CALEC® ST

Measuring of energy in heating and cooling installations

Application

CALEC® ST is a communications-enabled energy calculator designed for such demanding metering areas as heating installations, air conditioning solutions, combined systems for heating and air conditioning, cooling applications or solar heated systems in apartment blocks and larger buildings.

Characteristics

- Thermal energy measurement in refrigeration, heating and cooling systems (from $\Delta T > 0$)
- For combined heating and air-conditioning systems
- For glykole-based heat carrier liquids
- Battery or mains-powered
- Calculator module with separate calibration feature
- Logger saves up to 60 measurement readings
- Option: 2 impulse inputs or outputs
- Option: LonMark® 3.4 FTT-10A certified interface

Customer advantages

- High accuracy in thermal energy measurement
- Measurement of heat and cold in same device
- For use in refrigeration and solar-powered systems
- Choice of power supply
- Reduced processing costs at recalibration
- Support for operations monitoring
- Extendible module
- Optimal LON system integration

VD 3-180 e 05.2008

Application

The CALEC® ST is used for energy metering in split configuration with passive impulse-generating volume-measuring elements and Pt100 or Pt500 temperature sensors in two- or four-wire version. In most cases, CALEC® ST is used with the following volume-measuring elements:

- Multibeam meters in the range Qp 0.6 - 10 m^3/h
- Hydrometric vane in the range Qp 15 - 400 m^3/h
- Static volume-measuring elements up to Qp 400 m^3/h

Choose from our wide range of volume-measuring elements. Our advisers will be pleased to help you select the right ones for your needs.

For details of special and extended functions and configurations, please refer to the section entitled “Special Functions”.

Obligatory calibration and type-approval

Regulations in most countries stipulate that energy-metering devices must be calibrated, while making their use subject to type-approval procedures. The permits currently applying to CALEC® ST are listed in the section entitled “Official Permits”.
Heat meters in commercial use must be recalibrated before the expiry date of their current calibration. The user is responsible for ensuring that the recalibration deadline is maintained. The calibration procedure covers all parts (sensors, volume-metering element, counter mechanism) of a combined heat meter.
Type-approval is currently available only for water as a heat-transfer medium, and for purely heating or cooling operation. For this reason, some of the functions described here, such as

- Operation with glycol-based heat-transfer media
- Combined heating/cooling operation
- Low-flow OFF function

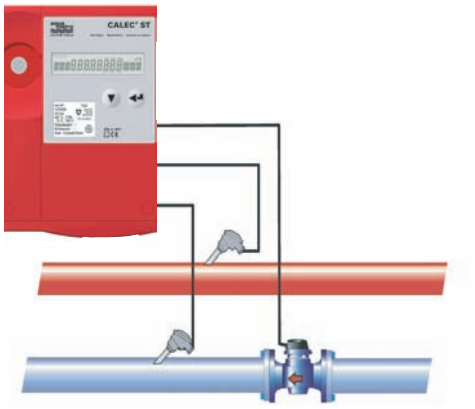
may not, on administrative grounds, be covered by type-approval procedures, or the corresponding functions may not apply to measuring devices that are subject to obligatory calibration.

The display on the CALEC® ST can be set to high-resolution mode for the purposes of testing and calibration. The CALEC® ST can also be checked/calibrated via an optical M-Bus interface (protocol in accordance with EN 1434-3). Software such as CALEC® Win (available as a download from the Aquametro website) can be used for this purpose.

An interface module for NOWA software is also available.

Basic function and measuring principle

A so-called “combined” heat meter requires the following individual elements:



- 1 x pair of temperature sensors
- 1 x volume-metering element with pulse generator
- 1 x transducer (counter mechanism)

The thermal output (P) of a pipe-conduit network is based on a measurement of the flow temperature, return-flow temperature and volume flow of the heat transfer medium.

P = specific heat (Tm, medium) * density (Tm, medium) * (Thot - Tcold)

T_{hot} :	"hot" side, flow temperature during warm-up phase
T_{cold} :	"cold" side, return-flow temperature during warm-up phase
T_m:	mean temperature = (T – T)/2

Energy can be determined by integration of output. The formula shows that, in order to meter energy, the specific heat and density of the heat transfer medium must be expressed in relation to the temperature of the counter mechanism. The following factors (among others) also have a decisive influence on metering accuracy:
- The static accuracy and stability of the temperature-measuring procedure
- The counter cycle of the temperature-measurement system, and the volume flow used to detect dynamic factors

