Technical Description

MULTICAL® 401

Kamstrup

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1 General Description

MULTICAL® 401 is a static heat meter based on the ultrasonic principle. The meter is intended for energy measurement in all types of heating installations with water as heat-conveying medium.

According to EN 1434 MULTICAL® 401 can be described as a "hybrid instrument" also called a "compact meter". In practice this means, that flow part and calculation unit must not be separated.

If flow part and calculation unit have been separated and the seals thereby have been broken, the meter will no longer be valid for billing purposes, and the factory guarantee will no longer apply.

MULTICAL® 401 is based on ultrasonic measurement and microprocessor technique. All circuits for calculation and flow measurement are gathered in a single-board construction providing a compact and rational design, and at the same time supreme measuring quality and reliability are achieved.

The volume measurement is carried out by means of a bidirectional ultrasound technique according to the transit time method which today is considered the most long-term stable and accurate measuring principle. Two ultrasonic transducers send ultrasonic signals with and against the flow direction. The ultrasonic signal travelling in the flow direction will reach the opposite transducer first, and the time difference between the two signals can subsequently be converted into flow quantity and thereby also volume.

The temperatures in flow and return pipes are measured by accurately matched Pt500 or Pt100 sensors according to EN 60751. MULTICAL® 401 is delivered either with short direct sensors according to EN 1434-2 or with ø5.8 mm pocket sensors that fit Kamstrup's stainless steel sensor pockets.

The accumulated thermal energy can be displayed in kWh, MWh or in GJ, all including seven significant digits and measuring unit. The display is specially constructed with a view to long lifetime and high contrast in a wide temperature range.

Other possible display indications are accumulated water consumption, operating hours, current temperature, current flow and power measurements. Furthermore, MULTICAL® 401 can be configured to read out target data, peak flow, peak power, information code, date and user-defined tariff.

MULTICAL® 401 is supplied via an internal lithium battery with a lifetime of up to 12 years. Alternatively, the meter can be mains supplied, either from 24 VAC or 230 VAC.

In addition to the heat meter's own data, MULTICAL® 401 indicates an accumulated consumption for two extra water meters, e.g. cold-water and hot-water meters, that supplies a contact signal to MULTICAL® 401 via a reed switch. The contact signals from the extra water meters are connected via the communication modules.

Furthermore, a multi-poled plug is placed under the top cover that is used in connection with calibration and adjustment during verification and partly in connection with communication modules. MULTICAL® 401 can be supplied with communication modules for radio, M-Bus and RS232.

1.1 Mechanical construction

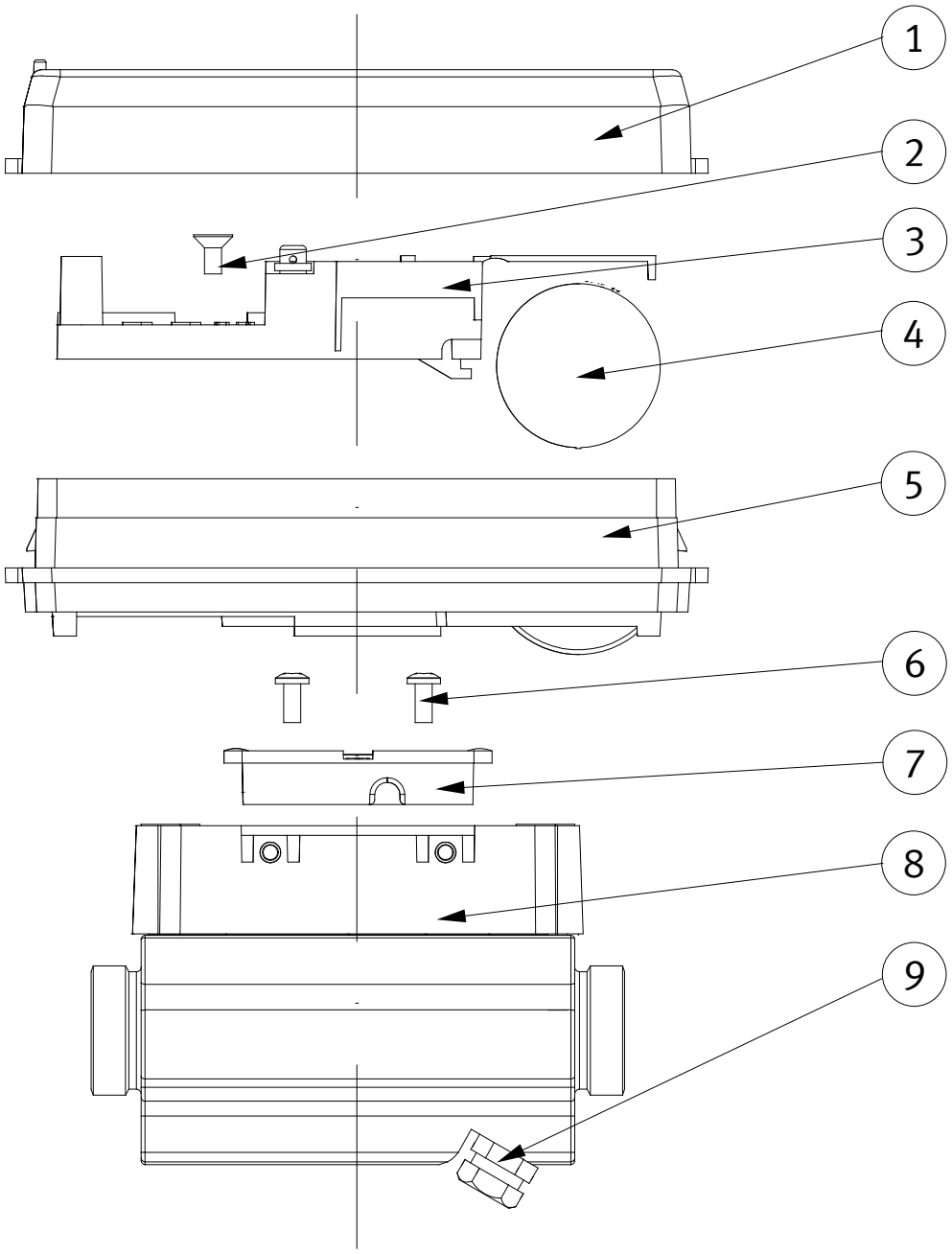


Figure 1

1 Transparent top cover with front plate

2 Sealing screw for verification cover

3 Verification cover including push button. The lid of the supply unit can be opened without breaking the verification

4 Supply: Battery, 24 VAC or 230 VAC. Can be replaced without breaking the verification

5 Case for electronics unit

6 Screws for bracket

7 Bracket. Can also be used for wall mounting (bracket: 3026-290)

8 Meter case with holes for cable binders (cable binders: 1650-145)

9 Connecting piece and blind plug for short direct sensor

2 Technical data

2.1 Approved meter data

MID designation

- Mechanical environment Class M1
- Electro-magnetic environment Class E1

Climatic environment 5…55°C, non condensing, closed location (indoor installation)

EN 1434 designation Accuracy class 2 or 3, environmental class A

Flow sensor types qp 0.6 m^3/h…qp 15 m^3/h (see *Table 1*)

Temperature range, calculator θ: 10°C…160°C and $\Delta\theta$: 3 K…150 K

Temperature sensor set Pt500 or Pt100, EN 60751

Media temperature in flow sensor θq: 15°C…130°C

Type number	Nom. flow [m^3/h]	Max. flow [m^3/h]	Min. flow [l/h]	Min. Cut off [l/h]	Pressure loss Δp @ qp [bar]	Connection to flow sensor	Length [mm]
66-W/Vx-xx**1**-xxx	qp 0.6	qs 1.2	6	3	0.04	G¾B	110
66-W/Vx-xx**4**-xxx	qp 1.5	qs 3.0	15	3	0.25	G¾B	110
66-Wx-xx**5**-xxx	qp 1.5	qs 3.0	15	3	0.25	G¾B	165
66-W/Vx-xx**7**-xxx	qp 1.5	qs 3.0	15	3	0.25	G1B	130
66-W/Vx-xx**9**-xxx	qp 1.5	qs 3.0	15	3	0.25	G1B	190
66-W/Vx-xx**A**-xxx	qp 3.0	qs 6.0	30	6	0.05	G1B	130
66-W/Vx-xx**B**-xxx	qp 3.0	qs 6.0	30	6	0.05	G1B	190
66-Vx-xx**C**-xxx	qp 3.0	qs 6.0	30	6	0.05	DN20	190
66-W/Vx-xx**D**-xxx	qp 3.5	qs 7.0	35	7	0.07	G5/4B	260
66-Vx-xx**E**-xxx	qp 3.5	qs 7.0	35	7	0.07	DN25	260
66-W/Vx-xx**F**-xxx	qp 6.0	qs 12	60	12	0.19	G5/4B	260
66-W/Vx-xx**G**-xxx	qp 6.0	qs 12	60	12	0.19	DN25	260
66-W/Vx-xx**H**-xxx	qp 10	qs 20	100	20	0.06	G2B	300
66-W/Vx-xx**J**-xxx	qp 10	qs 20	100	20	0.06	DN40	300
66-W/Vx-xx**K**-xxx	qp 15	qs 30	150	30	0.14	DN50	270

Table 1

2.2 Electrical data

Supply voltage	3.6 V ± 5%
Battery	3.65 VDC, D-cell lithium
Replacement interval	
- Mounted on the wall	12 years @ t_{BAT}< 30°C
- Flow sensor mounted	10 years @ t_{BAT}< 40°C
- "Fast mode"	4 years @ t_{BAT}< 30°C 3 years @ t_{BAT}< 40°C
Mains supply	230 VAC +15/-30%, 50 Hz 24 VAC ±50%
Power consumption supply	< 1W
Backup mains supply	Integral super-cap eliminates operational disturbances due to short-term power cuts
EMC data	Meets EN 1434 class A

2.3 Mechanical data

Metrological class	2 or 3
Environmental class	Meets EN 1434 class A
Ambient temperature	0...55°C (indoor installation)
Protection class	IP54
Medium temperature	15...130°C At medium temperatures higher than 90°C in the flow sensor, use of flange meters is recommended. Additionally, the calculator should be wall-mounted.
Storage temperature, empty meter	-25...60°C
Pressure stage (with thread)	PN16
Pressure stage (with flanges)	PN25
Flow sensor cable	1.4 m

2.4 Accuracy

Sub-elements of the heat meter	MPE according to EN 1434-1	MULTICAL® 401, typical accuracy
Flow sensor	± (2 + 0.02 qp/q) %	± (1 + 0.01 qp/q) %
Calculator	± (0.5 + $\Delta\Theta_{min}/\Delta\Theta$) %	± (0.15 + 2/$\Delta\Theta$) %
Sensor set	± (0.5 + 3 $\Delta\Theta_{min}/\Delta\Theta$) %	± (0.4 + 4/$\Delta\Theta$) %

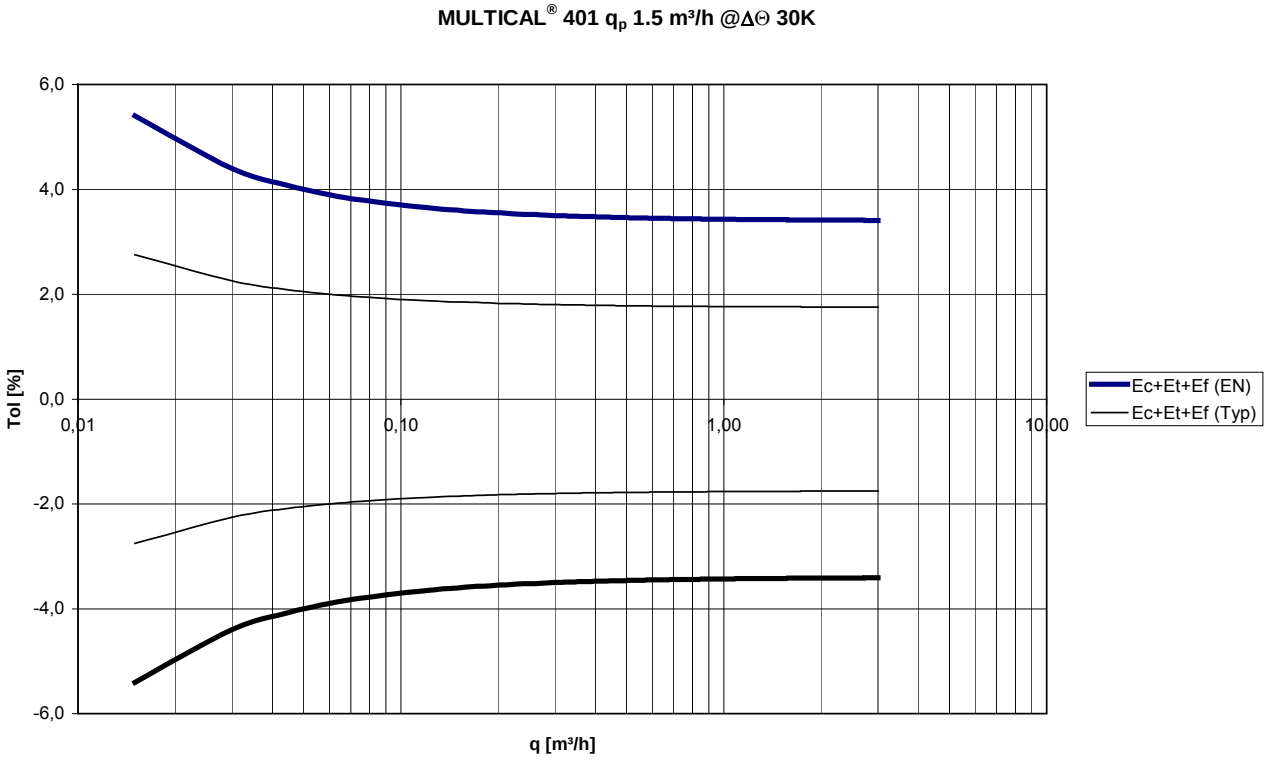


Diagram 1: MULTICAL® 401 typical accuracy compared with EN 1434-1.

2.5 Materials

Wetted parts

Housing, gland	Enkotal (alpha brass)
Housing, flange	RG5204 (red brass)
Transducer	AISI 316
Gaskets	EPDM
Measuring pipe	PES 30% GF
Reflectors	AISI 304

Flow sensor housing

Top/wall fittings	PC + 20% glass

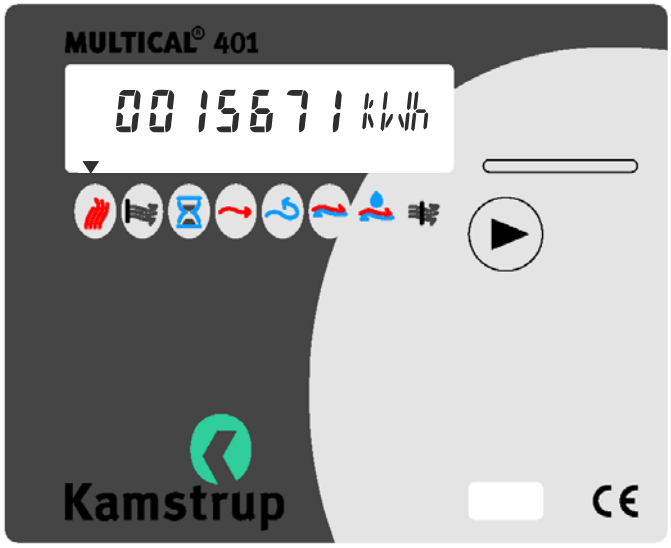
Calculator housing

Top	PC
Base	ABS with TPE gaskets (thermoplastic elastomer)
Internal cover	PP

Flow sensor cable

Silicone cable with internal teflon insulation

3 Type overview



3.1 Type number

66-W?-??**X**-???

Flow sensor

The type number of the flow sensor cannot be changed after programming at the factory.

3.2 PROG (Total prog)

A-B-CCC

3.3 CONFIG (Partial prog)

DD-E-FF-GG

3.4 DATA (Partial prog)

-Customer no.

