

Technical Description

MULTICAL® 302



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1 General description

MULTICAL® 302 is a static heat meter, cooling meter or combined heat/cooling meter based on the ultrasonic principle. The meter is intended for energy measurement in almost all types of thermal installations where water is used as the energy-conveying medium.

According to EN 1434 MULTICAL® 302 can be designated a "hybrid instrument", also called a compact meter. During production and initial verification in our factory the meter is treated as three separate units or "sub-assemblies" (flow sensor, calculator and temperature sensor pair) but after delivery the units must not be separated unless by an accredited laboratory.

If flow sensor, calculator or sensor pair have been separated and the seals broken, the meter is no longer valid for billing purposes. Furthermore, the factory guarantee no longer applies.

MULTICAL® 302 employs ultrasonic measuring technique, ASIC and microprocessor technology. A single board construction comprises all calculating and flow measuring circuits, which provides a compact and rational design and, in addition, exceptionally high measuring accuracy and reliability is obtained.

Volume is measured using bidirectional ultrasonic technique based on the transit time method, proven a long-term stable and accurate measuring principle. Two ultrasonic transducers are used to send sound signals with as well as against the flow. The ultrasonic signal travelling with the flow reaches the opposite transducer first. The time difference between the two signals can be converted into flow velocity and thereby also volume.

The temperature sensor type is Pt500 according to DS/EN 60751. Accurately matched Pt500 sensors measure the temperatures in inlet and outlet pipes. MULTICAL® 302 is supplied with a $\varnothing 5.2$ mm Pt500 sensor pair. One temperature sensor is mounted in the flow sensor from the factory and the other sensor is typically mounted as short direct sensor in e.g. a ball valve.

The accumulated heat energy and/or cooling energy can be displayed in kWh, MWh or GJ, all in the form of seven significant digits and measuring unit. The display has been specially designed to obtain long lifetime and sharp contrast in a wide temperature range.

Other reading options are: accumulated water consumption, operating hour counter, current temperature measurements, current flow and power readings. Furthermore, MULTICAL® 302 can display loggings, target day data, error hour counter, max. flow, max. power, information code and current date/time.

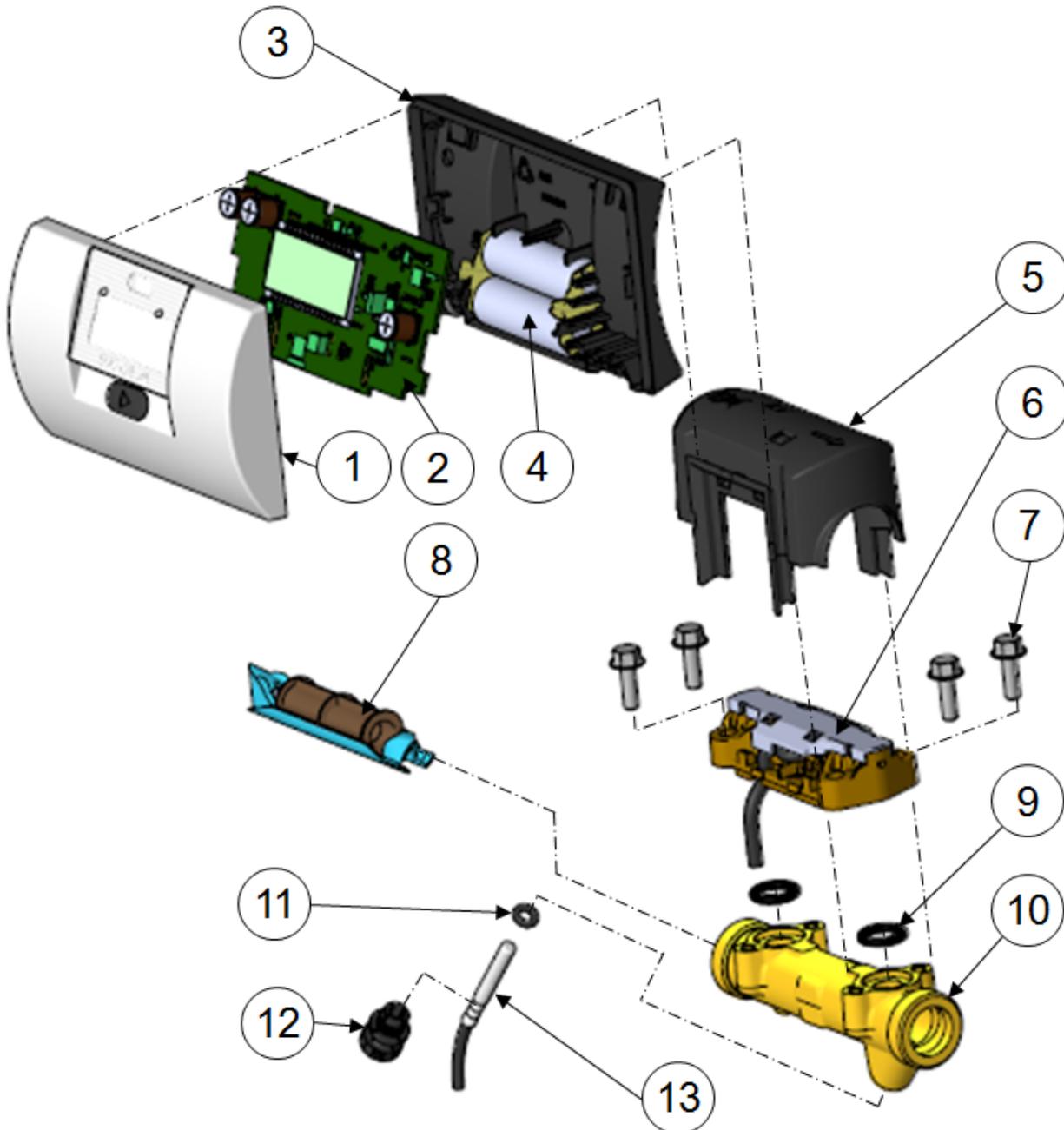
MULTICAL® 302 is powered by an internal A-cell lithium battery with 6 years' lifetime or by two A-cells with 12 years' lifetime.

MULTICAL® 302 is available with communication for either wired M-Bus and/or Wireless M-Bus.

In designing MULTICAL® 302 great importance has been attached to user comfort and compact external measurements, which makes it suitable for a wide range of applications.

This technical description has been written with a view to enabling operations managers, meter installers, consulting engineers and distributors to utilize all functions comprised in MULTICAL® 302. Furthermore, the description is targeted at laboratories performing tests and verification.

1.1 Mechanical construction



| No. | Description |
|-----|--------------------------------|
| 1 | Front cover |
| 2 | Meter electronics |
| 3 | Calculator base |
| 4 | A-cell battery |
| 5 | Sealing cover for flow sensor |
| 6 | Transducer assembly with cable |
| 7 | Screws for top beam |

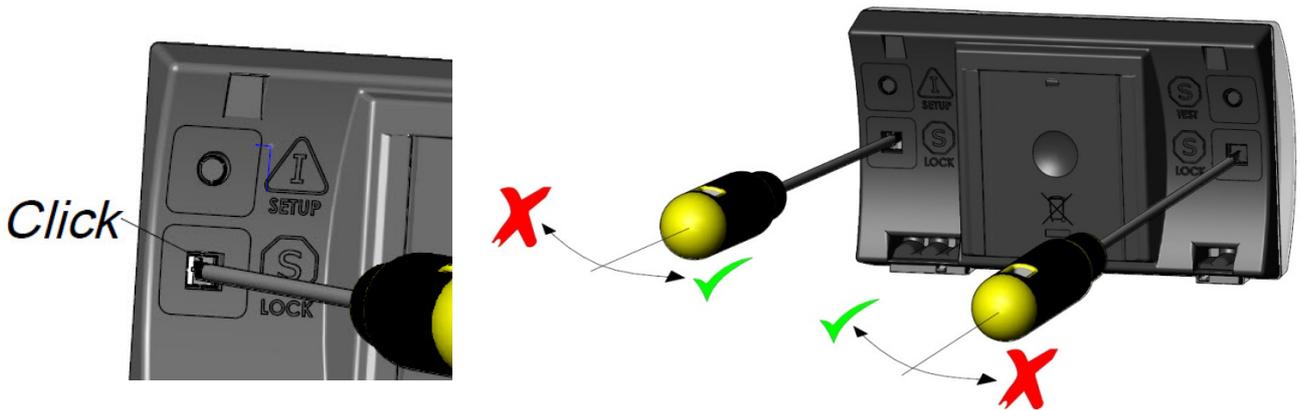
| No. | Description |
|-----|---------------------------------|
| 8 | Meter tube assembly |
| 9 | O-rings |
| 10 | Hot brass casing |
| 11 | O-ring for temperature sensor |
| 12 | Coupling for temperature sensor |
| 13 | Temperature sensor ø5.2 mm |

1.2 Seals

1.2.1 LOCK

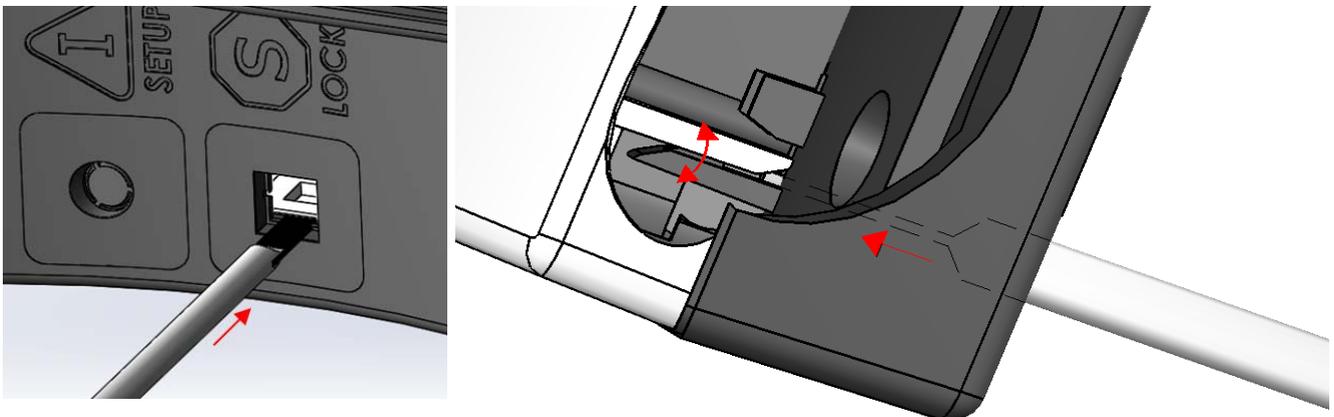
The meter's front cover and base are assembled by means of a "locking system" and the case cannot be separated without breaking the two seals marked  LOCK.

IMPORTANT: If the  seals have been broken, the meter may no longer be used for billing. Therefore, the case may only be opened by an accredited laboratory with authorisation to reseal the meter after reverification.



The seals are gently broken using a screwdriver.

The mechanical locks are released by carefully moving the screwdriver towards the centre of the meter.



Close-up illustration of locking function being released.



When the two mechanical locks have been released, remove the top cover from the base.

Reassembling the meter the seals must be re-established using 15 x 15 mm void labels. Note: If the meter is used for billing, this is a legal seal. Alternatively, Kamstrup's seal no. 2008-727 can be used.

1.2.2 Setup

See paragraph 8.4

1.2.3 Test

See paragraph 14.1.1

2 Technical data

2.1 Approved meter data

| | |
|---------------|---|
| Approvals | DK-0200-MI004-031, TS 27.02 001 and PTB TR K7.2 (22.72/13.04) |
| Standards | EN 1434:2007, prEN 1434:2013 and PTB TR K7.2 |
| EU directives | Measuring Instruments Directive, Low Voltage Directive, Electro-magnetic Compatibility Directive, Pressurised equipment Directive |

Heat meter approval, DK-0200-MI004-031

| | | |
|---|------------------------------|--|
| Temperature range | θ : 2 °C...150 °C | The stated minimum temperatures are only related to the type approval. The meter has no cut-off for low temperature and thus measures down to 0.01 °C and 0.01 K. |
| Differential range | $\Delta\theta$: 3 K...130 K | |
| Cooling meter approval, PTB TR K7.2 (22.72/13.04) | | |
| Temperature range | θ : 2 °C...150 °C | |
| Differential range | $\Delta\theta$: 3 K...85 K | |

| | |
|--------------------------------|---|
| Alternative temperature ranges | θ : 2 °C...130 °C / $\Delta\theta$: 3 K...110 K |
| | θ : 2 °C...50 °C / $\Delta\theta$: 3 K...30 K |

| | |
|---------------------|---|
| Accuracy | According to EN 1434 |
| Temperature sensors | Pt500 – EN 60 751, 2-wire, hard-wired connection |
| EN 1434 designation | Accuracy class 2 and 3 / Environmental class A |
| MID designation | Mechanical environment: Class M2 Electromagnetic environment: Class E1 Closed location (indoors), 5...55 °C |

| | Nom. flow | Max. flow | Min. flow | | Min. cut-off | Saturation flow | Pressure loss Δp @ q_p | Threaded connection on meter | Length |
|------------------------|------------------------------|------------------------------|----------------|----------------|--------------|---------------------|----------------------------------|---------------------------------|--------|
| | | | 100:1 | 250:1 | | | | | |
| Type number | q_p [m ³ /h] | q_s [m ³ /h] | q_i [l/h] | q_i [l/h] | [l/h] | [m ³ /h] | [bar] | | [mm] |
| 302Txxxx 10 xxx | 0.6 | 1.2 | 6 | - | 3 | 3.0 | 0.02 | G ³ / ₄ B | 110 |
| 302Txxxx 11 xxx | 0.6 | 1.2 | 6 | - | 3 | 3.0 | 0.02 | G ³ / ₄ B | 130 |
| 302Txxxx 12 xxx | 0.6 | 1.2 | 6 | - | 3 | 3.0 | 0.02 | G ³ / ₄ B | 165 |
| 302Txxxx 40 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.09 | G ³ / ₄ B | 110 |
| 302Txxxx 41 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.09 | G ³ / ₄ B | 130 |
| 302Txxxx 42 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.09 | G ³ / ₄ B | 165 |
| 302Txxxx 70 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.07 | G1B | 130 |
| 302Txxxx 71 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.07 | G1B | 195 |
| 302Txxxx 72 xxx | 1.5 | 3.0 | 15 | 6 | 3 | 5.0 | 0.07 | G1B | 220 |
| 302Txxxx A0 xxx | 2.5 | 5.0 | 25 | 10 | 5 | 7.0 | 0.09 | G1B | 130 |
| 302Txxxx A1 xxx | 2.5 | 5.0 | 25 | 10 | 5 | 7.0 | 0.09 | G1B | 195 |
| 302Txxxx A2 xxx | 2.5 | 5.0 | 25 | 10 | 5 | 7.0 | 0.09 | G1B | 220 |

Table 1

The overall lengths of the types in the grey fields include flow sensor and an extension piece, which is included in the supply.

2.2 Electrical data

Calculator data

| | |
|------------------------------|--|
| Typical accuracy | Calculator: $E_c \pm (0.15 + 2/\Delta\Theta) \%$ Sensor pair: $E_T \pm (0.4 + 4/\Delta\Theta) \%$ |
| Display | LCD – 7 (8) digits with digit height 6 mm |
| Resolution | 9999,999 – 99999,99 – 999999,9 – 9999999 |
| Energy units | MWh – kWh – GJ |
| Data logger (Eeprom) | 960 hours, 460 days, 24 months, 15 years, 50 Info-events, 25 config. logs |
| Clock/calendar | Clock, calendar, leap year compensation, target date |
| Data communication | KMP protocol with CRC16 used for optical communication |
| Wired M-Bus | Protocol according to EN 13757-3:2013, 300 and 2400 Baud communication speed with automatic baud rate detection. Current consumption 1 unit load (1.5 mA). 1.5 m fixed 2-wire cable. Polarity independent. |
| wM-Bus | Mode C1 protocol according to EN 13757-4:2013. Individual 128 bit AES encryption. Transmission interval 16 sec. Mode T1 OMS protocol according to EN13757-4:2013 and OMS Specification Volume 2 issue 3.0.1. Individual 128 bit AES encryption. Transmission interval 15 min. |
| Power of temperature sensors | < 0.5 μ W RMS |
| Supply voltage | 3.6 VDC \pm 0.1 VDC |
| EMC data | Fulfils EN 1434 class A (MID class E1) |

Temperature measurement

| 2-Wire Pt500 | T1 Inlet temperature | T2 Outlet temperature | $\Delta\Theta$ (T1-T2) Heat metering | $\Delta\Theta$ (T2-T1) Cooling metering |
|----------------------|--|-----------------------------|---|--|
| Measuring range | 0.00...155.00 °C | 0.00...155.00 °C | 0.01...155.00 K | 0.01...155.00 K |
| Battery | 3.65 VDC, 1 x A-cell lithium | | 3.65 VDC, 2 x A-cell lithium | |
| Replacement interval | 6 years | | 12 years | |
| | Data modules, frequent data communication and high ambient temperature reduce the replacement interval | | | |
| Lithium content | 0.96 g | | 2 x 0.96 g | |
| Transport class | Not subject to dangerous goods regulations | | | |
| Outside the USA | Non-restricted to transport/Non-assigned to Class 9 | | | |
| Within the USA | Belonging to the category of "small primary lithium cells" | | | |

2.3 Mechanical data

Environmental class Fulfils EN 1434 class A (MID class E1) and class M2

| | Protection class | Ambient temperature | Environmental class | |
|-----------------------------|------------------|---------------------|---------------------|---------------------------|
| Calculator | IP65 | 5...55 °C | Non-condensing | Indoors (closed position) |
| Flow sensor and sensor pair | IP68 | | Condensing | |

Medium temperatures

Heat meters 302-T 2...130 °C At medium temperatures below 15 °C the calculator must be wall mounted in order to prevent condensation.
 Cooling meters 302-T 2...130 °C
 Heat/cooling meters 302-T 2...130 °C At medium temperatures above 90 °C in the flow sensor the calculator must be wall mounted in order to prevent too high temperature, especially in relation to display and battery lifetime.

Medium in flow sensor Water

Storage temperature -25...60 °C (drained flow sensor)

Pressure stage (with thread) PN16 and PN25

Weight From 0.7 to 1.1 kg depending on flow meter size and extension piece

Flow sensor cable 1.2 m (undemountable cable)

Temperature sensor cables 1.5 m (undemountable cables)

2.4 Material

| | | |
|-------------------|--------------------------|---|
| Wetted parts | Flow sensor case | Hot dezincification proof brass (CW 602N) |
| | Diaphragms | Stainless steel, W.no. 1.4404 |
| | O-rings | EPDM |
| | Measuring tube | Thermoplastic, PES 30% GF |
| | Reflectors | Thermoplastic, PES 30% GF and stainless steel, W.no. 1.4306 |
| Flow sensor cover | Thermoplastic, PC 20% GF | |
| Wall bracket | | |
| Calculator case | Top | Thermoplastic, PC 10% GF |
| | Base | Thermoplastic, ABS with TPE gaskets (thermoplastic elastomer) |
| Cables | Flow sensor | |
| | Temperature | Silicone cable with inner Teflon insulation |
| | M-Bus | |

2.5 Accuracy

| Heat meter components | MPE according to EN 1434-1 | MULTICAL® 302, typical accuracy |
|-----------------------|---|--|
| Flow sensor | $E_f = \pm (2 + 0.02 \text{ qp}/q) \%$ | $E_f = \pm (1 + 0.01 \text{ qp}/q) \%$ |
| Calculator | $E_c = \pm (0.5 + \Delta\Theta_{\min}/\Delta\Theta) \%$ | $E_c = \pm (0.15 + 2/\Delta\Theta) \%$ |
| Sensor pair | $E_t = \pm (0.5 + 3 \Delta\Theta_{\min}/\Delta\Theta) \%$ | $E_t = \pm (0.4 + 4/\Delta\Theta) \%$ |

MULTICAL® 302 q_p 1.5 m³/h @ 30K

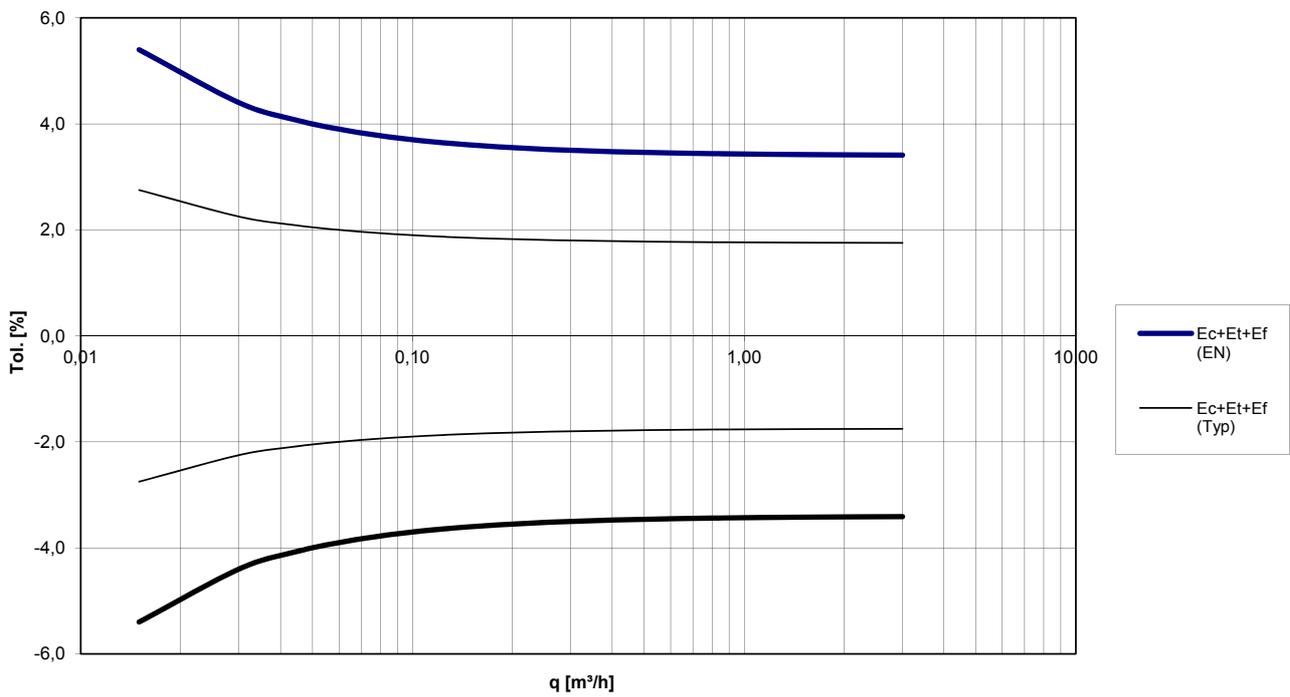


Diagram 1: Total typical accuracy of MULTICAL® 302 compared to EN 1434-1.

3 Type overview

MULTICAL® 302 can be ordered in various combinations as required by the customer. First select the required hardware from the type overview. Then select "Config" and "Data" to suit the application in question.

The meter is configured and ready for use from the factory. It can, however, be reconfigured before installation (see paragraph 8.4 Setup loop for further information).

3.1 Type and configuration overview



Type number

302-T-xx-x-xx-xx-xxx

Type number and serial number (factory set unique serial no.) are written on the meter and cannot be changed after production.

CONFIG >AB<

Inlet/outlet - Measuring unit - Resolution

- Can be changed via the pushbutton while the meter is still in transport state.
- Later, the seal "I (SETUP)" must be broken and the switch activated in order to change the configuration.

CONFIG >DDD<

Display

Change only possible via METERTOOL provided that the seal "I (SETUP)" is broken and the switch activated.

CONFIG >EFGHHMMM<

Other configurations (see paragraph 3.6)

Change only possible via METERTOOL provided that the seal "I (SETUP)" is broken and the switch activated.

CONFIG "ABDDD-EFGHHMMM" is not written on the meter, it can be read from the display.

