

APATOR
METRA

Compact heat meter

ELF 2

OPERATING MANUAL

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1 Subject

This technical specification is intended to present the characteristics, parameters and operation of the Elf 2 compact heat meters manufactured by Apator Powogaz. The heat meters are intended to meter the heat taken by small heat loads from district heating distribution networks (e.g. apartment space heating systems) within a heat power rating of 0.3 kW to 850 kW, with Building code compliant treated water as the heating medium. The heat meters are manufactured in five sizes for four nominal flow rate sizes. The sizes differ by diameter and connection types.

The heat meter comprises a flow transducer, a pair of Pt 500 temperature sensors and an electronic indicator calculator. All components form an integrated assembly for the user, which means a complete heat meter unit. The installed sensors are type TOPE43 Pt 500 temperature sensors and butterfly flow meters without a magnetic coupling, which must be used by conjunction with a specific type of electronic calculator.

The Elf 2 heat meters are compatible with remote reading interfaces and with up to four additional devices (e.g. a water meters or gas meter) which feature pulse outputs. The following interface types are available:

- Wireless M-Bus with 2x pulse inputs
- M-Bus with 4x pulse inputs
- M-Bus with 2x pulse inputs and 1x pulse output
- RS 485 over Modbus RTU
- USB

2 Regulatory and standard compliance

The Elf 2 heat meter meets the following standards and directives:

- Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments, with specific consideration to Annex VI (MI-004), Heat Meters
- Radio Equipment Directive (RED) 2014/53/EU
- PN EN-1434 – Heat meters, 6 parts
- PN EN 61000 – Electromagnetic compatibility (EMC). Parts 2-4
- PN EN 13757 – Communication systems for meters and remote reading of meters. Part 1-4
- OIML R75

3 Design, principle of operation & basic characteristics

Elf 2 compact heat meters consists of an electronic calculator with a pair of Pt 500 sensors permanently integrates with a butterfly flow meter. The heat meter enclosure prevents unauthorized access to the temperature sensors and the electronic system after the factory assembly of the product. The base of the electronic system enclosure is connected to the flow meter enclosure with a band clip locked with a tamper wire seal. The enclosure cover is bolted to the base with four screws. The enclosure is sealed by applying a self-adhesive tamperproof seal made of a special brittle sheet at the enclosure separation line, and on the fastening screw heat opening. The metrological parameters and the calibration mode are protected with a pin jumper, which itself is secured by the heat meter enclosure. The part of the set-up parameters which do not affect the measurement accuracy is adjustable by the user, i.e. the building administrator the technical service.

The flow meter rotor features a disk made of an EM filed insensitive metal. The rotation of the flow meter rotor is sensed by induction coils which output the detection signals to the electronic system. The connection between the flow sensor and the electronic system forms the complete flow transducer; with this assembly connected to the temperature sensor pair, a complete compact heat meter is formed. The latest rotation flow transducer system resolution enables detection of as little as ¼ of a rotor revolution; moreover, the implemented electronic calibration feature provides a very smooth error curve across the entire range of flow variations.

The temperature sensors are permanently soldered to the calculator PCB. In the basic operating mode with the heating medium flowing through the heat meter, the temperature measurement interval of the heating medium is 6 seconds; the temperature measurement interval grows to 20 seconds without any heating medium flow. The heat increment is calculated and added to the total consumption register at a minimum interval of 8 seconds and only if a volume increment of the heating medium occurs. The heat meter has an algorithm implemented to process dynamic integration period changes whenever the flow rate varies by more than 200 l/h. This variation results in a non-delayed measurement of the heating medium temperature and an energy value calculation. The next temperature measurement of the heating medium after a 2 second interval, and is then repeated at 2-seconds intervals. This feature enables a more accurate determination of energy consumption in systems with fast and short-lived energy loads

The volume of heating or cooling energy load is calculated with the following formula:

$$Q = \int_{V_1}^{V_2} k(t_1 - t_2) dV$$

with: Q, consumed / returned heat quantity; V, water flow rate; k, temperature coefficient of water; t₁ water supply temperature; and t₂ water return temperature.

Another value, which is called the calculator metrological test, is calculated to evaluate the metrological class of the electronic system operating as a stand-alone calculator of the heat meter.

The instantaneous water flow rate and the instantaneous heat power are calculated live.

The electronic calculator provides a user-configurable parameter called “the averaging period”. The period (which may range from 15 to 1,440 minutes) is used to calculate the average values of flow, power and temperature, and to save the states of the consumption registers, including the heat register, from the CPU RAM module to non-volatile flash memory. The parameters

logged for the user-defined averaging period are called the “minute archive”. The heat meter also logs data in the hourly archive, which is stored every defined minute of each hour. Every time a heat consumption increment is added to the main register, a checksum is calculated. If there is an operating disturbance and the checksum is modified in an invalid way (e.g. when replacing the meter’s battery), the consumption data is read back from the hourly archive stored in the non-volatile flash memory. This restores the meters status from no earlier than one hour before. If it is not possible to load the consumption data or the configuration data, operation is no longer possible, which is indicated by a suitable message.

The calculator determines the maximum and minimum values of flow, power and temperature from the values calculated in the averaging period. It is possible to record the states of the consumption logs and the maximum and minimum values in different time cycles. The heat meter also detects failure conditions, e.g. a failure of the temperature sensors.

All interfaces this heat meter is compatible with are located in separate enclosure which can be removed from the heat meter without breaching the temper-evident seal of the main enclosure.

The electronics system is powered by lithium batteries as standard, guaranteeing operation up to 12 years, or up to 6 years under normal operating conditions, depending on the design of the heat meter. The heat meter measures the battery voltage under load and sets the appropriate error code when it drops below the permissible value (3.2 V). When the voltage drops below 2.95 V, the operating of the heat meter is blocked.

The heat meter can work in three modes:

- Calibration modes – with the pin jumper installed; only this mode enables modification of the calibration parameters or metrological configuration of the heat meter;
- Test mode – the electronic system operates at a higher power consumption and generates dedicated signals for testing of the metrological class of the flow transducer
- User basic operating mode – with a minimum battery power consumption

The heat meter can be operated in the normal operation mode which has three selectable sub-modes:

- Heating energy meter, with 100% of the operating time in this sub-mode
- Cooling energy meter, with 100% of the operating time in this sub-mode
- Mixed energy meter – the heat meter alternates between the two sub-modes given above

Elf 2 automatically switches between the heating and cooling energy meters sub-modes by monitoring the differential temperature between the supply and the return, and the crossing of the supply temperature threshold.

4 Basic technical data

The basic technical data of the device are listed in the table below. The maximum error values are specified for the complete heat meter device and its individual measurement components.