-Target date

-TL2

-TL3

-Peak Average time

-Date/time

-Telephone numbers

-Preset VA and VB

3.1 Type number, MULTICAL® 401

			Type	**66-**	□	□	□ □ □	
Sensor connection								
Pt100					**V**			
Pt500					**W**			
Modules								
No module						**0**		
M-Bus/pulse inputs (MC 401)						**P**		
Data/pulse output						**Q**		
Data/pulse inputs						**R**		
M-Bus/pulse inputs						**S**		
Radio/pulse inputs						**U**		
Radio with external antenna connection/pulse inputs						**W**		
Supply								
No module							**0**	
Battery, D-cell							**2**	
230 VAC supply module							**7**	
24 VAC supply module							**8**	
Pt500 sensor set								
No sensor set								**0**
Pocket sensor set with 1.5 m cable								**A**
Pocket sensor set with 3.0 m cable								**B**
Short direct sensor set with 1.5 m cable								**F**
Short direct sensor set with 3.0 m cable								**G**
Flow sensor								
qp [m³/h]	**Connection**	**Length [mm]**						
0.6	G¾B (R½)	110						**1**
1.5	G¾B (R½)	110						**4**
1.5	G¾B (R½)	165	(only Pt500)					**5**
1.5	G1B (R¾)	130						**7**
1.5	G1B (R¾)	190						**9**
3.0	G1B (R¾)	130						**A**
3.0	G1B (R¾)	190						**B**
3.0	DN20	190	(only Pt100)					**C**
3.5	G5/4 (R1)	260						**D**
3.5	DN25	260	(only Pt100)					**E**
6.0	G5/4 (R1)	260						**F**
6.0	DN25	260						**G**
10	G2B (R1½)	300						**H**
10	DN40	300						**J**
15	DN50	270						**K**
Country code								**XXX**

In addition, the country code can be used for:

- language and approval on type label
- flow sensor dynamic range (1:50 and 1:100, respectively)
- flow sensor class 2 or 3
- marking of PN class
- special verification, if any
- selection of integration period 28 sec. and 4 sec., respectively

Customer lables (2001-XXX) are integrated in the front label.

3.1.1 Accessories

Glands including gaskets (PN16)

Size		Type no.	2 pcs.
DN15	(R½ x G¾)		65-61-321
DN20	(R¾ x G1)		65-61-322
DN25	(R1 x G5/4)	65-61-313	
DN40	(R1½ x G2)	65-61-315	

Gaskets

Gaskets for glands		Gaskets for flange meters	
Size	Type no.	Size	Type no.
G¾	2210-061	DN20	2210-147
G1	2210-062	DN25	2210-133
G5/4	2210-063	DN40	2210-132
G2	2210-065	DN50	2210-099

3.2 PROG (A-B-CCC)

Prog. no.		A	-	B	-	CCC
		☐		☐		☐☐☐
Flow sensor placing: According to k-factor table	Flow	**3**				
	Return	**4**				
Measuring unit, energy	GJ			**2**		
	kWh			**3**		
	MWh			**4**		
Flow sensor coding						**CCC**

3.2.1 Standard CCC codes

CCC table for MULTICAL® 401									
CCC no.	Number of decimals on the display							qp [m³/h]	Type 66-Wx-xxX-xxx
	kWh	MWh	GJ	m³	l/h	m³/h	kW		
116	0	3	2	2	0	-	1	0.6	1
119	0	3	2	2	0	-	1	1.5	4-5-7-9
136	0	3	2	2	0	-	1	3.0	A-B
151	-	2	1	1	0	-	1	3.5	D
137	-	2	1	1	0	-	1	6.0	F-G
178	-	2	1	1	0	-	1	10	H-J
120	-	2	1	1	0	-	1	15	K

3.2.2 Alternative CCC codes

CCC table for MULTICAL® 401									
CCC no.	Number of decimals on the display							qp [m³/h]	Type 66-Wx-xxX-xxx
	kWh	MWh	GJ	m³	l/h		kW		
107	-		3	3	0	-	1	1.5	4
136	0	3	2	2	0	-	1	3.5	D
138	0	3	2	2	0	-	1	6.0	F-G
183	0	3	2	2	0	-	1	10	H-J
185	0	3	2	2	0	-	1	15	K

3.3 CONFIG, DD-E-FF-GG

3.3.1 ›DD‹ CONFIGURATION OF DISPLAY

DD – codes ›Primary‹

Level 1	11	12 (13)	14 (15)	16 (17)	18	19 (20)	21 (22)	23	24	25	26	27	55	57	58	69	80
Energy	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	
Volume	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	1
Hour counter	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	8	4
T1, flow temperature	4	4		4	4	4	4	4	4	4	4	4	4	5	4	4	
T2, return temperature	5	5		5	5	5	5	5	5	5	5	5	5	6	5	5	
Differential temperature	6	6		6	6	6	6	6	6	6	6	6	6	7	6	6	
Actual power	7	7		7	7	7	7	7	7	7	7	7		8	7	7	
Peak power (monthly)	8	• 8	•	• 8	• 8	• 8		8	• 8	8	8	8	•		• 8		
Yearly peak power						9											
Actual flow	9	9		9	9	10	8	9	9	9	9	9	7	4	9	3	2
Peak flow (monthly)	• 10						• 9	• 10		• 10	•	• 10		• 9			3
Yearly peak flow							10										
All info	11							11									
All info, however, (-2)		10	4	10	10	11	11		10	11	10	11	8	10	10	9	5

DD -codes ›Secondary‹

Level A	11	12 (13)	14 (15)	16 (17)	18	19 (20)	21 (22)	23	24	25	26	27	55	57	58	69	80
VA								A	A			A				C	
VB								B	B			B				D	
Reading date 1	A			A							A				A		
Energy	B			B							B				B		
Volume 1	C			C													
Yearly peak power 1											C				C		
Yearly peak flow 1											D						
Reading date 2	D			D							E				D		
Energy 2	E			E							F				E		
Volume 2	F			F													
Yearly peak power 2															F		
Yearly peak flow 2																	
Monthly data 1-12											I	C			I	A	A
Energy											J	D			J	B	
Volume											K	E			K		B
Monthly peak power												F					
Monthly peak flow												G					C
TA 2					A	A						H	A	A			
TL 2					B												
TA 3					C	B						I	B	B			
TL 3					D												
Prog No.	G											J				E	
Customer No.	H	A	A	G	E	C	A	C	C	A	G	K	C	C	G	F	D
Actual date	I					D				B	H	L	D	D	H	G	
Software edition	J	B	B	H	F	E	B	D	D		11	12	E	E	11	H	E
Segment test	K	C	C	I	G	F	C	E	E	C	12	13	F	F	12	I	F

• Selection of peak power or peak flow for monthly data (/#5)

NB: Info code 128 is automatically controlled in the factory /METERTOOL configuration:

Type 66-Wx-**2**xx-xxx ⇒ Info code 128 is **active.** In connection with other supply modules ⇒ Info code 128 is **not** active

NBB: Remember that replacing of battery for power supply requires reconfiguration of the type number.

Yearly peak values are updated at the turn of the month.

3.3.2 ›E‹ CONFIGURATION OF MULTITARIF

E=	TARIFF TYPE	Fn	Pil	FUNCTION
0	No tariff active	-	-	No function
1	Power tariff	Yes	7	Energy is accumulated in TA2 and TA3 based on the power limites in TL2 and TL3.
2	Flow tariff	Yes	8	Energy is accumulated in TA2 and TA3 based on the flow limits in TL2 and TL3.
3	Cooling tariff	Yes	6	Energy is accumulated in TA2 and TA3 based on the Δt limits in TL2 and TL3.
4	$m^3 \times tF + m^3 \times tR$	-	-	$TA2 = m^3 \times tF$ and $TA3 = m^3 \times tR$
5	Return temperature tariff	Yes	5	Energy is accumulated in TA2 and TA3 based on the t_R limits in TL2 and TL3.

3.3.3 ›FF‹ Input a, ›GG‹ Input b, pulse division (f ≤ 0.5 Hz)

Input a Terminal 65-66		Input b Terminal 67-68					
FF	Max. input	**GG**	Max. input	**Pre-counter**	**l/pulse**	**Measuring unit and decimal point**	
00	OFF	**00**	OFF	-	-	-	-
01	50 m³/h	**01**	50 m³/h	1	100	m³a – m³b	000000.0
02	25 m³/h	**02**	25 m³/h	2	50	m³a – m³b	000000.0
03	12 m³/h	**03**	12 m³/h	4	25	m³a – m³b	000000.0
04	5 m³/h	**04**	5 m³/h	10	10	m³a – m³b	000000.0
05	2.5 m³/h	**05**	2.5 m³/h	20	5.0	m³a – m³b	000000.0
06	1 m³/h	**06**	1 m³/h	40	2.5	m³a – m³b	000000.0
07	0.5 m³/h	**07**	0.5 m³/h	100	1.0	m³a – m³b	000000.0
24	5 m³/h	**24**	5 m³/h	1	10	m³a – m³b	00000.00
25	2.5 m³/h	**25**	2.5 m³/h	2	5.0	m³a – m³b	00000.00
26	1 m³/h	**26**	1 m³/h	4	2.5	m³a – m³b	00000.00
27	0.5 m³/h	**27**	0.5 m³/h	10	1.0	m³a – m³b	00000.00
40	500 m³/h	**40**	500 m³/h	1	1000	m³a – m³b	0000000

NB: Electricity meters are not to be connected due to the low frequency allowed (min. 1 sec. pulse and pause)

3.3.4 ›FF‹ Output A, ›GG‹

Output A (CE) Terminal 16-17			
FF	Pulse duration	**GG**	
00	OFF	**00**	OFF
94	1 msec.		
95	30 msec.		
96	0.1 sec.		

3.3.5 ›FF‹ og ›GG‹

When FF=00 and GG=00 the pulse inputs/outputs are not active

3.4 DATA

	Automatic	To be stated when ordering	Default
Serial No. (S/N) and year	E.g. 2500000/2003	-	-
Customer number	-	Up to 11 digits	Customer number = S/N
Target date	-	MM=1-12 and DD=1-28	06.01 (1 june)
TL2	-	5 digits	0
TL3	-	5 digits	0
Peak average time	-	1…120 min.	60 min.
Date/time	YY.MM.DD/hh.mm.ss	-	-
Telephone number #1	-	Max. 12	-
Telephone number #2	-	Max. 12	-

3.5 Other functions

When making orders in BOS, select "Locked M-Bus adr", and all meters in one order are made with the same customer number, e.g. 001. However, this requires customer label 2001-500 or higher.

4 Dimentional sketches

MULTICAL® 401

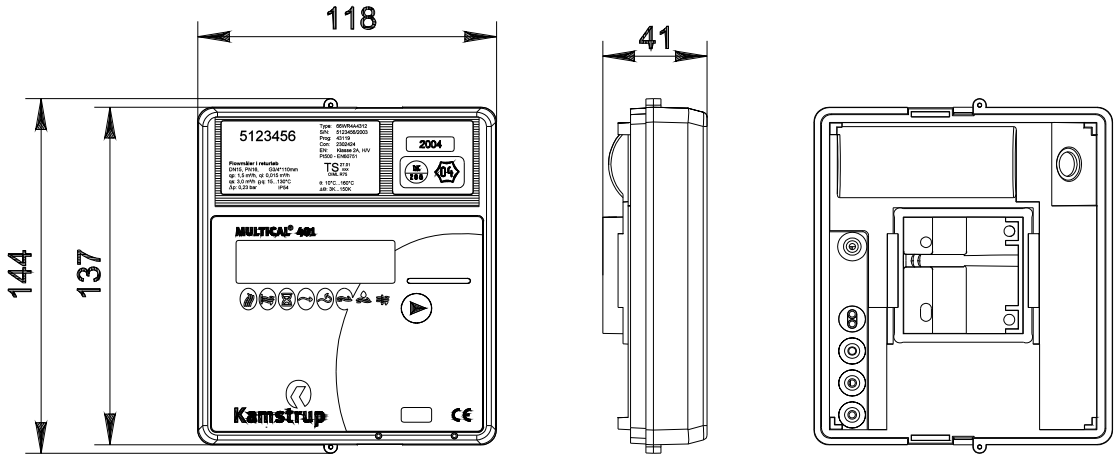
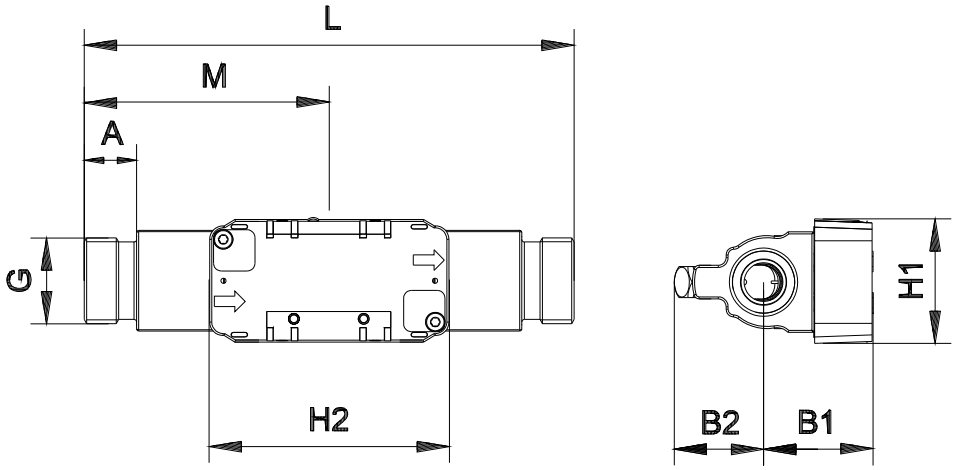


Figure 2: Mechanical dimensions on the electronic unit



Figuer 3: Flow sensor with G¾ and G1 thread connection

Thread	L	M	H2	A	B1	B2	H1	Approx. weight [kg]
G¾	110	L/2	92.5	10.5	42	35	47.5	1.4
G1 (q_p 1.5)	130	L/2	92.5	20.5	42	35	47.5	1.5
G1 (q_p 3.0)	130	L/2	92.5	20.5	42	35	47.5	1.4
G¾	165	L/2	92.5	20.5	42	35	47.5	1.8
G1 (q_p 1.5)	190	L/2	92.5	20.5	42	35	47.5	2.0
G1 (q_p 3.0)	190	L/2	92.5	20.5	42	35	47.5	1.9

Table 2: Weight includes 3 m short direct sensor set. Packing not included.

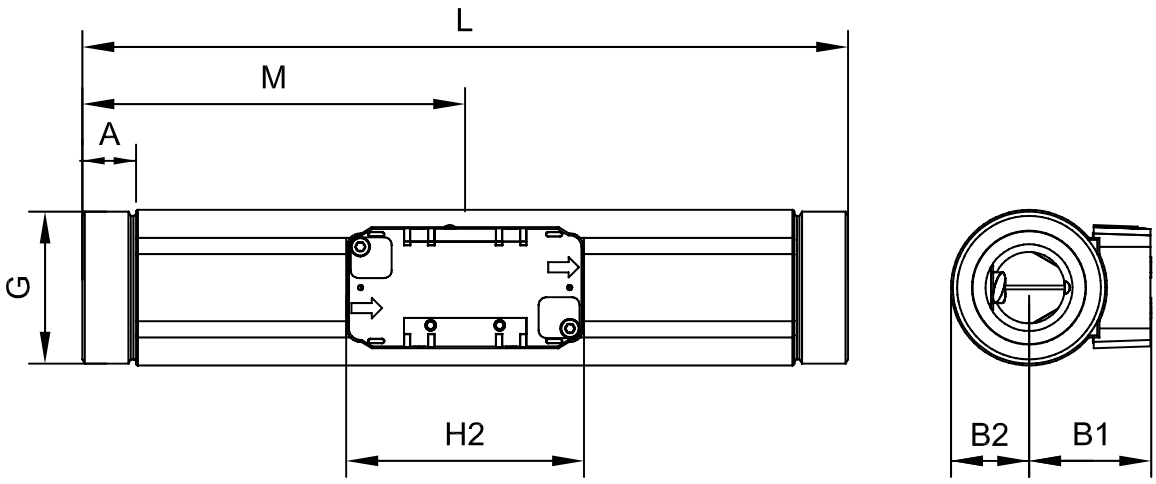


Figure 4: Flow sensor with G5/4 and G2 thread connection

Thread	L	M	H2	A	B1	B2	Approx. weight [kg]
G5/4	260	L/2	92.5	17	42	22	2.9
G2	300	L/2	92.5	21	48	31	5.1

Table 3: Weight includes 3 m sensor set. Packing not included.