DATA

- Can be changed via the pushbutton while the meter is still in transport state.
- Later, data can only be changed via METERTOOL provided that the seal "I (SETUP)" is broken and the switch activated.
- Customer No.
- Target date
- Average peak time (Max. flow and power)
- θ_{hc} (only active for country code 6xx)
- Date/time
- M-Bus primary address

3.2 Type number composition

| Type | 302- | □ | □□ | □ | □□ | □□ | □ | □□ |
|--|------------------------------------|-----------------------|----------------------------|--------------------------|----|----|---|----|
| Basic version | | | | | | | | |
| Pt500 sensor input | | T | | | | | | |
| Communication | | | | | | | | |
| No communication | | | 00 | | | | | |
| M-Bus (comes with 1.5 m factory mounted cable) | | | 20 | | | | | |
| M-Bus (comes with 2.0 m factory mounted cable) | | | 21 | | | | | |
| Wireless M-Bus, 868 MHz (configurable mode C1 or T1) | | | 30 | | | | | |
| Supply | | | | | | | | |
| 6 year battery, Normal Response meter | | | | 1 | | | | |
| 12 year battery, Normal Response meter | | | | 2 | | | | |
| 6 year battery, Fast Response meter | | | | 3 | | | | |
| Temperature sensors | | | | | | | | |
| Pt500, ø5.2 mm temperature sensors with cable length 1.5 m and composite union | | | | | Q9 | | | |
| Pt500, ø5.2 mm temperature sensors with cable length 1.5 m and brass union | | | | | QF | | | |
| Flow sensor qp | | | | | | | | |
| Flow sensor qp [m³/h] | Connection | Length [mm] | | | | | | |
| 0.6 | G¾B (R¾) DN15 | 110 | | | | 10 | | |
| | | | | With extension to 130 mm | | 11 | | |
| | | | | With extension to 165 mm | | 12 | | |
| 1.5 | G¾B (R¾) DN15 | 110 | | | | 40 | | |
| | | | | With extension to 130 mm | | 41 | | |
| | | | | With extension to 165 mm | | 42 | | |
| 1.5 | G1B (R¾) DN20 | 130 | | | | 70 | | |
| | | | | With extension to 190 mm | | 71 | | |
| | | | | With extension to 220 mm | | 72 | | |
| 2.5 | G1B (R¾) DN20 | 130 | | | | A0 | | |
| | | | | With extension to 190 mm | | A1 | | |
| | | | | With extension to 220 mm | | A2 | | |
| Meter type | | | | | | | | |
| Heat meter | MID approved as heat meter | | $\theta_{hc} = \text{OFF}$ | | | | 2 | |
| Heat/cooling meter | MID approved as heat meter | | $\theta_{hc} = \text{OFF}$ | | | | 3 | |
| Heat meter | With national approval | | $\theta_{hc} = \text{OFF}$ | | | | 4 | |
| Cooling meter | E.g. PTB approved as cooling meter | | $\theta_{hc} = \text{OFF}$ | | | | 5 | |
| Heat/cooling meter | Without approval marking | | $\theta_{hc} = \text{ON}$ | | | | 6 | |
| Country code (language on label etc.) Letters can also be used. | | | | | | | | XX |

Extension pieces, if any, are separately enclosed in the packing.

3.2.1 Integration time

Depending on selected type number MULTICAL® 302 is from the factory configured for integration (energy calculation) every 32 seconds or every 8 seconds.

| Supply | |
|--|---|
| 6 year battery, Normal Response meter | 1 |
| 12 year battery, Normal Response meter | 2 |
| 6 year battery, Fast Response meter | 3 |

Among other things the meter's current consumption depends on the integration frequency of the meter. A Fast Response meter integrates every 8 seconds and uses almost twice as much current as a Normal Response meter. This means that the battery life is halved.

Normal Response cannot be changed to Fast Response and vice versa after delivery.

3.2.2 Configuration during setup of country code

The last two characters of the type number are called the country code. The code is used for setting up language of text on label e.g. class 2 or 3, dynamic range, pressure stage PN 16 or PN 25, and indicates approval and verification marks.

| Type | 302- | | | | | | | |
|--------------|------|--|--|--|--|--|--|----|
| Country code | | | | | | | | XX |

Please contact Kamstrup for further details on available country codes. Currently available country codes appear from internal document 5514-863 on Kamstrup's Intranet.

3.2.3 Accessories

| | |
|------------|---|
| 3026-655.A | Wall fitting (LEXAN 3412R black) |
| 6561-346 | Holder for optical reading head |
| 3130-362 | Blind plug for temperature sensor in flow part (Copper alloy brass, CW614N) |
| 6556-491 | R $\frac{1}{2}$ x M10 nipple (Copper alloy brass, CW614N) |
| 6556-512 | R $\frac{3}{4}$ x M10 nipple (Copper alloy brass, CW614N) |
| 5920-257 | G $\frac{1}{2}$ ball valve with M10x1 sensor socket |
| 5920-271 | G $\frac{3}{4}$ ball valve with M10x1 sensor socket |
| 6557-302 | G $\frac{1}{2}$ sensor pocket 35 mm (Copper alloy brass, CW614N) |
| 6699-099 | Infra-red optical reading head w/USB plug |
| 6699-102 | Infra-red optical reading head RS232 w/D-sub 9F |
| 6699-304 | Infra-red optical reading head for NOWA |
| 6699-016 | Kamstrup NOWA KAS software |
| 6699-724 | METER TOOL for HCW |
| 6699-725 | METER TOOL LogView for MULTICAL® 302 |

Note: Ball valves with M10x1 socket (type: 6556-474, -475 and -476) are not suitable for sensors with O-ring seal as they are intended for flat gaskets.

3.2.3.1 Couplings (PN16):

| Article number | Size | Nipple | Coupling |
|----------------|------|-----------------|-----------------|
| 6561-323 | DN15 | R $\frac{1}{2}$ | G $\frac{3}{4}$ |
| 6561-324 | DN20 | R $\frac{3}{4}$ | G1 |

Material: Copper alloy brass, CW617N (nipple). Copper alloy brass, CW602N (coupling)

3.2.3.2 Gaskets for couplings:

| Article number | Size (coupling) |
|----------------|-----------------|
| 3130-126 | G $\frac{3}{4}$ |
| 3130-127 | G1 |

Material: Reinz AFM30

3.2.3.3 Extension pieces:

| Article number | Description | Length [mm] | Total length [mm] |
|----------------|-----------------------------------|-------------|-------------------|
| 6556-505 | Extension piece G $\frac{3}{4}$ B | 20 | 130 |
| 6556-506 | Extension piece G $\frac{3}{4}$ B | 55 | 165 |
| 6556-507 | Extension piece G1B | 60 | 190 |
| 6556-508 | Extension piece G1B | 90 | 220 |

Material: Copper alloy brass (CW614N)

3.3 Config. A-B

The legal parameters of the meter are determined by Config., which can only be changed before installation when the meter is still in transport state, or after breaking the seal "I (SETUP)" and activating the switch.

The **code A** indicates installation of the flow sensor in inlet or outlet pipe. As the density and specific heat capacity of water varies with temperature, the calculator must compensate for the installation type in question. Wrong configuration or installation will result in a measuring error. Further details on installation of flow sensor in inlet and outlet as far as heat and cooling meters are concerned appear from section 6.5.

The **code B** indicates the measuring unit used for energy registration, GJ, kWh or MWh, as well as the display resolution.

| | A | - | B |
|--------------------------------------|-------------------------|---|---|
| Flow sensor position | | | |
| Inlet | 3 | | |
| Outlet | 4 | | |
| Measuring unit and resolution | | | |
| 00000.01 GJ | 00000.01 m ³ | | 2 |
| 0000.001 GJ | 0000.001 m ³ | | 6 |
| 0000001 kWh | 00000.01 m ³ | | 3 |
| 000000.1 kWh | 0000.001 m ³ | | 7 |
| 0000.001 MWh | 00000.01 m ³ | | 4 |

3.3.1.1 Dependency between measuring unit and resolution

| qP [m ³ /h] | Number of decimals in display | | | | | | |
|---------------------------|-------------------------------|-----|----|----------------|-----|-------------------|----|
| | kWh | MWh | GJ | m ³ | l/h | m ³ /h | kW |
| 0.6 | 0 | 3 | 2 | 2 | 0 | - | 1 |
| 1.5 | 0 | 3 | 2 | 2 | 0 | - | 1 |
| 2.5 | 0 | 3 | 2 | 2 | 0 | - | 1 |
| 0.6 | 1 | - | 3 | 3 | 0 | - | 1 |
| 1.5 | 1 | - | 3 | 3 | 0 | - | 1 |
| 2.5 | 1 | - | 3 | 3 | 0 | - | 1 |

3.4 Config. DDD, Display coding

Display code "DDD" indicates the active readings of each meter type in "User Loop". "1" is the first indication. The display automatically returns to reading "1" after 4 minutes. During normal operation the display readings of the selected DDD-code, which are connected to User loop, are shown. See examples of DDD-codes below.

| User loop (Loop_1) | | Heat meter DDD=217 | Heat/cooling DDD=310 | Heat meter DDD=410 | Cooling meter DDD=510 | Heat/cooling DDD=610 |
|--------------------|---------------------------------|-----------------------|-------------------------|-----------------------|--------------------------|-------------------------|
| 1.0 | Heat energy (E1) | 1 | 1 *) | 1 | | 1 *) |
| 2.0 | Cooling energy (E3) | | 2 *) | | 1 | 2 *) |
| 3.0 | Volume | 2 | 3 | 2 | 2 | 3 |
| 4.0 | Hour counter | 3 | 4 | 3 | 3 | 4 |
| 5.0 | T1 (Inlet) | 4 | 5 | 4 | 4 | 5 |
| 6.0 | T2 (Outlet) | 5 | 6 | 5 | 5 | 6 |
| 7.0 | T1-T2 (Δt) (Cooling shown by -) | 6 | 7 | 6 | 6 | 7 |
| 8.0 | Flow | 9 | 8 | 7 | 7 | 8 |
| 9.0 | Power | 10 | 9 | 8 | 8 | 9 |
| 10.0 | Info Code | 11 | 10 | 9 | 9 | 10 |
| 11.0 | Customer number (N° 1) | 12 | 11 | 10 | 10 | 11 |
| 12.0 | Customer number (N° 2) | 13 | 12 | 11 | 11 | 12 |
| 13.0 | E8 (m³ x T1) | 7 | | | | |
| 14.0 | E9 (m³ x T2) | 8 | | | | |

*) The display order of DDD=3xx and 6xx can either start with "E1-E3" or "E3-E1".

DDD=210/310/410/510/610 are "standard codes" used by default. A complete overview of all created DDD-codes appears from Kamstrup document 5512-1256.

The different loops are described in paragraph 8.

3.5 Energy overview

The above-mentioned energy types E1, E3, E8 and E9 are calculated as follows:

| Formula | Example of application | Condition (country code 6xx only) | |
|--------------------|--|--|------------------------|
| $E1=V1(T1-T2)$ | Heat energy (V1 in inlet or outlet) $T1 > T2$ | $T1 > \theta_{hc}$ (Inlet temperature must be higher than the limit value) | Legal Display/Data/Log |
| $E3=V1(T2-T1)$ | Cooling energy (V1 in inlet or outlet) $T2 > T1$ | $T1 < \theta_{hc}$ (Inlet temperature must be lower than the limit value) | Legal Display/Data/Log |
| $E8=m^3 \times T1$ | Used for calculation of average temperature of inlet pipe | None | Display/Data/Log |
| $E9=m^3 \times T2$ | Used for calculation of average temperature of outlet pipe | None | Display/Data/Log |

θ_{hc} is the temperature, at which the meter shifts between heat and cooling measurement. The typical value is 25 °C, but other values can be supplied as required.

If θ_{hc} is set at 180 °C the function is disconnected, e.g. to be used for "purchase/sale" of heat. See paragraph 7.4 for further information on heat/cooling meters.

3.6 CONFIG >EFGHHMMM<

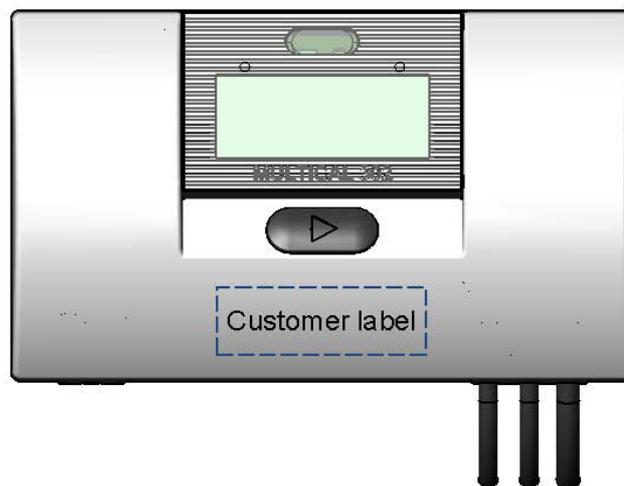
The configuration can only be changed via METERTOOL provided that the seal is broken and the switch activated.

| | E | F | G | HH | MMM |
|---|---|---|---|----|-----|
| Info codes | | | | | |
| Dynamic (Info codes are automatically deleted when the error has been remedied) | 1 | | | | |
| Static (Info codes can only be deleted by means of METERTOOL) | 2 | | | | |
| Wired M-Bus protocol | | | | | |
| Standard frame format *) | | 3 | | | |
| wM-Bus Encryption | | | | | |
| Encryption with common (customer) key | | | 2 | | |
| Encryption with individual key | | | 3 | | |
| wM-Bus protocol | | | | | |
| Mode C1 according to EN 13757 (16 sec. interval), yearly target data | | | | 01 | |
| Mode C1 according to EN 13757 (16 sec. interval), monthly target data | | | | 02 | |
| Mode C1 according to EN 13757 (16 sec. interval), yearly target data incl. E8 and E9 | | | | 11 | |
| Mode C1 according to EN 13757 (16 sec. interval), monthly target data incl. E8 and E9 | | | | 12 | |
| Mode T1 OMS (900 sec. interval), yearly target data | | | | 03 | |
| Mode T1 OMS (900 sec. interval), monthly target data | | | | 04 | |
| Customer label 2012-MMM | | | | | 000 |

*) Monthly data is transmitted by default. Change to yearly data possible by means of an M-Bus command. For further details we refer to the Technical description of M-Bus for MULTICAL® 302.

3.6.1 Customer label

In lower middle part of the meter an area of 15 x 38 mm is reserved for customer labels, e.g. utility logo, bar code, serial number or similar according to customer requirements. Unless otherwise specified in the order, MULTICAL® 302 will be supplied with customer label no. 2012-000, which comprises the meter's customer number.



Please contact Kamstrup for creation of new customer labels.

3.6.2 Configuration data

In addition to Config. >EFGHHMMM< values must be entered in the below-mentioned fields during production of MULTICAL® 302. Unless otherwise specified in the order, MULTICAL® 302 will be supplied with "Automatic" and "Default" data as listed below.

| | Automatic | To be stated in order | Default |
|--|--|--|--|
| Serial number (S/N) *) and year (year, however, only on the front) | 67,000,000/2013 | - | - |
| Customer No. Display No. 1 = 8 digits MSD Display No. 2 = 8 digits LSD | - | Up to 16 digits In the order system limited to 11 digits due to PcBase compatibility | Customer number = S/N |
| Target date | - | MM=1-12 and DD=1-28 | Dep. on country code setup |
| Average time of max. P and Q | - | 1...1440 min. | 60 min. |
| θ_{hc} Heat/cooling shift Only active with country code 6xx See paragraph 7.4 for functionality | - | 0.01...150.00 °C. $\theta_{hc} = 180.00$ °C switches off the function so that the meter can be used for "purchase/sale" of heat | Heat meter 2XX: 180.00 °C Heat/cooling 3XX: 180.00 °C Cooling meter 5XX: 180.00 °C Heat/cooling 6XX: 25.00 °C |
| Date/time | YYYY.MM.DD/hh.mm.ss GMT+offset acc.to del. code | GMT ± 12.0 hours (30 min. in leaps) | - |
| M-Bus primary addr. | | Address 0-250 | Deduced from the last 2-3 digits of the customer number |
| M-Bus ID-No. (used for secondary address) | | | Customer No. |
| wM-Bus ID-No. | | | Serial number |

*) S/N 67,000,000 to 68,499,999 have been reserved for MC302

3.6.3 Other functions

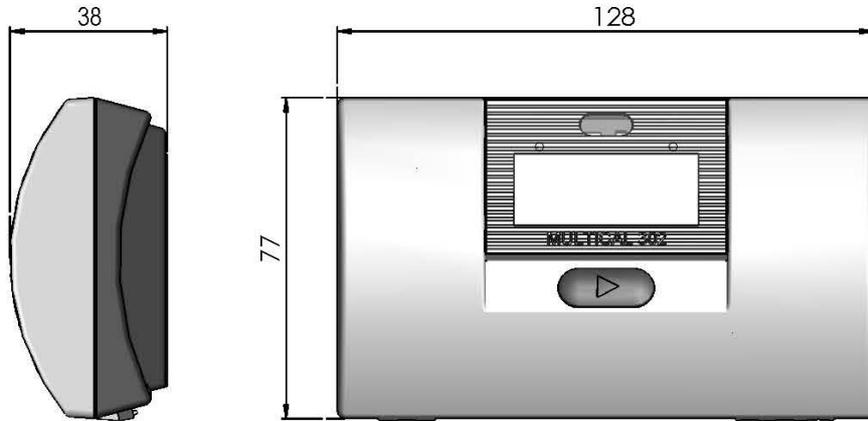
Creating an order in BOS you can choose "fixed M-Bus addr" which means that all meters included in the order in question will be configured with the same M-Bus address.

3.6.4 Internal configuration overview

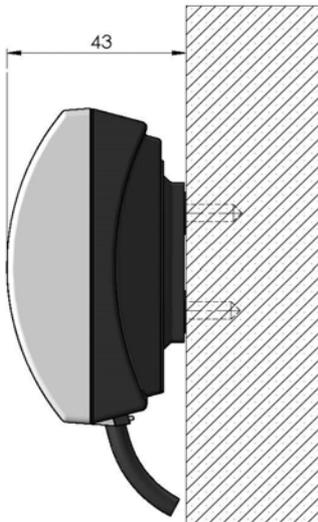
See instructions no. 5508-825 concerning update of configuration.

4 Dimensioned sketches

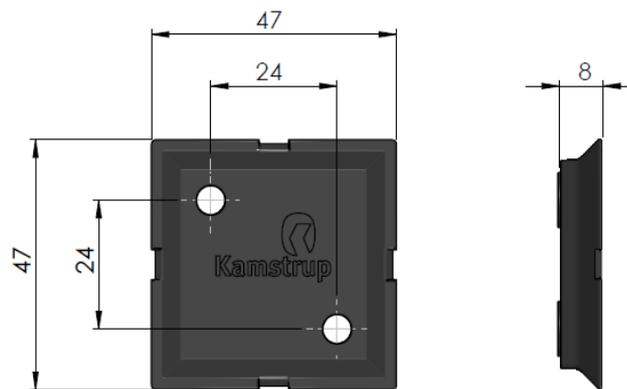
Calculator



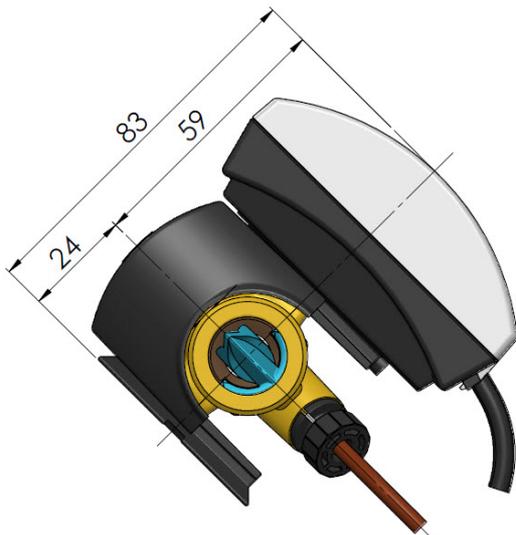
Wall-mounted calculator



Wall fitting for calculator

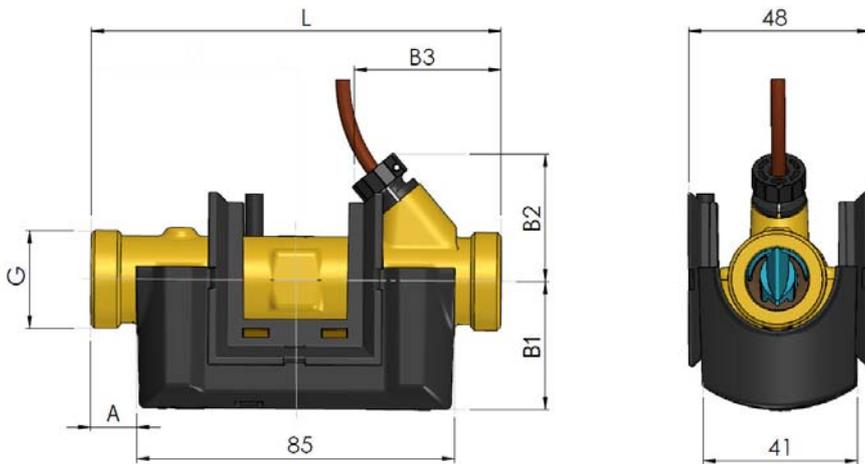


MULTICAL® 302 mounted on flow sensor

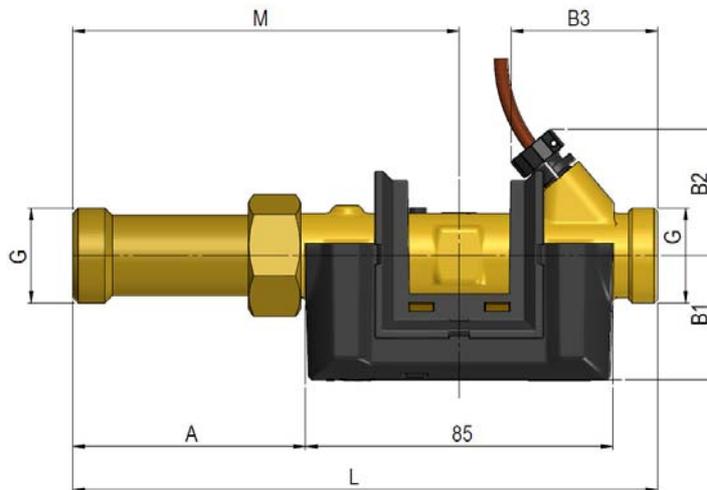


All measurements in [mm]

Flow sensor



| Thread | L | A | B1 | B2 | B3 | Approx. weight [kg] *) |
|--|-----|----|----|----|----|------------------------|
| G ³ / ₄ B (R ¹ / ₂) | 110 | 12 | 35 | 35 | 40 | 0.7 |
| G1B (R ³ / ₄) | 130 | 22 | 38 | 38 | 50 | 0.8 |



| Thread | L | M | A | B1 | B2 | B3 | Approx. weight [kg] *) |
|--|-----|-----|-----|----|----|----|------------------------|
| G ³ / ₄ B (R ¹ / ₂) | 130 | 73 | 30 | 35 | 35 | 40 | 0.8 |
| G ³ / ₄ B (R ¹ / ₂) | 165 | 109 | 66 | 35 | 35 | 40 | 0.8 |
| G1B (R ³ / ₄) | 190 | 124 | 81 | 38 | 38 | 50 | 1.0 |
| G1B (R ³ / ₄) | 220 | 154 | 111 | 38 | 38 | 50 | 1.1 |

All measurements in [mm]

*) The weight indication comprises the whole meter incl. flow sensor, calculator, sensor pair and 2 x A batteries. Enclosed accessories such as couplings, nipples and sensor pockets, if any, as well as packing are not included in the weight indication.

5 Pressure loss

Pressure loss in a flow sensor is stated as max. pressure loss at q_p . According to EN 1434 maximum pressure must not exceed 0.25 bar.

