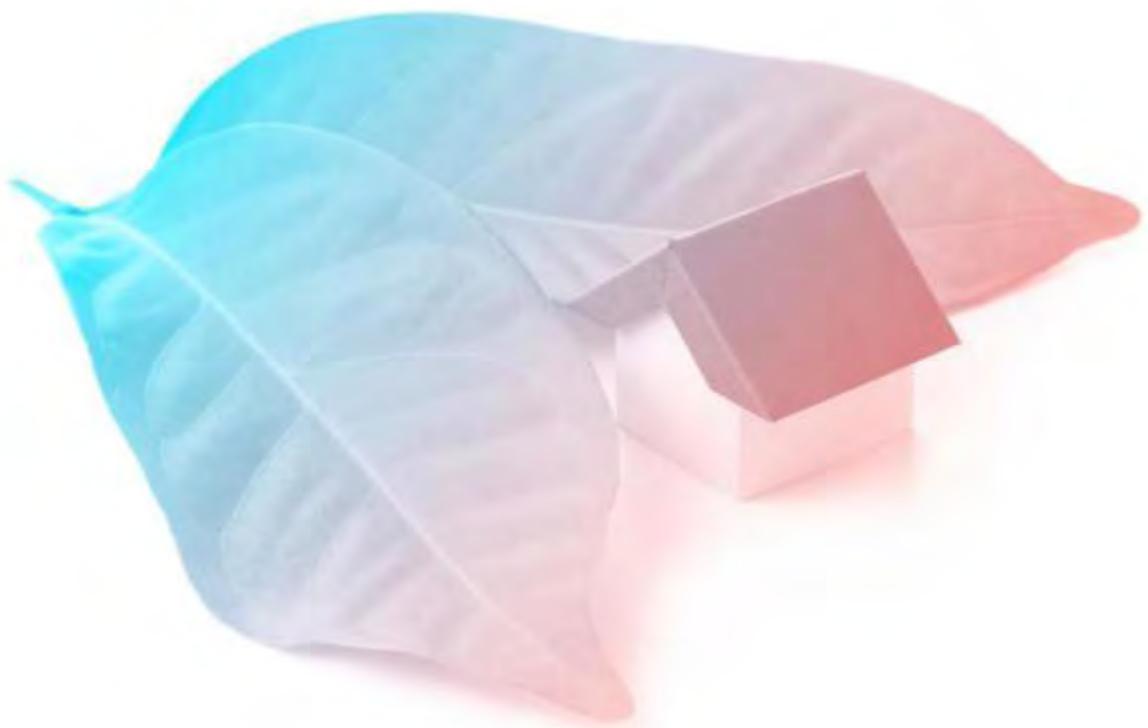




D6.2 Results from functional and quality acceptance tests



Gábor Fenyvesi, Eszter Hadju, Veronika Szabo (ÉMI Nonprofit Kft.)



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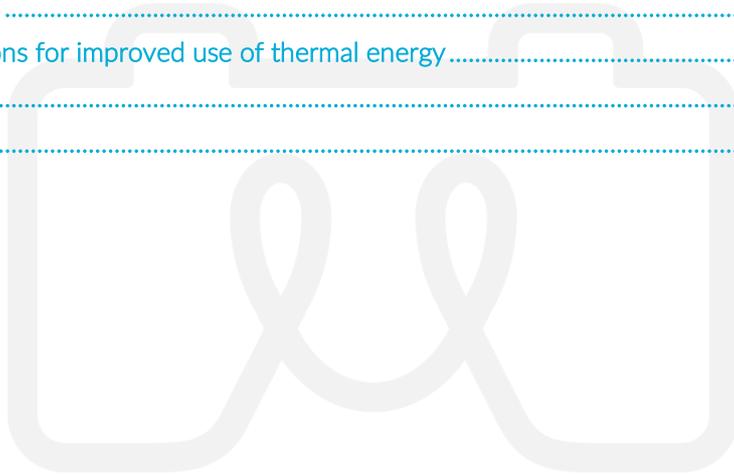
D6.2 Results from functional and quality acceptance tests

Summary			
<p>We took measurements on a MiniStor prototype without photovoltaic thermal panels for winter and summer operating modes. These measurements included assessing several thermal parameters, evaluating the heat storage capacity, and analysing the pressure conditions within the system for each mode. Efficiency values were calculated from the measured data.</p> <p>To carry out our measurements, we have set up at EMI's facilities a specially designed mechanical device to simulate different thermal input and output conditions through usage of hot water at different temperature levels instead of that produced by the panels, which depends on weather conditions. The deliverable describes the procedures and equipment used, and the results obtained from these measurements. Measurements were not continuous in some cases due to faults which are typical during the prototype stage. Results from the measurements will be used in WP3 and for the product audit program (PAP).</p>			
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1. Introduction

Our assigned task was to measure the energy use and efficiency characteristics of the MiniStor energy conversion and storage system.

The measurements were carried out for the winter and summer modes of the MiniStor system, due to the extreme thermal demands of those two seasons. Initially, measurements were planned to be performed for two weeks in both operating modes. In practice, these measurement times were modified due to the late finalisation of the prototype setup and other technical reasons, details of which are given in the following sections.

The original plan before reception of the prototype was for measurements to be carried out by placing the MiniStor unit in a climate chamber and using this to vary and model the temperature conditions around it. The climate chamber is designed according to EN 14240:2004. The building to be supplied by MiniStor would be a purpose-built "model building". The measurement procedure was designed to create a heat demand in the "model building" corresponding to the chosen season (e.g. summer), which the MiniStor would have to serve, measuring energy used and dissipated by the MiniStor. Our measurements were designed according to the standard MSZ EN 12599:2013, directly according to the specifications and indirectly using the measurement concept, where applicable.

In the current measurement setup, this planned idea has been changed as follows:

According to the information received from partners, the MiniStor seasonal operation mode can be set manually. The user decides to use the MiniStor's energy for cooling or heating. Other information received was that the MiniStor is an insulated and sealed device, with its own sensors and fans to evacuate air in case of detected ammonia leaks. Due to this information, the MiniStor prototype was placed in an open space next to building "E" on the ÉMI facilities. Location is shown in the google map photo in Image 1 and in the plan detail in Image 2. The implementation of the setup is shown in Images 3-5.

In order to discount any heat loss between piping and the prototype unit, temperature sensors were placed at the MiniStor unit exterior inlet and outlets, which are used to measure the energy consumption characteristics (see Image 15 in the next section for details). In this way, the thermal energy delivered and absorbed by the MiniStor is measured without any heat loss from the connected piping, so there is minimal impact of ambient temperature on the measured data. Minimal deviation can be caused by the internal heat loss of the MiniStor.

We have also replaced the "model building" in the initial plan. As mentioned above, the "model building" will create a heat demand that the MiniStor will have to supply. This heat demand is generated by a heat exchanger instead of the "model building". In more detail, the heat demand is generated on the primary side of the heat exchanger and the MiniStor is connected to the secondary side to serve the generated heat demand. For almost all MiniStor connections, separate heat exchangers have been built to produce the heat demand corresponding to the season to be modelled. "Almost all" because, due to the manual switching between winter and summer mode, a heat exchanger is installed at the cooling and heating connections of the MiniStor. The heat demand to be produced can be manually selected on this heat exchanger according to the season to be modelled.

The structure and design of our measurements and measuring system is based on the MiniStor unit as a prototype device. Therefore, there is no specific performance measurement procedure. Such a complex device as the MiniStor was measured for performance for the first time.

Measurements were started in March 2024 and finished in August 2024. The measurements were not continuous during this period due to the described setup and other technical reasons, which are explained in the following chapters.

The level of detail provided in this report is meant to provide reproducibility and traceability of the measurements done. They are among the first performed for a device of this type (thermal energy storage unit) and are also supervised for use in the Product Audit Program (PAP, WP8) and the representation of the prototype in whole building simulation (WP3), both which can help in future commercialization efforts of the system.



Image 3: MiniStor prototype in ÉMI View 1



Image 4: MiniStor prototype in ÉMI View 2



Image 5: MiniStor prototype in ÉMI View 3

2. Construction of the model building's mechanical system

This section describes the steps that were taking into the construction of the measurement setup:

2.1. Step 2-1: Design, Planning

It was mentioned in the previous section that the model building is represented via a heat exchanger. The heat demand of the model building is the heat demand generated by each heat exchanger which had to be supplied by the MiniStor unit. Image 6 shows a resulting schematic design of the MiniStor to supply the heat demand of the building.

For our model building, we needed a system that would produce the Cooling, Heating and DHW demands that the MiniStor had to supply. In addition to these thermal requirements, solar energy had to be modelled in order to be used as input to the thermal storage system.

The model building followed the thermal needs of a single-family home that is considered typical in the region (Hungary). The load demands with average thermal insulation are estimated at 6-9 kW in winter and 6-9 kW in summer.

The winter heat demand and DHW heat demand of the model building was generated by an outdoor liquid chiller with a cooling capacity of 8 kW.

The summer heat load and the modelled solar energy of the model building were produced by an electric heating cartridge of 7.5 kW.

The primary side of the heat exchangers simulating our model building was supplied by the MiniStor prototype, the secondary side by the aforementioned electric heating cartridge and the outdoor liquid chiller.

The heat exchangers chosen according to these parameters were SWEP EST x20 plate heat exchangers (see Image 7). The nominal heat output of the chosen heat exchangers is 20 kW.

In order to measure the energy characteristics, it was necessary to place measuring devices that integrate with the measurement system, so care had to be taken to ensure that they were installed in accordance with the manufacturer's specifications. Details of the installations that complied with these specifications are given in Section 2.4. Some of these measuring devices were placed at the external side of inlets and outlets of the system, and do not interfere with its functioning. The MiniStor system is manufactured with its own internal sensors which regulate the operation modes. Their readings accessible from the online control system (Programmable Logic Controllers- PLC). The PLC used the SCADA system, which is presented in the Annex to this document.

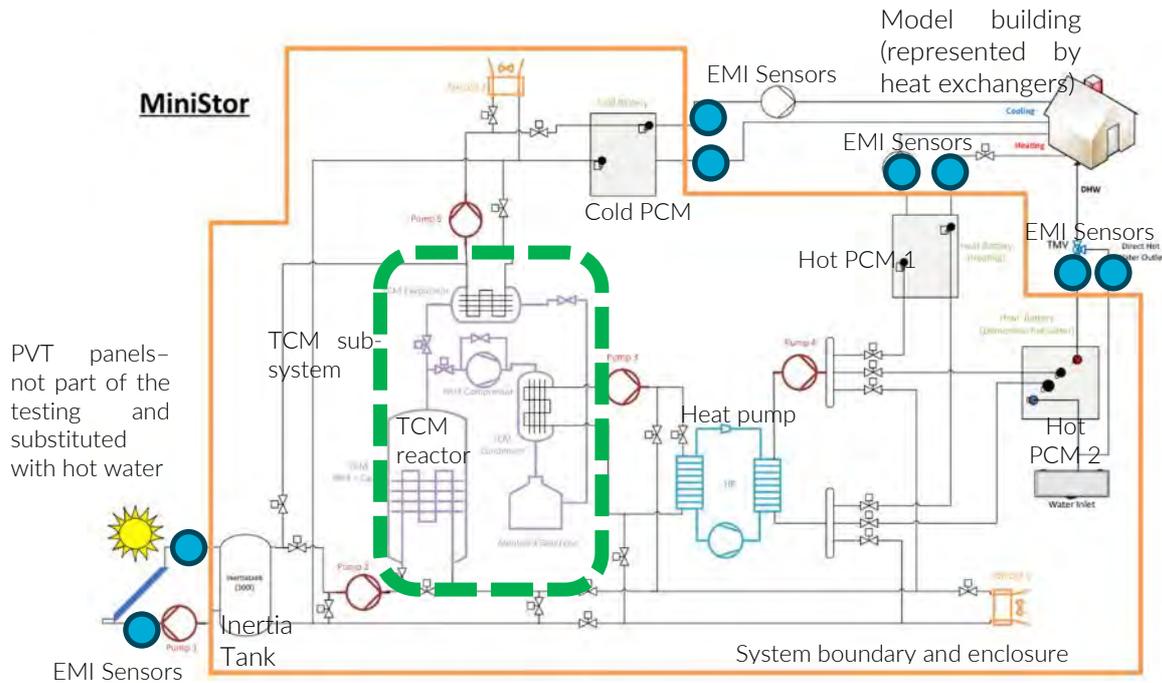


Image 6: MiniStor schematic plan with main internal components and location of some sensors

Image 7: Model building heat exchanger SWEP EST X20



2.2. Step 2-2: Planned operation of the model building

The mechanical system serving the model building is set up to produce the heat demand continuously. Piping traces were designed to model all heat demands simultaneously for a given modelled season. The mechanical system supplying the model building is shown in Image 8. The two white tanks on the right side of the image are used to produce chilled water using the outdoor liquid chiller and hot water using the electric heating cartridge. Piping delivers both waters to the heat exchangers in the model building. This piping system is shown at the bottom of the picture.



Image 8: Model building pipe system

In the present case, the building supplied by the MiniStor ("model building") consisted of two heat exchangers from a thermal point of view. One heat exchanger was used to generate the DHW heat demand, the other heat exchanger was used to generate the cooling or heating heat demand, manually switchable according to the season of the year to be modelled.

Solar energy for input water into the inertia tank was also modelled, also using a heat exchanger. This heat exchanger served the solar heat demand desired by MiniStor. The placement of the heat exchangers in the actual test setup is shown in Image 9.

The hot water was used for solar modelling and the heat demand of the hot water was needed to dissipate the cooling energy of the MiniStor in the summer operating mode. The heat demand of the cold water was used to dissipate the heating thermal energy of the MiniStor in the winter operating condition. The cold water was also needed to dissipate the DHW thermal energy, but in this case, it was used in both winter and summer operating conditions, because DHW is needed in winter and summer.

The electrical energy demand of the MiniStor unit was supplied from a purpose-built switchgear cabinet.

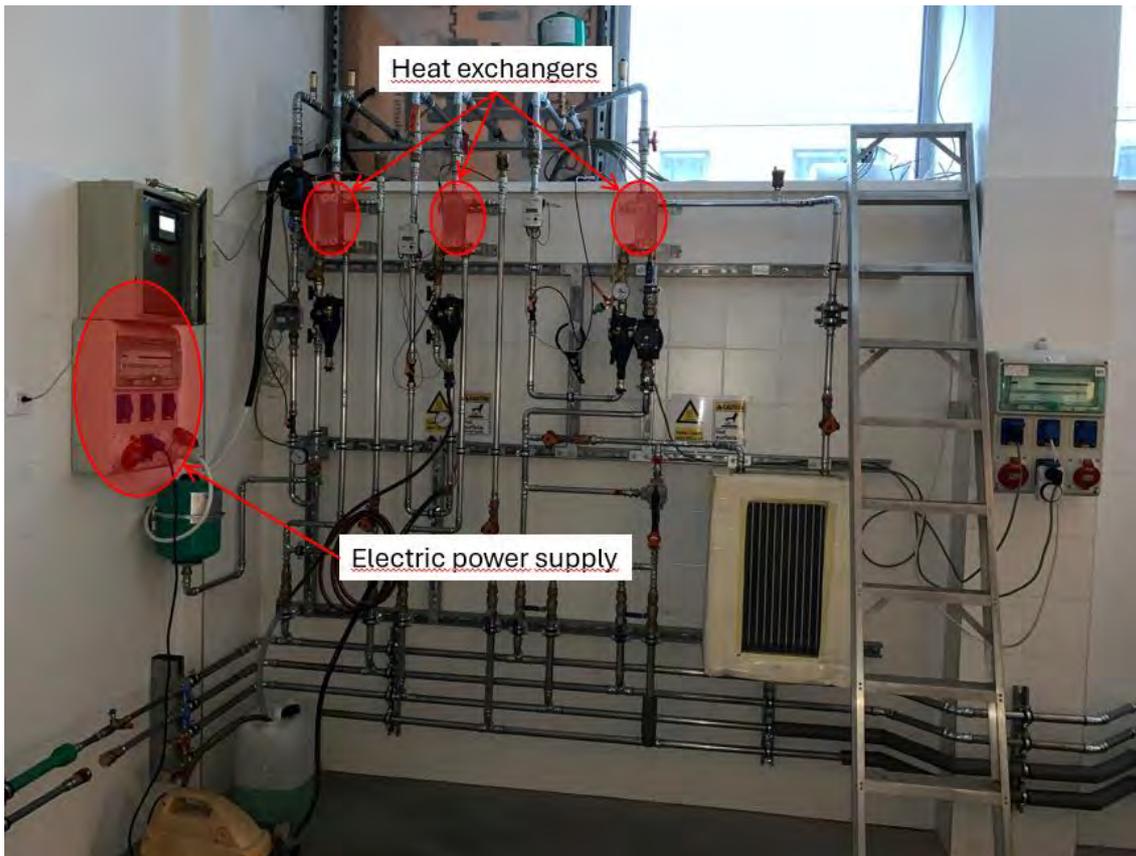


Image 9: Electric power supply and heat exchangers

A summary of the heat exchangers' (modelbuilding) performance matrix is shown in Table 1 below. The first column shows the operating status of the MiniStor and the heat exchanger connection side (primary or secondary), the second column shows the DHW heat exchanger, the third column shows the solar heat exchanger, and the fourth column shows the cooling-heating heat exchanger. And in the cells in the matrix is the thermal energy "delivered" by the system.

Mode:	Heat exchanger connection side	DHW heat exchanger	Solar heat exchanger	Heat/Cooling heat exchanger
Winter	Primary (MiniStor)	HEATING	COOLING	HEATING
Winter	Secondary (ÉMI)	COOLING	HEATING	COOLING
Summer	Primary (MiniStor)	HEATING	COOLING	COOLING
Summer	Secondary (ÉMI)	COOLING	HEATING	HEATING

Table 1: Heat exchangers working matrix

In summary, we designed our measurement procedure by continuously generating the heat demands, according to the modelled season, on the secondary sides of the heat exchangers that make up the model building. The continuously generated heat demand caused the MiniStor to be fully charged and fully discharged during our measurements. Due to continuous charge and discharge procedures, there was never a full thermal battery drain. Since the MiniStor continuously consumes power as energy is introduced (an increase in power consumption reduces efficiency), our goal was to make the most efficient use of power consumption during the measurements.

2.3. Step 2-3: Measurement system design

To measure energy characteristics, electricity meters and heat meters are needed, or devices that can be used to calculate heat quantities.

The heating/cooling heat energy transferred by the flow of fluid in a pipeline through a heat sink, such as a heat exchanger, can be determined by the following relationship:

$$Q[\text{kW}] = m[\text{kg/s}] * c_w [\text{kJ/kg} * \text{K}] * (t_2[\text{°C}] - t_1[\text{°C}])$$

where:

$Q[\text{kW}]$: the amount of heat dissipated by the MiniStor

$m[\text{kg/s}]$: mass flow rate of the flowing liquid, mass flow of water (we cannot measure this)

$c_w[\text{kJ/kg} * \text{K}]$: specific heat of water 4.19 kJ/kg*K

(a function of temperature, but we have taken this constant value as a basis, it is the design default value)

$t_2[\text{°C}]$: the main water temperature flowing through the MiniStor in the "to building" direction

$t_1[\text{°C}]$: the main water temperature flowing through the MiniStor in the "from building" direction

$t_2 > t_1$

The mass flow rate can also be written as follows, which we can already measure:

$$m[\text{kg/s}] = V[\text{m}^3/\text{s}] * \rho_w[\text{kg/m}^3]$$

where:

$V[\text{m}^3/\text{s}]$: the volume flow rate of water (we can measure this with the heat meter and the flowrate sensor)

$\rho_w[\text{kg/m}^3]$: density of water 1000 kg/m³

(density is dependent on temperature, but we have taken the constant value we have set, this is the design default value)

As the density will change due to the glycol mixture, we have calculated a constant multiplier in the data acquisition setup of the measuring instruments. Details of the setup and calculation are given in the following chapters.

The above relationship can be summarised as follows:

$$Q[\text{kW}] = V[\text{m}^3/\text{s}] * \rho_w[\text{kg/m}^3] * c_w [\text{kJ/kg} * \text{K}] * (t_2[\text{°C}] - t_1[\text{°C}])$$

The components of the relationship are defined as follows:

$V[\text{m}^3/\text{s}]$: volume flow rates with both flowrate sensors and heat rate meters

$\rho_w [\text{kg/m}^3]$: 1000*(constant adjustment due to glycol mixture multiplier, details in further chapters)

$c_w [\text{kJ/kg} * \text{K}]$: 4.19

$t_2 [\text{°C}]$; $t_1 [\text{°C}]$ liquid temperatures at the MiniStor outlets, thermocouples

To sum up, we needed instruments that could both determine the aforementioned relationship and handle it with our data collecting system.

A previous set of heat meters were considered for use, but they could not be placed outdoors, and their temperature sensing probe was only 1.5 meters long. They cannot connect to our data logger either, so were used for adjustment and control measurements.

The amount of heat can be determined from the above relationship by measuring the temperature of the fluid and the amount of fluid flowing. However, such instruments were already available on the MiniStor unit and therefore were connected to our data logger.

In addition to heat quantities, we also needed an instrument to measure electrical power. We obtained a device that could be connected to our data logger and that could display the electrical power consumed.

2.4. Step 2-4: Selection of measuring instruments

The tools we selected and used are summarised in Table 2.

In the first column of the table, the name of the manufacturer of the instrument is given. The second column shows the name and/or type of the device. The third column shows their unique identification number. In the fourth column, the measured characteristic is given. The fifth column indicates the uncertainty of the measurement. The sixth column indicates the status of the instrument. The status can be calibrated or set. The calibrated status devices were used as a reference for the adjustment to the data logger for flow meters and for electricity meters, since the calibrated device is not suitable for connection to the data logger. For the flow meters, we designed the heat meters to be installed on the same wiring as the set flow meters, so that we could perform a spot check during the measurement,

For the electric meters, we could not use an Etalon multimeter operated during the set-up of the prototype as it would have been unsafe. The electrical wiring would have had to be dismantled and left exposed for the instrument connection, which was not suitable from a contact protection point of view.

Manufacturer:	Name / Type:	Serial number:	Measurement Value range:	Uncertainty	Status*
IMI	TA Scope (Dp-Visio)	ÉMI 1388 / SN:14769 (SN:102112209)	3 - 1000kPa	+/- 0.2kPa	Calibrated
Metrix	Multimeter MX 54C	ÉMI 1318 / SN:249804XAX	0 - 250V 0 - 16A	+/- 0.17V +/- 0.025A	Calibrated
SIEMENS	Ultrasonic Heat meter WSM515 (T230)	ÉMI 1384 / SN:70283877	0 - 1000l/h 0 - 95°C	+/- 0.87% +/- 0.1°C	Calibrated
SIEMENS	Ultrasonic Heat meter WSM515 (T230)	ÉMI 1385 / SN:70283842	0 - 1000l/h 0 - 95°C	+/- 0.63% +/- 0.1°C	Calibrated
PLOUMETER	Ultrasonic Heat meter RC20130M	SN:42307628	0 - 1000l/h 0 - 95°C	class 2 class 2	Used only for control check
DACTON	Power meter PQRM5300 33	SN:188002/23.11	0 - 250VAC	+/- 0.2%	Set up
VORTEX	Flow meter SV5050	PA6T/6l (1)	0 - 32l/min	+/- 0.2%	Set up
VORTEX	Flow meter SV5050	PA6T/6l (2)	0 - 32l/min	+/- 0.2%	Set up
VORTEX	Flow meter SV5050	PA6T/6l (4)	0 - 32l/min	+/- 0.2%	Set up
Danfoss	Pressure transmitter MBS4510	ÉMI 1333 / SN:21257451	0 - 10bar	+/- 0.5%	Calibrated
Guenther	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /164	0 - 100°C	+/- 0.7°C	Calibrated
Guenther	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /139	0 - 100°C	+/- 0.7°C	Calibrated

<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /039	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /188	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /159	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /117	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /085	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /184	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /064	0 – 100°C	+/- 0.7°C	Calibrated
<i>Guenther</i>	Thermocouple 1xNiCr-Ni/K	Article Nr: ZP01374062022 /162	0 – 100°C	+/- 0.7°C	Calibrated
<i>National Instruments</i>	Rack NI9214	SN:195DA78	Thermocouple input	-	Set up
<i>National Instruments</i>	Rack NI9207 with DSUB	SN:2234BFA	4-20mA input	-	Set up
<i>National Instruments</i>	NI cDAQ 9189	SN:2134519	Data Logger	-	Set up
* SN: Serial Number Status Calibrated : see Certification in Annex Status Set up : see details in next chapters Status Used only for control check : this device measures only informative data					

Table 2: Measurements devices

2.5. Step 2-5: Compliance with standards and manufacturer's specifications

The measurements were made following the requirements of several standards and manufacturer's requirements. The application to our measurements is described below.

In the first proposed measurement layout (climate chamber), the following standards were communicated:

EN 14240:2004 - Ventilation for buildings - Chilled ceilings

MSZ EN 12599:2013 - Ventilation for buildings. Test procedures and measurement methods to hand over air conditioning and ventilation systems

The standard MSZ EN 12599:2013 has been applied indirectly in our current measurement set-up for the installation of our instruments. In page 78 of Annex H.2 of the standard, several measurement examples are given for flow velocity measurements, showing the distance from an elbow joint at which the accuracy of the measurement is appropriate. In the examples, the

appropriate distances are presented according to a range of duct cross-sections and flow velocities. These are the distances according to the standard:

In section H.2/a: $a/D=4$ (a = distance of the measuring point from the elbow node)

Section H.3/a: $a/D=6$ (for other channel diameters)

Section H.4/a: $a/D=2$ (for other channel diameters, with different principle of operation)

Other standards that can apply in the pipe network before the start of our measurements:

ISO 5167-1:2022(en) Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 1: General principles and requirements

The ISO 5167-1:2022 standard sets out a general requirement and refers to the following standard that already applies to the manufacturer's device:

ISO 5167-2:2022(en) Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 2: Orifice plates

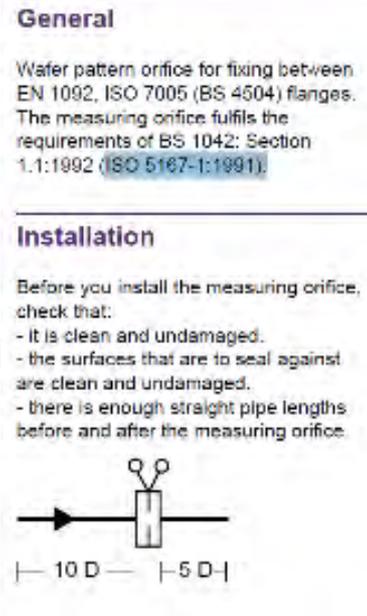
According to the manufacturer's device datasheet, if we install the manufacturer's device according to the datasheet, it will comply with this standard for the measurement procedure. A relevant extract from the manufacturer's data sheet for the IMI TA MDFO measuring flange is shown in image 10. The manufacturer's datasheet can be found in the link:

https://assets.imi-hydraulic.com/Documents/Catalogues/UK/PDF_low/MDFO_UK_low.pdf&ved=2ahUKewi4tLfNj52LAX58rsIH4DHgQFnoECBsQAQ&usq=AOvVaw15XT9rFMJh9k7WcSMKG0nW

A selected part of the datasheet is shown on Image 10.

Compliance with the following standard is also guaranteed by the manufacturer of the device when properly installed, which is a SIEMENS WSM5xx (T230) Ultrasonic compact heat and heat/cooling energy meter. It was used to set up the instrument for data heating and to check measurements during the measurement.

Image 10: IMI TA MDFO Flow measuring orifice (manufacturer data sheet page 3)



MSZ EN 1434-1:2023 Thermal Energy Meters - Part 1: General Requirements

The manufacturer's datasheet can be found in the Annex section, Image 11, detail from page 18.

Image 11: SIEMENS WSM_{5xx} (T260) (manufacturer data sheet page 18)

Settling paths are not required, neither upstream of nor downstream from the meter. If the meter is installed in the common return of 2 heating circuits, the mounting location must be at an adequate distance from the T-piece (min. 10 x DN) to allow the different water temperatures to properly mix.

Thoroughly flush the plant prior to installing the meter.

Mount the flow measuring section between 2 shutoff valves with the arrow pointing in the direction of flow. The sensors must be mounted in the same water circuit as the flow measuring section (observe mixing). Do not separate, shorten, or extend the lines. The sensors can be fitted in T-pieces or ball valves, or can be immersed, either directly or in pockets (observe all national regulations). In any case, the end of the sensors' probe must extend to at least the pipe center. Temperature sensors and fittings must be sealed to prevent tampering.

NOTICE

- Comply with all local mounting regulations for meters when mounting the meter.
- Protect the meter against damage from shocks and vibrations at the mounting location.
- Ensure that no water can enter the processor unit at the mounting location.

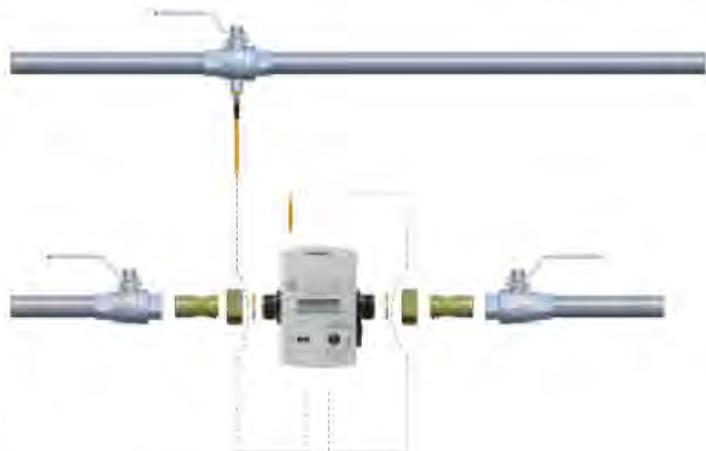
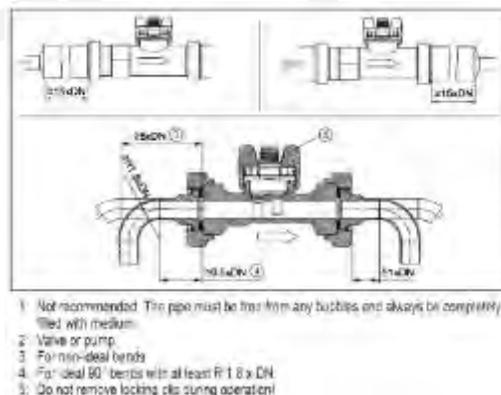


Fig. 1: Mounting with ball valve

Image 12 shows an extract from the VORTEX SV5050 instrument datasheet.

Image 12: VORTEX SV5050 (manufacturer installation instructions page 1)



In summary, the standards and manufacturer's specifications have a similar thought process for determining the flow rate in a pipeline (duct) by measurement. Even if we could not directly apply some of the standards to our measurements, the thought process and logic is clearly the same. We have taken the most stringent of these as the basis for the 10xDn (then times of diameter distance before) and 5xDn after requirement.

2.6. Step 2-6: Installation, construction of measuring sites

As mentioned above, the installation of the instruments had to consider the existence of a minimum straight pipe section of $10 \times D_n$ upstream and $5 \times D_n$ downstream of the flow direction. For example, when measuring the flow rate in a pipeline, a "protection section" is installed before ($10 \times D_n$) and after ($5 \times D_n$) the measuring device. Here, the protection section is called the undisturbed flow section. Image 13 shows the protective sections for the installation of a flow rate sensor in a flow circuit. The left side of the figure shows the dimensions of the pipe section, which is 200mm, and the pipe diameter (in which the flowrate sensor is installed), which is DN 22 mm. In our case, we need a straight section of $10 \times 22 \text{ mm} = 220 \text{ mm}$ before the centre axis of the device and $5 \times 22 \text{ mm} = 110 \text{ mm}$ after it.

A heat flow meter was installed in series with the flowrate sensor, which had the same installation requirements for the same protective clearances. The applications and settings of the meters are described in detail in the following chapters.

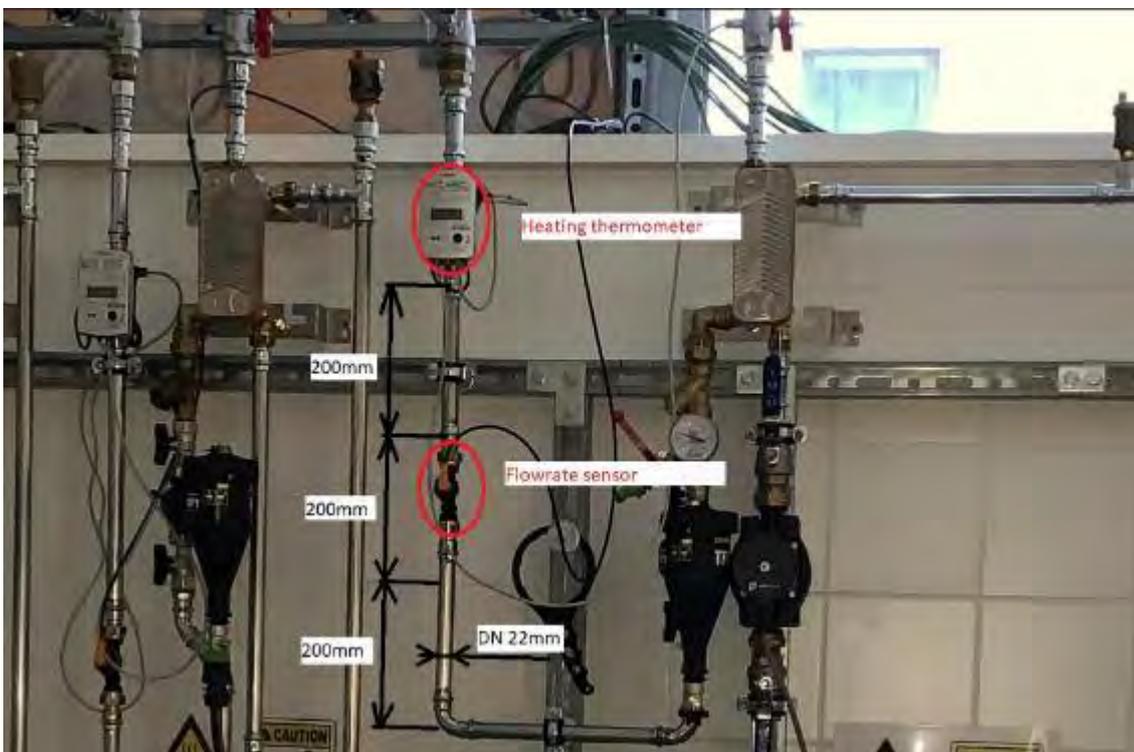


Image 13: ÉMI Flowrate sensor installation

When installing the electric meter, we only had to make sure that the meter would measure all the consumers that would be connected to the switchboard. The positioning of the electric meter and the flow meters is shown in Image 14.



Image 14: Electric power meter, Pressure and Flowrate sensors

As mentioned in the introduction, in order to minimize heat loss in the pipe network connecting the MiniStor to the Model Building, the temperature sensors were placed in the location shown in Image 15, directly at the MiniStor's connection points. In this way, the thermal effect of the outdoor environment is almost excluded from the measurement data. However, some internal heat loss from MiniStor cannot be completely excluded.

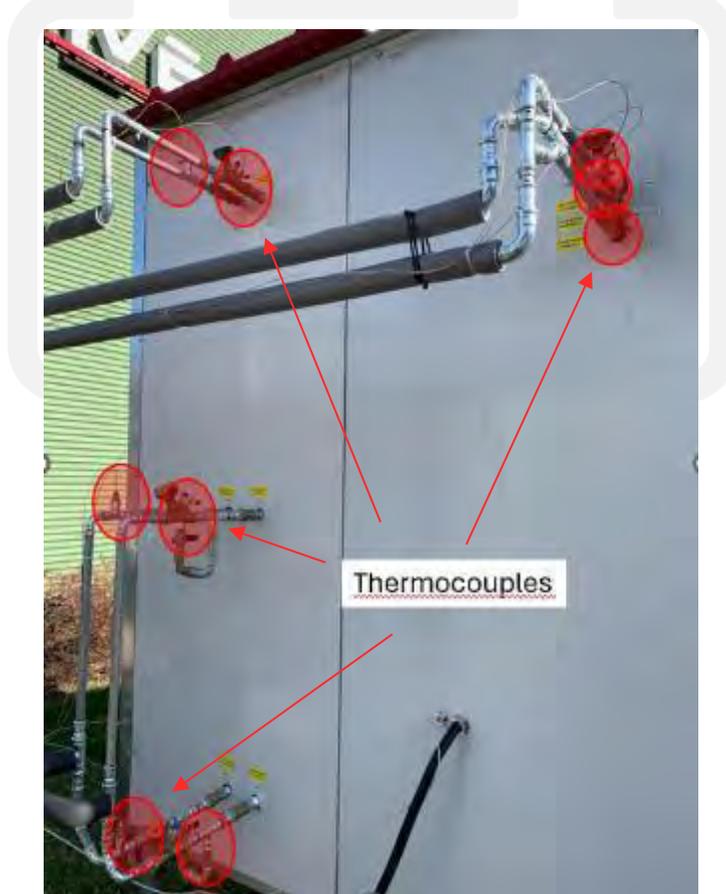


Image 15: Thermocouples positions 1 outside MiniStor

Image 16 shows how heat sensors are placed in the measuring socket of an IMI TA STAD control valve. The fitting is officially designed for the connection of the IMI TA Scope instrument we are

using, but it was possible to place the temperature sensors in it, so that the sensor is positioned directly in the middle of the fluid flow cross-section, which is the most ideal position for temperature measurement.