In accordance with PN-EN-1334-1:2015, the MPE of the integrated heat meter is the sum of errors of all components:

Flow transducer error:

$$\left(2 + 0,02 * \frac{q_p}{q}\right), \text{no more than } 5\%$$

Temperature sensor pair error:

$$E_t = \left(0,5 + 3 * \frac{\Delta\theta_{min}}{\Delta\theta}\right)$$

Calculator error:

$$E_c = \left(0,5 + \frac{\Delta\theta_{min}}{\Delta\theta}\right)$$

Flow transducer			Aparator				
Manufacturer mark		-					
Factory mark		-	JS90-0,6-TI	JS90-1-TI	JS90-1,5-TI	JS90-1,5-G1-TI	JS90-2,5-TI
Nominal diameter	DN	-	15	15	15	20	20
Minimum flow rate – horizontal installation orientation (H)	q _i	dm ³ /h	6	10	15	15	25
Minimum flow rate – vertical installation orientation (V)	q _j	dm ³ /h	12	20	30	30	50
Nominal flow rate	q _p	m ³ /h	0,6	1,0	1,5	1,5	2,5
Minimum flow rate	q _s	m ³ /h	1,2	2,0	3,0	3,0	5
Starting flow	q _r	dm ³ /h	2,5	2,5	4,5	4,5	7,5
Measurement range q _p /q _i – horizontal installation (H)		-	100				
Measurement range q _p /q _i – vertical installation (V)		-	50				
Maximum permissible errors MPE	E	%	E _f = ± (2+0,02 q _p /q)				
Counter indicating range		m ³	10 ⁴				
Scale interval value		dm ³	1				
Maximum operating pressure (MOP)	Ref. PN-EN 1434-1:2015	bar	PS16 MAP16				
Nominal pressure		bar	PN16				
Maximum pressure loss at q _p		kPa	ΔP25				
Temperature range limits		°C	θ _{min} = 0,1°C to θ _{max} = 90°C				
Flow disturbance sensitivity class ref. ISO4064-3:2017		-	U0, D0				

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Installation orientation		-	H, V				
Back flow		-	No				
Accuracy class ref. PN-EN-1434-1:2007 H (V) installation orientation		-	Class 2 (3)				
Water meter thread diameter	G	-	G 3/4	G 3/4	G 3/4	G1	G1
Water meter length	L	mm	110	110	110	130	130
Relative humidity		%	≤90				
Ambient conditions Class A	Climate		Operating in sheltered/indoor locations Operating in temperature range: -5 to +55°C -low relative humidity -normal electrical and electromagnetic exposure level -low mechanical exposure level				
	Mechanical		Class M1				
	Electromagnetic		Class E1				

Electronic calculator			
Manufacturer mark		-	Apator
Energy unit selectable		-	GJ, kWh, Gcal
Display type		-	LCD, 7 digits, height: 7 mm
Calculator-to-water end fastening type		-	Rotary – revolution angle 0 to 360°
Transducer electronic system		-	Integrated with the calculator electronical system
Reading cycling		-	One button
Auxiliary modules		-	M-Bus, Wireless M-Bus, USB, RS485
Temperature range limits	Ref. PN-EN 1434-1:2015	°C	$\theta_{min} = 1^{\circ}\text{C}$ to $\theta_{max} = 105^{\circ}\text{C}$
Differential temperature range limits		°C	$\theta_{min} = 3^{\circ}\text{C}$ to $\theta_{max} = 104^{\circ}\text{C}$
MPE		%	$E_c = \pm (0,5 + \theta_{min}/\Delta\theta)$
Temperature sensor		-	PT 500
Supply		-	Lithium battery, 3,6 V
Battery life		Years	Up to 12 (or up to 6) (depending on heat meter version)
Ingress protection class, IEC-529	IP	-	IP65
Ambient temperature		t_a	°C 5 to 55
Relative humidity		W	% <90
Overall dimensions		mm	78 x 90 x 73
Weight		kg	0,2
Serial baud rate		Baud	9,600
Stop bits		-	1
Data bits		-	8
Parity		-	Even
Mean current input in the operating/test operating mode		μA	~25/~100

Available data resolution	LCD	M-Bus	Archives
Energy	0,001 GJ/ 0,1 kWh/ 0,001 Gcal	0,1 kJ/ 0,01 Wh/ 0,1 kcal	0,1 kJ/ 0,01 Wh/ 0,1 kcal
Volume	0,001 m ³	0,001 m ³	0,001 m ³
Auxiliary input values			
Instantaneous temperature	0,01°C	0,01°C	-
Instantaneous flow	0,001 m ³ /h	0,01 m ³ /h	-
Instantaneous power	0,1 kW	0,1 kW	-
Average, maximum and minimum temperature	-	-	0,01°C
Average, maximum and minimum flow	-	-	0,001 m ³ /h
Average, maximum and minimum power	-	-	0,1 kW
Operating time	1h	1h	1h

Temperature sensor pair			
Manufacturer mark	-		Apator
Thermometer resistor	-		TOPE43
Calculator connection method	-		Solder
Temperature measurement range	°C		$\theta_{\min} = 1^{\circ}\text{C}$ to $\theta_{\max} = 105^{\circ}\text{C}$
Differential temperature range	°C		$\Delta\theta_{\min} = 3^{\circ}\text{C}$ to $\Delta\theta_{\max} = 104^{\circ}\text{C}$
Maximum operating pressure (MOP)	MPA		1,6
Maximum measurement current	mA		5
Sensor well material	-		Stainless steel/brass
Outer well material	-		No outer well
Maximum permissible errors MPE	E_t	%	$E_c = \pm (0,5 + 3 * \theta_{\min}/\Delta\theta)$
Connection cable	-		PU insulating sheath, 2x0,25 mm ²

5 Data types

The measured and calculated data are classified into two groups:

- Actual data, which is determined at 8 seconds intervals (except for temperature values in the basic operating mode)
- Averaging period data (with the period configurable by the user), displayed in the service data group
- Archive data, in up to 4 user-configurable cycles
- Configuration (service) data, which can also be configured by the user if not metrology-specific

The data reading methods are specified in the heat meter operating guide. The following presents the meaning and interpretation of measured values.

5.1 Actual data

This is the data from the measurements and from the calculations based on the current measurement input values. The data is updated according to the actual variable integration period (with the exception of the temperatures updated every 20 seconds when the heating medium flows). This data is displayed as the basic data. The exceptions include the data of the RTC (real time clock) and the metrological test; this data, although updated just as frequently, is qualified as service data.

5.1.1 Heat consumption

The heat consumption is calculated as specified in Section 3 and with one of the three available energy units: GJ, kWh or Gcal. The user specifies the displayed unit of measurement in the purchase order for the device. The displayed unit of measurement can be modified later with the Elf2Serwis application.

5.1.2 Water volume

The water volume is calculated by totalling the very small volumes per revolution of the flow transducer rotor. The revolution measurement resolution is $\frac{1}{4}$ of revolution, although this resolution is only used to sense rotation occurrence. The volume is summed only per full revolution with the correct sense of rotation detected. The revolution value in milliliters varies with the instantaneous rotational speed, which in turn is determined by measuring the time interval between each two successive revolutions. The calibration of the flow transducer is done by experimental determination of the revolution value at the characteristic points of the flow transducer error curve, after which the revolution value is logged by the electronic system's memory module. This results in a smooth error plot over the entire flow range for each flow transducer.

The volume is displayed as a seven-digit value with an accuracy of 1 dm³ (litre). To enable quick metrological tests, the heat meter can be switched to the test mode and a fast pulse output enabled according to the technical data table. An additional register of simulated volume is also enabled in the test mode – see the test mode description.

5.1.3 Supply and return temperatures; differential temperature

Temperature is determined by measuring the Pt500 sensor resistance. The memory stores the supply and return temperature values of the heating medium with differential temperature. Each temperature value is determined down to 0,001°C, displayed with an accuracy of 0,01°C, and transmitted to remote reading devices with an accuracy of 0,1°C.

If one of the two temperature sensors fails or runs above or below its range, the heat meter outputs a relevant error code to indicate the failure. The failure is also indicated with a flashing icon next to the applicable values in the menu. If the temperature sensor inputs are shorted to ground or the detected temperature is below the measurement range, the displayed values is 0.00°C. If the temperature sensor inputs are broken in continuity or the detected temperature is above the measurement range, the displayed values is 999.99°C. The same values are displayed respectively for the average temperature determined while a temperature measurement error is active. In both these fault states, the displayed differential temperature is 999.99°C, which is also indicated with the flashing error symbol. The temperature value transmitted to remote reading devices is labelled as a value during an error and is displayed as 999.9°C or 000.0°C, respectively.

5.1.4 Power and flow

Instantaneous flow is determined by measuring the duration of one full revolution of the flow transducer rotor. The flow calculation accuracy error is below 4%. Instantaneous power is determined as the product of instantaneous flow and metrological test values (see Section 6.1).