The pressure loss in a sensor increases with the square of the flow and can be stated as:

$$Q = kv \times \sqrt{\Delta p}$$

where:

Q = volume flow rate [m^3/h]

kv = volume flow rate at 1 bar pressure loss [m^3/h]

Δp = pressure loss [bar]

| Graph | q_p [m^3/h] | Housing | Nom. diameter [mm] | $\Delta p@q_p$ [bar] | kv | $Q@0.25$ bar [m^3/h] |
|-------|----------------------|----------------|-----------------------|-------------------------|------|-----------------------------|
| A | 0.6 | G3/4B x 110 mm | DN15 | 0.02 | 4.89 | 2.4 |
| A | 1.5 | G3/4B x 110 mm | DN15 | 0.09 | 4.89 | 2.4 |
| B | 1.5 | G1B x 130 mm | DN20 | 0.07 | 5.71 | 2.9 |
| C | 2.5 | G1B x 130 mm | DN20 | 0.09 | 8.15 | 4.1 |

Table 2: Approximated pressure loss table

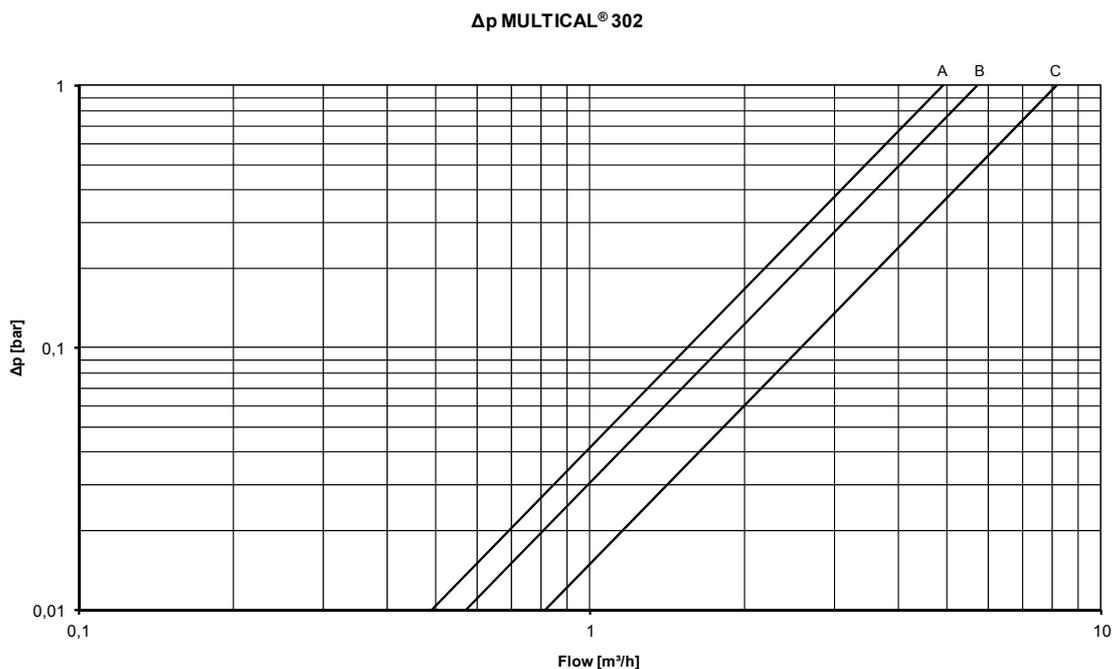


Diagram 2: Pressure loss graphs

5.1 Calculation of pressure loss

The pressure loss at a given water flow can be calculated as: $\Delta p = (Q/kv)^2$.

Example: a q_p 1.5 meter with a current flow of 0.5 m^3/h : $\Delta p = (0.5/5)^2 = 0.01$ bar

6 Installation

6.1 Installation requirements

Prior to installation of MULTICAL® 302 the heating system should be flushed while a fitting piece replaces the meter. Remove the adhesive wafers from the meter's inlet and outlet and mount the flow sensor with couplings. New fibre gaskets in original quality must be used. The flow sensor must be mounted with the arrow pointing in the flow direction.

If other couplings than the original ones from Kamstrup A/S are used you must make sure that the threaded lengths of the couplings do not prevent proper tightening of the sealing surface.

Correct mounting of flow sensor in inlet or outlet appears from the display.



Example of display reading if the meter is configured for "flow sensor in inlet pipe"



Example of display reading if the meter is configured for "flow sensor in outlet pipe"

In order to prevent cavitation the operating pressure at the flow sensor must be min. 1 bar at qp and min. 2 bar at qs. This applies to temperatures up to approx. 80 °C. See paragraph 6.4 for further information on operating pressure.

When the installation has been completed, water flow can be turned on. The valve on the inlet side of the flow sensor must be opened first.

The flow sensor must not be exposed to lower pressure than the ambient pressure (vacuum).

Permissible operating conditions

Ambient temperature: 5...55 °C (indoors). Max. 30 °C for optimum battery lifetime.

Temperature of medium: 2...130 °C with calculator mounted on a wall
15...90 °C with calculator mounted on flow sensor

System pressure: 1...16 bar or 1...25 bar depending on the meter's marking

Service

When the meter has been mounted in the heating system neither welding nor freezing is allowed. Dismount the meter from the heating system before starting such work.

In order to facilitate replacement of the meter, closing valves should be mounted on both sides of the meter.

Under normal operating conditions no pipe strainer is required in front of the meter.

6.2 Installation angle of MULTICAL® 302

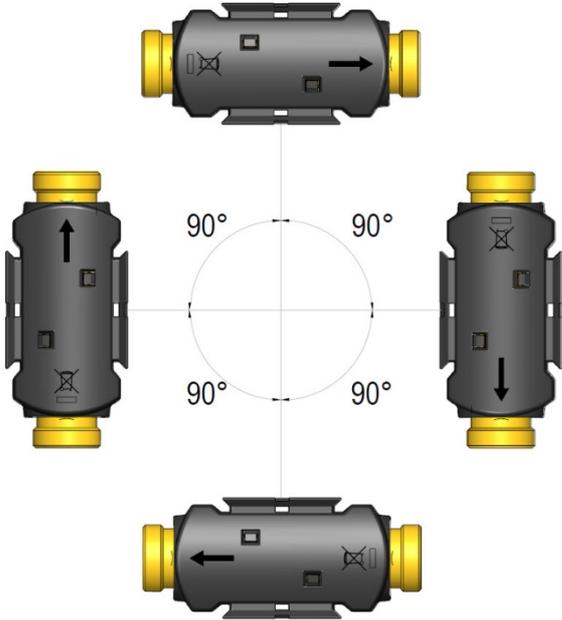


Figure 1

MULTICAL® 302 can be installed horizontally, vertically, or at an angle.

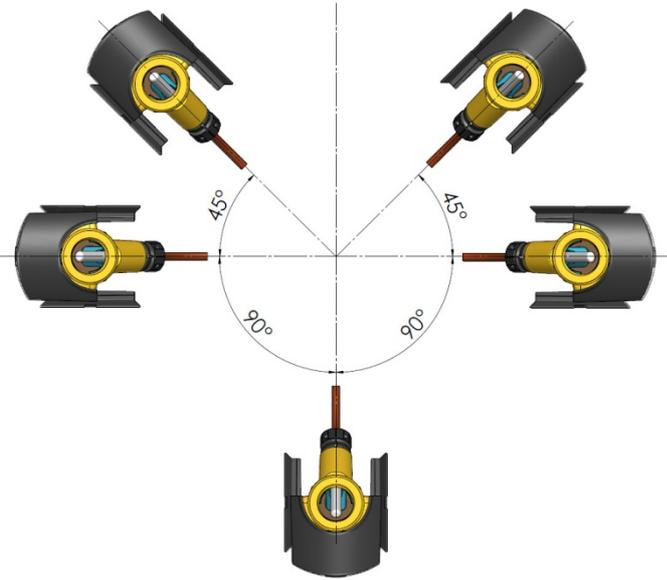


Figure 2

Important!
MULTICAL® 302 may be turned upwards to max. 45° and downwards to max. 90° compared to the pipe axis.

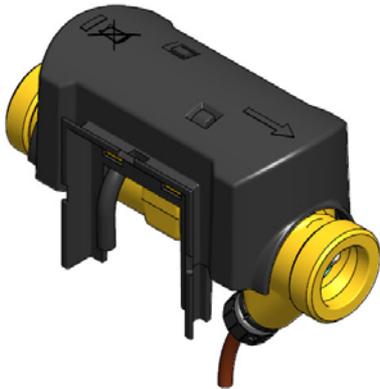


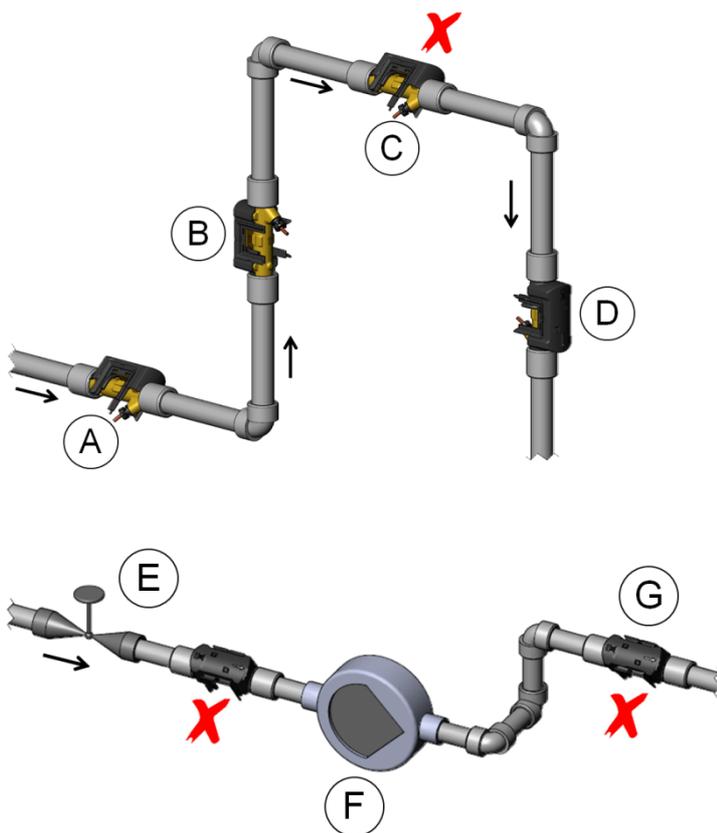
Figure 3

Important!

The meter is most sensitive to air bubbles in the water when the plastic case points upwards. Therefore, this mounting position ought only to be used in installations with high operating pressure and automatic ventilation, like e.g. direct connected district heating.

6.3 Straight inlet

MULTICAL® 302 requires neither straight inlet nor straight outlet in order to fulfil the Measuring Instruments Directive (MID) 2004/22/ EC and EN 1434:2007. A straight inlet section will only be necessary in case of heavy flow disturbances before the meter. We recommend you to follow the guidelines of CEN CR 13582. Optimal position can be obtained if you take the below-mentioned installation methods into consideration:



- A Recommended flow sensor position
- B Recommended flow sensor position
- C Unacceptable position due to risk of air build-up
- D Acceptable position in closed systems
- E A flow sensor should not be placed immediately after a valve, except for block valves, which must be fully open when not used for blocking
- F A flow sensor should not be placed close to the inlet side of a pump
- G A flow sensor should not to be placed close to a two-level double bend.

Figure 4

For general information concerning installation see CEN report *DS/CEN/CR 13582, Heat meter installation*. Instructions in selection, installation and use of heat meters.

Installation examples:

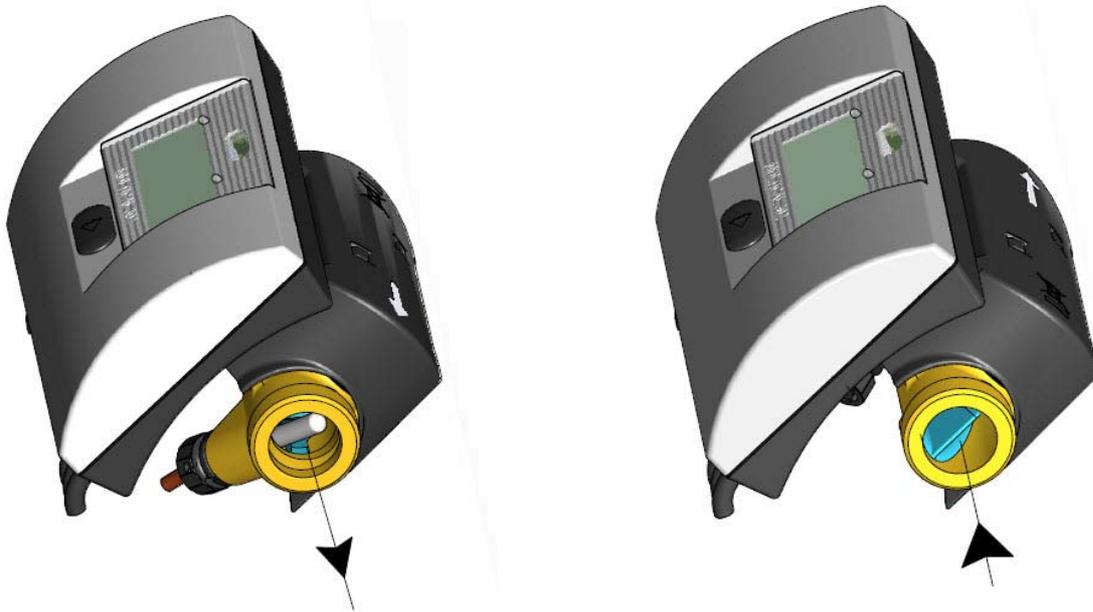
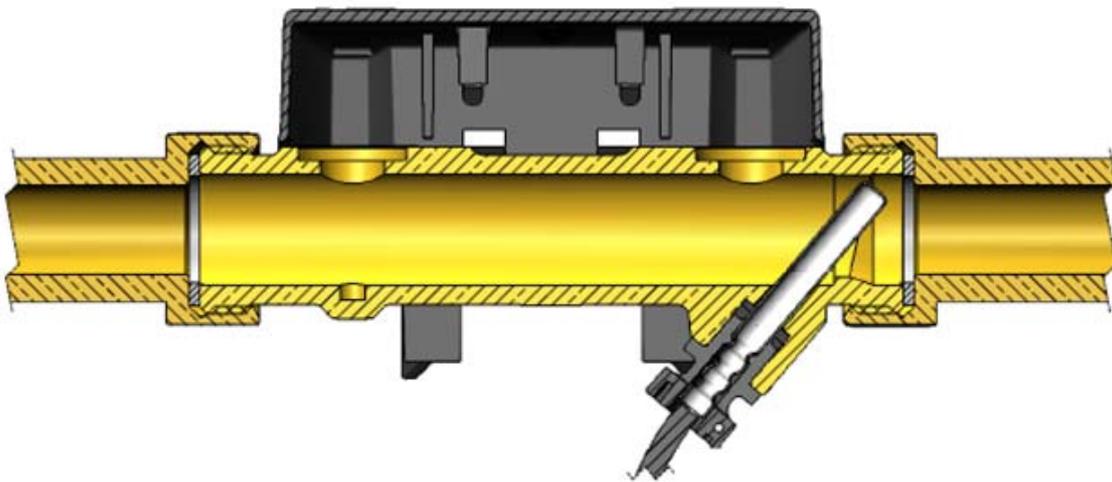


Figure 5: Threaded meter



Mounting of couplings as well as temperature sensor mounted in MULTICAL® 302 flow sensor.

Flow and temperature sensor can be installed in both PN16 and PN25 installations. Enclosed couplings, if any, are only intended for PN16. Suitable PN25 couplings must be used for PN25 installations.

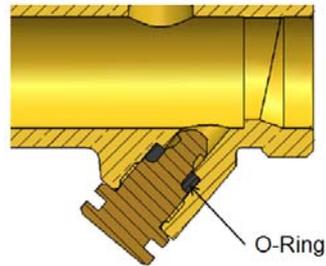
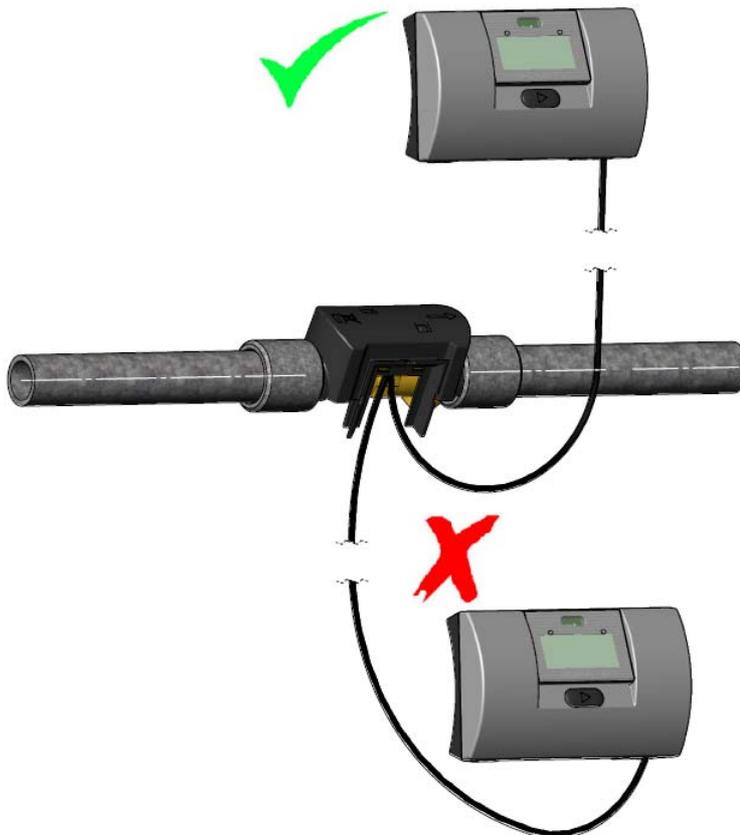


Figure 6

A blind plug, which can be used if the temperature sensor is removed from the flow sensor and e.g. installed in a sensor pocket, is available.

6.4 Position of calculator

If the flow sensor is mounted in a humid or condensing environment, the calculator must be placed in a higher position than the flow sensor.



6.5 Operating pressure of MULTICAL® 302

In connection with installations it has proved practical to work with minimum the pressure mentioned below:

| Nominal flow q_p [m ³ /h] | Recommended back pressure [bar] | Max. flow q_s [m ³ /h] | Recommended back pressure [bar] |
|---|---------------------------------------|--|---------------------------------------|
| 0.6 | 1 | 1.2 | 2 |
| 1.5 | 1 | 3 | 2 |
| 2.5 | 1 | 5 | 2 |

Table 3

The purpose of recommended back pressure is to avoid measuring errors as a result of cavitation or air in the water.

It is not necessarily cavitation in the sensor itself, but also bubbles from cavitating pumps and regulating valves mounted before the sensor. It can take some time until such bubbles have been dissolved in the water.

Furthermore, water can include dissolved air. The amount of air which can be dissolved in water depends on pressure and temperature. This means that air bubbles can be formed due to falling pressure, e.g. caused by a velocity rise in a contraction above the sensor.

The risk of these factors affecting accuracy is reduced by maintaining a fair pressure in the system.

In relation to above table, the steam pressure at the current temperature must also be taken into consideration. Table 3 applies to temperatures up to approx. 80 °C. Furthermore, it must be taken into account that the above-mentioned pressure is the back pressure at the sensor, and that the pressure is lower in a contraction than before one (cones among other things). This means that pressure measured elsewhere in the system may be different from the pressure at the sensor.

This can be explained by combining the continuity equation and Bernoulli's equation. The total energy from the flow will be the same at any cross section. It can be reduced to: $P + \frac{1}{2}\rho v^2 = \text{constant}$.

When dimensioning a flow sensor you must take this into account, especially if the sensor is used within the scope of EN 1434 between q_p and q_s , and in case of heavy contractions of the pipe.

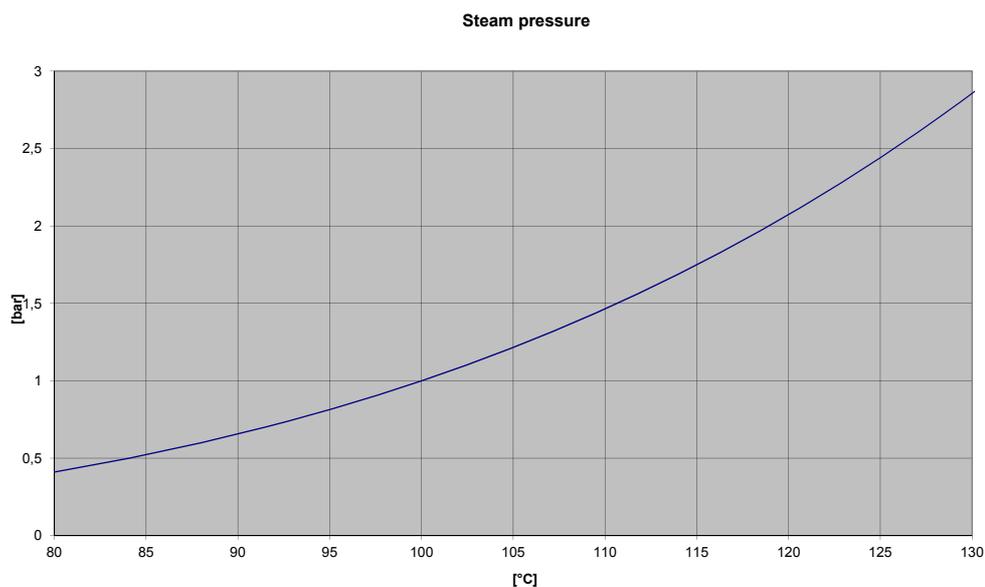
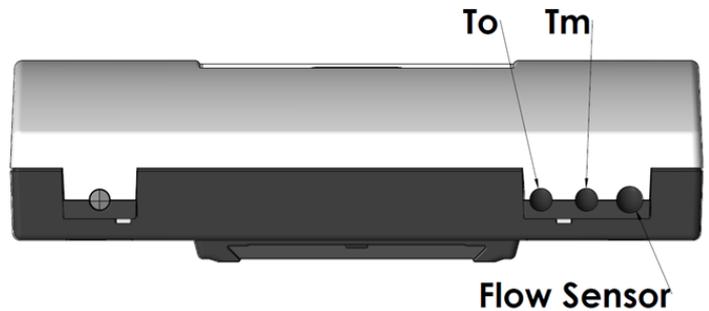
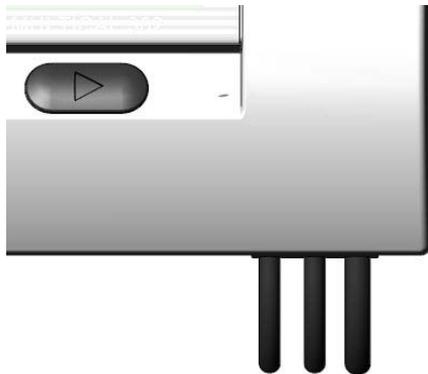


Diagram 3

6.6 Mounting in inlet or outlet pipe



In one side of the meter three cables appear. One cable is connected to the flow sensor. The other two cables are temperature sensors, connected to the meter. If one temperature sensor is mounted in the flow sensor, this sensor is called Tm and the other sensor is called To. See examples below:

| | |
|------------------------------|--------------------------|
| Config. number | A |
| | <input type="checkbox"/> |
| Flow sensor position: | |
| - Inlet | 3 |
| - Outlet | 4 |

MULTICAL® 302 is configured for flow sensor mounted in either inlet or outlet pipe. The table below indicates installation conditions of:

- ◆ Heat meters
- ◆ Cooling meters
- ◆ Heat/cooling meters

| Formula | k-factor | Config. | Hot pipe | Cold pipe | Installation |
|--|---------------------------|----------------------------------|----------------------------|----------------------------|--------------|
| Heat meter $E1 = V1(T1 - T2)k$ | k-factor for T1 in inlet | A=3 (Flow sensor in inlet pipe) | V1 and T1(T _M) | T2(T ₀) | |
| | k-factor for T2 in outlet | A=4 (Flow sensor in outlet pipe) | T1(T ₀) | V1 and T2(T _M) | |

| | | | | | |
|---|---------------------------|----------------------------------|----------------------------|----------------------------|--|
| Cooling meter $E3=V1(T2-T1)k$ | k-factor for T1 in outlet | A=3 (Flow sensor in inlet pipe) | T2(T _o) | V1 and T1(T _M) | |
| | k-factor for T2 in inlet | A=4 (Flow sensor in outlet pipe) | V1 and T2(T _M) | T1(T _o) | |

6.7 EMC conditions

MULTICAL® 302 has been designed and CE-marked according to EN 1434 Class A (corresponding to Electromagnetic environment: Class E1 of the Measuring Instruments Directive) and can thus be installed in both domestic and industrial environments.