Image 16: Thermocouples positions 2 within pipe

2.7. Step 2-7: Filling and pressure test

After deployment of the measurement system came the filling of the pipes that will carry out the transfer fluid. According to the information received, the photovoltaic thermal panel piping uses a 33% glycol-67% water mixture. Image 17 shows the pump used for filling and the canister containing the glycol mixture, with the markings for the 1/3 glycol, 2/3 water mixture used. This mix gives a 33% glycol to water ratio, but was modified on occasions to avoid frost risk.



Image 17: 1/3 Glycol – 2/3 water fluid mixture for the piping

All valves were set to open before filling. Then, based on the information obtained, the system was test-charged to a pressure of 2.5 - 3 bar and the hydraulic connections between unit and test setup were checked for water leaks. Some were found and corrected after discussion with the manufacturer, who indicated they did not affect operation. The points of water leakage were seen in the areas indicated in Images 18 - 19.



Image 18: Detected water leakage point 1 during pressure test



Image 19: Detected water leakage point 2 during pressure test

3. Data collection system installation, measurement system setup:

The measurement tools used for data collection were put in place in the test setup as a result of the steps in the previous chapter. To the extent possible, they conform to the standard and the manufacturer's specification. After a successful pressure test, the positioned gauges were set up for the data logger.

3.1. Step 3-1: Data collection measurement system

To determine the energy consumption of the MiniStor, we measured the electrical energy consumption, the modelled solar, cooling-heating and DHW thermal energy. The energy absorbed by the MiniStor unit is electrical energy and modelled solar thermal energy. The energy delivered by the MiniStor unit to the model building is DHW and cooling-heating thermal energy. The measurements were designed to be carried out by automatic computer data acquisition. The devices forming the measurement lines are summarised in Table 3 in the order of their connection. In the table, the devices that make up the measurement lines are arranged vertically. The main characteristics of each device, which we used for the grouping, are arranged horizontally. The table explanation is as follows:

First column: the serial number of the position in the measurement line.

Second column: the function of the instrument for which it is being used in the measurement.

Third column: name and type of the instrument.

Fourth column: type of output signal of the instrument, range of values proportional to the quantity measured.

Fifth column: the maximum value set or measurable by the instrument in the unit of measurement.

Sixth column: the connection of the device to the given elements of the measuring line.

Seventh column: quantity used from the given measuring instrument.

Measurement line number:	Measurement function:	Software/ Device:	Output signal:	Max value:	Connection device:	Used quantity
1.	Software, data logger	NI FlexLogger 2023 Q1	-	-	PC Notebook	1
2.	Data Logger	NI cDAQ 9189	-	-	PC Notebook (LAN)	1
3.	Rack	NI 9207	-	-	NI cDAQ 9189	1
4.	Rack	NI 9214	-	-	NI cDAQ 9189	1
5.	Flowrate sensor	Vortex SV5050	4-20 [mA]	32 [l/min]	NI 9207	3
6.	Pressure sensor	Danfoss MBS4510	4-20 [mA]	10 [bar]	NI 9207	1
7.	Electric power meter	DACTON PQRM5300 33	4-20 [mA]	~12 [kW] (we customized)	NI 9207	1
8.	Thermal sensor	FireTECH Thermocouple 1xNiCr-Ni/K	analogue	1372 [°C]	NI 9214	10

Table 3: Measurement lines and devices

3.2. Step 3-2: General settings for the data collection programme

Data collection was performed using NI FlexLogger 2023 Q1 software. This programme manages the NI cDAQ 9189 datalogger in which we inserted analogue and digital signal receiving units NI 9207 and NI 9214. The NI 9207 receives the output signals of the electrical power sensor, the pressure sensor and the flow sensor. The NI 9214 unit handles the thermocouples. These units are identified in the programme and the parameters for each device can be set. The programme generally collects data at a frequency of 1 Hz, which is the lowest frequency value. This data is always saved in files with the extension "file_name.tdms". If the frequency is not suitable for us and a sparser sampling is sufficient, we can change this to 0.005Hz at export time, which will export the data with a sampling rate of 200s with the extension "file_name.csv". Our measurements were extracted with these sampling settings.

The adequacy of the sampling frequency was verified. The check was done so that the exported "file_name.csv" files will have the same measurement dataset, but with the name "file_name_x2.csv". The "x2" indicates that for this file, the export setting was set to double (x2) the frequency to 0.01 Hz, which corresponds to 100 s. The check is done so that the evaluated characteristics of the data exported at 0.005 Hz and 0.01 Hz should differ only slightly, giving the same result.

For the exported data, the columns in the *.csv file are entered in alphabetical order. In all cases, the first column is the date of the measurement, and the second column contains the measured and calculated characteristics. In the programme, it is possible to create channels that are defined by a calculation using a relation where the value of the characteristics measured by the instruments is used.

3.3. Step 3-3: Setting the channels of the data collection programme

As mentioned previously, we have created a device that dissipates the thermal energy produced by the MiniStor through heat exchangers to measure the MiniStor energy characteristics. The measuring instruments have been selected and assembled to measure these energies directly or indirectly (by calculation).

3.3.1. Measurement of electric energy (DACTON data logger setup):

To measure the amount of electric energy used, we chose a device that measures the amount of energy consumed directly. Here, too, we calculated a constant multiplier, the setting value of which is described in this section.

For the electrical power meter, two types of electrical power characteristics were measured. The effective and the apparent electrical power characteristics. The apparent electrical power is the value taken from the electrical network. The effective electrical power is the power used without the MiniStor's internal dissipation losses. The difference between the two electrical powers is the internal electrical loss of the MiniStor. For the efficiency calculation, the apparent electrical power is considered.

Setting up this device for the data logger involves disconnecting the electrical wiring. For the setup, this modification has been temporarily made. The setup layout is shown in Image 20. As can be seen in the image, we have carried out a separate check for each phase, firstly to verify that the digital display of the instrument is correct. As a second step, the setup for data acquisition was performed. The comparison between the instrument selected as the reference (multimeter) and the values displayed on the meter is summarised in Table 4. The procedure for the comparison was to connect, as indicated in Image 20, switchable single loads to the phases, generating increasing current draws.

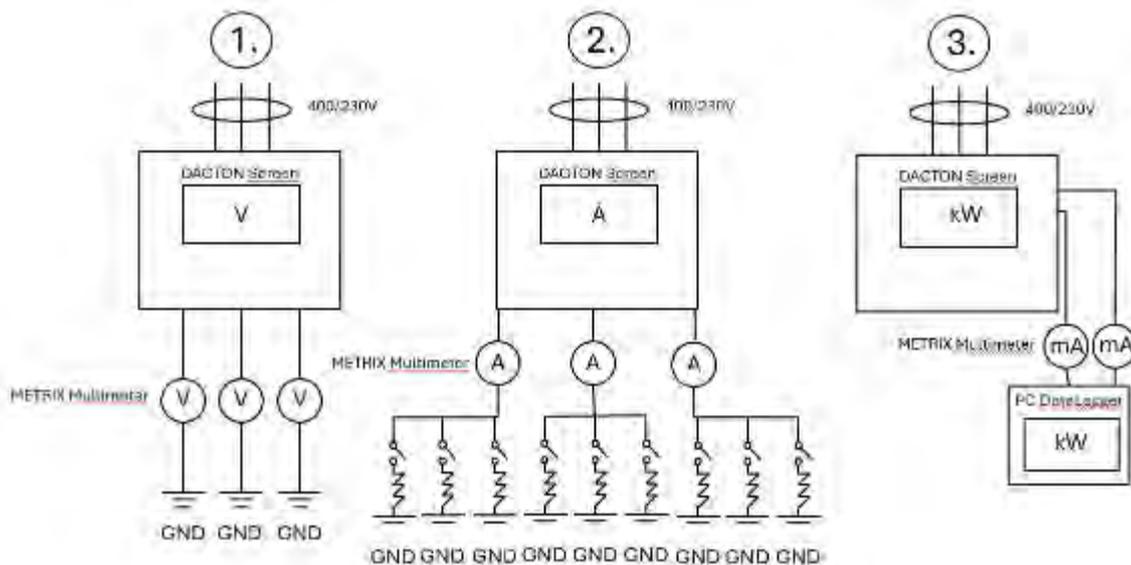


Image 20: DACTON data logger setup

Setup nr.*: *based on Image 20	Phase nr.:	Setpoint nr.:	Metrix MX54C Screen Value	DACTON Screen Value:
1. Checking the Voltage	L1	I.	239.2 (V)	239.2 (V)
2. Checking the Current	L1	I.	2.347 (A)	2.345 (A)
2. Checking the Current	L1	II.	4.370 (A)	4.420 (A)
2. Checking the Current	L1	III.	6.670 (A)	6.712 (A)
2. Checking the Current	L1	IV.	9.080 (A)	9.121 (A)
2. Checking the Current	L1	V.	11.100 (A)	11.162 (A)
2. Checking the Current	L1	VI.	13.460 (A)	13.538 (A)
1. Checking the Voltage	L2	I.	237.8 (V)	237.8 (V)
2. Checking the Current	L2	I.	2.313 (A)	2.310 (A)
2. Checking the Current	L2	II.	4.320 (A)	4.373 (A)
2. Checking the Current	L2	III.	6.580 (A)	6.658 (A)
2. Checking the Current	L2	IV.	9.000 (A)	9.040 (A)
2. Checking the Current	L2	V.	10.930 (A)	11.0110 (A)
2. Checking the Current	L2	VI.	13.240 (A)	13.327 (A)
1. Checking the Voltage	L3	I.	237.1 (V)	237.1 (V)
2. Checking the Current	L3	I.	2.306 (A)	2.290 (A)
2. Checking the Current	L3	II.	4.350 (A)	4.349 (A)
2. Checking the Current	L3	III.	6.590 (A)	6.590 (A)
2. Checking the Current	L3	IV.	8.930 (A)	8.940 (A)
2. Checking the Current	L3	V.	10.910 (A)	10.920 (A)
2. Checking the Current	L3	VI.	13.200 (A)	13.210 (A)

Table 4: Etalon Multimeter – DACTON main screen control check

Once the comparison was finished, adjustment to the data logger was done based on the values displayed on the DACTON display. The DACTON meter is capable of measuring the two electrical characteristics already mentioned for data collection. Two output signals can be set, which will be 4-20 mA. On the meter, it was possible to set the electrical characteristic quantity for the 4 mA output signal and the value of the 20 mA output signal.

It was verified that the output signal was indeed the set value of 4-20 mA. At the time of setting, a constant multiplier was defined for the output signal so that the value displayed in the software would be in kW units. The displayed values of the adjustment and counter-correction are summarised in Table 5. The constant multipliers calculated during the adjustment are summarised in table 7 in the next section.

The values for the output signals are set so that 0 W consumption has a 4 mA output signal and ~12000 W consumption has a 20 mA output signal.

For the two selectable output signals we chose the effective and apparent electrical characteristics.

Setup nr.*: *based on Image 20	Phase nr.:	Setpoint nr.:	Metrix MX54C Screen Value	DACTON Screen Value:	PC DataLogger Value:
3.	L2	I.	6.080 (mA)	1.57 (kW)	6.080 (mA)*
3.	L2	II	8.158 (mA)	3.13 (kW)	8.158 (mA)*
4-20 mA output signal@ 0-12kW => 16 mA/12kW=> mA/1.33=kW					

Table 5: DACTON – FlexLogger 2023 Q1

3.3.2. Measurement of flowrate (VORTEX SV5050):

Flowrate sensors also provide a 4-20 mA output signal. In this case, the maximum value cannot be set, as it is specified by the manufacturer. The output signal is 4 mA for 0 flow and 20 mA for the maximum flow rate of 32 l/min. The manufacturer also defines a multiplier value to be used in the software, in our case x2. This value z is for water, but in our case all hydraulic circuits are filled with a 33% glycol-water mixture, so a constant multiplier must be set in the software for the correct measurement.

For the flow meters, we have already indicated in the previous chapters that the device is connected to a pipe with a heat flow meter from Etalon (Image 21). By manually starting the MiniStor pump on a given circuit, we created a flow in that hydraulic circuit. A constant multiplier was set in the software to the displayed value of the SIEMENS heat meter, which was used as the reference, so that the displayed flow rates were almost identical. The 3 flowrate sensors were swapped in the hydraulic circuit to be set in the software according to a standard. The flowrate values displayed during the adjustments are summarized in Table 6. The constant multipliers for each flowrate sensor are shown in Table 6.

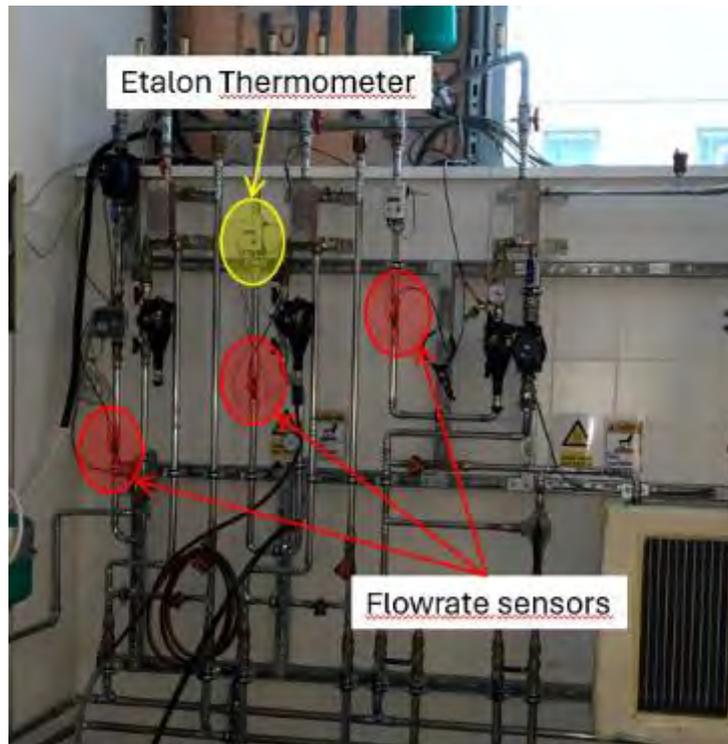


Image 21: VORTEX SV5050 data logger setup

Device name:	#SIEMENS Screen Value:	PC Datalogger Screen Value**:	Difference:	Constant number calculation
Vortex SV5050 PA6T/6I 1	0.00 (l/min)	0.01 (l/min)	-0.01	15.23/14.13 =1.0778 mA*2*1.0778=l/min
	15.23 (l/min)	14.13 (l/min)	-1.10	
Vortex SV5050 PA6T/6I 2	0.00 (l/min)	0.01 (l/min)	-0.01	15.23/14.09 =1.0809 mA*2*1.0808=l/min
	15.23 (l/min)	14.09 (l/min)	-1.14	
Vortex SV5050 PA6T/6I 4	0.00 (l/min)	0.01 (l/min)	-0.01	15.23/14.09 =1.0809 mA*2*1.0858=l/min
	15.18 (l/min)	13.98 (l/min)	-1.20	
**based on manufacturer data sheet, mA*2=l/min				
#SIEMENS WSM515 SN:70283877				

Table 6: VORTEX SV5050 – FlexLogger 2023 Q1

3.3.3. Measurement of fluid and ambient temperatures (Thermocouples):

Once the temperature sensors are connected to the data logger, the temperature values are displayed correctly in the software one by one. In this case, all we had to do was to name the temperature sensors connected to the corresponding channels according to the MiniStor connection, to facilitate the further definition of the calculated characteristics.

3.3.4. Measurement of solar system fluid pressure (DANFOSS Pressure Transmitter):

The Danfoss MBS4510 pressure transmitter was installed in the system measuring partial information, to support the readings during measurement and operation. The experience during our measurements was that the pressure varies significantly with the temperature in the solar system (0.5 bar - 3 bar). The pressure transmitter also gives a 4-20 mA output signal, 4 mA value corresponds to 0 bar, and 20 mA output signal value corresponds to 10 bar pressure value. By dividing this range, the constant multiplier value is obtained. Offset -4; $K = \text{measured (mA)} / 1.6$. The total of the constant multipliers is summarized in Table 7.

3.4. Step 3-4: Setting the channels of the data collector

In the steps of the previous chapter, we have set up all the instruments needed to display the energy characteristics on the data logger. The settings in the data logger can be done by creating calculated channels, otherwise the data logger will display the 4-20 mA signals. The values of the constant multipliers defined in the instrument setup are summarized in Table 7. The explanations of the table are as follows:

The first column in the table shows the function of the device.

The second column shows the type of device, with an identification number where relevant.

In the third column, the system measured by the device (DHW, Solar...etc.) is indicated.

The fourth column shows the signal output by the device and received by the data logger.

In the fifth column, we have entered the offset value of the signal emitted by the device. This is necessary to ensure that the data logger records a value of zero for a physical, real value of zero. Otherwise, it should be applied to the calculated characteristics.

The sixth column contains the constant values that must be determined from the manufacturer's specification to obtain the desired physical characteristic value.

In the seventh column, the desired physical characteristics mentioned above are given. The physical characteristics can be determined by performing the operation in column "K constant number" on the value of the ("output signal") with the value given there. For example, Solar flowrate $[\text{l/min}] = \text{Solar flowrate sensor [mA]} * 2 * 1.0778$.

Device function:	Device type:	Measured system:	Output signal:	Offset:	"K" constant number	Physical value:
Electric power meter (Effective)	DACTON PQR5300 33	Electric power (effective)	mA	-4	/1.33	kW
Electric power meter (Apparent)	DACTON PQR5300 33	Electric power (apparent)	mA	-4	/1.33	kW
Flowrate sensor	Vortex SV5050 PA6T/6I 1	Solar flowrate	mA	-4	*2*1.0778	l/min
Pressure sensor	Danfoss MBS4510	Solar system	mA	-4	/1.6	bar

Flowrate sensor	Vortex SV5050 PA6T/6I 2	DHW flowrate	mA	-4	*2*1.0808	l/min
Flowrate sensor	Vortex SV5050 PA6T/6I 4	Heat/Cooling flowrate	mA	-4	*2*1.0858	l/min
Fire TECH Thermocouple	1xNiCr-Ni/K	Solar to Panels (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Solar from Panels (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Solar from FCU (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	DHW to Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	DHW from Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Heating to Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Heating from Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Cooling to Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Cooling from Building (fluid temperature)	°C	0	-	°C
Fire TECH Thermocouple	1xNiCr-Ni/K	Ambient (air temperature)	°C	0	-	°C

Table 7: Measurement devices data logger setup

4. Measurement procedure of MiniStor operating conditions

4.1. Winter mode (Solar buffer to PCM) manual control:

4.1.1. Step 4-1-1: Start the Data Logger

At the beginning of the measurements, we checked the correctness of the pressures in the hydraulic circuits, the open status of the valves (if any installation or repair work was carried out on the system), the ready-to-run status of the data acquisition programme, and the correct output signal of all the instruments in the programme. If everything was found to be in order, data collection was started, followed by Step 4-1-2.

4.1.2. Step 4-1-2: Start MiniStor system Filling mode

Based on the description given (see Annex), the solenoid valves of the MiniStor were adjusted (switched) and the other pumps were started according to the description. Photos of the setup are shown in Images 22-24.

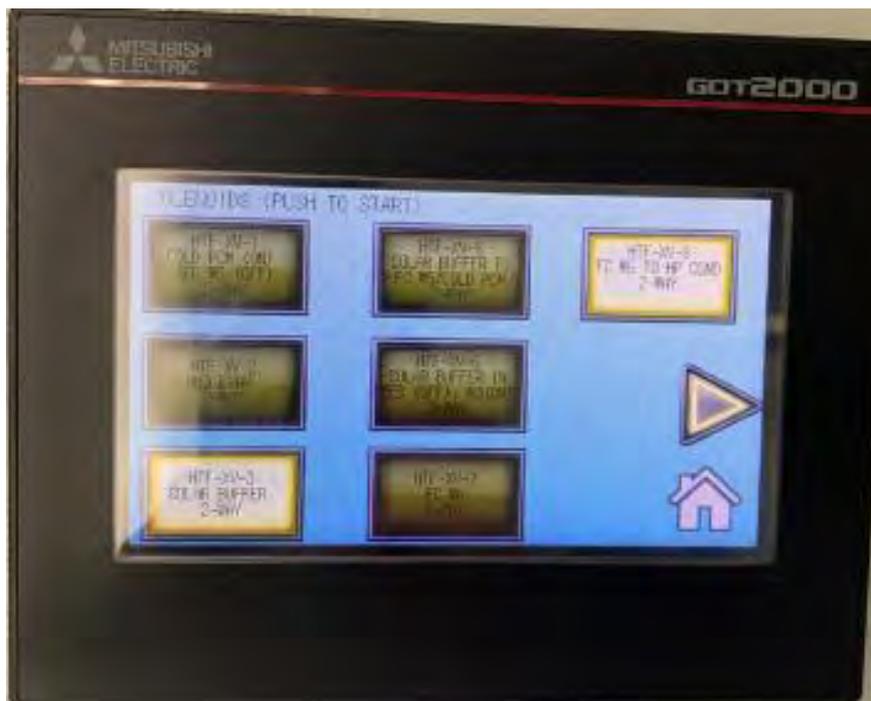


Image 22: Solenoid valves setup 1 (Solar to PCM Filling mode)



Image 23: Solenoid valves setup 2 (Solar to PCM Filling mode)

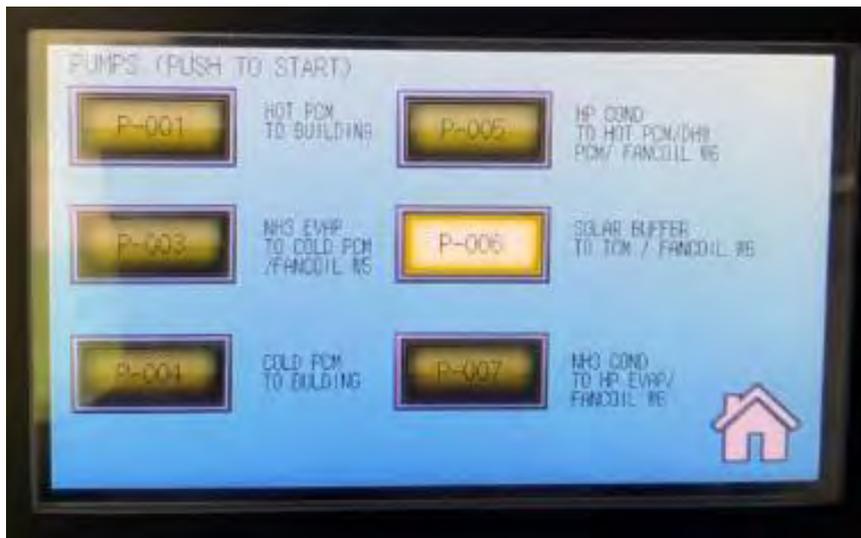


Image 24: MiniStor Pumps ON (Solar to PCM Filling mode)

The MiniStor Solar pump had to be started separately, manually (later, the solar pump start-stop function could be solved from the online control).

4.1.3. Step 4-1-3: MiniStor system emptying mode

Based on the description given (see Annex), the solenoid valves of the MiniStor were adjusted (switched) and the other pumps were started according to the description. Photos of the setup are shown in Images 25-27.

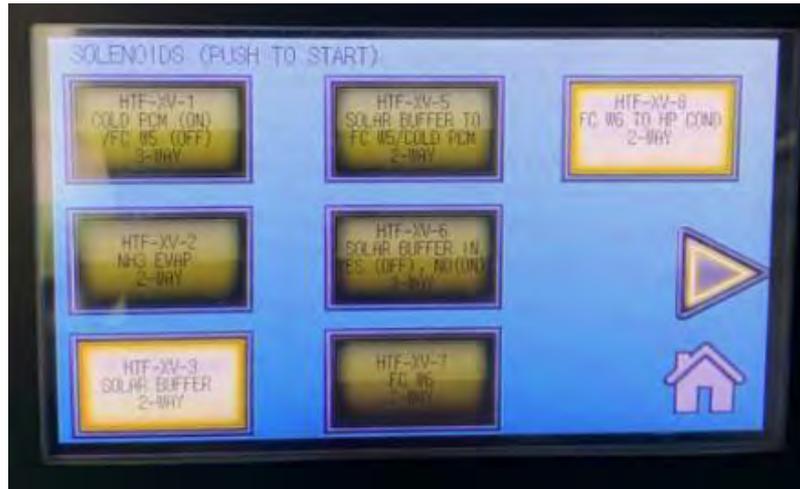


Image 25: Solenoid valves setup 1 (Solar to PCM Emptying mode)

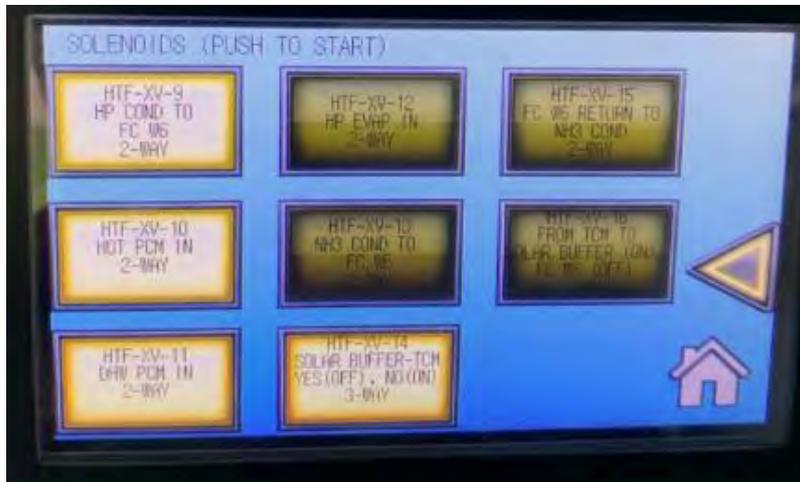


Image 26: Solenoid valves setup 2 (Solar to PCM Emptying mode)

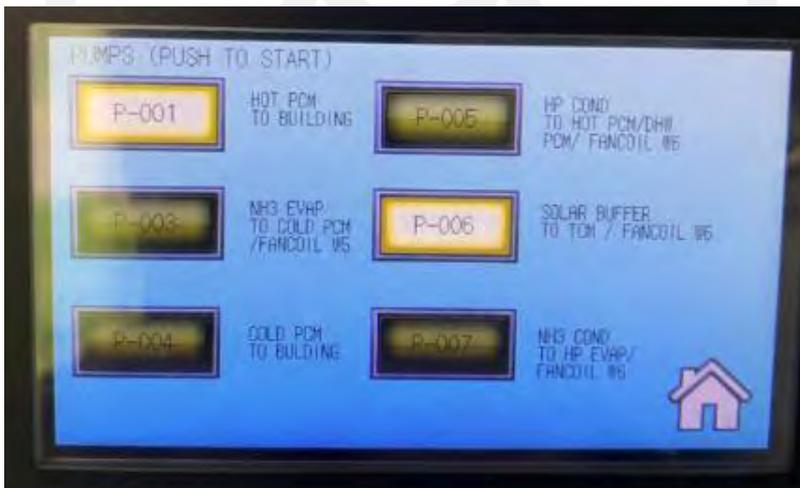


Image 27: MiniStor Pumps ON (Solar to PCM Emptying mode)

The MiniStor Solar pump had to be shut down separately, manually.

4.1.4. Step 4-1-4: Stopping the Data Logger

After the measurements were completed, we shut down the MiniStor pumps and closed the solenoid valves as described. After shutting down the MiniStor, we stopped the data collection (data collection and MiniStor shutdown are interchangeable). Photos of the shutdown are shown in Images 28-30.

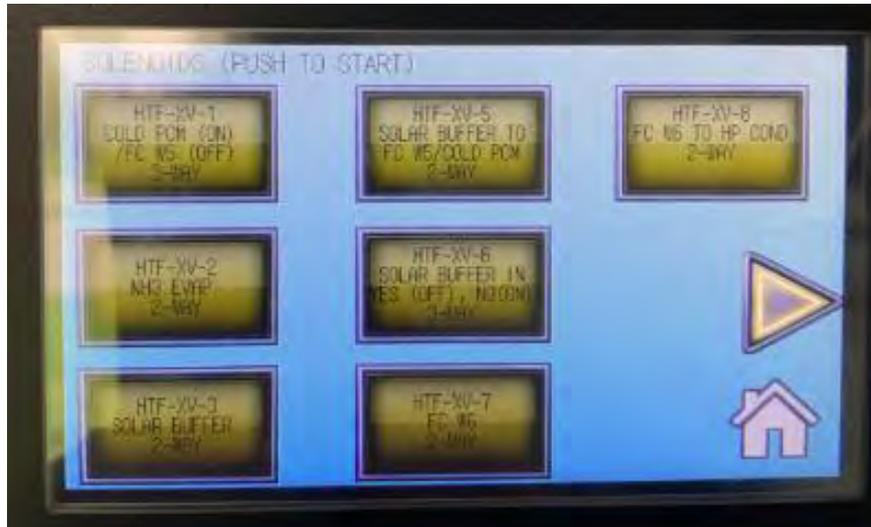


Image 28: Solenoid valves setup 1 (Solar to PCM STOP)

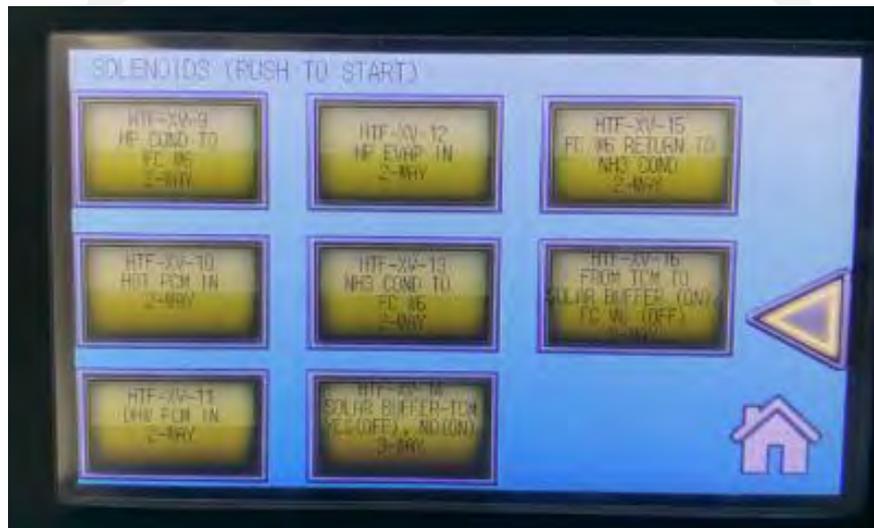


Image 29: Solenoid valves setup 2 (Solar to PCM STOP)

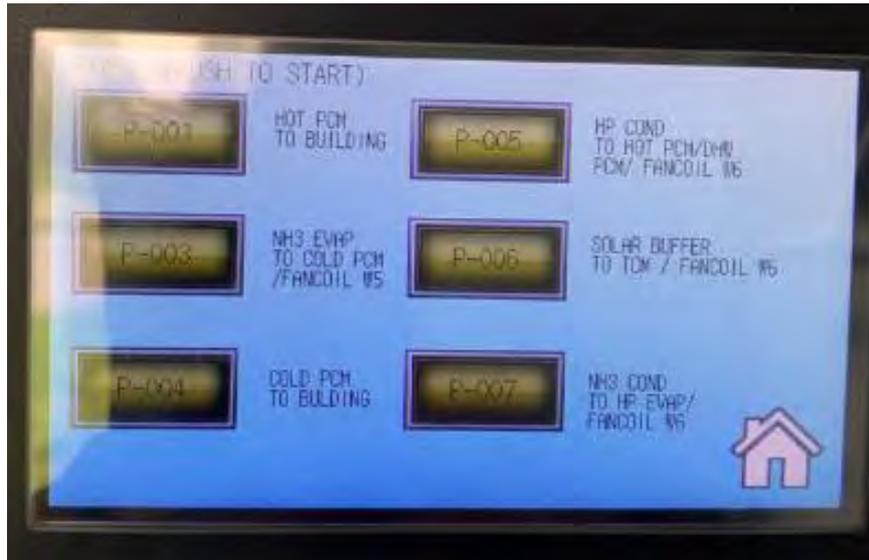


Image 30: MiniStor Pumps OFF (Solar to PCM STOP)

4.2. Winter mode (Solar buffer to PCM) online control

4.2.1. Step 4-2-1: Start the Data Logger

At the beginning of the measurements, we checked the correctness of the pressures in the hydraulic circuits, the open status of the valves (if any installation or repair work was carried out on the system), the ready-to-run status of the data acquisition programme, and the correct output signal of all the instruments in the programme. If everything was found to be in order, data collection was started, followed by Step 4-2-2.

4.2.2. Step 4-2-2: Start the online control filling mode

According to the manual and the online control instructions (see appendix), the "manual control" steps were done in the same order, but with an online interface. A screenshot of the online interface is shown in Image 31. The screenshot shows the direction of fluid flow in the MiniStor's internal system and thus the transfer of heat and electricity.

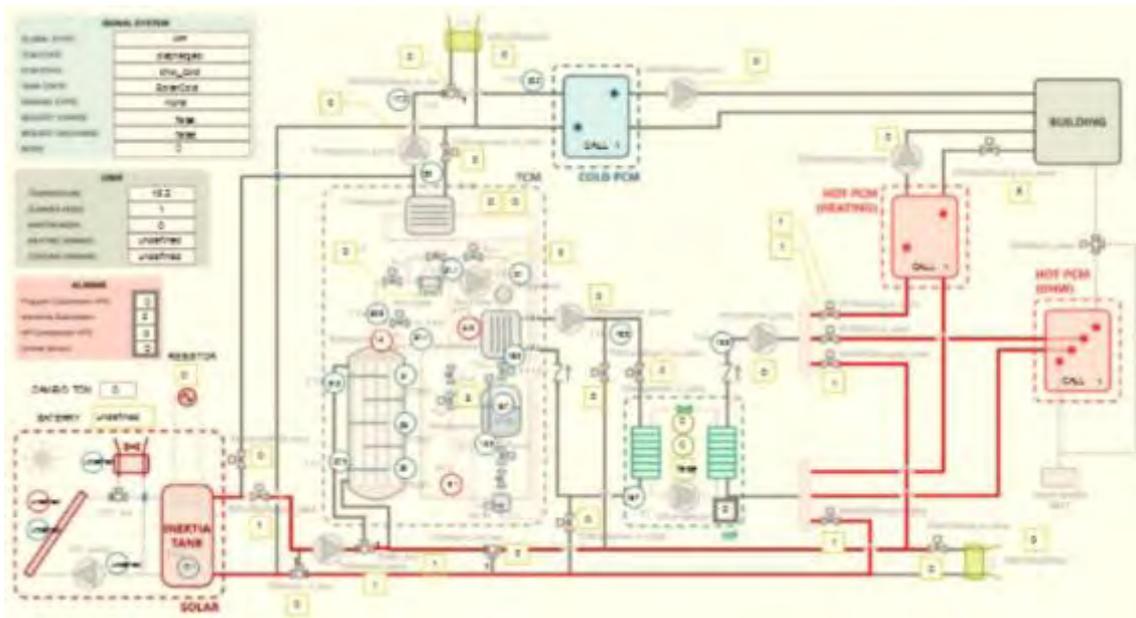


Image 31: Online control Winter mode (Solar to PCM) Filling

4.2.3. Step 4-2-3: Switch the online control to emptying mode

After filling mode, we manually switch to emptying mode in the online interface, as we did for manual control. When switching valves and pumps, we had to switch the same elements as for manual control. The screenshot of the online control emptying mode is shown in Image 32.

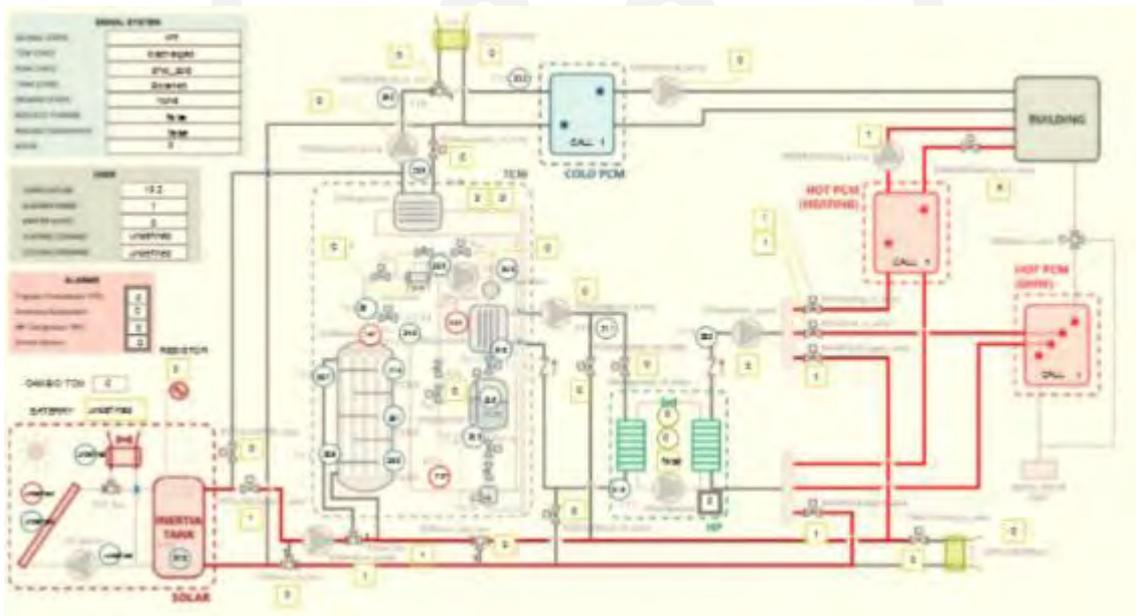


Image 32: Online control Winter mode (Solar to PCM) Emptying

4.2.4. Step 4-2-4: Stop the Data Logger

At the end of the measurements, we shut down the MiniStor pumps, then closed the solenoid valves as described. After shutting down the MiniStor, we stopped data collection (data collection and MiniStor shutdown are interchangeable).