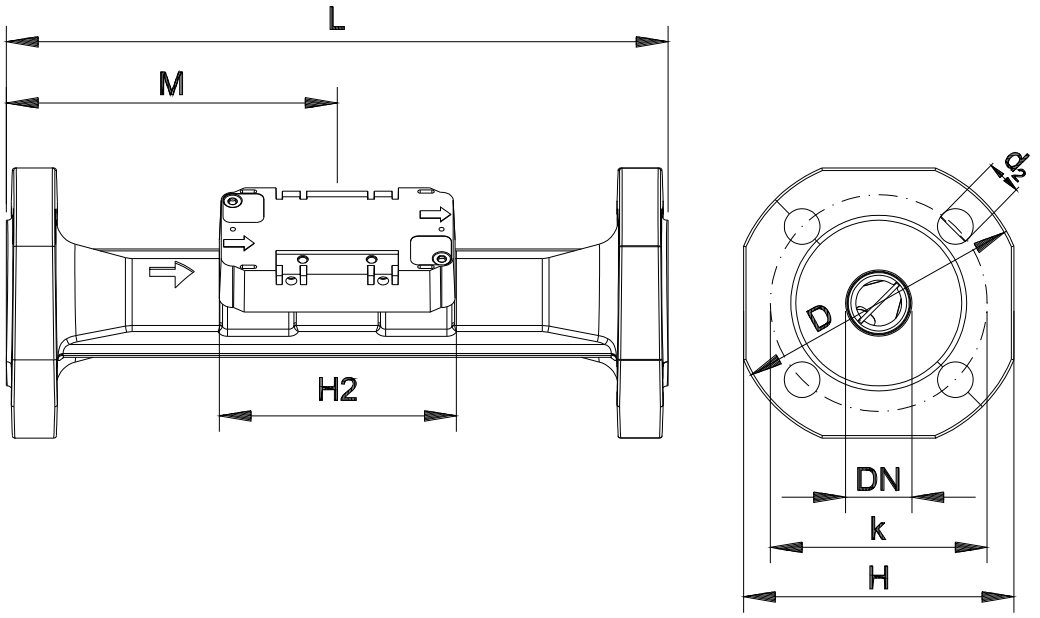


Figure 5: Flow sensor with DN25 to DN50 flange connection

Nom. diameter	L	M	H2	D	H	k	Bolts			Approx. weight.
							Number	Thread	d_2	[kg]
DN25	260	L/2	92.5	115	106	85	4	M12	14	5.6
DN40	300	L/2	92.5	150	136	110	4	M16	18	8.9
DN50	270	155	92.5	165	145	125	4	M16	18	10.7

Table 4: Weight includes 3 m sensor set. Packing not included

5 Pressure loss

The pressure loss in a flow sensor is stated as the max. pressure loss at q_p. According to EN 1434 the max. pressure loss must not exceed 0.25 bar, unless the energy meter has a flow controller or functions as pressure reducing equipment.

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

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

where:

Q =volume flow rate [m³/h]

kv=volume flow rate at 1 bar pressure loss [m³/h]

Δp=pressure loss [bar]

Graph	q_p [m³/h]	Nom. diameter [mm]	kv	Q@0.25 bar [m³/h]
A	0.6 & 1.5	DN15 & DN20	3	1.5
B	3 & 3.5 & 6	DN20 & DN25	13.5	6.8
C	10 & 15	DN40 & DN50	43	21.7

Table 5: Pressure loss table

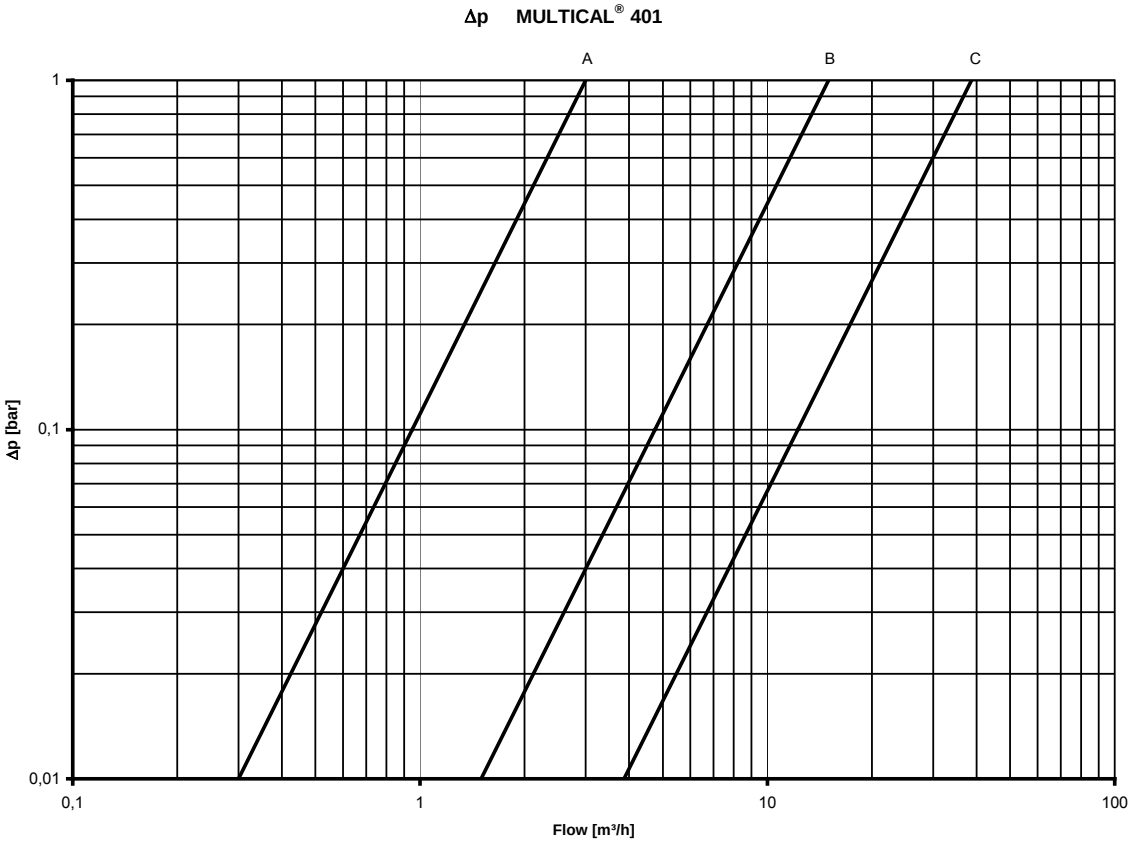


Diagram 2: Pressure loss graphs

6 Installation

6.1 Installation requirements

Before mounting MULTICAL® 401, flush the system thoroughly with a fitting pipe mounted instead of the energy meter. Then remove the protection caps from the input and the output of the meter and mount it by means of glands and gaskets. Always use original new fibre gaskets.

If other types of glands or extension nipples are used, it must be checked that the thread length of the glands does not prevent the sealing surface from being sufficiently tightened.

Correct position of the flow sensor, in flow or return pipe, appears from the type sign on the side of the meter, and the flow direction is shown by an arrow cast in the flow part.

In order to prevent cavitation the working pressure at ULTRAFLOW® must be min. 1.5 bar at qp and min. 2.5 bar at qs. This applies to temperatures up to approx. 80°C.

When the installation is complete, the water flow can be turned on. The valve on the inlet side must be opened first.

ULTRAFLOW® must not be exposed lower pressure than the ambient pressure (vacuum).

Permitted operating conditions

Ambient temperature:	0…55°C (indoors)
Medium temperature:	15…130°C with the calculator mounted on the wall
	15…90°C with the calculator mounted on the flow sensor
System pressure:	1.5…16 bar for thread meters
	1.5…25 bar for flange meters

EMC conditions

MULTICAL® 401 is intended for installation in residential houses as well as in light industrial environments and the meter is CE marked according to EN 1434 type test in environment class A and the low-voltage directive.

Control cables from the meter must be drawn at a minimum distance of 25 cm from other installations.

Electrical installations

MULTICAL® 401 is available for both 24 VAC and 230 VAC mains supply. The mains connection is made with a 2 wire cable, without earth connection.

Use a strong connection cable with an outside diameter of max. 7 mm and ensure a correct cable retainer in the meter. Max. fuse before the meter is 6 A (when using 2 x 0.75 mm^2 connection cable).

National regulations for electric installations must always be met, including e.g. a cable cross section in relation to the fuse size of the installation (short-circuit current).

For installations made in Denmark, the information from "Elråd" concerning installations for mains supplied heat meters applies for both direct 230 VAC supplied meters as for 24 VAC meters supplied via a safety transformer.

Service

When the meter has been mounted in the heating system neither welding nor freezing is permitted. Before starting such work dismount the meter from the heating system and disconnect the power supply, if any.

In order to facilitate possible service of the meter, closing valves ought to be mounted on both sides of the meter.

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

6.2 Installation angle for MULTICAL® 401

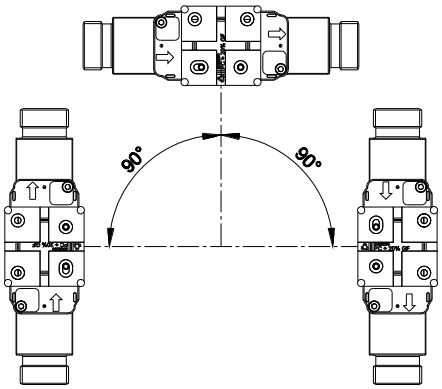


Figure 6

MULTICAL®401 may be installed horizontally, vertically, or at an angle.

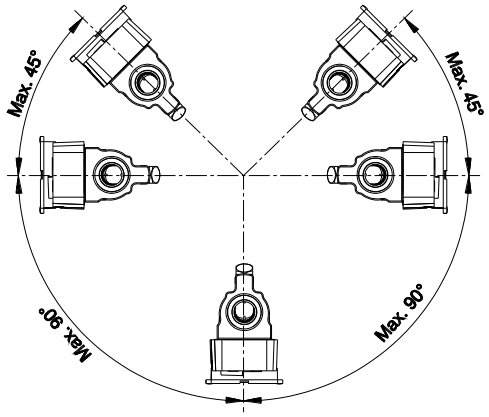


Figure 7

Important!

MULTICAL®401 may be turned upwards to max. 45° and downwards to max. 90° in relation to the pipe axis.

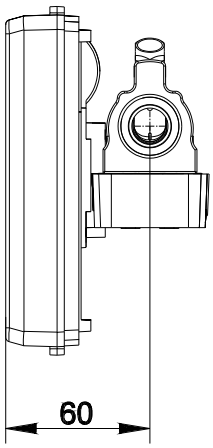


Figure 8

If min. built-in depth (G¾ and G1) is required, the flow sensor must be turned with the plastic case downwards and the calculator on the side.

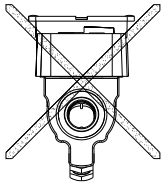


Figure 9

The plastic housing must **not** be turned upwards.

6.3 Straight inlet

MULTICAL®401 does not require either straight inlet or outlet pipe. However, to obtain optimum installation conditions a straight inlet of min. 5 x DN before the flow sensor is recommended.

Meter size		Recommended
DN15…DN50	qp 0.6…qp 15	Min. 5 x DN inlet

For general information concerning installation see CEN rapport *DS/CEN/CR 13582, Heat meter installation – Some guidelines for selecting, installation and operation of heat meters.*

6.4 Installation examples

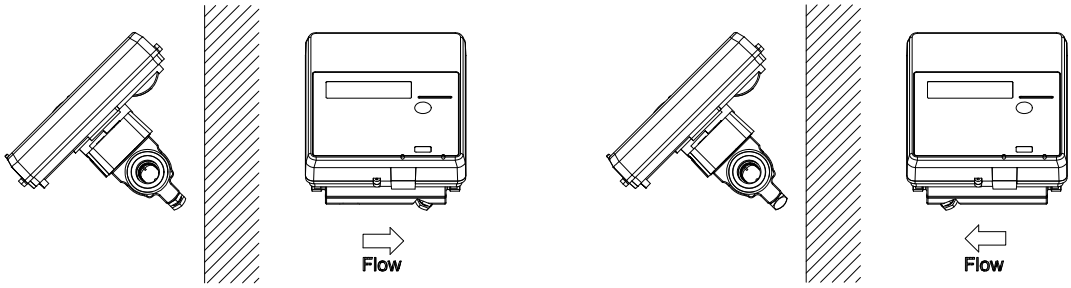


Figure 10: Gland meter

Glands and short direct sensor fitted into MULTICAL®401 (only G¾ (R½) and G1(R¾)).

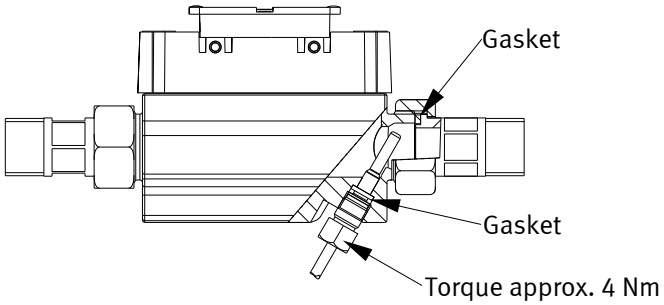


Figure 11

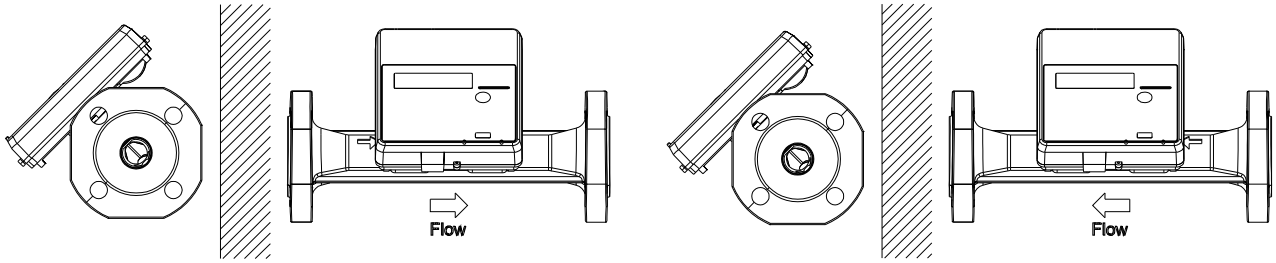


Figure 12: Flange meter

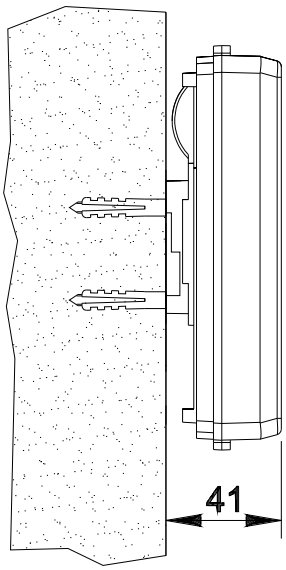


Figure 13: Wall-mounted MULTICAL® 401

Figure 14: Fastening the cable

7 The calculator

7.1 Measurement and calculation

MULTICAL® 401 uses time based integration, i.e. the calculations of accumulated volume and energy are carried out at fixed intervals irrespective of the actual water flow. In normal mode MULTICAL® 401 has an integration interval of 28 sec., whereas in "fast mode" it has an interval of 4 sec.

"Normal mode"

In normal mode MULTICAL® 401 has an integration sequence of 28 sec. Through this sequence the water flow is measured at an average interval of 3.5 sec. Flow and return temperatures are measured in the middle of the sequence and at the end of the sequence, the energy and volume calculations are made. All display values are updated at an interval of 28 sec. In addition, the display showing actual flow is updated at an interval of 14 sec.

"Fast mode"

In fast mode MULTICAL® 401 runs through an integration sequence of 4 sec. Through this sequence the water flow is measured at an average interval of 1 sec. Flow and return temperatures are measured in the middle of the sequence, and at the end of the sequence, the energy and volume calculations are made.

All display values are updated every 4 seconds.

7.2 Push buttons

MULTICAL® 401 has a front key for display change. During normal operation the display shows the accumulated thermal energy in kWh, MWh or GJ, depending on the programming selected.

When the front key is activated the display will move to accumulated volume, hour counter, flow and return temperatures etc. (See section 3.3.1 C*onfiguration of display*).

If the front key is activated for 4 sec., the display changes to a submenu indicating secondary registers, e.g. Input A, Input B, target data, tariffs, and customer number.

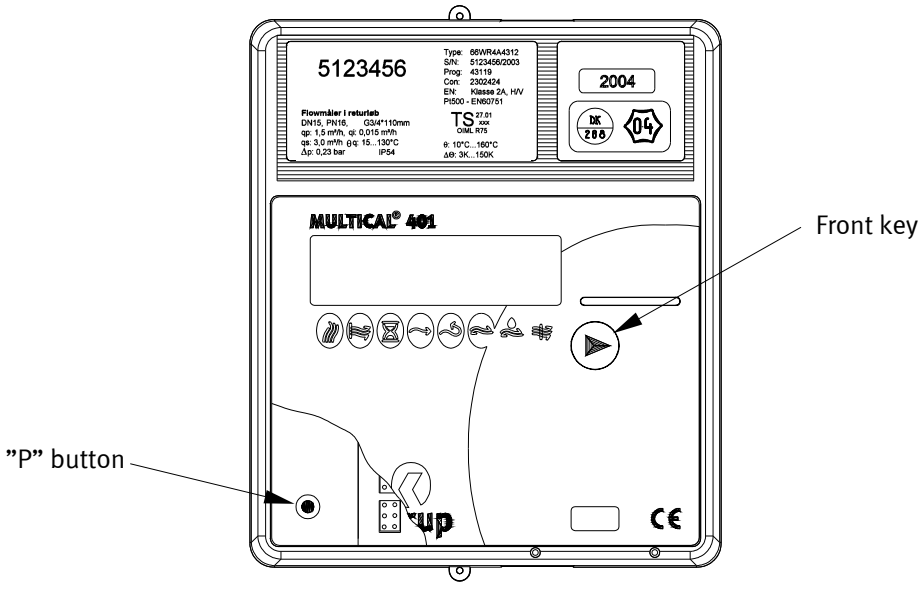


Figure 15

Under the transparent top cover an internal push button "P" is found. This button is used during verification of the meter (see section 13 *Calibration and verification*).