All control cables must be drawn separately and not parallel to e.g. power cables or other cables with the risk of inducing electromagnetic interference. There must be a distance of min. 25 cm between signal cables and other installations.

6.8 Climatic conditions

MULTICAL® 302 is designed for indoor installation in non-condensing environments with ambient temperatures from 5...55 °C, but max. 30 °C for optimum battery lifetime. However, the flow sensor is specially protected against humidity and tolerates condensing environment.

Protection class IP65 for the calculator allows splashes of water, but the calculator does not withstand permanent water/humidity impact or submergence.

Protection class IP68 for the flow sensor allows permanent condensation and submergence.

7 Calculator functions

7.1 Measuring sequences

MULTICAL® 302 uses time-based integration, which means that calculations of accumulated volume and energy are carried out at fixed time intervals independent of current water flow. In normal mode the integration interval of MULTICAL® 302 is 32 sec., whereas the interval is 8 sec. in "fast mode".

"Transport state"

In "Transport state" MULTICAL® 302 runs through an integration sequence of 96 sec., which minimizes the power consumption during transport.

"Normal mode"

In "normal mode" MULTICAL® 302 passes through an integration sequence of 32 sec. During this sequence water flow is measured at 4-second intervals. Inlet and outlet temperatures are measured in the middle of the sequence and at the end of the sequence energy and volume are calculated. All display readings are updated at 32-second intervals.

"Fast mode"

In "fast mode" MULTICAL® 302 passes through an 8-second integration sequence. During this sequence water flow is measured at 2-second intervals. Inlet and outlet temperatures are measured in the middle of the sequence and at the end of the sequence energy and volume are calculated. All display readings are updated at 8-second intervals.

"Test mode"

In "test mode" MULTICAL® 302 passes through a 4-second integration sequence. During this sequence water flow is measured at half-second intervals. Inlet and outlet temperatures are measured in the middle of the sequence and at the end of the sequence energy and volume are calculated. All display readings are updated at 4-second intervals.

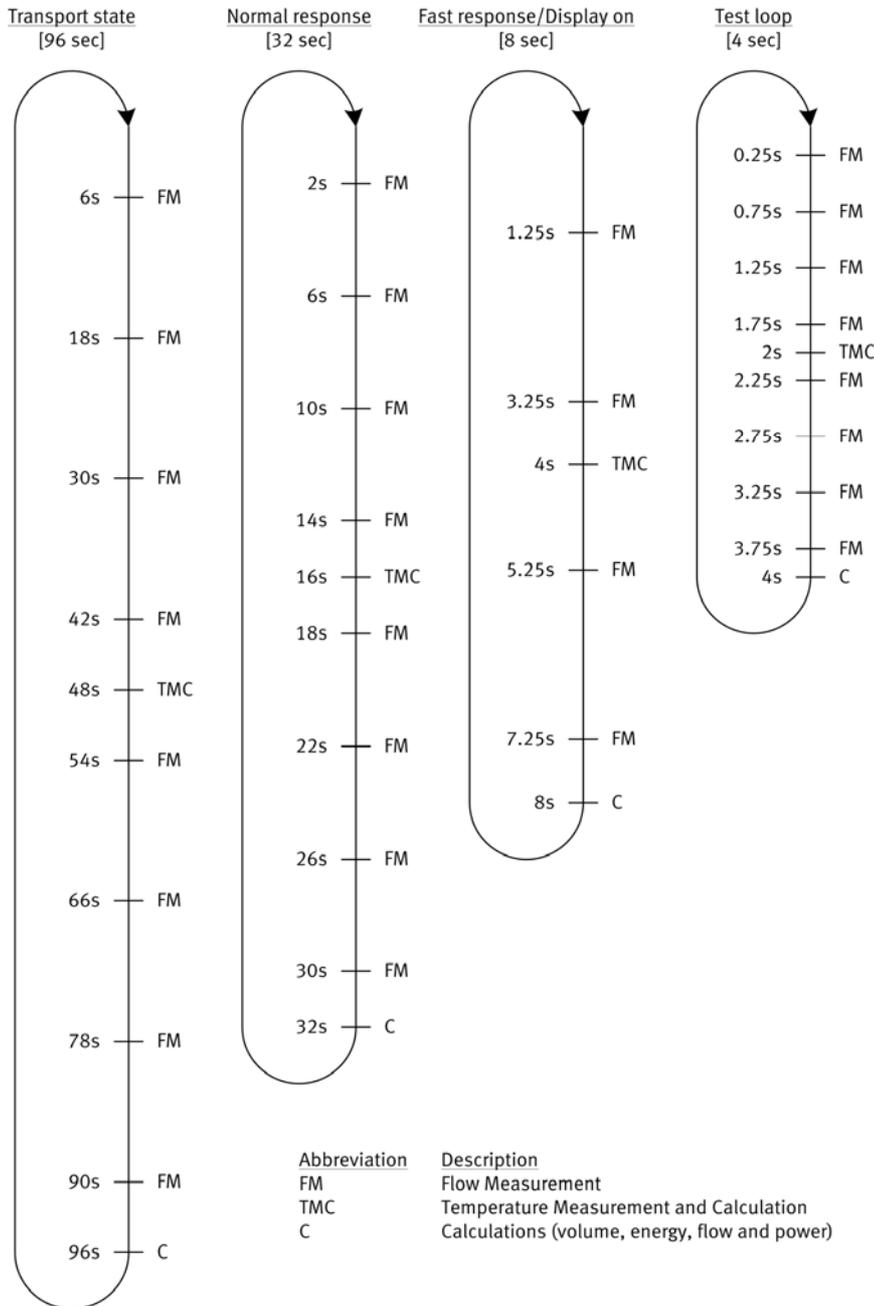
If you press the front button for 5 seconds the display reverts to energy reading. Alternatively, the display reverts to energy reading after 9 hours in test mode.

"Display on"

Press the front button to switch on the display. If you leave the display at other readings than energy, it automatically reverts to the primary energy indication after 4 minutes, and after 4 more minutes without touching the button the display switches off.

Tolerance of time indications

The timing of the measuring sequences can vary approx. $\pm 3\%$ in order to secure correct synchronisation with data communication.



| Display loop | Mode | Measuring sequence |
|--------------|--|--------------------|
| Display off | Normal mode (Type number 302-x-xx-1 and -2) | 32 sec. |
| | Fast mode (Type number 302-x-xx-3) | 8 sec. |
| USER loop | Fast mode | 8 sec. |
| TECH loop | | |
| SETUP loop | | |
| TEST loop | Test mode | 4 sec. |

7.2 Energy calculation

MULTICAL® 302 calculates energy on the basis of the formula stated in EN 1434-1:2007, which uses the international temperature scale issued in 1990 (ITS-90) and the pressure definition of 16 bar.

In a simplified form the energy calculation can be expressed as: $\text{Energy} = V \times \Delta\Theta \times k$. The calculator always calculates energy in [Wh], and then converts the value to the selected measuring unit.

| | |
|-----------|---|
| E [Wh] = | $V \times \Delta\Theta \times k \times 1,000$ |
| E [kWh] = | $E [\text{Wh}] / 1,000$ |
| E [MWh] = | $E [\text{Wh}] / 1,000,000$ |
| E [GJ] = | $E [\text{Wh}] / 277,780$ |

v is the added (or simulated) water volume
in m^3

$\Delta\Theta$ is the measured temperature difference

Heat energy (E1):

$\Delta\Theta = \text{inlet temperature} - \text{outlet temperature}$

Cooling energy (E3):

$\Delta\Theta = \text{outlet temperature} - \text{inlet temperature}$

Both in the display and during data reading each energy type is uniquely defined, e.g.

Heat energy: $E1 = V1(T1-T2)k$



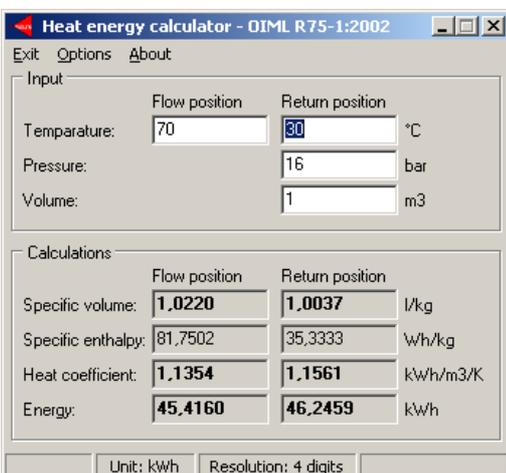
Cooling energy: $E3 = V1 (T2-T1)k$



k is the heat coefficient of water, which is calculated according to the formula of EN 1434-1:2007 (identical with the energy formula of OIML R75-1:2002)

Note: In case of temperature sensor error $\Delta\Theta$ is set at 0.00 K, which causes the meter's energy calculation to stop. A sensor error also stops volume accumulation. Energy calculation and volume accumulation continue as soon as the error has been remedied. Please note that the error will remain visible in the info-event-counter if static info codes have been selected (until the error has been deleted via METERTOOL), although the error has been corrected and the meter counts again.

Kamstrup can supply an energy calculator for check measurement:

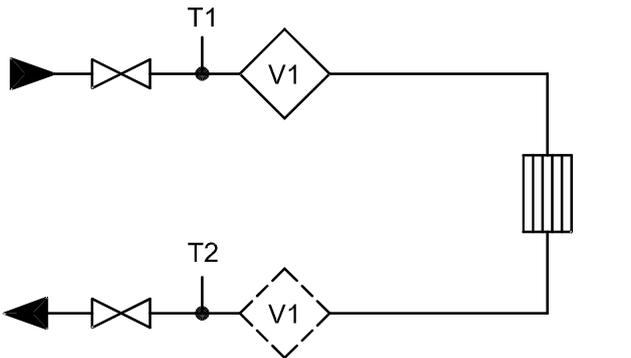
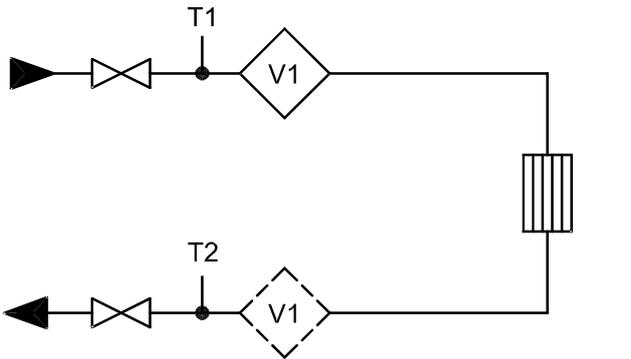
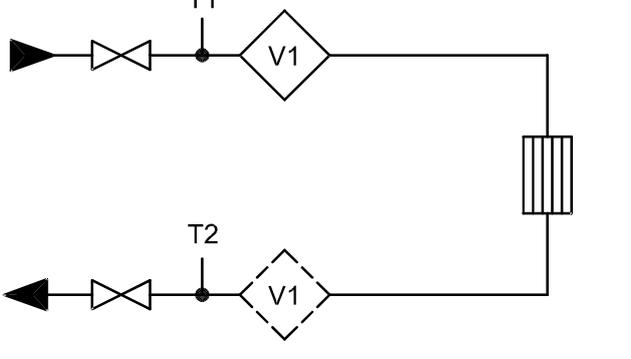


7.3 Application types

MULTICAL® 302 operates with 4 different energy formulas, E1, E3, E8 and E9, which are all calculated parallel with each integration no matter how the meter is configured. E8 and E9 are used as basis for calculation of average temperatures in inlet and outlet pipes only, whereas E1 and E3 are used for heat and cooling measurement respectively.

7.3.1 E1 and E3

Energy types E1 and E3 are described by application examples below.

| | |
|--|--|
|  <p>302-Txxxxxx2xx</p> | <p>Application A</p> <p>Closed heating system with one flow sensor</p> <p>Heat energy: $E1 = V1(T1-T2)k_{T1:Inlet \text{ or } T2:Outlet}$</p> <p>Flow sensor V1 is placed in inlet or outlet as selected during Config.</p> |
|  <p>302-Txxxxxx5xx</p> | <p>Application B</p> <p>Closed cooling system with one flow sensor</p> <p>Cooling energy: $E3 = V1(T2-T1)k_{T2:Inlet \text{ or } T1:Outlet}$</p> <p>Flow sensor V1 is placed in inlet or outlet as selected during Config.</p> |
|  <p>302-Txxxxxx3xx 302-Txxxxxx6xx</p> | <p>Application C</p> <p>Closed heat/cooling system with one flow sensor</p> <p>Heat energy: $E1 = V1(T1-T2)k_{T1:Inlet \text{ or } T2:Outlet}$</p> <p>Cooling energy: $E3 = V1(T2-T1)k_{T2:Inlet \text{ or } T1:Outlet}$</p> <p>Flow sensor V1 is placed in inlet or outlet as selected during Config.</p> |

7.3.2 E8 and E9

E8 and E9 are used as a basis for calculation of volume-based average temperatures in inlet and outlet pipes respectively. With every volume increase (every 0.01 m³ or 0.001 m³) the registers are increased by the product of m³ x °C, which makes E8 and E9 suitable for calculation of volume-based average temperature.

E8 and E9 can be used for average calculation during any period of time as long as the volume register is read at the same time as E8 and E9.

E8 = m³ x tF

E8 is increased by the product of m³ x T1



E9 = m³ x tR

E9 is increased by the product of m³ x T2



Resolution of E8 and E9

E8 and E9 depend on the resolution of volume (m³)

| Volume resolution | Resolution of E8 and E9 |
|-------------------------|--------------------------|
| 0000.001 m ³ | m ³ x °C x 10 |
| 00000.01 m ³ | m ³ x °C |

Example 1: Within a year a heating installation has used 250.00 m³ district heating water and the average temperatures have been 95 °C in inlet and 45 °C in outlet.
E8 = 23750 and E9 = 11250.

Example 2: The average temperatures are to be measured together with the yearly reading. Therefore, E8 and E9 are included in the yearly reading.

| Date of reading | Volume | E8 | Average of inlet pipe | E9 | Average of outlet pipe |
|--------------------|-----------------------|-------|-----------------------------------|-------|-----------------------------------|
| 2012.06.01 | 534.26 m ³ | 48236 | | 18654 | |
| 2011.06.01 | 236.87 m ³ | 20123 | | 7651 | |
| Yearly consumption | 297.39 m ³ | 28113 | 28113/297.39 = 94.53 °C | 11003 | 11003/297.39 = 36.99 °C |

Table 4

7.4 Combined heat/cooling metering

MULTICAL® 302 is available as heat meter (meter type 2xx or 4xx), cooling meter (meter type 5xx) or combined heat/cooling meter (meter type 3xx or 6xx).

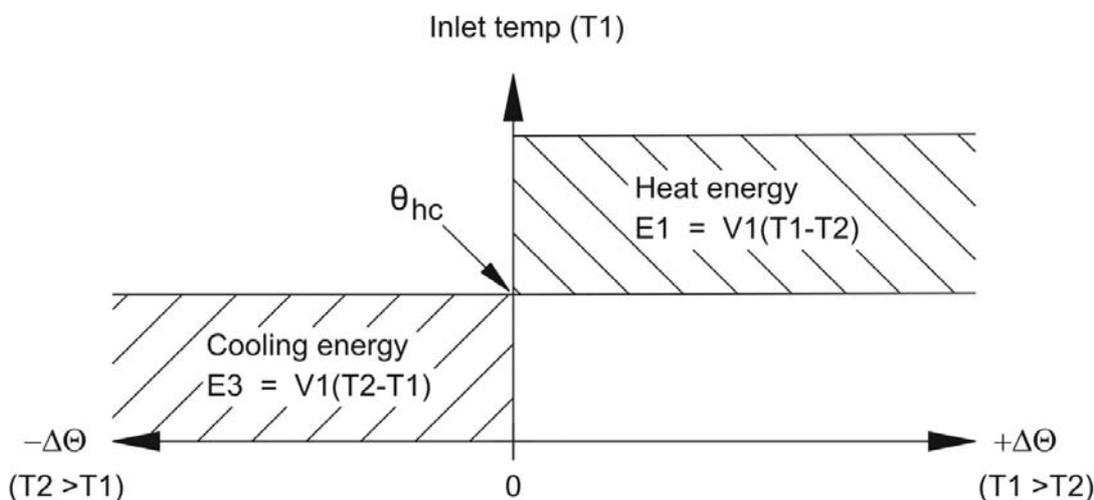
| Meter type | | | | |
|---|------------------------------------|----------------------------|---|--|
| Heat meter | MID approved as heat meter | $\theta_{hc} = \text{OFF}$ | 2 | |
| Heat/cooling meter | MID approved as heat meter | $\theta_{hc} = \text{OFF}$ | 3 | |
| Heat meter | With national approval | $\theta_{hc} = \text{OFF}$ | 4 | |
| Cooling meter | E.g. PTB approved as cooling meter | $\theta_{hc} = \text{OFF}$ | 5 | |
| Heat/cooling meter | Without approval marking | $\theta_{hc} = \text{ON}$ | 6 | |
| Country code (language on label etc.) Characters can be used. | | | | |

If MULTICAL® 302 has been supplied as a combined heat/cooling meter (meter type 3xx or 6xx), it measures heat energy (E1) at a positive temperature difference ($T1 > T2$), whereas it measures cooling energy (E3) at a negative temperature difference ($T2 > T1$).

7.4.1 Heat/cooling cutoff function

Meter type 6xx has a cutoff function, which ensures that heat energy is only measured if the inlet temperature exceeds a preprogrammed temperature (θ_{hc}) and correspondingly that cooling energy is only measured if the inlet temperature is lower than the preprogrammed temperature.

θ_{hc} is the temperature point used to shift between heat and cooling measurement. θ_{hc} is configurable within temperature range 0.01...150.00 °C.



If current $T1$ exceeds or equals θ_{hc} , only heat energy can be measured. If current $T1$ is lower than or equals θ_{hc} , only cooling energy can be measured.

In combined heat/cooling meters θ_{hc} should correspond to the highest occurring inlet temperature in connection with cooling, e.g. 25 °C. If the meter is to be used for "purchase and sale of heat", θ_{hc} is set at 180.00 °C, which cancels the θ_{hc} function.

If you want to switch the q_{hc} function on or off compared to current condition, it is necessary to perform a total programming of the meter by means of METERTOOL.

The change between heat and cooling measurement involves no hysteresis ($\Delta\theta_{hc} = 0.00 \text{ K}$).

θ_{hc} is configured by means of METERTOOL (see paragraph 15).

7.5 Max. flow and max. power

MULTICAL® 302 registers maximum flow values and maximum power values on a yearly as well as a monthly basis. The registration can be read via data communication or via the display in "TECH mode".

Max. registration includes the following flow and power values with indication of date:

| |
|---|
| Type of registration: |
| Max. this year (since latest target date MM.DD) |
| Max. yearly data, up to latest 15 years |
| Max. this month (since latest target date DD) |
| Max. monthly data, up to latest 24 months |

All max. values are calculated as the highest average of a number of current flow or power measurements. The average period used for all calculations can be selected in the interval 1...1440 min. in one minute leaps. (1,440 min. = 24 hours).

Average period and target date must be stated in the order or reconfigured by means of METERTOOL. Unless otherwise stated in the order, average period will be set at 60 min. and the target date applying to the selected delivery code will be used, normally the first day of each month or first January every year.

At the end of a year or a month max. values are saved in the data logger, and the current max. registers are "reset" according to selected target date and the meter's internal clock and calendar.

Date of this month's max. power



Value of this month's max. power



Lines above and below the month indication show that monthly data are displayed.

Example of max. power on a monthly basis

Date of this year's max. flow



Value of this year's max. flow



Lines above and below the year indication show that yearly data are displayed.

Example of max. flow on a yearly basis

7.6 Temperature measurement

Inlet and outlet temperatures are measured by means of an accurately matched Pt500 sensor pair. During each temperature measurement MULTICAL® 302 sends measuring current through each sensor. For Pt500 the current is approx. 0.5 mA. Two measurements are carried out in order to suppress mains voltage picked up via sensor cables (50 Hz or 60 Hz, depending on country code). Furthermore, current measurements are made by internal reference resistors in order to secure optimum measuring stability.

The display presents inlet and outlet temperatures as well as temperature difference in the range 0.00 °C to 155.00 °C.

Inlet or outlet temperatures below 0 °C are displayed as 0.00 °C and temperatures above 155 °C are displayed as 155.00 °C. When the temperature sensors are outside measuring range, Info=8 (inlet) or Info=4 (outlet) is set.

At negative temperature difference (inlet < outlet) the temperature difference is displayed with a negative sign and cooling energy is calculated (provided that the meter has been configured for cooling metering).

Note: When Info = 4 or 8, the meter's energy calculation and volume accumulation stop.

7.6.1 Measuring current and power

Measuring current is only sent through the temperature sensors during the short duration of the temperature measurement. The effective power that is deposited in the sensor elements is thus very small, and its influence on self-heating of the temperature sensors is less than 1/1000 K.

| | Pt500 |
|---|------------|
| Measuring current | < 0.5 mA |
| Measuring period | < 12 msec. |
| Peak power | < 200 µW |
| RMS influence ("fast mode") | < 0.5 µW |
| RMS influence ("normal mode") | < 0.08 µW |

7.6.2 Average temperatures

MULTICAL® 302 currently calculates the average temperatures of inlet and outlet (T1 and T2) in °C without decimals. The background calculations E8 and E9 (m³ x T1 and m³ x T2) are carried out with every volume increase (every 0.01 m³ or 0.001 m³ determined by the meter's configuration). The display is updated every day at midnight. The average temperatures are thus volume weighted and can be used directly for checking purposes.

| <i>Type of registration:</i> | <i>Average</i> | <i>Yearly data</i> | <i>Monthly data</i> |
|--|----------------|--------------------|---------------------|
| <i>Year-to-date average (since latest target date MM.DD)</i> | • | • | |
| <i>Month-to-date average (since latest target date DD)</i> | • | | • |



Year-to-date average of T1.

(Current date with a stipulated line under year or month is displayed immediately BEFORE this reading)

7.7 Info codes

MULTICAL® 302 constantly monitors a number of important functions. If a serious error occurs in measuring system or installation, a flashing “info” will appear in the display. The “Info” field keeps flashing as long as the error exists no matter which reading you choose. The “Info” field automatically disappears when the reason for the error has been removed.

However, configuration for “Manual reset of info codes” (static info codes) is possible. If “Manual reset of info codes” has been selected, info codes will remain in the display until they have been manually reset).

7.7.1 Info code types

| Info code | Description | Response time |
|-----------|---|-----------------------------------|
| 0 | No irregularities | - |
| 1 | Supply voltage has been interrupted | - |
| 4 | Temperature sensor T2 outside measuring range | < 32 sec. |
| 8 | Temperature sensor T1 outside measuring range | < 32 sec. |
| 32 | Temperature difference has wrong polarity | < 32 sec. and 0.05 m ³ |
| 128 | Supply voltage too low | < 10 sec. |
| 16 | Flow sensor with weak signal or air | < 32 sec. |
| 2 | Flow sensor with wrong flow direction | < 32 sec. |

If more than one info code appear at a time, the sum of info codes is displayed. If e.g. both temperature sensors are outside measuring range, info code 12 (info codes 4+8) is displayed.