4.3. Winter mode online control

4.3.1. Step 4-3-1: Start the Data Logger

At the beginning of the measurements, we checked the pressures in the hydraulic circuits, the open status of the valves (if any installation or repair work was carried out on the system), the ready-to-run status of the data acquisition programme, and the correct output signal of all the instruments in the programme. If everything was found to be in order, data collection was started, followed by Step 4-3-2.

4.3.2. Step 4-3-2: Start the online control (charging mode)

In the online control, you had to select "Winter"; "Automatic"; "Solar pump ON*" and the MiniStor charging mode started automatically. This option was included in the programme because of the EMI test system.

The online screen shot of the charging mode is shown in Image 33. In this case it can be observed that the thermal energy flow is in a different direction compared to the previous case.

It is important to note that the thermal demand for the ÉMI model building should be provided continuously for measurement of the heat supply by the MiniStor unit, since the controllers in the prototype dissipate excess thermal energy automatically, via the built-in fan coils. They are designed to be fail-safe and user friendly. In our case, this step is an important one, since we want to measure all the thermal energy emitted by the MiniStor.

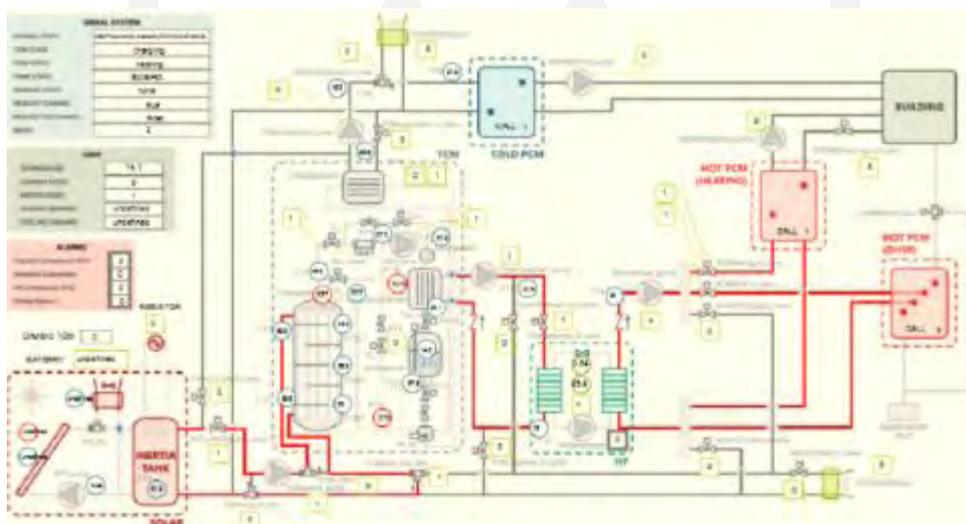


Image 33: Online control: Winter mode CHARGING

4.3.3. Step 4-3-3: Switch the online control to discharging mode (automatic)

At the end of the charging mode, when the NH₃ level reaches the set maximum value, the MiniStor unit automatically switches to discharging mode. A screenshot of the online control of the discharging mode is shown in Image 34. Again, it can be observed that the thermal energy flows in a different direction within the MiniStor system. It can also be observed that the MiniStor control in this mode transfers the cooling energy to the outside via the fan coil at the top of the screen. According to information received, this is the MiniStor winter mode setting.

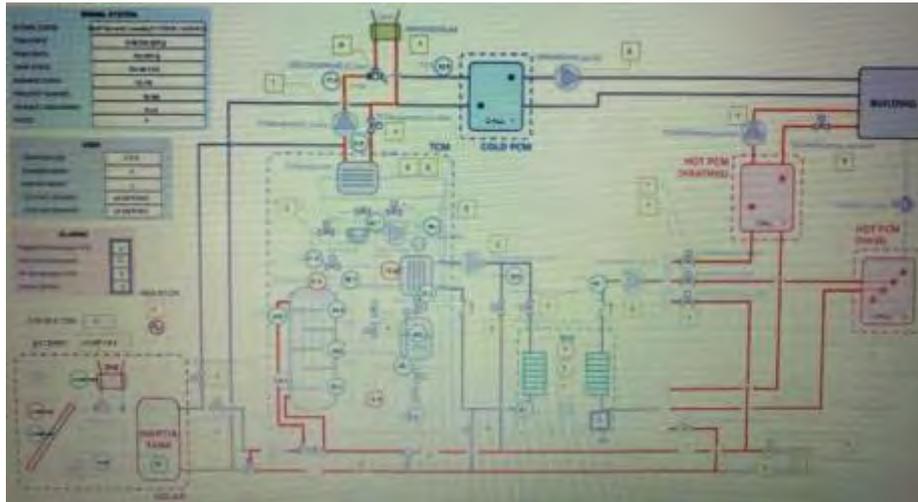


Image 34: Online control: Winter mode DISCHARGING

4.3.4. Step 4-3-4: Stop MiniStor (automatic); Stop the Data Logger

After the discharging mode is finished, when the NH₃ level reaches the minimum value, the MiniStor will automatically stop. After the MiniStor is shut down, data collection is also stopped (data collection and MiniStor shutdown are interchangeable).

4.4. Summer mode online control:

4.4.1. Step 4-4-1: Start the Data Logger

At the beginning of the measurements, we checked the pressures in the hydraulic circuits, the open status of the valves (if any installation or repair work was carried out on the system), the ready-to-run status of the data acquisition programme, and the correct output signal of all the instruments in the programme.

If everything was found to be in order, data collection was started, followed by Step 2.

4.4.2. Step 4-4-2: Start the online control (charging mode)

In the online control, we had to select "Summer"; "Automatic"; "Solar pump ON*" and the MiniStor charging mode started automatically. *This option was included in the programme because of the EMI test system.

The online screen shot of the charging mode is shown in Image 35. In this case it can be observed that the thermal energy flow is in a different direction compared to the previous case.

It is important to note that the thermal demand for the ÉMI model building must be provided continuously, because the MiniStor control wants to dissipate excess thermal energy on the move, which, if it is to be measured, must be provided continuously. The MiniStor control will in any case dissipate the thermal energy according to its set programme, it is just the other case that it will do so via the built-in FanCoil fans. So, the system is fail-safe and user friendly. In our case, this step is the only important one, because we want to measure all the thermal energy emitted by the MiniStor.

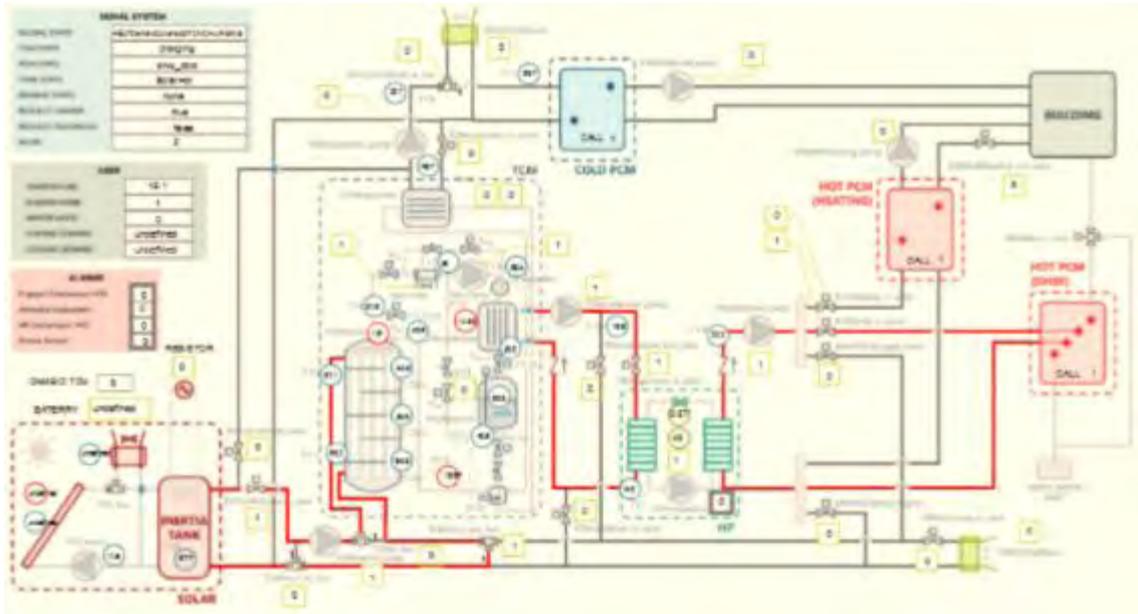


Image 35: Online control: Summer mode CHARGING

4.4.3. Step 4-4-3: Switch the online control to discharging mode (automatic)

At the end of the charging mode, when the NH_3 level reaches the set maximum value, the MiniStor automatically switches to discharging mode. A screenshot of the online control of the discharging mode is shown in Image 36. Here again it can be observed that the thermal energy flows in a different direction within the MiniStor system. It can also be observed that the MiniStor control in this mode delivers the heating energy to the outside via the fan coil at the bottom of the screen. According to information received, this is the MiniStor summer mode setting.

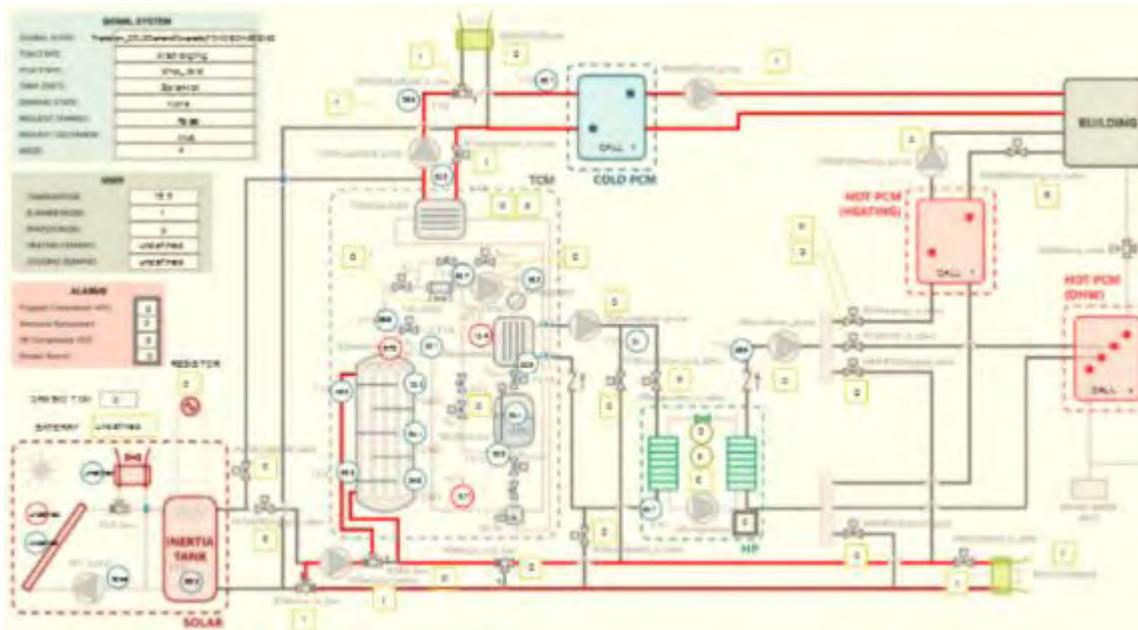


Image 36: Online control: Summer mode DISCHARGING

4.4.4. Step 4-4-4: Stop the Data Logger

After the discharging mode is finished, when the NH_3 level reaches the minimum value, the MiniStor will automatically stop. After the MiniStor is shut down, data collection is stopped (data collection and MiniStor shutdown are interchangeable).

4.5. Measurement of the hydraulic characteristics of the MiniStor

At the end of our measurement series and after familiarizing with the unit, it was possible to measure pressure conditions. In our experience, the MiniStor pumps operate at a constant duty point, with no variable speed control.

4.5.1. Step 4-5-1: Prepare hydraulic measurements

At the beginning of the measurements, we checked the pressures in the hydraulic circuits, the open status of the valves, if any installation or repair work had been carried out on the system, the ready-to-run status of the data acquisition programme, and the correct output signal of all the instruments in the programme. If everything was found to be in order, data collection was started, followed by Step 4-5-2.

4.5.2. Step 4-5-2: Turn MiniStor Pumps ON

Using the online interface or manual mode, we can manually open the required solenoid valves in the MiniStor. After the valve openings, the pumps to be tested were ready to be switched on.

4.5.3. Step 3 Measure the MiniStor hydraulic parameters

The IMI TA Scope is placed in the pressure measurement point on each hydraulic circuit of the MiniStor at the ** to building and ** from building connections. These pressure measurement points are also the measurement points for the thermocouples. The thermocouples are removed for the duration of the pressure measurement. Photos of the pressure measurement are shown in Images 37 - 40. We measured the pressure difference between the connecting stubs, which determines the working point of the pump on the circuit in the installed pipe network. The measurement results are detailed in the following section.

4.5.4. Step 4-5-4: Turn MiniStor Pumps OFF

When the measurements are finished, first the pumps are switched off, then the solenoid valves.

Image 37: pressure measurement in MiniStor DHW system



Image 38: pressure measurement in MiniStor Heating system



Image 39: pressure measurement in MiniStor Cooling circuit



Image 40: pressure measurement in MiniStor Solar system

5. Evaluation procedure and data visualization

5.1. Step (i): Processing exported data (*.csv file)

The data logger program can be configured to automatically export measurement data after these are completed. Exported data are saved in a *.csv file format that can be managed in a spreadsheet application such as Excel. During the measurement, the data logger program saves the data using *.tdms extension files. These can still be retrieved in case of an error (which could be caused by a power failure, data connection error...etc), but exporting the data is more difficult since they need to be retrieved using the experiment date and time. The programme has been configured so that the file name contains the test mode (MiniStor function), the modelled solar temperature and the start date of the measurement, so that it can be compared with the measurement data generated from the CARTIF data cloud. In this way, when opening the files it is not needed to know the date of the measurements.

File name components summarized and illustrated on a specific measurement example:

The names of the exported files:

Winter-70_20240626-062208.csv

Winter-70_20240627-062208.csv

Winter-70_20240628-062208.csv

Winter-70_20240629-062208.csv

Winter-70_20240630-062208.csv

File name interpretation: Winter (= MiniStor function under test); 70 (= 70°C average solar inlet liquid temperature); _20240630-062208 (= Start time of measurement: _yyymmdd-hhmmss → year, month, day – hour minute second)

The programme is set up to make an automatic backup (generate a *.csv file) every 24 hours and resume the measurement by starting a new file. The measurement procedure was repeated here every day. With MiniStor, one cycle was measured every day. During the day in question, the MiniStor was in stand-by mode for the rest of the time remaining.

In the files, as mentioned in the previous sections, the measurement time is always indicated in the first column (in our case in samples every 200 seconds).

5.2. Step (ii): Process exported data, generate (*.xlsx) file

Spreadsheet (*.xlsx files) can be created from *.csv files by opening the *.csv file and selecting *.xlsx in the Save As function. This is preferable for evaluation using Excel as pointed out.

After opening the *.csv files, we copied the measurement contents of all files in chronological order into a *.xlsx file.

With this step, we measured from 26 to 30 June i.e. over five days, and thus ran five test cycles in Winter mode with an average solar input temperature of 70°C.

After this transformation is done, the first column is selected (the measurement dates) and a cell formatting is done to treat the whole column as date and hour (in our programme this is cell formatting/"hhmmss"). This way the cell keeps the date of measurement, but the cell value is "hhmmss", which is important for the next step in the evaluation.

5.3. Step (iii): Processing exported data diagrams

The step after formatting was to determine when the charging and discharging cycles were beginning and ending. This was facilitated by adding an additional worksheet placing graphs of the measurements.

For the case of pumps, we already learned from the measurement procedure section that the charging mode starts with the start of the solar pump, which the MiniStor control automatically switches off when switching to discharging mode. In discharging mode, we have seen in the online control that either the heating or the cooling pump is running, depending on which seasonal mode we are testing. In our example we are looking at winter mode, so the heating pump flowrate is what we are measuring.

As mentioned before, the heat exchanger representing the ÉMI model building requires manual adjustment between winter and summer mode. There is a vortex sv5050 flowrate sensor measuring the heating and cooling pump flow on the circuit. For data processing purposes, it does not matter if the heating or cooling pump are switched on, because the same vortex sv5050 flowrate sensor will measure the flow. This also means that we cannot measure heating and cooling flow at the same time, but this was not a requirement in the design because of the separate operation of winter and summer mode.

The pumps flowrate graphs should be created with the volume of liquid delivered by the pumps on the vertical axis and the elapsed time on the horizontal axis. This diagram is shown in Image 41. The colour codes for the pumps are also shown on the left side of the diagram. The cycles start when the solar pump starts. The cycles end when the solar, cooling, heating pumps and the internal system of the MiniStor have stopped. The starting and stopping of the pumps is clearly shown in the diagram. The stop of the MiniStor's internal system can be clearly seen by the significant drop in power consumption. In our case, the pumps stop if the NH3 level reaches the minimum level, making the MiniStor internal system to also stop.

Image 41 diagram shows five cycles over time. The start of the solar pumps (blue line) is the beginning of the cycle and the stop of the heating pump (yellow line) is the end of the cycle. The diagram shows that the MiniStor control has turned on the heating pump several times to dissipate heat. The stop of the MiniStor cannot be clearly defined by the stop of the heating pump, so the input energies must also be displayed (Image 42). The two diagrams clearly show the start and end of the cycle.

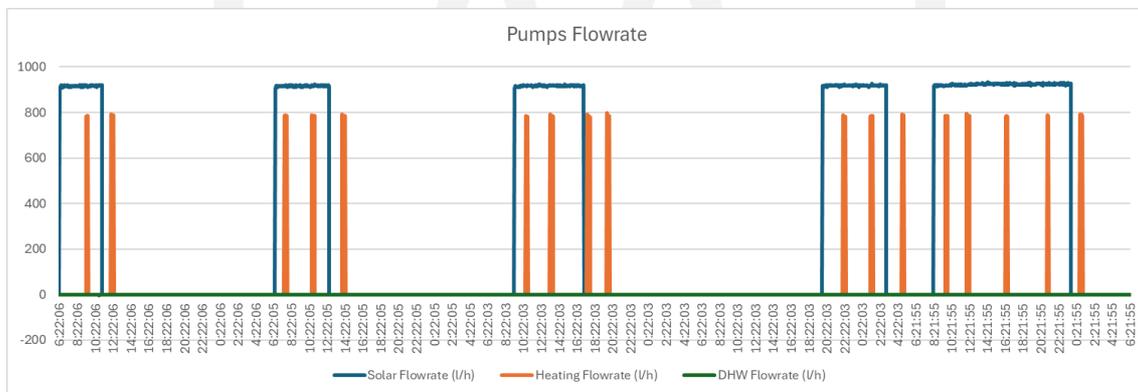


Image 41: Winter 70 (20240626(30)-062208 pumps flowrate

In addition to the pump diagrams, input and output energy were shown separately on a single diagram. They are shown in Images 42-43. The diagrams should be scaled to the same size and placed under each other. This way it is clear to see that, for example, when the solar pump is started and the input energy increases, we conclude that there is a heat flow. If in this example the pump would run but there is no heat energy, this means that the MiniStor's inertia tank is full of liquid at 70°C and there is no or very minimal heat transfer.

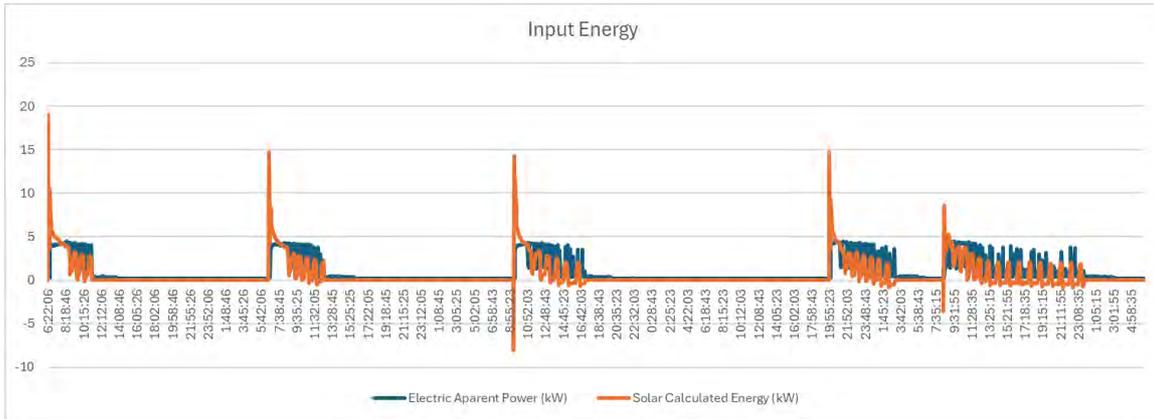


Image 42: Winter 70 (20240626(30)-062208 Input energy

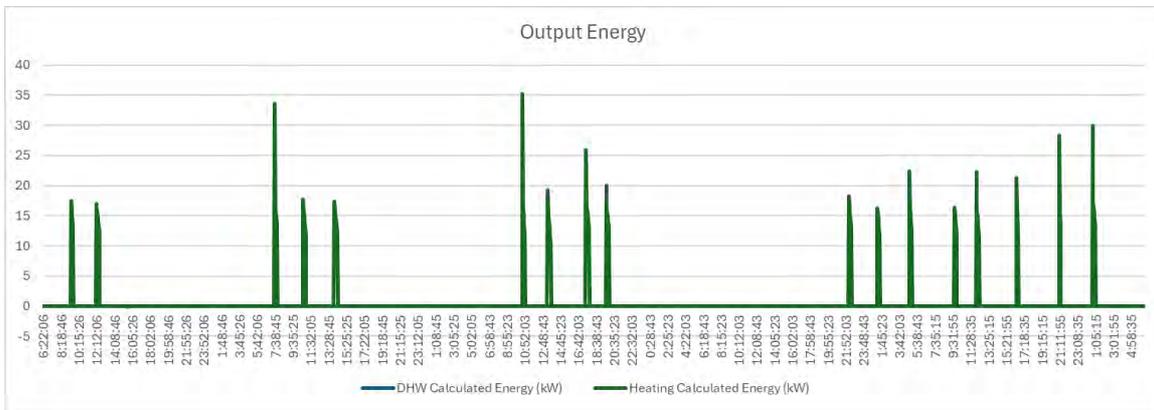


Image 43: Winter 70 (20240626(30)-062208 Output energy

5.4. Step (iv): Processing exported data tables

After the graphs are drawn up, the next step is the evaluation. In the previous chapters, we have already mentioned the advantages of the calculated channels of the data collection software. In this case, we used the calculated channels for the evaluation.

Due to the cyclical operation of the MiniStor, it was considered worthwhile to characterize the performance data with heat capacity values. This characteristic represents the total energy consumed and produced by the MiniStor in a given cycle.

Table 8 shows the correlations used, as entered in the programme for the calculated channels of the data collector.

The calculation relationships and numerical values of the heat capacities per cycle are summarised in Table 9 and Table 10.

Calculated Channels*:

*name

used calculation

Cooling Calculated Energy (kW)	'Heating Flowrate (l/h)*1000*4.19*(Cooling from Building [Thermocouple 1xNiCr-Ni/K] (°C)-Cooling to Building [Thermocouple 1xNiCr-Ni/K] (°C))/3600/1000
Cooling Calculated Energy (kWh)	'Cooling Calculated Energy (kW)/3600*200
Cooling Flowrate (l/h)	'Heating Flow Sensor (PA6T/6I_4) Signal (mA)*(2*1.0858)*60
DHW Calculated Energy (kW)	'DHW Flowrate (l/h)*1000*4.19*(DHW to Building [Thermocouple 1xNiCr-Ni/K] (°C)-DHW from Building [Thermocouple 1xNiCr-Ni/K] (°C))/3600/1000
DHW Calculated Energy (kWh)	'DHW Calculated Energy (kW)/3600*200
DHW Flowrate (l/h)	'DHW Flow Sensor (PA6T/6I_2) Signal (mA)*(2*1.0778)*60
Electric Apparent Power (kW)	'Electric Power Sensor (PQRM5300 33) Apparent Signal (mA)/(1.33)
Electric Apparent Power (kWh)	'Electric Apparent Power (kW)/3600*200
Electric Effective Power (kW)	'Electric Power Sensor (PQRM5300 33) Effective Signal (mA)/(1.33)
Electric Effective Power (kWh)	'Electric Power Sensor (PQRM5300 33) Effective Signal (mA)/(1.33)/3600*200
Heating Calculated Energy (kW)	'Heating Flowrate (l/h)*1000*4.19*(Heating to Building [Thermocouple 1xNiCr-Ni/K] (°C)-Heating from Building [Thermocouple 1xNiCr-Ni/K] (°C))/3600/1000
Heating Calculated Energy (kWh)	'Heating Calculated Energy (kW)/3600*200
Heating Flowrate (l/h)	'Heating Flow Sensor (PA6T/6I_4) Signal (mA)*(2*1.0858)*60
INPUT ENERGY (kW)	'Electric Apparent Power (kW)+'Solar Calculated Energy (kW)'
OUTPUT ENERGY Summer (kW)	'DHW Calculated Energy (kW)+'Cooling Calculated Energy (kW)'
OUTPUT ENERGY Winter (kW)	'DHW Calculated Energy (kW)+'Heating Calculated Energy (kW)'
Solar Calculated Energy (kW)	'Solar Flowrate (l/h)*1000*4.19*(Solar from Panels [Thermocouple 1xNiCr-Ni/K] (°C)-Solar to Panels [Thermocouple 1xNiCr-Ni/K] (°C))/3600/1000
Solar Calculated Energy (kWh)	'Solar Calculated Energy (kW)/3600*200
Solar Flowrate (l/h)	'Solar Flow Sensor (PA6T/6I_1) Signal (mA)*(2*1.0808)*60
Solar Pressure (bar)	'Solar Pressure Sensor (Danfoss MBS4510) Signal (mA)/1.6

Table 8: Winter 70 (20240626(30)-062208 Used Calculation Equations

The explanation of the table is as follows:

The first column of Table 9 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the apparent electricity consumption in kWh is given.

In the third column of the table, the solar thermal energy consumption in kWh is given.

The fourth column of the table shows the heating thermal energy gain in kWh.

The fifth column of the table shows the DHW thermal energy gain in kWh.

In the sixth column of the table, the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		Apparent Electric Power [kWh]	Solar Energy [kWh]	Heating Energy [kWh]	DHW Energy [kWh]	
0626-06	0626-12	16.083	16.251	9.204	0.000	28.5
0627-06	0627-14	18.310	15.432	16.598	0.000	49.2
0628-09	0628-19	19.895	15.523	22.287	0.000	62.9
0629-19	0630-04	19.827	14.495	13.409	0.000	39.1
0630-08	0631-01	26.366	13.951	21.777	0.000	54.0

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 9: Winter 70 (20240626(30)-062208 Results

5.5. Step (v): Calculation of uncertainty in measurement data

Given the measurement results obtained, we needed to determine the measurement uncertainties. In our case, we set up our instruments directly used for data collection using a single reference instrument. Once set up, a value nearly identical to the one displayed on the reference instrument was read on the display of the data acquisition programme.

We measured the amount of electrical energy consumed by the MiniStor (apparent and effective) (kW).

We measured the flow of fluid through each hydraulic circuit (DHW, Solar and Heating-Cooling) (l/h; l/min., etc.).

We measured the fluid temperatures in the connecting piping and the ambient temperature at the MiniStor's outlet points.

When determining the uncertainty of the measured data, we calculate the extent to which the accuracy of the instruments affected the result. In the case of indirect measurement, as for electricity consumption, the manufacturer's data was used. In the case of indirect measurement of energy consumption, the resulting measurement uncertainty was calculated using the formula used to determine the energy consumption.

The thermal energy consumed in the DHW, Solar and Heater-Cooling hydraulic system, was determined using the following relationship (the relationship, discussed in previous chapters):

$$Q[\text{kW}] = V[\text{m}^3/\text{s}] * \rho_w[\text{kg}/\text{m}^3] * c_w[\text{kJ}/\text{kg} * \text{K}] * (t_2[^\circ\text{C}] - t_1[^\circ\text{C}])$$

The efficiency was determined using this relationship. The efficiency is the ratio of the useful energy consumption to the introduced energy consumption expressed as a percentage. The energy consumptions introduced were electricity and solar energy. Useful energy consumptions were

DHW and Heating-Cooling energy, depending on whether winter or summer was the measurement condition under study.

Uncertainty of measurement was determined in accordance with the requirements of Standard EA-4-02M-2022, "Evaluation of the Uncertainty of Measurement in Calibration". The results of the calculation are summarised in Table 10.

In the first column, the row number of the context used in EA-4-02M-2022 is given.

In the second column, we have displayed the name of the characteristic we are calculating.

In the third column we have indicated the uncertainty of measurement by the manufacturer.

In the fourth column, we have displayed the application of the cited context to our case.

In the fifth column, we have indicated the result obtained.

Equation number in the EA-4-02M-2022	Characteristic name:	Uncertainty in Manufacturer datasheet	The equation width our data value	Results
Baseline data:				
(5.1)	Electric Power (kW)	+/- 0.2 (%)	$u=0.2(\%)/2$	(-)
(5.1)	Flow rate (l/h) "V"	+/- 0.2 (%)	$u=0.2(\%)/2$	(-)
(5.1)	Thermocouples (°C) "t1; t2"	+/- 0.7 (°C)	$u=0.7(^{\circ}\text{C})/2$	(-)
Electric Power uncertainty calculation (k=2; 95 %):				
	Example:	+/- 0.2 (%)	max 12 (kW)	+/- 0.024 (kW)
	Uncertainty:	+/- 0.2 (%)		+/- 0.2 (%)
Heat energy uncertainty calculation (k=2; 95 %):				
(4.3)	# V' derivative	(-)	$1 \cdot \rho w \cdot c w \cdot (t2-t1)$	(-)
(4.3)	# t2' derivative	(-)	$V \cdot \rho w \cdot c w \cdot (1-t1)$	(-)
(4.3)	# t1' derivative	(-)	$V \cdot \rho w \cdot c w \cdot (t2-1)$	(-)
	# Measured values	(-)	V; t1; t2	(-)
	# Constant values	(-)	$\rho w; c w$	(-)
Example (csv file row: 2024.06.28 10:38:43 #943):				
(4.1)	Equation:			
			$=2 \cdot \left(\left(\left(\frac{X2}{3600/1000} \right) \cdot \frac{0,2/2}{100} \right) \cdot \left(1 \cdot 1000 \cdot 4,19 \cdot (Z2-Y2) \right) \right)^2 + \left(\left(\frac{0,7/2}{100} \right) \cdot \left(\frac{X2}{3600/1000} \right) \cdot 1000 \cdot 4,19 \cdot (1-0) \right)^2 + \left(\left(\frac{0,7/2}{100} \right) \cdot \left(\frac{X2}{3600/1000} \right) \cdot 1000 \cdot 4,19 \cdot (0-1) \right)^2 \right)^{1/2}$	
	where: X2 (l/h); Y2 (°C); Z2 (°C)			
(4.1)		(-)	35.231 (kW)	+/- 0.905 (kW)
	Uncertainty:			+/- 2.6 (%)

Table 10: Uncertainty Calculation (k=2; 95 %)

The relation for the calculation of the resulting measurement uncertainty is valid for a given measurement point. The exact determination of the measurement uncertainty should be carried out for each measured data. Using the measurement data series used in our example in this chapter, we have plotted the measurement uncertainty as a function of time in Image 44. The diagram in the image shows clearly how the measurement uncertainty of the calculated value evolves for the largest measured values. The most unfavourable value is shown for our measurement data.

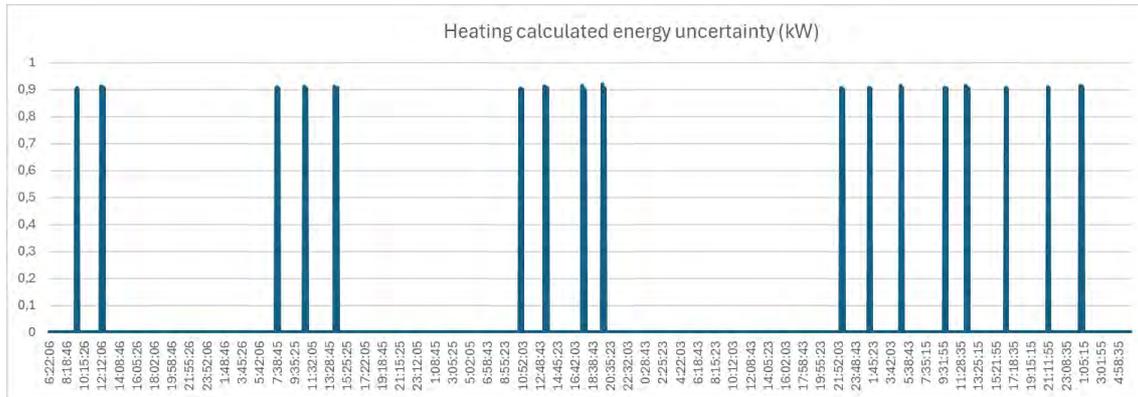


Image 44: Winter 70 (20240626(30))-heating calculated energy uncertainty (kW)

6. Measurement results:

In this chapter we summarise our measurement data. In reporting the measurement data, we have focused on the energy characteristics of the MiniStor.

In case of repeated occurrences of MiniStor malfunctions, as detailed in the next chapter, all measurement data will be sent as an annex to the documentation and will be treated as indicative, after consultation with the manufacturer. In this documentation, we have included those measurements for which we were most confident that there were no warnings within the MiniStor system during the measurements.

The two main features of MiniStor are the winter and summer modes. Within the winter mode two options are possible, the solar to PCM mode and solar tank charged at 70 C. We also included the measurements when the tank reaches a higher temperature of 80 C, which would be a limit condition. Details of the measurement results are given in the further subchapters.

6.1. Solar to PCM Winter mode

In this sub-mode, the MiniStor operates without using the NH₃ tank and NH₃ phase shifter feature. Essentially, it flows thermal energy from the Solar buffer tank directly to the PCM tanks. In turn, the thermal energy flows from the PCM tanks to the building supplied (in our case, the model building). The measurement results are summarised in Table 11 and Table 12. The graphs of heat consumption results are shown in Images 45-47.

The energy efficiency calculation method for this mode is different from the calculation method for the other modes.

The cycle starts when the solar pump is started and the MiniStor Solar system reaches a minimum water temperature of 40°C at the "to Panels" connection.

The end of the cycle was considered to have been achieved when the following three conditions were met:

- The solar pump was off.
- The temperature at the MiniStor DHW "to Building" connection was measured to be below 40°C.
- The MiniStor Heating "to Building" connection was measured to be below 40°C.

In measuring this mode, we investigated the impact of solar pump operating time and solar temperature on energy efficiency.

From the measured data, it can be observed that there was an apparent power failure at the third cycle, which did not significantly affect energy efficiency. For the last cycle, the solar pump was operated for a significantly longer period of time, which adversely changed the energy efficiency.

The first column of Table 11 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the solar temperature is indicated in °C.

The third column of the table the average apparent electrical energy consumption in kW is given.

The fourth column of the table shows the average value of solar thermal energy in kW.

In the fifth column of the table shows the average value of heating thermal energy in kW

In the sixth column of the table, the average value of DHW thermal energy in kW is given.

In the seventh column of the table the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)			OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		Solar temp (°C) +/- 0,7 (°C)	AVG Electric Power (kW) +/- 0.2 (%)	AVG Solar Energy (kW) +/- 2.6 (%)	AVG Heating Energy (kW) +/- 2.6 (%)	AVG DHW Energy (kW) +/- 2.6 (%)	
0418-07	0418-14	85	0.289	2.867	1.772	0.562	73.9
0418-14	0418-17	75	0.290	4.806	2.559	1.138	72.6
0419-07	0419-11	80	0.280	4.425	2.797	1.009	80.9
0419-11	0419-15	70	0.291	4.173	2.278	1.375	81.8
0420-11	0420-15	70	0.296	4.220	2.938	0.992	87.0
0422-07	0422-17	75	0.288	1.880	0.772	0.320	50.4

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = ÉMI; Heating, Cooling pump control = ÉMI

Table 11: Winter mode AVG (Solar to PCM)

The first column of Table 12 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the solar temperature is indicated in °C

In the third column of the table, the apparent electricity consumption in kWh is given.

The fourth column of the table the solar thermal energy consumption in kWh is given.

The fifth column of the table shows the heating thermal energy gain in kWh.

In the sixth column of the table, shows the DHW thermal energy gain in kWh.

In the seventh column of the table the calculated efficiency is given in %

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)			OUTPUT ENERGY (Heating + DHW)		
		Solar temp (°C) +/- 0,7 (°C)	Electric Power (kWh) +/- 0.2 (%)	Solar Energy (kWh) +/- 2.6 (%)	Heating Energy (kWh) +/- 2.6 (%)	DHW Energy (kWh) +/- 2.6 (%)	Efficiency [%]
0418-07	0418-14	85	1.944	19.271	11.912	3.775	73.9
0418-14	0418-17	75	0.886	14.686	7.820	3.478	72.6
0419-07	0419-11	80	0.934	14.749	9.324	3.365	80.9
0419-11	0419-15	70	0.970	13.909	7.595	4.582	81.8
0420-11	0420-15	70	0.988	14.067	9.793	3.306	87.0
0422-07	0422-17	75	2.899	18.902	7.764	3.220	50.4

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = ÉMI; Heating, Cooling pump control = ÉMI

Table 12: Winter mode (Solar to PCM) energy capacity [kWh]

In Image 45, the delivery of the pumps is marked on the vertical axis and the elapsed time is marked on the horizontal axis.