5.1.5 Pulse inputs

The heat meter can be connected to a maximum of four additional devices, one per pulse input of the heat meter. The user can configure the inputs as volume meters or energy meters.

Each pulse input can be enabled or disabled. If an input is disabled, the meter status for that input is omitted on the display and not transmitted in the M-Bus or wM-Bus data frames.

Only low frequency transmission signals are used; however, it is possible to order custom-developed interfaces of any type which will convert specified data signals to a compatible pulse format. Only the interfaces from Apator Powogaz must be used, since they ensure proper interference protection of the pulse inputs.

5.1.6 Error codes

The error register is not displayed when the heat meter is operating normally (which means there are 0 error codes). An error detected by the heat meters causes the icon “!” to flash on the display and the basic data menu gives the applicable error code(s). The failure states of the measurement system are indicated. The indication of error codes which do not directly affect the energy measurement (*) can be disabled at the heat meter production stage or later, with the Elf2Serwis service application.

- **1* - Minimum flow** – this error event occurs when the average minute flow is higher than the starting flow and below the minimum flow. The error event is terminated by the heat meter when the flow rises above the minimum flow or falls below the starting flow.
- **2 - Flow meter failure** – This error event occurs when the device does not detect any flow for a predetermined time and the differential temperature is higher than the differential temperature threshold. The error event is terminated by the heat meter when the device detects a flow again.
- **4 – Return temperature error** – This error event occurs when the device detects a temperature out of the measurement range or that a temperature sensor has failed. The error event is terminated by the heat meter when the temperature returns to the measurement range. These prerequisite conditions must occur in 2 subsequent integration periods.

- **8 – Supply temperature error** – This error event occurs when the device detects a temperature out of the measurement range or that a temperature sensor has failed. The error event is terminated by the heat meter when the temperature returns to the measurement range. These prerequisite conditions must occur in 2 subsequent integration periods.
- **16 – Differential temperature error** – This error occurs when the following conditions are true:
 - Heating energy meter sub-mode: (return temperature – supply temperature) > dT
 - Cooling energy meter sub-mode: (supply temperature – return temperature) > dT
 - Mixed energy meter: (return temperature – supply temperature) > dT, and supply temperature > cooling energy counting threshold

This error event can occur if the temperature sensors are wired in reverse polarity. The error event is terminated when the following conditions are true:

- Heating energy meter sub-mode: (return temperature – supply temperature) ≤ dT
 - Cooling energy meter sub-mode: (supply temperature – return temperature) ≤ dT
 - Mixed energy meter: (return temperature – supply temperature) ≤ dT, and supply temperature ≤ cooling energy counting threshold
- **32 – Maximum flow** – This error occurs when the device detects that the average minute flow Q_s is higher than Q_p and equal to or lower than $2Q_p$ ($Q_p < Q_s \leq 2 \cdot Q_p$). The error event is terminated by the heat meter when the average minute is equal to or lower to Q_p .
 - **64 – Memory failure** – Critical error – This error occurs when a memory data communication error occurs or the count of CRS errors during data reading is above 100
 - **128 – Low battery voltage** – This error event occurs when the device detects that the battery voltage is below the low battery voltage limit in three consecutive measurements. The error event is terminated by the heat meter when the battery voltage is above the low battery voltage limit in three consecutive measurements.
 - ***256 – Daily abnormal nominal flow overrun** – This error event occurs when the nominal flow is detected at $Q > Q_p$ for 1h per day (24h), whereas one day is measured from the moment the overrun is detected. The error event is automatically deleted 24 h after its detection.
 - ***512 – Annual abnormal nominal flow overrun** – This error occurs when the nominal flow is detected at $Q > Q_p$ for 200 h in 1 year, whereas one year is calculated from the start of billing period n to start of billing period n+1 (which is when the annual data is saved to the archive). The error event is automatically deleted after one year from its detection.
 - ***1024 – Differential temperature too low** – This error event occurs when the volume count is incremented in 3 consecutive integration cycles while the differential temperature is below the configured differential temperature insensitivity threshold. The

error event is terminated even the differential temperature stays above the configured differential temperature insensitivity threshold in 2 consecutive integration cycles or there is no flow detected in the same period.

- **2048 – CRC error – Critical error** – This error occurs when there is a CRC mismatch between the firmware and its saved model
- ***4096 – Flash CRC error** – This error event occurs when a data CRC error is detected while reading the non-volatile flash memory module. The error event is terminated when no data CRC error is detected during the next reading of the heat meter.
- **8192 – Critical battery voltage – Critical error** – This error event occurs when the device detects that the battery voltage is below the critical battery voltage limit in three consecutive measurements
- ***16384 – CPU overtemperature** – This error occurs when the CPU temperature exceeds its maximum operating limit. The error event is terminated when the CPU temperature falls below the maximum operating limit.
- ***32768 – UART limit overrun** – This error occurs when the number of data bytes transmitted and received by the heat meter exceeds the configured byte count limit.
- **65536 – Measurement line error – Critical error** – This error event occurs when the device detects an error in the measurement line
- **131072 – Coil failure – Critical error** – this error event occurs when the device detects a coil failure
- ***262144 – Back flow** – This error event occurs when the counted and totalled back flow volume is equal to or higher than the back flow limit. The error event is terminated when the heat meter starts detecting a forward flow (the flow in the rated direction of operation)

The error codes can be totalled, e.g. “Er 12” means that both temperature sensors have failed. Errors are automatically deleted once their cause(s) have been removed. Every instance of an error is logged in the archive data. The incorrect operation time counter is incremented only if the error persists for a whole hour. There is a special archive for emergency operation (failure) states. It is specified further in this manual.

Whenever an error is detected which has been caused by corruption of the heat consumption register contents, the correct data is uploaded from the non-volatile flash memory. If the data cannot be loaded due to a non-volatile flash memory module failure or when the battery voltage is too low (> 2,95V), a corresponding error message is displayed and the heat meter stops metering.

5.1.7 Actual time and operating time

The RTC data is updated every second, yet its display is shown in the service data. The user can modify the data. The calendar automatically switches to the Polish daylight-saving time and back. The user can disable the automatic daylight-saving time switchover. The RTC is based on a standard 32,768 Hz quartz crystal the accuracy of which depends on the ambient temperature. Since the heat meter is operated at varying temperatures which can reach up to 90°C, the RTC readings can have a significant error of as much as several minutes per month.

The operating time and the error operating time are counted in hours. The error operating time count is incremented only if an error persists for a whole hour.

Operating time

The heat meter uses three registers for counting its operating time:

- Continuous operating time, counted from the moment of turning the power on
- Error operating time, counted when one or more following error codes is present: 2, 3, 8, 16; it can optionally be counted for error code 1024 (if configured at the production stage of the device)
- Abnormal operating time, counted for the active error codes specified during the product configuration. The abnormal operating time counting includes the error operating time in standard configuration, which means that when active, error code 2, 4, 8 and 16 will be included in this operating time classification.

Each time classification is counted in full minutes and displayed in full hours.

5.2 Calibration, configuration and service data

The data is classified into two categories: the data which affects the heat meter measurement accuracy and the data for configuration of the operating functions. The critical parameters can be read from the LCD (see the operating guide); the rest is accessed only via the serial communication interface (see the description of the heat meter communication).

5.2.1 Metrology-specific calibration and configuration data

During the production stage of the device, i.e. before its enclosure is closed and the tamper seal stickers, the metrological parameters of the heat meter are calibrated and configured. A separate area of the non-volatile flash memory is dedicated for this group of data. It is programmed at the production stage with dedicated production station software. When the production of the meter is complete, the user cannot access that data.

5.2.2 User configuration data

The user configuration data can be configured by the user operating the Elf2Serwis service application.