7.3 Display functions

No matter which indication you have selected in the main menu or sub menu, the display will automatically return to indicate accumulated thermal energy, if the front key has not been activated for 150 sec.

Figure 16

The contents of both main and submenus are determined by the configuration selected for the meter (see section 3.3.1 *Configuration of display*). The display in MULTICAL® 401 includes both a main menu and a submenu. In addition to accumulated thermal energy and accumulated volume the main menu includes hour counter, temperature, power and flow readings. When the front key is activated briefly, the display moves through the readings.

The submenu is activated by pressing the front key for 4 sec. Afterwards the front key can be used to move through the readings of the submenu. When the submenu has been selected, an "A" will appear in the left side of the display.

Figure 17

7.4 Information codes

MULTICAL® 401 constantly checks a series of vital functions, whereby serious system errors can be detected. Should one or several serious errors occur in the energy meter, the display will show an "E" at the left side. In case of short-duration errors the "E" will only be displayed as long as the error exists. If an error situation has existed for more than and hour, the information code will be permanent and can now only be deleted by opening the meter (see section 7.5 *Reset functions*).

When the first permanent information code occurs, it is stored in the EEPROM together with the date and the energy and volume registers at the time the error occured.

The meter's actual "info code" appears from the last display indication in the main menu, i.e. when the front key has been activated 4-10 times depending on the selected display configuration. During normal operation the meter shows "000 info".

Figure 18

If one or more of below errors occur, the sum of the information codes is shown. E.g. a simultaneous error in both temperature sensors is shown as "012 info".

Info	Description
+000	No errors found
+002	The information code indicating flow sensor error is activated when the water flow has continously been below cut-off for 48 hours, while Δt has been >20 K
+004 [1)]	The return sensor does not comply with its measuring range 0…165°C. The sensor can be short-circuited or disconnected.
+008 [1)]	The flow sensor does not comply with its measuring range 0…165°C. The sensor can be short-circuited or disconnected.
+016 [1)]	Air is detected in the flow sensor (is only indicated as long as the error exists)
+128 [2)]	The battery must be replaced. This code occurs 12 years after the hour counter was reset.

Table 6

[1)] These information codes occur during transport below freezing point as well as during storage.

During installation the info codes are reset as described in section 7.5 *Reset functions*.

[2)] Info code 128 is only active when the meter is ordered with a battery (type number 66-Wx-**2**xx-xxx).

Use METERTOOL (see section 14) for reprogramming.

7.5 Reset functions

MULTICAL® 401 includes a "Power On Reset" circuit which is activated every time the supply voltage is switched on. This reset function only resets the internal high-resolution registers and therefore does not influence the display registers. After each "Power On Reset" all registers are loaded from the EEPROM thereby ensuring that the meter always starts up with hourly data from the EEPROM.

If the "Power On Reset" function is combined with activating the front key or the internal verification button, the following reset functions are obtained:

Action	Function
Reset + front key	Reset info
Reset + verification button	Reset info and hour counter
Use METERTOOL and data cable 66-99-108 (Under the verification seal)	Total reset: Reset of info code, hour counter, energy and volume indication as well as back-up and target data.

Tablel 7

Do not reset by short-circuiting the battery !

"Power On Reset" is carried out by loosening one of the screw terminals 60(+) or 61(-). When the display goes out, reestablish the connection and at the same time activate the required push button combination.

Remember to fasten the screw terminals.

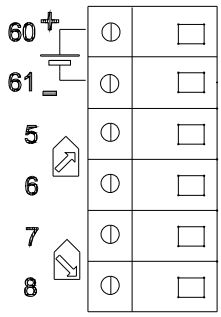


Figure 19

7.6 Tariff functions

MULTICAL® 401 has two extra energy registers TA2 and TA3, which accumulates energy parallel to the main register on the basis of an entered tariff condition. TA2 and TA3 always have the same measuring unit as the main register (kWh, MWh or GJ), however, except from E=4 [$m^3 \times °C$].

Irrespective of the selected tariff, the unit field always indicates TA2 and TA3.

As it is considered legal accounting register, the main register is always accumulated irrespective of the selected tariff function. The tariff conditions TL2 and TL3 are checked before each integration. When the tariff conditions are fulfilled, the thermal energy used is accumulated in either TA2 or TA3 parallel to the main register.

Each tariff function has two connected tariff conditions, TL2 and TL3, which are always used in the same tariff type. Therefore, it is imposible to "mix" two tariff types.

Below table indicates, which tariff types MULTICAL® 401 can be configured into:

E=	Tariff type	Function
0	No tariff active	No function
1	Power tariff	Energy will be accumulated in TA2 and TA3 based on the power limits in TL2 and TL3
2	Flow tariff	Energy will be accumulated in TA2 and TA3 based on the flow limits in TL2 and TL3
3	Cooling tariff	Energy will be accumulated in TA2 and TA3 based on the Δt-limits in TL2 and TL3
4	$m^3 \times tF + m^3 \times tR$	TA2 = $m^3 \times tF$ and TA3 = $m^3 \times tR$
5	Return temperature tariff	Energy will be accumulated in TA2 and TA3 based on the tR-limits in TL2 and TL3

Table 8

TARIFF TYPES

E=0 No tariff active

If you do not wish to use the tariff function, select set-up E=0.

However, the tariff function can be made active by reconfiguring by means of METERTOOL for MULTICAL® 401. See section 14.1 *Programming with METERTOOL*.

E=1 Power controlled tariff

If the actual heat flow rate, in kW, is higher than TL2, but lower than TL3, the thermal energy will be counted in TA2 and in the main register. If the actual power exceeds TL3, thermal energy will be counted in both TA3 and the main register.

P <TL2	Counting in main register only
TL3 >P ≥TL2	Counting in TA2 and main register
P ≥ TL3	Counting in TA3 and the main register

Table 9

During set-up of data, TL3 must naturally be higher than TL2.

Among other things the power controlled tariff is used as a basis for calculating the individual heat consumer's connection costs.

Furthermore, this tariff form provides valuable statistical data when the utility evaluates new construction activities.

E=2 Flow controlled tariff

When the actual water flow (q), in l/h or m^3/h is higher than TL2 but lower than TL3, thermal energy will be counted in both TA2 and the main register. If the actual water flow exceeds TL3, the thermal heat is counted in TA3 and the main register.

q < TL2	Counting in main register only
TL3 > q ≥ TL2	Counting in TA2 and main register
q ≥ TL3	Counting in TA3 and main register

Table 10

During set-up of data, TL3 must naturally be higher than TL2.

Among other things the flow controlled tariff is used as a basis for calculating the individual heat consumer's connection costs. Furthermore, this tariff form provides valuable statistical data when the utility evaluates new construction activities.

When power or flow tariff is used it is possible to get a total overview of the total consumption compared to the part of the consumption that is used above the tariff limits.

Figure 20

Figure 21

Figure 22

E=3 Cooling tariff (Δt)

If the actual cooling (Δt), in °C, is lower than TL2, but higher than TL3, the thermal energy is counted in TA2 and the main register. If the actual cooling gets lower than TL3, the thermal energy will be counted in both TA3 and the main register.

Δt > TL2	Counting only in main register
TL3 < Δt ≤ TL2	Counting in TA2 and main register
Δt ≤ TL3	Counting in TA3 and main register

Table 11

During set-up of tariff limits TL3 must naturally be lower than TL2, as shown in below example with TL2=30.00°C and TL3=20.00°C:

Figure 23

Figure 24

The cooling tariff can be used as the basis for weighted user payment. Low cooling (small difference between flow and return temperatures) is uneconomical for the heat supplier.

E=4 $m^3 \times tF + m^3 \times tR$

TA2 is accumulated by the product of $m^3 \times tF$ (integer m^3 x integer °C) and TA3 is accumulated with the product of $m^3t \times R$.
The resolution is the same irrespective of the flow sensor size (qp 0.6...qp 15 m^3/h).

Example 1: After one year a heat installation has used 250 m^3 of district heating water and the average temperatures have been 95°C in flow and 45°C in return.
TA2 = 23750 and TA 3 = 11250.

Example 2: It is required that the average temperatures are measured with the annual reading and therefore TA2 and TA3 are included in the annual reading.

Reading date	Volume	TA2	TA 3
2003.06.01	534.26 m^3	48236	18654
2002.06.01	236.87 m^3	20123	7651
Annual consumption	297.39 m^3	28113	11003

Table 12

Average flow temperature for the year = 28113/297.39 = 94.53°C
Average return temperature for the year = 11003/297.39 = 36.99°C

E=5 Return temperature tariff

If the actual return temperature (t_R), in °C, exceeds TL2, but is lower than TL3, the thermal energy will be counted in both in TA2 and the main register. If the actual return temperature exceeds TL3, thermal energy will be counted in both TA3 and the main register.

tR < TL2	Counting only in the main register
TL3 > tR ≥ TL2	Counting in TA2 and the main register
tR ≥ TL3	Counting in TA3 and the main register

Table 13

During set-up of data TL3 must naturally be higher than TL2.

The return temperature tariff can be used as basis for weighted user payment. A high return temperature indicates insufficient heat utilization and is uneconomical for the heat supplier.

7.7 Temperature measurement

The temperatures in flow and return are measured by an accurately matched Pt500 and Pt100 sensors. During each temperature measurement MULTICALÒ 401 sends a measuring current through each sensor, approx. 0.5 mA for Pt500 and 3.0 mA for Pt100. 2 measurements are made to suppress any 50 Hz ripple collected via the sensor cables.

In addition, measurements are constantly made on internal reference resistances to ensure optimal measuring stability.

When the measurement current runs through the sensors, a peak power of < 0.2 mW is left in each sensor, which corresponds to an average power of < 1 μW in "normal mode" or < 5 μW in "fast mode".

Flow and return temperatures and the temperature difference from 0.00°C to 165.00°C are displayed.

Flow or return temperatures under 0°C are displayed as 0.00°C, and temperatures over 165°C are shown as 165.00°C. When one or both temperature sensors are outside the measuring range, Info=008 (flow), Info=004 (return) or Info=012 is set when both sensors are outside the measuring range.

In connection with negative temperature difference (flow < return) the temperature difference is shown as 0.00°C, energy is not calculated.

8 The flow part

8.1 Ultrasound with piezoceramics

Manufacturers of flow sensors have been working with alternative techniques to replace the mechanical principle. Research and development at Kamstrup have proven that ultrasonic measuring is the most viable solution. Combined with microprocessor technology and piezoceramics, ultrasonic measuring is not only accurate but also reliable.

8.2 Principles

The size of a piezoceramic element changes when exposed to an electrical field (voltage). When the element is influenced mechanically, an electric charge is generated. In this way the piezoceramic element can function both as a sender and as a receiver.

There are two main principles within ultrasonic flow measuring: the transit time method and the Doppler method.

The Doppler method is based on the frequency shifting which is generated when sound is reflected from a moving particle. This is very similar to the effect you experience when a car drives by. The sound (frequency) is reduced, when the car passes by.

8.3 The transit time method

The transit time method used in MULTICAL® 401 utilizes the fact that an ultrasonic signal, that is sent in the opposite direction of the flow, takes a longer time to travel from the sender to the receiver, than a signal travelling in the same direction as the flow.

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

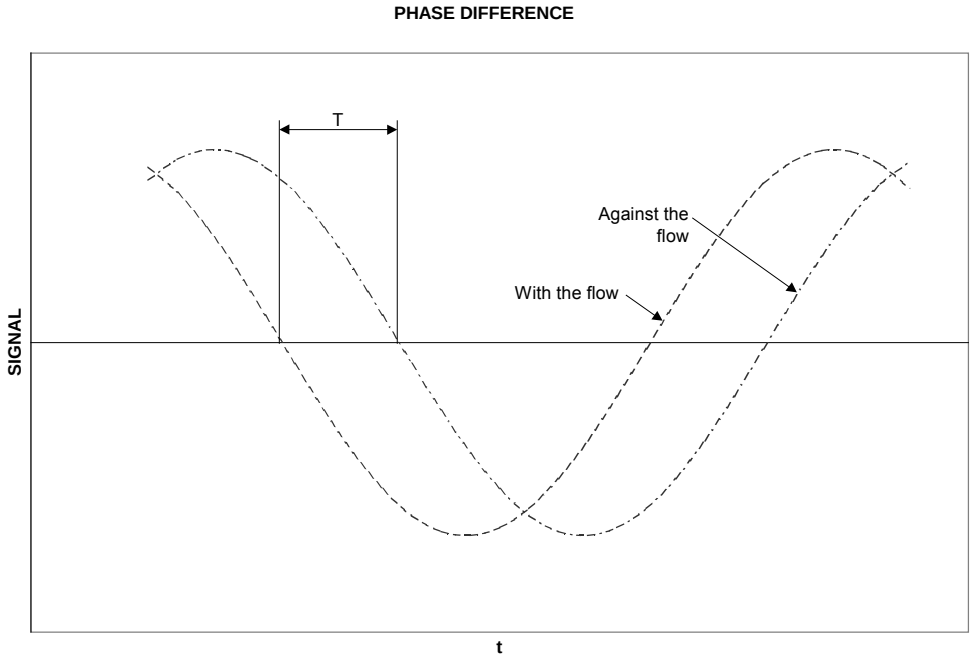


Diagram 3

In principle, flow is obtained by measuring the flow velocity and multiplying it by the diameter 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 that the signal travels in the sensor are well-known factors. The length with which the signal travels can be expressed as $L = T \times V$, and can also be stated as:

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

where:

L is the measuring distance

V is the sound radiation 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 og V_2 can be stated as:

$V_1 = C - F$ and $V_2 = C + F$ respectively

where: C is the velocity of sound in water

By using above formula following is obtained:

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

that can also be written as:

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

$$\Downarrow$$

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

As $C \rangle\rangle F$, it is possible to omit F^2 and write the formula as:

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

To counteract the influence from variations in the velocity of sound in the water, this is measured. Velocity of sound in water is measured by means of the built-in ASIC. For this purpose a number of absolute time measurements are made between the two transducers. These absolute time measurements are then converted into the current velocity of sound used in connection with the flow calculations.

8.4 Signal paths

q_p 0.6...1.5 m³/h

Parallel

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

q_p 3...15 m³/h

Triangle

The sound path covers the measuring pipe in a triangle and is sent round from the transducers in the measuring pipe via reflectors.

8.5 Flow limits

In the meter's working area, i.e. from min. cut-off till far above qs, there is a linear connection between the water volume flowing through and the water flow measured.

In practice the highest possible water flow through the meter will be limited by the pressure of the installation pressure or of cavitation that has arisen as a consequence of a too low back pressure.

If the flow is lower than min. cut off or reversed, MULTICAL® 401 will not measure any flow.

The upper flow limit q_s is according to EN 1434 the highest flow, at which the flow sensor may operate for short periods of time (<1 h/day, <200 h/year) without exceeding the max. permissible error. MULTICAL® 401 has no functional limitations during this period, when the meter operates over q_p. However, please note that high flow velocities may cause cavitation, especially at low static pressures.

8.6 Guidelines for dimensioning MULTICAL® 401

In connection with installations it has proved to be practical to work with pressures larger than the pressures stated below:

Nominal flow q_p [m³/h]	Min. operating pressure [bar]	Max. flow q_s [m³/h]	Min. operating pressure [bar]
0.6	1	1.2	2
1.5	1.5	3	2.5
3	1	6	2
3.5	1	7	2
6	1.5	12	2.5
10	1	20	2
15	1.5	30	2.5

Table 14

The purpose of recommended operating 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 or adjusting valves mounted before the sensor.

In addition, the water may contain air in the form of small bubbles or air in the water.

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

In relation to above table, the steam pressure at actual temperatures must also be considered. Furthermore, it must be considered that the above-mentioned pressure is the pressure at the sensor, and that the pressure is lower after a contraction than before (among other things due to cones). This means that the pressure – when measured elsewhere – might 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 identical at any cross section. To simplify, it can be written as: $P + \frac{1}{2} \rho v^2 = \text{constant}$.

When dimensioning the flow sensor above must be taken into consideration, especially if the sensor is used within the scope of EN 1434 between qp and qs, and in case of severe contractions in the pipe.