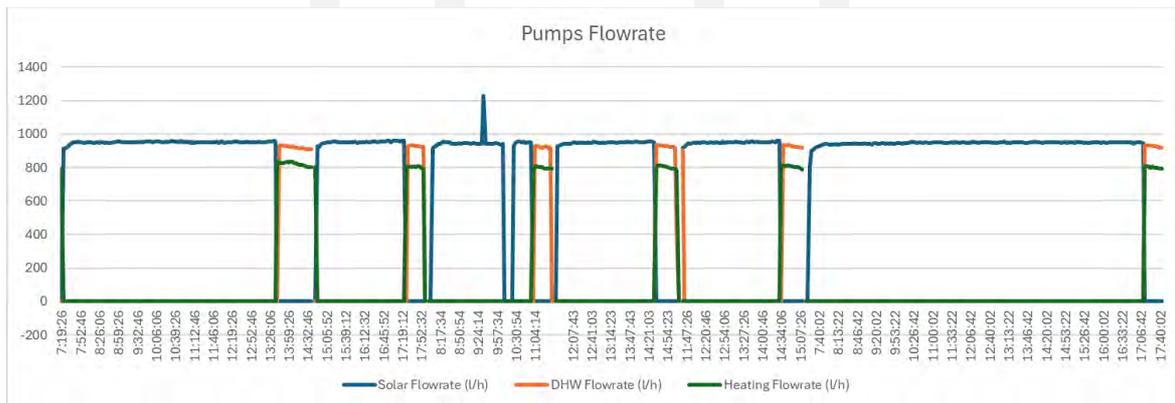


Image 45: Winter mode (Solar to PCM) Pumps flowrate

In Image 46, the input energy (solar energy and apparent electric power) (kWh) is on the vertical axis and the elapsed time is on the horizontal axis.

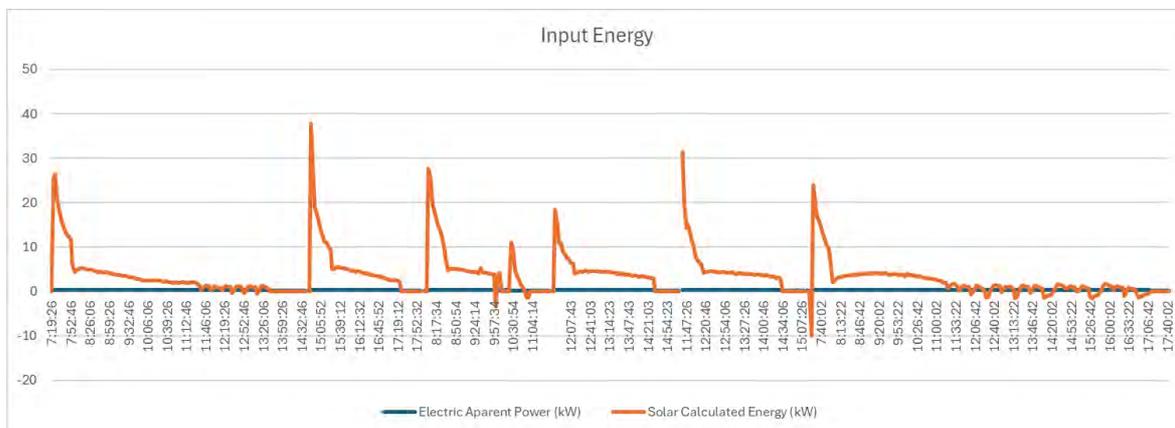


Image 46: Winter mode (Solar to PCM) input energy (kW)

In Image 47, the output energy (DHW heat energy and Heating heat energy) (kWh) is shown on the vertical axis and the elapsed time is shown on the horizontal axis.

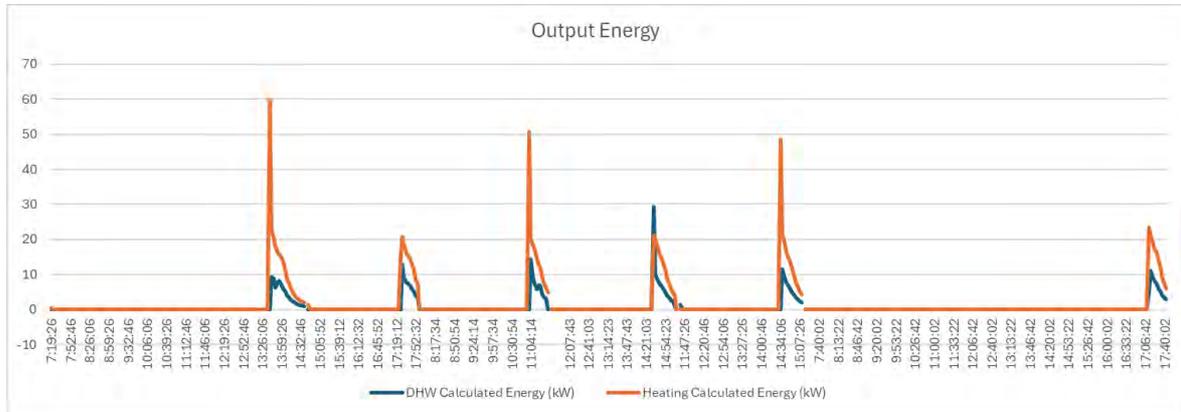


Image 47: Winter mode (Solar to PCM) output energy (kW)

6.2. Solar temperature charging at 70°C Winter mode

The results of the series of measurements using the NH₃ phase change property of the winter mod (solar temp 70°C) are summarized in Table 13 and Table 14. As indicated in the chapter title, the modelled boundary condition is the solar 70°C average liquid temperature. The MiniStor, using this quality of modelled solar thermal energy gain, gave the results summarised in Table 13 and Table 14.

As shown in the previous chapter, graphs of the heat consumption results are shown in Images 48-50.

The first column of Table 13 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the average apparent electrical energy consumption in kW is given.

The third column of the table shows the average value of solar thermal energy in kW.

The fourth column of the table shows the average value of heating thermal energy in kW.

In the fifth column of the table the average value of DHW thermal energy in kW is given.

In the sixth column of the table, the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		AVG Electric Power (kW) +/- 0.2 (%)	AVG Solar Energy (kW) +/- 2.6 (%)	AVG Heating Energy (kW) +/- 2.6 (%)	AVG DHW Energy (kW) +/- 2.6 (%)	
0626-06	0626-12	2.703	2.659	1.506	0.000	28.1
0627-06	0627-14	2.337	1.970	2.119	0.000	49.2
0628-09	0628-19	1.865	1.455	2.089	0.000	62.9
0629-19	0630-04	2.176	1.591	1.472	0.000	39.1
0630-08	0631-01	1.587	0.840	1.311	0.000	54.0

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 13: Winter mode (Solar temp. 70°C): Average Energy results [kW]

The first column of Table 14 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient. In the second column of the table, the apparent electricity consumption in kWh is given. In the third column of the table, the solar thermal energy consumption in kWh is given. The fourth column of the table shows the heating thermal energy gain in kWh. The fifth column of the table shows the DHW thermal energy gain in kWh. In the sixth column of the table, the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		Electric Power (kWh) +/- 0.2 (%)	Solar Energy (kWh) +/- 2.6 (%)	Heating Energy (kWh) +/- 2.6 (%)	DHW Energy (kWh) +/- 2.6 (%)	
0626-06	0626-12	16.083	16.251	9.204	0.000	28.5
0627-06	0627-14	18.310	15.432	16.598	0.000	49.2
0628-09	0628-19	19.895	15.523	22.287	0.000	62.9
0629-19	0630-04	19.827	14.495	13.409	0.000	39.1
0630-08	0631-01	26.366	13.951	21.777	0.000	54.0

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 14: Winter mode (Solar temp. 70°C): Energy capacity results [kWh]

In the Image 48 diagram, the delivery of the pumps is marked on the vertical axis and the elapsed time is marked on the horizontal axis.

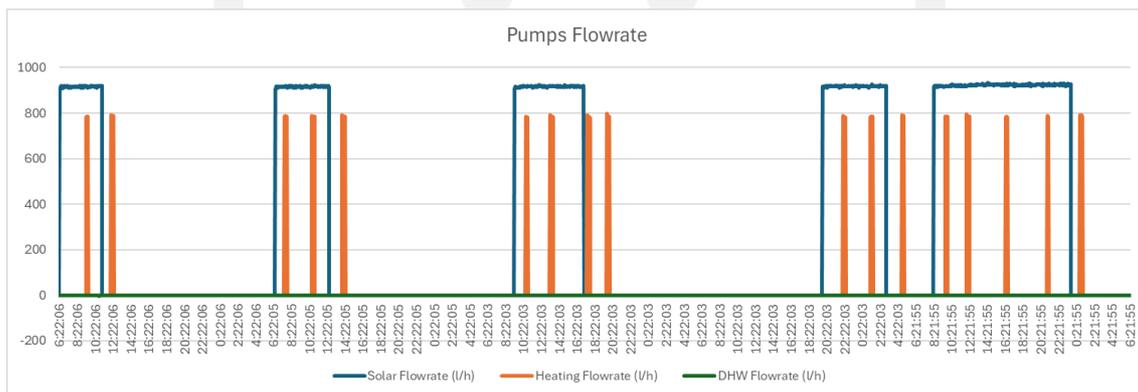


Image 48: Winter mode (Solar temp. 70°C) Pumps flowrate

In the Image 49 diagram, the input energy (solar energy and apparent electric power) (kWh) is on the vertical axis and the elapsed time is on the horizontal axis.

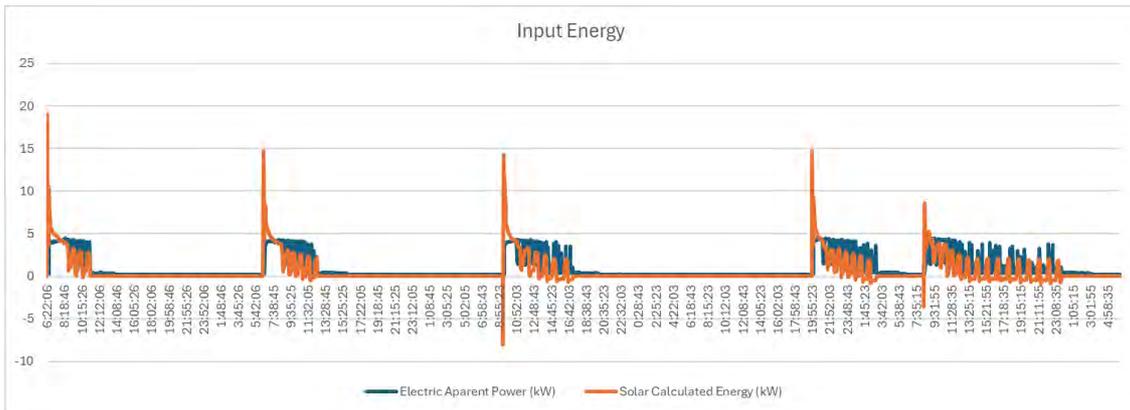


Image 49: Winter mode (Solar temp. 70°C) input energy (kW)

In the Image 50 diagram, the output energy (DHW heat energy and Heating heat energy) (kWh) is shown on the vertical axis and the elapsed time is shown on the horizontal axis.

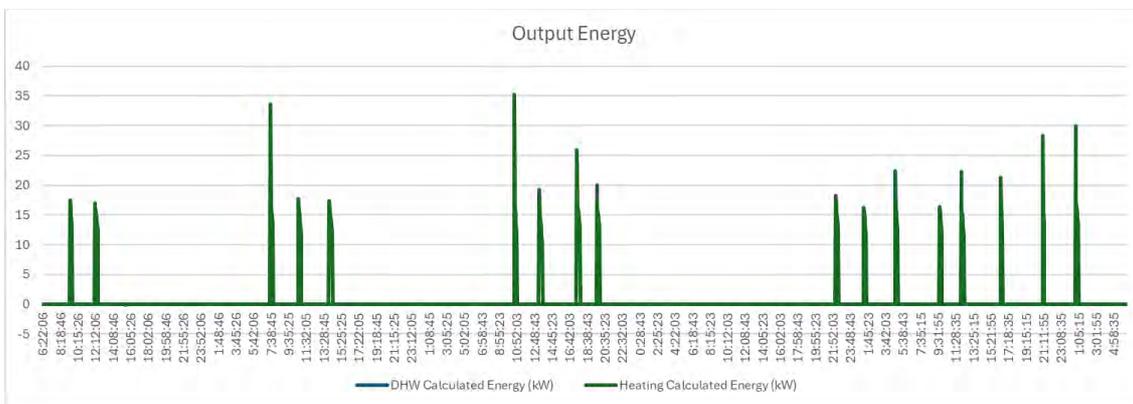


Image 50: Winter mode (Solar temp. 70°C) output energy (kWh)

6.3. Winter mode (Solar temp. 80°C):

The results of the series of measurements using the NH3 phase change property of the winter mode (solar temp 80°C) are summarized in Table 15 and Table 16. As indicated in the chapter title, the modelled boundary condition is the solar 80°C average liquid temperature. The MiniStor, using this quality of modelled solar thermal energy gain, gave the results summarised in Table 15 and Table 16.

In the last rows of the tables, we have included and marked, for representativeness, the data to be evaluated for which the MiniStor had alarms and stops during the measurement.

As shown in the previous chapter, graphs of the heat consumption results are shown in Images 51-53.

The first column of Table 15 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the average apparent electrical energy consumption in kW is given.

The third column of the table shows the average value of solar thermal energy in kW.

The fourth column of the table shows the average value of heating thermal energy in kW.

In the fifth column of the table the average value of DHW thermal energy in kW is given.

In the sixth column of the table, the calculated efficiency is given in %.

		INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		
Start date [mmdd-hh]	End date [mmdd-hh]	AVG Electric Power (kW) +/- 0.2 (%)	AVG Solar Energy (kW) +/- 2.6 (%)	AVG Heating Energy (kW) +/- 2.6 (%)	AVG DHW Energy (kW) +/- 2.6 (%)	Efficiency [%]
0711-00	0711-18	1.010	0.906	0.662	0.749	73.6
0711-18	0712-05	1.791	1.621	1.092	1.458	74.7
0712-05	0713-09	0.883	0.686	0.481	0.710	75.9
0715-13	0716-05	1.112	1.203	0.632	0.972	69.2
0716-05	0716-21	1.300	1.069	0.782	1.013	75.8
0716-21	0717-13	1.331	1.054	0.766	1.047	76.0
0717-14	0718-05	1.164	1.326	0.910	1.064	79.3
0718-05	0719-05	1.353	0.768	0.581	1.142	81.2

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 15: Winter mode (Solar temp. 80°C): Average Energy results [kW]

The first column of Table 16 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient. In the second column of the table, the apparent electricity consumption in kWh is given. In the third column of the table, the solar thermal energy consumption in kWh is given. The fourth column of the table shows the heating thermal energy gain in kWh. The fifth column of the table shows the DHW thermal energy gain in kWh. In the sixth column of the table, the calculated efficiency is given in %.

		INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		
Start date [mmdd-hh]	End date [mmdd-hh]	Electric Power (kWh) +/- 0.2 (%)	Solar Energy (kWh) +/- 2.6 (%)	Heating Energy (kWh) +/- 2.6 (%)	DHW Energy (kWh) +/- 2.6 (%)	Efficiency [%]
0711-00	0711-18	18.400	16.516	12.064	13.644	73.6
0711-18	0712-05	19.904	18.015	12.133	16.204	74.7
0712-05	0713-09	24.184	18.778	13.161	19.442	75.9
0715-13	0716-05	17.675	19.108	10.034	15.438	69.2
0716-05	0716-21	19.929	16.391	11.984	15.535	75.8
0716-21	0717-13	22.413	17.746	12.899	17.617	76.0
0717-14	0718-05	16.362	18.633	12.786	14.949	79.3
0718-05	0719-05	32.330	18.348	13.875	27.288	81.2

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 16: Winter mode (Solar temp. 80°C): Energy capacity results [kWh]

In the Image 51 diagram, the delivery of the pumps is marked on the vertical axis and the elapsed time is marked on the horizontal axis.

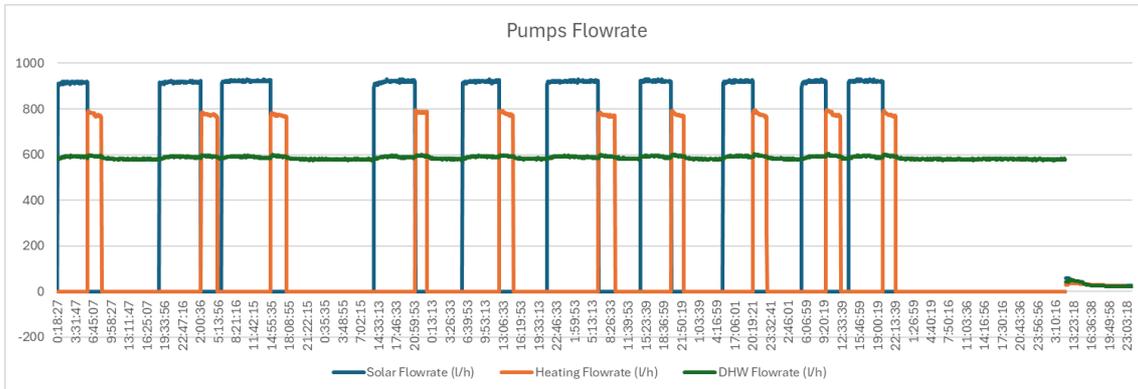


Image 51: Winter mode (Solar temp. 80°C) Pumps flowrate

In the Image 52 diagram, the input energy (solar energy and apparent electric power) (kW) is on the vertical axis and the elapsed time is on the horizontal axis.

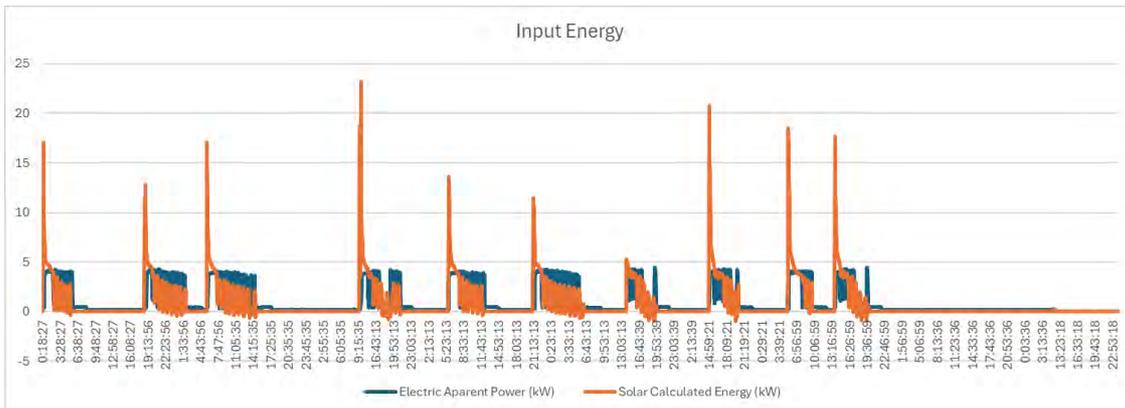


Image 52: Winter mode (Solar temp. 80°C) input energy (kW)

In the Image 53 diagram, the output energy (DHW heat energy and Heating heat energy) (kW) is shown on the vertical axis and the elapsed time is shown on the horizontal axis.

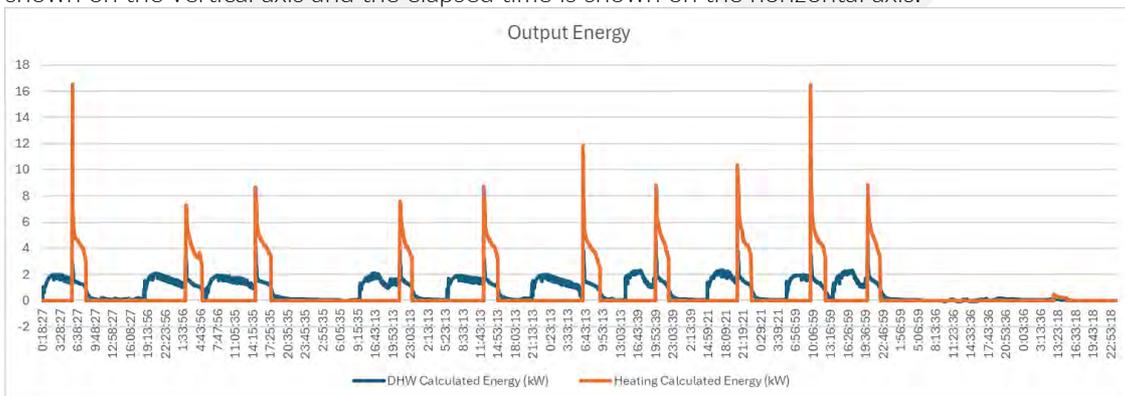


Image 53: Winter mode (Solar temp. 80°C) output energy (kW)

6.4. Summer mode (Solar temp. 70°C):

The results of the series of measurements using the NH3 phase change property of the summer mode (solar temp 70°C) are summarized in Table 17 and Table 18. As indicated in the chapter title,

the modelled boundary condition is the solar 70°C average liquid temperature. The MiniStor, using this quality of modelled solar thermal energy gain, gave the results summarised in Table 17 and Table 18.

As shown in the previous chapter, graphs of the heat consumption results are shown in Images 54-56.

The first column of Table 17 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the average apparent electrical energy consumption in kW is given.

The third column of the table shows the average value of solar thermal energy in kW.

The fourth column of the table shows the average value of cooling thermal energy in kW.

In the fifth column of the table, the average value of DHW thermal energy is given in kW.

In the sixth column of the table, the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		AVG Electric Power (kW) +/- 02 (%)	AVG Solar Energy (kW) +/- 26 (%)	AVG Heating Energy (kW) +/- 26 (%)	AVG DHW Energy (kW) +/- 26 (%)	
0701-14	0702-06	1.027	0.822	0.635	0.631	68.4
0702-06	0702-15	1.810	1.752	0.595	1.070	46.8
0702-15	0703-01	1.626	1.308	0.762	1.057	62.0
0703-01	0703-12	1.747	1.483	0.718	0.954	51.8
0703-12	0704-05	1.103	0.893	0.490	0.666	57.9
0704-05	0704-16	1.697	1.572	0.716	0.981	51.9
0704-16	0705-05	1.340	1.043	0.222	0.840	44.6
0705-05	070516-16	1.773	1.587	0.702	0.999	50.6

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 17: Summer mode (Solar temp. 70°C): Average Energy results [kW]

The first column of Table 18 is the start and end date of the measurement (mmdd-hh - mmdd-hh). In the names of the exported files, the start date of the measurement is more detailed, but for clear identification, the value shown in the table was considered sufficient.

In the second column of the table, the apparent electricity consumption in kWh is given.

In the third column of the table, the solar thermal energy consumption in kWh is given.

The fourth column of the table shows the heating thermal energy gain in kWh.

The fifth column of the table shows the DHW thermal energy gain in kWh.

In the sixth column of the table, the calculated efficiency is given in %.

Start date [mmdd-hh]	End date [mmdd-hh]	INPUT ENERGY (Electric + Solar)		OUTPUT ENERGY (Heating + DHW)		Efficiency [%]
		Electric Power (kWh) +/- 0.2 (%)	Solar Energy (kWh) +/- 2.6 (%)	Heating Energy (kWh) +/- 2.6 (%)	DHW Energy (kWh) +/- 2.6 (%)	
0701-14	0702-06	15.865	12.696	9.800	9.743	68.4
0702-06	0702-15	16.187	15.672	5.324	9.571	46.8
0702-15	0703-01	16.168	13.004	7.576	10.513	62.0
0703-01	0703-12	19.601	16.638	8.061	10.706	51.8
0703-12	0704-05	18.199	14.735	8.087	10.997	57.9
0704-05	0704-16	18.949	17.556	7.997	10.960	51.9
0704-16	0705-05	16.973	13.211	2.809	10.639	44.6
0705-05	0705-16	18.909	16.926	7.484	10.655	50.6

Pump controls: DHW pump control = ÉMI; Solar pump START = ÉMI; Solar pump STOP = MiniStor; Heating, Cooling pump control = MiniStor

Table 18: Summer mode (Solar temp. 70°C): Energy capacity results [kWh]

In Image 54, the delivery flowrate of the pumps is marked on the vertical axis and the elapsed time is marked on the horizontal axis.

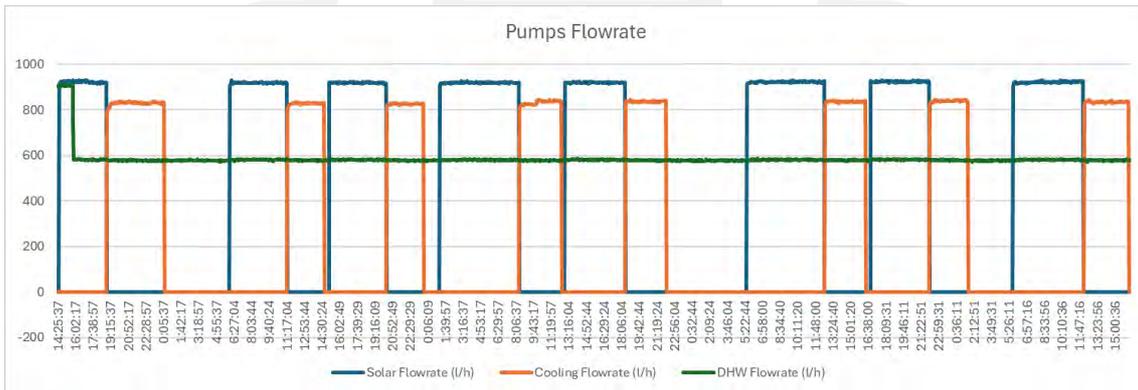


Image 54: Summer mode (Solar temp. 70°C) Pumps flowrate

In the diagram of Image 55, the input energy (solar energy and apparent electric power) (kWh) is on the vertical axis and the elapsed time is on the horizontal axis.

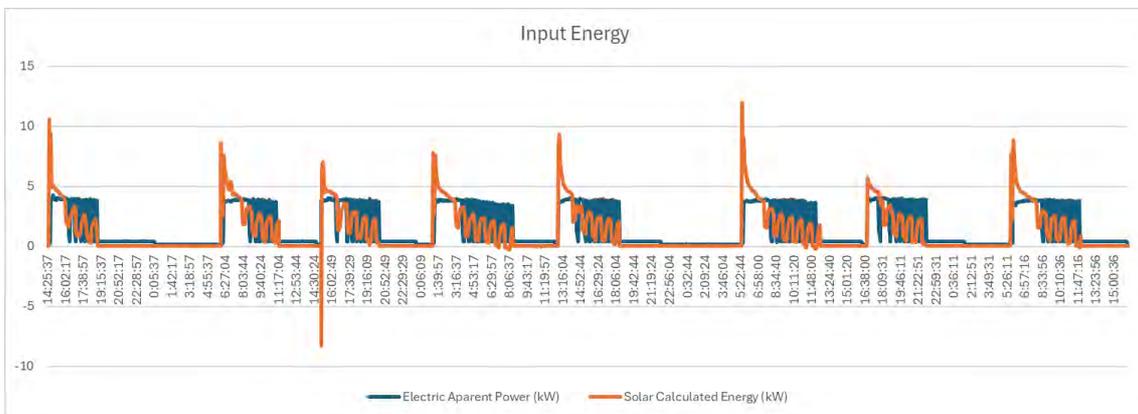


Image 55: Summer mode (Solar temp. 70°C) input energy (kWh)

In Image 56, the output energy (DHW heat energy and Heating heat energy) (kWh) is on the vertical axis and the elapsed time is on the horizontal axis.

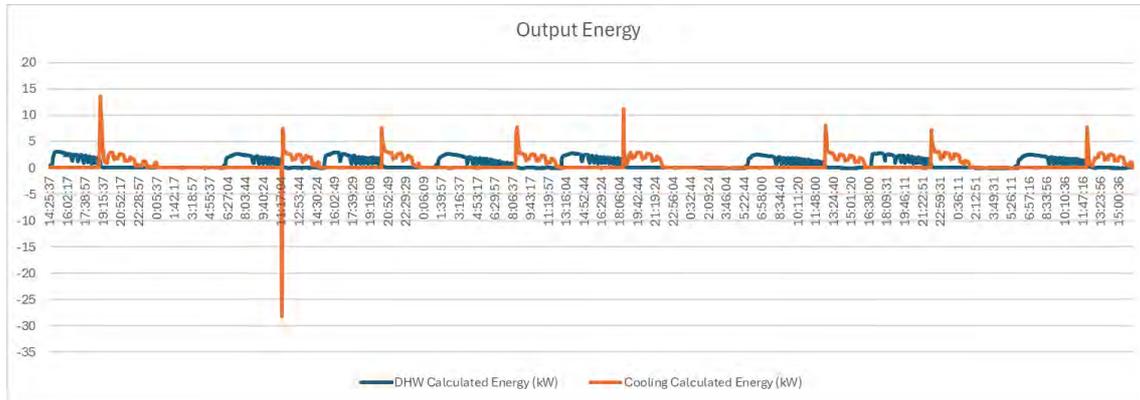


Image 56: Summer mode (Solar temp. 70°C) output energy (kWh)

6.5. Measurement of MiniStor operating pressure

Based on the measurement experience, we measured the pressure response of the MiniStor pumps at the end of our measurements. The measurement procedure is described in the previous chapters. With this measurement data, it was possible to clearly determine the pipe network parameters under which the energy characteristics of the MiniStor were measured. The results of the measurement are shown in Table 19 and the graph summarising the measurement conditions is shown in Image 57.

It is important to note that if we set the boundary condition values indicated in the measurement locations marked in Image 57, our measurement conditions will be almost the same as in our measurements.

Independent of size of the piping system, the type of filter installed, etc., if the system flowrate and pressure drop are the same, the hydraulic conditions will be the same as well.

Measured

system:	Flowrate (l/h):	Δp 1 (kPa):	Δp 2 (kPa):	Δp 3 (kPa):	Δp_{AVG} (kPa):
DHW	520	2.97	3.00	3.01	~3.00
DHW	813 (810)**	7.24	7.14	7.20	~7.20
Heating:	694 (700)**	25.3	25.3	25.3	25.3
Cooling	701 (700)**	23.3	23.3	23.2	23.3
Solar	876 (880)**	34.9	35.0	35.0	35.0

** these values are used in Image 56

Pump controls: DHW pump control = $\acute{E}MI$; Solar pump START = $\acute{E}MI$; Solar pump STOP = $\acute{E}MI$; Heating, Cooling pump control = $\acute{E}MI$

Table 19: MiniStor pressure characteristics



Image 57: MiniStor pressure characteristics

7. Faults causing interruptions to the measurements

As an experimental equipment being used for the first time, the thermal storage prototype was expected to develop certain faults or interruptions that could produce gaps in the measurements. In this section, we summarise those events that interrupted data gathering which had an impact on the duration of our measurements and the evaluation process. These are documented due to the novelty of the system and which also helped to provide feedback by the rest of partners in terms of solving problems and situations that could produce a system stoppage.

7.1. MiniStor internal pipe system leakage:

A small piping mistake was done during installation, which caused slight leakages in one water pump as shown in Image 58. During a first round of measurements, these leaks increased and became more significant. As part of its failsafe, the MiniStor control system repeatedly shut down the equipment providing the corresponding alarms. These water leaks caused a pressure loss in the system that made the thermal energy flow difficult and hindered the flow of heat energy. The alarm detected a fault in the thermal energy flow process and shut down the MiniStor system.

We consulted with the manufacturer constantly and discussed how to fix the leaks. The manufacturer was very receptive to our suggestions to fix the faults. In May 2024, during a stoppage caused by a fault in the NH₃ compressor, these leaks were repaired.



Image 58: MiniStor water Pipe system leakage 1



Image 59: MiniStor water Pipe system leakage 2

7.2. Setting MiniStor operating parameters online

The MiniStor is a prototype device and at the time, the first launch had been done at the pre-demo site of Thessaloniki. As a consequence, the setup and operation experience were limited to one demo site, and there was limited connectivity to the data cloud, making the setup of parameters to remain constant at the local level.

We were in constant communication with the manufacturer (Psycrotherm) and with CARTIF as the partner managing online control. They were flexible and very cooperative in handling the situation.

7.3. Faults in the NH₃ compressor

During measurement, the component had faults twice, stopping the entire system. According to the manufacturer, the causes of the fault must be found before restarting. The first occasion was solved by the manufacturer replacing the compressor with a new one. In the second occasion, this forced the stoppage of measurements, even though sufficient data was collected beforehand to characterize system performance. By that time, it was also required to send the prototype to its final destination at Sopron demo site, so the compressor will be examined there.

7.4. Faults in NH₃ level indicator

During our measurements and after replacing the NH₃ compressor, we found some discrepancies between our measurement data and the manufacturer's online interface. As confirmed by the manufacturer, the discrepancies were caused by a malfunction of the NH₃ tank level indicator. As a workaround, manual recalibration was done for the level indicator according to the manufacturer's instructions and consultation, which required dismantling the instrument casing. The manufacturer was very helpful and gave proper instructions to perform the operation. As a check, the level indicator reading in charging and discharging mode had to be monitored manually using both the digital display and the control view holes on the side of the tank. Pictures of the manual control of the levels are shown in Images 60-64.

Image 60: NH₃ Receiver Tank Level Indicators



Image 61: NH₃ Level 90% In the NH₃ Receiver tank



Image 62: NH₃ Level 90% in the MiniStor control main screen

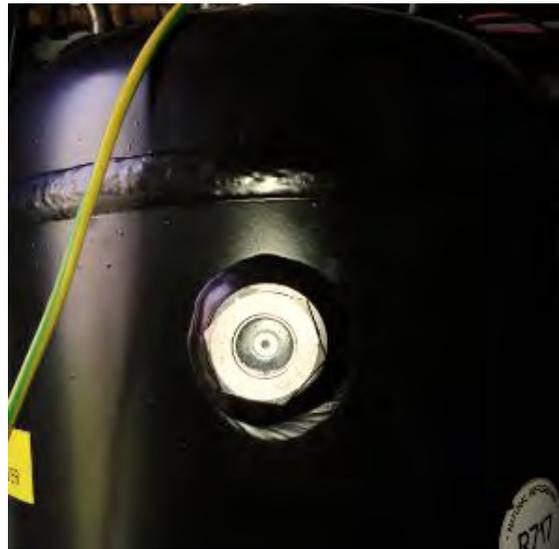


Image 63: False reading of 90% NH₃ Level indicator in the NH₃ Receiver tank



Image 64: Actual NH₃ Level at 78%

7.5. Residual effects of indicator level

Measurements were stopped mid 2024 as the MiniStor NH₃ level indicator fault persisted and the NH₃ compressor had a fault for a second time.

Due to the unit being an experimental prototype, and in consultation with the manufacturer, our measurement data should therefore be **treated as indicative**. Based on this discussion, we included the data of our first test measurements in our measurement data. These first test measurements can be seen from the measurement data by the fact that the headers in the exported *csv files have different names. In the exported data, however, the units of the measured characteristics are indicated in the header in all cases. Based on the data reported so far, the energy characteristics can be calculated from all exported data.

8. Energy functions of operation modes from measurement data

The analysis of the measurement data is based on the MiniStor features mentioned in the introductory chapter. It is important to note that the conversion of electrical energy from solar energy (also a MiniStor function) was not considered nor measured. Measurements only were done to the heat input and output section of the prototype.

8.1. Winter mode Solar to PCM

Winter mode in the solar to PCM function, essentially makes the solar buffer tank release the thermal energy stored in it. This thermal energy is DHW and heating thermal energy only. This function bypasses the NH₃ phase change process. The energy storage function in this case is the heat content of the hot water stored in the solar buffer tank

8.2. Winter mode solar temp. 70°C

The results for winter mode (solar temp. 70°C) are measured using the MiniStor NH₃ phase shifter function with a solar temperature input parameter set to 70°C. The results of the energy indicators show a significant scatter in comparison to each other. One suspected reason are the interruptions to the measurements reported in the previous section.

The energy conversion function in this case is formed by the use of energies from electrical energy (pumping works and NH₃ compressor (2.2 kW) and HP pump (0.75 kW)) and solar thermal energy. The energy gains will be cooling energy (ejected to the open air via Fan Coil), DHW and Heating thermal energy.

The energy storage function in this case is the NH₃ tank already used for NH₃ phase change. The heat capacity from the hot water stored in the solar buffer tank is not used by the control in this function.

8.3. Winter mode solar temp. 80°C

The results of the winter mode (solar temp. 80°C) are measured using the MiniStor NH₃ phase shifter function with the solar temperature set to 80°C as input parameter. The calculated efficiencies from the energy sensor results vary by about ~12%. The calculated efficiency values show significantly better results than the Winter mode solar temp. 70°C measurements.

The energy conversion function in this case is designed so that the energies used are electrical energy (pumping works and NH₃ compressor (2.2 kW) and HP pump (0.75 kW)) and solar thermal energy. The energy gains will be cooling energy (ejected to the outside via Fan Coil), DHW and Heating thermal energy.

The energy storage function in this case is the NH₃ tank used for NH₃ phase change. The heat capacity from the hot water stored in the solar buffer tank is not used by the control in this function.

8.4. Summer mode solar temp. 70°C

The results of the summer mode (solar temp. 70°C) are measured using the MiniStor NH₃ phase shifter function with a solar temperature input parameter set to 70°C. The efficiencies calculated from the results of the energy characteristics are within ~17% of each other. The calculated

efficiency values show relatively better results than the Winter mode solar temp. 70°C measurements.

The energy conversion function in this case is formed by the energy used being electrical energy (pumping works and NH₃ compressor (2.2 kW) and HP pump (0.75 kW)) and solar thermal energy. The energy gains will be cooling energy (ejected to the open air via Fan Coil), DHW and Heating thermal energy.

The energy storage function in this case is already the NH₃ tank used for NH₃ phase change. The heat capacity from the hot water stored in the solar buffer tank is not used by the control in this function.