Info codes 4 and 8 are set when the temperature falls below 0.00 °C or exceeds 155.00 °C. Info codes 4 and 8 are also set for short-circuited and disconnected sensors.

Note: If Info = 4 or 8, the meter's energy calculation and volume accumulation stop.

7.7.2 Examples of displayed info codes

Example 1



Flashing "INFO"

If the information code exceeds 0, a flashing "INFO" will appear in the information field.

Example 2



Current information code

Activating the push-button, the current information code is displayed.

Example 3



Info-event-counter

- shows how many times the information code has been changed (only available in Tech-loop).

Example 4



Info logger

If you press the push-button once more, data logger for information code is displayed (only visible in Tech-loop).

First the date of the latest change is shown...

...next the information code set on this date is displayed. In this case there has been a sensor error in temperature sensor T1 on 04 January 2013.



The data logger saves the latest 50 changes. The latest 36 changes can be displayed, and the rest can be read by means of METERTOOL.

Furthermore, the info code is saved in hourly, daily, monthly and yearly logger for diagnostic purposes.

7.7.3 Info-event-counter



Enumeration takes place every time the info code is changed (the info code is added to the info-event counter and data logged when it has remained present for minimum an hour).

The info-event counter of a new meter will be 0 as “transport state” prevents counting during transportation.

| Info code | ”info” in display | Registration in info, hourly, daily, monthly and yearly logger | Enumeration of Info-event |
|-----------|-------------------|--|---|
| 1 | No | Yes | Upon each ”Power-On-Reset” |
| 4, 8 | Yes | Yes | When Info 4 or 8 is set or removed |
| 16, 2 | Yes | Yes | When Info is set and when Info is deleted |
| 32 | Yes | Yes | At wrong temperature difference |
| 128 | Yes | Yes | Battery voltage below 3.0 VDC |

7.7.4 Transport state

The meter leaves the factory in transport state, i.e. the info codes are active in the display, but not in the data logger. This prevents ”info-event” from counting during transportation and non-relevant data from appearing in the info logger. The first time the meter enumerates the volume register after installation, the info code automatically becomes active in the data logger (after one hour).

If the meter has built-in wM-Bus communication, the radio transmitter will be switched off when the meter is in transport state.

7.8 Data loggers

MULTICAL® 302 has a permanent memory (EEPROM), in which the results from various data loggers are saved. The meter includes the following data loggers:

| Data logging interval | Data logging depth | Logged value |
|-----------------------|--|----------------------|
| Yearly logger | 15 years | Counter register • |
| Monthly logger | 24 months | Counter register • |
| Daily logger | 460 days | Counter register • |
| Hourly logger | 960 hours | Counter register • |
| Info logger | 50 Events (36 events can be displayed) | Info code and date |
| Config. logger | 25 config. changes | New config. and date |

Loggers are static ones. Therefore, register types and logging intervals cannot be changed. When the last record has been written into the EEPROM the oldest one will be overwritten.

The meter only permits 25 reconfigurations, which means that the config. logger cannot be overwritten (unless the seal is broken).

7.8.1 Yearly, monthly, daily and hourly loggers

The following registers are logged every year and every month on target date. Furthermore, the daily registers are logged at midnight and the hourly registers are logged every hour.

All the below registers are logged as counter registers.

| Register type | Description | Yearly logger | Monthly logger | Daily logger | Hourly logger |
|---------------------|---|---------------|----------------|--------------|---------------|
| Date (YY.MM.DD.hh) | Logging time: year, month, day and hour | • | • | • | • |
| E1 | Heat energy | • | • | • | • |
| E3 | Cooling energy | • | • | • | • |
| E8 | $E8 = m^3 \times T1$ (inlet) | • | • | - | - |
| E9 | $E9 = m^3 \times T2$ (outlet) | • | • | - | - |
| V | Volume register | • | • | • | • |
| INFO | Information code | • | • | • | • |
| h | Hour counter | • | • | - | - |
| h-INFO | Error hour counter | • | • | - | - |
| DATE FOR MAX. FLOW | Date stamp for max. flow during period | • | • | - | - |
| MAX. FLOW | Value of max. flow during period | • | • | - | - |
| DATE FOR MAX. POWER | Date stamp for max. power during period | • | • | - | - |
| MAX. POWER | Value of max. power during period | • | • | - | - |

7.8.2 Info logger

Every time the information code has remained changed for minimum one hour, date and info code are logged. Thus, it is possible to data read the latest 50 changes of the information code as well as the date the change was made.

| Register type | Description |
|------------------|-----------------------------------|
| Date (YY.MM.DD) | Logging time: year, month and day |
| Info | Information code on above date |
| E1 | Heat energy |
| E3 | Cooling energy |
| Clock (hh.mm.ss) | Time |

If the info logger is read from the display, the latest 36 changes including dates can be read too. All of the 50 changes can be read by means of the PC program LogView.

7.8.3 Config. logger

Every time config. is changed, date, energy and the new config. are logged. Thus, it is possible to data read the latest 25 config. changes as well as the date the change was made. The meter only permits 25 config. changes, unless the legal seal is broken.

| Register type | Description |
|-----------------------|--|
| Date (YY.MM.DD) | Year, month and day of config. change |
| E1 and E3 | Counter values just before reconfiguration |
| Config. ABDDDEFGHHMMM | The new config. number |

8 Display functions

MULTICAL® 302 is fitted with an easily readable LC-display comprising 8 digits, measuring units and an information field. Energy and volume readings use 7 digits and corresponding measuring units, whereas 8 digits are used to display e.g. the meter number.

If the push-button has not been activated for 8 minutes, the display switches off. When the display is off, three lines will appear in the right side of the display every 32 seconds in "normal mode" or every 8 seconds in "fast mode". In order to activate the display you press the push-button.

Basically accumulated energy is displayed. Activating the push-button, the display immediately switches to other readings. The display automatically returns to energy reading four minutes after the latest activation of the push-button, and after four more minutes without activation of the push-button the display switches off in order to save current.

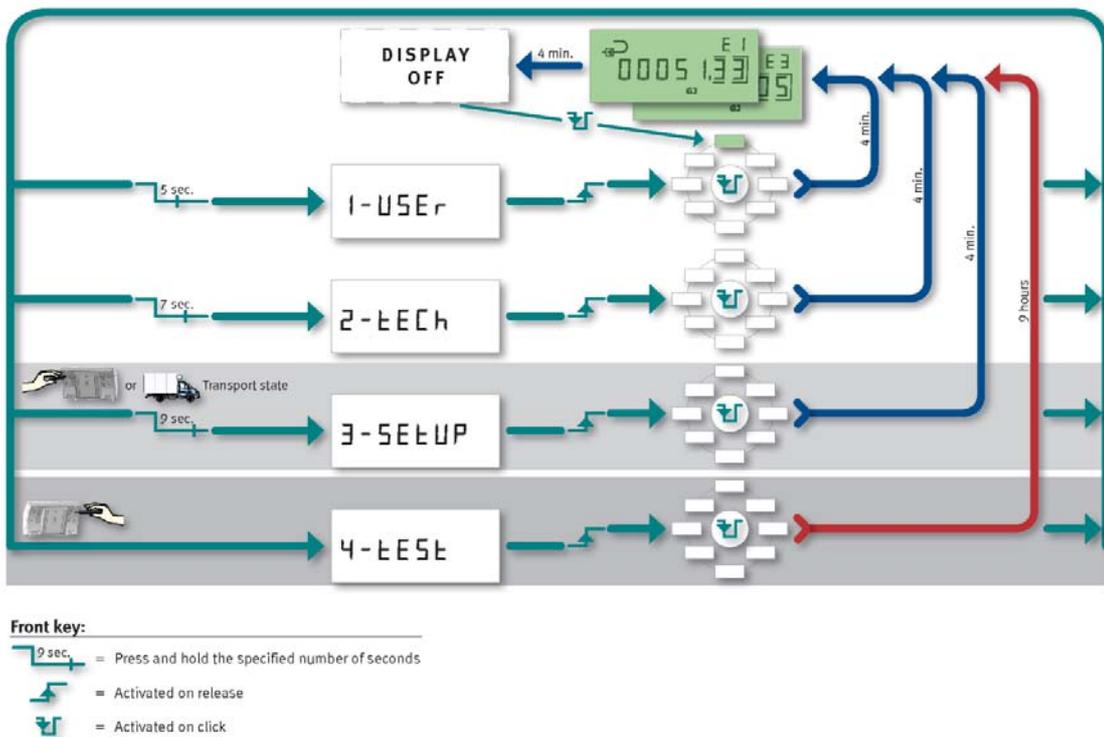
The meter uses four different loops for four different user situations: User loop, Tech loop, Setup loop and Test loop. It is only possible to display one loop at a time.

8.1 Select display loop

By means of the push-button on the front of the meter you can choose between four display loops. No matter which display you have selected you can change to User-loop by pressing the push-button for 5 sec. until "1-User" is displayed and then releasing the button. If the button is pressed for 7 sec. instead, "2-Tech" is displayed, and if you release the push-button now, you have access to Tech loop.

When you receive the meter it is in "Transport State", from which you access Setup loop (depending on country code) by pressing the push-button for 9 seconds and then releasing the button. When the meter has registered its first volume accumulation, either 0.01 m³ (10 L) or 0.001 m³ (1 L) – determined by selected resolution, the meter changes from "Transport State" to "Normal State", from which Setup loop cannot be accessed unless the seal at the back of the meter is broken and the installation switch activated.

There is only access to Test loop if the Test seal is broken and the Test switch activated.



From the three top loops the meter automatically reverts to energy (heat energy or cooling energy, depending on the meter's configuration) 4 min. after the last activation of the push-button.

The individual display loops are described below.

8.2 USER loop

User loop is the primary loop, which is accessible when the meter has been installed and is in normal operation. The loop includes legal and most used readings. User loop is primarily intended for the user of the meter. See paragraph 3.4 for more details.



Display code "DDD" indicates the active readings of each meter type. "1" is the first reading, to which the display automatically reverts after 4 minutes.

Change to a different DDD-code is only possible via METERTOOL

| User loop (Loop_1) | | Heat meter DDD=217 | Heat/cooling DDD=310 | Heat meter DDD=410 | Cooling meter DDD=510 | Heat/cooling DDD=610 |
|--------------------|---|-----------------------|-------------------------|-----------------------|--------------------------|-------------------------|
| 1.0 | Heat energy (E1) | 1 | 1 *) | 1 | | 1 *) |
| 2.0 | Cooling energy (E3) | | 2 *) | | 1 | 2 *) |
| 3.0 | Volume | 2 | 3 | 2 | 2 | 3 |
| 4.0 | Hour counter | 3 | 4 | 3 | 3 | 4 |
| 5.0 | T1 (Inlet) | 4 | 5 | 4 | 4 | 5 |
| 6.0 | T2 (Outlet) | 5 | 6 | 5 | 5 | 6 |
| 7.0 | T1-T2 (Δt) (Cooling shown by -) | 6 | 7 | 6 | 6 | 7 |
| 8.0 | Flow | 9 | 8 | 7 | 7 | 8 |
| 9.0 | Power | 10 | 9 | 8 | 8 | 9 |
| 10.0 | Info Code | 11 | 10 | 9 | 9 | 10 |
| 11.0 | Customer number (N° 1) | 12 | 11 | 10 | 10 | 11 |
| 12.0 | Customer number (N° 2) | 13 | 12 | 11 | 11 | 12 |
| 13.0 | E8 (m ³ x T1) | 7 | | | | |
| 14.0 | E9 (m ³ x T2) | 8 | | | | |

*) The display order of DDD=3xx and 6xx can either start with "E1-E3" or "E3-E1".

After 4 minutes without activation of the button the meter reverts to energy reading in "User loop". There is no "index number" in "User-loop".

8.3 TECH loop

Tech loop is primarily for technicians and other persons who are interested in viewing further data. Tech loop displays all legal registers, other important registers as well as logged data (see paragraph 7.8 for data loggers).



Tech loop comprises everything that the meter can display. Tech loop is displayed when the front key has been pressed continuously for 7 sec. The content of Tech loop is not configurable. After a brief activation in Tech loop the display moves to the next main reading, whereas two seconds' activation in Tech loop makes the meter switch to sub-reading. After a brief activation in sub-reading the display changes to the next sub-reading. Two seconds' activation in sub-reading makes the meter revert to main reading.

After five seconds' activation in Tech loop the display reverts to User loop.

| Tech loop (Loop_2) | | Tech loop (Loop_2) | | Index number in display | |
|--------------------|---|--------------------|------------------------------|-------------------------|---------------|
| Main | | Sub | | Start number | Record number |
| 1.0 | Heat energy (E1) | | | 2-01 | |
| | | 1.1 | Yearly date | 2-01-01 | Log 01-02 |
| | | 1.2 | Yearly data | 2-01-02 | |
| | | 1.3 | Monthly date | 2-01-03 | Log 01-24 |
| | | 1.4 | Monthly data | 2-01-04 | |
| 2.0 | Cooling energy (E3) | | | 2-02 | |
| | | 2.1 | Yearly date | 2-02-01 | Log 01-02 |
| | | 2.2 | Yearly data | 2-02-02 | |
| | | 2.3 | Monthly date | 2-02-03 | Log 01-24 |
| | | 2.4 | Monthly data | 2-02-04 | |
| 3.0 | Volume | | | 2-03 | |
| | | 3.1 | Yearly date | 2-03-01 | Log 01-02 |
| | | 3.2 | Yearly data | 2-03-02 | |
| | | 3.3 | Monthly date | 2-03-03 | Log 01-24 |
| | | 3.4 | Monthly data | 2-03-04 | |
| 4.0 | Hour counter | | | 2-04 | |
| | | 4.1 | Error hour counter | 2-04-01 | |
| 5.0 | T1 (Inlet) | | | 2-05 | |
| | | 5.1 | Year-to-date average | 2-05-01 | |
| | | 5.2 | Month-to-date average | 2-05-02 | |
| 6.0 | T2 (Outlet) | | | 2-06 | |
| | | 6.1 | Year-to-date average | 2-06-01 | |
| | | 6.2 | Month-to-date average | 2-06-02 | |
| 7.0 | T1-T2 (Δt) (Cooling shown by -) | | | 2-07 | |
| | | 7.1 | E8 (m ³ *T1) | 2-07-01 | |
| | | 7.2 | E9 (m ³ *T2) | 2-07-02 | |
| 8.0 | Flow | | | 2-08 | |
| | | 8.1 | Date of max. yearly data | 2-08-01 | |
| | | 8.2 | Max. yearly data | 2-08-02 | |
| | | 8.3 | Date of max. monthly data | 2-08-03 | |
| | | 8.4 | Max. monthly data | 2-08-04 | |
| 9.0 | Power | | | 2-09 | |
| | | 9.1 | Date of max. yearly data | 2-09-01 | |
| | | 9.2 | Max. yearly data | 2-09-02 | |
| | | 9.3 | Date of max. monthly data | 2-09-03 | |
| | | 9.4 | Max. monthly data | 2-09-04 | |
| 10.0 | Info Code | | | 2-10 | |
| | | 10.1 | Info event counter | 2-10-01 | Log 01-36 |
| | | 10.2 | Info logger date | 2-10-02 | |
| | | 10.3 | Info logger data | 2-10-03 | |
| 11.0 | Customer No. | | | 2-11 | N° 1 |
| | | 11.1 | Customer No. | 2-11-01 | N° 2 |
| | | 11.2 | Date | 2-11-02 | |
| | | 11.3 | Hour | 2-11-03 | |
| | | 11.4 | Target date | 2-11-04 | |
| | | 11.5 | Serial number | 2-11-05 | N° 3 |
| | | 11.6 | Config. 1 (ABDDD) | 2-11-06 | N° 5 |
| | | 11.7 | Config. 2 (EFGHHMMM) | 2-11-07 | N° 6 |
| | | 11.8 | Software edition | 2-11-08 | N° 10 |
| | | 11.9 | Software checksum | 2-11-09 | N° 11 |
| | | 11.10 | Average time of max. P and Q | 2-11-10 | |
| | | 11.11 | θ_{hc} | 2-11-11 | |
| | | 11.12 | Segment test | 2-11-12 | |
| | | 11.13 | M-Bus primary address | 2-11-13 | N° 31 |
| | | 11.14 | M-Bus secondary address | 2-11-14 | N° 32 |

After 4 minutes without activation of the button the meter reverts to energy reading in "User loop".

8.4 SETUP loop

Setup loop comprises everything that can be changed in the meter. Setup loop automatically "disappears" as an option, when the meter has registered its first volume accumulation or if you exit via the "EndSetup" function.

Setup-loop can be enabled again by breaking the seal and activating the switch. In that case Setup is locked by "EndSetup" or automatically 4 min. after the last activation of the button.

In Setup-loop selected configurations of the meter can be changed:

- Customer number
- Date
- Time
- Target date
- Flow sensor position (inlet/outlet)
- Energy unit
- Primary M-Bus address
- Average peak time max./min.
- Heat/cooling switching
- Radio (on/off)



Setup

When delivered the meter is in transport state, which means that display loop "Setup" is available.

Setup loop is selected by activating the button continuously for 9 sec. until "SETUP" is displayed.

The meter remains in Setup loop until the front button is pressed for 5 sec. However, a time-out secures that the meter reverts from Setup mode to normal mode after 4 minutes.

Transport state ends when the meter has registered its first volume accumulation, either 0.01 m³ (10 L) or 0.001 m³ (1 L) – determined by the selected resolution.

When the meter has left transport state, display loop Setup is no longer available, unless the  SETUP seal is broken and the contact points behind the seal short-circuited with short-circuit pen type 66-99-278. After that Setup is displayed.

When setup is finished the seal must be re-established using a void label size 15 x 15 mm (Kamstrup's seal no. 2008-727 can be used). The seal is important with a view to the meter's approval and to maintaining its protection class.

Note: The option Setup has been deselected in certain country codes.

The readings of Setup loop are listed below including index numbers:

| Setup loop (Loop_3) | Index number in display |
|----------------------------|--------------------------------|
|----------------------------|--------------------------------|

| | | |
|-------------|--|------|
| 1.0 | Customer number (N° 1) | 3-01 |
| 2.0 | Customer number (N° 2) | 3-02 |
| 3.0 | Date | 3-03 |
| 4.0 | Hour | 3-04 |
| 5.0 | Target date (MM.DD) | 3-05 |
| 6.0 | Flow sensor in: Inlet or Outlet (code A) | 3-06 |
| 7.0 | Measuring unit and resolution (code B) | 3-07 |
| 8.0 | M-Bus primary address (N° 31) | 3-08 |
| 9.0 | Average time of max. P and Q | 3-09 |
| 10.0 | θ_{hc} (Can only be changed with country code6xx. Other country codes show 180°C without changing option) | 3-10 |
| 11.0 | Radio "on" or "off" | 3-11 |
| 12.0 | End setup | 3-12 |

After 4 minutes without activation of the button the meter reverts to energy reading in "User loop".

8.4.1 Changing the installation position

The setup of the meter's installation position can be changed from inlet meter to outlet meter (and vice versa):



Setup mode

When the meter is in operation Setup mode can be selected by breaking the seal and using the short-circuit pen to make a brief short-circuit, which makes the reading shown to the left appear.

Do not forget to seal with a void label.



Installation position, reading 3-06

Subsequently reading 3-06 is found by means of the button below the display.



Inlet

If the meter is set to be a inlet meter, the text "inlet" is displayed. In order to change the setting, press the button for two seconds. "Setup" is briefly displayed and then "Inlet" flashes. Press the button once and "Outlet" is displayed. If you want to save the setting, press the button for two seconds until "OK" appears in the display.



Outlet

If the meter is set to be a outlet meter, the text "Outlet" is displayed. In order to change the setting, press the button for two seconds. "Setup" is briefly displayed and then "Outlet" flashes. Press the button once and "Inlet" is displayed. If you want to save the setting, press the button for two seconds until "OK" appears in the display.

8.4.2 Changing the energy unit

The energy unit can be changed. In order to do so you follow the example downstairs, but instead of reading 3-06 you find reading 3-07.



If you change the energy unit setting in Setup loop you must be aware that the change can influence the most significant digits of the display. If for instance you change from GJ with 2 decimals to GJ with 3 decimals, the most significant digit will disappear. The same applies if you change from kWh without decimals to kWh with 1 decimal. And conversely the least significant digit disappears if e.g. you change from kWh with 1 decimal to kWh without decimals. See examples below:

Example 1



GJ with 2 decimals (B=2)

This is an example of how the energy reading E1 can appear – counted in GJ.

Example 2



GJ with 3 decimals (B=6)

Here the most significant digit has disappeared compared to example 1. In outlet you receive a higher resolution.

Example 3



kWh without decimals (B=3)

This is an example of how energy reading E1 can appear – counted in kWh.

Example 4



kWh with 1 decimal (B=7)

Here the most significant digit has disappeared compared to example 3. In outlet you receive a higher resolution.

Example 5



MWh with 3 decimals (B=4)

In principle this is the same resolution as in example 3, but energy is now counted in MWh.

8.5 TEST loop

Test loop is intended for laboratories and others who are to verify the meter. (See paragraph 14 for further details on Test).

9 Flow sensor

9.1 Ultrasound combined with piezo ceramics

For more than 20 years ultrasonic measurement has proved the most long-term stable measuring principle for heat measurement. Experience with ultrasonic meters in operation as well as repeated reliability tests carried out in Kamstrup's accredited long-term test equipment and at AGFW in Germany have documented the long-term stability of ultrasonic meters.

9.2 Principles

The thickness of a piezoceramic element changes when exposed to an electric field (voltage). If the element is influenced mechanically, it generates a corresponding electric charge. Therefore, the piezoceramic element can function as both transmitter and receiver.

Within ultrasonic flow measuring there are two main principles: the transit time method and the Doppler method.

The Doppler method is based on the frequency change which occurs when sound is reflected by a moving particle. This is very similar to the effect you experience when a car drives by. The sound (the frequency) decreases as the car passes by.

9.3 Transient time method

The transient time method used in MULTICAL® 302 utilizes the fact that it takes an ultrasonic signal sent in the opposite direction of the flow longer to travel from transmitter to receiver than a signal sent in the same direction as the flow.

The transient time difference of a flow sensor is very small (nanoseconds). Therefore, the time difference is measured as a phase difference between the two 1 MHz sound signals in order to obtain the necessary accuracy.