CALEC® ST is ideally equipped for use in demanding metering tasks, thanks to:
- The use for temperature-measuring purposes of a high-resolution AD converter (16 bit) designed with long-term stability in mind and equipped with self-calibration and filter functions
- Short counter-cycle (mains version: 1 s)
- The ability to use high-resolution mechanical or electronic flow indicators operating at pulse frequencies of up to 200 Hz (mains version)

Flow-rate measurement

The system is compatible with all standard flow meters that work on the pulse output principle. Adjust the pulse value to the lowest possible setting if you do require continuous measurement or high-resolution energy metering.
When it is running on battery power, the CALEC® ST can only handle contact makers working at pulse frequencies of up to 6 Hz. The mains-powered CALEC® ST can operate with contacts makers running at up to 20 Hz and electronic transmitters (NAMUR, optical units, etc.) with pulse frequencies of up to 200 Hz.
The point of installation of the flow-rate meter is of vital importance, as the volume-to-mass conversion is based on the temperature detected at this point.
Use of the terms "inflow" and "return flow" in particular can lead to misunderstandings when dealing with refrigeration systems. The terms "cold side" and "hot side" give a clearer definition in this respect. It is preferable to fit the flow indicator to the section of conduit where the temperature is nearest to room temperature. This has the twin result of increasing the measurement accuracy and lengthening the service life of the flow detector.

Temperature measurement

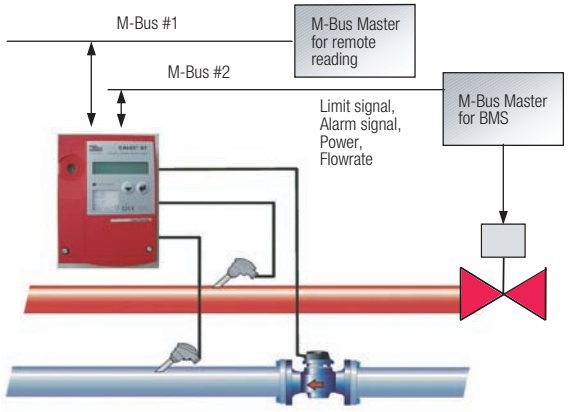
The CALEC® ST is fitted with two highly-accurate temperature-measurement inputs, which are each connected to type-approved, paired temperature sensors in two- or four-wire configuration. For optimum measuring accuracy, use the CALEC® ST only with sets of temperature sensors paired at ≤ 0.05 K. Pairs of temperature sensors with 0.1 K pairing are prone to intrinsic errors, which not even the best counter mechanisms can compensate for. The planning of systems should conform to heat meter standard EN 1434, parts 2 and 6. EN 1434-4 stipulates that only sensors of the same design and length should be paired together.
The counter mechanism is available in either Pt 100 or Pt 500 configuration.

Thermal energy is measured from a temperature difference from dT above (respectively below) 0 K. The CALEC® ST is the ideal solution for air-conditioning or cooling installation when used with appropriate temperature sensors and flow meters for cooling.

Communication

M-Bus

The M-Bus offers, on the basis of its conformity with standard EN 1434-3, such outstanding characteristics as:



- Simple installation
- Cost-effectiveness
- Compatibility with units from other suppliers

Widely used as a readout bus in building-management systems.

The CALEC® ST can be equipped with up to two galvanic M-Bus interfaces for this purpose. The M-Bus interfaces can provide readouts not only of such standard data as meter status and current readings, but also of the additional data available in the device, including - for example - critical-date and stored readings.
CALEC® ST allows primary addresses and baud rates to be configured via the control keys, thus permitting start-up without the use of a PC.
The "freeze" function allows real-time readings to be obtained even over large-scale M-Bus networks with major delays in communication.
The M-Bus is configured as a single-master bus, i.e. each slave can communicate with a single master only. If a device is to transfer, in parallel with the telemetering function, data to another M-Bus master forming part of a building-management system, this can only be carried out using devices equipped with two M-Bus interfaces. The CALEC® ST can be equipped with a second M-Bus interface for this purpose.