9 Temperature sensors

9.1 EN 60751 table for Pt100 and Pt500 sensors

For MULTICAL® 401 either Pt100 or Pt500 temperature sensors are used according to EN 60751 (DIN/IEC 751). A Pt100 or Pt500 temperature sensor is a platinum sensor with a nominal ohmic resistance of 100.000 Ω and 500.000 Ω, respectively, at 0.00°C and 138.506 Ω and 692.528 Ω at 100.00°C, respectively. All values for the ohmic resistance are laid down in the international standard IEC 751 valid for Pt100 temperature sensors. The values for the ohmic resistances in Pt500 sensors are 5 times higher. In below tables the resistance values in [Ω] are stated for every whole degree celcius for both Pt100 and for Pt500 sensors:

Pt100										
°C	0	1	2	3	4	5	6	7	8	9
0	100.000	100.391	100.781	101.172	101.562	101.953	102.343	102.733	103.123	103.513
10	103.903	104.292	104.682	105.071	150.460	105.849	106.238	106.627	107.016	107.405
20	107.794	108.182	108.570	108.959	109.347	109.735	110.123	110.510	110.898	111.286
30	111.673	112.060	112.447	112.835	113.221	113.608	113.995	114.382	114.768	115.155
40	115.541	115.927	116.313	116.699	117.085	117.470	117.856	118.241	118.627	119.012
50	119.397	119.782	120.167	120.552	120.936	121.321	121.705	122.090	122.474	122.858
60	123.242	123.626	124.009	124.393	124.777	125.160	125.543	125.926	126.309	126.692
70	127.075	127.458	127.840	128.223	128.605	128.987	129.370	129.752	130.133	130.515
80	130.897	131.278	131.660	132.041	132.422	132.803	133.184	133.565	133.946	134.326
90	134.707	135.087	135.468	135.848	136.228	136.608	136.987	137.367	137.747	138.126
100	138.506	138.885	139.264	139.643	140.022	140.400	140.779	141.158	141.536	141.914
110	142.293	142.671	143.049	143.426	143.804	144.182	144.559	144.937	145.314	145.691
120	146.068	146.445	146.822	147.198	147.575	147.951	148.328	148.704	149.080	149.456
130	149.832	150.208	150.583	150.959	151.334	151.710	152.085	152.460	152.835	153.210
140	153.584	153.959	154.333	154.708	155.082	155.456	155.830	156.204	156.578	156.952
150	157.325	157.699	158.072	158.445	158.818	159.191	159.564	159.937	160.309	160.682
160	161.054	161.427	161.799	162.171	162.543	162.915	163.286	163.658	164.030	164.401
170	164.772	165.143	165.514	165.885	166.256	166.627	166.997	167.368	167.738	168.108

Pt100, IEC 751 Amendment 2-1995-07

Table 15

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
170	823.861	825.716	827.571	829.426	831.280	833.133	834.986	836.838	838.690	840.541

Pt500, IEC 751 Amendment 2-1995-07

Table 16

9.2 Sensor types

MULTICAL® 401 can be supplied with two different sensor sets, both with 1.5 m or 3.0 m cable. Below is stated the most important characteristics for both types (see data sheet 5810-337 for further information on sensor sets and sensor pockets):

Type 66-	□	□	□	□	□	□□□
Sensor connection						
Pt100 (Kamstrup does not supply Pt100 sensors)	**V**					
Pt500	**W**					
Pt500 sensors						
Pocket sensor with 1.5 m cable				**A**		
Pocket sensor with 3.0 m cable				**B**		
Short direct sensor with 1.5 m cable				**F**		
Short direct sensor with 3.0 m cable				**G**		

9.3 Pt500 sensor set for pockets

Pt500 cable sensor based on a 2-wire silicone cable and closed by a stainless steel tube with a diameter of 5.8 mm protecting the sensor element.

The steel tube is fitted in a sensor pocket that has an inside diameter of 6 mm and an outside diameter of 8 mm. The sensor pockets are supplied with an R½ (conical ½") connection in stainless steel in lengths of 65, 90, and 140 mm. The sensor design with separate pocket means that the sensors can be replaced without the water being shut off. Additionally, the large selection of pocket lengths means that the sensors can be fitted in all pipe sizes.

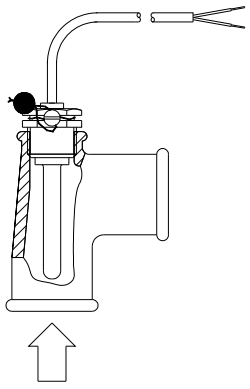


Figure 25

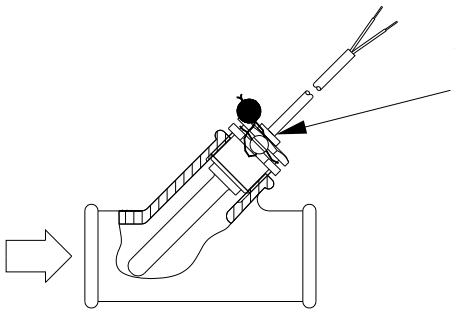


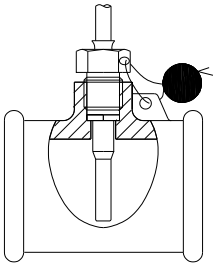
Figure 26

The stainless steel pockets can be applied when mounting in PN25 systems!

9.4 Pt500 short direct sensors

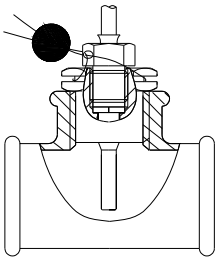
Pt500 short direct sensor is designed according to the European standard for thermal heat meters EN 1434-2. The sensor is designed for fitting directly into the measuring medium, i.e. without sensor pocket, thereby giving an extremely fast response time on temperature changes from e.g. tap water exchanger.

The sensor is based on a 2-wire silicone cable. The sensor pipe is made in stainless steel and has a diameter of 4 mm at its end, where the sensor element is placed. Furthermore, mounting can be made directly in many types of flow sensors, which reduces the installation costs.



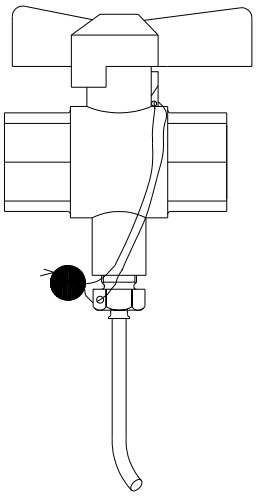
The sensor can be fitted in a special T-section, which can be supplied for ½", ¾" and 1" pipe installations.

Figure 27



The short direct sensor can also be fitted by means of a R½ or R¾ to M10 nipple in a standard 90° tee.

Figure 28



To obtain the best service during meter replacement, the short direct direct sensor can be placed in a ball plug valve with a sensor connecting piece.

Ball plug valve with provision for sensor are supplied in G½, G¾ and G1.

No.	66-99-474	66-99-475	66-99-476
	G½	G¾	G1

Max. 130°C and PN16

Figure 29

10 Supply modules

Type 66- □ □	□	□	□	□	□□□
Supply					
No module	**0**				
Battery, D-cell	**2**				
230 VAC supply module	**7**				
24 VAC supply module	**8**				

MULTICAL® 401 must always be supplied internally with approx. 3.6 VDC between terminals 60(+) and 61(-). This is obtained through one of the following supply modules:

10.1 Built-in D-cell lithium battery

A lithium D-cell battery must always be used for the meter. The battery is placed in the upper part of the connection bracket and is easily replaced solely by using a screw driver.

The battery lifetime partly depends on the temperature that the battery is exposed to, and partly if a fast calculation interval has been selected.

Application	Battery lifetime	
	Normal mode	Fast mode
MULTICAL® 401 mounted on the wall	12 years	4 years
MULTICAL® 401 mounted on the flow part	10 years	3 years

Table 17

Above battery lifetimes apply to standard installations. The following may reduce the battery lifetime:

- Warm ambient temperature
- Frequent data communication
- Connection of data modules
- Fast mode

For further information, please contact Kamstrup.

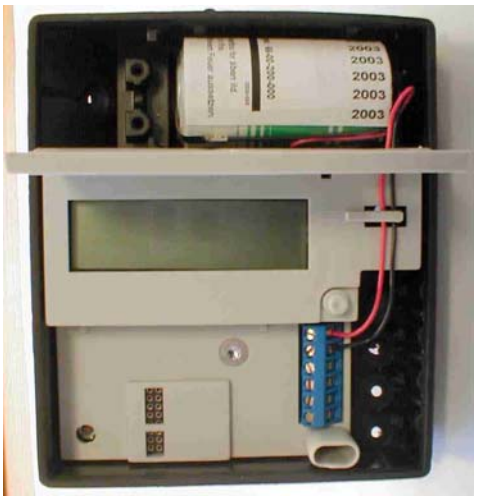


Figure 30

10.2 Supply module 230 VAC

This print module is galvanically separated from the mains supply and is suitable for direct mains installation. The module includes a double-chamber safety transformer which fulfils the requirements of double-insulation. The power consumption is less than 1 VA/1 W.

Figure 31

National installation requirements must be met. The 230 VAC module must only be connected by authorised personnel. In Denmark "Elråd nr. 5/98" or later edition must be followed.

Changes from battery to mains supply requires a re-programming, as info 128 will still be active for the mains supplied meter.

10.3 Supply module 24 VAC

The energy meter includes a print module which reduces the input voltage to approx. 3.6 VDC. The module has a built-in transient protection, but includes no galvanic separation between input and output voltages. The module is specially suited for installation together with a galvanically separated transformer, e.g. type 66-99-403, which can be installed in the switch cabinet. When the transformer is used, the total power consumption of the meter will be less than 4 VA/1.5 W for the entire meter.

Figure 32

10.4 Changing the supply unit

The supply unit for MULTICAL® 401 can be changed from mains supply to battery or vice versa, concurrently with changed needs at the utility. Thus, mains supplied meters can be exchanged into battery meters with advantage in connection with buildings under construction, as the mains supply may be unstable or may even lack in periods.

In connection with changes it is, however, important to note that the information code 128 (*Battery must be changed. The code is set 12 years after resetting the hour counter)* is only active at type number 66-Wx-**2**x-xxx.

Use METERTOOL (see section 14) for reprogramming.

10.5 Mains supply cables

MULTICAL® 401 can be supplied with mains supply cables for either 24 V or for 230 V (l=1.5 m):

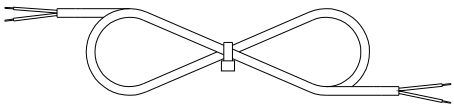


Figure 33

Supply cable, type 5000-286 (2x0.75 mm²)

11 Plug-in modules

Type 66-	□	□	□	□	□	□□□
Modules						
No module	**0**					
M-Bus/pulse inputs (MC 401)	**P**					
Data/pulse output	**Q**					
Data/pulse inputs	**R**					
M-Bus/pulse inputs	**S**					
Radio/pulse inputs	**U**					
Radio with external antenna connection/pulse inputs	**W**					

11.1 Data/pulse output (66-0Q)

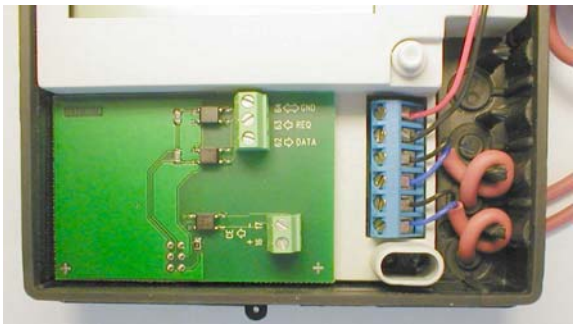


Figure 34

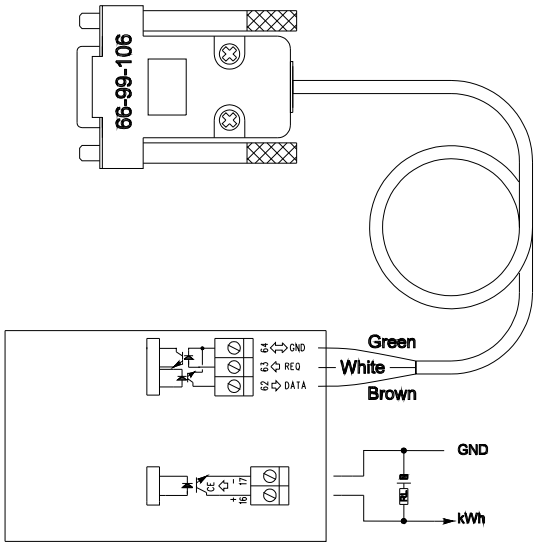


Figure 35

The module comprises data connection, which e.g. can be used for an external data plug, designed for use with the hand-held terminal MULTITERM, or as a semi-permanent PC connection.

The data connection is galvanically isolated by opto-couplers and therefore a data cable type 66-99-105 or type 66-99-106 is necessary to adjust the signal to RS-232 level, which is used by PC and MULTITERM.

See section 12 *Data communication* for information on data strings and protocols.

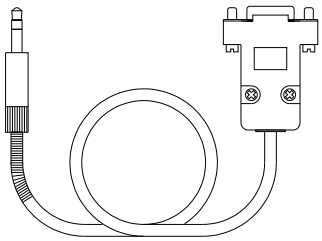


Figure 36

Type number 66-99-105

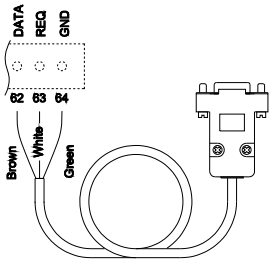


Figure 37

Type number 66-99-106

The module can also transmit energy pulses to CTS-systems or similar remote accumulation. As energy pulses are not transmitted "real-time", they cannot be used for regulation purposes.

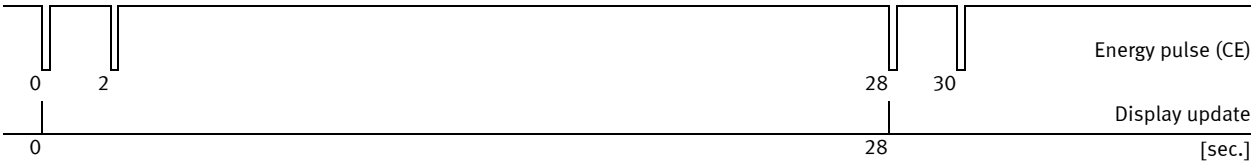
The pulse output is convenient for connecting electronic counter inputs, while electro-mechanical counters normally require a higher current than 10 mA which the module allows.

Every time the energy display is updated, one pulse on the CE output is transmitted. Example: CCC=119 causes 1 kWh/pulse. The pulses are transmitted immediately after each display updating, in connection with which the number of energy pulses transmitted corresponds to the consumption in the preceding 28 sec. (or 4 sec. when the meters is configured to "fast mode"). If the consumption is larger than 1 display resolution for each 28 sec., the pulses are transmitted with a 2 sec. interval.

Example: MULTICAL® 401 qp 3.0 with CCC=136. Current flow = 3000 l/h and the differential temperature 75 K, which corresponds to a current power of 257 kW.

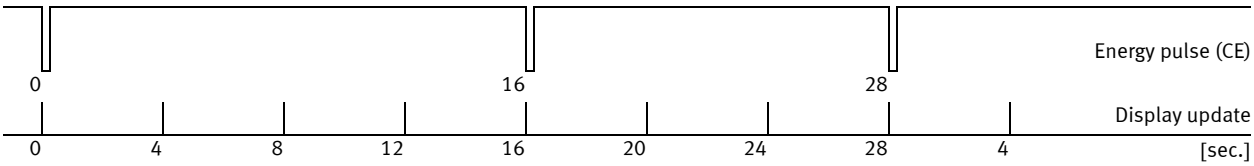
In normal mode the power of 257 kW will be transmitted as 2 pulses for each 28 sec.

Normal mode



In fast mode the power of 257 kW will be transmitted with 16 and 12 sec. intervals alternating.

Fast mode



Voltage: < 30 V

Uce (ON): Typically 1 V @ 10 mA

Load: < 10 mA

Pulse duration: Programmable via the ›FF‹ code:

Output A (CE) Terminal 16-17	
FF	Pulse duration
00	OFF
94	1 msec.
95	30 msec.
96	0.1 sec.