9. Conclusions

The energy conversion function of the MiniStor can provide in a compact device cooling, DHW and heating thermal energy from electricity and solar energy.

The energy storage capability is a highly advantageous solution that uses the NH₃ phase change process to store thermal energy, which is also cooling energy as mentioned above. The solar buffer tank is also available for thermal energy storage for certain cases (e.g. if the NH₃ circuit is under maintenance and heat is still required).

The scheduling of each mode is programmable. During our discussions with the manufacturer and the online control partner, they were able to resolve almost any setup request on the online control interface. This allowed us to start the solar pump from the online control, without the need of having the solar thermal panels.

Despite the faults described in Section 7, which correspond to those of a prototype device, the MiniStor system always operated safely. In case of faults being detected, emergency stops were properly performed, bringing the system to a safe state. The causes of the alarms were traceable using the online control.

The average storage capacities of the MiniStor can be found in the tables of measurement results. The "OUTPUT ENERGY" values, displayed in kWh, indicate the storage capacity measured at the given operating condition.

It is important to note that the MiniStor was used with the same settings as recommended for the demo sites, with the following exceptions for operating the prototype. This can introduce a difference in the measurement of storage capacities and thermal efficiencies when compared with monitoring from the demonstration sites:

- the solar pump was started manually by us (ÉMI)
- parameters had to be set manually at the PLC and not as response of solar controllers.
- the solar energy was artificially generated and did not use the same dynamic of the solar thermal panels (combined flat plate collectors and photovoltaic thermal panels).
- Heating and cooling demands are generated by a heat exchanger and not by specific occupancy patterns that require fulfilling thermal comfort.
- the MiniStor unit was shut down automatically after discharging mode.
- In the demo sites, the charging, discharging modes are in continuous operation, while cycles in the EMI test could be interrupted after their completion.
- Operation modes have been streamlined as a response to the challenges that were faced during our measurements, such as the defective NH₃ level sensors and other operation challenges to accommodate solar-heated water input.

The calculated energy capacities for each mode according to these test conditions are as follows:

Winter Mode (Solar to PCM):	AVG Energy capacities: 13 kWh
Winter Mode (Solar temp 70°C):	AVG Energy capacities: 17 kWh (+) energy loss fan coil kWh
Winter Mode (Solar temp 80°C):	AVG Energy capacities: 30 kWh (+) energy loss fan coil kWh
Summer Mode (Solar temp 70°C):	AVG Energy capacities: 18 kWh (+) energy loss fan coil kWh

The storage capacity of MiniStor provides significantly better results when compared to the thermal storage capacities of water.

For example, hot water in an outdoor insulated tank setting will lose a lot of its heat storage capacity over time. However, the MiniStor will not, since it stores heat energy in a combined thermochemical and phase change process.

We consider that errors that could have occurred during our measurements are so-called "prototype errors". These errors were corrected as soon as possible during our measurements. According to the information received, the reported faults in the MiniStor device that were experienced have been corrected since we stopped measuring.

10. Suggestions for improved use of thermal energy

Our recommendations are based on measurements and experience with the MiniStor prototype, based only on the operation modes available to us and without interfering with any internal processes.

For best efficiency, the MiniStor prototype should be set up as described so that it can usefully dissipate the heat energy generated during discharging mode, without heat loss from the fan coil. This can be achieved if the building being serviced has mechanical elements that use this thermal energy. For example, an air handling unit for combined cooling and heating energy, air humidity treatment.

During the charging mode, the air handling unit could be in internal circulation mode. The continuous heating demand would be supplied by the MiniStor in "solar to PCM" mode using the solar energy generated. In essence, a suitable combination of charging mode and solar to PCM mode could be used, as far as possible.

In summer, a specific point is when there is no DHW demand in the building and the cooling demand is still maintained during charging mode. The sizing of thermal processing of the building must take into account that during charging mode, the internal temperature of the building must remain within the calibrated tolerance limit.

Taking advantage of the MiniStor's storage function, it could possibly be set to shut down after charging mode if there is no additional heat demand for the building. Due to the phase change process, the stored energy could be available almost immediately for the building to be supplied.

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MSZ EN 12599:2013 *Ventilation for buildings. Test procedures and measurement methods to hand over air conditioning and ventilation systems*

EA-4-02M:2022 Evaluation of the Uncertainty of Measurement in Calibration.

Annexes

- Annex 01: IMI TA Scope_Calibration Certificate (2 page) + (1 photo)
- Annex 02: Multimétre Calibration Certificate (7 pages) + (1 photo)
- Annex 03: SIEMENS WSM515 (T260) Calibration Certificates (6 pages) + (1 photo)
- Annex 04 SIEMENS WSM515 (T260) Calibration Certificates (6 pages) + (1 photo)
- Annex 05 RC12 Manufacturer data sheet (5 pages) + (1 photo)
- Annex 06 DACTON PQRM5300_33_EN data sheet (11 pages) + (1 photo)
- Annex 07 VORTEX SV5050-01_EN-GB data sheet (8 pages) + (3 photos)
- Annex 08 Danfoss MBS4510_EN datasheet (7 pages) + (2 photo)
- Annex 09 Thermocouples Calibration Certificates (12 pages) + (10 photos)
- Annex 10 Ministor_manual_winter_operation (5 pages)
- Annex 11 MiniStor_SCADAQuickUserGuidelines_EN_v1.0 (18 pages)
- Annex 12 Exported measured data (solar to PCM mode) (26 files)
Available at <https://doi.org/10.5281/zenodo.14826571>
- Annex 13 Exported measured data (winter mode) (46 files)
Available at <https://doi.org/10.5281/zenodo.14826571>
- Annex 14 Exported measured data (summer mode) (8 files)
Available at <https://doi.org/10.5281/zenodo.14826571>

Annex 01: IMI TA Scope_Calibration Certificate (2 page) + (1 photo)



KALIBRÁLÁSI BIZONYÍTVÁNY

Megrendelő neve, címe: **ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.**
2000 Szentendre, Dózsa György út 26.

Kalibrálandó mérőeszköz megnevezése: **Számkijelzésű nyomáskülönbség mérő külső érzéklővel**

Gyártó, típus, gyári szám: **IMI** Tip.: TA SCOPE Gy.sz.: 14769

Méréshatár: **3 ... 1000** kPa

Elfogadási hibahatár: 3 - 10 kPa tartományban: $\pm 0,2$ kPa
100 - 1000 kPa tartományban: $\pm 0,1$ kPa

Külső érzékelő: **DpS-Visio** Gy.sz.: 102112209

Egyedi azonosító szám: 1388

Átvételi állapot: Használt / kalibrálásra alkalmas

A kalibráláshoz használt etalonok megnevezése, gyári száma, és a visszavezethetőséget igazoló dokumentum:

1. Nyomásetalon: **Budenberg 551A** gy.sz.: A7154 BFKH MMFF NYO-0102/2019

2. Nyomásetalon: **SI 6390-6/X3000** gy.sz.: 8322/X3000 ATKIS 73407

Egyéb mérőeszköz:

Hőmérő **ATKIS TM6** gy.sz.: – **KALIBRA 59 K/101849**

Kalibrálás eredményei:

Névl. érték (kPa)	Leolvasott érték (kPa)		Hiba (kPa)		Elfogadási hibahatár [TL]	Kiterjesztett mérési bizonytalanság (kPa) [U]
	növekvő	csökkenő	növekvő	csökkenő		
3	2,95	2,97	-0,05	-0,03	$\pm 0,2$ kPa	0,0058
5	4,90	4,90	-0,10	-0,10		0,0058
10	10,0	10,1	0,0	0,1		0,058
100	99,9	99,9	-0,1	-0,1	$\pm 0,1$ kPa	0,059
500	500	500	0	0		0,58
1000	1000	1000	0	0		0,59

Környezeti hőmérséklet: 22,2 °C

Kalibrálás módja: Közvetlen összehasonlítással KE-1/2018 kalibrálási eljárás alapján.

Visszavezethetőség: Az alkalmazott használati etalonokkal mért értékek az országos etalonokra visszavezethetők.

A közölt mérési eredmények a manométer talált metrológiai jellemzőire vonatkoznak.

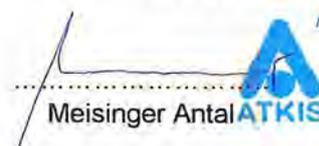
A kiterjesztett mérési bizonytalanság a 2-es szorzóval megszorított standard bizonytalanság, azaz $k=2$, amely normális eloszlás esetén közelítőleg 95%-os fedési valószínűségnek felel meg.

Ez a bizonytalanság tartalmazza az etalonokból, a kalibrálás módszerével a környezeti feltételekből és a kalibrált eszköz okozta rövid ideig tartó hatásokból eredő részbizonytalanságokat az EA-4/02 szerint.

Minősítés: ¹ A közölt kalibrálási eredmények alapján a készülék a megrendelő pontossági igényének ($w = 0$ biztonsági sávval) **megfelel.**

A kalibrálás helye és időpontja: **ATKIS AUTOMATIKA Kft. Kalibráló Laboratórium**
Budapest, 2022.09.21.

Kiadás dátuma: 2022.09.21

Kalibrálást végezte:  **Meisinger Antal**  **ATKIS** 
Kalibráló Laboratórium
1161 Bp., Köztársaság útja 9.
Tel.: 06-1-329-5453
Tel./Fax: 06-1-451-0981

Ellenőrizte:  **Muszka Zoltán**

¹ Döntési szabály: **ILAC-G8:09/2019 [4.2.1]**

Annex01: IMI TA Scope (1 photo):



Image 1: IMI TA Scope

Annex 02: Multimeter Calibration Certificate (7 pages) + (1 photo)

KALIBRÁLÁSI BIZONYÍTVÁNY

Certificate of Calibration

A mérőeszköz típusa / Part number : MX 54C**Megnevezése / Description : Digital multimeter****Gyári száma / Serial number : 249804XAX****Eszköz azonosító / Asset number : -****Gyártó / Manufacturer : Metrix****A tulajdonos neve / Name of the owner : ÉMI Építésügyi Minőségellenőrző Innovációs NKFT.****A tulajdonos címe / Address of the owner : H-2000 Szentendre, Dózsa György út 26.****A megrendelő neve / Name of the customer : ÉMI Építésügyi Minőségellenőrző Innovációs NKFT.****A megrendelő címe / Address of the customer : H-2000 Szentendre, Dózsa György út 26.****A megrendelés száma / Number of order : 44503****Átvételi állapot / Incoming condition : Üzemképes / Serviceable****A kalibrálás helye / Place of calibration : ACE KL. 8/A szoba****A kalibrálás körülményei / Environmental conditions****Hőmérséklet / Temperature : 23,4 °C****Páratartalom / Humidity : 46,3 %rH****A kalibrálás dátuma / Date of calibration : 2023.05.19****A kalibrálás módja / Method of calibration****Eljárás azonosítója / No. of calibration procedure : KE01/06****Dokumentáció száma / No. of documentation : M87/14****A kalibráláshoz használt etalonok, mérőeszközök / The reference, working standards:**

Megnevezés (Description)	Típus (Part number)	Gyári szám (S/N)	Kal.biz.szám (S/N of Cal.Cert.)	Kal.dátuma (Date of Cal.)	Kal. ciklus lejár (Due date)
hő és páratartalom regisztráló	42280	9105029	HE425/23	2023.04.03	2024.04.
ac/dc kalibrátor	9000	27255	HE713/22	2022.07.12	2023.07.
referencia multiméter	8508A	906651995	RE10/22	2022.06.30	2024.06.
ellenállás dekád	RK11M	65523	HE949/22	2022.09.07	2023.09.

Az etalonok révén a mérések eredményei nemzeti és nemzetközi etalonokra vannak visszavezetve.

The results of measurements with the standards are traceable to national and international standards.

Mérési eredmények / Measurement results:

A készülék részletes mérési eredményeit a következő oldal(ak) tartalmazza(ák).

The results of the calibration are give on the next page(s).

Mérési bizonytalanság / Uncertainty of the measurement:

A mérési bizonytalanság kiszámítása az EA-4/02 M dokumentum szerint történt.

A kiterjesztett mérési bizonytalanság a kettes kiterjesztési tényezővel megszorított standard bizonytalanság, azaz $k=2$, ami normál eloszlás esetén 95 %-os konfidencia szintnek felel meg.

The uncertainty was calculated in accordance with the document EA-4/02 M.

The reported expanded uncertainties are based on the standard uncertainties multiplied by a coverage factor $k=2$, providing a level of confidence of approx. 95 %.

Bélyegzés / Marking:

Az ACE Kalibráló Labor címkéjével ellátva. / The instrument is marked with label of ACE Calibration Laboratory.

Megjegyzés / Note:

A bizonyítványban közölt adatok a mérőeszköz talált metrológiai jellemzőire vonatkoznak.

The certificate reports the results at the time of the calibration.

A megrendelő a kalibrálási ciklusidő ajánlását kérte /

Igen / Yes Nem / No

The customer has requested to give a recommended calibration interval

A mérőeszköz rendeltetésszerű használata és az előírás szerinti gondos tárolása és szállítása esetén az újra kalibrálás javasolt ciklus ideje: - hónap

In case of proper usage and handling of the instrument the proposed interval of the calibration is: - months.

Minősítés / Statement of compliance:

A megrendelő a minősítést kérte / The customer has requested the evaluation :

Igen / Yes Nem / No

Követelmények / Basis of evaluation : -

Kiadható / Approved by:

A kiadás dátuma / Date of issue: 2023.05.19



.....
Bujtás István
Kalibráló Labor vezető / Head of Cal. Lab.

1. DC feszültségmérés ellenőrzése / Check DC voltage measurement

Méréshatár	Helyes érték	Mért érték	Hiba	Hibahatár	Mérési biz.	Kiértékelés
Range	True value	Meas. Value	Error	Limits of error	Uncertainty	Evaluation
[mV]	[mV]	[mV]	[mV]	[mV]	[mV]	
500	25,00	24,98	-0,02	-	0,01	-
500	250,00	249,85	-0,15	-	0,02	-
500	475,00	474,72	-0,28	-	0,01	-
500	-475,00	-474,70	0,30	-	0,01	-
[V]	[V]	[V]	[V]	[V]	[V]	
5	0,2500	0,2498	-0,0002	-	0,0001	-
5	2,5000	2,4985	-0,0015	-	0,0002	-
5	4,7500	4,7472	-0,0028	-	0,0001	-
5	-4,7500	-4,7470	0,0030	-	0,0001	-
50	2,500	2,498	-0,002	-	0,001	-
50	25,000	24,985	-0,015	-	0,002	-
50	47,500	47,471	-0,029	-	0,001	-
50	-47,500	-47,469	0,031	-	0,001	-
500	25,00	24,98	-0,02	-	0,01	-
500	250,00	249,86	-0,14	-	0,02	-
500	475,00	474,73	-0,27	-	0,01	-
500	-475,00	-474,68	0,32	-	0,01	-
1000	50,0	49,9	-0,1	-	0,1	-
1000	500,0	499,6	-0,4	-	0,1	-
1000	950,0	949,4	-0,6	-	0,1	-
1000	-950,0	-949,3	0,7	-	0,1	-

2. AC feszültségmérés ellenőrzése (f=50 Hz) / Check AC voltage measurement (f=50 Hz)

Méréshatár	Helyes érték	Mért érték	Hiba	Hibahatár	Mérési biz.	Kiértékelés
Range	True value	Meas. Value	Error	Limits of error	Uncertainty	Evaluation
[mV]	[mV]	[mV]	[mV]	[mV]	[mV]	
500	25,00	25,04	0,04	-	0,12	-
500	250,00	250,30	0,30	-	0,14	-
500	475,00	475,00	0,00	-	0,44	-
[V]	[V]	[V]	[V]	[V]	[V]	
5	0,2500	0,2502	0,0002	-	0,0001	-
5	2,5000	2,4957	-0,0043	-	0,0014	-
5	4,7500	4,7410	-0,0090	-	0,0044	-
50	2,500	2,502	0,002	-	0,001	-
50	25,000	24,960	-0,040	-	0,014	-
50	47,500	47,396	-0,104	-	0,029	-
500	25,00	25,05	0,05	-	0,01	-
500	250,00	249,61	-0,39	-	0,17	-
500	475,00	473,95	-1,05	-	0,35	-
750	37,5	38,0	0,5	-	0,1	-
750	375,0	375,0	0,0	-	0,3	-
750	662,5	662,0	-0,5	-	0,5	-

3. DC árammérés ellenőrzése / Check DC current measurement

Mérés határ	Helyes érték	Mért érték	Hiba	Hibahatár	Mérési biz.	Kiértékelés
Range	True value	Meas. Value	Error	Limits of error	Uncertainty	Evaluation
[μA]						
500	25,00	25,00	0,00	-	0,02	-
500	250,00	249,90	-0,10	-	0,08	-
500	475,00	474,79	-0,21	-	0,22	-
[mA]						
5	0,2500	0,2499	-0,0001	-	0,0001	-
5	2,5000	2,4987	-0,0013	-	0,0007	-
5	4,7500	4,7485	-0,0015	-	0,0026	-
50	2,500	2,499	-0,001	-	0,001	-
50	25,000	24,989	-0,011	-	0,002	-
50	47,500	47,484	-0,016	-	0,003	-
500	25,00	24,99	-0,01	-	0,01	-
500	250,00	249,90	-0,10	-	0,07	-
500	475,00	474,98	-0,02	-	0,10	-
[A]	[A]	[A]	[A]	[A]	[A]	
10	0,500	0,499	-0,001	-	0,001	-
10	5,000	4,985	-0,015	-	0,005	-
10	9,500	9,471	-0,029	-	0,008	-

4. AC árammérés ellenőrzése (f=50 Hz) / Check AC current measurement (f=50 Hz)

Mérés határ	Helyes érték	Mért érték	Hiba	Hibahatár	Mérési biz.	Kiértékelés
Range	True value	Meas. Value	Error	Limits of error	Uncertainty	Evaluation
[μA]						
500	25,00	25,05	0,05	-	0,03	-
500	250,00	249,54	-0,46	-	0,55	-
500	475,00	473,28	-1,72	-	0,73	-
[mA]						
5	0,2500	0,2503	0,0003	-	0,0006	-
5	2,5000	2,4954	-0,0046	-	0,0024	-
5	4,7500	4,7372	-0,0128	-	0,0075	-
50	2,500	2,503	0,003	-	0,002	-
50	25,000	24,957	-0,043	-	0,024	-
50	47,500	47,396	-0,104	-	0,081	-
500	25,00	25,03	0,03	-	0,02	-
500	250,00	249,55	-0,45	-	0,27	-
500	475,00	473,85	-1,15	-	1,10	-
[A]	[A]	[A]	[A]	[A]	[A]	
10	0,500	0,509	0,009	-	0,001	-
10	5,000	4,996	-0,004	-	0,015	-
10	9,500	9,481	-0,019	-	0,025	-

5. Ellenállás mérés ellenőrzése / Check resistance measurement

Méréshatár	Helyes érték	Mért érték	Hiba	Hibahatár	Mérési biz.	Kiértékelés
Range	True value	Meas. Value	Error	Limits of error	Uncertainty	Evaluation
[Ω]	[Ω]					
500	25,00	24,98	-0,02	-	0,02	-
500	250,00	250,12	0,12	-	0,07	-
500	475,00	475,10	0,10	-	0,17	-
[$k\Omega$]	[$k\Omega$]					
5	0,2500	0,2502	0,0002	-	0,0001	-
5	2,5000	2,4998	-0,0002	-	0,0005	-
5	4,7500	4,7494	-0,0006	-	0,0017	-
50	2,500	2,499	-0,001	-	0,001	-
50	25,000	25,006	0,006	-	0,001	-
50	47,500	47,526	0,026	-	0,001	-
500	25,00	25,00	0,00	-	0,01	-
500	250,00	249,66	-0,34	-	0,08	-
500	475,00	475,26	0,26	-	0,01	-
[$M\Omega$]	[$M\Omega$]					
5	0,2500	0,2496	-0,0004	-	0,0001	-
5	2,5000	2,4930	-0,0070	-	0,0021	-
5	4,7500	4,7378	-0,0122	-	0,0051	-
50	2,500	2,494	-0,006	-	0,002	-
50	25,000	24,940	-0,060	-	0,017	-
50	47,500	47,318	-0,182	-	0,079	-



Köffer Krisztián

A mérést végezte / Calibrated by

Annex02: Multimeter (1 photo):



Image 1: Multimeter MX 54C

Annex 03: SIEMENS WSM515 (T260) Calibration Certificates (6 pages) + (1 photo)

  Carol - Víz Méréstechnikai Kft.	CAROL-VÍZ Méréstechnikai Kft. 1183 Budapest, Gyömrői út. 210. Tel: 30-332-8781 Telephely: 7100 Szekszárd, Keselyűsi út. 22. Tel: 74/506-557	
	Bankszámlaszám: Budapest Bank 10104617-43851800-01004006 Adószám: 11295585-2-43	

Sorszám: 17/2022

KALIBRÁLÁSI JEGYZŐKÖNYV

A mérés helye: Carol-Víz Méréstechnikai Kft
1183 Budapest Gyömrői út 210.

A mérés ideje: 2022.03.31

Vizsgálati módszer: 6/2-2021

Alkalmazott etalonok:

Megnevezés	Gyártó	Típus	Gyártási szám	Mérési Tartomány	Bizonyítvány száma	Érvényessége
Mérleg	Mettler-Toledo	ID1-2071743	2153354	0-300 kg	BP/2002/00974-2/2021/0002	2022.04.01
Indukciós vízmérő	Krohne	IFC300	A 1100820	0,2-20 m ³ /h	BP/2004/00305-2/1/2022	2023.03.26
Ultrahangos vízmérő	Landis&Gyr	UH50	66446955	0,006-1,2 m ³ /h	BP/2004/00305-2/1/2022	2023.03.26
Hőérzékelő	IAS	Pt100	0014/2000	10-70 C	Carol-Víz Méréstechnikai Kft.	2025.03.09

A mérőeszköz:

megnevezése:	Hőfogyasztásmérő átfolyásmérője
gyártója:	Siemens
típusa:	T230
mérési tartománya: [l/h]	0,15-3000 l/h
gyártási száma:	70283877
számláló állása: [m ³]	42,31

Mérési eredmények:

Beállított térfogat	Mért érték	Helyes érték	Eltérés	Hiba	Hibatár	
[liter/óra]	[liter]	[liter]	[liter]	[%]	[%]	
1	500	20,30	20,383	-0,083	-0,41	+/- 3
2	1000	50,30	50,742	-0,442	-0,87	+/- 3
3	1500	105,86	107,639	-1,779	-1,65	+/- 3
4	2000	200,13	203,876	-3,746	-1,84	+/- 3
5	2500	250,46	254,668	-4,208	-1,65	+/- 3
6	3000	302,35	306,807	-4,457	-1,45	+/- 3

Minősítés: nem minősített

Megjegyzés: Vízhőmérséklet 40 °C


 CAROL-VÍZ Méréstechnikai Kft.
 1183 Budapest, Gyömrői út. 210.
 Adószám: 11295585-2-43
 Mézinger István



ÉMI ÉPÍTÉSÜGYI
MINŐSÉGELLENŐRZŐ
INNOVÁCIÓS NKFT.

Bizonyítvány szám: MK-095-2022
Oldal szám: 1/2
Hivatkozási szám: -

2000. Szentendre, Dózsa György út 26, Postacím: 2001. Szentendre, Pf. 180.

A NAH által NAH-2-0331/2017 számon akkreditált kalibrálólaboratórium.

KALIBRÁLÁSI BIZONYÍTVÁNY

A kalibrálás tárgya: Digitális hőmérő
Gyártó: Siemens
Típus: T230-A21C-HU06-P zöld jelű szonda, bal oldali kijelzett érték
Gyártási szám/azonosító: 70283877 / 1 - 1384
Méréstartomány: 0 ... 180 °C
Osztásérték: 0,1 °C
Az eszköz állapota: Kalibrálható

A vevő neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A tulajdonos neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A kalibrálás helye, ideje: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Kalibráló Laboratórium
2000 Szentendre, Dózsa György út 26.
2022.02.28

A kalibrálást végezte: Kovács Máttyás

Használati etalonok:

Megnevezés	Digitális hőmérő	Hő és légnedvességmérő
Gyártó	Ahlborn GmbH	Steinberg
Típus	Almemo 2290-3	SBS-DL-123E
Gyári szám	H99041502M	462620210533
Méréstartomány	-40..180 °C (0,01°C)	-40..125°C , 0...100%rH
Kalibrálási bizonyítvány	HŐM-0119/2021	MK-285-2021 , MK-286-2021

A használati etalonok mérési bizonytalanságát a fenti táblázatban megadott számú bizonyítványok tartalmazzák, amelyek értelmében a használati etalonnal végzett mérések eredményei az országos etalonra visszavezethetők.

A kalibrálás módja:

A kalibrálás az ÉMI Nonprofit Kft. Kalibráló laboratóriumának KL-T02/2016 kódszámú eljárási utasítása alapján történt.

Környezeti feltételek: hőmérséklet 19,9 ... 20,1 °C
páratartalom 31,8 %rH

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Mérési eredmények

Helyes érték (°C)	Mért érték (°C)	Hiba (°C)	Kiterjesztett mérési bizonytalanság (°C)
19,8	19,9	0,1	0,1
39,7	39,6	-0,1	0,1
60,0	60,0	0,0	0,1
79,9	79,9	0,0	0,1
95,0	94,9	-0,1	0,1
-	-	-	-

A közölt kiterjesztett mérési bizonytalanság a standard bizonytalanság $k=2$ -vel szorzott értéke, ami normális eloszlás esetén közelítőleg 95%-os fedési valószínűséggel felel meg. A standard bizonytalanság meghatározása az EA-4/02M (Expression of the Uncertainty of Measurement in Calibration) kiadványnak megfelelően történt.

A minősítést az ILAC-G8:09/2019 4.2.1-2.döntési szabály alapján a vevő:

Kérte

Nem kérte

 $w = 0$

A minősítést a vevő kérésére végeztük.

Minősítési paraméter: a helyes értéktől való megengedett legnagyobb eltérés: $\pm 2^\circ\text{C}$.

Megfelelt

Nem felelt meg

Ellenőrzést tanúsító jel:

ÉMI KAL

MK-095-2022

Szentendre, 2022.03.01

A bizonyítvány kiadható:



laboratóriumvezető

Dali Judith Zita

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

2000. Szentendre, Dózsa György út 26, Postacím: 2001. Szentendre, Pf. 180.

A NAH által NAH-2-0331/2017 számon akkreditált kalibrálólaboratórium.

KALIBRÁLÁSI BIZONYÍTVÁNY

A kalibrálás tárgya:	Digitális hőmérő
Gyártó:	Siemens
Típus:	T230-A21C-HU06-P kék jelű szonda, jobb oldali kijelzett érték
Gyártási szám/azonosító:	70283877 / 1 - 1384
Méréstartomány:	0 ... 180 °C
Osztásérték:	0,1 °C
Az eszköz állapota:	Kalibrálható
A vevő neve és címe:	ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. Központi Anyag- és Szerkezetvizsgáló Laboratórium 2000. Szentendre, Dózsa György út 26
A tulajdonos neve és címe:	ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. Központi Anyag- és Szerkezetvizsgáló Laboratórium 2000. Szentendre, Dózsa György út 26
A kalibrálás helye, ideje:	ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft. Kalibráló Laboratórium 2000 Szentendre, Dózsa György út 26. 2022.02.28
A kalibrálást végezte:	Kovács Mátyás 

Használati etalonok:

Megnevezés	Digitális hőmérő	Hő és légnedvességmérő
Gyártó	Ahlborn GmbH	Steinberg
Típus	Almemo 2290-3	SBS-DL-123E
Gyári szám	H99041502M	462620210533
Méréstartomány	-40..180 °C (0,01°C)	-40..125°C , 0...100%rH
Kalibrálási bizonyítvány	HŐM-0119/2021	MK-285-2021 , MK-286-2021

A használati etalonok mérési bizonytalanságát a fenti táblázatban megadott számú bizonyítványok tartalmazzák, amelyek értelmében a használati etalonnal végzett mérések eredményei az országos etalonra visszavezethetők.

A kalibrálás módja:

A kalibrálás az ÉMI Nonprofit Kft. Kalibráló laboratóriumának KL-T02/2016 kódszámú eljárási utasítása alapján történt.

Környezeti feltételek:	hőmérséklet	19,9 ... 20,1 °C
	páratartalom	31,8 %rH

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Mérési eredmények

Helyes érték (°C)	Mért érték (°C)	Hiba (°C)	Kiterjesztett mérési bizonytalanság (°C)
19,8	19,8	0,0	0,1
39,7	39,5	-0,2	0,1
60,0	59,9	-0,1	0,1
79,9	79,9	0,0	0,1
95,0	94,8	-0,2	0,1
-	-	-	-

A közölt kiterjesztett mérési bizonytalanság a standard bizonytalanság $k=2$ -vel szorzott értéke, ami normális eloszlás esetén közelítőleg 95%-os fedési valószínűséggel felel meg. A standard bizonytalanság meghatározása az EA-4/02M (Expression of the Uncertainty of Measurement in Calibration) kiadványnak megfelelően történt.

A minősítést az ILAC-G8:09/2019 4.2.1-2.döntési szabály alapján a vevő:

Kérte

Nem kérte

 $w = 0$

A minősítést a vevő kérésére végeztük.

Minősítési paraméter: a helyes értéktől való megengedett legnagyobb eltérés: $\pm 2^\circ\text{C}$.

Megfelelt

Nem felelt meg

Ellenőrzést tanúsító jel:

ÉMI KAL

MK-094-2022

Szentendre, 2022.03.01

A bizonyítvány kiadható:



laboratóriumvezető

Dali Judith Zita

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Annex03: SIEMENS WSM515 (T260) (1 photo):

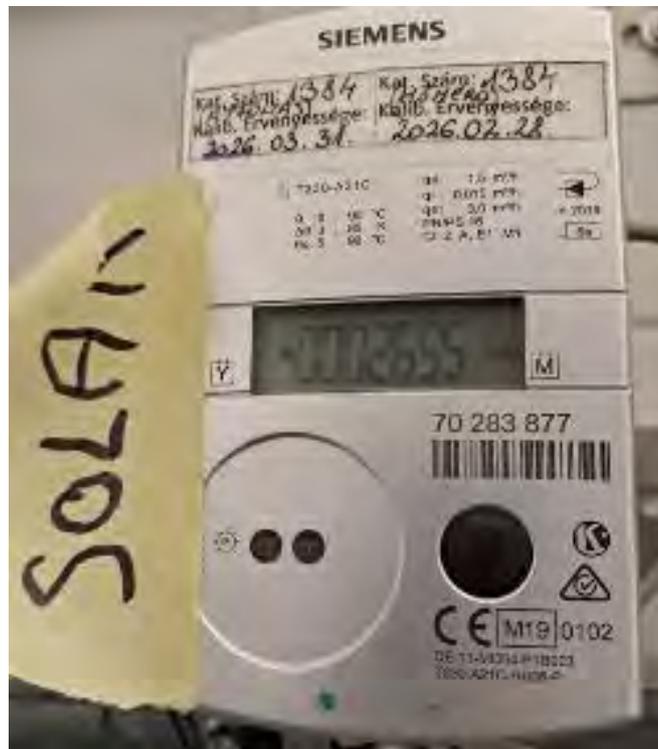


Image 1: SIEMENS WSM515 (T260) (Solar ÉMI No.1384)

Annex 04 SIEMENS WSM515 (T260) Calibration Certificates (6 pages) + (1 photo)

 Carol - Víz Méréstechnikai Kft.	CAROL-VÍZ Méréstechnikai Kft. 1183 Budapest, Gyömrői út. 210. Tel: 30-332-8781 Telephely: 7100 Szekszárd, Keselyűsi út. 22. Tel: 74/506-557	
	Bankszámlaszám: Budapest Bank 10104617-43851800-01004006	

Sorszám: 16/2022

KALIBRÁLÁSI JEGYZŐKÖNYV

A mérés helye: Carol-Víz Méréstechnikai Kft
1183 Budapest Gyömrői út 210.

A mérés ideje: 2022.03.31

Vizsgálati módszer: 6/2-2021

Alkalmazott etalonok:

Megnevezés	Gyártó	Típus	Gyártási szám	Mérési Tartomány	Bizonyítvány száma	Érvényessége
Mérleg	Mettler-Toledo	ID1-2071743	2153354	0-300 kg	BP/2002/00974-2/2021/0002	2022.04.01
Indukciós vízmérő	Krohne	IFC300	A 1100820	0,2-20 m ³ /h	BP/2004/00305-2/1/2022	2023.03.26
Ultrahangos vízmérő	Landis&Gyr	UH50	66446955	0,006-1,2 m ³ /h	BP/2004/00305-2/1/2022	2023.03.26
Hőérzékelő	IAS	Pt100	0014/2000	10-70 C	Carol-Víz Méréstechnikai Kft.	2025.03.09

A mérőeszköz:

megnevezése:	Hőfogyasztásmérő átfolyásmérője
gyártója:	Siemens
típusa:	T230
mérési tartománya: [l/h]	0,15-3000 l/h
gyártási száma:	70283842
számláló állása: [m ³]	33,95

Mérési eredmények:

Beállított térfogatáram [liter/óra]	Mért érték [liter]	Helyes érték [liter]	Eltérés [liter]	Hiba [%]	Hibahatár [%]
1	500	20,29	20,383	-0,093	-0,46
2	1000	50,42	50,742	-0,322	-0,63
3	1500	106,64	107,639	-0,999	-0,93
4	2000	201,60	203,876	-2,276	-1,12
5	2500	252,18	254,668	-2,488	-0,98
6	3000	304,30	306,807	-2,507	-0,82

Minősítés: nem minősített

Megjegyzés: Vízhőmérséklet 40 °C


CAROL-VÍZ Méréstechnikai Kft.
1183 Budapest Gyömrői út 210.
Adószám: 11295585-2-43
Mézinger István



ÉMI ÉPÍTÉSÜGYI
MINŐSÉGELLENŐRZŐ
INNOVÁCIÓS NKFT.

Bizonyítvány szám: MK-092-2022
Oldal szám: 1/2
Hivatkozási szám: -

2000. Szentendre, Dózsa György út 26, Postacím: 2001. Szentendre, Pf. 180.

A NAH által NAH-2-0331/2017 számon akkreditált kalibrálólaboratórium.

KALIBRÁLÁSI BIZONYÍTVÁNY

A kalibrálás tárgya: Digitális hőmérő
Gyártó: Siemens
Típus: T230-A21C-HU06-P kék jelű szonda, jobb oldali kijelzett érték
Gyártási szám/azonosító: 70283842 / 1 - 1385
Méréstartomány: 0 ... 180 °C
Osztásérték: 0,1 °C
Az eszköz állapota: Kalibrálható

A vevő neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A tulajdonos neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A kalibrálás helye, ideje: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Kalibráló Laboratórium
2000 Szentendre, Dózsa György út 26.
2022.02.28

A kalibrálást végezte: Kovács Mátyás

Használati etalonok:

Megnevezés	Digitális hőmérő	Hő és légnedvességmérő
Gyártó	Ahlborn GmbH	Steinberg
Típus	Almemo 2290-3	SBS-DL-123E
Gyári szám	H99041502M	462620210533
Méréstartomány	-40..180 °C (0,01°C)	-40..125°C , 0...100%rH
Kalibrálási bizonyítvány	HŐM-0119/2021	MK-285-2021 , MK-286-2021

A használati etalonok mérési bizonytalanságát a fenti táblázatban megadott számú bizonyítványok tartalmazzák, amelyek értelmében a használati etalonnal végzett mérések eredményei az országos etalonra visszavezethetők.

A kalibrálás módja:

A kalibrálás az ÉMI Nonprofit Kft. Kalibráló laboratóriumának KL-T02/2016 kódszámú eljárási utasítása alapján történt.

Környezeti feltételek: hőmérséklet 19,9 ... 20,1 °C
páratartalom 31,8 %rH

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Mérési eredmények

Helyes érték (°C)	Mért érték (°C)	Hiba (°C)	Kiterjesztett mérési bizonytalanság (°C)
19,8	19,8	0,0	0,1
39,7	39,7	0,0	0,1
60,0	60,0	0,0	0,1
79,9	80,0	0,1	0,1
95,0	94,9	-0,1	0,1
-	-	-	-

A közölt kiterjesztett mérési bizonytalanság a standard bizonytalanság $k=2$ -vel szorzott értéke, ami normális eloszlás esetén közelítőleg 95%-os fedési valószínűséggel felel meg. A standard bizonytalanság meghatározása az EA-4/02M (Expression of the Uncertainty of Measurement in Calibration) kiadválynak megfelelően történt.

A minősítést az ILAC-G8:09/2019 4.2.1-2.döntési szabály alapján a vevő:

Kérte Nem kérte

$w=0$

A minősítést a vevő kérésére végeztük.

Minősítési paraméter: a helyes értéktől való megengedett legnagyobb eltérés: $\pm 2^\circ\text{C}$.

Megfelelt Nem felelt meg

Ellenőrzést tanúsító jel: **ÉMI KAL**
MK-092-2022

Szentendre, 2022.03.01

A bizonyítvány kiadható:



laboratóriumvezető
Dali Judith Zita

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!



ÉMI ÉPÍTÉSÜGYI
MINŐSÉGELLENŐRZŐ
INNOVÁCIÓS NKFT.

Bizonyítvány szám: MK-093-2022
Oldal szám: 1/2
Hivatkozási szám: -

2000. Szentendre, Dózsa György út 26, Postacím: 2001. Szentendre, Pf. 180.

A NAH által NAH-2-0331/2017 számon akkreditált kalibrálólaboratórium.