Below is the list of data and explanations (the parentheses include the factory defaults):

- Minute cycle recording period, programmable from 15 to 1,440 minutes (60); this is the recalculation period of average values for cycle 1 and the minimum and maximum values for monthly and annual recording
- Hour cycle recording period
- Daily cycle recording period
- Monthly cycle recording period
- Annual cycle recording period
- Minimum differential temperature for Error 2 determination (1°C) – see the description of error codes
- Time to Error 2 determination (24 h), counted in full hours – see the description of error codes
- Client/user identification number: 8-digit identification number (user configurable); the default value is the heat meter serial number; the ID number is used for secondary M-Bus

- Pulse constant values for additional device pulse inputs, specified in dm³/pulse or pulse/kWh, and the meter measurement accuracy
- Data recording archive configuration (see the description of archive data)
- Serial data transmission parameters (9,600 baud, parity: even)
- M-Bus network number, data communication baud rate (01; 2,400 baud)
- Modbus network number, data communication baud rate, and parity (01, 9,600 baud, parity)
- Monthly and annual data saving time (01:00)
- Monthly and annual data saving date
- Annual data saving month (July)
- Pulse output mode configuration, available options
 - Fast test output, pulse/rev
 - Fast output, pulse/l, with the constant dependent on the flow sensor body type
 - Pulse value equal to 1, 0.1, or 10 times the lowest heat value shown on the LCD
 - Output disabled

5.3 Archive data

The archiving of the heat meter data is fully user-configurable with the Elf2Serwis configuration application.

The memory space for archive data is classified into 5 archive types: minute archive, hourly archive, daily archive, monthly archive and annual archive. The user can configure the writing period for the minute archive and define when the write is committed for all other archive types.

See table below for a detailed specification of saving data in the archives

Name	Periods	Number	Properties
Minute	15 min to 1,440 min	200 (1,5 days to 5 months)	User-configurable data saving period
Hourly	1h	744 (month)	Data saved for the minute defined by the user
Daily	1 day	366 (year)	Data saved for the hour defined by the user
Monthly	1 month	241 (20 years)	Data saved for the month day defined by the user, at the time (hour) defined for the daily archive
Annual	1 year	20 (20 years)	Data saved for the month defined by the user, at the month day defined for the monthly archive and at the time (hour) defined for the daily archive

5.3.1 Archive structure

Name	Size [B]	Explanation
Timestamp	4	Timestamp2000 UTC
Archive type	1	0 – minute 1 – hourly 2 – daily 3 – monthly 4 – annual
Heat	4	[MJ]
Cool	4	[MJ]
Volume	4	[l]
Cooling volume	4	[l]
Error operating time	4	[h]
Abnormal operating time	4	[h]
Pulse input #1 register	5	See table 4 for the pulse input record description. Pulse input record.
Pulse input #2 register	5	
Pulse input #3 register	5	
Pulse input #4 register	5	
Average power per period	2	[0,1 kW]
Average flow per period	2	[l/h]
Average supply temperature per period	2	[0,01 deg. C]
Average return temperature per period	2	[0,01 deg. C]
Maximum power per period	2	Only for monthly and annual archive records
Minimum power per period	2	
Maximum flow per period	2	
Minimum flow per period	2	
Maximum supply temperature per period	2	
Minimum supply temperature per period	2	
Maximum return temperature per period	2	
Minimum return temperature per period	2	
Min/max timestamps	32	
CRC	1	

The following shows the structure of a pulse input record

Name	Size [B]	Explanation
Unit	1	1b – input ON flag (0 – off, 1 – on) 1b – unit of measure (m ³ /kWh) 6b – unit of measure exponent and character (10 ⁿ)
Value	4	Displayed indication, an integer

6 Heat meter operating guide

LCD display

The heat meter is operated by a single push-button and an LCD. The push-button has two functions: each short press cycles between the successive display screens within one menu group; a long press enters or exits a menu group. If the readings need to be displayed or configured remotely, use the software application, interfaces and other tools from Apator Powogaz and flow the manuals supplied with them.

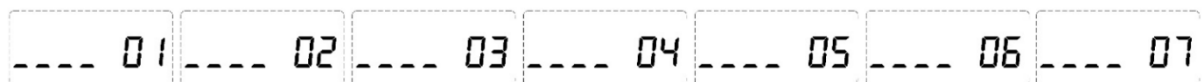
The display of data on Elf 2 heat meters is divided into five menu groups which correspond to the functionality of the data:

- Actual data – Group 1
- Monthly recording data – Group 2
- Annual recording data – Group 3
- Service data – Group 4
- Module Configuration – Group 5
- Global registers – Group 6 (optional)
- Basic configuration – Group 7

The data from recording in cycle 1 and 2 and from failure recording can only be read via the communication interface. To change the display group, press and hold the push-button for approx. 2 seconds until the group number is displayed.



Press the push-button repeatedly until the desired group number is displayed with messages.



Press and hold the push-button again until the first value of the selected group is displayed.

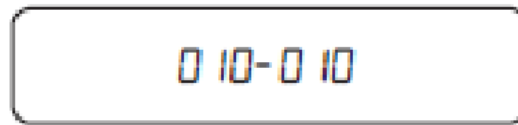
The successive values in group 1, 4, 5, 6 and 7 (actual, service, module configuration, global register and basic configuration) are displayed by pressing the push-button repeatedly.

When switched to display the data in group 2 and 3 (recording data), the displayed values cycle every 2 seconds. The first reading is the message with the number of maximum registrations available in the group. This message is displayed only once for each access to the data group (it does not repeat in cycling).



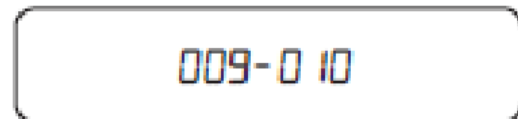
The displayed number depends on the user configuration. If "0" is configured for a group, that group is disabled from recording data.

This reading is followed by a cycled display of successive values in the record; at the beginning of each record a message is shown stating which record will be displayed at the given moment and how many records have been registered, e.g.



10th registration (the latest) out of 10 is displayed.

A short press of the push-button displays the next written record as shown below:



9th registration (the second latest) out of 10.

If the saved record is corrupted, (the CRC of the data in the record is invalid), the record number will be displayed alternately with the error message. Example (see below): the message will be displayed alternately to warn that the data is invalid.



If the next registration increments the number of registrations above the maximum limit (set by the user), the 4 oldest registrations will be deleted and the new one written. Hence, the displayed number of registrations will be decreased by 3 and increase by 1 after the next data write, etc. If the next registration occurs when the archive is viewed, the recording data display is stopped and restarted by showing the number of maximum registrations available for the specific archive group. If, during the display of data in group 2 or 3, a data write which configures the registration cycles is made, the display stops and the LCD will revert to group 1 of the basic data.

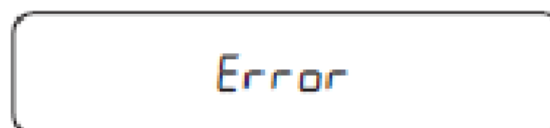
If the symbol flashes while displaying the actual data, an error has occurred and the error code is not zero

If is displayed, there is flow in the direction of heat and volume counting.

The symbol means that the actual direction of flow is wrong. At a very slow flow rate, the flow direction symbols appear and disappear briefly.

The symbol means that the pin jumper is installed and enables calibration and configuration data writing.

If the heat meter cannot correctly read the configuration or consumption data following a battery replacement, its operation is halted and the following message is displayed.:



The user should contact the manufacturer's service for assistance.

The LCD returns to the actual data display and shows the heat consumption in any operating mode if the push-button is not operated for approximately 3 minutes.

6.1 Metrological test

The value "test" is the heat quantity [kJ] per 1 m³ of water (the heating medium), per specific differential temperature. The value is used to verify that the calculator works correctly. In order to test the meter, call the indication "test". For the given differential temperature, calculate the heat energy per 1 m³ of water and compare the calculation result to the indication.