Table 18

11.2 Data/pulse inputs (66-0R)

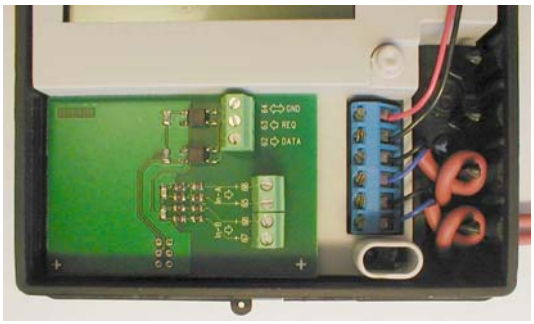


Figure 38

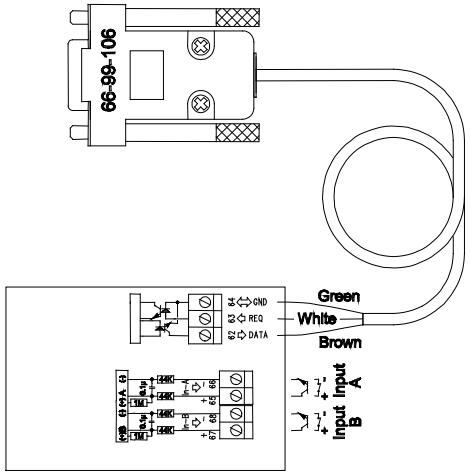


Figure 39

The data connection in this module is identical with that described earlier.

Two extra pulse signals, e.g. from cold-water and hot-water meters, can also be connected to the meter. Meters with both Reed switch and transistor output can be connected. The inputs have a max. input frequency of ≤ 0.5 Hz.

Reed switches with built-in protective resistances of up to 1 kOhm can be used and both Input A and Input B contains the necessary de-bouncing for Reed switches.

No Darlington transistors should be used when connecting the transistor outputs to Input A and Input B, as the voltage level at logical"0" must be < 0.5 V. In addition, the leak current in the output must be less than 1 µA.

The pulse inputs can be configured for most cold-water and hot-water meters.

See section 3.3.3 *›FF‹ Input a, ›GG‹ Input b* for information on configuration of pulse values and maximum flowrate. Required configuration must be stated when ordering. Reconfiguration can be done by the use of the PC-program METERTOOL.

11.3 M-Bus, EN 1434, EN 13757/pulse inputs (66-0P)
M-Bus, EN 1434/pulse inputs (66-0S)

Figure 40

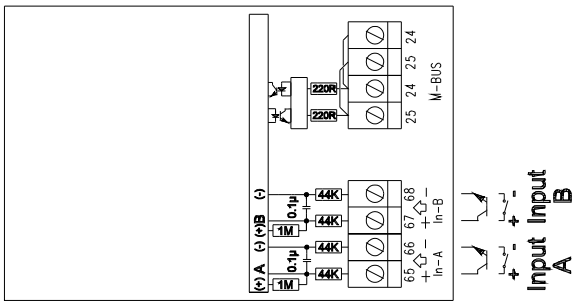


Figure 41

The M-Bus modules are used for remote reading of MULTICAL® 401 via an M-Bus net work.

To make an M-Bus system work, it is necessary to give each M-Bus module a unique address. The M-Bus address is automatically generated based on the customer meter number, and can easily be changed either by means of the hand-held terminal MULTITERM or by means of the PC program of METERTOOL.

M-Bus module 66-0P contains further M-Bus functionality. In addition to primary addressing it also supports secondary and enhanced secondary addressing as well as wildcard search and collision detection. Via the M-Bus network it is possible to reprogram customer numbers, date/time and the pulse inputs In-A and In-B.

The M-Bus modules have two sets of parallel M-Bus terminals marked 24 and 25, to which the M-Bus can be connected. The M-Bus connection is independent of polarity.

The M-Bus modules are galvanically separated from the meter and is supplied via the M-Bus.

Each M-Bus module has a power consumption of 1.5 mA (1 Unit Load)

The data transmission speeds are 300 or 2400 baud and both M-Bus modules have a built-in autodetection of the baud rate.

The pulse inputs on these modules are identical with the ones described earlier.

The Kamstrup M-Bus system is designed to meet the demands in the EN 1434-3 standard.

For further information, see the Technical Description for Kamstrup's M-Bus system (5511-710), and Technical Description for M-Bus module 66-0P (5512-243).

11.4 Radio (66-0U)

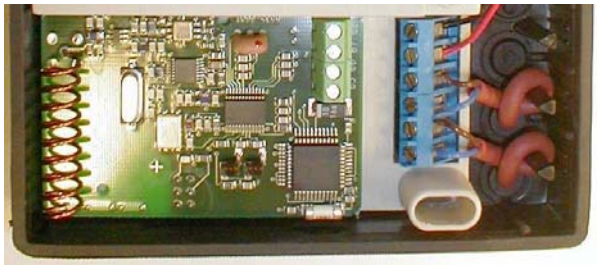


Figure 42

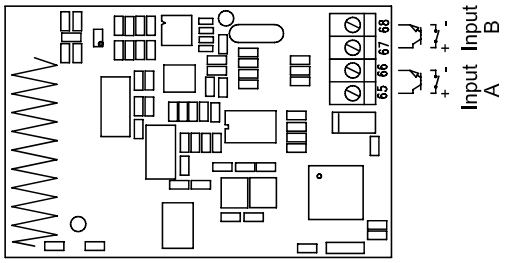


Figure 43

The radio module is used for wireless reading of MULTICAL® 401.

During installation the radio module retrieves the type and meter number of the meter and transfers data to the memory of the module.

The radio module is ready to communicate in less than 10 seconds.

The radio module is supplied as standard with internal antenna.

The radio module can be read via the hand-held terminal MULTITERM, but it is also prepared to form part of a radio network.

The pulse inputs on this module are identical with the ones previously described.

The radio system is designed to meet the requirements in the EN 300 220 and EN 301 489 standards as well as the R&TTE directive (**R**adio & **T**ele **T**erminal **E**quipment).

For further information, see Technical Description 5512-012.

11.5 Radio (66-0W)

Radio module with connection plug for external antenna to increase the range.

Other functions are identical with the ones described earlier.

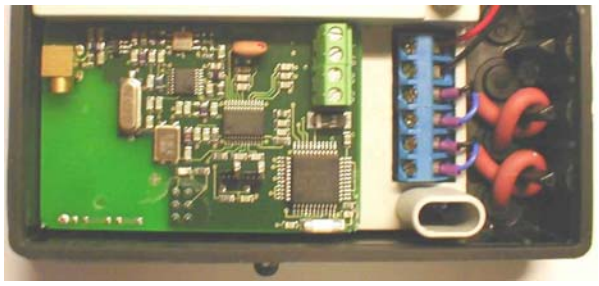


Figure 44

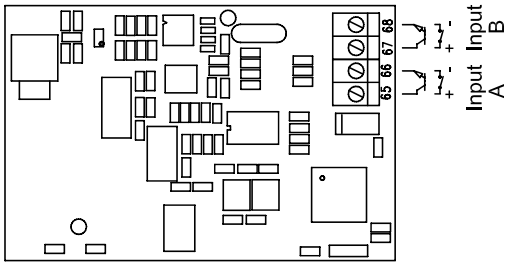


Figure 45

12 Data communication

12.1 Optical reading

An optical, infrared receiver/transmitter is placed on the front of MULTICAL® 401. The data format fulfils IEC 870 in start mode and can then be converted into a producer specific format. A standardized optical reading head with a permanent magnet is used for data reading and configuration. Flow meter position and selection of measuring unit for accumulated energy can also be programmed by means of the optical reading head. To be able to change this data, however, an internal connection must be made before programming as the data in question is legal measuring data. If data cable 66-99-108 or verification equipment 66-99-385 are used, the internal connection are integrated. Kamstrup's reading head, type 66-99-102, can be connected to Kamstrup's hand-held terminal, MULTITERM, as well as a standard IBM compatible PC with Windows 98 or newer version installed.

For further information on functions in the hand-held terminal and programming software, please refer to documentation for:

MULTITERM type 66-99-15X

METERTOOL type 66-99-702

Functioning

When the connected reading unit, MULTITERM, or the PC sends a recognizable request string, MULTICAL® 401 answers with a data string 1-2 sec. after having received the request string. MULTICAL® 401's optical data reading uses following communication setup:

300/1200 baud, 1 startbit, 7 databits, even parity, 2 stopbits

NB: Except from optical reading, section 12.2, the other data strings neither contain measuring units nor decimal points (raw data). Information on decimal points can be seen from the CCC tables in this technical description.

12.2 Optical data reading

Following data can be read via the optical eye placed on the front of MULTICAL® 401 and via the data terminals.

Command (300BAUD)	Return string (300BAUD)
/?! [CR] [LF] [ACK]000 [CR] [LF]	/KAM [0] MCC [CR] [LF] [STX]0.0(11 digits C/N) 6.8(Energy * unit) 6.26(Volume * m3) 6.31(Hours * h) ! [CR] [LF] [ETX] [BCC]

Table 19

In general, the reading is built-up according to EN61107/IEC1107, Mode A, but BCC is calculated arithmatically as on M-Bus and not as module 2-binary sum ISO1155.

12.3 Data strings

Following data strings are compatible with the corresponding data strings in MULTICAL® Compact, MULTICAL® III, and MULTICAL® 66-CDE. The data strings can be read via an optical reading head or via the data terminals on the plug-in modules.

Please note that 300 baud is used at request and 1200 baud at data.

For analytical purposes of /#5 monthly data, we recommend Kamstrup software METERTOOL LogView, type 66-99-703.

Req	**STANDARD DATA 1**									
/#1	Energy	Volume	Hours	T1	T2	T1-T2	Power	Flow	Peak power/flow actual	Info
	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii

Req	**STANDARD DATA 2**									
/#2	Cust. No.	TA2	TL2	TA3	TL3	In-A	In-B	ABCCC	DDEFFGG	Date
	11 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii

Req	**TARGET DATA**								
/#3	Cust. No.	Reading day	Energy	Volume	TA2	TA3	In-A	In-B	Peak power/flow year
	11 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii

Req	**MONTHLY DATA**								
/#5	Cust. No.	Reading date	Energy	Volume	TA2	TA3	In-A	In-B	Peak power/flow actual
		Reading date	Energy	Volume	TA2	TA3	In-A	In-B	Peak power/flow month
25 months back									
26 Blank									
27 Blank									
29 Blank									
30 Blank									
31 Blank									
	11 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii	7 ascii

Table 20

12.4 Communication driver

To develop your own software for data communication, e.g. between a PC and MULTICAL® 401, below pseudo code can be used as a draft. The example shows a request for /#1:

```
mscomm1.Settings = "300,E,7,2"
mscomm1.InBufferCount = 0
mscomm1.Output = "/#1"
Do While mscomm1.OutBufferCount <> 0
Handle Windows Events
Loop
Delay for 300 ms

mscomm1.Settings = "1200,E,7,2"
mscomm1.InBufferCount = 0
mscomm1.InputLen = 1
strData = ""
While mscomm1.InBufferCount > 0
strData = strData & mscomm1.Input
Handle Windows Events
Wend
```

In connection with development of the concrete communication driver, above can only be used as an example of the essential commands, whereas e.g. ”timers” and ”flags” are omitted for clarity.

13 Calibration and verification

In order to be able to carry out test/verification of MULTICAL® 401 with a minimum use of time the meter has a testing mode. When the meter is in testing mode the program runs approx. 4 times faster than in standard mode. Testing mode also has some extra functions as described below.

(NB. MULTICAL® 401 uses approx. 4 times more current in testing mode. However, under normal circumstances the meter will only be in testing mode e.g. 9 hours per 5 years, which has no influence on the total lifetime of the battery)

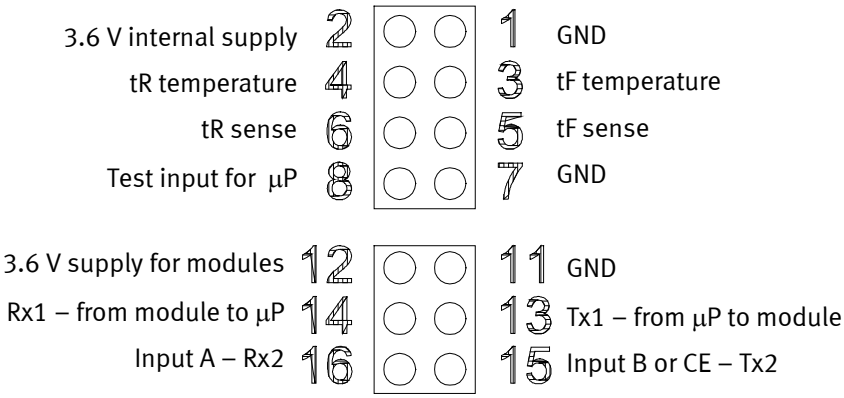


Figure 46: Module and test plug (No. 1-8 is sealed by a verification seal)

Flow verification

Flow measurement operates with absolute time measurement, and is therefore independent of the temperature sensors. The flow part can be verified as a separate unit, if a 3-part verification is required.

STARTING UP

16 seconds must ellapse from start up to calibration in order to allow a true reading to be reached.

MEASURING FLOW

To obtain a correct flow measurement, calibration must take min. 2 minutes.

EVACUATION

MULTICAL® 401 must NOT be evacuated (subjected to vacuum).

Calculator verification

The calculator can be verfied separately by means of temperature simulation resistances connected to the terminal strips Nos. 5-6-7-8. Volume simulation can be made by means of the built-in "Autointegration" (see section 13.2).

Temperature simulation via the test plug is only possible when verification equipment type 66-88-385 is used (see section 14.3 *Verification with METERTOOL*).

13.1 Testing mode

Extra display readings

In addition to the display readings in standard mode there are two extra testing counters/verification registers for energy and volume respectively. The testing counters appear as extra indications immediately after the main counters for energy (E) and volume (Q). The resolution of the extra testing counters is for energy (E') 10 [mWh] and for volume (Q') 1 [ml]. The main counters do not change unit or resolution in testing mode.

NB.: The resolution for the extra testing counters apply for all meter sizes from qp 0.6 to qp 15 m^3/h.

Testing mode

The meter can be switched to testing mode by pressing the internal button marked "P" for approx. 5 sec. or serially through the test plug in the meter. When the meter is in testing mode a "P" appears farthest to the left in the meter's display. The internal push button is placed under the top cover. When the internal push button is activated the meter changes to testing mode, whereas subsequent activation for 5 seconds brings the meter back to standard operation.

In testing mode MULTICAL® 401 runs through an integration sequence of 4 sec. Through this sequence the water flow is measured with an average interval of 1 sec. Flow and return temperatures are measured in the middle of the sequence, and at the end of the sequence the energy and volume calculations are made.

All display values are updated at an interval of 4 sec.

If both the internal push button and the front key are activated at the same time, an auto-integration sequence starts in the meter (see section 13.2 *Auto-integration*).

To be able to operate the internal button and the test plug, modules or seals, if any, above the test plug must be removed.

Resetting test counters Q' and E'

The extra counters can be reset by pressing the internal button marked "P" or serially.

When resetting the testing counters, internal energy and water residue in the meter are also reset. This means that accumulated energy and water may be missing in the main counters after repeated resets.

Standard mode

The meter can be put into normal mode again by pressing the internal button marked "P" for approx. 5 sec., or serially through the test plug in the meter. If the meter is not put into standard mode it will automatically change into standard mode after approx. 8 hours. When the meter has returned to standard mode the "P" which earlier appeared in the left side of the meter's display will be turned off. Instead an "E" may appear in the left side of the display (see section 7.4 *Information codes*).

External control of testing counters Q' and E'

It is possible to control the testing counters externally by means of a contact function. The contact must be connected to pins 16 and 11 of the test plug. Only possible when pins 7-8 are short-circuited under the verification seal. The function works as follows:

1. When connection is established, verification registers Q' and E' are reset, and the counting starts.
2. When the connection is released, the verification registers Q' and E' are locked.
3. Subsequently, the registers can be read from the display or serially.
4. A new test point can be carried out starting from point 1.

13.2 Auto-integration

When the meter is in testing mode, auto-integration can be started by simultaneously pressing the display change button and the internal button marked "P" for approx. 0.5 seconds. Auto-integration can also be started serially through the test plug.

If the function is started manually, the meter automatically carries out an energy calculation corresponding to a flow quantity of 100 l and 10 energy calculations with the current temperatures.

This test takes approx. 20 sec. Once an auto-integration has been started it cannot be interrupted.

NB: Only possible when pins 7-8 are short-circuited under the verification seal.

13.3 Energy calculation

The "true" energy supplied to a MULTICAL® 401 during verification must be calculated very accurately as the "true" energy forms the basis of the meter's verification deviation.

The energy can be calculated as follows:

EMJ=	**$m^3 \times \Delta t \times k_{STUCK}$**	**[MJ]**
EGJ=	$\frac{EMJ}{1000}$	[GJ]
EkWh=	$\frac{EMJ}{3.6}$	[kWh]
EMWh=	$\frac{EMJ}{3600}$	[MWh]

Table 21

m^3 is the water quantity applied (or simulated) during verification.