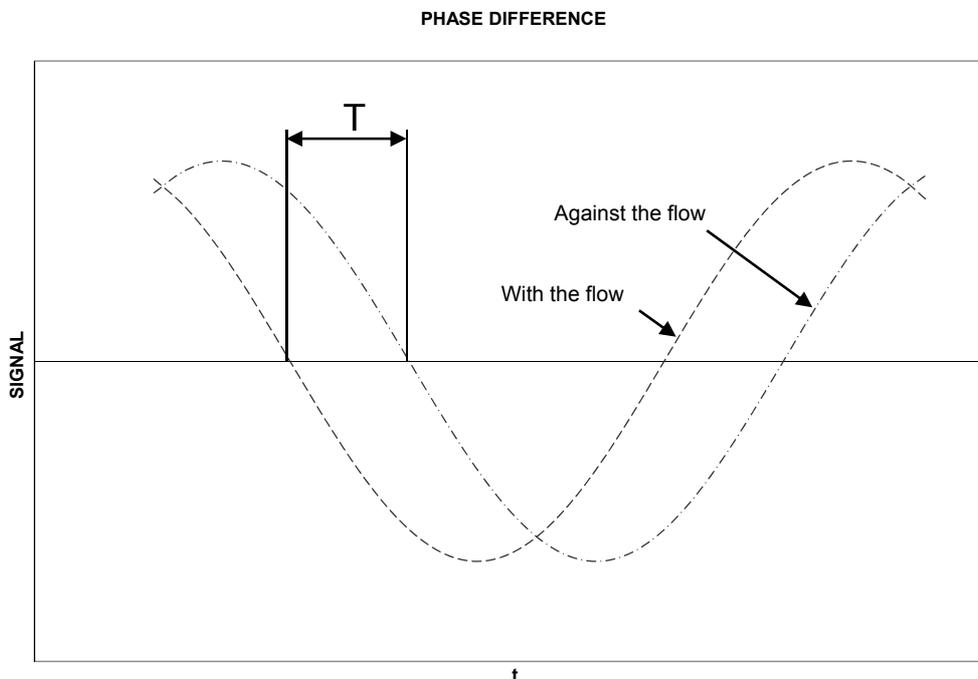


Diagram 4

In principle, the flow is determined by measuring the flow velocity and multiplying it by the area of the measuring pipe:

$$Q = F \times A$$

where:

Q is the flow

F is the flow velocity

A is the area of the measuring pipe

The area and the length, which the signal travels in the sensor, are well-known factors. The length which the signal travels can be expressed by $L = T \times V$, which can also be written as:

$$T = \frac{L}{V}$$

where:

L is the measuring distance

V is the sound propagation velocity

T is the time

$$\Delta T = L \times \left(\frac{1}{V_1} - \frac{1}{V_2} \right)$$

In connection with ultrasonic flow sensors the velocities V_1 and V_2 can be stated as:

$$V_1 = C - F \quad \text{and} \quad V_2 = C + F \quad \text{respectively}$$

where: C is the velocity of sound in water

Using the above formula you get:

$$\Delta T = L \times \frac{1}{C - F} - \frac{1}{C + F}$$

which can also be written as:

$$\Delta T = L \times \frac{(C + F) - (C - F)}{(C - F) \times (C + F)}$$

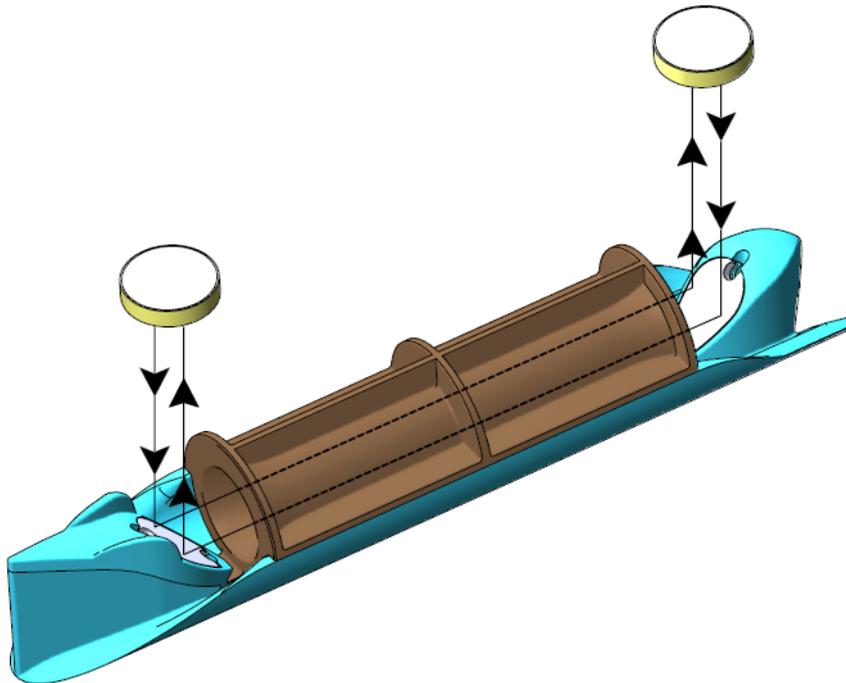
↓

$$\Delta T = L \times \frac{2F}{C^2 - F^2}$$

As $C \gg F$, F^2 can be omitted and the formula reduced as follows:

$$F = \frac{\Delta T \times C^2}{L \times 2}$$

9.4 Signal paths



q_p 0.6 - 1.5 - 2.5 m³/h

Parallel measurement

The sound path is parallel to the measuring pipe and the sound signal is sent from the transducers via reflectors.

9.5 Flow limits

In the meter's working range from min. flow cutoff and far beyond q_s there is a linear connection between the flow rate and the measured water flow.

In practice the highest possible water flow through the meter will be limited by the pressure in the system or possible cavitation due to too low back pressure.

If the flow is lower than min. cutoff or negative, MULTICAL® 302 does not measure any flow.

According to EN 1434 the upper flow limit q_s is the highest flow at which the flow sensor may operate for short periods of time (<1h/day, <200h/year) without exceeding max. permissible errors. MULTICAL® 302 has no functional limitations during the period, when the meter operates above q_p . Please note, however, that high flow velocities may cause cavitation, especially at low static pressure. See paragraph 6.4 for further details on operating pressure.

10 Temperature sensors

MULTICAL® 302 comes with fixed (soldered) Pt500 temperature sensors according to EN 60751 (DIN/IEC 751). A Pt500 temperature sensor is a platinum sensor, which has a nominal ohmic resistance of 500.000 Ω at 0.00 °C and 692.528 Ω at 100.00 °C. All ohmic resistance values are laid down in the international standard IEC 751 applying to Pt100 temperature sensors. The ohmic resistance values of Pt500 sensors are five times higher. The table below shows resistance values of Pt500 sensors in [Ω] for each degree Celsius:

| Pt500 | | | | | | | | | | |
|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| °C | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 500.000 | 501.954 | 503.907 | 505.860 | 507.812 | 509.764 | 511.715 | 513.665 | 515.615 | 517.564 |
| 10 | 519.513 | 521.461 | 523.408 | 525.355 | 527.302 | 529.247 | 531.192 | 533.137 | 535.081 | 537.025 |
| 20 | 538.968 | 540.910 | 542.852 | 544.793 | 546.733 | 548.673 | 550.613 | 552.552 | 554.490 | 556.428 |
| 30 | 558.365 | 560.301 | 562.237 | 564.173 | 566.107 | 568.042 | 569.975 | 571.908 | 573.841 | 575.773 |
| 40 | 577.704 | 579.635 | 581.565 | 583.495 | 585.424 | 587.352 | 589.280 | 591.207 | 593.134 | 595.060 |
| 50 | 596.986 | 598.911 | 600.835 | 602.759 | 604.682 | 606.605 | 608.527 | 610.448 | 612.369 | 614.290 |
| 60 | 616.210 | 618.129 | 620.047 | 621.965 | 623.883 | 625.800 | 627.716 | 629.632 | 631.547 | 633.462 |
| 70 | 635.376 | 637.289 | 639.202 | 641.114 | 643.026 | 644.937 | 646.848 | 648.758 | 650.667 | 652.576 |
| 80 | 654.484 | 656.392 | 658.299 | 660.205 | 662.111 | 664.017 | 665.921 | 667.826 | 669.729 | 671.632 |
| 90 | 673.535 | 675.437 | 677.338 | 679.239 | 681.139 | 683.038 | 684.937 | 686.836 | 688.734 | 690.631 |
| 100 | 692.528 | 694.424 | 696.319 | 698.214 | 700.108 | 702.002 | 703.896 | 705.788 | 707.680 | 709.572 |
| 110 | 711.463 | 713.353 | 715.243 | 717.132 | 719.021 | 720.909 | 722.796 | 724.683 | 726.569 | 728.455 |
| 120 | 730.340 | 732.225 | 734.109 | 735.992 | 737.875 | 739.757 | 741.639 | 743.520 | 745.400 | 747.280 |
| 130 | 749.160 | 751.038 | 752.917 | 754.794 | 756.671 | 758.548 | 760.424 | 762.299 | 764.174 | 766.048 |
| 140 | 767.922 | 769.795 | 771.667 | 773.539 | 775.410 | 777.281 | 779.151 | 781.020 | 782.889 | 784.758 |
| 150 | 786.626 | 788.493 | 790.360 | 792.226 | 794.091 | 795.956 | 797.820 | 799.684 | 801.547 | 803.410 |
| 160 | 805.272 | 807.133 | 808.994 | 810.855 | 812.714 | 814.574 | 816.432 | 818.290 | 820.148 | 822.004 |

Pt500, EN 60 751:2008

Table 5

10.1 Sensor types

MULTICAL® 302 comes with a $\varnothing 5.2$ mm Pt500 sensor pair (matched sensors) with 1.5 m silicone cable. This sensor type can be used as direct sensor using a coupling and an O-ring and as pocket sensor to be mounted in a sensor pocket.

One temperature sensor is mounted in the flow sensor from the factory. The other sensor ought to be mounted as direct sensor. Alternatively, both sensors must be mounted in sensor pockets as symmetrical sensor installation gives the best measuring result. If one of the temperature sensors is not to be mounted in the flow sensor, it has to be mounted within a distance of max. 12 cm from the outlet of the flow sensor instead.

The enclosed plastic coupling can be removed, thus allowing the sensor to be used in a sensor pocket. Please note that not all types of couplings can be removed.

Asymmetrical sensor installation (one direct sensor and one pocket sensor) is only advisable where national regulations allow this, and never in systems with low differential temperature and/or low water flow.

Note: In Germany "Eichordnung" EO-1988 stipulates that in new installations it is only permissible to use direct temperature sensors for heat meters with pipe diameter DN 25 or less. Replacing heat meters in existing installations it can in some cases be permitted to use pocket sensors in small heat meters; sensor type versus pocket type must, however, appear from "Bestandsliste der verwendeten kurzen Tauchhülsen".

The temperature sensor which is mounted in the flow sensor from the factory has no marking on the sensor cable. The other sensor, which is marked with a green plastic ring, must be mounted in the "opposite" pipe compared to the flow sensor.



Example:

If the display shows that the flow sensor is to be mounted in the outlet pipe, the sensor with the green plastic ring must be mounted in the inlet pipe. See the table in paragraph 6.5 for further information.

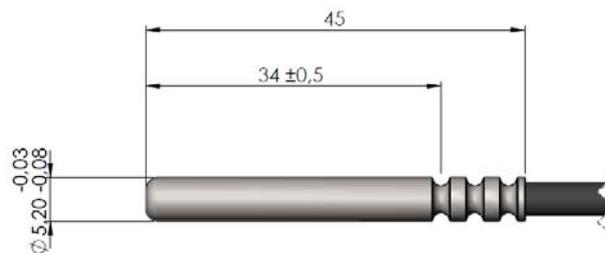
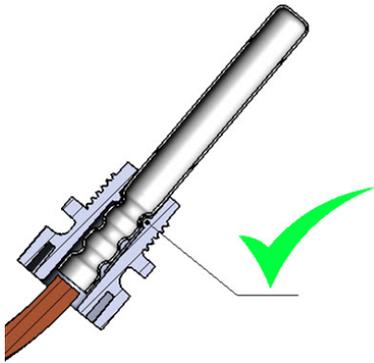


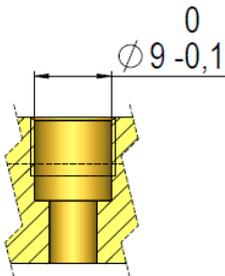
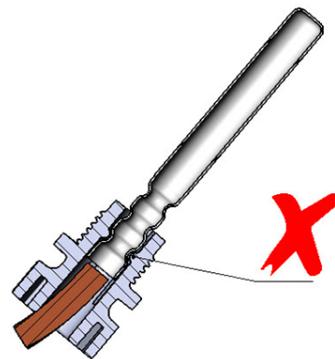
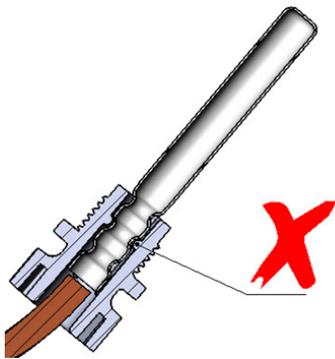
Figure 7

10.2 Coupling for direct sensor



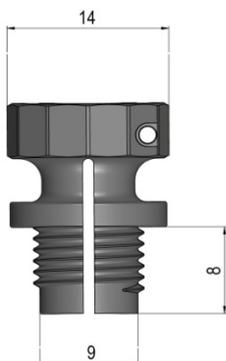
Slide the enclosed plastic coupling into place from the end of the sensor tube until you feel a click when the coupling has reached the first knurling.

The coupling must not be pushed further down than the first knurling.



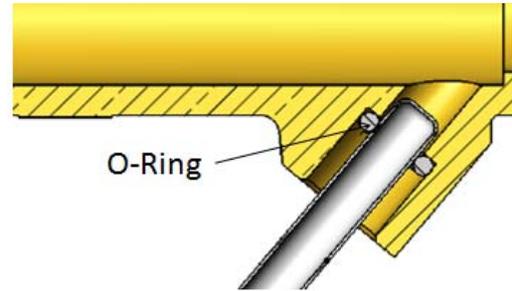
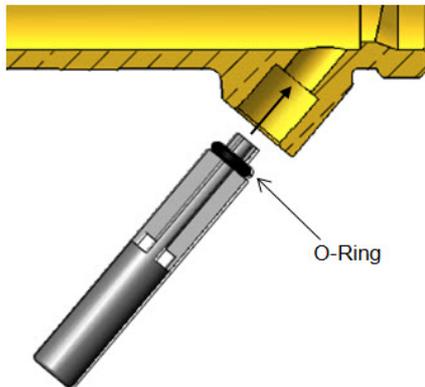
No matter where the direct sensor is installed it is very important that you observe the tolerances stated in the drawing to the left. If not, the O-ring may not provide correct sealing.

10.2.1 Specification of coupling

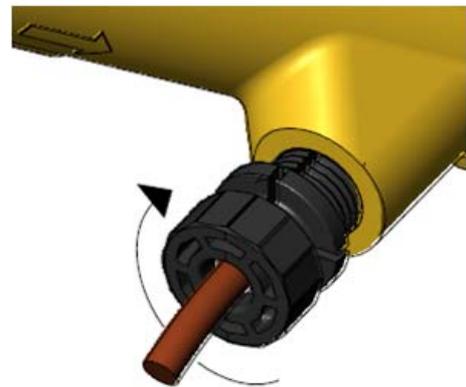


Material: PPS
 Max. temp.: 150 °C permanently
 Pressure stage: PN16 and PN25

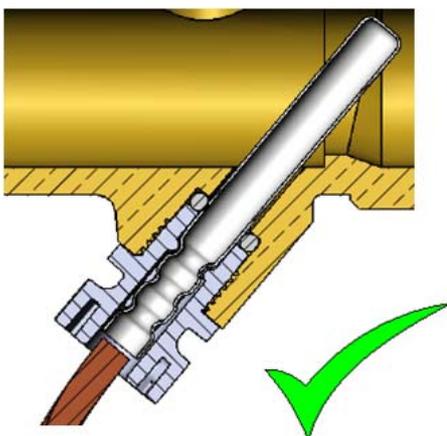
10.3 Installation of direct sensor



Use the O-ring guide to slide the O-ring into place and then push the sensor as far as it will go.



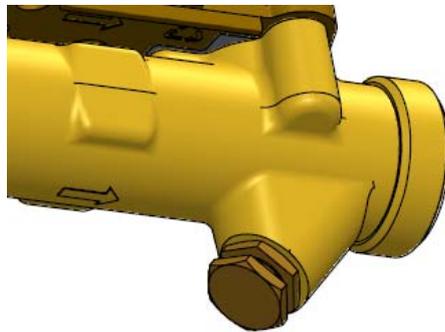
Fasten the plastic coupling manually. The use of tools is not permitted.



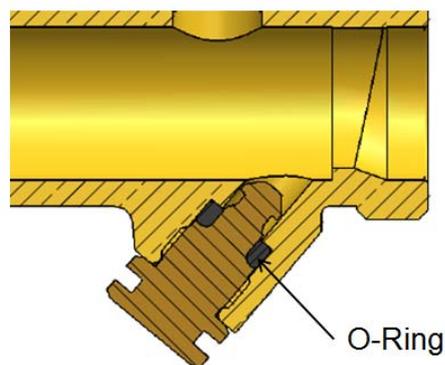
The sensor is mounted like this from the factory.

Do not forget to finish the installation by sealing the sensor.

10.4 Blind plug for sensor socket



If the sensors are to be mounted as pocket sensors, dismount the temperature sensor which is mounted in the flow sensor and remove the plastic coupling from the sensor. Subsequently, mount a blind plug in the flow sensor.



Furthermore, the blind plug is suitable for removing the O-ring

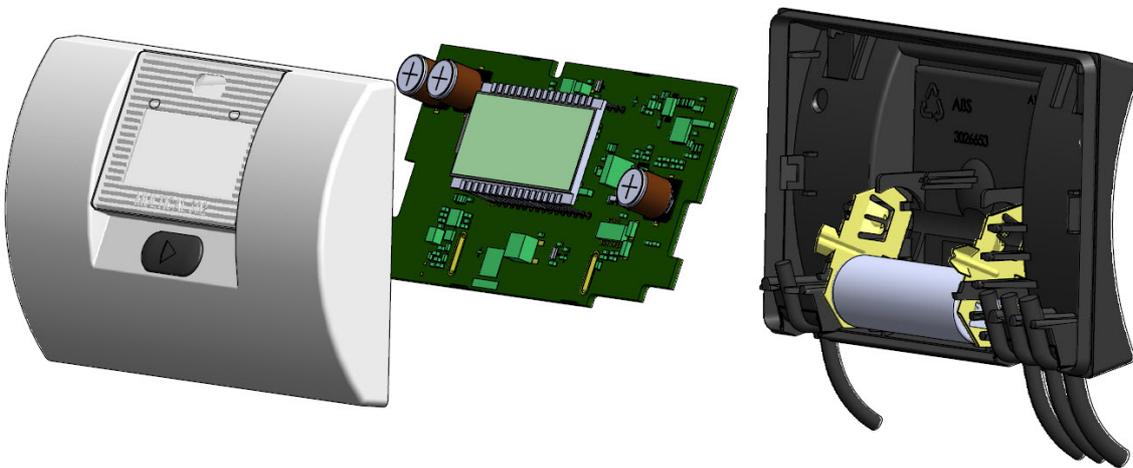
11 Power supply

MULTICAL® 302 is powered by 3.6 VDC from 1 or 2 built-in batteries, according to the type ordered.

| Type | 302- | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|--|------|--------------------------|--------------------------|--------------------------|
| Supply | | | | |
| 6 year battery, Normal Response meter | | | | 1 |
| 12 year battery, Normal Response meter | | | | 2 |
| 6 year battery, Fast Response meter | | | | 3 |

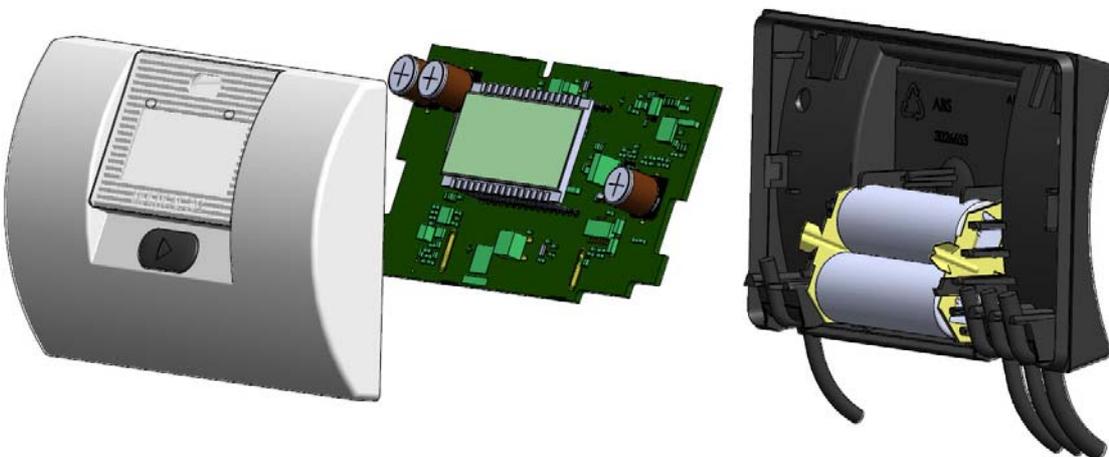
11.1 Built-in A-cell lithium battery

The A-cell lithium battery is sufficient to power MULTICAL® 302 for a 6-year period of operation. A-cell lithium batteries include 0.96 g lithium each and are thus not subject to transport restrictions.



11.2 Built-in 2 x A-cell lithium battery

2 x A-cell lithium battery must be selected for MULTICAL® 302 if a battery lifetime of 12 years is required. The 2 x A-cell lithium batteries contain 2 x 0.96 g lithium each and are thus not subject to transport restrictions.



Note: MULTICAL® 302 cannot be mains supplied.

12 Communication

MULTICAL® 302 offers two different forms of communication, namely wired M-Bus or Wireless M-Bus.

12.1 Wired M-Bus

If the meter is supplied with built-in wired M-Bus, M-Bus protocol according to EN 13757-3:2013 is used. Connection to the M-Bus master is established via the fixed 1.5 m 2-wire cable. Connection is independent of polarity and the M-Bus interface is galvanically separated from the rest of the meter.

The communication speed with automatic baud rate detection is 300 or 2400 Baud. Both primary and secondary addressing is supported. Current consumption is 1 unit load (1.5 mA).

Reading intervals down to one hour do not influence the specified battery lifetime, whereas reading intervals down to 5 minutes halves the battery lifetime.

We recommend a communication speed of 2400 Baud as the current consumption is higher at a communication speed of 300 Baud.

The following data can be read via M-Bus:

| M-Bus data header | Current data | Target data*) | Meter data |
|-------------------|----------------------------|----------------------------|-------------------|
| M-Bus ID | Heat energy E1 | Heat energy E1 | Serial number |
| Producer ID | Cooling energy E3 | Cooling energy E3 | Customer number 1 |
| Version | Energy $m^3 \cdot T1 = E8$ | Energy $m^3 \cdot T1 = E8$ | Customer number 2 |
| Device type | Energy $m^3 \cdot T2 = E9$ | Energy $m^3 \cdot T2 = E9$ | Config. number 1 |
| Access counter | Volume V1 | Volume V1 | Config. number 2 |
| Status | Hour counter | Max. power | Meter type |
| Configuration | Error hour counter | Max. flow | SW-revision |
| | T1 | Target date | |
| | T2 | | |
| | T1-T2 | | |
| | Current power | | |
| | Max. power current month* | | |
| | Current flow | | |
| | Max. flow current month* | | |
| | Info code | | |
| | Date/time | | |

*) Monthly data is transmitted by default. Change to yearly data possible by means of an M-Bus command. For further details we refer to Technical description on M-Bus for MULTICAL® 302.

12.2 Wireless M-Bus

If the meter has built-in wireless M-Bus, you can choose between Mode C1 or Mode T1 OMS.

Mode C1 is used in connection with Kamstrup's reading systems and for drive-by meter reading in general.

Mode T1 OMS is used in connection with OMS-based stationary networks. The meter has an internal antenna.

Mode C1

Protocol according to EN 13757-4:2013. Transmission interval of 16 sec. Individual 128 bit AES encryption.

Data packets Mode C1

| Heat meter HH = 01 or 02 | Heat meter HH = 11 or 12 | Cooling meter | Heat/cooling meter |
|---|--|---|--|
| Header Manufacturer Id Serial number Version Device type Hour counter | Header Manufacturer Id Serial number Version Device type Hour counter | Header Manufacturer Id Serial number Version Device type Hour counter | Header Manufacturer Id Serial number Version Device type Hour counter |
| Current data Heat energy E1 Volume V1 Power Info code | Current data Heat energy E1 Info code | Current data Cooling energy E3 Volume V1 Power Info code | Current data Heat energy E1 Cooling energy E3 Power Info code |
| Target data Date Heat energy E1 Last month or last year*) | Target data Date Heat energy E1 Volume V1 Energy m ³ *T1 = E8 Energy m ³ *T2 = E9 Last month or last year*) | Target data Date Cooling energy E3 Last month or last year*) | Target data Date Heat energy E1 Cooling energy E3 Last month or last year*) |

*) Monthly or yearly data depends on the HH configuration. See paragraph 3.6 Config >EFGHMMMM<.

Mode T1 OMS

Protocol according to EN13757-4:2013 and OMS Specification Volume 2 issue 3.0.1. Transmission interval of 900 sec. Individual 128 bit AES encryption.

