*TECHNICAL ANNEX*

# Explaining self-monitoring tolerances

This explanatory memorandum explains how the proposed tolerances for self-monitoring of energy efficiency parameters for hydronic space heaters were derived from

- Characteristics existing (utility) metering products,
- the tolerances in the 2014 Measurement Instrument Directive (MID),
- specific tolerances of still affordable (class A) temperature sensors,
- an extra margin of about 50% (rounded up) with respect of the MID tolerances because the self-monitoring cannot be expected to have the same tolerances as dedicated utility meters, due to cost and technical reasons (derived metering will be less accurate than dedicated metering).

## HEAT METER

**Example typical product:**


Ultrasonic flowmeter + temperature sensors + calculator € 156,-

Nominal flow (qp) 0.6 m3/h, Qmin (qi) 24 l/h, Qmax (qs) 1.2 m3/h, dynamic range q/qp is 1:25, pressure loss ΔP at qp 0.155 bar, ΔP at qs 0.660 bar, MID accuracy class 3, minimum ΔT 0.05 K, temperature precision of the display 0.01 °C, temperature range 0-100 °C, LCD display, M-bus interface, G3/4"connection, data storage 24 monthly values, IP 65, 3V Li-battery.

Temperature sensor Pt1000 (5mm diameter, 2-wire), sensor accuracy class not given, probably class B (±0,3K at 0°C, ±0,8K at 100°C) or even A (±0,15K at 0°C, ±0,35K at 100°C) classification according to IEC 60751:2008. Class B costs around €2,-/sensor; Class A (2 wire) at least €11,-/sensor.

*Example Class A: RS PRO PT1000 RTD Sensor, 5mm Diameter, 50mm Long, 2 Wire, Class A +100°C Max*

*Example class B: TE Connectivity PT1000 RTD Sensor, 2mm Diameter, 5mm Long, Chip, ±0.15 °C, +300°C Max.*

***MID-specifications***

*Definitions*

$\Delta\Theta$ = the temperature difference $\Theta_{in}$ — $\Theta_{out}$ with $\Theta\Delta \geq 0$;
$\Theta_{max}$ = the upper limit of $\Theta$ for the heat meter to function correctly within the MPEs;
$\Theta_{min}$ = the lower limit of $\Theta$ for the heat meter to function correctly within the MPEs;
$\Delta\Theta_{max}$ = the upper limit of $\Delta\Theta$ for the heat meter to function correctly within the MPEs;
$\Delta\Theta_{min}$ = the lower limit of $\Delta\Theta$ for the heat meter to function correctly within the MPEs;
$q$ = the flow rate of the heat conveying liquid;
$q_s$ = the highest value of q that is permitted for short periods of time for the heat meter to function correctly;
$q_p$ = the highest value of q that is permitted permanently for the heat meter to function correctly;
$q_i$ = the lowest value of q that is permitted for the heat meter to function correctly;

Rated operating conditions,
concerning the temperature differences: $\Delta\Theta_{max}$, $\Delta\ \Theta_{min}$. They are subject to the following restrictions: $\Delta\Theta_{max}/\ \Delta\Theta_{min} \geq 10$; $\Delta\Theta_{min}$ = 3K or 5K or 10K.
**However, for a LT heat pump $\Delta\Theta_{max}$ = 5K and $\Delta\Theta_{min}$ = 1K. For a HT boiler $\Delta\Theta_{max}$ = 20K and $\Delta\Theta_{min}$ = 4-5K**
For the flow rates of the liquid: $q_s$, $q_p$, $q_i$, where the values of $q_p$ and $q_i$ are subject to the following restriction: $q_p/q_i \geq 10$.

There are 3 operating classes (1,2,3). Operating class 3 (the lowest) is typical of residential utility meters.

**MPEs applicable to complete heat meters in class 3:**

**For class 3**: $\mathbf{E = E_f + E_t + E_c}$, with $E_f$, $E_t$, $E_c$ according to paragraphs 7.1 to 7.3.

The relative **MPE of**

7.1 **the flow sensor $E_f$**, expressed in %: $\mathbf{E_f = (3 + 0{,}05\ q_p/q)}$, but not more than 5 %,

7.2 **the temperature sensor pair $E_t$**, expressed in %: $\mathbf{E_t = (0{,}5 + 3 \cdot \Delta\Theta_{min}/\Delta\Theta)}$,

7.3 **the calculator $E_c$**, expressed in %: $\mathbf{E_c = (0{,}5 + \Delta\Theta_{min}/\Delta\Theta)}$

Ad 7.1.

