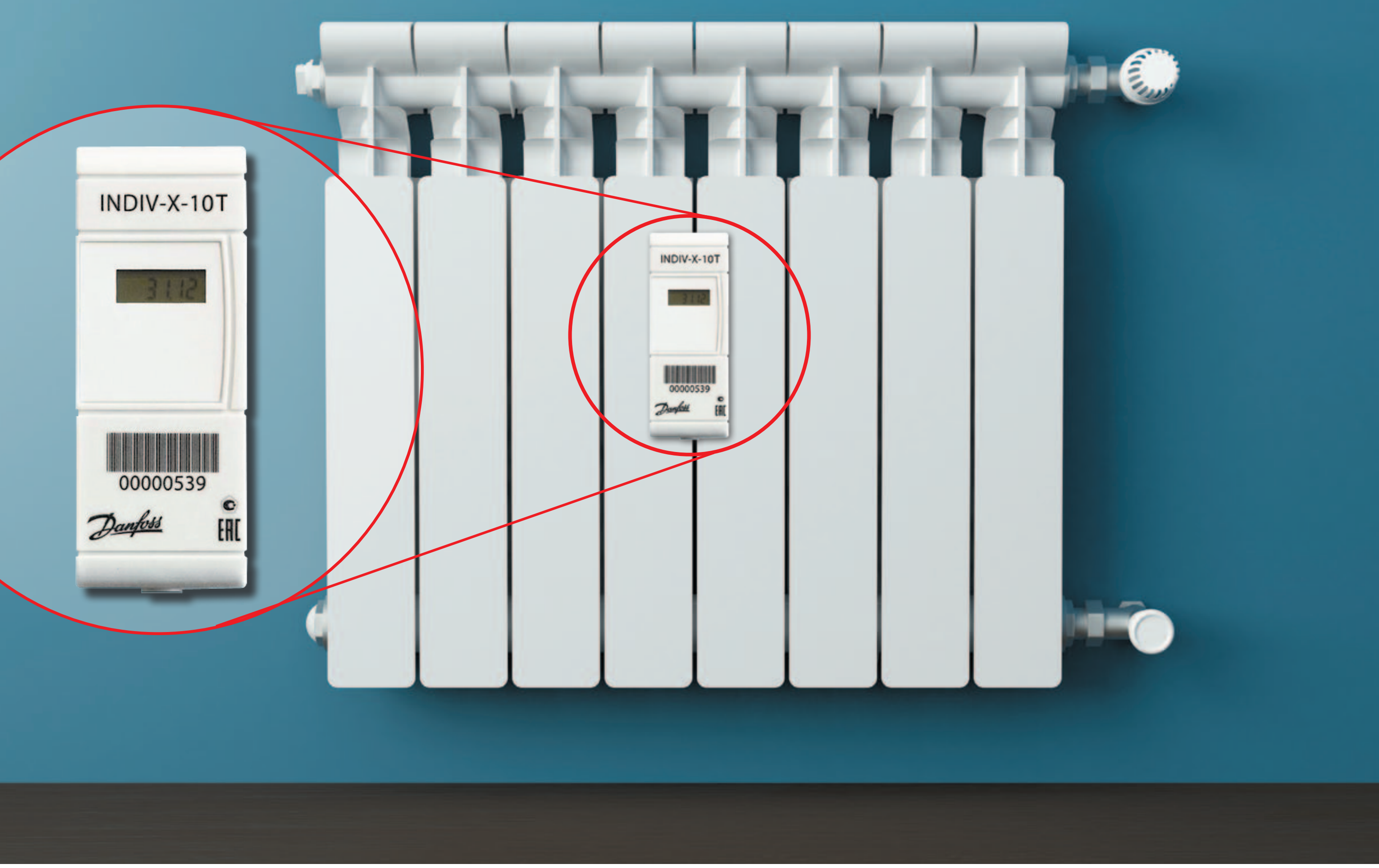


Materials employed play a special role in design of energy-efficient buildings. They can carry out functions of energy development, keep heat, and also provide a heat-shielding during the summer period.