LON interface

In contrast to M-Bus systems, the use of a LON network offers the possibility of combining building-management and meter-reading functions into a single system. LON (Local Operating Network), a multiple-master system with intelligent nodes, can use a range of different transfer media. A LON interface card (FTT-10A) compatible with CALEC® ST is available for data transfer via a twisted pair of wires.
One outstanding characteristic of LON technology is its interoperability, which ensures that a building-management system remains operable throughout the service life of its individual components. CALEC® ST is the first energy meter to be certified in accordance with LONMARK® 3.4 to back up fully these promises of interoperability. This translates into trouble-free integration with a LON network, thus saving on both time and costs. There are also no unpleasant surprises with respect to missed start-up deadlines. LONMARK® certification means, along with other benefits, that:

- The data objects of the network node can be retrieved from the object library of the integration tools (e.g. LonMaker™).
- The signals and interfaces are fully described in the XIF file (eXternal Interface File). This means that the system function can be programmed offline (i.e. without additional devices).
- CALEC® ST offers the full functionality of a LON node, including such diagnosis and installation aids as a service LED and service button.
- The arrangement of nodes with respect to data points can be tracked using the identification number of the Neuron® chip, its "Neuron® ID". The device is supplied with a stick-on label printed with the Neuron®ID in barcode form. Once installation is complete, the technician can stick the label to the corresponding point on the layout plan, so that the integrator can read it with a desktop barcode scanner and assign it its place in the system.

Please refer to document no. 11784: CALEC® ST LON FTT-10A interface for further details.

Digital inputs and outputs

The CALEC® ST can be fitted with two digital-signal interfaces, which can be configured – by means of a switch – as either inputs or outputs. These signals can be used to process counter impulses, or to warn when limit values have been exceeded, or to transmit alarm messages to the building-management system.

Limit-value signals
Digital output signals can be used to emit limit-value monitoring signals. The following parameters can be monitored in this respect:

Factor	Display
Temperature on “hot” side	t-hot
Temperature on “cold” side	t-cold
Temperature difference	t-diff
Output	POUEr
Flow rate	FLOU
C-factor	C-Factor
Density	dEnSitY

1. Function of one-sided limit-value monitoring (Limit1)
If an adjustable maximum limit is exceeded **or** if the reading fails to reach an adjustable minimum, the output signal switches over, hysteresis (0-10%) and control direction are selectable as required. While the excess-reading remains in force, the meter (showing “Cnt” for “counter”) calculates the total duration of the error for inspection purposes.

2. Function of two-sided limit-value monitoring (Limit2)
If an adjustable maximum limit is exceeded **and** if there is failure to reach an adjustable minimum, the functions operate in a similar way to those of Limit1.

Alarm message
The microprocessor monitors the temperature sensor and internal functions, and displays any resulting error messages. This information can also be used to generate an alarm signal via the digital outputs.

Analogue outputs

CALEC® ST can be equipped with two passive analogue outputs. An external power supply is required for operating purposes. The outputs are electrically isolated from each other and from the counter mechanism. The current per channel can be adjusted within a range of 0-20mA or 4-20mA. The following readings can be emitted as current signals:

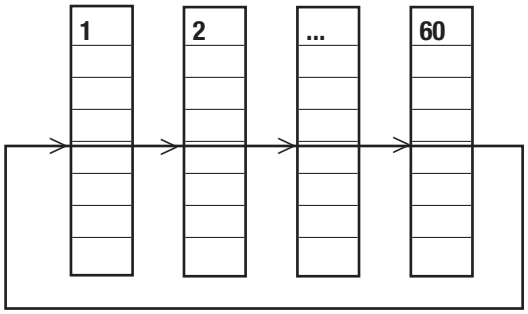
Reading	Display
Temperature on “hot” side	t-hot
Temperature on “cold” side	t-cold
Temperature difference	t-diff
Output	POUEr
Flow rate	FLOU
C-factor	C-Factor
Density	dEnSitY

Additional functions

Crucial-date factors
Two freely-programmable crucial dates (e.g. March 31st and September 30th) can be entered into the metering system and checked at any time.

Data logging
The CALEC® ST can periodically save up to 60 data records in a circular buffer.

Factor	Display
Date	-
Energy	Total
Volume	Total
Auxiliary meter 1	Total
Auxiliary meter 2	Total
Output	Peak value
Downtimes	Total



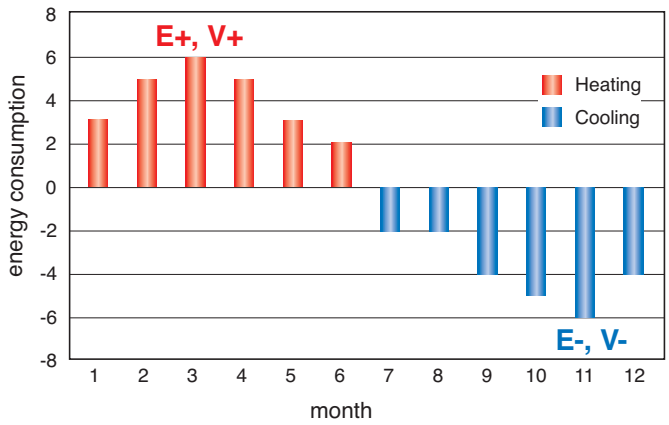
Real-time M-Bus and LON readings ("freeze" function)
Given the sometimes-considerable communication times, it is not possible to obtain real-time readings from several meters via a counter-bus system.