Use the heat measurement principle:

$$Q = V * k * (t_1 - t_2)$$

With: Q, the heat quantity; V, the heating medium volume; k, the temperature coefficient of water; t₁ the supply temperature; and t₂, the return temperature.

The reference value of heat quantity per 1 m³ of heating medium is:

$$Q = 1 * k * (t_1 - t_2)$$

Example:

Input data: t₁ = 70°C, t₂ = 50°C

The temperature coefficient for the heat meter supply side, calculated from EN-1434-1:2015 Appendix A, is k = 4,09105 [MJ/m³ K].

Reference heat:

$$Q_w = 1 * 4.09105 * (70 - 50) = 81.821 [MJ] = 81821 [kJ]$$

Assume that the tested meter shows QT = 82000 [kJ], then the calculator error is:

$$E_o = [(82000 - 81821)] * 100\% = 0,22\%$$

Compare the determined error value E_o to the maximum permissible error values E_l from the technical data table. If at the given differential temperature E_o < E_l, the heat meter correctly calculates the heat energy quantity. The test procedure presented here can be carried out on an online heat energy metering system without stopping the heat meter or breaking the meter tamper seals. The meter calculates the value "test" after each temperature measurement. The best method for determining the calculator error is to calculate the average of several (e.g. eight) successive readings from the calculator test; a single measurement suffers from a statistical fluctuation of approx. ±0,5% (at the minimum differential temperature).

7 Remote reading of data

The elf 2 heat meters feature a connector for communication interfaces which enable remote reading and writing of data. The communication interface connector also enables connection of pulse signals with additional pulse inputs, and to output the pulses generated by the heat meter to one of the output interfaces. Only the interfaces from Apator Powogaz must be used, since they are fully compatible with the heat meter. The interfaces are installed on the heat meter without tampering with the heat meter verification markings, as shown in the following diagram.

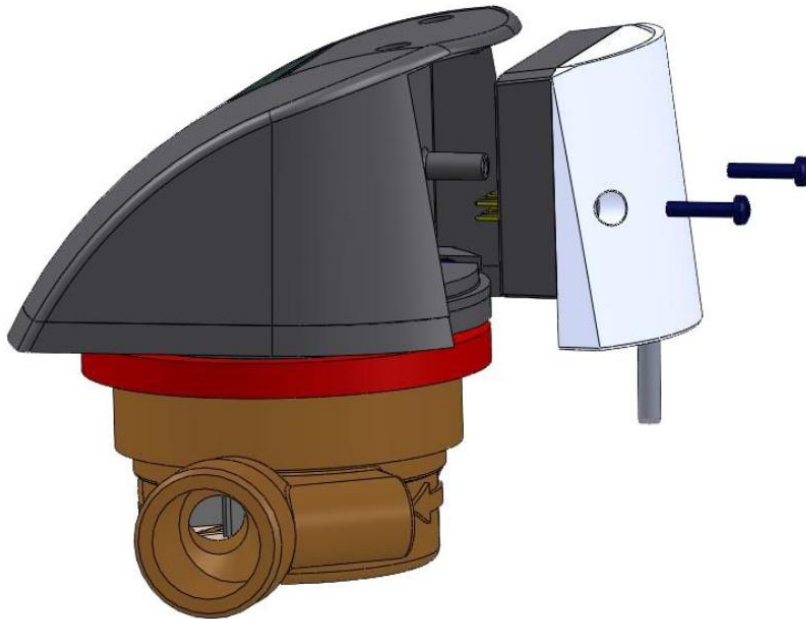


Figure 1: Connecting the interfaces

The correct installation of the communication module to the ELF 2 heat meter, in order to maintain the IP65 protection degree, consists in plugging the module into the device casing, putting the cables through appropriate slots (as required) and installing two mounting screws. The calculator with uncovered interface port, i.e. without the plug or module, does not fulfil the requirements of IP65 protection degree. Wired M-Bus interfaces are available for connection of up to four additional pulse inputs and with one pulse output, a Wireless M-Bus interface, and a USB interface.

Attention:

When a radio communication module (APT-ELF2-WMBUS-1) is or was installed in the Elf 2, changing to M-Bus cable modules (APT-ELF2-MBUS-1 and APT-ELF2-MBUS-2) will result in a lack of communication in such a combination.

This is due to the fact that the UART limit (a certain value of transferred bytes) is exceeded during the operation of the radio module (for this module the limit is irrelevant), and for M-Bus cable communication this constitutes a transmission block.

The UART limit is verified once a day at the end of the day, so when the modules are replaced, it does not report an error and the device works properly. Only the next day, after verification of the level of bytes transferred, the transmission is completely closed for all M-Bus and wM-Bus modules.

In this case, returning to the wM-Bus module does not solve the problem, because the limit has already been closed, and with the possibility of transmission.

In case of the above described situation, it is necessary to contact Apator Powogaz S.A. in order to verify possible solutions.

Interface	M-Bus	Pulse OUT	Pulse IN
M-Bus + 4 pulse inputs	+	+	-
M-Bus + 2 pulse inputs + 1 pulse output	+	+	+
RS 485	-	-	-
RF (wireless M-Bus) + 2 pulse inputs	-	-	+
USB	-	-	-

7.1 M-Bus with 4x pulse inputs

7.1.1 Basic information

The following figure shows the structure of the APT-ELF2-MBUS-1 module:

Key:

- 1 – module installation screw holes
- 2 – Pulse input cable #2
- 3 – M-Bus cable
- 4 – Pulse input cable #1
- 5 – Elf 2 hat meter connection
- 6 – cable glands

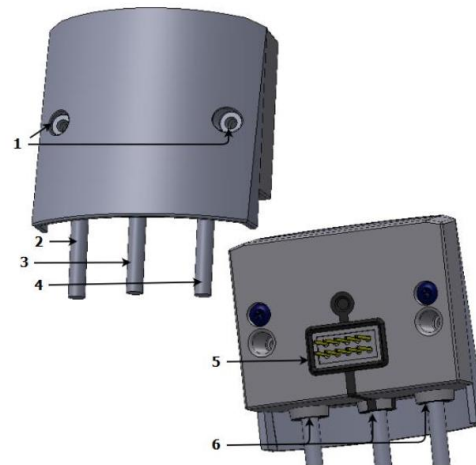


Figure 2: Structure of the APT-ELF2-MBUS-1 module

7.1.2 Key features

- An interface between the Elf 2 heat meter and reading system devices
- Includes an M-Bus data communication interface and wired interface; up to 4 additional pulse inputs can be connected
- Data reading over M-Bus is based on the transmission protocol compliant with PN-EN 13757-3:2005 and PN-EN 1434-3:2009
- Pulse input interface operating classification: IB or IC (ref. PN-EN 1434-2)

7.1.3 Device characteristics

Device name		APT-ELF2-MBUS-1
Enclosure ingress protection rating		IP65
Operating temperature		5 to 55 deg. C
Cable lead-outs		
Pulse input cable #1		
Cable type		YTTY
Wire no. and size		3 x 0,15 mm ²
Wire colour and function	White	GND
	Brown	In 1