Short history and background of heat cost allocation in Germany

The First Decree on heat cost allocation (HKVO) was put into effect on 1st of March 1981. Main activator for the decree was the first oil crisis in 1973.

At the moment of the issue of HKVO c. a. 8,4 mio of flats have been concerned and about 6 mio of flats had already been equipped by allocation devices. It means that actually the mass equipment of the dwelling houses with individual metering devices for heat cost allocation started several years earlier.

At that time as well as today the expected energy saving potential of heat cost allocation is 15 % ~ 20 %.The decree covers heating and domestic hot water provided by central systems. The focus of the decree is not on fair heat cost allocation but on the aspect of energy saving.

Range of application of heat cost allocation devices

According to HKVO, there are mainly 2 types of devices for individual metering: heat cost allocators and heat meters. Heat cost allocators in their turn are also divided in 2 types: evaporation devices (HKVV) and electronic devices with electrical energy supply (HKVE). HKVV are designed, produced and approved in accordance with the Standard EN 835; for HKVE the main normative document is the Standard EN 834.

Heat meters for the heat cost allocation are directly measuring the value of heating energy consumption and must be gauged every 5 years. Heat cost allocators are measuring temperatures and calculating the approximate value, proportional to the heat emission of radiator, and they need not be gauged during their life cycle (typically 10 years). However, the readings of individual heat meters are used for the billing of heating costs in the very same way as the units of heat cost allocators. It means that during the billing the total heating costs of multifamily houses are always allocated proportionally to the readings of individual metering devices, either heat cost allocators ("measuring" in proportional units) or individual heat meters (measuring in physical energy units, kWh or kcal).

The choice of the convenient devices for the building depends on the piping of the heating system (vertical vs. horizontal threads). In heating systems with vertical piping (both in one-pipe systems and in two-pipe systems) only heat cost allocators can be applied. In the appliances with horizontal piping, when every apartment has its individual input of heat supply, it is possible to use heat meters as well as heat cost allocators.

Electronic heat cost allocators

The construction of electronic heat cost allocators includes following main units: radiator temperature sensor, room temperature sensor, processor unit, display, battery, casing and seal.

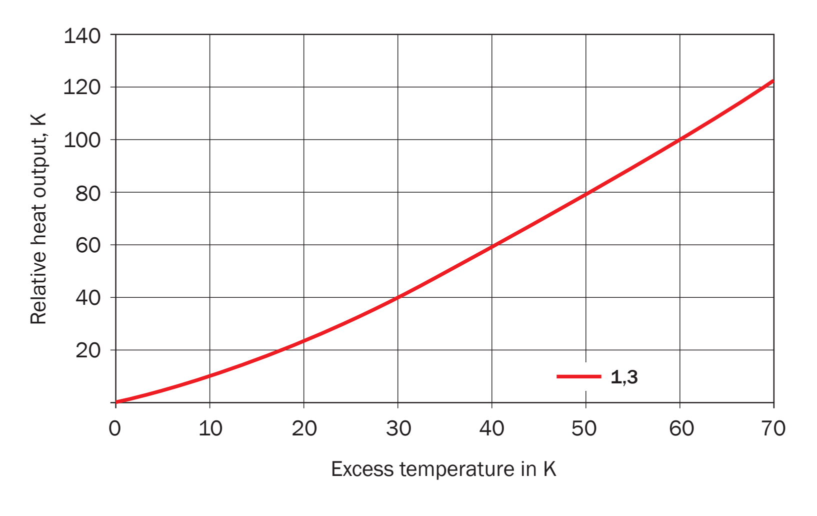
The temperature of the radiator or heat sensor is more or less close to the mean water temperature of the radiator. But this is not the case for the room sensor. At an excess temperature of the radiator of ≈ 50 K, a typical room sensor temperature is about 35 °C. Hence this is a systematic deviation (for each different type of radiator), this temperature difference between the heat sensor and the room sensor can be used as a basis for the heat cost allocation anyway.