The CALEC® ST "freeze" function supplies an elegant solution for this task. A broadcast command causes all devices to save their measurement readings simultaneously, so that they can then be read in succession. The "freeze" function is available in both M-Bus and LON operation.

Low-flow OFF function
The system is factory-adjusted to carry out an energy calculation as soon as a temperature difference of > 0 (when measuring heat) or < 0 (when measuring cold) is detected. If, for example, a circulation conduit carries, over a long period of time, large quantities of heat transfer medium with a very low temperature difference, this can lead to significant reading errors in temperature measurement. The so-called "low-flow OFF function" can be activated to avoid this, ensuring that energy is only detected when a pre-defined temperature difference is exceeded.

Special functions

Energy metering in heating/cooling systems



The "bi-directional energy metering" (BDE) option allows emitted energy to be metered even in twin-conduit networks that perform a combined heating and cooling function. The measurement readings for heating and cooling are recorded separately for their corresponding cost-calculation purposes.

Refrigeration systems
The below-freezing temperatures involved in running a refrigeration plant require the use of additional frost protection. This poses an insurmountable problem for many conventional heat meters, as has been investigated in detail in such publications as PTB Report PTB-ThEx-24 of June 2002.

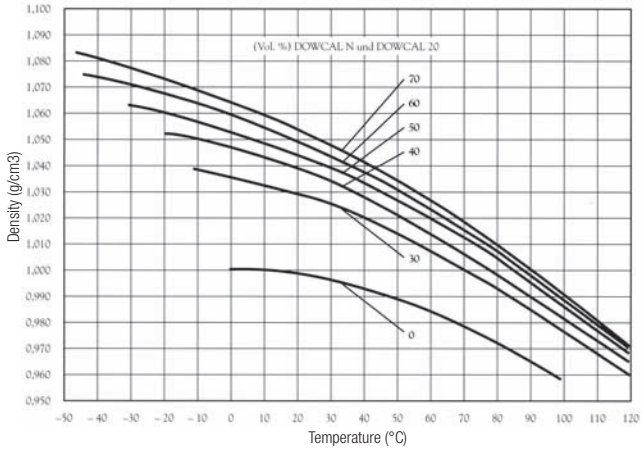
The "Glycol-based heat transfer medium" option available with CALEC® ST ensures that metering is accurate even in these situations, as energy and volume can be calculated with a sliding scale of values for density and heating capacity for each temperature, independently of that temperature. CALEC® ST gives accurately polynomial readings for the physical characteristics of 11 widely-used heat transfer liquids with respect to concentration and temperature (see following table).

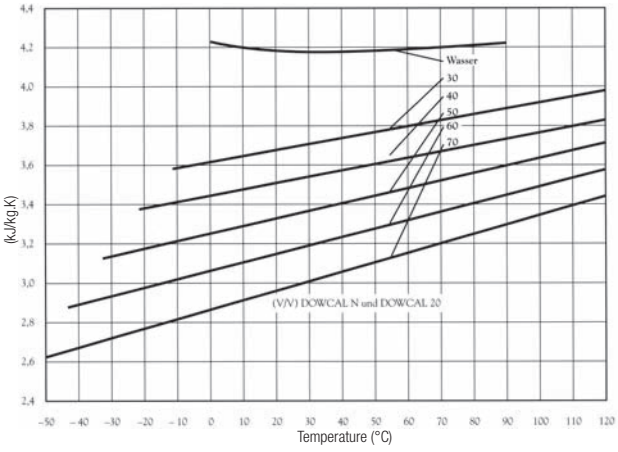
Only the heat transfer medium and concentration are established at start-up (see table):