Data packets Mode T1 OMS

| Heat meter | Cooling meter | Heat/cooling meter |
|---|---|--|
| Header Device type Producer Id Serial number Version Status | Header Device type Producer Id Serial number Version Status | Header Device type Producer Id Serial number Version Status |
| Current data Heat energy E1 Volume V1 Power Flow T1 T2 Hour counter Date Info code | Current data Cooling energy E3 Volume V1 Power Flow T1 T2 Hour counter Date Info code | Current data Heat energy E1 Cooling energy E3 Volume V1 Power Flow T1 T2 Hour counter Date Info code |
| Target data*) Heat energy E1 last month Volume V1 last month or Heat energy E1 last year Volume V1 last year Target date | Target data*) Cooling energy E3 last month Volume V1 last month or Cooling energy E3 last year Volume V1 last year Target date | Target data*) Heat energy E1 last month Cooling energy E3 last month Volume V1 last month or Heat energy E1 last year Cooling energy E3 last year Volume V1 last year Target date |

*) Monthly or yearly data depends on the HH configuration. See paragraph 3.6 Config >EFGHHMMM<.

13 Data communication

13.1 MULTICAL[®] 302 Data Protocol

Internal data communication in MULTICAL[®] 302 is based on the Kamstrup Meter Protocol (KMP) which provides a fast and flexible reading structure and also fulfils future requirements to data reliability.

The KMP protocol is used in all Kamstrup consumption meters launched from 2006 onwards. The protocol is used for the optical eye.

The KMP protocol has been designed to handle point to point communication in a master/slave system (e.g. a bus system) and is used for data reading of Kamstrup energy meters.

Software and parameter protection

The meter's software is implemented in a Flash and cannot be changed, neither deliberately nor by mistake. Legal parameters cannot be changed via data communication.

Software conformity

Software check sum, based on CRC16, is available via data communication and in the display.

Integrity and authenticity of data

All data parameters include type, measuring unit, scaling factor and CRC16 check sum. Every produced meter includes a unique identification number.

Two different formats are used for communication between master and slave. Either a data frame format or an application acknowledgement.

- A request from master to slave is always sent in a data frame
- The response from the slave can either be sent in a data frame or as an application acknowledgement

The data frame is based on the OSI model using the physical layer, the data link layer and the application layer.

| | | | | | | |
|---------------------|----------------|---------------------|-------------------|------|-----|-----------|
| Bytes in each field | 1 | 1 | 1 | 0-? | 2 | 1 |
| Field designation | Start byte | Destination address | CID | Data | CRC | Stop byte |
| OSI – layer | | | Application layer | | | |
| | | Data link layer | | | | |
| | Physical layer | | | | | |

The protocol is based on half duplex serial asynchronous communication with the setup: 8 data bits, no parity and 2 stop bits. The data bit rate is 1200 or 2400 baud. CRC16 is used in both request and response.

Data is transferred byte for byte in a binary data format, in which the 8 data bits represent one byte of data.

Byte Stuffing is used to extend the value range.

13.1.1 MULTICAL® 302 Register Ids

| ID | Register | Description |
|------|--------------------|---|
| 1003 | Date | Current date (YYMMDD) |
| 1002 | Clock | Current hour (hhmmss) |
| 99 | InfoCode | Info code register, current |
| 113 | InfoEventCounter | InfoEvent counter |
| 1004 | HourCounter | Operating hour counter |
| 60 | Energy1 | Energy register 1: Heat energy |
| 63 | Energy3 | Energy register 3: Cooling energy |
| 97 | Energy8 | Energy register 8: [m ³ x T1] |
| 110 | Energy9 | Energy register 9: [m ³ x T2] |
| 68 | Volume1 | Volume register V1 |
| 86 | Temp1 | Current inlet temperature |
| 87 | Temp2 | Current outlet temperature |
| 89 | Temp1-Temp2 | Current differential temperature |
| 74 | Flow1 | Current water flow |
| 80 | Power1 | Current power |
| 239 | V1HighRes | High-resolution volume register for test purposes |
| 266 | E1HighRes | High-resolution heat energy register for test purposes |
| 267 | E3HighRes | High-resolution cooling energy register for test purposes |
| 98 | LogDaySetUp | Target date (reading date) |
| 146 | AvrTemp1(y) | Year-to-date average of T1 |
| 147 | AvrTemp2(y) | Year-to-date average of T2 |
| 149 | AvrTemp1(m) | Month-to-date average of T1 |
| 150 | AvrTemp2(m) | Month-to-date average of T2 |
| 229 | AutoIntT1Average | T1 average of latest autointegration |
| 230 | AutoIntT2Average | T2 average of latest autointegration |
| 123 | MaxFlow1Date(y) | Date of this year's max. |
| 124 | MaxFlow1(y) | This year's max. value |
| 127 | MaxPower1Date(y) | Date of this year's max. |
| 128 | MaxPower1(y) | This year's max. value |
| 138 | MaxFlow1Date(m) | Date of this month's max. |
| 139 | MaxFlow1(m) | This month's max. value |
| 142 | MaxPower1Date(m) | Date of this month's max. |
| 143 | MaxPower1(m) | This month's max. value |
| 98 | Xday | Target date |
| 153 | ConfNo1 | Config no. ABDDD |
| 168 | ConfNo2 | Config. no. EFGHMMM |
| 1001 | SerialNumber | Serial no. (unique number of each meter) |
| 112 | MeterNo(high) | Customer number (8 most significant digits) |
| 1010 | MeterNumber(low) | Customer number (8 least significant digits) |
| 1005 | MeterType | Meter type |
| 184 | MBusBotDispPriAddr | Primary M-Bus address |
| 185 | MBusBotDispSecAddr | Secondary M-Bus address |
| 154 | Checksum | Software checksum |
| 175 | Infohour | Error hour counter |

13.1.2 Data protocol

Utilities and other relevant companies who want to develop their own communication driver for the KMP protocol can order a demonstration program in C# (.net based) as well as a detailed protocol description (in English language).

13.2 Optical eye

The optical eye can be used for data communication via the optical interface. The optical eye is placed on the front of the integrator just above the display as shown in the picture below. Please note that the optical eye includes a very strong magnet, which should be covered by a protection plate when not in use.

MULTICAL[®] 302 does not include a metal plate, which can retain the reading head's magnet. Therefore, the optical reading head must be held in place manually during brief data readings.



In connection with prolonged data readings, reading of data loggers, or if you want the optical reading head to be retained on the meter for other reasons, you can use a transparent holder, which is clicked onto the meter.



Different variants of the optical eye (with USB-plug and 9-pole D-Sub plug) appear from the list of accessories (see paragraph 3.2.2).

13.2.1 Power-saving in connection with the optical eye

In order to limit the power consumption of the circuit around the optical eye, the circuit is not permanently switched on.

It is activated by pressing the key. The circuit will remain on 8 minutes after the last activation of the button.

14 Test

MULTICAL® 302 can be tested as a complete energy meter or as a hybrid meter determined by the available equipment.

The test as a complete energy meter can be carried out without disassembling the meter, except from the fact that the "TEST" seal must be broken (see paragraph 14.1.1). The high-resolution test registers can be read from the display, via serial data reading, or via high-resolution pulses.

Before test as a hybrid meter MULTICAL® 302 must be disassembled and the sensor pair must be soldered off. Subsequently, the calculator is tested separately by means of precision resistors and the meter's built-in "Auto-integration". Flow sensor and temperature sensors are tested separately too. During test of the flow sensor it is important that the temperature sensor, to be mounted in the flow sensor, is installed.

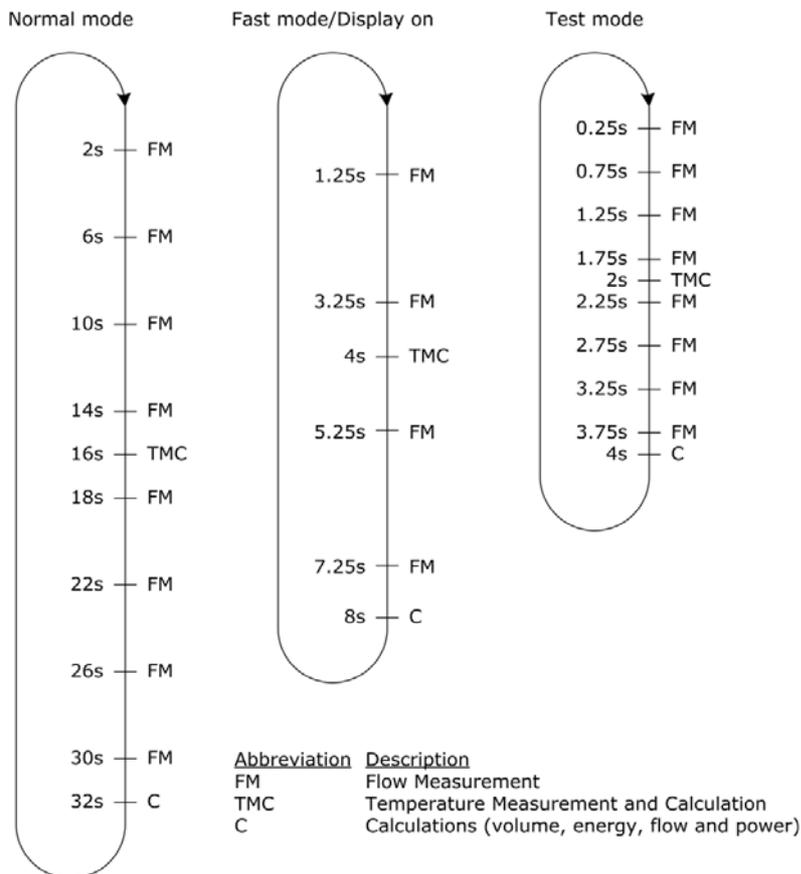
If "energy verification" with separate temperature baths is used, it is important that the medium in the flow sensor and the temperature bath, in which the temperature sensor mounted in the flow sensor is placed, have the same temperature.

In order to obtain quick test/verification of MULTICAL® 302, the meter has a test mode which repeats the measuring sequence every four seconds, i.e. eight times faster than in normal mode or twice as fast as in fast mode. In test mode heat energy, cooling energy and volume are displayed with a resolution which is higher than normal in order to enable a shorter test duration.

MULTICAL® 302 uses more current in test mode, but under normal circumstances where the meter is in test mode a few times during its lifetime, this is without importance for the meter's battery lifetime.

14.1 Meter modes

The meter can operate in three different modes: "Normal", "Fast" and "Test" mode, as shown below. The choice between normal and fast mode must be made when ordering the meter and this choice cannot be changed subsequently. No matter whether the meter is supplied with normal mode or fast mode, test mode (see paragraph 14.1.1) can be selected.



14.1.1 Test mode



In order to access test mode the "TEST" seal  on the back of the meter must be carefully broken with a screwdriver and the contact points behind the seal short-circuited with short-circuit pen type 66-99-278.

Subsequently, test is displayed.



The meter remains in test mode until the front button is activated for 5 sec. However, a time-out secures that the meter returns from test mode to normal mode after 9 hours.

When tests are finished the seal must be re-established using a void label size 15 x 15 mm (Kamstrup's seal no. 2008-727 can be used). The seal is important with a view to the meter's approval and to maintain its protection class.

14.1.2 Test loop

Test loop includes six different main readings and three different sub-readings:

| Test loop (Loop_4) | | <i>Test loop (Loop_4)</i> | | Index number in display |
|--------------------|--|---------------------------|---------------------|-------------------------|
| Main | | Sub | | |
| 1.0 | High-resolution heat energy *) | | | 4-01 |
| | | 1.1 | Heat energy (E1) | 4-01-01 |
| 2.0 | High-resolution cooling energy *) | | | 4-02 |
| | | 2.1 | Cooling energy (E3) | 4-02-01 |
| 3.0 | High-resolution volume *) | | | 4-03 |
| | | 3.1 | Volume | 4-03-01 |
| 4.0 | T1 (Inlet) | | | 4-04 |
| 5.0 | T2 (Outlet) | | | 4-05 |
| 6.0 | Flow | | | 4-06 |

After 9 hours the meter reverts to energy reading in "User loop".

*) Register/resolution of the high-resolution registers are as follows: **"0000001 Wh"** and **"00000.01 l"**

Test-loop can only be displayed if the verification seal is broken and the switch activated.

The high-resolution registers can only be reset in connection with a total reset. See paragraph 15 for further information about METERTOOL.

14.2 Test connection

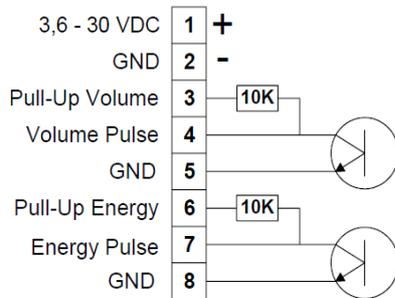
During test either optical reading head with USB plug (66-99-099) for serial reading of high-resolution energy and volume registers, or Pulse Interface (66-99-143) with optical reading head and connection unit for high-resolution pulse outputs is used. Do not forget that the meter must be in Test mode.



14.2.1 Verification pulses

When Pulse Interface type 66-99-143 is connected to power supply or battery, the unit is placed on the meter, and the meter is in test mode, the following pulses are transmitted:

- High-resolution energy pulses (1 Wh/pulse) on terminals 7 and 8
- High-resolution volume pulses (10 ml/pulse) on terminals 4 and 5

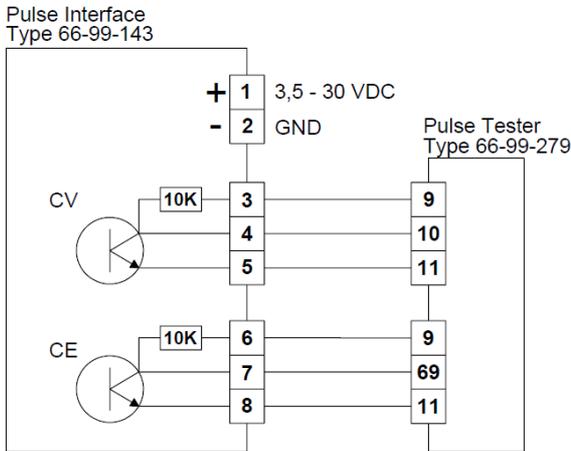


Pulse Interface 66-99-143, technical data

| | |
|---------------------|--------------------------------|
| Supply voltage | 3.6 – 30 VDC |
| Current consumption | < 15 mA |
| Pulse outputs | < 30 VDC < 15 mA |
| Pulse duration | 3.9 ms. |
| Energy pulse | 1 Wh/pulse (1000 pulses/kWh) |
| Volume pulse | 10 ml/pulse (100 pulses/litre) |

14.2.2 Use of high-resolution pulses

High-resolution energy and volume pulses can be connected to the test stand used for calibration of the meter, or to Kamstrup's Pulse Tester, type 66-99-279, as shown in the drawing below.



14.2.3 Auto-integration

The purpose of auto-integration is to test the calculator's accuracy. During auto-integration the water flow through the meter must be cut off to make it possible to read the volume and energy counted during auto-integration without the meter continuing normal counting in the registers afterwards.

At the beginning of an auto-integration the meter receives a serial data command with test volume and number of integrations over which the meter is to distribute the volume.

In MULTICAL® 302 the high-resolution test registers cannot be separately reset, so the test must be based on the increase in the high-resolution registers during test.

After auto-integration all volume and energy registers – incl. the high-resolution test registers – have been enumerated by the given volume and the calculated energies. Furthermore, the average of the temperatures measured during auto-integration has been saved in two registers, "T1 average inlet temperature" and "T2 average outlet temperature".

For calculation of accuracy and precision the below-mentioned registers can be read after auto-integration:

| Verification registers | | RID |
|-------------------------------|-------------------|-----|
| Heat energy | E1HighRes | 266 |
| Cooling energy | E3HighRes | 267 |
| Volume | V1HighRes | 239 |
| T1 average inlet temperature | T1average_AutoInt | 229 |
| T2 average outlet temperature | T2average_AutoInt | 230 |

14.3 Handling different test methods

14.3.1.1 Standing start/stop

Standing start/stop is a method used for testing the flow sensor's accuracy. During the test the meter must be mounted in a flow test stand. The flow through the sensor is cut off. Subsequently, water flow is added for a certain period, during which the water passing through the sensor is collected. Having switched off the flow the volume of the collected water is compared to the volume counted by the meter. In general, standing start/stop requires bigger test volume than flying start/stop.

14.3.1.2 Standing start/stop via display reading

Condition: MULTICAL® 302 must be in test mode (see paragraph 14.1.1).

The high-resolution display readings are updated at 4-second intervals.

14.3.1.3 Standing start/stop using pulse outputs

Condition: MULTICAL® 302 must be in test mode (see paragraph 14.1.1).

Verification pulses are connected as described in paragraph 14.2.1 above.

14.3.1.4 Flying start/stop

Condition: MULTICAL® 302 must be in test mode (see paragraph 14.1.1).

Verification pulses are connected as described in paragraph 14.2.1 above.

“Flying start/stop” is the most frequently used method for testing the accuracy of flow sensors. During the test the meter must be mounted in a flow test stand and there is constant water flow through the sensor.

Verification pulses, as described in paragraph 14.2.1, can be directly used for the test stand if it is designed to control the start/stop synchronisation. Alternatively, Pulse Tester, type 66-99-279, can be used as external start/stop pulse counter.

As the meter calculates volume and energy every four seconds in test mode (see paragraph 14.1.1), the verification pulses will also be updated every four seconds as described in paragraph 14.2.1. It is important to allow for this time interval, which means that the test duration from start to stop must be so long that the update time does not influence the measuring uncertainty to any very considerable extent.

14.4 True energy calculation

During test and verification the heat meter's energy calculation is compared to the "true energy", which is calculated according to the formula of EN 1434-1:2007 or OIML R75:2002.

For control calculations Kamstrup can supply an energy calculator:

The true energy at the most frequently used verification points is indicated in the table below.

| T1 [°C] | T2 [°C] | $\Delta\Theta$ [K] | Flow [Wh/0.1 m ³] | Outlet [Wh/0.1 m ³] |
|---------|---------|--------------------|-------------------------------|---------------------------------|
| 42 | 40 | 2 | 230.11 | 230.29 |
| 43 | 40 | 3 | 345.02 | 345.43 |
| 53 | 50 | 3 | 343.62 | 344.11 |
| 50 | 40 | 10 | 1146.70 | 1151.55 |
| 70 | 50 | 20 | 2272.03 | 2295.86 |
| 80 | 60 | 20 | 2261.08 | 2287.57 |
| 160 | 40 | 120 | 12793.12 | 13988.44 |
| 160 | 20 | 140 | 14900.00 | 16390.83 |

15 METERTOOL for HCW

15.1 Introduction

The Kamstrup Software product “METERTOOL HCW” (66-99-724) is used for configuration of MULTICAL® 302 as well as configuration of other Kamstrup heat, cooling and water meters.

15.1.1 System requirements

As a minimum METERTOOL HCW requires Windows XP SP3, Windows 7 Home Premium SP1 or newer, as well as Windows Internet Explorer 5.01 or newer.

| | | | |
|-----------------|-------------------------------|---------------------|---------------------|
| Minimum: | 1 GB RAM | Recommended: | 4 GB RAM |
| | 10 GB free HD space | | 20 GB free HD space |
| | Display resolution 1366 x 768 | | 1920 x 1080 |
| | USB | | |
| | Printer installed | | |

Administrator rights to the PC are needed in order to install and use the programs. They must be installed under the user login of the person, who is to use the programs.

15.1.2 Interface

The following interfaces can be used:

| | | |
|------------------------|------|----------|
| Optical eye USB | type | 6699-099 |
| Optical eye COM port | type | 6699-102 |
| Blue Tooth optical eye | type | 6699-005 |

15.1.3 Installation

Check that system requirements are fulfilled.

Close other open programs before starting the installation.

Download the METERTOOL software from Kamstrup’s FTP-server and follow the program’s directions through the installation.

During installation of the METERTOOL-program the USB-driver for the optical readout head is automatically installed if not already existing.

When the installation is completed, the icon “METERTOOL HCW” will appear in the ‘All Programs’ menu under ‘Kamstrup METERTOOL’ (or from the menu “start” for Windows XP) and as a link on the desktop. Double-click on link or icon in order to start the program.

15.2 How to use METERTOOL HCW for MULTICAL[®] 302

15.2.1 General information

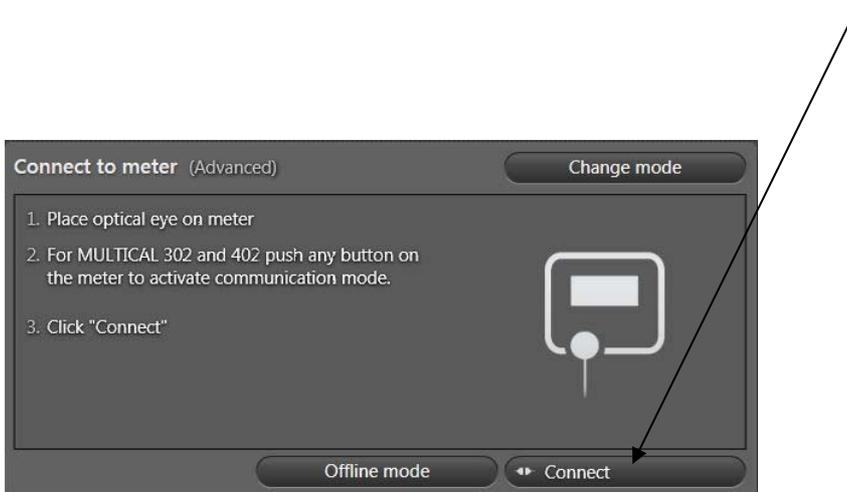
It is important to be familiar with the calculator's functions before starting programming.

The Kamstrup Software product "METERTOOL HCW" (66-99-724) is used for MULTICAL[®] 302.

Before running the program, connect your optical readout head to your computer and place the head in the plastic holder on the calculator.

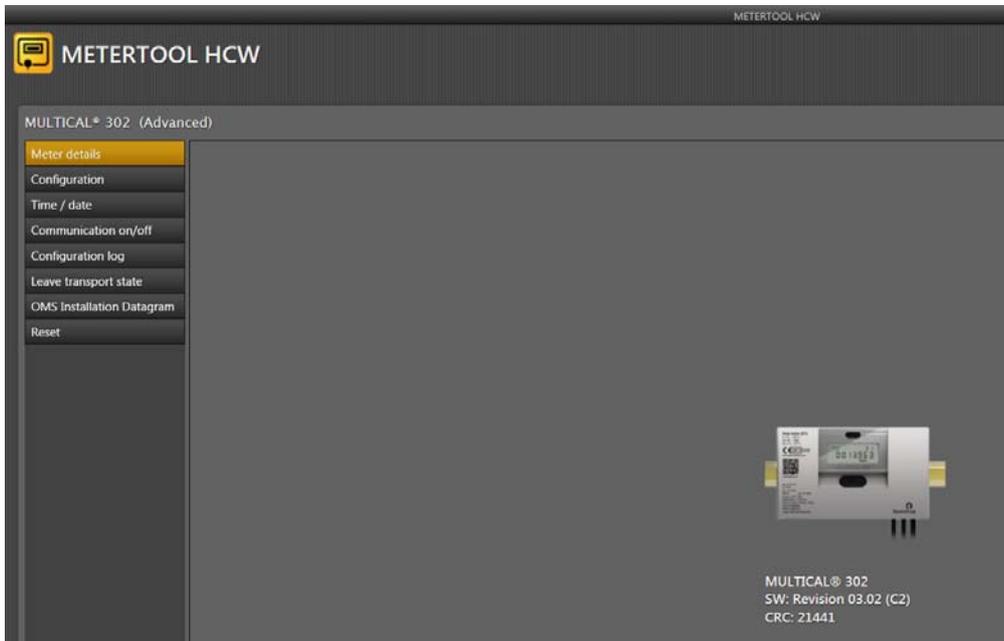


Start up METERTOOL HCW, press the button on the calculator and click "Connect" in METERTOOL HCW.