Δt is the difference between the flow and return temperatures (t_F - t_R). No matter whether the verification is carried out with the sensors in liquid bath or with precision resistors, the temperatures must be entered with great accuracy.

k_{STUCK} is the heat coefficient of the water, which is found in the tables of "Tabellen von Wärmekoeffizienten für Wasser als Wärmeträgermedium", issued in 1986 by Wirtschaftverlag NW.

On Kamstrup's METERTOOL CD a calculation program for the "true energy" is found under verification.

Please note that before looking up the k-value the following information must be available:

– Flow temperature, t_F

– Return temperature, t_R

– Flow sensor position: flow or return pipe

– System pressure (16 bar according to EN 1434)

The k-factor is stated in the table as a basis for energy measurement in MJ and must therefore be converted in accordance with the above-mentioned formulas, if the energy should be expressed in other measuring units.

NB.: Only passive precision resistors can be used for test and verification of MULTICAL® 401. An electronic resistance simulator, e.g. based on a power controlled FET, is not suitable as MULTICAL® 401's testing current is intermittent (bursting).

13.4 Pulse Interface for MULTICAL® 401

When the meter is in testing mode, verification on rigs with pulse interface, the pulse interface type type 66-99-109 is to be used. Type 66-99-109 can be used for both MULTICAL® Compact (MCC) and for MULTICAL® 401 (MC 401). Please note, that the pulse values change for meters larger than qp 2.5 m^3/h.

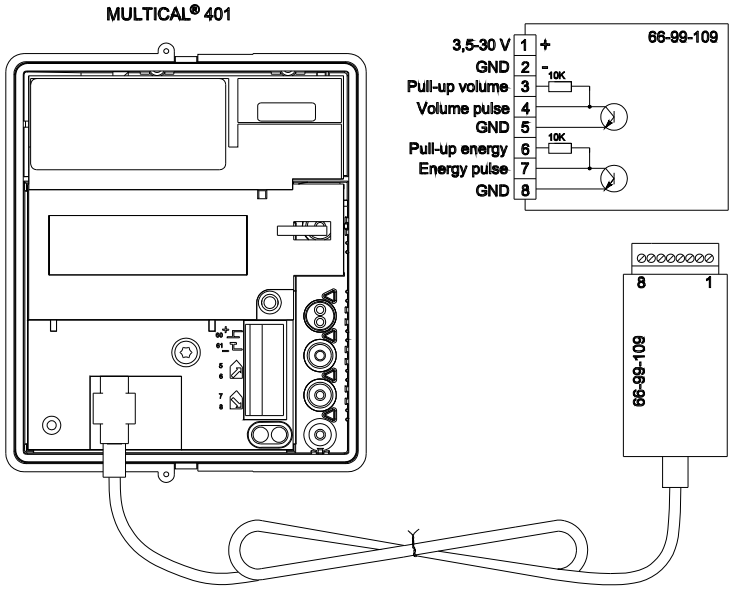


Figure 47

Supply: 3.5-30 VDC < 5 mA

Stand-by: < 1 mA

Pulse: < 30 V < 15 mA

Puls duration: 50% Duty cycle or pulse < 0.1 sec.

Meter size		Energy (pulses/kWh)		Volume (pulses/litre)	
MCC	**MC 401**	**MCC**	**MC 401**	**MCC**	**MC 401**
-	qp 0.6	-	1000	-	100
qp 0.75	-	1000	-	100	-
-	qp 1.5	-	1000	-	100
qp 1.5	-	1000	-	100	-
qp 2.5	-	1000	-	100	-
-	qp 3.0	-	500	-	50
-	qp 3.5	-	500	-	50
-	qp 6.0	-	250	-	25
-	qp 10	-	125	-	12.5
-	qp 15	-	125	-	12.5

Table 22

14 METERTOOL for MULTICAL® 401

14.1 Introduction

METERTOOL for MULTICAL® 401 type 66-99-702 is a Windows based software, which can be installed on a PC and used to program, test and verify the heat meter.
METERTOOL is developed with a view to offering distributors, utilities, and laboratories a simple and effective access to programming, testing, adjusting, and verifying the heat meter.
Reading of data from the meter can be made by means of METERTOOL for LogView type 66-99-703. Data can be seen in section 12.3 *Data strings*. The LogView program will present data with units and decimals according to the coding of the meter.

14.1.1 PC and printer requirements

METERTOOL is suitable for installation under Windows 98/NT/2000/XP on Pentium based PC's with min. 16 MB RAM, 20 MB free hard disk and VGA monitor min. 640 x 480. Recommended 800 x 600 or higher.
In order to be able to install the program, the PC must be equipped with a CD drive.
To program MULTICAL® 401 a serial data connection (COM-port) between the calculator and PC is used.
An IR head 66-99-102 can be used for configuration.
If verification equipment type 66-99-385 is used both programming and verification can be made.
With all types of connection the program can be set up to use the PC's COM 1...8.
The program can also be used for printing lables for MULTICAL® 401. The printer must be compatible with Windows and be suitable for printing small self-adhesive label sheets.
The printer is connected to the computer's parallel port, LPT1.
Kamstrup A/S recommends a laser printer, but other printer types can also be used.
Sheets with original self-adhesive lables, type 2007-084, can be ordered from Kamstrup A/S.

14.1.2 Installation of software

Please check if the computer has min. 20 MB free space on the hard disk, e.g. by means of Windows File Manager. Close all active Windows programs before installing the program.
Insert the CD in the drive and follow the program's instructions as they appear on your screen.
When the installation is completed, the icon "METERTOOL" will appear in the start menu. Double click on the new icon "METERTOOL" to start the program.
Please note: If the right printer driver is not installed, the program will not be able to print label or certificate.

14.1.3 Connecting MULTICAL® 401 to PC

The calculator is programmed by serial data transmission between the calculator and the computer. Data can be transmitted by means of an optical IR head type 66-99-102 or verification equipment, e.g. type 66-99-385. Data cable type 66-99-108 can also be used in laboratories, where it is permitted to break the verification seal.

14.1.4 Optical IR head type 66-99-102

The optical head is placed between the two pins on the front of the calculator where it is held in place by means of a magnet. The IR head cable must always point downwards ±20°. The optical IR head MUST NOT be used or stored near diskettes or computers as the magnet can damage the data. Always cover the magnet with the protection plate when it is not in use.
The optical head combined with a lap-top computer is the ideal way to program the meter. E.g. new tariff limits can be programmed quickly and simply on site without removing the energy meter. If MULTICAL®401 is furnished with a plug-in communication module, e.g. M-Bus, programming via the optical head may be non-functional. In these cases, we would recommend that you use the verification equipment.
If the computer has a 25-pole COM plug, a 9M/25F adapter, type 66-99-120 must be used. For computers with a USB port, Kamstrup can supply a USB/COM converter.

Figur 48

14.1.5 Verification equipment type 66-99-385

See section 14.3 *Verification with METERTOOL* for further information.

14.1.6 Reading MULTICAL® 401

Connect the serial data communication as described in previous sections and start the program by clicking on the icon "METERTOOL" and select MULTICAL® 401. Select the button "Read meter", and data will be transmitted from the meter and shown on the monitor.

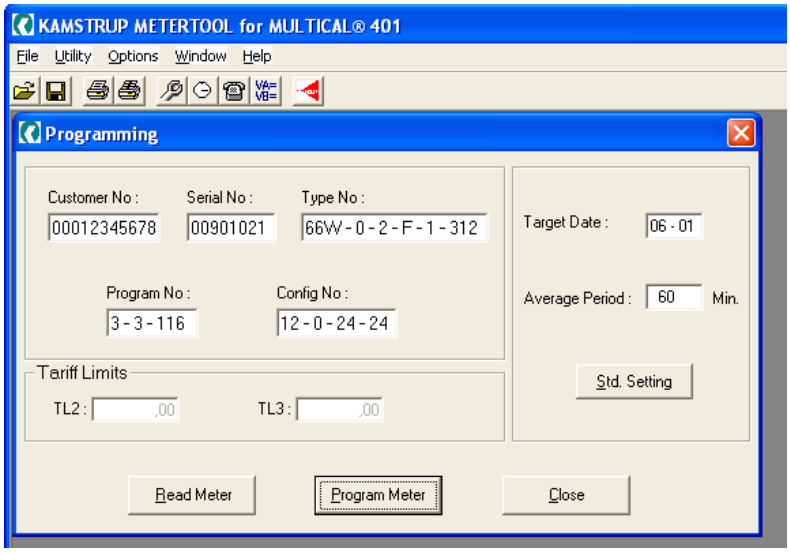


Figure 49

14.2 Programming

It is important that you are familiar with all calculator functions before programming.
All necessary information appears in this technical description.
Furthermore, you must check the computer's internal clock before programming, as date and time will be transmitted from the PC to the calculator when programming "Time/Date".

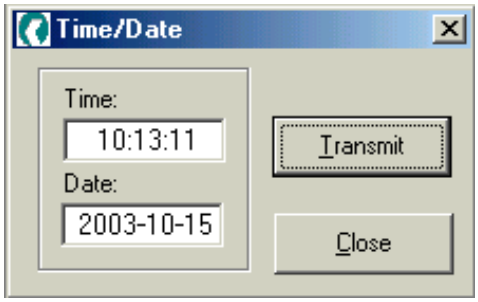


Figure 50

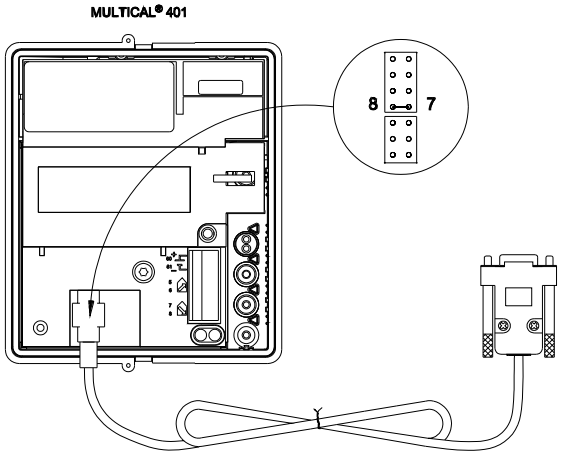


Figure 51

14.2.1 Partial programming

If the programming lock in MULTICAL® 401 (indicated by a ring in the diagram above) is open, the meter can only be partially programmed.

This limitation means that the legal parameters program, type and serial Nos. cannot be changed, while all other data can be programmed as required.
This limitation is used to prevent the original operating parameters from being changed on type approved and verified meters.

National verification demands must be checked before the calculator's verification seal is broken.

14.2.2 Complete programming

If the programming lock is short-cirnuited, it is possible to reprogram MULTICAL® 401, including the legal data program, type and serial Nos. When data cable 66-99-108 or verification equipment 66-99-385 is used, the programming lock is short-circuited.
Please note that the verification seals are automatically broken, when the test plug is used.
Sealing must be carried out by an autorised laboratory.
Please note that the data logging memory in the calculator cannot be changed/erased during programming, unless this is selected in the software.

14.2.3 File

Under the menu "File" one of the following functions can be selected:

Open Customer	Retrieves stored customer settings from the database
Save Customer	Saves new customer settings in the database
Print Certificate	Starts printing test certificate
Print Label	Starts printing front label
Print Setup	Printer setup for printing front label and certificate
Exit	Terminates METERTOOL

14.2.4 Utility

This menu gives access to the following dialog boxes:

Programming	General view which is used when reading and programming
Time/Date	The PC's date and time are transmitted to MULTICAL® 401
Telephone No.	2 different telephone numbers can be programmed in MULTICAL® 401
Preset VA/VB	Presetting of input A/B values. The position of the decimal point depends on the meter's FF/GG coding.
M-Bus address	The primary M-bus address of the meter can be entered here independent of the meter's customer number.
Info Code	Is used for reading the info code as well as date, energy and volume at the time when the info code occurred
Meter type	Reads the meter's internal software revision
Reset	Resets all registers if the programming lock is short-circuited
Verification	See section 14.3 *Verification via METERTOOL*
Flow meter Adjustment	Is only used when adjusting the MULTICAL® 401 flow part (requires a password) Password can be disclosed by Kamstrup A/S

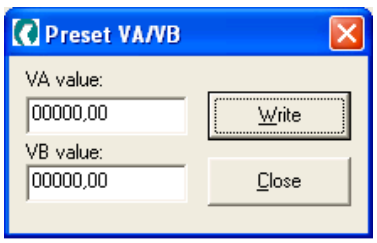


Figure 52

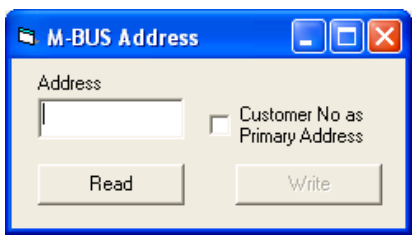


Figure 53

Figure 54

14.2.5 Options

The menu has a few settings which are not used very often:

Verification data See section 14.3.3 *Verification data*.
COM port Indicates the choice of COM1...8

14.2.6 Window

This function makes it possible to shift between the open dialog boxes.

14.2.7 Help

About Includes program numbers and revisions.

Figure 55

14.2.8 True energy calculation

The program offers the possibility of an exact energy calculation, where the k-value has been taken into consideration.

DELTA k-factor.exe

14.3 Verification via METERTOOL

14.3.1 Equipment description

Verification equipment type 66-99-385 is used for testing and verifying the MULTICAL® 401 calculator.
The test includes volume simultation and simultation of temperatures for the sensor inputs T1 - T2, which together with volume simultation forms the basis of verification of the energy calculation.
The equipment is primarily designed for use in laboratories which test and verify energy meters, but it can also be used to test meter operation.
The PC program METERTOOL type 66-99-702 is used for configuration, testing and verification.
All data communication beween the computer and the calculator is transmitted via the computer's serial port, COM1...8, which are connected to the verification equipment. Please note that the equipment must be supplied via the associate mains adapter.
Verification does not include temperature sensors and flow part.
The verification equipment is supplied in below variants and is supplied complete with mains adapter, data cable and calibration certificate.
During the verification the temperature sensors must be disconnected the terminals.

66-99-385 Standard (EN 1434) Type 66-W	T1 [°C] 160 80 43	T2 [°C] 20 60 40

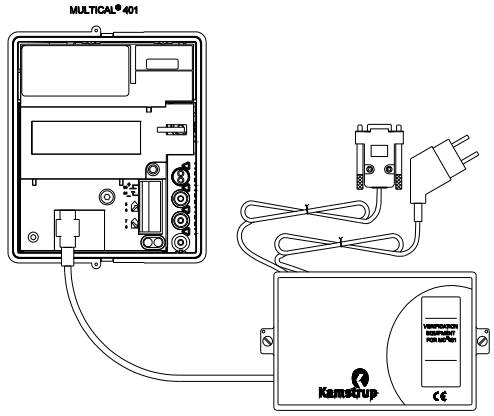


Figure 56

14.3.2 Function

Verification equipment 66-99-385 is mounted in a standard MULTICAL® base and contains battery, connection print, verification print, microprocessor, control relays and precision resistors.
Connection between the verification equipment and MULTICAL® 401 is made by the use of an 14-pole test plug.
During testing the calculator is supplied by the battery.
The verification print is supplied via the associate external mains adaptor with 12 VDC.
The microprocessor simulates the volume based on the number of integrations per test point determined in the computer program. Temperature is simulated by means of permanent precision resistors which are changed automatically via relays controlled by the micro-processor.
After testing the computer reads all registers in the calculator and compares the values with the calculated values.
Deviation, determined for each test point – indicated as a percentage – can be printed on a test certificate or stored in the computer under the serial number of the tested MULTICAL® 401.

14.3.3 Verification data

The first time that METERTOOL and the verification equipment are used, a number of calibration data must be entered in the menu “Verification data”. As this data is of crucial importance for the verification result, they are protected by a password which can only be disclosed by Kamstrup A/S.

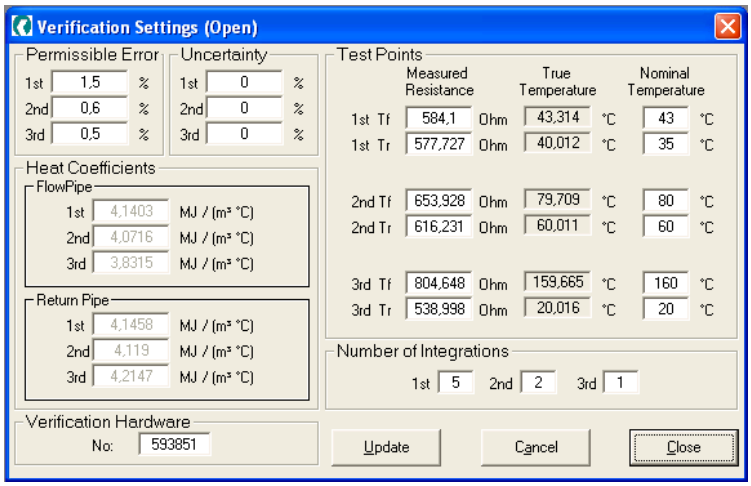


Figure 57

14.3.4 Permissible error and uncertainty

Max. permissible error, indicated as a percentage, and the equipment’s measuring uncertainty must be indicated under each of the three verification points; 1st, 2nd, og 3rd. The “permitted error” minus “uncertainty” will be indicated as MPE on the verification certificate.
According to EN 1434, MPE is ±(0.5 + Δθ min./Δθ)%.