Medium 4)	Display	Concentration	Temperature range	Manufacturer	Type	Application/observations
Antifrogen N	AntifroN	20% - 60%	- 120°C 1)	Clariant	E 2)	Confirms to DIN 4757-1; toxicity class 4 For cooling, solar, heating and heat pump systems Low viscosity, requires lower
Antifrogen L	AntifroL	20% - 60%	- 120°C 1)	Clariant	P 3)	Not harmful to health For pharma-sector, food use
Tyfocor	Tyfocor	20% - 60%	- 120°C 1)	Tyfocor	E	See type E
Tyfocor-L	TyfocorL	20% - 60%	- 120°C 1)	Chemie	P	See type P
DowCal 10	DOUCAL10	30% - 70%	- 120°C 1)	Dow	E	See type E
DowCal 20	DOUCAL20	30% - 70%	- 120°C 1)	Dow	E	See type E
Glythermin P44	GLYTHP44	40% - 80%	- 100°C 1)	BASF	P	FDA-approved in USA, corrosion protection less effective For pharma-sector and food-production plants
Temper -10	TEMPER10	100% fixed	-10 … 150 °C	Temper	S	Ready-to-use saline solution
Temper -20	TEMPER20	100% fixed	-20 … 150 °C	Temper	S	Not harmful to health, (also for pharma and food sectors) Biodegradable, water-protection class 1
Temper -30	TEMPER30	100% fixed	-30 … 150 °C	Temper	S	Low viscosity
Temper -40	TEMPER40	100% fixed	-40 … 150 °C	Temper	S	High heat-transfer capacity

1) Minimum temperature depends on concentration -40 ... 0 °C
2) Ethylene glycol-based
3) Propylene glycol-based
4) The above designations are the registered trademarks of their respective manufacturers.

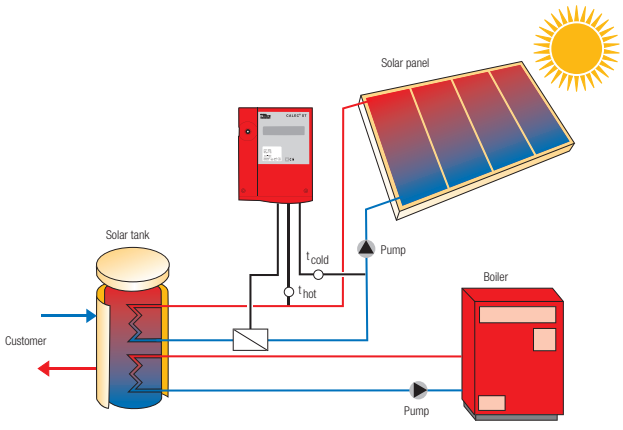
The following graphs give an example of how the dependency of temperature on specific heat and density can have an important bearing on the final calculation.





DOWCAL is a registered trademark of the Dow Chemical Company

Solar-powered thermal systems



Solar thermal systems likewise pose demanding tasks for energy metering with respect to temperature range and heat transfer medium.

The "**Glycol-based heat transfer medium**" (GLY) option available with CALEC® ST also offers an excellent solution in these cases (further details in the section on refrigeration systems).

CALEC® ST Flow
The CALEC® ST Flow configuration is designed for flow-rate measurement purposes. Temperature measurement (“hot” and “cold” side) is disabled in this configuration, i.e. no temperatures are detected or displayed. CALEC® ST Flow uses the accumulated pulse signals from the flow detector to calculate the current flow-rate reading. These measurement readings can be sent to the display, the analogue outputs and/or the M-Bus or LON interface for reading or further processing.

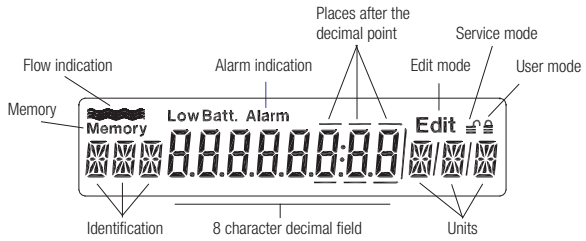
CALEC® ST configurations

Available CALEC® ST configuration variants in accordance with our country-specific price lists.

Operation

Thanks to their logically-structured functioning, all setting adjustments on the CALEC® ST can be carried out locally and without the use of additional equipment.

Multi-function display



The multi-function display shows the eight-digit meter reading, along with symbols and short texts for user operation purposes.