KALIBRÁLÁSI BIZONYÍTVÁNY

A kalibrálás tárgya: Digitális hőmérő
Gyártó: Siemens
Típus: T230-A21C-HU06-P zöld jelű szonda, bal oldali kijelzett érték
Gyártási szám/azonosító: 70283842 / 1 - 1385
Méréstartomány: 0 ... 180 °C
Osztásérték: 0,1 °C
Az eszköz állapota: Kalibrálható

A vevő neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A tulajdonos neve és címe: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Központi Anyag- és Szerkezetvizsgáló Laboratórium
2000. Szentendre, Dózsa György út 26

A kalibrálás helye, ideje: ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
Kalibráló Laboratórium
2000 Szentendre, Dózsa György út 26.
2022.02.28

A kalibrálást végezte: Kovács Mátyás

Használati etalonok:

Megnevezés	Digitális hőmérő	Hő és légnedvességmérő
Gyártó	Ahlborn GmbH	Steinberg
Típus	Almemo 2290-3	SBS-DL-123E
Gyári szám	H99041502M	462620210533
Méréstartomány	-40..180 °C (0,01°C)	-40..125°C , 0...100%rH
Kalibrálási bizonyítvány	HŐM-0119/2021	MK-285-2021 , MK-286-2021

A használati etalonok mérési bizonytalanságát a fenti táblázatban megadott számú bizonyítványok tartalmazzák, amelyek értelmében a használati etalonnal végzett mérések eredményei az országos etalonra visszavezethetők.

A kalibrálás módja:

A kalibrálás az ÉMI Nonprofit Kft. Kalibráló laboratóriumának KL-T02/2016 kódszámú eljárási utasítása alapján történt.

Környezeti feltételek: hőmérséklet 19,9 ... 20,1 °C
páratartalom 31,8 %rH

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Mérési eredmények

Helyes érték (°C)	Mért érték (°C)	Hiba (°C)	Kiterjesztett mérési bizonytalanság (°C)
19,8	19,8	0,0	0,1
39,7	39,5	-0,2	0,1
60,0	59,9	-0,1	0,1
79,9	79,8	-0,1	0,1
95,0	94,8	-0,2	0,1
-	-	-	-

A közölt kiterjesztett mérési bizonytalanság a standard bizonytalanság $k=2$ -vel szorzott értéke, ami normális eloszlás esetén közelítőleg 95%-os fedési valószínűséggel felel meg. A standard bizonytalanság meghatározása az EA-4/02M (Expression of the Uncertainty of Measurement in Calibration) kiadványnak megfelelően történt.

A minősítést az ILAC-G8:09/2019 4.2.1-2.döntési szabály alapján a vevő:

Kérte

Nem kérte

 $w=0$

A minősítést a vevő kérésére végeztük.

Minősítési paraméter: a helyes értéktől való megengedett legnagyobb eltérés: $\pm 2^\circ\text{C}$.

Megfelelt

Nem felelt meg

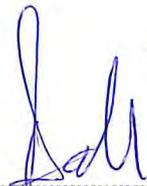
Ellenőrzést tanúsító jel:

ÉMI KAL

MK-093-2022

Szentendre, 2022.03.01

A bizonyítvány kiadható:



laboratóriumvezető

Dali Judith Zita

A bizonyítvány a kalibráló laboratórium írásbeli engedélye nélkül csak teljes terjedelemben másolható!

Annex 04: SIEMENS WSM515 (T260) (1 photo):

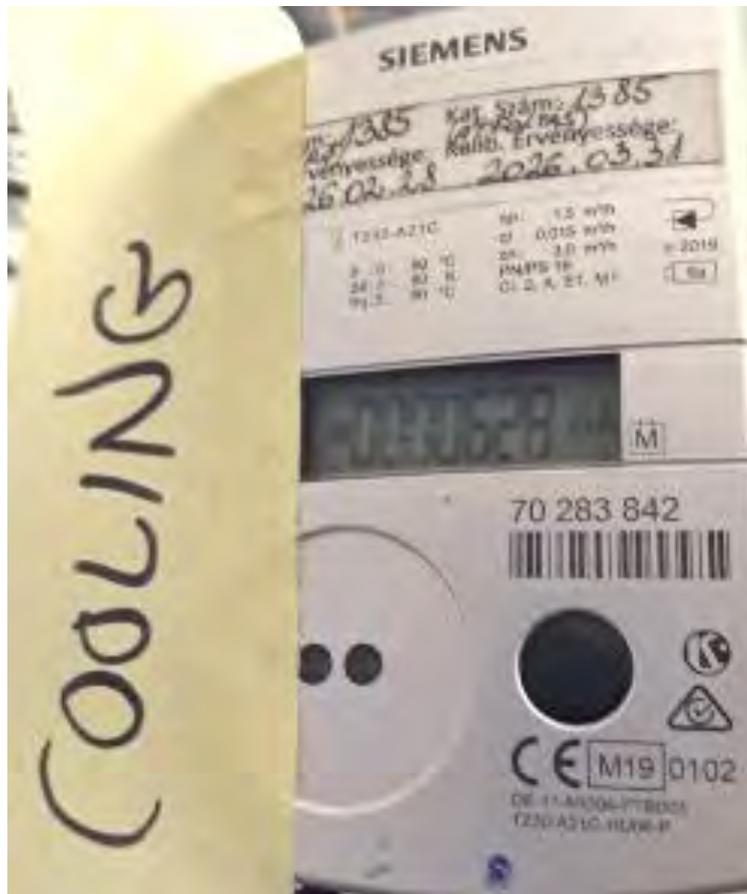


Image 1: SIEMENS WSM515 (T260) (Heating-Cooling ÉMI No.1385)

Annex 05 RC12 Manufacturer data sheet (5 pages) + (1 photo)

RC12 Ultrasonic Heat Meter Manual



Please read this user manual before using the meter, in order to help you understand the products basic functions, operation and maintenance.

Note: We reserve the right to alter the product specifications, appearance and design without prior notice.

⚠ Important

Environmental Requirements

- This product should NOT be used if the humidity exceeds 85%
- No user serviceable parts are inside the meter.

Profile

Application	Heating/cooling/heating-cooling energy metering
Approval	MID, CE
Mounting position	Vertical or horizontal
Enclosure protection class	IP 65
Battery supply	3.6V lithium battery life up to 8 years
Temperature sensor type	PT1000
Cable length of temperature sensor	1.5 meter

Cabling Requirements

- Do not shorten or replace the cables
- The external cabling must use multi-strand shielded twisted pair of not less than 0.75 mm².
- Do not install the cabling in trunking that contains power lines to avoid electrical interference on the signal lines.
- The RS485 network must have the correct topology and be correctly terminated.

Other Requirements

- Do not damage the product calibration seal. If it is destroyed any warranty or calibration will be invalidated.

Product Features

- Internal 3.6V lithium battery power supply.
- Due to the unique case design the display can be rotated for ease of viewing.
- Supports flow and return installation side (Default installation: return).
- Supports horizontal and vertical installation.
- Supports optical interface, RS485 interface and M-Bus interface.

RC12 Ultrasonic Heat Meter Manual

Calculator basic features

Environmental class	EN1434/MID E1+M1
Ambient operating temperature	A Class (5~55) °C or B Class(-25 ~ +55) °C optional
Ambient storage temperature	-20 to +70 °C
Protection class	IP 65
Standard interface	Optical interface
Interfaces optional	1 Slot for modules with M-Bus, RS485, Pulse Output
Temperature range heating	4 to 95°C
Temperature range cooling	4 to 95°C
Extensive data memory	720 days flow data and heat data

Display

Display indication	LCD, 8 digits
Units	MWh - kWh - GJ - Gcal - °C -K - m ³ - m ³ /h
Total values	99,999,999 - 9,999,999.9 - 999,999.99 - 99,999.999
Values displayed	Energy - Power - Volume - Flow Rate - Temperature

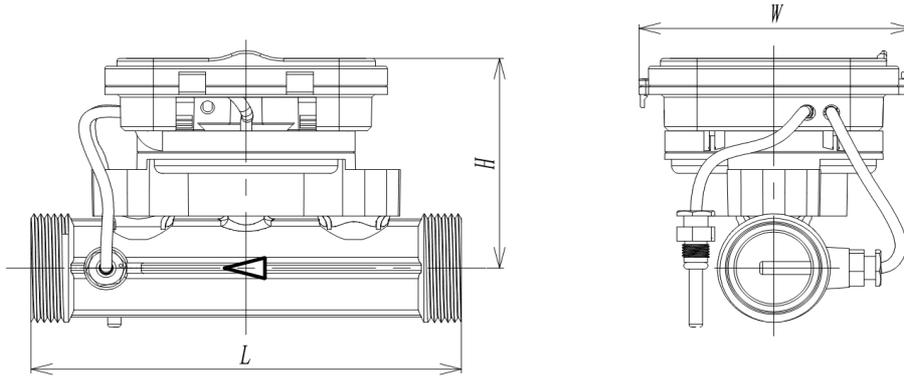
Interfaces

Optical	Baud rate 2400
M-Bus	Baud rate 300-9600
RS485	Baud rate 300-9600
Pulse output	One pulse output/kWh

Temperature input

Min. temperature difference	$\Delta\Theta_{min}$ K	3 (2K can be customized)
Max. temperature difference	$\Delta\Theta_{max}$ K	60 (105 can be customized)
Absolute Temperature measuring range	Θ °C	4 to 95 (4-130 can be customized)

RC12 Ultrasonic Heat Meter Manual



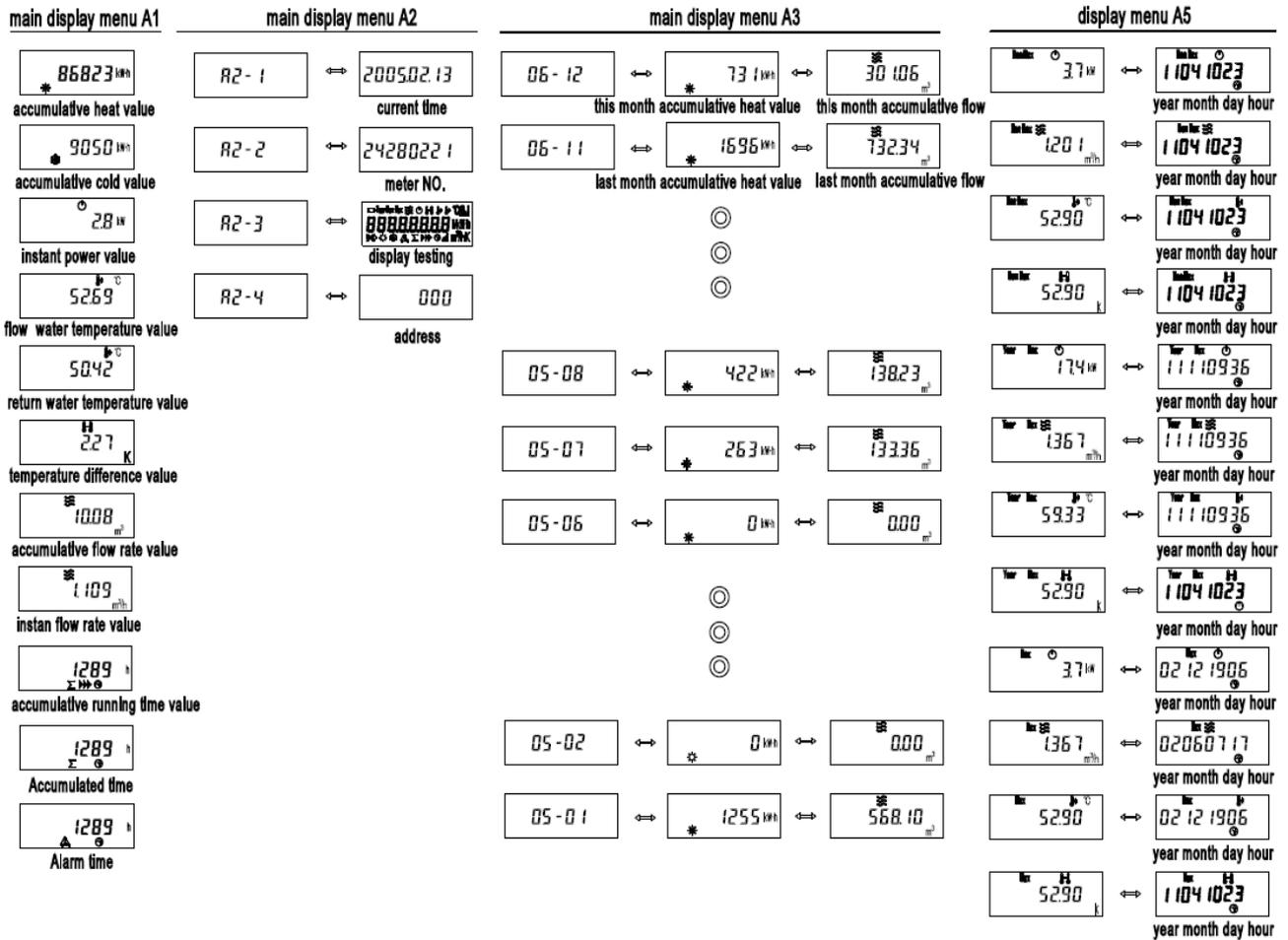
Screw thread connection

Nominal flow rate	q_p	m^3/h	0.6	1.5	1.5	1.5	2.5	2.5
Nominal diameter	DN	mm	15	15	20	20	20	20
Body Length	L	mm	110	110	130	190	130	190
Height	H	mm	100	75	78	78	78	78
Width	W	mm	101	101	101	101	101	101
Screw thread on meter		inch	G3/4B	G3/4B	G1B	G1B	G1B	G1B
Screw thread of coupling		inch	R1/2	R1/2	R3/4	R3/4	R3/4	R3/4
Working pressure		MPa			1.6/2.5			
$Q_p : Q_i$				50:1, 100:1, 250:1				

Nominal flow rate	q_p	m^3/h	3.5	6	10			
Nominal diameter	DN	mm	25	32	40			
Body Length	L	mm	160/260	180/260	200/300			
Height	H	mm	81	84	88			
Width	W	mm	101	101	101			
Screw thread on meter		inch	G1 1/4B	G1 1/2B	G2B			
Screw thread of coupling		inch	R1	R1 1/4	R1 1/2			
Max working pressure		MPa			1.6/2.5			
$Q_p : Q_i$				50:1, 100:1, 250:1				

RC12 Ultrasonic Heat Meter Manual

LCD



Error codes

Err 0	Incorrect ion flow direction or wrong installation	Checking the flow or mounting direction, correction if necessary
Err 1	Negative temperature difference	Check the installation position of the sensor, replace it if necessary
Err 2	Open circuit in flow temperature sensor	Repair or replacement by professionals
Err 3	Short circuit in flow temperature sensor	Repair or replacement by professionals
Err 4	Open circuit in return temperature sensor	Repair or replacement by professionals
Err 5	Short circuit in return temperature sensor	Repair or replacement by professionals
Err 6	Air tube	Remove air from the system

Annex05: RC12 Ultrasonic heat meter (1 photo):



Image 1: RC12 Ultrasonic heat meter (DHW)

Annex 06 DACTON PQRM5300_33_EN data sheet (11 pages) +
(1 photo)

Szállítólevél

1. eredeti példány
Ez a Szállítólevél 3 példányban került nyomtatásra

sorszám: 2018326/2023
azonosító: DM01048/2023

Eladó: Datcon Ipari és Elektronikai Kft. 1148 Budapest, Fogarasi út 5. Adószám: 12256040-2-42 Tel: 460-1000 Fax:460-1001 e-mail: datcon@datcon.hu	Vevő: ÉMI Építésügyi Minőségell. Innovációs Nonprofit Kft. 2000 Szentendre, Dózsa Gy. út 26. Megrendelés száma / ügyintézője: 45706 6441/2023/Beszi / Fenyvesi Gábor
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Sorszám	Termék megnevezése / vámtarifa szám	Mennyiség (db)	Gyártási szám
1	PQRM5300 33 U250 I1 2IA PS	1	188002/23.11
2	LCTM 62/W 10/1	3	
3	DT2040/2023 számla 1 pld.		

Kiállítás helye, időpontja: Budapest, 2023.11.24	Kiállító aláírása: Pogátsné Kraller Gabriella <i>Pogátsné</i>	Kiállító bélyegzője:  IPARI ELEKTRONIKAI KFT. 1148 Bp. Fogarasi út 5. 27. ép.
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Alulírott - mint a vevő által áruátvétellel jogosult személy - aláírással igazolom, hogy a fent felsorolt termékeket, tartozékait, azok Minőségi bizonyítványát, Kezelési útmutatóját hiánytalanul átvettem. Igazolom, hogy az eladó a megfelelő csomagolásról gondoskodott. Mennyiségi reklamációt a csomag átvételét követő 1 (egy) napon belül fogadunk el.

Figyelem! Postai szállítás esetén az alábbi 1-3. rovatokat kitöltve, kérjük az Eladónak elektronikus úton visszaküldeni a datcon@datcon.hu e-mail címre.		
1. Átvétel helye, időpontja: 2023. 11. 28. Szentendre ÉMI Nonprofit kft.	2. Átvevő neve (olvashatóan): FENYVESI GÁBOR	3. Átvevő aláírása, bélyegzője vagy sz. ig. száma:  413 065 SA



IPARI ELEKTRONIKAI KFT.

Minőségi bizonyítvány

Gyártmány: **PQRM5300 33 U250 I1 2IA PS**
Háromfázisú
multifunkciós teljesítménymérő

Gyártási szám: 188002/23.11

Gyártó: Datcon Ipari Elektronikai Kft.
1148 Budapest, Fogarasi út 5. 27. ép.

A termék jellemzői:

Bemeneti feszültség: 0–250 VAC (nem elválasztott)
Bemeneti áram: 0–1 AAC
Impulzus kimenet: —
Opció: 2x 0 / 4–20 mA távadó kimenet
Tápfeszültség: 230 V AC/DC ±10 %
1.5 VA / 1 W
Működési hőmérséklettartomány: 0–60 °C
Védettség: IP 50 / IP 20

A készülék valamennyi paramétere megfelel a kezelési útmutatóban megadott műszaki adatoknak.

Nyomtatás dátuma:
Budapest, 2023. november 21.

EU-megfelelőségi nyilatkozat

A gyártó saját kizárólagos felelősségére kijelenti, hogy a megadott minőségi bizonyítványban feltüntetett gyártmány megfelel a következő EU rendeleteknek:

2014 / 30 / EU direktíva (EMC)	
MSZ EN IEC 61326-1:2021	Méréstechnikai, irányítástechnikai és laboratóriumi villamos berendezések EMC követelményei, 1.rész: Általános követelmények Zavartűrés: Ipari környezet
MSZ EN 55011:2016 MSZ EN 55011:2016/A1:2017 MSZ EN 55011:2016/A2:2021	Ipari, tudományos és orvosi (ISM) rádiófrekvenciás berendezések. Határértékek és vizsgálati módszerek. Zavar kibocsátás: 1. csoport, B osztály
2014 / 35 / EU direktíva (LVD)	
MSZ EN 61010-1:2011	Villamos mérő-, szabályzó- és laboratóriumi készülékek biztonsági előírásai
2011 / 65 / EU direktíva (RoHS 2)	
MSZ EN IEC 63000:2019	Elektromos és elektronikus termékek értékelésének műszaki dokumentációja a veszélyes anyagok korlátozására vonatkozóan

A terméket az ISO 9001:2015 szabványnak megfelelő minőségirányítási rendszer szerint tervezték, gyártották és ellenőrizték.
A minőségirányítási rendszert az DNV GL - Business Assurance B.V. tanúsította.

Kiadás dátuma:
Budapest, 2022. január 12.



IPARI ELEKTRONIKAI KFT.

Miskovits Péter
ügyvezető igazgató

TRANSFORMER SERIES LCTM, LCTR, LCTB, LCTS, LCTP

Operating Manual

Low Voltage-Current Transformer -

- LCTR • LCTM
- LCTB • LCTP
- LCTS



Indication

Before initial operation we ask you to pay full attention to these assembling instructions in order to guarantee the reliability and to ensure the performance of the device.

Functional description

Current transformers of the model range mentioned above are inductive single conductor-current transformers operating according to the transformer principle. Due to the applied measuring principle, current transformers of this type may only be installed in alternating current (AC) networks.

Safety instructions



In order to avoid personal and material damage the following assembling steps must be performed only by authorised, qualified and trained personnel.



If the secondary circuit is operated without a burden/load (open) high voltages may appear. These voltage values are dangerous for persons as well as for the functional reliability of the current transformer.
It is forbidden to operate the current transformer without a secondary circuit (open)!

Technical parameters

Primary current:	30A to 6000A
Secondary current:	1A or 5A
Accuracy class:	0.2, 0.2s, 0.5, 0.5s & 1
Over current limiting factor:	FS5, FS10, Fs15
Rated frequency:	50Hz or 60Hz <small>(if otherwise is specified)</small>
Rated continuous thermal current (standard):	1,2 x In <small>(if otherwise is specified)</small>
Rated short time thermal current Ith:	60 x In, 1 s (Max 40kA)
Rated isolation level:	0,6/3/-kV or 0,6/4/-kV <small>(if otherwise is specified)</small>
Place of installation:	Indoor
Altitude:	up to 2000 m
Degree of protection:	2
Degree of pollution:	2
Ambient temperature:	-25°C ≤ θ ≤ +40°C (0...95% relative humidity, non condensing)
Storage temperature:	-50°C ≤ θ ≤ +80°C
Applied standards:	IEC - 61869- 1&2 ; Performance IEC - 61010 - 2 ; Safety.



DINRAIL MOUNTING
HORIZONTAL 3PH CT

DINRAIL MOUNTING
VERTICAL 3PH CT



WALL MOUNTING 3PH CT

Environmental instruction

When the product has reached it's "end of life", it must be recycled. Pass it to an electrical waste disposal. Do not dispose as unsorted municipal waste!



This product was developed and manufactured in accordance with the applicable regulations (IEC 61010, IEC 61869) and meets the requirements of the low voltage guideline 2006/95/EG

Subject to change without notice!

AMAN-001M-0068_Rev. C_10/2016

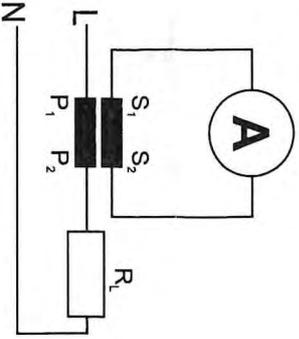
LUMEL
L I C Z Y S I Ę W S Z Y S T K O

LUMEL S.A.
ul. Sulechowska 1,
65-022 Zielona Góra
fax 68 32 55 650
e-mail: promocja@lumel.com.pl

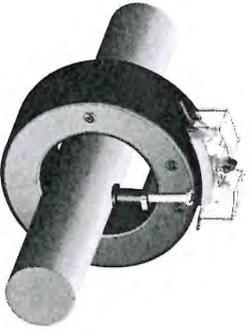
Assembly

1. Ensure a safe work environment during assembly, maintenance and inspection operations. If necessary interrupt the current supply of the primary conductor and take precautions against unintentional switching.
 2. (i) For Split core CT : Open the current transformer and fix it on the primary conductor using the fixing clamps (mounting material).
(ii) For Window type CT : Bar or cable primary insert through primary cable or bus bar & fix it using mounting screw assembly.
 - P1: Direction of power supply
 - P2: Direction of power source
- Attention:** (i) Do not close the current transformer, high voltages may appear on the open secondary leads.
(ii) Check for cleanliness of the cut surfaces of the split core.
3. Connect the secondary wires of the current transformer with the measuring device (ampere meter, energy meter). Pay attention to the installation guide of the measuring device.
 4. Now fasten the current transformer, press until the lock engage.
 5. If necessary, start the current supply again.
 6. Check whether the current transformer is assembled correctly and the secondary leads are connected properly.
 7. For split core CT, use "lock pin" supplied along with CT to protect accidental opening of CT, during in use.

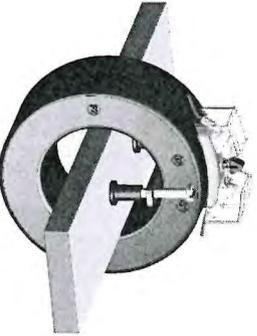
Wiring diagram



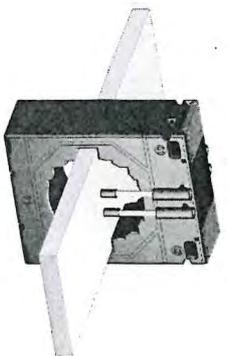
Mounting of CT



CABLE MOUNTING



BUS BAR MOUNTING



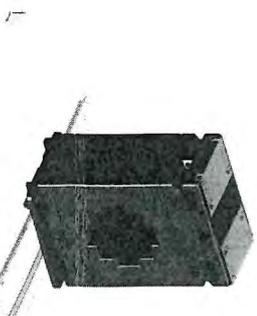
BUS BAR MOUNTING



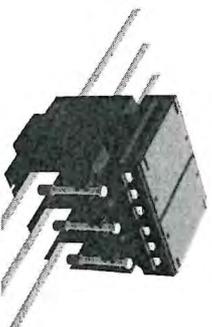
WALL MOUNTING



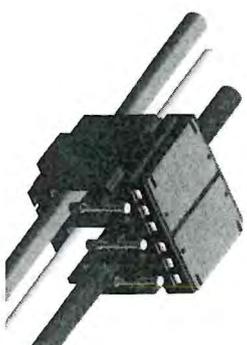
DINRAIL MOUNTING HORIZONTAL



DINRAIL MOUNTING VERTICAL



BUS BAR MOUNTING 3PH CT



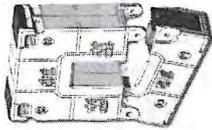
CABLE MOUNTING 3PH CT

TRANSFORMER SERIES LCTM, LCTR, LCTB, LCTS, LCTP

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It is forbidden to operate the current transformer without a secondary circuit (open)!

Technical parameters

Primary current:	30A to 6000A
Secondary current:	1A or 5A
Accuracy class:	0.2, 0.2s, 0.5, 0.5s & 1
Over current limiting factor:	FS5, FS10, Fs15
Rated frequency:	50Hz or 60Hz <small>(if otherwise is specified)</small>
Rated continuous thermal current (standard):	1, 2 x In
Rated short time thermal current Ith:	60 x In, 1 s (Max 40kA)
Rated isolation level:	0.6/3-kV or 0.6/4-kV <small>(if otherwise is specified)</small>
Place of installation:	Indoor
Altitude:	up to 2000 m
Degree of protection:	Ip20
Degree of pollution:	2
Ambient temperature:	-25°C ≤ θ ≤ +40°C
Storage temperature:	(0...95% relative humidity, non condensing!)
Applied standards:	-50°C ≤ θ ≤ +80°C
	IEC - 61869- 1&2 ; Performance
	IEC - 61010 - 2 ; Safety.



DINRAIL MOUNTING
HORIZONTAL 3PH CT

DINRAIL MOUNTING
VERTICAL 3PH CT



WALL MOUNTING 3PH CT

Environmental instruction

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Subject to change without notice!

AMAN-001M-0068_Rev. C_10/2016

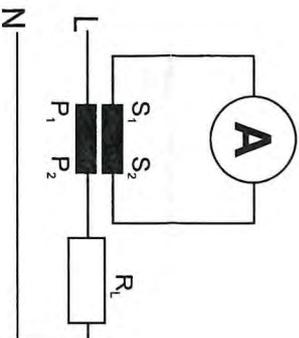
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ul. Sulechowska 1;
65-022 Zielona Góra
fax 68 32 55 650
e-mail: promocija@lumel.com.pl

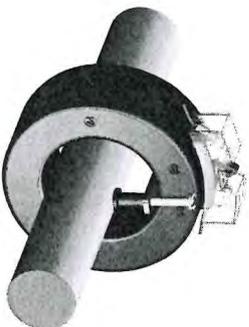
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6. Check whether the current transformer is assembled correctly and the secondary leads are connected properly.
7. For split core CT, use "lock pin" supplied along with CT to protect accidental opening of CT, during in use.

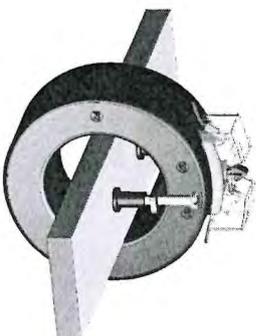
Wiring diagram



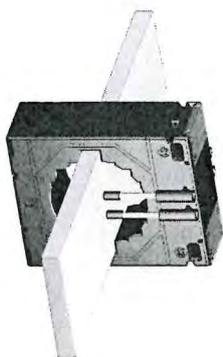
Mounting of CT



CABLE MOUNTING



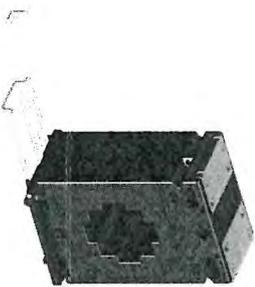
BUS BAR MOUNTING



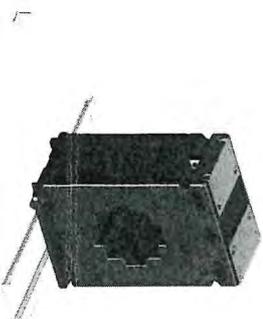
BUS BAR MOUNTING



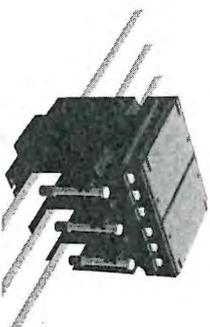
WALL MOUNTING



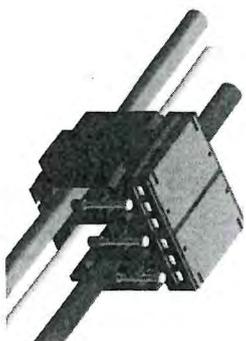
DINRAIL MOUNTING HORIZONTAL



DINRAIL MOUNTING VERTICAL



BUS BAR MOUNTING 3PH CT



CABLE MOUNTING 3PH CT

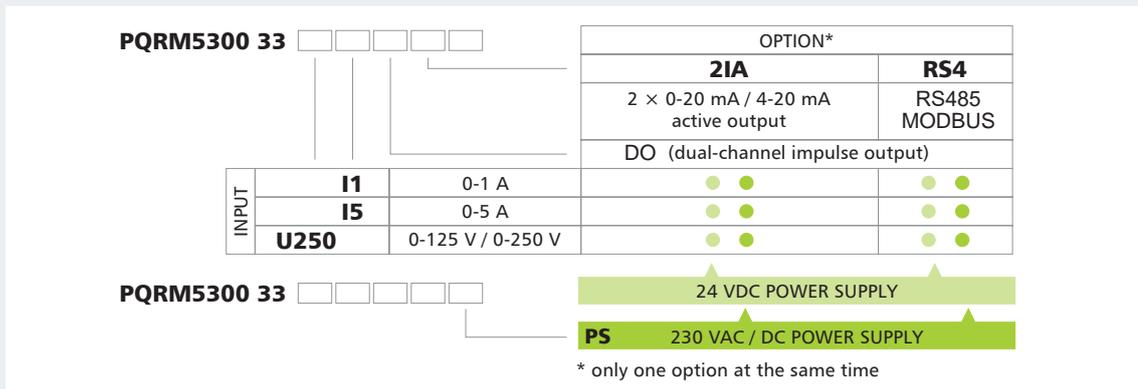
Three phase multifunction Power Transmitter

Product features

- Measuring of 51 different parameters
- 3 × 0-125 VAC / 0-250 VAC voltage input (CAT III)
- 3 × 0-5 AAC / 0-1 AAC galvanic isolated current inputs (CAT III)
- different measurement layouts application with null wire network and without null wire network, using one, two, or three power measure inputs
- 2 × 0-20 mA / 4-20 mA galvanic isolated outputs
- RS485 communication, MODBUS RTU / ASCII Slave protocol
- 2 energy pulse outputs / limit outputs
- Synchronous and time zone signal inputs
- Adjustment are performed via the front panel keypad monochrome graphic display
- 24 VDC ±10% or 230 V AC/DC ±10% power supply
- 96 × 96 mm panel instrument



Type designation



The **PQRM5300 33 ... Three phase multifunction Power Transmitter** suitable for the measuring of 51 different parameters of the three phase power network: • the TRMS values of phase voltages and phase currents • active power, reactive power, apparent power and power factor per each phase • +active energy, -active energy, inductive energy, capacitive energy per each phase and per 3 phase • frequency, phase angle, line voltages, phase angles between phase voltages.

The voltage inputs of the equipment are resistor networks (nonisolated) and the current inputs are isolated from the network with wideband current transformers. The current inputs 0-5 AAC or 0-1 AAC, and the voltage inputs 0-125 VAC / 0-250 VAC are in compliance with the requirements for measurement category CAT III.

The PQRM5100 31... is available with the following output options:

- 2 × 0-20 mA / 4-20 mA galvanic isolated, scalable, active analog current outputs *
- MODBUS RTU galvanic isolated communication which makes possible the reading of all measurement values via the communication line, with a PLC or with a PC *.

(* only one option at the same time)

2 energy pulse outputs / limit outputs for limit-switching and for simple control tasks.

The operating parameters of the device can be configured via the front panel push buttons via the graphical display menu system (current transformer, voltage converters, limit values, limit mode, output configuration, power limitation, etc.)

The PQRM5300 33 ... has two power supply versions 24 VDC ±10% (PQRM5300 33 ...) or 230 V AC/DC ±10% (PQRM5300 33 ... PS).

Safety data:

The connection terminals of the supply voltages are isolated from each other, the isolation is in compliance with the standard EN 61010-1, taking into consideration the following:

Pollution level:	2
Measurement category:	CAT III
Overcurrent protection in instalation:	4A

Input parameters:

Measured parameters:	$U_{12}, U_{23}, U_{31}, U_{L1}, U_{L2}, U_{L3}, I_{L1}, I_{L2}, I_{L3}, P_{L1}, P_{L2}, P_{L3}, Q_{L1}, Q_{L2}, Q_{L3}, S_{L1}, S_{L2}, S_{L3}, PF_{L1}, PF_{L2}, PF_{L3}, \phi_{L1}, \phi_{L2}, \phi_{L3}, \Sigma P, \Sigma Q, \Sigma S, \Sigma PF, f_1, f_2, f_3, \rho_{12}, \rho_{13}, P_{mom}, 15, P_{prog}, 15, +EP1, -EP1, +EQ1, -EQ1, +EP2, -EP2, +EQ2, -EQ2, +EP3, -EP3, +EQ3, -EQ3, +\Sigma EP, -\Sigma EP, +\Sigma EQ, -\Sigma EQ,$ 1/4 h demand, 1/4 h estimated demand, last 1/4 h demand
Input voltage:	3 × 0-125 VAC / 0-250 VAC resistor network (specified at ordering)
Input current:	3 × 0-5 AAC / 0-1 AAC galvanic isolated (specified at ordering)
Overrange:	2 × I, 1.2 × U, 300 V (max.)
Short overrange (1 sec.):	20 × I, 100 A (max.)
Consumption of the input:	0.5 VA (max.)
Frequency range:	40-80 Hz
Error:	0.2%
Refreshing time:	250 ms
Temperature coefficient:	25 ppm / °C (max.)

Output parameters:

Analogue outputs (optional):

Output type:	2 active current outputs (configurable, specified at ordering)
Range:	0-20 mA / 4-20 mA (scalable)
Burden:	500 ohm (max.)
Refreshing time:	same as the measuring time
Overcurrent:	20.8 mA
Error:	< 4 uA (23 °C ±2 °C) < 40 uA (-20 – +60 °C)
Burden resistance effect:	practically zero

Pulse outputs (optional):

Output type:	2 galvanic isolated transistor, passiv switching transistor
Rating:	30 V, 50 mA

MODBUS communication interface (optional):

Interface type:	RS485, galvanic isolated
Baud rate:	300 / 600 / 1200 / 2400 / 4800 / 9600 / 14400 / 19200 / 32800 Baud
Parity:	even / odd / none
Protocol:	MODBUS RTU slave
Address:	1-255
Possible commands:	3 (register read)

Power supply:

Supply voltage:	24 VDC ±10% PQRM5100 11 230 V AC/DC ±10% PQRM5100 11 PS
Power consumption:	1.5 VA / 1 W

Galvanic isolation:

Current power measure input:	Galvanic isolated, R < 20 mOhm
Voltage power measure input:	Resistordivider, R = 1.6 MOhm
Operating isolation voltage:	250 V _{eff} (between measuring inputs and power supply input)
Test voltage:	4200 VDC (1 min.) (between measuring inputs and power supply input) 500 VDC (between output-power supply terminals)

Ambient conditions:

Operating temperature range:	0-60 °C
Storage temperature range:	0-70 °C
Relative humidity:	90% (max., non condensing)
Place of installation:	cabinet

Electromagnetic compatibility (EMC)

accordance with the standard EN 61326-1

Immunity:	industrial area
Noise emission:	Group 1, Class B

General data:

Housing:	panel instrument
Connection:	push-in direct connection
Connection cable:	4.5 mm ² (max.)
Dimensions / weight:	104 × 104 × 120 mm (width × height × depth) / 0.5 kg (max.)
Protection:	IP 54 front / IP 20 rear

Detailed information see in operating instructions. The Manufacturer maintains the right to change the technical data!

Annex06: DACTON PQRM5300_33 (1 photo):



Image 1: DACTON PQRM5300_33
Serial number is inside the device

Annex 07 VORTEX SV5050-01_EN-GB data sheet (8 pages) + (3 photos)

Manufacturer Certificate
Werksbescheinigung

ZC0001 EN 10 204-2.1

ÉMI Nonprofit Kft
Dózsa György út 26.
2000 Szentendre
Ungarn

ifm electronic gmbh
Friedrichstr. 1
45128 Essen
Telefon / Phone: +49 201 2422-0
Telefax: +49 201 2422-200
E-Mail: info@ifm.com
Internet: ifm.com

Datum / Date: 05.02.2024

We hereby certify that the below-mentioned product is integrated in the quality planning and subjected to a final test. On leaving our dispatch department this product complies with the technical data indicated in the data sheet.