At the same time, there exist electronic heat cost allocators with one sensor, which have only a radiator temperature sensor. In this case the ambient room temperature is programmed into HCA as a constant value of typically 20 °C.

The basis of measuring principle of electronic HCA is physical dependence of radiator heat output on the access temperature of the radiator (so-called radiator characteristic, see fig.1)

This diagram shows the characteristic of a radiator with an excess-temperature-exponent of 1,3 as a typical and representative value. The range of exponents for different types of radiators is 1,25 ~ 1,35 (1,40).

FIG.1. RADIATOR CHARACTERISTIC BASED ON 90 / 70 / 20 °C (60 K)



The characteristic of the counting rate of electronic HCA is principally following the radiator characteristic, depending on the type of device (1-or 2-sensor mode) and the brand of the heat cost allocator (fig.2)

Device exponents lower than the typical radiator exponent of 1,30 are often seen in order to pre-compensate the heat output below the counting start threshold that is not counted by the HCA.

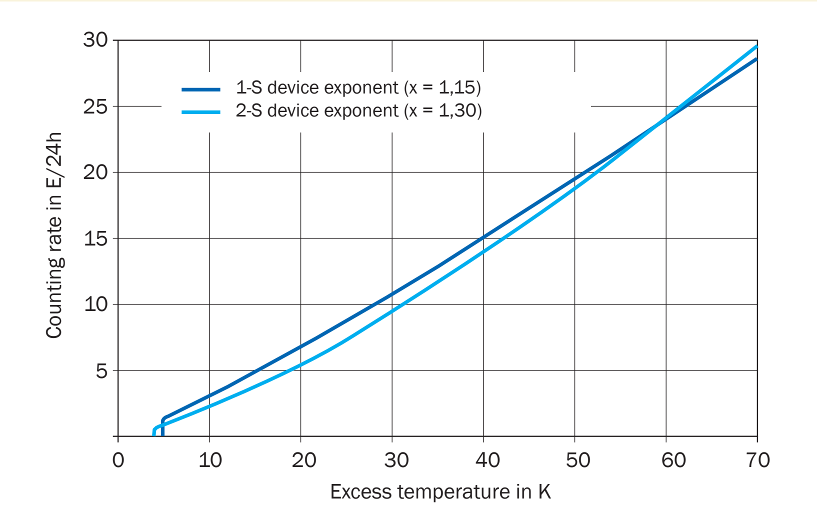
C-values and rating factors

The c-value is an expression for the degree of thermal coupling of the sensors to the detected temperatures of the room heating system. It is defined as a temperature ratio.

The c-value is used to calculate the rating factor Kc

For the HCA with one sensor, c-value is calculated according to the formula (1):

FIG.2. ELECTRONIC HCA: DISPLAY CHARACTERISTICS



$c_{HS} = 1 - (\vartheta_{HS} - \vartheta_A)/(\vartheta_{RAD,m} - \vartheta_A)$, where (1)

c_{HS} is the c-value for one-sensor HCAs,

ϑ_{HS} is the temperature of radiator sensor,

$\vartheta_{RAD,m}$ is the mean heat medium temperature of the radiator,

ϑ_A is the reference (basic) ambient room temperature.

For HCAs with 2 sensors, the calculation formula (2) is the following:

$c_2 = 1 - (\vartheta_{HS} - \vartheta_{RS})/(\vartheta_{RAD,m} - \vartheta_A)$, where (2)

C_2 is c-value for one-sensor HCA,

ϑ_{HS} is the temperature of radiator sensor,

ϑ_{RS} is the temperature of room sensor,

$\vartheta_{RAD,m}$ is the mean heat medium temperature in the radiator,

ϑ_A is the reference (basic) ambient room temperature.

A typical value for c2 is about 0,5, which means that the sensor difference is about half of the excess temperature.