The displays can be selected using two buttons during operation or when the housing is closed:

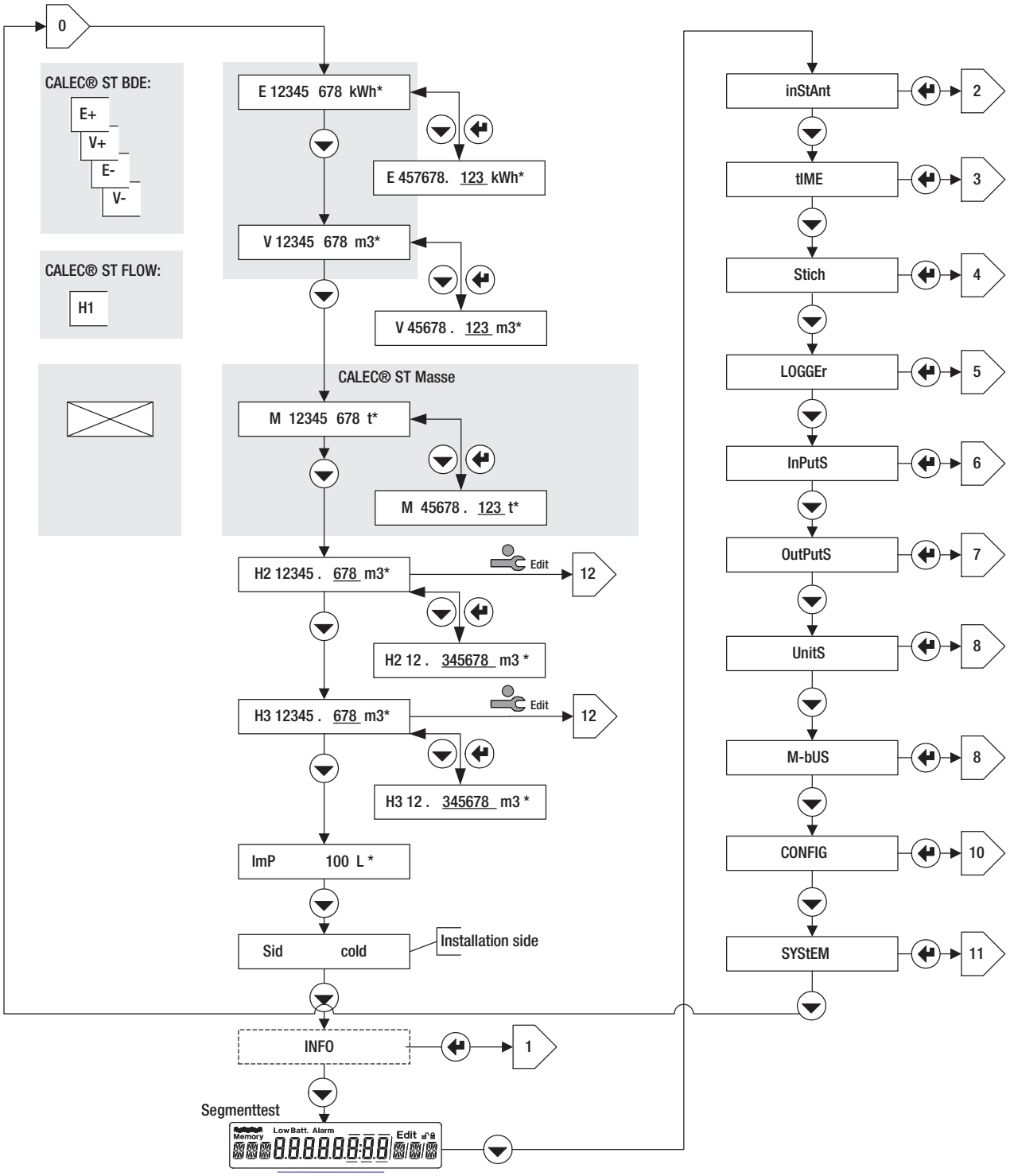
Operating buttons

Under the cover, and thus protected by the lead seal, is the Service button, which allows additional service information to be displayed and adjustments to be carried out.

Service button

Professional installers have the PC software CALEC® Win at their disposal (available for download from our website), which provides effective support for initial start-up, data analysis and order specifications.

The following graph shows the information available at various points on the main operating flowchart, along with the short text designations of various sub-functions:



Display:	Description:
Info:	Error message display
InstAnt:	Current readings for temperature, output, flow rate, C-factor, density
Time:	Date and time
Stich:	Critical-date values
LoGGer:	Data-log memory settings
InPuts:	Settings and status of signal inputs
OutPuts:	Settings and status of signal outputs
UnitS:	Measurement-unit settings
M-bUS:	M-Bus settings
CONFIG:	Further settings (e.g. for glycol-based heat transfer medium)
SYStem:	System data (e.g. firmware version)