Hiermit bestätigen wir, dass das unten genannten Produkt in die Qualitätsplanung integriert ist und einer Endprüfung unterzogen wird. Beim Verlassen unseres Versandes erfüllt dieses Produkt die im Datenblatt angegebenen technischen Daten.

Type of unit/Gerätetyp	Article number/Artikelnummer	Designation/Bezeichnung
Vortex flow meter Vortex-Durchflusssensor	SV5050	SVM34XXXD0KG/US-100

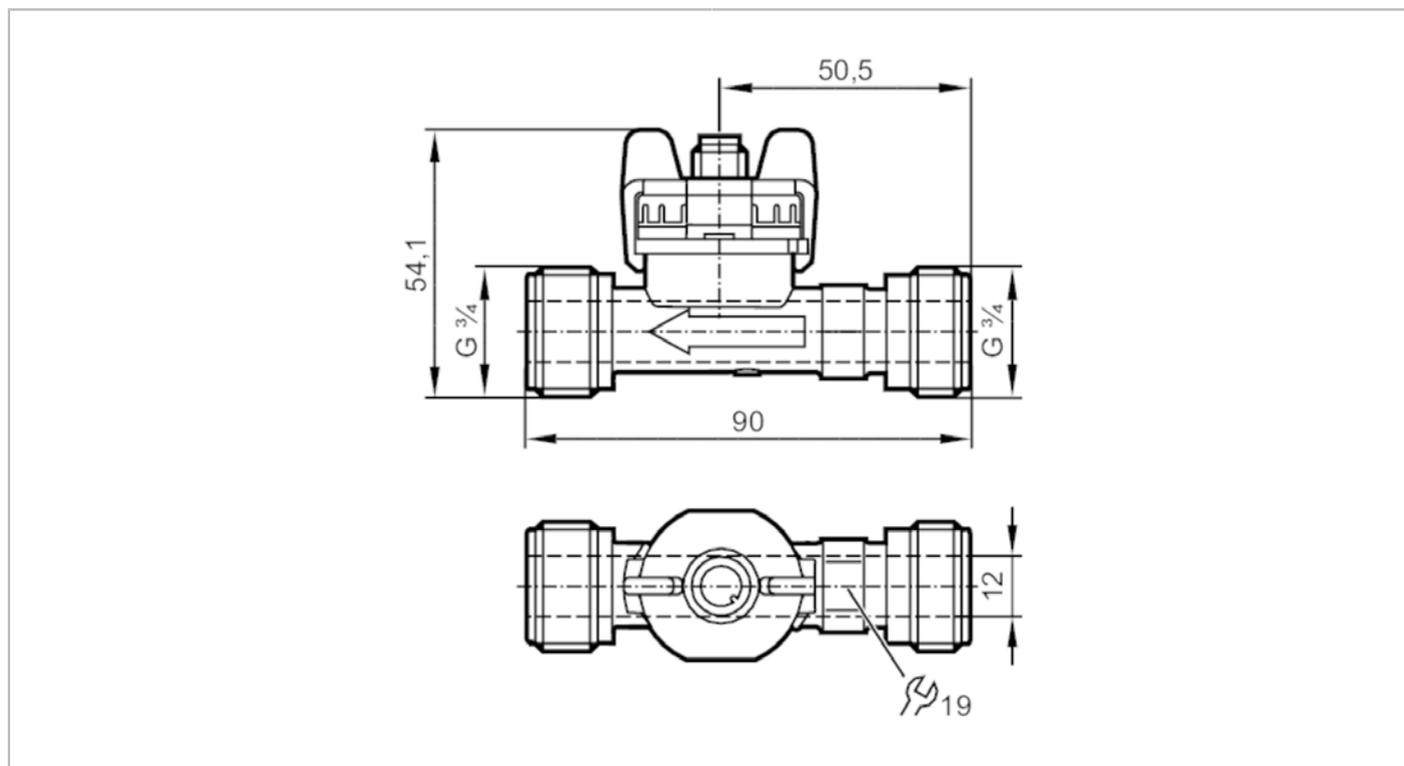
The technical datasheet is available on ifm.com.
Das technische Datenblatt finden Sie auf ifm.com.

SV5050



Vortex flow meter

SVM34XXXD0KG/US-100



Product characteristics

Number of inputs and outputs	Number of analogue outputs: 1	
Measuring range	1.8...32 l/min	0.265...4.716 m/s
Process connection	threaded connection G 3/4 internal thread DN10	

Application

Special feature	Gold-plated contacts	
Measuring element	1 x Pt 1000; (to DIN EN 60751, class B)	
Application	for industrial applications	
Installation	connection to pipe by means of an adapter	
Media	water; glycol solutions; coolants	
Medium temperature [°C]	-40...100	
Min. bursting pressure [bar]	25	
Min. bursting pressure [MPa]	2.5	
Pressure rating [bar]	12	
Pressure rating [MPa]	1.2	
Note on pressure rating	up to 40 °C	

Electrical data

Operating voltage [V]	8...33 DC	
Min. insulation resistance [MΩ]	100; (500 V DC)	
Protection class	III	
Power-on delay time [s]	< 2	
Measuring principle	Vortex	

SV5050



Vortex flow meter

SVM34XXXD0KG/US-100

Inputs / outputs		
Number of inputs and outputs	Number of analogue outputs: 1	
Outputs		
Total number of outputs	1	
Output signal	analogue signal	
Number of analogue outputs	1	
Analogue current output [mA]	4...20; (water: $Q [l/min] = 2,0 \times (I - 4 \text{ mA})$; water-glycol: $Q [l/min] = 2,0 \times (I - 4 \text{ mA}) - Q_0$ see Figure 2)	
Max. load [Ω]	$< (U_b - 8 \text{ V}) / 20 \text{ mA}$; $U_b = 24 \text{ V}$: 800	
Measuring/setting range		
Measuring range	1.8...32 l/min	0.265...4.716 m/s
Temperature monitoring		
Internal heating temperature probe	1 K/mW	
Measuring range [$^{\circ}\text{C}$]	-40...100	
Accuracy / deviations		
Flow monitoring		
Accuracy (in the measuring range)	$Q < 50 \% \text{ MEW}: < 1 \% \text{ MEW} / Q > 50 \% \text{ MEW}: < 2 \% \text{ MW}$; (water)	
Repeatability	0,2; (% of the final value)	
Temperature monitoring		
Accuracy [K]	$\pm 0,3 \pm 0,005 \times T$	
Response times		
Flow monitoring		
Response time [s]	0.5	
Operating conditions		
Ambient temperature [$^{\circ}\text{C}$]	-15...85	
Storage temperature [$^{\circ}\text{C}$]	-30...85	
Protection	IP 65	
Cavitation	$P(\text{absolute discharge}) / P(\text{difference}) > 5.5$ to avoid cavitation	
Tests / approvals		
EMC	EN 61326-2-3	
Shock resistance	DIN EN 60068-2-27	30 g (11 ms)
Vibration resistance	DIN EN 60068-2-6	with water / 10...61 Hz 1 mm with water / 61...2000 Hz 2 g
MTTF [years]	380	
Pressure Equipment Directive	Sound engineering practice; can be used for group 2 fluids; group 1 fluids on request	
Mechanical data		
Weight [g]	87.8	
Housing	rectangular	
Dimensions [mm]	90 x 30.22 x 54.1	
Materials	PA 6T	
Materials (wetted parts)	ETFE; PA 6T; FKM	
Tightening torque [Nm]	12	

SV5050



Vortex flow meter

SVM34XXXD0KG/US-100

Process connection threaded connection G 3/4 internal thread DN10

Displays / operating elements

Display colour display 1,44", 128 x 128 pixels
2 x LED, yellow

Remarks

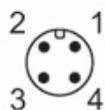
Remarks MW = measured value

MEW = Final value of the measuring range

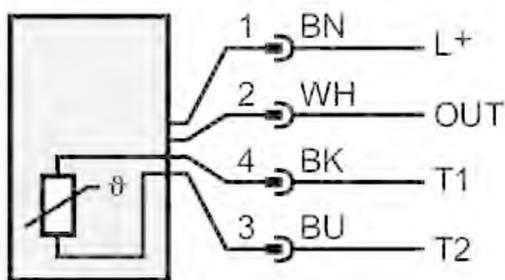
Pack quantity 1 pcs.

Electrical connection

Connector: 1 x M12; coding: A; Contacts: gold-plated



Connection



OUT: analogue output

T1 / T2: Pt1000
colours to DIN EN 60947-5-2

Core colours :

- BK = black
- BN = brown
- BU = blue
- WH = white

SV5050

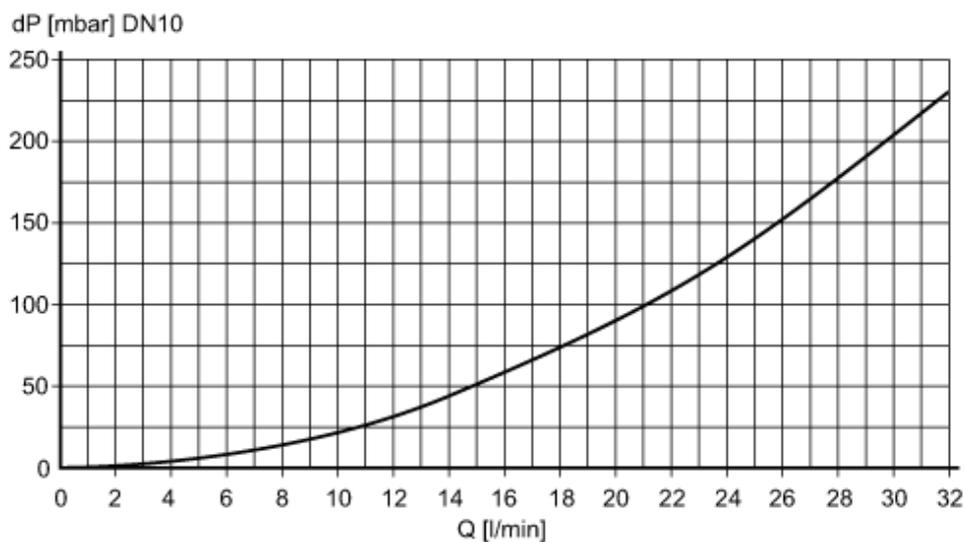


Vortex flow meter

SVM34XXXD0KG/US-100

Diagrams and graphs

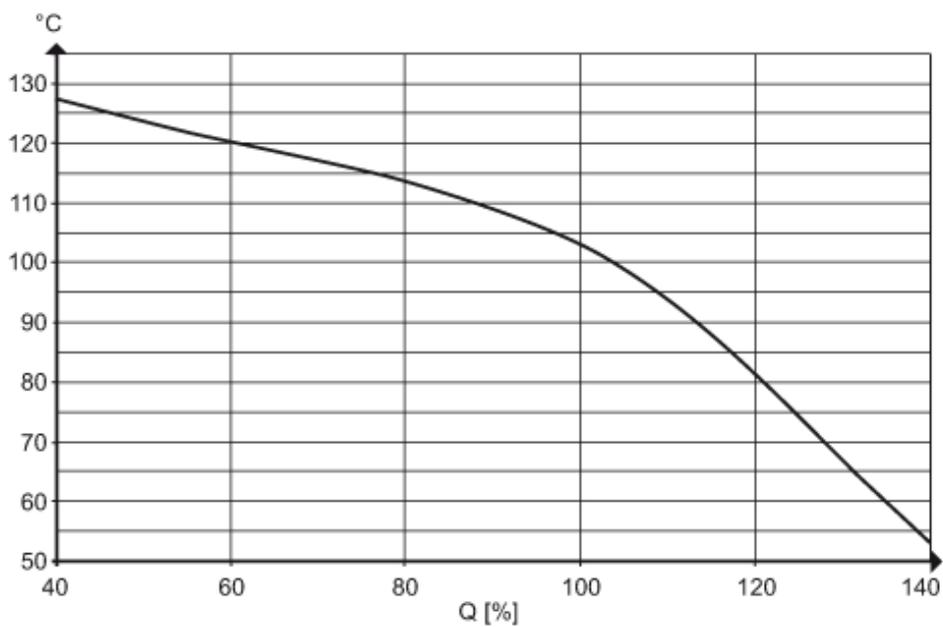
Pressure loss



dP Pressure loss

Q volumetric flow quantity

min. life 10 years referred to flow and high medium temperatures



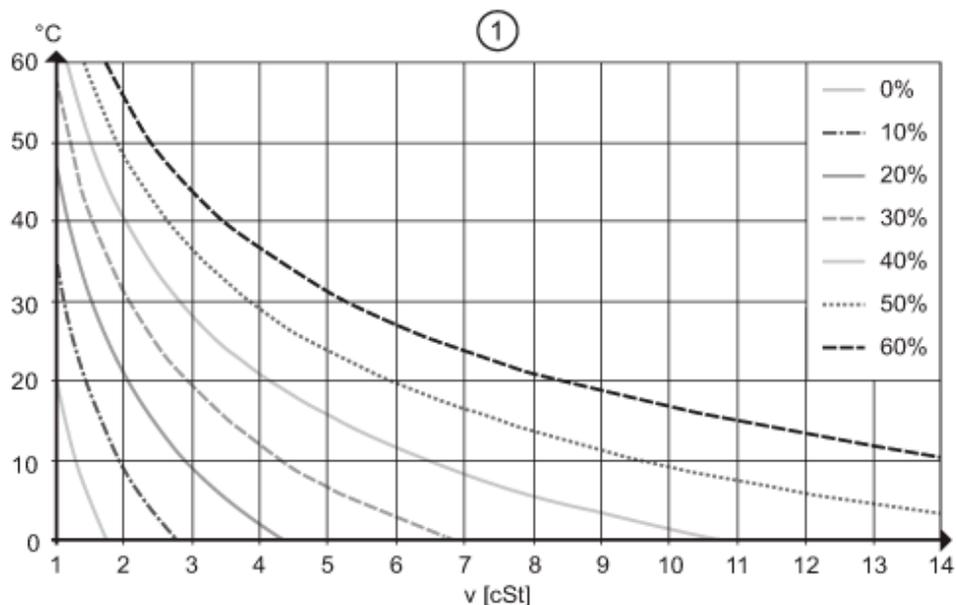
SV5050



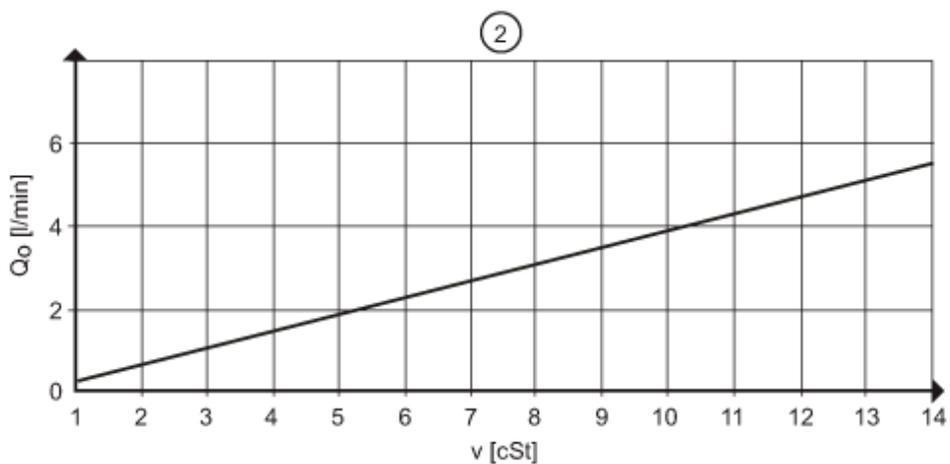
Vortex flow meter

SVM34XXXD0KG/US-100

determination of the kinematic viscosity (ν) of glycol-water mixtures depending on the temperature



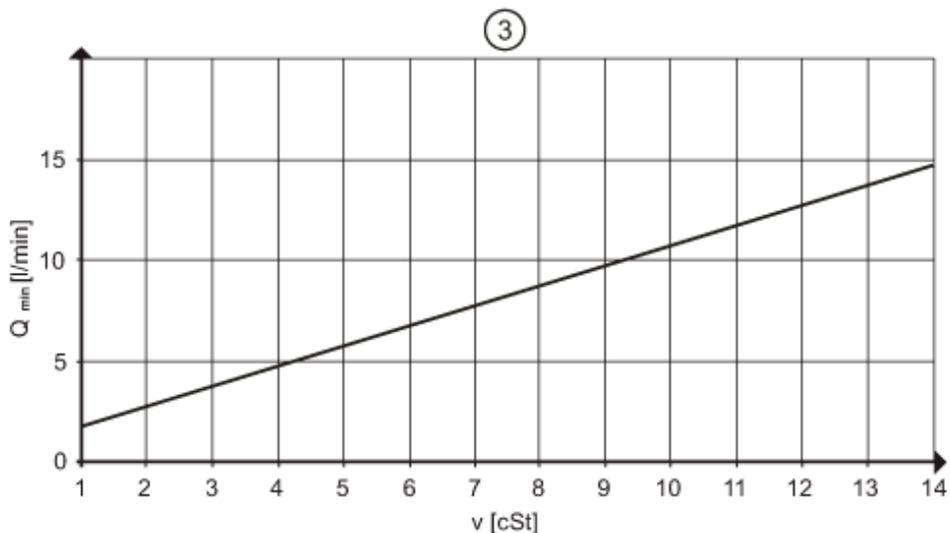
determination of the compensation value Q_0 for glycol-water mixtures



$\nu < 4$ cSt measuring accuracy 3% MEW

$4 < \nu < 14$ cSt measuring accuracy 4% MEW

response threshold Q_{min} depending on the kinematic viscosity



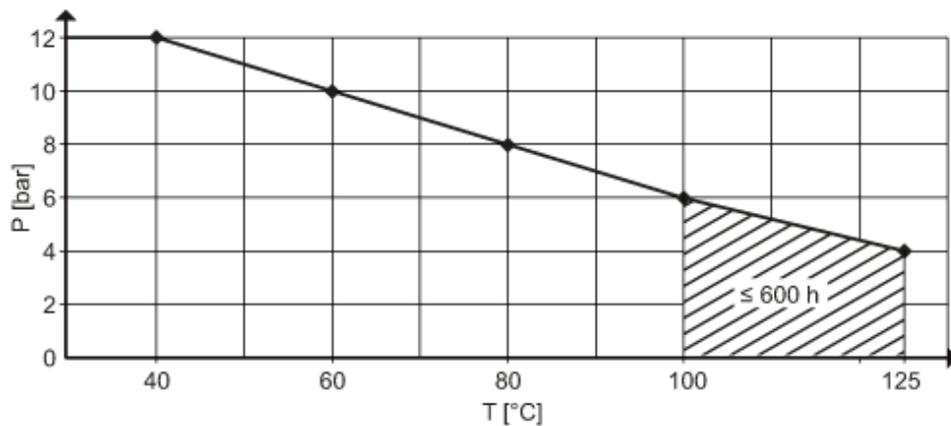
SV5050

Vortex flow meter

SVM34XXXD0KG/US-100



pressure rating (bar)



Annex07: VORTEX SV5050 (3 photo):



Image 1: VORTEX SV5050 (Solar Flow Sensor PA6T/6I_1)

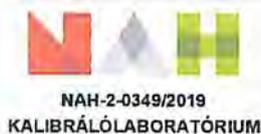


Image 2: VORTEX SV5050 (DHW Flow Sensor PA6T/6I_2)



Image 3: VORTEX SV5050 (Heating Flow Sensor PA6T/6I_4)

Annex 08 Danfoss MBS4510_EN datasheet (7 pages) + (2 photo)



KALIBRÁLÁSI BIZONYÍTVÁNY

Megrendelő neve, címe: **ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.**
2000 Szentendre, Dózsa György út 26.

Kalibrálandó mérőeszköz megnevezése: **Nyomástávadó**

Gyártó, típus, gyári szám: **DANFOSS** Típus: MBS 4510 Gy.sz.: 21257451
Méréshatár, pontosság: **0 - 10** bar o.p. **0,5**
Átvételi állapot: Használt / kalibrálásra alkalmas

A kalibráláshoz használt etalonok megnevezése, gyári száma, és a visszavezethetőséget igazoló dokumentum:

1 Multiméter: KEITHLEY 197 DMM gy.sz.: 437326 KALTECH 3138/2021
2 Etalon 100 Ω : ZIP P331 gy.sz.: 151101 KALIBRA 59 K/22-1845
3 Nyomásetalon: Budenberg Fig. 246 gy.sz.: 11769 ATKIS 78005
Egyéb mérőeszköz:
Hőmérő ATKIS TM6 gy.sz.: - KALIBRA 59 K23-1793

Kalibrálás eredményei:

Névleges érték (bar)	Névleges érték (μ A)	Leolvasott érték (μ A)		Ismétlőképesség vizsgálat (méréstartomány 20, 50, 80%)					
		növekvő	csökkenő	növ.	csökk.	növ.	csökk.	növ.	csökk.
0	4000	3995	3990						
1	5600	5597	5592						
2	7200	7198	7195	7198	7195	7198	7195	7198	7195
3	8800	8798	8797						
4	10400	10400	10403						
5	12000	11998	11997	11998	11997	11998	11997	11998	11997
6	13600	13598	13599						
7	15200	15199	15199						
8	16800	16797	16796	16797	16796	16797	16796	16797	16796
9	18400	18400	18400						
10	20000	20001	20001						

Talált legnagyobb hiba: 10 μ A 0,006 bar
Kiterjesztett mérési bizonytalanság (U): 6,96 μ A 0,004 bar
Specifikált hibahatár: 80,00 μ A 0,05 bar
Elfogadási hibahatár ($w = 0$): 80,00 μ A 0,05 bar

Környezeti hőmérséklet: 22,3 °C

Kalibrálás módja: Közvetlen összehasonlítással KE-3/2018 kalibrálási eljárás alapján.

Visszavezethetőség: Az alkalmazott használati etalonokkal mért értékek az országos etalonokra visszavezethetők.

A közölt mérési eredmények a távadó talált metrológiai jellemzőire vonatkoznak.

A kiterjesztett mérési bizonytalanság a 2-es szorzóval megszorított standard bizonytalanság, azaz $k=2$, amely normális eloszlás esetén közelítőleg 95%-os fedési valószínűségnek felel meg.

Ez a bizonytalanság tartalmazza az etalonokból, a kalibrálás módszerével a környezeti feltételekből és a kalibrált eszköz okozta rövid ideig tartó hatásokból eredő részbizonytalanságokat az EA-4/02 szerint.

Minősítés:¹ A közölt kalibrálási eredmények alapján a készülék a gépkönyv szerinti pontosságnak: **megfelel** **nem-felel meg**

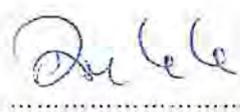
A kalibrálás helye és időpontja: ATKIS AUTOMATIKA Kft. Kalibráló Laboratórium
Budapest, 2023.06.12.

Kiadás dátuma: 2023.06.12

Kalibrálást végezte: 
Muszka Zoltán



ATKIS AUTOMATIKA Kft.
Kalibráló Laboratórium
1161 Bp., Köztársaság útja 9.
Tel.: 06-1-329-5453
Tel./Fax: 06-1-451-0981

Ellenőrizte: 
Bekker Csaba

¹ Döntési szabály: ILAC-G8:09/2019 [4.2.1]

Data sheet

Pressure transmitter for industrial applications

MBS 4510



The high accuracy flush diaphragm pressure transmitter MBS 4510 is designed for use in non-uniform, high viscous or crystallizing media within industrial applications, and offers a reliable pressure measurement, even under harsh environmental conditions.

The flexible pressure transmitter programme covers a 4 – 20 mA output signal, absolute or gauge (relative) versions, measuring ranges from 0 – 0.25 to 0 – 25 bar zero and span adjustment. A rotatable plug connection and a G1A conic pressure connection with flush mounted diaphragm.

Excellent vibration stability, robust construction, and a high degree of EMC/EMI protection equip the pressure transmitter to meet the most stringent industrial requirements.

Features

- Designed for use in severe industrial environments
- Enclosure and wetted parts of acid-resistant stainless steel (AISI 316L)
- Pressure ranges in relative (gauge) or absolute up to 25 bar
- Output signal: 4 – 20 mA
- Temperature compensated and laser calibrated
- Accuracy 0.5% FS
- Zero and span adjustment
- USDA-H1 approved oil filling
- For use in Zone 2 explosive atmosphere

Technical data
Performance (EN 60770)

Accuracy (incl. non-linearity, hysteresis and repeatability)		$\leq \pm 0.2\%$ FS (typ.)
		$\leq \pm 0.5\%$ FS (max.)
Non-linearity BFSL (conformity)		$\leq \pm 0.2\%$ FS
Hysteresis and repeatability		$\leq \pm 0.1\%$ FS
Thermal zero point shift	Measuring range:	0 – 250 mbar $\leq \pm 0.4\%$ FS / 10K
		0 – 400 mbar $\leq \pm 0.3\%$ FS / 10K
		≥ 0 – 600 mbar $\leq \pm 0.2\%$ FS / 10K
Thermal sensitivity (span) shift	Measuring range:	0 – 250 mbar $\leq \pm 0.4\%$ FS / 10K
		0 – 400 mbar $\leq \pm 0.35\%$ FS / 10K
		≥ 0 – 600 mbar $\leq \pm 0.2\%$ FS / 10K
Response time		< 4 ms
Durability, P: 10 – 90% FS		$> 10 \times 10^6$ cycles
Zero point adjustment	Measuring range:	0 – 0.25 to 0 – 10 bar -5 – 20% FS
		0 – 16 to 0 – 25 bar -5 – 10% FS
Span adjustment	Measuring range:	0 – 0.25 to 0 – 25 bar -5 – 5% FS

Available measuring ranges

Pressure range [bar]	Max. Overload pressure [bar]	Burst pressure [bar]
-0.25 – 0.50	2	50
0.00 – 0.25	2	50
0.00 – 0.40	2	50
0.00 – 0.60	2	50
0.00 – 1.00	2	50
0.00 – 1.60	8	50
0.00 – 2.50	8	50
0.00 – 4.00	8	50
0.00 – 6.00	20	50
0.00 – 10.00	20	50
0.00 – 16.00	100	100
0.00 – 25.00	100	100

Electrical specifications

Nom. output signal (short-circuit protected)	4 – 20 mA
Supply voltage [U _B], polarity protected	10 – 30 V DC
Supply voltage dependency	$\leq \pm 0.1\%$ FS / 10 V
Current limitation (linear output signal up to 1.5 × rated range)	28 mA (typ.)
Load [R _L] (load connected to 0 V)	$R_L \leq (U_B - 10 V) / 0.02 A [\Omega]$

Technical data
(continued)
Environmental conditions

Sensor temperature range	Normal	-40 – 85 °C
	ATEX Zone 2	-10 – 85 °C
Media temperature	115 - (0.35 × ambient temperature)	
Ambient temperature range	-10 – 85 °C	
Compensated temperature range	0 – 80 °C	
Transport / Storage temperature range	-25 – 85 °C	
EMC – Emission	EN 61000-6-3	
EMC – Immunity	EN 61000-6-2	
Insulation resistance	> 100 MΩ at 100 V	
Mains frequency test	Based on SEN 361503	
Vibration stability	Sinusoidal	15,9 mm-pp, 5 Hz – 25 Hz 20 g, 25 Hz – 2 kHz
	Random	7.5 g _{rms} , 5 Hz – 1 kHz
Shock resistance	Shock	500 g / 1 ms
	Free fall	1 m
Enclosure (depending on electrical connection)	IP65	

Explosive atmospheres

Zone 2 applications	  II 3G Ex nA IIA T3 Gc -20C<Ta<85C	EN60079-0; EN60079-15
---------------------	--	-----------------------

When used in ATEX Zone 2 areas at temperatures <-10 °C the cable and plug must be protected against impact

Mechanical characteristics

Materials	Wetted parts	EN 10088-1; 1.4404 (AISI 316 L)
	Enclosure	EN 10088-1; 1.4404 (AISI 316 L)
	Electrical connections	Glass filled polyamid PA 6.6
Gasket (above thread)	DIN 3869-33-NBR	
Net weight (depending on pressure connection and electrical connection)	0.4 kg	

Ordering standard

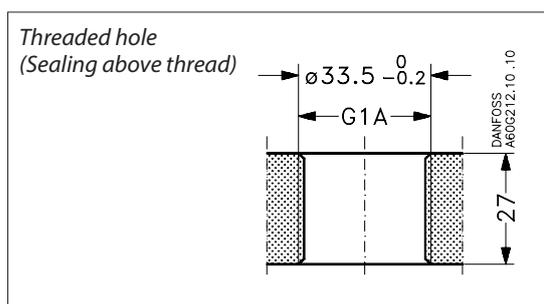
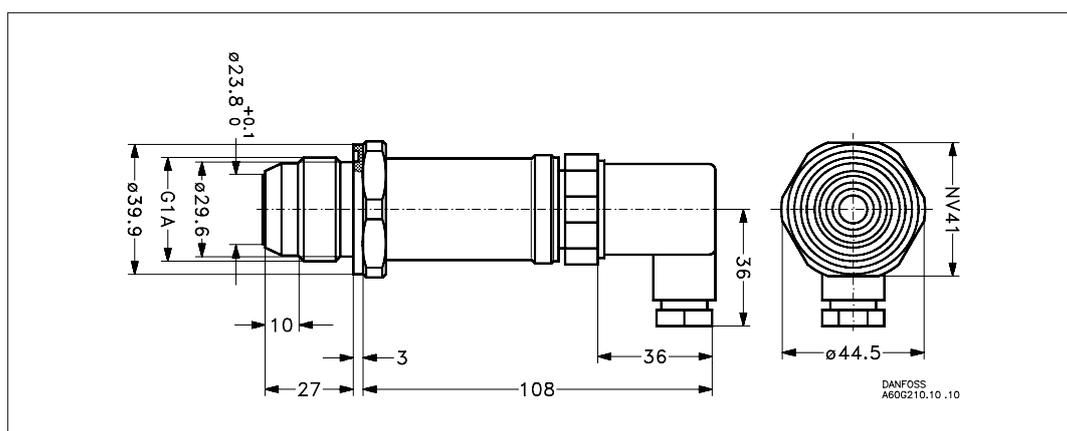
MBS 4510	1 - A1 C B 1 2	Pressure connection G1A, ISO 228-1, Flush male
Measuring range	A 4	Electrical connection Plug Pg 9 (EN 175301-803-A)
0.25 – 0.5 bar	A 4	Output signal 1 4 – 20 mA
0 – 0.25 bar	0 4	
0 – 0.4 bar	0 6	
0 – 0.6 bar	0 8	
0 – 1.0 bar	1 0	
0 – 1.6 bar	1 2	
0 – 2.5 bar	1 4	
0 – 4.0 bar	1 6	
0 – 6.0 bar	1 8	
0 – 10 bar	2 0	
0 – 16 bar	2 2	
0 – 25 bar	2 4	
Pressure reference	1	
Gauge (relative)	1	
Absolute	2	

☐ Preferred version

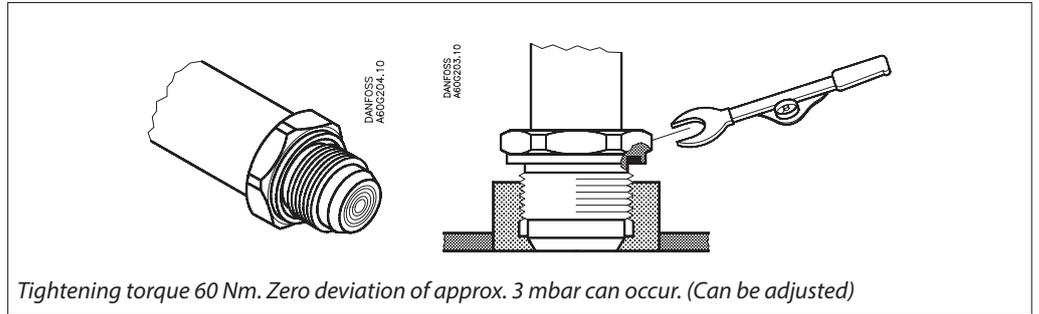
Electrical connections

Electrical connection	4 – 20 mA output (2 wire)
<p>EN 175301-803-A, Pg 9</p>	<p>Pin 1: + supply Pin 2: ÷ supply Pin 3: Not used</p> <p>Earth: Connected to MBS enclosure</p>

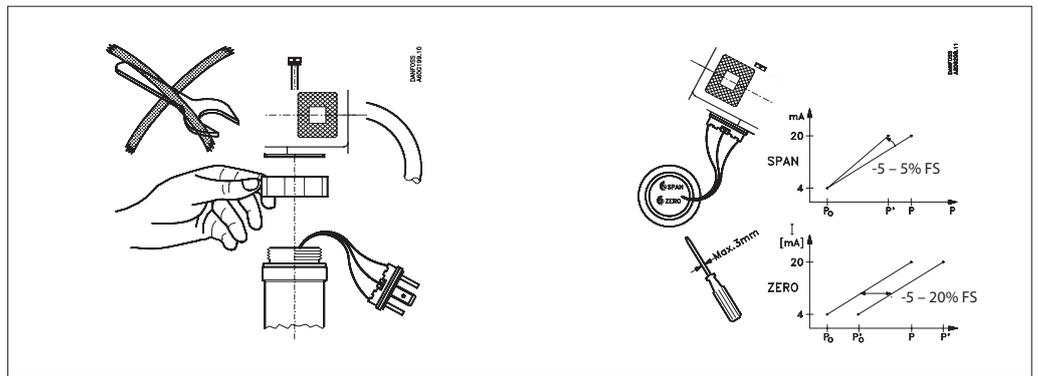
Dimensions



Installation



Adjustment



Accessories

<p>Welding nipple for conic metal/metal seal Code no.: 060G2501</p>	<p>DIN 11851 (dairy connection), DN40 Code no.: 060G2505</p>
<p>DIN 11851 (dairy connection), DN50 Code no.: 060G2506</p>	<p>Clamp, ISO 2852, 1½ in. Code no.: 060G2502</p>
<p>Clamp, ISO 2852, 2 in. Code no.: 060G2510</p>	<p>SMS 1145 connection, 1½ in. Code no.: 060G2503</p>

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Annex08: Danfoss MBS4510 (2 photo):



Image 1: Danfoss MBS4510 (Solar)



Image 2: Danfoss MBS4510 (Solar)

Annex 09 Thermocouples Calibration Certificates (12 pages) +
(10 photos)

Fenyvesi Gábor

Feladó: Molnár Erzsébet <molnar.erzsi@dicontrol.hu>
Küldve: péntek 2025. január 24 9:32
Címzett: Fenyvesi Gábor
Másolatot kap: Kovács Miklós
Tárgy: RE: jkv-ek

Kedves Gábor!

Igen, megerősítjük a leírtakat.

Üdvözlettel:

Molnár Erzsébet
irodavezető

H-1147 Budapest Öv u. 143
Tel: +36-1-467-0830
Mobil: +36-20-320-97-84



www.dicontrol.hu

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From: Fenyvesi Gábor <fenyvesig@EMI.HU>
Sent: Thursday, January 23, 2025 2:45 PM
To: Molnár Erzsébet <molnar.erzsi@dicontrol.hu>
Subject: RE: jkv-ek

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Konzultáltam az auditorral a hőelemek ügyében és **kérem erősítse meg ezt a levelet, hogy jól értettem.**
Ugyan azt írom le, amit Ön, csak bele kell írnom a hivatkozási számokat.

Az alábbi képen látható hőelemmel végeztünk mérést:
Azonosító száma: ZP01374062022/117



Ez a hőelemhez tartozó teljesítmény **nyilatkozat sorszáma: ZS-00000116/06/2022P**

A **ZS-00000116/06/2022P** teljesítmény nyilatkozathoz tartozó **kalibrálási jegyzőkönyv sorszáma: PS2208001a**

A jegyzőkönyveket csatoltam a kapott filenévvel.

Még egyszer nagyon szépen köszönöm a segítségét.

FENYVESI GÁBOR

VIZSGÁLÓ MÉRNÖK

KÖZPONTI VIZSGÁLÓ LABORATÓRIUM

ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.

m +36 30 728 6387

e fenyvesig@emi.hu

w www.emi.hu



From: Fenyvesi Gábor

Sent: Thursday, January 23, 2025 1:43 PM

To: Molnár Erzsébet <molnar.erzsi@dicontrol.hu>

Subject: RE: jkv-ek

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Nagyon szépen köszönöm a segítséget.

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VIZSGÁLÓ MÉRNÖK

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ÉMI Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.

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From: Molnár Erzsébet <molnar.erzsi@dicontrol.hu>

Sent: Thursday, January 23, 2025 11:18 AM

To: Fenyvesi Gábor <fenyvesig@EMI.HU>

Subject: FW: jkv-ek

Kedves Gábor!

Az ügyvezetőtől kapott levelet továbbítottam Önnek. A beszállító is csak ezeket a dokumentumokat tudja újra küldeni amit már elküldtem e-mailben.

Üdvözlettel:

Molnár Erzsébet

irodavezető

H-1147 Budapest Öv u. 143

Tel: +36-1-467-0830

Mobil: +36-20-320-97-84



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From: Kovács Miklós <kovacs.miklos@dicontrol.hu>

Sent: Thursday, January 23, 2025 10:52 AM

To: 'Molnár Erzsébet' <molnar.erzsi@dicontrol.hu>

Subject: RE: jkv-ek

A Kalibrálási jkv és a Megfelelőségi nyilatkozat2. tartoznak össze, az 5m hosszú, "K" típusú köpenyhőelemre (200db) vonatkoznak.

(A Megf.Nyil.1 a lapos végű tűzvédelmi hőelemhez tartozik., ezt ne küldje el!)