For $\mathbf{q_p}$ the rated flow capacity of a circulator for an average heater (24 kW) is estimated to be 3 m³/h, whereas the average flow rate **q** in operation, including pre- and post switch time, is estimated to be 300 L/h. Hence $\mathbf{q_p/q = 10}$ **and thus $\mathbf{E_f}$ = 3,5%.**

Ad 7.2

For the case of an **LT heat pump** the maximum temperature difference is $\mathbf{\Delta\Theta = 5K}$.
Typically heat pumps cannot modulate back to lower than 30%, hence when $\mathbf{\Delta\Theta_{min}}$ is **about 1,75 K**. Below $\Delta\Theta$ the compressor of the heat pump will switch off, the circulator pump will continue for a preset time (e.g. 10 minutes or longer depending on settings) and will then also switch off until triggered by the room thermostat. The residual heat in the system when the

heat pump switches off can be calculated. Hence, $\Delta\Theta_{min}$ of 1,75 K is enough for monitoring purposes. Hence $\mathbf{\Delta\Theta_{min}/\Delta\Theta = 0.35}$ and **Et=(0,5+3*0,35)= 1,55 %** .

The problem is that with a pair of class A temperature sensors this is not achievable at the lowest setting of $\Delta\Theta$ = 1,75 K at 35% lowest modulation, using a class A sensor at 25 °C is with tolerance ± 0,2K (at about 30-35°C ambient, see table hereafter)

Pt100 sensor accuracy classes and tolerances defined by IEC 60751:2008 are:

- **Class AA** ± (0,1+0,0017 * t), ±0,1 °C (0 °C), ±0,27 °C (100 °C), defined on range -50…+250 °C (wire wound resistor), 0…+150 °C (thin film resistor)
- **Class A** ± (0,15+0,002 * t), ±0,15 °C (0 °C), ±0,35 °C (100 °C), defined on range -100…+450 °C (wire wound resistor), -30…+300 °C (thin film resistor)
- **Class B** ± (0,3+0,005 * t), ±0,3 °C (0 °C), ±0,8 °C (100 °C), defined on range -196…+600 °C (wire wound resistor), -50…+500 °C (thin film resistor)
- **Class C** ± (0,6+0,01 * t), not commonly used for industrial measuring circuits.

<u>Ad 7.3</u>

Using the same $\mathbf{\Delta\Theta_{min}/\Delta\Theta = 0.2}$ the MPE of the calculator becomes $\mathbf{E_c = (0,5 + 0,2\,) = 0,7\%}$

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The tolerance in line with the MID for a class 3 heat meter is thus
$E = E_f + E_t + E_c$ = 3,5% + 1,55% + 0,7% = 5,75%

Because self-monitoring is not expected to have the same accuracy as a utility meter (technical and cost considerations), a tolerance level of about 7-8% could be deemed reasonable. However, taking into account the tolerance of a class A sensor at LT conditions it is proposed to use a staged tolerance level as indicated below

| **Range** | **ΔΘ ≤ 5K** | **5<ΔΘ ≤ 10K** | **ΔΘ > 10K** |
|---|---|---|---|
| **Tolerance** | 15% | 10% | 7,5% |

# ELECTRICITY METER

**Example typical products:**


(1) (2) (3)

(1) Ferraris electricity meter, only available refurbished (original price €200,- refurbished €20), 10A nominal ($I_n$), 40A maximum ($I_{max}$). MPE at 10A is +2%, at 40A is -2% (laboratory measurement).

(2) Electronic meter ABB € 269,- accuracy class B, $I_{max}$ 65A, M-bus communication

(3) Small conventional 1-phase DIN-rail, class B (till 1%), Nominal 5A, Max. 40A, electronic kWh meter with digital LCD (5+2) display. Size (LxWxD): 116x17.5x63mm. IP51, safety class II. Complies with (MID B+D), suitable for partitioning bills with 3rd parties in all EU Member States. Price € 89,-

DEFINITIONS

An active electrical energy meter is a device which measures the active electrical energy consumed in a circuit.

I = the electrical current flowing through the meter;
In = the specified reference current for which the transformer operated meter has been designed;
Ist = the lowest declared value of I at which the meter registers active electrical energy at unity power factor(polyphase meters with balanced load);
Imin = the value of I above which the error lies within maximum permissible errors (MPEs) (polyphase meters with balanced load);
Itr = the value of I above which the error lies within the smallest MPE corresponding to the class index of the meter;
Imax = the maximum value of I for which the error lies within the MPEs;
U = the voltage of the electricity supplied to the meter;
Un = the specified reference voltage;

f = the frequency of the voltage supplied to the meter;
fn = the specified reference frequency;
PF = power factor = cosφ = the cosine of the phase difference φ between I and U.