The better the contact of HCA's back plate to the surface of the radiator is, the lower is the c-value (fig.3; source: Minol, Manual for heat cost billing).

In fact for all types of radiators in the field the c-value (s) have to be determined by competent bodies. Regarding the huge amount of different radiator types in the flats this is a real challenge. But the long time experience in Germany proves that this challenge can be handled properly.

C-value tests and other measurements on HCAs in the HLK laboratory are performed in 2 types of test chambers: open test chamber according to the DIN 4704–2 and closed test rooms according to the standard for radiator testing EN 442.

When c-values are determined, the further calculation of HCA consumption units takes place. Basing on the information of the sensor difference in every time step (2 ~ 4 minutes) the counting rate of HCA is calculated by the algorithm of the device using the total rating factor K and another constant factor for to get convenient values.

Counting rate = K • $\Delta t_{sensors}^{x}$ • factor
Total rating factor
K = K_Q • K_C, where
$K_Q = Q_n/Q_{basic}$ and Q_{basic} = 1 kW (typically);
$K_C = 1/(1-c)^x$, so that $\Delta t_{RAD} = K_C$ • • $\Delta t_{sensors}$

K_Q is given by the nominal heat output of the radiator for 90/70/20 typically and a reference value that typically is defined to 1 kW.

Application of K_Q allows to consider the nominal heat output and size of the radiator. It means, for example, that the readings of two HCA on two radiators of different size with different nominal heat output Q_n can be equal, but the consumption units, corrected by K_Q factor, will be different proportionally to the value of Q_n.

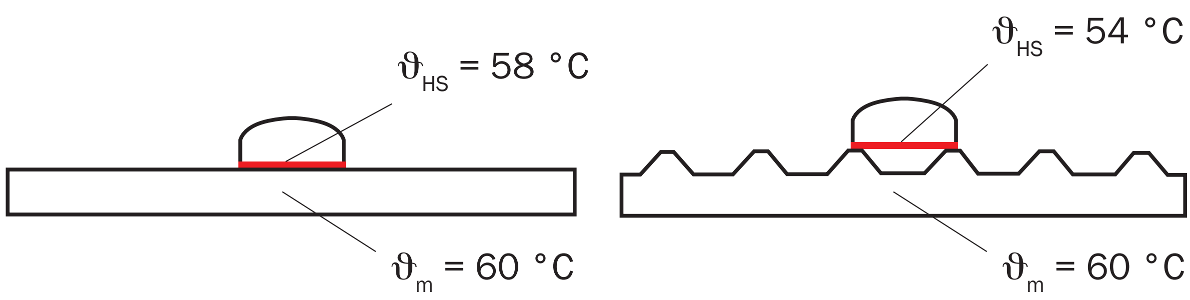
Similarly, application of K_C allows considering better or worse thermal contact of the sensors to the measured mediums (heat medium in the radiator and ambient air). For example, the readings of 2 HCA can be equal on two radiators with the same nominal heat output, but of different type and with different surfaces, and after correction with K_C value the total consumption units will be different.

Unit scale vs. product scale

The term „scale“ has its historical background from evaporators with their real scales. That term is still used for electronic HCAs.

Unit scaled HCAs have the very same parametrization on each radiator. The rating with the total rating factor K is

FIG.3. C-VALUE FOR A FLAT PANEL RADIATOR (LEFT) AND A PROFILED PANEL RADIATOR (RIGHT).



$$C = 1 - \frac{(58 - 20)}{(60 - 20)} = 0{,}05 \qquad C = 1 - \frac{(54 - 20)}{(60 - 20)} = 0{,}15$$

DISCUSSION, ANSWERS TO THE QUESTIONS

– What is the accuracy of HCA?

Basically, the allowable limits of display deviation of HCA are stated in the standard EN 834. But at the same time there exist such a notion as correlation between consumption units, measured by HCA, and real heat output of the radiator. This correlation depends on many factors, such as measuring principle of HCA, radiator exponent (comparing to the HCA exponent), mass flow through the radiator and other.