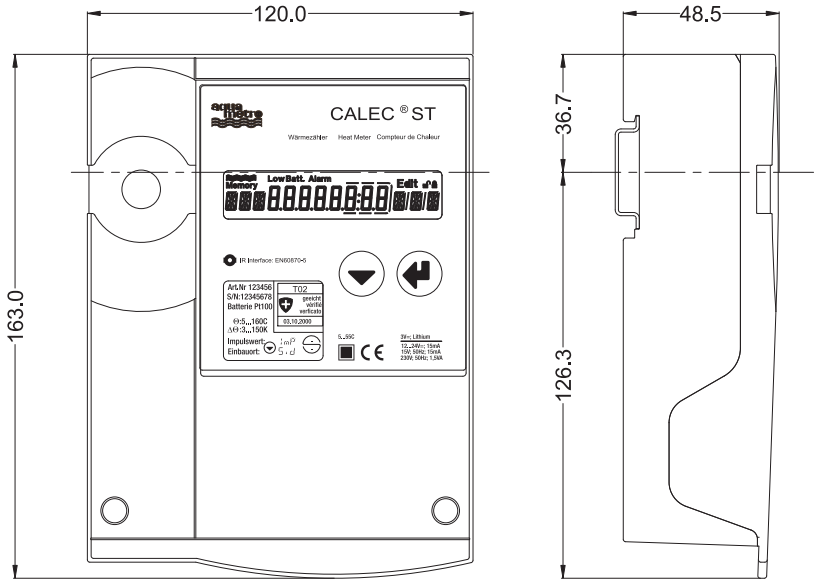
Plug-in calculator module

The energy calculator is housed in a plug-in module. The bottom of the housing (which contains the field wiring) does not have to be removed when recalibrating the unit. Furthermore, device-specific data are retained in the configuration memory (EEPROM) in the bottom of the housing (except parameters that are subject to calibration, like impulse value and installation side).

Housing, dimensions

Housing
Lower section with connection terminals, computer module and cover

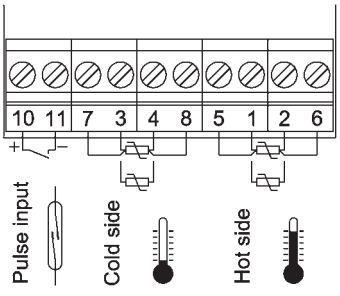
Installation
DIN-standard rail or three-point attachment directly to the wall



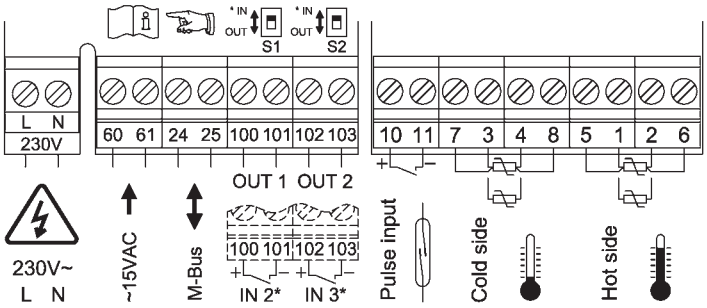
Electrical connections

The wiring layout used depends on device configuration and applicable options. The factory-configured state of the unit is shown on the diagram attached to the inside of the housing cover.

Battery-powered version (Example)



Mains-powered version (with M-Bus and low-voltage supply) (Example)



Technical specifications and applicable standards

Standards			
European-conformity directive	Directive 89/336/EEC, 92/31/EEC, 93/68/EEC Electromagnetic compatibility (EMC)		
Standards	EN 1434 EN 55081-1 EN 50082-2	Heat meters Electromagnetic compatibility Electromagnetic compatibility	
Housing and operating conditions			
Dimensions	B x H x T = 120 x 163 x 49 mm		
Ambient temperature	+ 5 ... + 55 °C, EN 1434 class C		
Storage temperature	0 °C ... 60 °C		
Optical interface	In accordance with IEC 870-5, M-Bus protocol		
Measurement			
Temperature-measurement range	0 ... +183 °C	Type approval 5 °C ...	180 °C
Temperature difference	0 ... 175 K	Type approval 3 K ...	175 K
Temperature sensor	Pt 100 or Pt 500 paired as per IEC751, with 2- or 4-wire connection		
Installation side	"Hot" or "cold" side "Cold" side preferable for heating purposes, "hot" side for cooling		
Impulse value for volume	0.001 ml to 9999.999 m3		
Impulse value for energy	0.001 kWh to 9999.999 GJ or 0.001 KBtu to 9999.999 MBtu		
Error limits	Better than those required for counter mechanisms conforming to EN 1434-1 Suitable for combined class-2 heat metering as per EN-1434-1 when used with suitable volume-metering elements		
Display			
Display units, volume	m3, USGal		
Display units, energy	KWh, MWh, MJ, GJ, KBtu, MBtu		
Data backup in event of power failure	In EERPOM > 10 years		
Data memory	60 data records, tracing 1 x per month, every 2 days, daily (also hourly in mains-powered version)		
Additional functions			
Low-flow OFF function	Energy calculation is suppressed whenever the temp. difference is < DT = 0 - 2.99 K		
Limit-value monitoring	Single- or two-sided, hysteresis 0-10%, selectable control direction of output signal		