	Green	In 2
Pulse input cable #2		
Cable type		YTTY
Wire no. and size		3 x 0,14 mm ²
Wire colour and function	White	GND
	Brown	In 3
	Green	In 4
M-Bus Cable		
Cable type		YTTY
Wire no. and size		2 x 0,14 mm ²
Wire colour and function	White	M-Bus 1
	Brown	M-Bus 2
Pulse inputs		
Maximum voltage		6 V
Maximum current		0,05 mA
Cable insulation voltage rating		>500 V
Supplied cable length		30 cm
Maximum cable length		10 m
Inputs pulse max frequency		20 Hz
Inputs pulse duration		50 ms
Input pulse interval		50 ms
Reed relay make input impedance		<10 kΩ
Reed relay break input impedance		>3 MΩ
M-Bus		
Maximum voltage		42 V
Maximum current		2 mA
Cable insulation voltage rating		>500 V
Supplied cable length		30 cm
Maximum cable length in a network		<1000 m
Module-to-heat meter data transmission rate		9600 Baud
M-Bus data communication rate (standard)		2400 Baud
Maximum recommended reading frequency (at 2400 baud)		900 s
Internal interface register refresh interval		60 s
General		
Weight		30 g
Dimensions (h x w x d)		48,5 x 53 x 26 mm

7.2 M-Bus module with 2x pulse inputs and 1x pulse output

7.2.1 Basic information

The following figure shows the structure of the APT-ELF2-MBUS-2 module:

Key:

- 1 – Module installation screw holes
- 2 – Pulse output cable
- 3 – M-Bus cable
- 4 – Pulse input cable
- 5 – Elf 2 heat meter connection
- 6 – cable glands

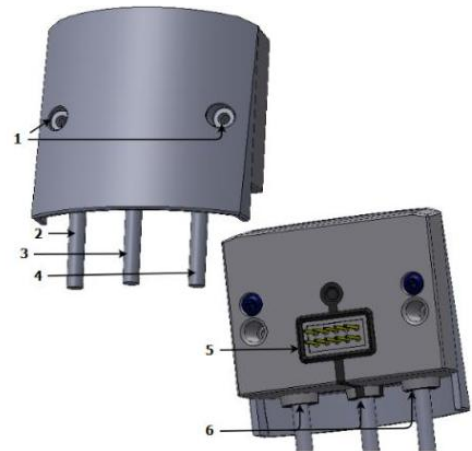


Figure 3: Structure of the APT-ELF2-MBUS-2

7.2.2 Key features

- An interface between the Elf 2 heat meter and reading system devices
- Includes an M-Bus data communication interface and wired interfaces; up to 2 additional pulse inputs can be connected; features 1 pulse output
- Data reading over M-Bus is based on the transmission protocol compliant with PN-EN 13757-3:2005 and PN-EN 1434-3:2009
- Pulse input interface operating classification: IB or IC (ref. PN-EN 1434-2)
- The pulse outputs can operate in one of six states:
 - Basic state: output inactive
 - Pulse per revolution of the flow sensor rotor
 - Test mode: the pulse value is directly proportional to the volume measured by the flow transducer and the pulse constant depends on the flow sensor
 - Heat-proportional output:
 - One pulse is a 0,1 increment of the lowest possible heat value displayed on the LCD
 - One pulse is the increment by the lowest possible heat value displayed on the LCD
 - One pulse is an increment equal to 10 times the lowest possible heat value displayed on the LCD

7.2.3 Device characteristics

Device name	APT-ELF2-MBUS-2	
Enclosure ingress protection rating	IP 65	
Operating temperature	5 to 55 deg. Celsius	
Cable lead-outs		
Pulse input cable		
Cable type	YTTY	
Wire no. and size	3 x 0,14 mm ²	
Wire colour and function	White	GND
	Brown	In 1
	Green	In 2
Pulse output cable		
Cable type	YTTY	
Wire no. and size	2 x 0,14 mm ²	
Wire colour and function	White	GND
	Brown	Out
M-Bus cable		
Cable type	YTTY	
Wire no. and size	2 x 0,14 mm ²	
Wire colour and function	White	M-Bus 1
	Brown	M-Bus 2
Pulse inputs		
Maximum voltage	6 V	
Maximum current	0,05 mA	
Wire insulation voltage rating	>500 V	
Supplied cable length	30 cm	
Maximum cable length	10 m	
Input pulse max frequency	20 Hz	
Input pulse duration	50 ms	
Input pulse interval	50 ms	
Reed relay make input impedance	<10 k Ω	
Reed relay break input impedance	>3 M Ω	
Pulse output		
Maximum voltage	24 V	
Maximum current	10 mA	
Voltage drop across optical coupler at I _{max}	1 V	
Cable insulation voltage rating	>500 V	
Supplied cable length	30 cm	
Maximum cable length	10 m	
Max frequency	1000 Hz	
Minimum pulse duration	250 ms	
Minimum pulse interval	7,8 ms	
M-Bus		
Maximum voltage	42 V	
Maximum current	2 mA	
Cable insulation voltage rating	>500 V	
Supplied cable length	30 cm	
Maximum cable length in a network	<1000 m	
Module-to-heat meter data transmission rate	9600 Baud	
M-Bus data communication rate (standard)	2400 Baud	
Maximum recommended reading frequency (at 2400 baud)	900 s	
Interval interface register refresh interval	60 s	

General	
Weight	30 g
Dimensions (h x w x d)	48,5 x 53 x 26 mm

7.3 RS485 module

7.3.1 Basic information

The following figure shows the structure of the APT-ELF2-RS485-1 module:

Key:

- 1 – Module installation screw holes
- 2 – RS485 module cable
- 3 – Power cable
- 4 – Elf 2 heat meter connection
- 5 – cable glands

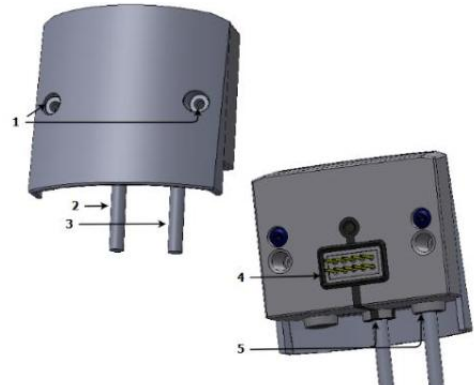


Figure 4: Structure of the APT-ELF2-RS485-1 module

7.3.2 Key features

- An interface between the Elf 2 heat meter and reading system devices
- Communication with master devices over MODBUS
- RS-485 Standard for direct single serial connection with up to 32 devices
- External power supply
- Replaceable without breaking the tamper seal of the heat meter enclosure

7.3.3 Device characteristics

Device name	APT-ELF2-RS485-1	
Enclosure ingress protection rating	IP 65	
Operating temperature	5 to 55 deg. Celsius	
Supply voltage	24 VDC	
Input current	3 mA	
Cable lead-outs		
Power cable		
Cable type	YTTY	
Wire no. and size	2 x 0,14 mm ²	
Wire colour and function	White	GND
	Brown	+24
RS485 data cable		
Cable type	YTTY	
Wire no. and size	2 x 0,14 mm ²	
Wire colour and function	White	A
	Brown	B
Modbus		
Address	1-247	
Baud rate	<ul style="list-style-type: none"> • 300 Baud • 600 Baud • 1200 Baud • 2400 Baud 	

	<ul style="list-style-type: none"> • 4800 Baud • 9600 Baud - standard • 14400 Baud • 19200 Baud
Operating mode	<ul style="list-style-type: none"> • RTU, data frame format: 8E1 • RTU, data frame format: 8n1
Max time to response initiation	125 ms
General	
Weight	30 g
Dimensions (h x w x d)	48,5 x 53 x 26 mm

7.4 Wireless M-Bus module

7.4.1 Basic information

The following figure shows the structure of the APT-ELF2-WMBUS-1 module:

Key:

- 1 – Module installation screw holes
- 2 – Pulse input cable**
- 3 – Elf 2 heat meter connection
- 4 – cable glands