14.3.5 Heat coefficient in flow and return

When the calibration values for the temperature simulators are entered into the program, it automatically calculates the true k-factor, according to the formula in EN 1434.

14.3.6 Test points

The test points 1st, 2nd, and 3rd are determined by the value of the temperature simulation resistances, which are mounted in the test equipment. The rated temperature points are indicated in above section.

14.3.7 Measured resistance

In order to update the temperature simulators' calibration, the temperature resistances' latest measured resistance values are entered. A calibration sheet with declaration of measured resistance values for all simulators is supplied by Kamstrup A/S together with the verification equipment. The temperature simulators must be calibrated at Kamstrup A/S once a year.

14.3.8 Enter number of integrations

In this field, enter the number of integrations required at each test point. Minimum required No. of integrations is 5, 2, and 1 concerning 1st, 2nd, and 3rd test. A higher number will reduce the reading uncertainty, but will prolong the verification time.

14.3.9 Verification

All necessary information can be transmitted directly from the calculator via serial data transmission, which simplifies the verification. Before test or verification can be started, a control must be made to confirm that all verification data are correct.
The procedure is started by clicking on "Start test".
The test takes between one and five minutes depending on the number of integrations.
When the test is completed, the results are shown on the monitor. If the results can be approved, click on "Save", and all verification data will be saved in the database under the calculator serial number.
It is possible to save data on both verification and control. Up to 99 certificates can be saved at each serial number (per meter).

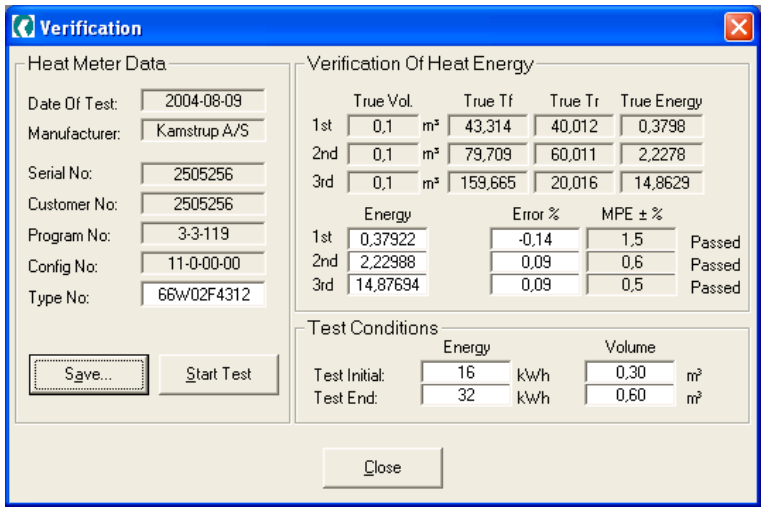


Figure 58

NB: Type number must be typed in before clicking on "Save".

If a printed certificate with the test results is desired, select "Print certificate" in the "File" menu, and the required S/N is selected.

14.3.10 Maintenance

Verification equipment type 66-99-385 is designed to work a number of years with a minimum of maintenance. The following must, however, be executed frequently in order to ensure optimal operation:

Recalibration

On delivery, a calibration certificate is enclosed issued by Kamstrup A/S. The applied calibrated resistance values must be entered under "Verification data". The equipment must be recalibrated once a year.

Kamstrup

CERTIFICATE OF CALIBRATION

Verification Equipment for MULTICAL® / MULTICAL® Compact / PICOCAL

Customer: **Kamstrup B.V.**

Type No.: **66-99-385** Type of meter: **66-W**

Serial No.: **600574**

Procedure: Kamstrup A/S No.: 5509-405 QI

Test equipment:

DMM, Fluke 8508A Kamstrup A/S No.: 1400098

Standard resistor, Vishay RTB 10 Kamstrup A/S No.: 1400020

This certificate provides traceability of measurement to recognised national/international standards.

Expanded Uncertainty: ± 15 ppm
(Coverage factor k=2)

Measurements:

		Nominal temperature [°C]	Nominal resistance [ohm]*	Measured resistance [ohm]	Calculated temperature [°C]*
T1	tF	43	583.495	**584,043**	43,284
	tR	40	577,704	**577,726**	40,011
T2	tF	80	654,484	**653,893**	79,690
	tR	60	616,210	**616,231**	60,011
T3	tF	160	805,272	**804,605**	159,642
	tR	20	538,968	**538,993**	20,013

*According to IEC 751/EN 60751 Amendment 2, 1995-07 "Industrial platinum resistance thermometer sensors"

Date: **2007-04-04** Calibrated by: **CNI** Tamb.: **23,8** °C

5509-404 Rev. G1, Kamstrup A/S, DK-8660 Skanderborg, Denmark

14.4 Flow meter adjustment

Should it be necessary to adjust the flow sensor during verification, this can be carried out by selecting "Flowmeter Adjustment" under the "Utility" menu. This function is protected by a password which can only be disclosed by Kamstrup A/S. Data connection between the PC and MULTICAL® 401 can be made either by means of a data cable type 66-99-108 or via verification equipment 66-99-385.

Example: Verification of a MULTICAL®401 flow sensor shows following result:

1% af qp:	+1.1%
10% af qp:	+0.3%
100% af qp:	-0.1%

To adjust the deviation following corrections must be typed in:

1% af qp:	-1.1%
10% af qp:	-0.3%
100% af qp:	+0.1%

Adjustments larger than +/-5% should not be carried out, as this might be caused by a faulty flow sensor.

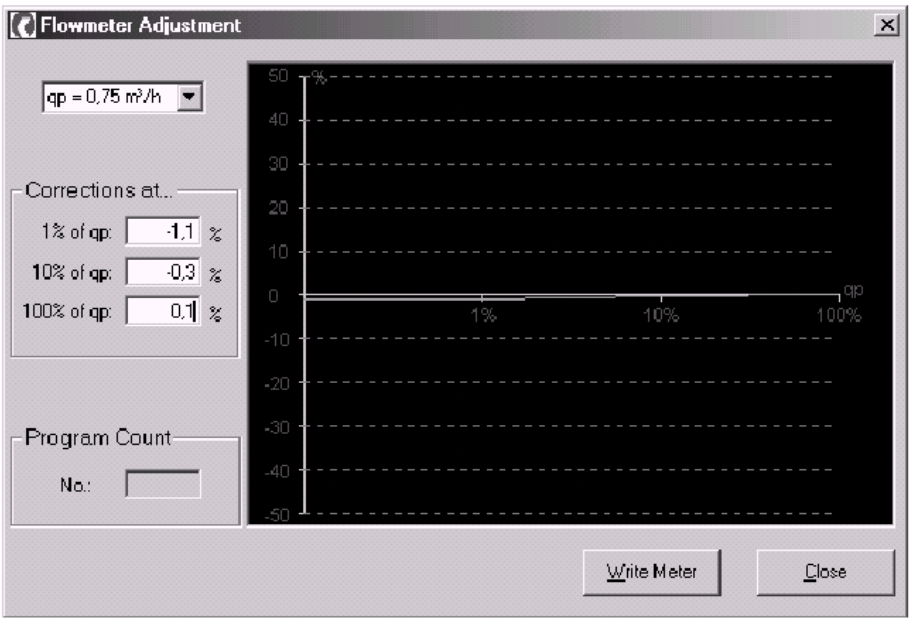


Figure 59

14.5 Alphabetical register

The following alphabetical register explains the terms which appear on the monitor.
The register can be read as information and used as a reference, when questions arise.

A-B-CCC	The calculator's programming number. Determines the flow sensor's placement in flow or return, measuring unit and flow sensor size.
Average	Indicates the averaging periode, over which the peak flow or peak power is measured.
CCC	Flow sensor size. E.g. CCC=119 is used with qp 1.5 m³/h.
Com 1...8	The computer's serial data port number 1, 2, 3.... to 8.
Config. No.	The meter's configuration number. = DD-E-FF-GG indicates display reading, tariff type and input/output.
Customer No.	11-digit customer number, that can be read on the display. The customer number can be changed without changing the serial number.
Date	The computer's date which is transferred to the calculator. The format is YY-MM-DD.
DD	Display code indicating the display reading selected.
DD-E-FF-GG	The meter's configuration no. = DD-E-FF-GG indicates display reading, tariff type and input/output.
E	The required tariff is selected by means of "E". E.g. E=3 means "cooling tariff", whereas E=0 means "no tariff".
EN 1434	European standard for heat meters (can be ordered at Dansk Standard (The Danish Standards Association)).
Energy	Accumulated energy (e.g. in kWh) is stored in the memory, when the info code is changed.
FF	Flow sensor coding of water meter (VA). E.g. FF=24 means that a water meter VA is coded for 10 l/pulses.
Flow	The actual flow can be used as tariff basis (E=2).
GG	Flow sensor coding of water meter (VB). E.g. GG=24 means that water meter VB is coded for 10 l/pulses.
Info code	The error code of the meter.
Info date	The date when the information code appeared.
Landscape	Means that sheets with front labels will be printed horizontally.
Min	The number of minutes selected as average time for peak flow or peak power. Between 1...120 min. can be selected.
mm	The number of milimeters with which the front label's print must be adjusted.
MPE	Maximum Permissible Error
Power	The actual heat flow rate can be used as tariff basis (E=1).
Print label	Starts printing the label displayed.

Print certificate	Starts printing the calibration certificate.
Preset	Starting values for input A and input B.
Programming	Starts programming the meter. All data displayed will be transmitted to the meter.
Read meter	Reads the meter's setting. All the meter's data are transmitted to the display.
Save Customer	Stores a setting in the database.
Serial No.	The meter's serial number.
Start test	This command is used to start the automatic verification sequence.
Target date	The yearly target date which most often is the district heating company's billing date. On target date all relevant registers are stored for later reading. The format is MM-DD, where MM=1...12 and DD = 1...28.
Tariff limits	The tariff limits determine when the tariff registers TA2 and TA3 must accumulate energy parallel with the energy reading. The tariff limits are only used with E=1, 2, 3 or 5.
Test initial	Registers the value before verification.
Time	The computer's actual time, which is transmitted to the meter at programming.
TL2	Tariff limit 2 indicates the start conditions for TA2.
TL3	Tariff limit 3 indicates the start conditions for TA3.
Type No.	The meter's type number contains information on power supply, data module, sensor module, pick-up unit and language on the front label.

15 Approvals

15.1 Type approvals

MULTICAL® 401 er type approved in Denmark according to OIML R75:2002.

The test reports, project E820068 and E820099, is made by DELTA and forms the basis of type approvals in a number of countries, among these Denmark and Germany.

For further information on type approvals and verification, please contact Kamstrup A/S.

TS 27.01 145
EN 1434 - OIML R75:2002

PTB 22.52 04.02

15.2 CE marking

MULTICAL® 401 is CE marked in accordance with following directives:

EMC directive	89/336/EEC
LV directive	73/23/EEC
PE directive	97/23/EC (DN50 in category I)

15.3 Measuring instrument directive

MULTICAL® 401 is available with marking according to MID (2004/22 EC). The certificates have the following numbers:

B-Module:	DK –0200-MI004-001
D-Module:	DK –0200-MIQA-001

Declaration of Conformity

Overensstemmelseserklæring
Déclaration de conformité
Konformitätserklärung

We
Vi
Nous
Wir

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 seule responsabilité que le/les produit(s):
erklären in alleiniger Verantwortung, dass das/die Produkt(e):

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
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®	65-S/R/T	Cl 3, M1, E1	DK-0200-MI004-003
Flow Sensor	ULTRAFLOW® qp 0,6...40 m3/h	65-S/R/T	Cl 2/3, M1, E1	DK-0200-MI004-003
Calculator	MULTICAL® 601	67-A/B/C/D	M1, E1/E2	DK-0200-MI004-004
Flow Sensor	ULTRAFLOW® 54	65-5	Cl 2/3, M1 E1/E2	DK-0200-MI004-008
Water Meter	MULTICAL® 41	66-Z	Cl 2, M1, E1	DK-0200-MI001-003

is/are in conformity with the requirements of the following directive(s):
er i overensstemmelse med kravene i følgende direktiv(er):
est/sont conforme(s) aux exigences de la/des directive(s):
mit den Anforderungen der Richtlinie(n) komform ist/sind:

Measuring Instrument Directive	2004/22/EC
EMC Directive	89/336/EEC
LVD Directive	2006/95/EEC
PE-Directive (Pressure)	97/23/EC
R&TTE	1999/5/EC

Date: 2007-12-21 **Sign.:**

Kurt Stochholm
Quality Assurance Manager
Kvalitetschef
Responsable Assurance Qualité
Qualitätsleiter

5518-050,Rev.: G1, Kamstrup A/S, DK8660 Skanderborg, Denmark

16 Trouble shooting

MULTICAL® 401 is constructed with a view to fast and simple mounting as well as long-term, reliable operation at the heat consumer's.

Should you, however, experience an operating problem with the meter, the error detection table below can help you clarify the possible reason.

In connection with repair, if necessary, we recommend that only battery and temperature sensors, and communication modules are replaced during service, alternatively the whole meter must be replaced.

Major repairs can only be made in our factory.

Before you send in the meter for repair, we ask you kindly to go through below error detection table to help clarify the possible cause of the problem:

Symptom	Possible cause	Suggested corrections
No display function (blank display)	No power supply	Replace the battery or check the mains supply. Is there 3.6 VDC on terminal 60(+) and 61(-) ?
No accumulation of energy (e.g. MWh) and volume (m^3)	Read "info" on the display.	Check the error indicated by the info code. (See section 7.4)
	If "info" = 000 ⇒	Check that the flow direction corresponds with the arrow on the flow sensor
	IF "info" = 004, 008 or 012 ⇒	Check the temperature sensors. If defects are detected, replace the sensor set
	IF "info" = 016 ⇒	There is air in the flow sensor. Release air from the system and check the meter once more.
Accumulation of volume (m^3), but not of energy (e.g. MWh)	Flow and return sensors have been reversed, either during installation or connection.	Mount the sensors correctly
No accumulation of volume (m^3)	Flow sensor angle is incorrect	Check that the flow direction corresponds with the arrow on the flow sensor
Incorrect temperature indication	Defective temperature sensor Insufficient installation	Replace the sensor pair. Check the installation
Temperature display is too low or accumulated energy is too little (e.g. MWh)	Poor thermal sensor contact Heat dissipation Sensor pockets too short	Place the sensors in the bottom of the sensor pockets. Insulate the sensor pockets Replace sensor pockets with longer ones

17 Disposal

Kamstrup A/S is environmentally certified according to ISO 14001, and as far as possible and as part of our environmental policy we use materials that can be recycled in an environmentally correct way.

• Disposal made by Kamstrup A/S

Kamstrup are willing to dispose of worn out meters in an environmentally safe manner - please contact us before sending the meters.
The disposal arragement is free of charge to the customer, who only pays for transportation to Kamstrup A/S.

• If the customer sends for disposal

The meters must not be separated prior to dispatch. Submit the entire meter for nationally/locally approved destruction. Copy of this page should be attached to inform on the contents.

• When the customer disposes himself

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

Subject	Material	Recommended destruction
Lithium cells in MULTICAL® 401	Lithium and Thionylclorid ›UN 3090‹ D-cell: 4.9 g lithium	Approved destruction of lithium cells
PC boards in MULTICAL® 401 (LC display and electrolytic capacitor are removed)	Copper epoxide laminate with soldered components	Print board scrap for concentration of noble metals
LC display	Glass and liquid crystals	Approved processing of LC displays
Cables for flow sensors and sensors	Copper with silicone mantle	Cable recycling
Transparent top cover	PC	Plastic recycling
Black base unit	ABS with TPE gaskets	Plastic recycling
Internal cover	PP	Plastic recycling
Other plastic parts, cast	PC + 20% glass	Plastic recycling
Meter case	> 84% Alpha brass/redbrass < 15% standard steel (St 37) < 1% Stainless steel	Metal recycling
Packing	Environmental cardboard	Cardboard recycling (Resy)

Please direct any questions you may have concerning environmental matters to:

Kamstrup A/S
FAO: Environmental and quality assurance department
Fax: +45 89 93 10 01
info@kamstrup.dk

18 Documents

	Danish	English	German
Technical description	5512-090	5512-091	5512-248
Data sheet	5810-437	5810-438	5810-439
Installation guide	5512-107	5512-109	5512-112
Operating manual	5512-108	5512-110	5512-113