– Are there now at the market any models of HCA, which are able to measure individual heat consumption in real physical energy units (kWh or kcal)?

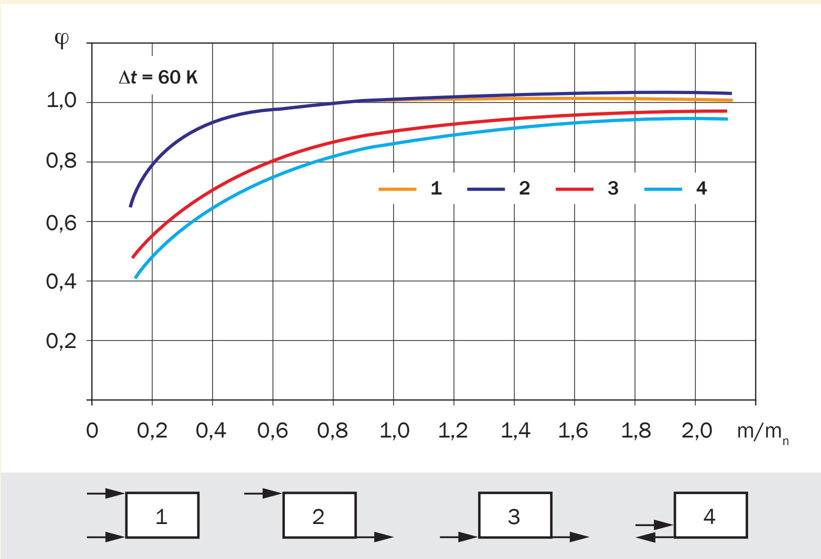
No, at the current moment no one of existing at the market HCAs is able to measure the heating energy directly over the whole range of varying mass flow and supply temperature. But in future it possibly might be achievable to find a reasonable accuracy for the ratio of units to kWh for

- 2-sensor HCAs,
- individual adaption of the HCA exponent to each radiator exponent,
- modification of the typical mounting in 75 % of the radiator height to a lower position; this would have to be investigated.

– How the situation with Bottom-top-same-end connection of the radiator should be managed regarding the mounting place of HCA and c-value?

This type of connection of the radiator is incorrect, as it was already mentioned in the report. Due to the thermal buoyancy, the heat medium, supplied from the bottom, passes only the first few sections of the radiator, and the rest of the radiator remains cold. The productivity of radiator with such connection is very low. But if such connection is used in practice in spite of everything, then c-value will be different, and it is necessary to make separate tests to determine it.

FIG.4. RELATIVE HEAT OUTPUT Φ (RELATING TO THE NOMINAL HEAT OUTPUT) DEPENDING ON THE CONNECTION TYPE AND THE MASS FLOW



done on the bill at the end of the billing period.

Product scaled HCAs have an individual parametrization on each radiator. The display values are already rated with the total rating factor K and are at the same time the consumption values.

Unit scaled HCAs may be more convenient for the allocation and billing companies, as they can put their HCAs on the radiators in a property, fix manufacturer, type and dimensions of each radiator. The identification can be done later until the first bill has to be provided.

Product scaled HCAs are more convenient and transparent for the users, as they can immediately compare the values of all their radiators in the flat.

Impact of the radiator connection to heat output and c-values

In real practice, radiators can be connected to the heating system by several ways (fig.4; source: Bach, H. et al., Low temperature heating).

Fig.4. Relative heat output ϕ (relating to the nominal heat output) depending on the connection type and the mass flow

The impact of the two different top-bottom connections on the heat output is negligible, but for the bottom-bottom-connections this is not the case as the curves 3 and 4 in the diagram show. The reduction is up to 15 %.

And as the temperature stratification of the bottom-bottom-connections is differing as well the c-values and Kc-values are not the same as for the top-bottom connections.

Conclusion: the connection should be taken into consideration when radiators are being identified and rated. ●