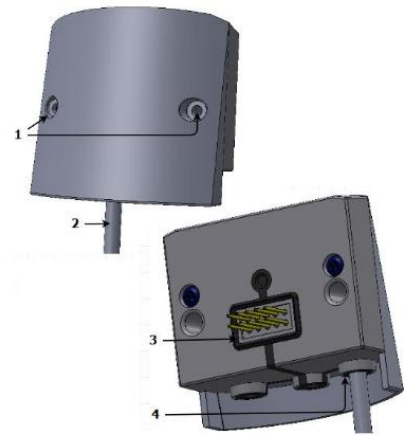


Figure 5: Structure of the APT-ELF2-WMBUS-1 module

7.4.2 Key features

- An interface between the Elf 2 heat meter and reading system devices
- System operation on the PN-EN 13757 Wireless M-Bus data communication protocol
- RF (wireless) data transmission at 868.95 MHz
- Communication mode T1
- Battery-powered
- Min. operating life: 5 years

Device name	APT-ELF2-WMBUS-1	
Enclosure ingress protection rating	IP 65	
Operation life	Min. 5 years	
Operation temperature	5 to 55 deg. Celsius	
Supply		
Power source	CR2z lithium battery	
Supply voltage	3 V	
Capacity	1000 mAh	
Reed relay break input impedance	>3 M Ω	
Cable lead-outs		
Pulse input cable		
Cable type	YTTY	
Wire no. and size	3 x 0,14 mm ²	
Wire colour and function	White	GND
	Brown	In 1
	Green	In 2
Pulse inputs		
Maximum voltage	6 V	
Maximum current	0,05 mA	
Cable insulation voltage rating	>500 V	
Supplied cable length	30 cm	
Maximum cable length	10 m	
Input pulse max frequency	20 Hz	
Input pulse duration	50 ms	
Input pulse interval	50 ms	
Reed relay make input impedance	<10 k Ω	
Reed relay break input impedance	>3 M Ω	
RF communication		
Frequency band	868.95 MHz	
Communication mode	T1	
Data transmission period	15s	
Register refresh rate	900s	
Transmitter power	10 dBm	
Transmitted registers	<ul style="list-style-type: none"> • Serial number • Error flags • Date • Heat energy • Primary volume • Supply temperature • Return temperature • Last month's heat energy 	
Range	300 m outdoor	
General		
Weight	40 g	
Dimensions (h x w x d)	48,5 x 53 x 26 mm	

7.5 USB module

7.5.1 Basic information

The following figure shows the structure of the APT-ELF2-USB-1 module:

Key:

- 1 – module installation screw holes
- 2 – USB module cable**
- 3 – Elf 2 heat meter connection
- 4 – cable glands



Figure 6: Structure of the APT-ELF2-USB-1 module

7.5.2 Key features

- Includes an USB interface for heat meter configuration and data reading with a PC and Elf2Serwis service application
- No additional converters required for data transmission

Device name	APT-ELF2-USB-1
Enclosure ingress protection rating	IP 65
Operating temperature	5 to 55 deg. Celsius
Data transmission baud rate	9,600 b/s
Supply	
Power source	Directly from the USB interface port
Voltage	5 V DC
Cable	
Communication connector type	USB-A 2.0
Cable length	1,5 m
General	
Weight	30 g
Dimensions (h x w x d)	48,5 x 53 x 26 mm

7.6 Module installation

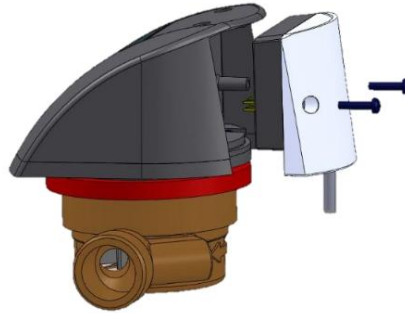


Figure 7: Module installation

Connect and bolt the module to the Elf 2 heat meter.

Pass the module connection wiring through the respective cable glands to maintain the declared enclosure IP rating. The correct installation of the communication module to the Elf 2 heat meter, in order to maintain the IP65 protection degree, consists in plugging the module into the device casing, putting the cables through the appropriate slots (as required) and installing two mounting screws. The calculator with uncovered interface port, i.e. without the plug or the module, does not fulfil the requirements of IP65 protection degree.

A competent service technician should install the interfaces.

The wiring of additional pulse inputs must be as short as possible; the wire length of passive pulses (dry contacts with an open collector) must not exceed 10 m – if extension is necessary, make it with an additional terminal strip installed in a junction box.

If data transmission network interfaces are used, especially when the wires are laid outside the building, provide increased protection against electrical interference.

Once installed in the calculator, the data communication interfaces require no further configuration settings. For M-Bus modules, install the interface in the heat meter before supplying power to the M-Bus network; data communication with connected heat meters is then enabled.

Attention:

When radio communication module (APT-ELF2-WMBUS-1) is or was installed in the Elf 2, changing to M-Bus cable modules (APT-ELF2-MBUS-1 and APT-ELF2-MBUS-2) will result in a lack of communication in such a combination.

This is due to the fact that the UART limit (a certain value of transferred bytes) is exceeded during the operation of the radio module (for this module the limit is irrelevant), and for M-Bus cable communication this constitutes a transmission block.

The UART limit is verified once a day at the end of the day, so when the modules are replaced, it does not report an error and the device works properly. Only the next day, after verification of the level of bytes transferred, the transmission is completely closed for all M-Bus and wM-Bus modules.

In this case, returning to the wM-Bus module does not solve the problem, because the limit has already been closed, and with it the possibility of transmission.

In case of the above described situation, it is necessary to contact Apator Powogaz S.A. in order to verify possible solutions.

8 Transport and installation

Transport the heat meters only in closed load body vehicles and protected against movement and damage. Store the heat meters in unit packaging, in dry and clean indoor areas above +5°C and below 90% relative humidity. The heat meter can be identified (traced) by the markings and technical data featured on the enclosure label sticker. The heat meter receiver should inspect the condition of the shipment for the following before unpacking the heat meter:

- Shipping container condition
- Delivery completeness
- Compliance of product types and versions with the purchase order
- Condition of the enclosure and its tamper seals (see Section 8.1)

The heat meters are delivered only as complete units with the temperature sensor pair installed, where one sensor is installed in the flow transducer body and the other is to be installed in a dedicated installation fitting (i.e. a pipe tee or a valve) connected to the heating system piping. A quick start manual should be enclosed with the product.

Check the heat meter for damage before installation. If any damage, missing parts or discrepancies against the specifications is found, send a claim for the delivered product. The product must be installed in the heating system piping by a professional service technician and according to the design requirements of the building and those specified in PN-EN 1434-6:2015. The flow direction shown by the arrow on the flow transducer enclosure must match the actual flow in the metering circuit. The heat meter must be installed in the correct pipe (supply or return) as indicated on the label sticker in the enclosure. If the heat meter is installed on the heating supply line, install the supply temperature sensor in the flow transducer body and the return sensor on the return sensor on the heating return line. If the heat meter is installed in the heating return line, install the supply temperature sensor on the supply line and the return temperature sensor in the flow transducer body.