| **Single phase E-meter; polyphase meter if with balanced loads** | | | | | | MPE at Imin ≤ I< Itr | | MPE at Itr ≤ I< Imax | |
|---|---|---|---|---|---|---|---|---|---|
| | Type | Ist | Imin | In | Imax | +5 to 30°C | -10 to +5°C | +5 to 30°C | -10 to +5°C |
| **Class A** | **For direct-connected meters** | ≤ 0,05 Itr | ≤ 0,5 Itr | 20 Itr | ≥ 50 Itr | **3,5%** | 5% | **3,5%** | 5% |
| | **For transformer-operated meters** | ≤ 0,06 Itr | ≤ 0,4 Itr | 20 Itr | ≥ 1,2 In | **3,5%** | 4,5% | **3,5%** | 4,5% |

If $I_n$ = 10A then $I_{tr} \le In/20=0.5A$, $I_{min} \le 0.5*I_{tr}=0.25A$, $I_{max} \ge 35A$ (typically 40-65 A)

Expecting that the ambient temperature will be in the range of +5 to 30°C a tolerance in accordance with the MID can be expected to 3,5%. Because self-monitoring is not expected to have the same accuracy as a utility meter (technical and cost considerations), a tolerance level of about 5% could be deemed reasonable.

# GAS METER

## Typical product

**Diaphragm-type gas meter** ***type*** **G 1.6**, (lxwxd) 214x190x156mm, steel casing, 3/4" connections, capacity 0.02 - 2.5m³/h, max. operational pressure 0.2 bar, approved EN 1359, accuracy 98%. Price(NL): 204,92 Incl BTW.

The electronic version is often still a diaphragm-type but with electronic reading/calculator part. Accuracy class 1.5. Ultrasonic gas meters exist, but are more used in non-residential applications

Definitions

**Minimum flowrate ($Q_{min}$)** The lowest flowrate at which the gas meter provides indications that satisfy the requirements regarding maximum permissible error (MPE.)

**Maximum flowrate ($Q_{max}$)** The highest flowrate at which the gas meter provides indications that satisfy the requirements regarding MPE.

**Transitional flowrate ($Q_t$)** The transitional flowrate is the flowrate occurring between the maximum and minimum flowrates at which the flowrate range is divided into two zones, the 'upper zone' and the 'lower zone'. Each zone has a characteristic MPE.

**Maximum Permissable Error (MPE)**

| **Gas meter** | Conditions | | **MPE** | |
|---|---|---|---|---|
| MPE Class | Qmax/Qmin | Qmax/Qt | **Qmin ≤ Q< Qt** | **Qt ≤ Q ≤ Qmax** |
| 1,5 | ≥ 150 | ≥ 10 | **3 %** | **1,5 %** |

In reality, gas boilers can modulate back to no more than 10-15% of Qmax, so Qmax/Qmin ≥10. And if Qt is in the middle of Qmax and Qmin then Qmax/Qt ≥ 2. All in all, it is assumed that only the MPE for **Qmin ≤ Q< Qt applies, i.e. 3%.**

Because self-monitoring is not expected to have the same accuracy as a utility meter (technical and cost considerations), a tolerance level of about **5%** could be deemed reasonable for gas measurements.

# FUEL OIL METER

**Oil meters the MID specifies a Qmac/Qmin ratio ≥ 4:1**

For measuring systems of liquid fuels a class 2,5 is assumed, meaning an accuracy of ±2,5% (line A).

Because self-monitoring is not expected to have the same accuracy as a utility meter (technical and cost considerations), a tolerance level of about **5%** could be deemed reasonable for gas measurements.

# SUMMARY

For the assessment of hydronic heat energy output, a staged maximum permissible error (MPE) applies as indicated in the table

| **Temperature difference range ΔΘ** | **ΔΘ ≤ 5K** | **5<ΔΘ ≤ 10K** | **ΔΘ > 10K** |
|---|---|---|---|
| Tolerance ± | 15% | 10% | 7,5% |

For the assessment of electricity, gas and fuel consumption or cogenerating electricity an MPE of ±5% applies.

## Storage of data

The storage of data is derived from Directive (EU) 2019/944 on common rules for the internal market for electricity and frequency and size of data storage in existing smart meters.

1) Instantaneous values will be displayed at an appropriate sample rate[1]. The values mentioned in point 1 will be stored with the following frequency :

   (a) cumulative data for at least the three previous years or the period since the start of the electricity supply contract, if that period is shorter. The data shall correspond to the intervals for which frequent billing information has been produced; and

   (b) detailed cumulative data according to the time of use for any day, week, month and year, which is made available to the final customer without undue delay via the internet or the meter interface, covering the period of at least the previous 24 months or the period since the start of the electricity supply contract, if that period is shorter.

   Furthermore, for the purpose of detailed analysis, hourly and quarter of an hour values will be stored for a period of 10 days (240 hours, 960 quarters of an hour)

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[1] E.g. 5 seconds