Battery-powered version			
Power supply	3 V lithium battery, service life > 6 years at ambient temperature of < 45 °C		
Counter cycle	20 s		
Main pulse input	High-resistance for contact or transistor output Impulse ≥ 8 ms With symmetrical impulse signal, max. 6 Hz	Pause ≥ 80 ms	Max. 10 Hz

Battery-powered options	
Output card	
2 x transistor outputs	Max. 48 VDC 50 mA
M-Bus card	
M-Bus interface	As per EN 1434-3, 300 and 2400 baud Power supply to interface via M-Bus
IN/OUT function, channel # 1	Impulse input #2 or relay output #1
IN/OUT function, channel # 2	Impulse input #3 or relay output #2
Impulse input	For connection of a contact /"open-collector" pulse generator with: Impulse length: > 8ms Impulse pause: < 80ms Frequency: < 10Hz (symmetrical <6Hz)
Relay output	Max.48 V / 100 mA (AC/DC) RON: < 20 Ω ROFF: > 10 MΩ The relay outputs are electrically isolated from each other and from the counter mechanism. Max. potential difference between relay contact and device earth (ground): 48 VDC
LON-FTT-10A card	For technical specifications, see mains-powered configuration
M-Bus card #2	Additional second M-Bus interface (only with M-Bus card)

Mains configuration	
Power supply	230 VAC, 50/60 Hz, max. 7 mA, approx. 0.35 VA
Counter cycle	1 s
Backup battery	3 V Li button cell, 48 mAh
Main pulse input	For NAMUR, contact or transistor output NAMUR: 8V/ 1 kΩ, forward break-over points 1.5mA, 2.1 mA Impulse ≥0.35 ms, pause >2.5 ms, max. 200 Hz

Mains-supply card, light	
Mains supply	230VAC ±10% 50/60Hz, <0.5VA
Mains-supply card	
Power supply	230VAC ±10% 50/60Hz, <0.5VA 12 ... 24 VDC or 15 VAC
M-Bus interface	As per EN 1434-3, 300 and 2400 baud
IN/OUT function, channel # 1	Impulse input #2 or relay output #1
IN/OUT function, channel # 2	Impulse input #3 or relay output #2
Impulse input	For connection of a contact /"open-collector" pulse generator with: Impulse length: >8ms Impulse pause: <80ms Frequency: <10Hz (symmetrical <6Hz)
Relay output	Max.48 V / 100 mA (AC/DC) RON: <20 Ω ROFF: >10 MΩ The relay outputs are electrically isolated from each other and from the counter mechanism. Max. potential difference between relay contact and device earth (ground): 48 VDC
LON card FTT-10A	
Power supply	230VAC ±10% 50/60Hz, <0.5VA 12 ... 42 VDC ±10% or 12 ... 24 VAC ±30% 50/60Hz
IN/OUT function, channel # 1	Impulse input #2 or relay output #1
IN/OUT function, channel # 2	Impulse input #3 or relay output #2
Impulse input	See mains-supply card
Relay output	See mains-supply card
LON interface	FTT-10A, free topology (2-wire twisted pair), certified as per LonMark® 3.4
Transfer rate	78 kBaud
Max. bus length	500 m/ 2700 m without/with terminal resistances 64 nodes per segment
Analogue output card	
Power supply	230VAC ±10% 50/60Hz, <0.5VA
IN/OUT function, channel # 1	Impulse input #2 or relay output #1
IN/OUT function, channel # 2	Impulse input #3 or relay output #2
Impulse input	See mains-supply card
Relay output	See mains-supply card
Analogue outputs	2
Current range	4 ... 20 mA or 0 ... 20 mA
Supply voltage	6 ... 24 VDC
Resolution	12 bit

Approval permits

Approval as per EN 1434-1:
Germany (PTB) 22.55/01.02 Details for other countries available on request
Switzerland (metas) T2/725
Approved according to the European Measurement Instruments Directive 2004/22/EG, CH-MI004-07001-00

A1 - 05.2008 - Art. Nr. 11837