Before installing the temperature sensor in the seat of a tee or a valve, verify that the fitting intended for installation of the temperature sensor meets the dimensional requirements for the temperature sensor seat depth and that the seat diameter matches the temperature sensor diameter. See the dimensions in the figure below:

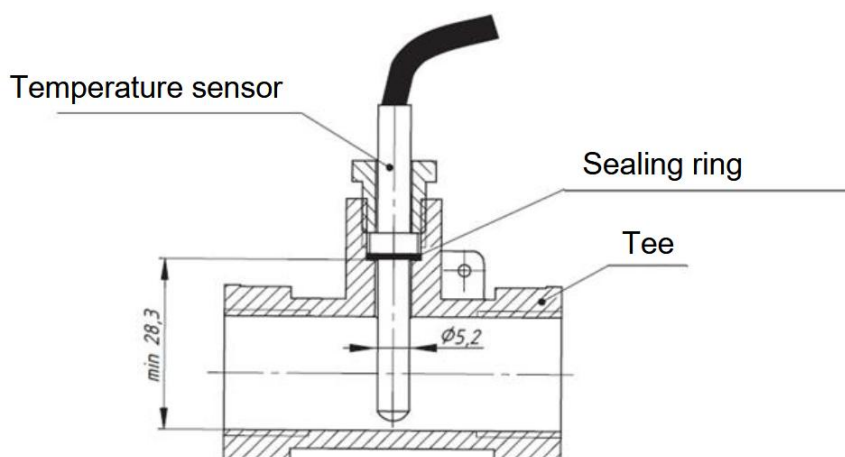


Figure 8: Temperature sensor installation in a tee

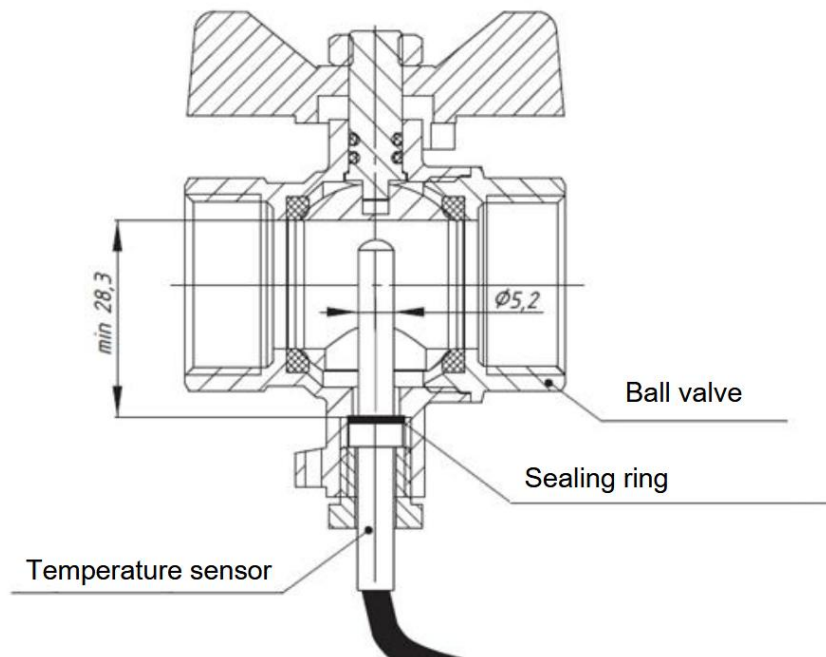


Figure 9: Temperature sensor installation in a ball valve

Use of valves and pipe fittings that do not meet these requirements may damage the temperature sensor.

Seal the heat meter connections on both heating system lines with one length of tamper seal wire passed through the holes of the threaded connections and through the tamper seal wire lug on the flow transducer body.

The following figure is an example of installation and tamper seal of the heat meter on the return line.

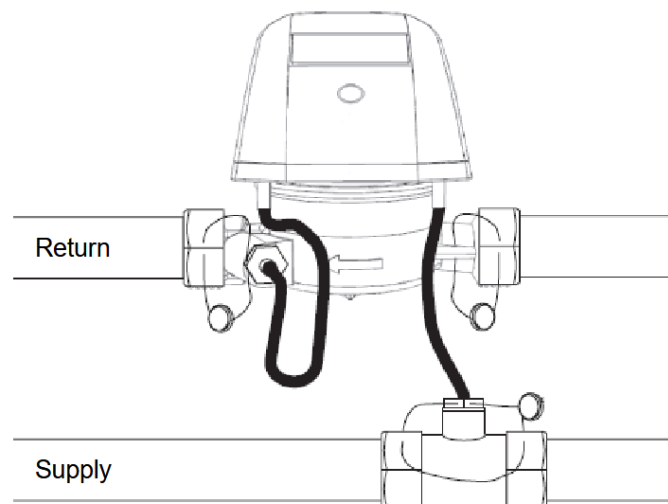


Figure 10: Heat meter installation and tamper sealing

8.1 Tamper sealing

The Elf 2 heat meters are tamper-evident seal with self-adhesive seals to prevent unauthorised access to the electronic system – see the figure below.



Figure 11: Tamper sealing of the heat meter

The enclosure base is sealed together with the enclosure body with a tamper seal wire threaded through the holes in the band clip. Once closed, the complete enclosure assembly is tamper evident sealed with stickers made of a special film which brittles when peeled. The tamper seals are located in the fastening screw and on the mating line between the enclosure base and enclosure body.

The interface enclosure features an additional tamper seal sticker, see Section 7.6. The tamper seal sticker can be legally removed by an authorized technical service during installation of the interfaces. Once the interfaces have been commissioned, it is recommended to apply a service tamper seal or an Apator Powogaz branded tamper seal sticker.

Seal the heat meter connections on both heating system lines with one length of tamper seal wire passed through the holes of the threaded connections and through the tamper seal wire lug on the flow transducer body.

Electrical interference

The Elf 2 heat meters do not require special protection from electrical interference; however, electromagnetic interference must be avoided. The sensor wiring must be away from all power cables and other high-power electrical equipment or systems. Do not splice the original wiring of the sensors to extend or reduce its length. If connected, the additional pulse input wiring must be as short as practically possible. For passive pulses (dry contacts with an open collector), the maximum wire length must be 10 m. If extension is necessary, make it with an additional terminal strip installed in a junction box.

If data transmission network interfaces are used, especially when the wires are laid outside of the building, provide increased protection against electrical interference. Detailed information is available from competent Apator Powogaz personnel.

9 Warranty

The reliable operation of the heat meter is guaranteed for warranty period specified in the enclosed warranty certificate, provided that operation of the heat meter meets the requirements provided in this document. The warranty does not cover any damage caused by improper shipping or operation. The user's warranty rights will be void and null of the product is repaired without authorization by the manufacturer.

The warranty expires if the device is installed and operated inconsistently with the operating instructions and intended use (requirements for installation of heat meters are contained in PN-EN-1434-6 standards).

Elf 2 heat meters run self-diagnostic features the outcome of which is displayed with error codes, if any. The error codes are displayed as long as the failure is present. When the cause or the error code ceases, the error code automatically removed. Example: water hammering may occur during starting or finishing flow, which can cause error code 32 (overflow); of the error code indication is reset, there is no need to call the service. By analogy, when the flow to the meter is isolated, error code 2 does not necessarily indicate a significant failure. However, service assistance will be necessary if the error code is not reset when the flow is started, since it means the flow transducer has failed. The following table presents the trouble shooting procedures for the heat meter.

Problem	Cause	Remedy
LCD blank, push-button non-responsive	The battery is dead or has failed	Return the product to the manufacturer's service agent
Error code 4 or 8 persists	Failure of the respective temperature sensor	Return the product to the manufacturer's service agent
The heat meter is suspected of under or overmetering	The supply filter of the flow transducer is clogged or undermetering is caused by incorrect installation of the temperature sensors	The heat provider service personnel must make sure that the supply pipe is unobstructed and that the sensors have been properly installed; if both are not correct, return the product to the manufacturer's service agent
Error code 2	The cut-off valve is closed	Open the valve
	The supply filter of the flow transducer is blocked	The heat provider service personnel must make sure that the supply pipe is not obstructed; if it is obstructed and the error code persists, return the product to the manufacturer's service agent
Error code 12	The temperature sensor connections or installation locations have been swapped	The heat provider service personnel must swap the sensor installation locations/connections

9.1 Recommendations for end of life

The heat meter is designed for 5 years of uninterrupted operation. Once this period is reached, the heat meter requires essential maintenance. The minimum maintenance includes verification of the metrological conformity and, if necessary, change of the battery (this applies to the product version with 6 years of battery-powered operating life).

The battery must be replaced by a qualified technician; it requires breaking the enclosure tamper seals and soldering of connections. Flow meter handling and disposal requirements are the same as for household water meters.