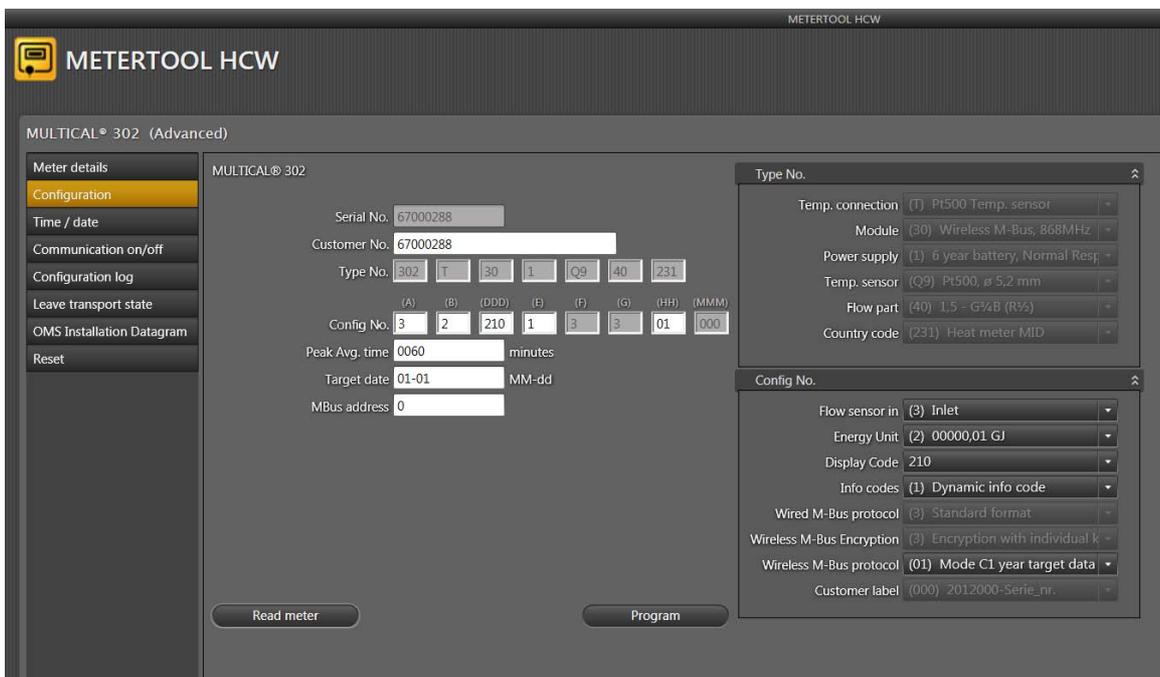
MULTICAL® 302

METER TOOL HCW will respond by showing a picture of MULTICAL® 302 with information about S/W revision etc.



From the menu in the left side of the screen a number of different options are available, depending on mode (Basic/Advanced).

15.2.2 Configuration (Basic/Advanced Mode)



The configuration of MULTICAL® 302 can be read without setting the meter to Setup Loop. The program is self-explanatory as to most coding numbers (see text in "combo-boxes"), further details can be found in the respective paragraphs of the technical description.

15.2.3 Changing the configuration of MULTICAL® 302

To program new values into the meter it must be in Setup Loop. If the MULTICAL® 302 has not yet been used it will be in “Transport State” and the programming can take place without further action. METERTOOL for MULTICAL® 302 will automatically set the meter to Setup Loop.

If the MULTICAL® 302 has been in use prior to the programming, the meter will have to be set to “Setup loop” before the programming can commence. This can be done only by first breaking the  SETUP seal and short-circuiting the contact points behind the seal with short-circuit pen type 66-99-278. After that, “Setup” is displayed.

Note! This should be done only by an authorized installer, and an approved seal has to be replaced after programming.

After shorting  SETUP seal, the meter will remain in Setup loop for 4 minutes. To extend this period the front button can be pressed, which will extend the Setup loop time by another 4 minutes. This can be done multiple times.

Figure 8



It is not possible to change the series number, as this is a unique number which is allocated to the meter during production.

15.2.4 Time / date (Basic/Advanced Mode)

In this menu the built-in clock in the meter can be read out and adjusted either manually or by setting the meter to the clock of the PC where METERTOOL is running. It is only possible to write to a meter in “Setup Loop”.

15.2.5 Communication on/off (Advanced Mode)

In this menu the M-Bus radio transmitter can be switched on or off. This is useful if the meter is being transported e.g. by air.

15.2.6 Configuration log (Advanced Mode)

Displays how many times the meter configuration has been changed since the first configuration. The maximum number of configuration changes is 25.

15.2.7 Reset (advanced mode)

This menu comprises three different types of reset.

1. Normal Reset

This reset does not zero any registers. The data logger structure implemented in the meter permits logging at intervals: hour, day, month, year. Furthermore, info events and configuration events are logged. In addition to the logs mentioned, which are dedicated to reading, a backup log, which is used in case of voltage failure or reset, is logged. "Normal Reset" updates the backup log, the meter restarts and restores the configuration parameters. It may be necessary to perform a "Normal Reset" if the configuration parameters are changed as a "Normal Reset" restores the configuration parameters, which means that the meter registers the changes.

2. Data logger reset

This reset zeroes the meter's data protocols, including yearly, monthly, daily and hourly logs as well as info code and configuration log.

3. Static info code reset

If the meter has been configured for "Manual reset of info codes", the info code remains visible in the meter's display until a "Static info code reset" has been performed. If the meter has been configured with "Dynamic info codes", however, the info code disappears when the error has been corrected. A "Static info code reset" does not reset the info code logger.

15.2.8 Leave transport state (Advanced Mode)

If the meter has not yet been commissioned and no water has passed through the flow sensor, the meter is still in Transport state. If needed, the meter can be taken out of Transport state by clicking "Yes" to leave "Transport state".

15.2.9 Autointegration (Advanced Mode)

Using this feature you will have to either connect two known (precision) resistors to the temperature sensor inputs of the meter or use the existing connected temperature sensors and keep them at two known temperatures e.g. boiling water = 100°C and icy water = 0°C.

Thus, you can simulate energy consumption and thereby verify the energy calculation of the meter.



15.2.10 Settings

By clicking the "Settings" tab the following can be changed:

Change language

The program language can be changed between 6 different languages: Danish, German, English, French, Polish and Russian.



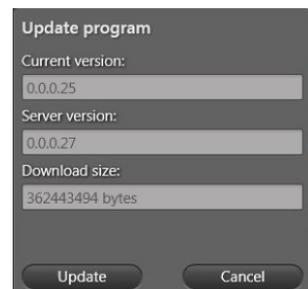
COM port settings

The COM port can be selected manually instead of the default setting which is automatic.



Update program

In this menu the METERTOOL program can be updated if a newer revision is available on Kamstrup's FTP-server. Also the driver for the USB optical read out head can be installed manually from this menu.



Update database

In this menu the METERTOOL database can be updated if a newer revision is available on Kamstrup's FTP-server.



Backup & Rest. databases This button is not used with MULTICAL® 302.

Install USB driver This button installs the USB driver used or the optical read out head.

15.2.11 Help button

Contact The contact button gives you the links to Kamstrup's Website and mailbox.

Output This function shows the latest functions used in the program.

User manual Links to the user manual for the meter on Kamstrup's website.

15.2.12 About button

About lists the METERTOOL program version and revision numbers as well as all sub-programs, their type numbers and revision numbers for the entire METERTOOL HCW program.

15.3 Flow sensor adjustment

Flow sensor adjustment of MULTICAL® 302 can only be done by an authorized laboratory using LabTool, which is not available for ordinary users.

15.4 LogView HCW for MULTICAL® 302

15.4.1 Introduction and installation

Regarding "Introduction", "Interface" and "Installation" see paragraph **15.1 Introduction METERTOOL HCW** since it is similar for LogView HCW.

15.4.2 General information

"LogView HCW" (ordering no. 6699-725) is used for read-out of logging data from MULTICAL® 302 meter. The read out data can be used for analysis and diagnostic test of the heating installation. Data can be presented as table and graphics, tables can be exported to "Windows Office Excel".

For available logging data see paragraph **7.8 Data loggers**.

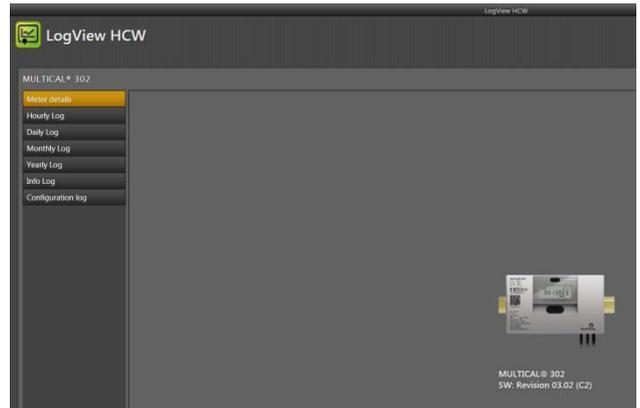
15.4.3 "Log"

Select the required data function.

Daily Data, Monthly Data and Yearly Data allow read-out of data logged by MULTICAL® 302 with optional data period and values.

Info Data allows read-out of the latest 50 info events from MULTICAL® 302, reading includes date and info code of the info event.

Configuration log allows read out of all configuration changes (max. 25) that have been made to the meter.



15.4.4 Help button

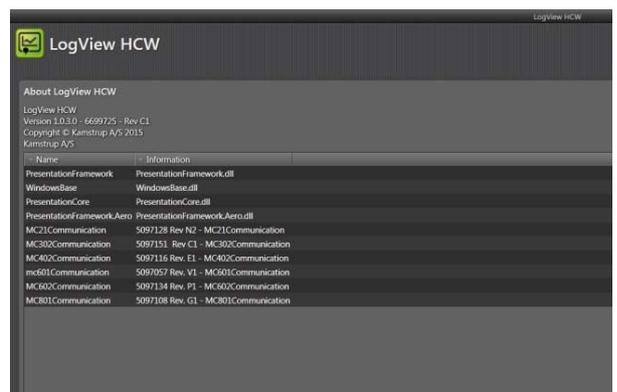
Contact The contact button gives you the links to Kamstrup's website and mailbox.

Output This function shows the latest functions used in the program.

User manual Links to the user manual for the meter on Kamstrup's website.

15.4.5 About button

About lists the LogView HCW program version and revision numbers as well as all sub-programs, their type numbers and revision numbers for the entire LogView HCW program.

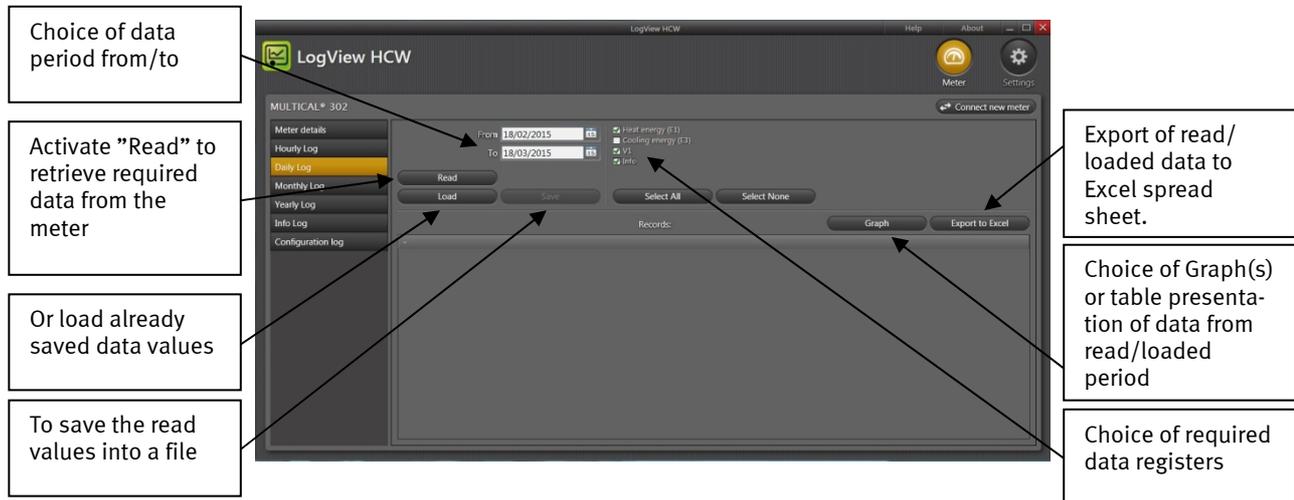


15.4.6 Application

Double-click on link or icon for "LogView HCW" in order to start the program, and select the required data function.

Meter identification! Click "connect to meter"

"Daily Data" is used as an example:



Select the required registers by clicking on the box next to the register name. To read out all data, activate "Select All" to select all values.

When read-out has been completed the read values can be saved by clicking "Save". We recommend to save the read-outs, securing that data can be reopened later for further analysis or documentation.

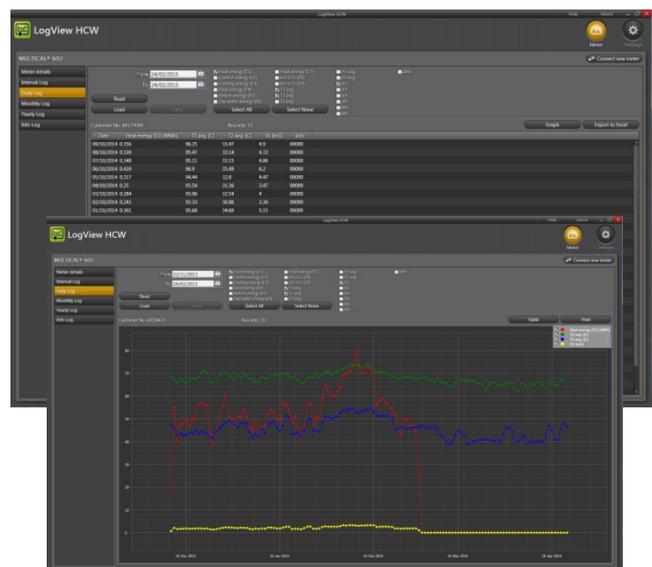
The values appear in graphs or list form by activating "Graph"/"Table" (toggle function).

In order to carry out a new data read-out, you just select a new period and new data registers. If the formerly read values are not already saved, you will be asked if you want to do so.

Tables can be exported direct to "Windows Office Excel" or printed.

To zoom in activate (+), to zoom out activate (-) on the axes.

The arrows (↑↓→←) on the axes are used for manoeuvring in the graph area.



16 Approvals

16.1 Type approvals

MULTICAL® 302 is type approved according to MID on the basis of EN 1434-4:2007 and prEN 1434-4:2013.

MULTICAL® 302 has a national Danish cooling approval TS 27.02 001.

MULTICAL® 302 has a national German cooling approval based on PTB TR K7.2.

16.2 The Measuring Instruments Directive

MULTICAL® 302 is available with CE-marking according to MID (2004/22/EC). The certificates have the following numbers:

Module B: DK-0200-MI004-031

Module D: DK-0200-MIQA-001



Declaration of Conformity

Overensstemmelseerklæring
Déclaration de conformité
Konformitätserklärung
Deklaracja Zgodności
Declaración de conformidad
Declaratie de conformitate

We
Vi
Nous
Wir
My
Nosotros
Noi

Kamstrup A/S
Industrivej 28, Stilling
DK-8660 Skanderborg
Denmark
Tel: +45 89 93 10 00

declare under our sole responsibility that the product(s):
erklærer under eneansvar, at produkt(erne):
déclarons sous notre responsabilité que le/les produit(s):
erklären in alleiniger Verantwortung, dass/die Produkt(e):
deklarujemy z pełną odpowiedzialnością że produkt(y):
Declaramos, bajo responsabilidad propia que el/los producto
declaram pe proprie raspundere ca produsul/produsele:

| Instrument | Type | Type No.: | Classes | Type Approval Ref.: |
|---------------------|--|--|---|--|
| Heat Meter | MULTICAL® 401 | 66-V and 66-W | Cl 2/3, M1, E1 | DK-0200-MI004-001 |
| Heat Meter | MULTICAL® 402 | 402-V, 402-W, 402-T | | DK-0200-MI004-013 |
| Heat Meter | MULTICAL® 302 | 302-T | Cl 2/3, E1, M1, M2 | DK-0200-MI004-031 |
| Temperature Sensors | PL and DS | 65-00-0A/B/C/D 66-00-0F/G 65-00-0L/M/N/P 66-00-0Q3/4 65-56-4 | M1 | DK-0200-MI004-002 |
| Flow Sensor | ULTRAFLOW® qp 0.6...400 m ³ /h | 65-S/R/T | Cl 3, M1, E1 | DK-0200-MI004-003 |
| Flow Sensor | ULTRAFLOW® qp 0.6...40 m ³ /h and qp 150...400 m ³ /h | 65-S/R/T | Cl 2/3, M1, E1 | DK-0200-MI004-003 |
| Calculator | MULTICAL® 601 MULTICAL® 601+ MULTICAL® 602 MULTICAL® 6L2 SVM S6 MULTICAL® 801 | 67-A/B/C/D 67-E 602-A/B/C/D 6L2-F S6-A/B/C/D 67-F/G/K/L | M1, E1/E2 M1, E1/E2 M1, E1/E2 M1, E1/E2 M1, E1/E2 M1, E1/E2 | DK-0200-MI004-004 DK-0200-MI004-004 DK-0200-MI004-020 DK-0200-MI004-020 DK-0200-MI004-020 DK-0200-MI004-009 |
| Flow Sensor | ULTRAFLOW® 54/34 qp 0.6...100 m ³ /h qp 150...1000 m ³ /h ULTRAFLOW® 54 | 65-5/65-3 65-5 | Cl 2/3 M1, E1/E2 M1/M2, E1/E2 M1/M2, E1/E2 | DK-0200-MI004-008 DK-0200-MI004-033 |
| Water Meter | MULTICAL® 21 MULTICAL® 41 MULTICAL® 61 MULTICAL® 62 flowIQTM 2101 flowIQTM 3100 | 021 66-Z 67-Z 62-Z 021 031 | Cl 2, M1, E1/E2 Cl 2, M1, E1 Cl 2, M1, E1, B Cl 2, M1, E1, B Cl 2, M1, E1/E2 Cl 2, M1, E1/E2 | DK-0200-MI001-015 DK-0200-MI001-003 DK-0200-MI001-010 DK-0200-MI001-016 DK-0200-MI001-015 DK-0200-MI001-017 |

are in conformity with the requirements of the following directives:

er i overensstemmelse med kravene i følgende direktiver:
sont conforme(s) aux exigences de la/des directives:
mit den Anforderungen der Richtlinie(n) konform ist/sind:
s' zgodne z wymaganiami następujących dyrektyw:
es/son conformes con los requerimientos de las siguientes directivas:
este/sunt in conformitate cu cerintele urmatoarelor directive:

Measuring Instrument Directive 2004/22/EC, Module D
EMC Directive 2004/108/EC
LVD Directive 2006/95/EC
PE-Directive (Pressure) 97/23/EC, Module A1
R&TTE 1999/5/EC
RoHS II Directive 2011/65/EU

Date: 2015/05/18

Sign.:

Notified Body, Module D Certificate:
Force Certification A/S
EC Notified Body nr. 0200
Park Alle 345, 2605 Brøndby
Denmark

Lars Bo Hammer
Quality Assurance Manager

5518-050, Rev.: AA1, Kamstrup A/S, DK8660 Skanderborg, Denmark

17 Troubleshooting

MULTICAL® 302 has been constructed with a view to quick and simple installation as well as long and reliable operation at the heat consumer.

Should you, however, experience an operating problem with the meter, the table below can be used for troubleshooting.

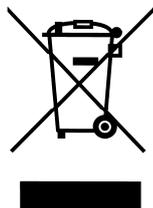
The meter may only be opened and/or repaired by an authorized laboratory or at Kamstrup A/S.

Before sending us the meter to be repaired or checked, we recommend that you go through the error options listed below in order to clarify the possible cause of the problem.

| Symptom | Possible reason | Proposal for correction |
|--|--|---|
| No display function (empty display) | Display is in "sleep mode" | Press the front button in order to activate the display. |
| No energy accumulation (e.g. MWh) and volume (m ³) | Read "info" in the display | Check the error indicated by the info code (see paragraph 7.8) |
| | If "info" = 2 ⇒ | Check that the flow direction matches the arrow on the flow sensor |
| | If "info" = 4, 8 or 12 ⇒ | Check temperature sensors. If defective, replace the meter. |
| Accumulation of volume (m ³) but not of energy (e.g. MWh) | Temperature sensors can be defective. Check the temperature sensor cable for visible damage. | Replace the meter |
| | Heat/cooling cutoff θ_{hc} has been configured too low (only relevant for meter type 6xx) | Reconfigure θ_{hc} at a suitable value, or configure θ_{hc} at 180 °C, thereby disconnecting the cutoff function. |
| Incorrect temperature reading | Defective temperature sensor | Check the installation |
| | Insufficient installation | Replace the meter |
| Temperature indication a little too low, or accumulation of energy (e.g. MWh) slightly too low | Bad thermic sensor contact | Make sure that the sensors have been pushed to the bottom of the sensor pockets |
| | Heat dissipation | Insulate sensor pockets |
| | Too short sensor pockets | Replace by longer pockets |

18 Disposal

Kamstrup A/S holds an environmental certification according to ISO 14001, and as part of our environment policy we use materials which can be recovered environmentally correct to the greatest possible extent.



As from August 2005 Kamstrup's heat meters are marked according to EU Directive 2002/96/EEC and the standard EN 50419.

The purpose of the marking is to inform our customers that the heat meter cannot be disposed of as ordinary waste.

• Disposal

Kamstrup accept end-of-life MULTICAL® 302 for environmentally correct disposal according to previous agreement. The disposal arrangement is free of charge to the customer, except for the cost of transportation to Kamstrup A/S or the nearest disposal system.

The meters should be disassembled as described below and the separate parts handed in for approved destruction. The batteries must not be exposed to mechanical impact and the lead-in wires must not be short-circuited during transport.

| Item | Material | Recommended disposal |
|---|---|------------------------------------|
| 2 x A Lithium cells | Lithium and thionyl chloride 2 x A-cells: 2 x 0.96 g lithium | Approved deposit of lithium cells |
| 1 x A Lithium battery | Lithium and thionyl chloride 1 x A-cell: 0.96 g lithium | Approved deposit of lithium cells |
| PCBs in MULTICAL® 302 (remove LC-display) | Coppered epoxy laminate, components soldered on | PCB scrap for metal recovery |
| LC-display | Glass and liquid crystals | Approved processing of LC-displays |
| Cables for flow sensor and temperature sensors | Copper with silicone mantle | Cable recovery |
| Transparent top cover | PC + 10% glass | Plastic recycling or combustion |
| PCB case and connecting base | ABS with TPE gaskets | Plastic recycling or combustion |
| Wall bracket | PC + 20% glass | Plastic recycling or combustion |
| Meter case | Hot dezincification proof brass, CW 602N | Metal recovery |
| Transducer/reflector | < 1% stainless steel | |
| Packing | Environmental cardboard | Cardboard recycling (Resy) |
| Packing | Polystyrene | EPS recovery |

Please send any questions you may have regarding environmental matters to:

Kamstrup A/S
 For the attention of:
 Quality and environmental dept.
 Fax: +45 89 93 10 01
info@kamstrup.com

19 Documents

| MULTICAL® 302 | Danish | English | German | Russian |
|-------------------------------|---------------|----------------|---------------|----------------|
| Technical description | 5512-1333 | 5512-1334 | 5512-1335 | 5512-1336 |
| Data sheet | 5810-1203 | 5810-1205 | 5810-1206 | 5810-1207 |
| Installation and user's guide | 5512-1350 | 5512-1351 | 5512-1352 | 5512-1353 |

| | Danish | English | German | Russian |
|------------------------------|---------------|----------------|---------------|----------------|
| Technical description M-Bus | - | 5512-1329 | - | - |
| Technical description wM-Bus | - | 5512-1330 | - | - |