Üdvözlettel

Kovács Miklós

ügyvezető

DICONTRON Kft

tel/fax: +36 1 467 0830, +36 1 467 0833

mobil: +36 203 443 707

kovacs.miklos@dicontrol.hu

www.dicontrol.hu

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Cégünk Adatvédelmi Szabályzatát kérésre csatolt Emailban megküldjük

Deklaracja zgodności z zamówieniem wg PN EN 10204 2.1
Certificate of compliance with the order acc to PN EN 10204 2.1**ZS-00000116/06/2022/P**

Wystawione dla / Making out for : **DICONTROL**
Irányítástechnika Korlátolt Felelősségű Társaság
1147 Budapest, 14 Öv u. 143.
Budapest

Nr zamówienia / order-nr : **A045-22**

Części / Parts : **Seria FireTECH TERMOPARA PŁASZCZOWA 1,5x5000 Z**
PRZEWODEM 1,0M SS I WTYCZKĄ STD

Typ / type : **FT-71155001-0100.5000.S00**

Nr. artykułu/ Article no : **22060002**
ZP01374062022

Zaświadczenie / Certification :

Firma Guenther potwierdza, że dostarczony produkt jest zgodny ze specyfikacją związaną z wymienionym powyżej zamówieniem.

Guenther company certifies that the product supplied are in compliance with the specification of the order.

Wszystkie wymienione powyżej części zostały poddane dokładnej inspekcji.

All above mentioned parts have been subjected to a final inspection.

Dane techniczne wyżej wymienionych części są zgodne z (w momencie dostarczenia):

The technical data for above mentioned parts are in accordance to(at time of delivery):

**Klasa 1 wg PN-EN 60584-1:2014****Termoelementy- Część 1: Specyfikacje i tolerancje EMF****Class 1 acc. to EN 60584-1:2013****Thermocouples-Part 1 : EMF specifications and tolerances**

Stwierdzenie zgodności na wyjściu towaru:

Wyrób zgodny z zamówieniem numer: **A045-22** oraz normami zakładowymi.

Podpis osoby kontrolującej na wyjściu



Guenther Polska Sp. z o.o.
ul. Wrocławska 27 C
55-095 Długoleśka
NIP 895-19-06-589 REGON 020702531
KRS 0000300821

Guenther Polska Sp. z o.o.

potwierdzenie zgodności
quality assurance

Sp. z o.o.
JAKOŚĆ

Data / date:

22.07.2022 Długoleśka

2004605
fotel

CALIBRATION CERTIFICATE NO. :PS2208001a

CALIBRATION CERTIFICATE NO.

Release date: 18.08.2022

APPLICANT Dicontrol Iranyitastechnika Korlatolt Felelossegu
Tarsasag
1147 Budapest, 14Ov u. 143. 00-117 Budapest

PLACE OF CALIBRATION Guenther Polska Sp. z o.o.
ul. Wrocławska 27c
55-095 Długołęka

EXTERNAL ORDER NO. Angebot 01.08.2022 Guenther Polska

INTERNAL ORDER NO. ZS 4/08/2022/P

OBJECT OF CALIBRATION

Name:	Thermocouple	Type:	1 x NiCr-Ni/K
Article code:	22062524	Registration No.:	From: PS2208001/1 To: PS2208001/200
Charge:	0101013202207	Manufacturer/ Model:	Guenther

DATE OF CALIBRATION 17.08.2022

TYPE OF CALIBRATION Initial

CALIBRATION METHOD The calibration has been performed in accordance with procedure QMV9.01.01 Calibration of the thermocouple by the comparison method ver.3.0 from 12.10.2021 (based on the ASTM E220-19).

MEASUREMENT TRACEABILITY The certificate provides traceability of measurement results with of the International System of Units (SI).

MEASUREMENT UNCERTAINTY The measurement uncertainty has been determined in accordance with EA-4/02 M: 2022. Provided uncertainty values are expanded uncertainties with a probability of extension of about 95% and a expansion factor of $k = 2$.

COMMENTS Calibration results apply only calibrated object.
This certificate may be presented or copied as a whole document only.

REFERENCE PROBES AND MEASURING DEVICES

Cold junction 0°C

WIKA	2022-465-PT-1	L-Z-0002	30-05-2023
------	---------------	----------	------------

Measuring instrument

Keysight	6394/2021	L-M-0008	30-11-2022
----------	-----------	----------	------------

Temperature source

Fluke	immersion depth = 150 mm	L-H-0008
-------	--------------------------	----------

Reference probes

PtRh10-Pt/S	Z2-Z21.4180.61.2022.2153.1	L-T-0025	11-07-2023
-------------	----------------------------	----------	------------

ENVIRONMENTAL CONDITIONS

Ambient temperature (22,5 + 23,0) °C

Humidity (43,6 + 45,0) %

RESULTS OF CALIBRATION

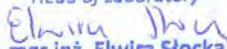
SENSOR TYPE	TEMPERATURE			THERMOVOLTAGE	MEASUREMENT ERROR	MEASUREMENT UNCERTAINTY	COMMENTS
	NOMINAL	REFERECE	CALCULATED				
	[°C]			[mV]	[°C]	+/- [°C]	
K	50,0	50,2	50,2	2,029	0,0	0,7	thermocouple roll start
	200,0	200,2	200,4	8,155	0,2	0,7	
	350,0	350,2	350,7	14,321	0,5	0,7	
K	50,0	50,2	50,2	2,030	0,0	0,7	thermocouple roll end
	200,0	200,2	200,6	8,162	0,4	0,7	
	350,0	350,2	350,9	14,333	0,7	0,7	

COMMENTS

- Nominal temperature: set point specified in the order.
- Reference temperature: average value of the measurements read from the reference standard.
- Calculated temperature: calculated temperature value on the basis of the PN-EN 60584-1:2014-04 from the measured thermovoltage of the calibrated object.
- Measurement error = Calculated temperature - Reference temperature
- Average measurement error of calibrated objects.

SENSOR TYPE	NOMINAL TEMPERATURE	AVERAGE MEASUREMENT ERROR
	[°C]	
K	50,0	0,0
	200,0	0,3
	350,0	0,6

Made by:

Kierownik Laboratorium
 Head of Laboratory

 mgr inż. Elwira Słocka

Approved:

Inżynier Laboratorium
 Laboratory Engineer

 mgr inż. Tomasz Słocki

Signature:

Signature:

END

Annex09: Thermocouples (10 photo):



Image 1: Thermocouple (Solar from FCU)



Image 2: Thermocouple (Cooling to Building)



Image 3: Thermocouple (Cooling from Building)



Image 4: Thermocouple (Heating from Building)



Image 5: Thermocouple (DHW from Building)

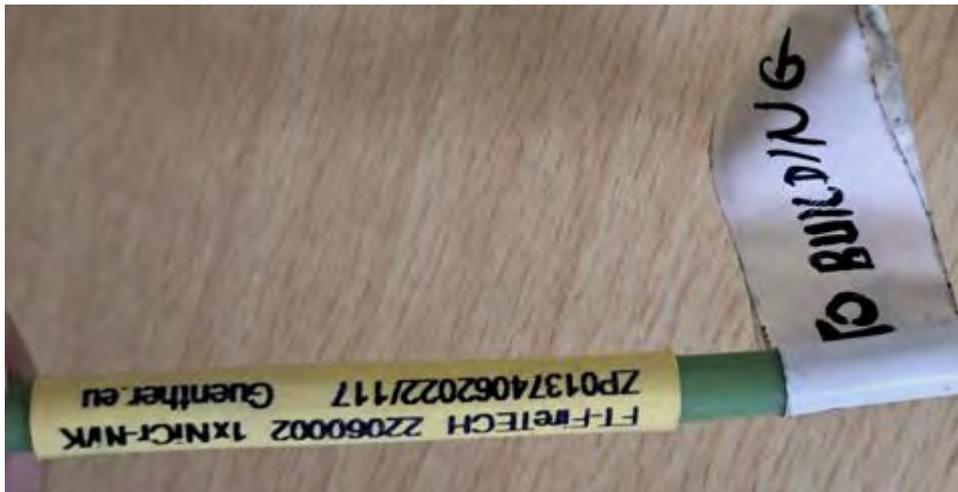


Image 6: Thermocouple (Heating to Building)



Image 7: Thermocouple (Solar to Panels)



Image 8: Thermocouple (Solar from Panels)

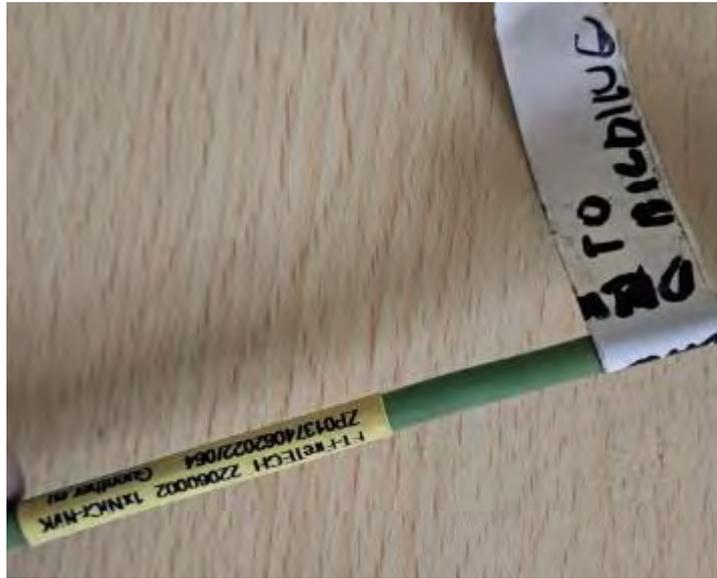


Image 9: Thermocouple (DWH to Building)



Image 10: Thermocouple (Ambient)

Annex 10 Ministor_manual_winter_operation (5 pages)

Guideline for “Winter” Operation of Ministor

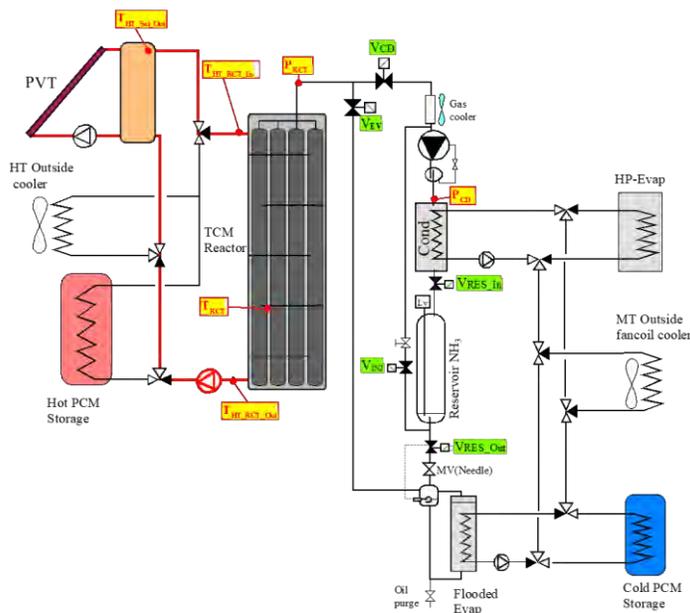
The basic operating principle of the Ministor system during winter, includes both charging and discharging phase.

TCM unit during the **charging** phase

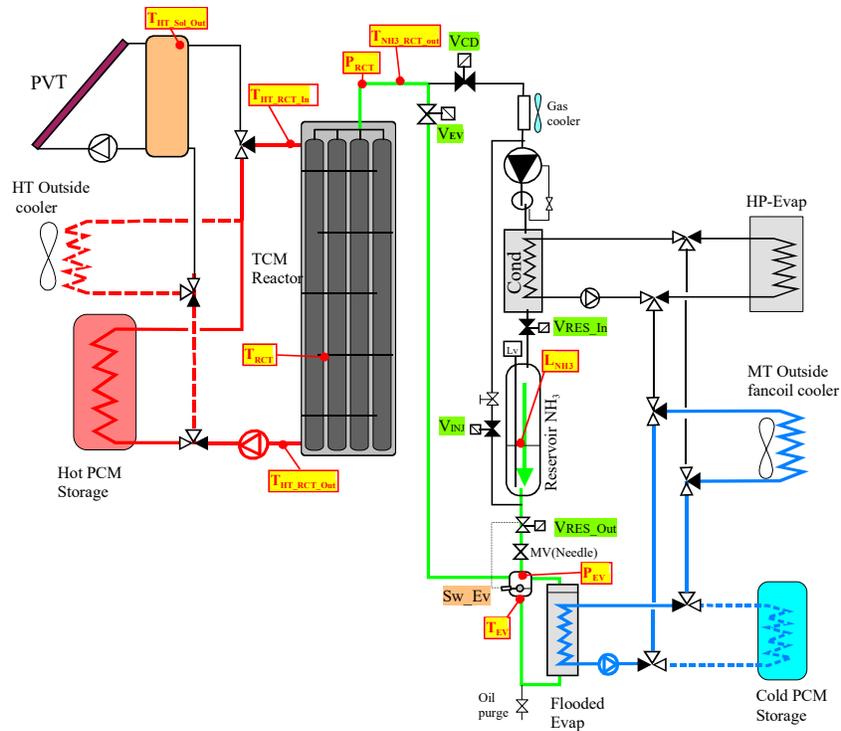
During winter, the solar collectors should provide heat at a minimum temperature of about 60 °C to allow the ammonia compressor to operate with an acceptable compression ratio. The operating pressure of the TCM reactor should be around 2 bars for this HTF inlet temperature of 60°C. Indeed, if solar heat is supplied at a lower temperature, the TCM operating pressure is then lower.

The charging phase consists of two steps: firstly establishing the temperature and pressure in the TCM reactor (pre-conditioning) followed by the decomposition of the ammoniated salt in the TCM reactor using the compressor (compressor-assisted charging).

When the temperature of the solar loop is high enough, the hot heat transfer fluid is pumped through the TCM reactor while it is isolated and disconnected from the other components (i.e., all valves are closed). This heats the ammoniated salt in the TCM reactor and starts the decomposition reaction, causing an increase in pressure in the reactor as ammonia vapour builds up.



When the reactor pressure is high enough in comparison to that at the condenser, the second step commences. The reactor is then connected to the compressor by opening the valve (VCD) and switching on the compressor. The compressed ammonia vapour is then condensed and the liquefied ammonia is stored in the liquid reservoir. The heat of condensation can be recovered and upgraded by the mechanical HP providing heat to the HOT PCM/ DHW PCM.



Manual Operation through Ministor Human – Machine Interface

Charging operation

- 1) During charging mode, the solar buffer tank must be hot enough at temperatures above 60 °C. Then, the first step is to heat up the TCM reactor with all the other valves closed. In order to do so:
 - a. HTF XV3 ON, HTF-XV16 ON,
 - b. Pump P-006 ON

After that, we are waiting until the TCM temperature is above 60 °C (NH3 TY1, NH3 TY2) and finally the system is ready for charging.

- 2) Connect heat pump (HP) evaporator with Ammonia condenser.
 - a. HTF-XV12 ON
 - b. Pump P-007 ON
- 3) Connect HP condenser with PCM tanks
 - a. HTF-XV10 ON (for HOT PCM), HTF-XV11 ON (for DHW PCM)
 - b. Pump P-005 ON
- 4) Turn on the HP from the Ministor screen (Green button HEAT PUMP)
 !!!!! IF THE HEAT PUMP DOESN'T WORK DON'T START THE CHARGING MODE.
 !!!!! IF YOU ACTIVATE THE HEAT PUMP AND DOESN'T START TO OPERATE, CHECK THE HP INVERTER IN THE MAIN ELECTRICAL PANEL. PRESS THE RED BUTTON STOP/RESET.
- 5) Turn on the Charging Mode from the Ministor screen (Green button MODES → Charging)

Stop charging operation:

- Turn off the charging mode
- Turn off the heat pump
- Turn off all the Pumps
- Turn off all the valves

Discharging operation

The first step, before starting discharging is to de-pressurize the TCM reactor. In order to do that, we need to cool down the reactor by circulating water at temperatures below 60 °C.

If the solar buffer has temperature < 55 °C we can use the solar buffer circuit for that reason.

- HTF-XV3 ON, HTF-XV16 ON
- Pump P-006 ON

By cooling down the TCM reactor, we reduce its pressure in order $P_{\text{reactor}} < P_{\text{evaporator}}$ or $\text{NH}_3 \text{ PT-1} < \text{NH}_3 \text{ PT-3}$

Another way to cool down the TCM reactor is the fan W-006 (V-005). In order to use the fan coil:

- HTF-XV-7 ON, HTF-XV-6-ON
- Pump P-006 ON
- V-005 ON

When the TCM reactor is de-pressurized we are ready for discharging. **Then turn off all the previous components and proceed to the discharging mode.**

If the TCM temperature is <55 °C proceed directly to the discharging mode without taking into account the above.

At discharging mode during WINTER, the evaporator of the Ammonia circuit is connected to the Cold PCM or the fan W-005 (V-004). The TCM reactor is connected to the HOT/DHW PCM, providing heat. For that reason:

- 1) HTF-XV-2 ON, HTF-XV1-ON (If we want the COLD PCM) – HTF-XV1-OFF (if we want the V-004 fan). IF we use the Fan V-004 we should turn on also the V-004 from the FANS menu.
- 2) Pump P-003 ON. Be sure that the flow switch HTF-FS-1 is ON.
- 3) HTF -XV-9 ON, HTF-XV-10 ON (Only if we want to heat up the Hot PCM), HTF-XV-11 ON (Only if we want to heat up the DHW PCM), HTF-XV-8 ON, HTF-XV-6 ON
- 4) Pump P-006 ON
- 5) Turn ON the Discharging mode from the Ministor screen (MODES → Discharge)

Stop Discharging Operation.

- Turn off the Discharging mode
- Turn off all the pumps and fans

- **Turn off all the valves**

Hot PCM to Building

- Be sure that all the valves connecting HOT PCM with the building are open
- Pump P-001 ON

DHW PCM to Building

- Be sure that all the valves connecting HOT PCM with the building are open
- The water circulating pump is NOT in the ministor box (Local Installation)

Transfer heat from solar buffer to PCM tank

If you want to heat up the PCM tanks with hot water from the solar buffer (temperature above 60 °C):

- HTF-XV3 ON, HTF-XV-14 ON, HTF-XV-9 ON, HTF-XV-10 ON (Only for HOT PCM), HTF-XV-11 ON (Only for DHW PCM), HTF-XV-8 ON
- Pump P-006 ON

Annex 11 MiniStor_SCADAQuickUserGuidelines_EN_v1.0 (18 pages)

Date

Rev

Page 1 out of 18

VALIDATION CERTIFICATE
 VERIFICATION REPORT

MEETING MINUTES
 REVIEW MINUTES

TECHNICAL REPORT
 FINAL REPORT

This document will detail the handling of the user interface designed in the Smartserver IoT, as well as the control of the MiniStor system from this PLC.

The first thing is to access to this SCADA. To do this, it will be necessary to run the following link within the ÉMI network where the PLC is located, just as CARTIF does with the VPN provided by ÉMI.

<https://192.168.42.100/node-red/ui/#!/0?username=apollo&password=845V-pvn7>

It is probable that you will have problems to access the first time if when you execute the link you are redirected to another page where you are asked for the credentials. Re-enter the same link without closing the browser. This problem is due to security issues of the PLC server.

If you continue to have problems, please contact us and we will try to solve them.

1 User Interface

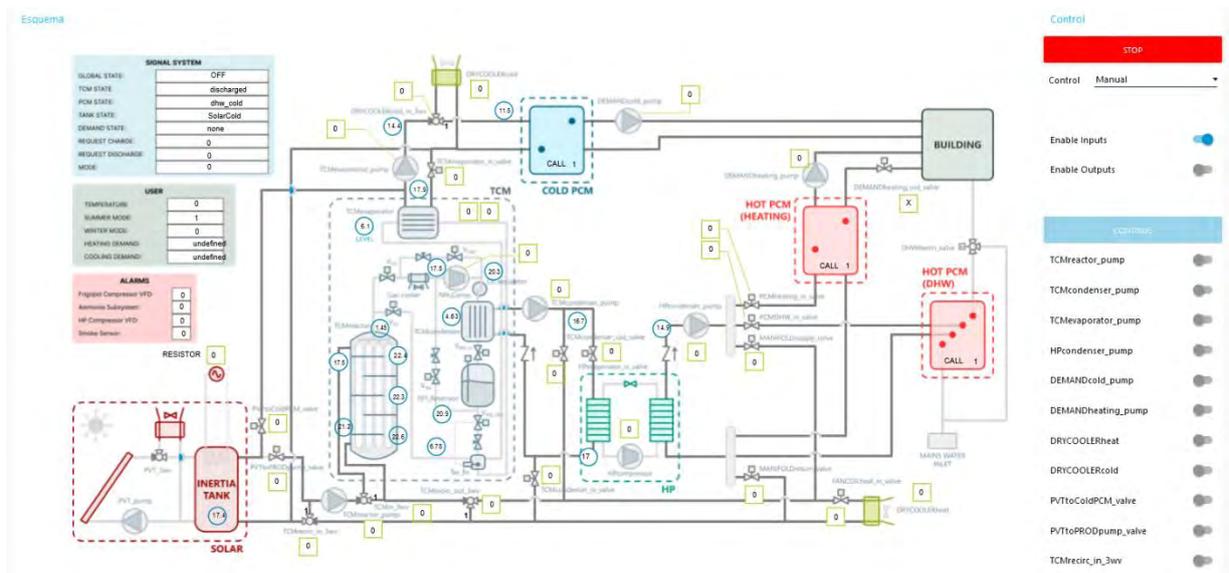


Figure 1: SCADA

Figure 1 shows the user interface programmed in the Smartserver IoT PLC. This interface is divided into two parts: the first is the system schematic (on the left), and the second is the control area (on the right).

In the schematic above, you can see the values of the main system variables that the PLC uses for control in addition to other indicators such as alarms, temperatures or pressures within the TCM. Different symbols are used to differentiate whether the variable in question is a temperature or the status of an actuator. Specifically:

- The temperature is represented by a circle 
- Actuator states with a square 

Apart from this type of MiniStor system signals, the schematic has two other sections on the left side. The first one is the "system signals", an image of which can be seen below (Figure 2):

Date

Rev

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MEETING MINUTES
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 FINAL REPORT

SIGNAL SYSTEM	
GLOBAL STATE:	OFF
TCM STATE:	discharged
PCM STATE:	dhw_cold
TANK STATE:	SolarCold
DEMAND STATE:	none
REQUEST CHARGE	0
REQUEST DISCHARGE	0
MODE:	0

Figure 2: System Signals

These "system signals" are those that indicate the general status of the system to the controller. **The first 5 signals are only useful when the system is in semi-automatic or automatic mode.**

- *Global State* indicates which operating mode the MiniStor system is in (see section **Hiba! A hivatkozási forrás nem található.** for more information).
- *TCM State* indicates the mode of operation of the TCM (see the introduction in section **Hiba! A hivatkozási forrás nem található.** for more information).
- *PCM State* indicates which of the thermal batteries (PCM units) are being charged: the heating unit (Heating), cooling unit (Cold), or domestic hot water (DHW).
- *Tank State* indicates if the tank temperature is sufficient to start (around 60-65 °C).
- *Demand State* indicates whether the building requires cooling or heating; in other words, if there is demand or not. This signal depends on the Heating/Cooling Demand signal from the user and takes into account restrictions to prevent simultaneous discharge of heating and cooling batteries, prioritizing one over the other depending on the time of year.
- *Request Charge/Discharge* indicates if the MiniStor system requests charging or discharging from the TCM.
- *Mode* indicates the same as TCM State but this signal comes directly from the TCM, while the other comes from the control; both must match. This means that the control is operating properly with the TCM.

The second section within the left area of the diagram consists of the "building signals." These signals indicate the state of the consumption system (demand) to which the MiniStor system is connected.

USER	
TEMPERATURE	0
SUMMER MODE:	1
WINTER MODE:	0
HEATING DEMAND:	0
COOLING DEMAND:	1

Figure 3: User Signals

- *Temperature* indicates the temperature outside the MiniStor system.



MINISTOR

C.P.

05-II-22

Date

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- *Summer/Winter Mode* indicates the control mode applied in the MiniStor system, as it differs depending on whether the period is summer or winter. Currently, it is manually controlled, meaning that the user (or otherwise the system manager) must indicate whether they want to use the heating or cooling system (if activated).
- *Heating/Cooling Demand* indicates if there is demand from the user (in the building) and therefore is the signal that indicates if discharging the PCM batteries is required.

The installation diagram has two functionalities to facilitate visualization. The first is that you can zoom in (by clicking on the diagram and moving the mouse wheel) to enlarge a specific section of the system. The second is that water circulation through the pipes can be visualized by changing the color from black to red, according to the opening of actuators. Below there is an example:

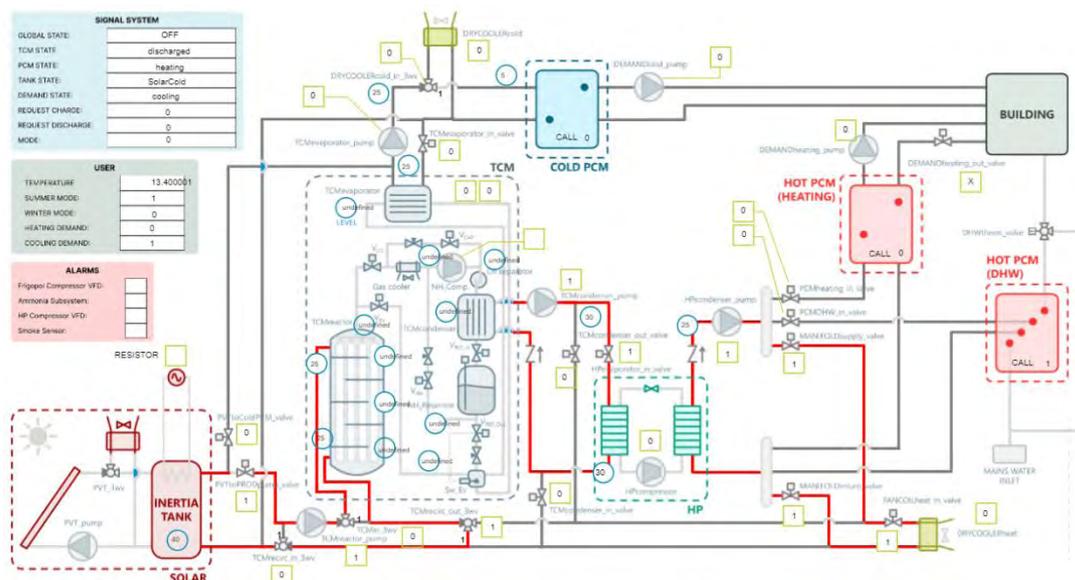


Figure 4: Example of visualization of water flow through pipes (in red color)

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VALIDATION CERTIFICATE
 VERIFICATION REPORT

MEETING MINUTES
 REVIEW MINUTES

TECHNICAL REPORT
 FINAL REPORT

Note: The values that can be observed in many of the images included in this document do not reflect the normal operation of the system and are solely illustrative, as this report was prepared during a testing period when none of the systems were operating continuously. The same applies to those fields that reflect 'undefined'.

The second part of the user interface, on the right side of it, includes the system controls. From this section, the operation of the PLC is managed. Within this part, there are two sections: the first corresponds to a console for choosing between the types of system control, and the second with the control of the different actuators (valves, pumps, and fan coils).

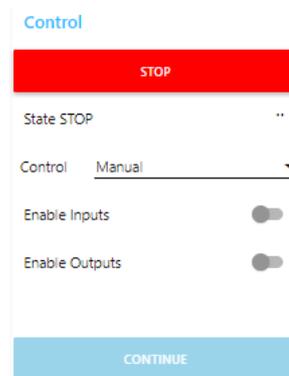


Figure 5: Control console

Figure 5 shows the initial state of the console where the control type is selected. It should be noted that, as of the date of preparation of this report, the system is initialized in manual mode. The different fields of the console are:

“STOP” Button: Performs a safe shutdown of the MiniStor system. When this button is pressed, the system switches to manual mode. However, the user does not control the actuators; instead, the control itself executes the control strategy for this safe shutdown situation. This strategy includes first shutting down the TCM and the HP by setting the 'Request Charge' and 'Request Discharge' requirements to 0 and setting the HP run to 0, respectively. When the control verifies that the TCM and the HP are actually shut down, it initiates a recirculation period to dissipate both the heat and the cold generated in these subsystems, which can negatively affect the system. This time is currently set to around 10 minutes (modifiable based on the behavior of each demo). After this time elapses, the actuators are sequentially closed: first, pumps; then, fan coils; and finally, valves. This time is currently estimated at 5 seconds for each open element (modifiable based on the behavior of the MiniStor system).

When the system is in the process of stopping, a label appears in State STOP indicating 'stopping':

State STOP stopping

And when is stopped:

State STOP STOPPED

- The dropdown list "Control" indicates the control strategy that the PLC will follow:
 - *Manual:* The control will open and close those actuators according to the user's instructions in the actuator control section (switches in the bottom right area).
 - *Semiautomático:* The control will follow the automatic control strategy but will only open and close actuators if the user manually validates it as a supervisor. For example, in a scenario where the system is off and the temperature and pressure conditions are met to start precharging, before initiating

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precharging, the control screen will first appear as shown in Figure 6 on the left, while the system is prepared to proceed with precharging, and subsequently as shown in Figure 6 on the right. In this way, the user will validate the mode change once the system is ready for it.

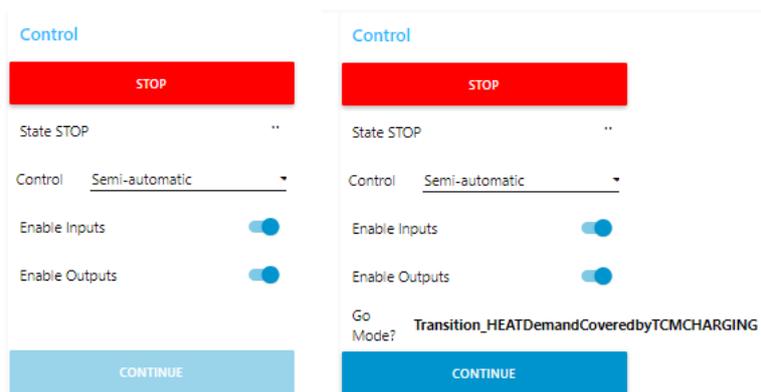


Figure 6: Console appearance in inactive (left) and active state (right)

To execute the step to the next mode, click on the *Continue* button. When doing so, you will see Illustration 6 on the left again, while the actuators and the rest of the system signals change progressively until the new system state is reached.

- *Automático*: The control will follow the automatic strategy without any user intervention.

Note: It is possible that the switches when clicked open or closed may experience some delay until they turn on if after 5 seconds they are not opened and clicked again.

The **Enable Inputs** and **Enable Outputs** buttons indicate whether the PLC has read and write enabled respectively. You can read the data and not write anything or directly disable both and the PLC control will be totally excluded.

The second section, the actuator control section is simpler and is **only** controlled in manual mode. It consists of a list of all actuators and a switch to open or close each of them.

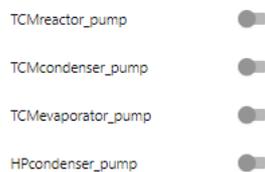


Figure 7: Control list of actuators

Note: Actuators are arranged from top to bottom, first pumps then Fan Coils, Valves, 'Requests', HP, solar tank resistance and period of the year. The name of these actuators does not correspond to the PID. The reason is a better understanding of the position of the actuator in the system. The name conversion can be found in the **registersMiniStorSystem** file attached to this document.

There is also a button called "reset labels" that causes all values that are not displayed in SCADA to appear. This happens the first time it is entered since the value is only updated when a change occurs.



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2 Operation Modes

This section will detail the safe and informed operation of the SCADA for the different operating modes of the MiniStor system.

It is worth noting that the TCM has its own (additional) control aimed at ensuring that both the charging and discharging processes are carried out under optimal pressure and temperature conditions. The following images show the different modes of the TCM as well as the flow diagram followed by this control. While this is not critical when handling the system, it would be advisable to take it into account since the overall system is often conditioned by the TCM.

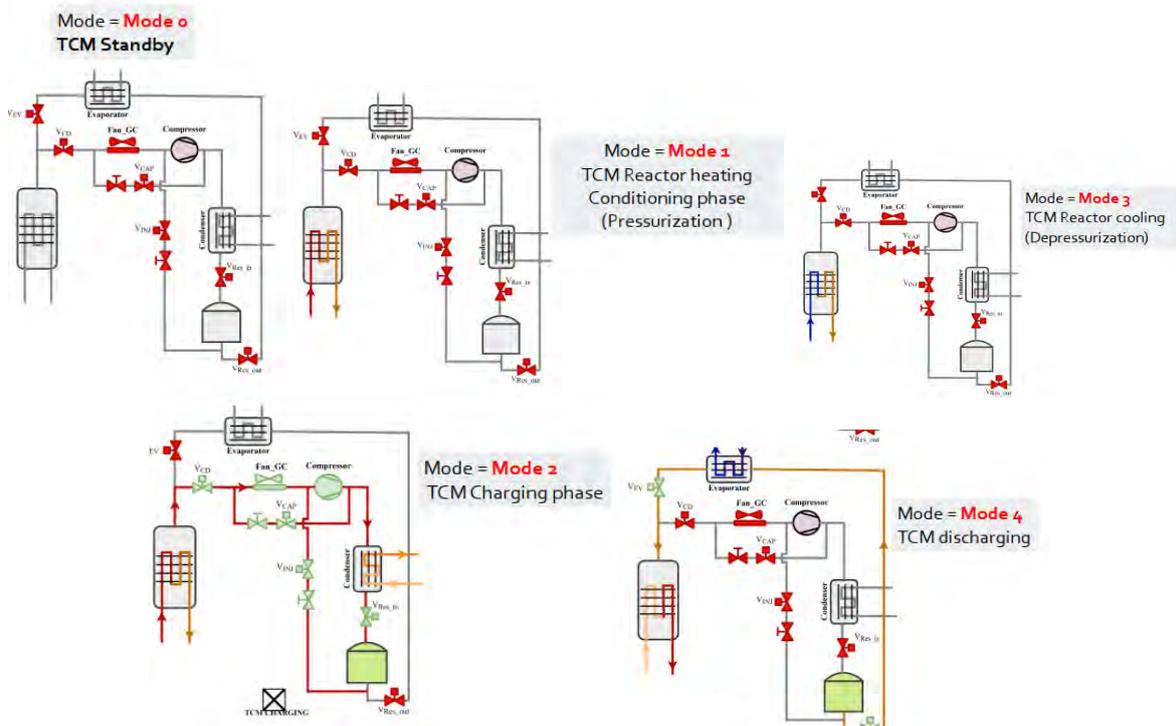


Figure 8: Graphical description of TCM modes of operation

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2.1 Operation Mode: Off

It is the state from which the system starts and to which it returns when the conditions or requirements to be in another state are not met. In this mode, all actuators are closed, and the TCM and HP are off. However, it is worth noting that some controls, such as the resistance, are operated entirely manually, so even in this mode, it could be operational. Therefore, the automatic and semi-automatic control will act considering the tank temperature but will not affect the operation of the resistance.

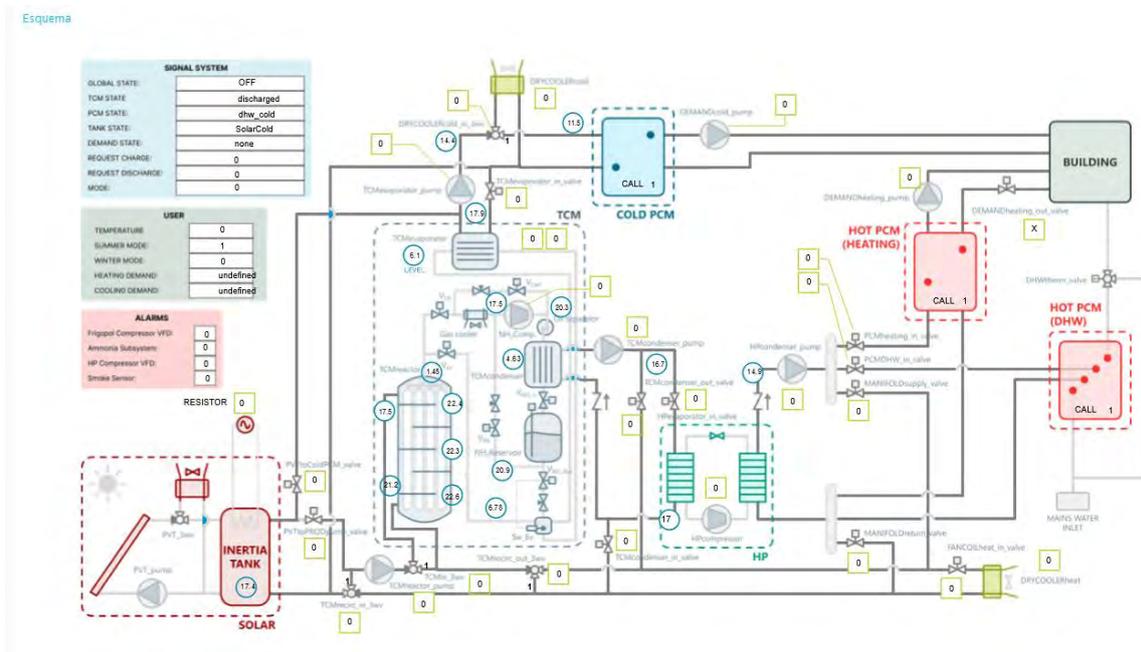


Figure 10: Appearance of SCADA in the off mode of operation

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2.2 Operation Mode: Transition to charge the TCM without demand from PCM

It is the pre-charge state of the system when the temperature and pressure requirements are met. What the system does is to open all the actuators necessary to start charging after receiving that the TCM is in mode 1 (precharge) after sending the 'Request Charge'. The following illustration shows which actuators are to be opened once the TCM is in Mode 1.

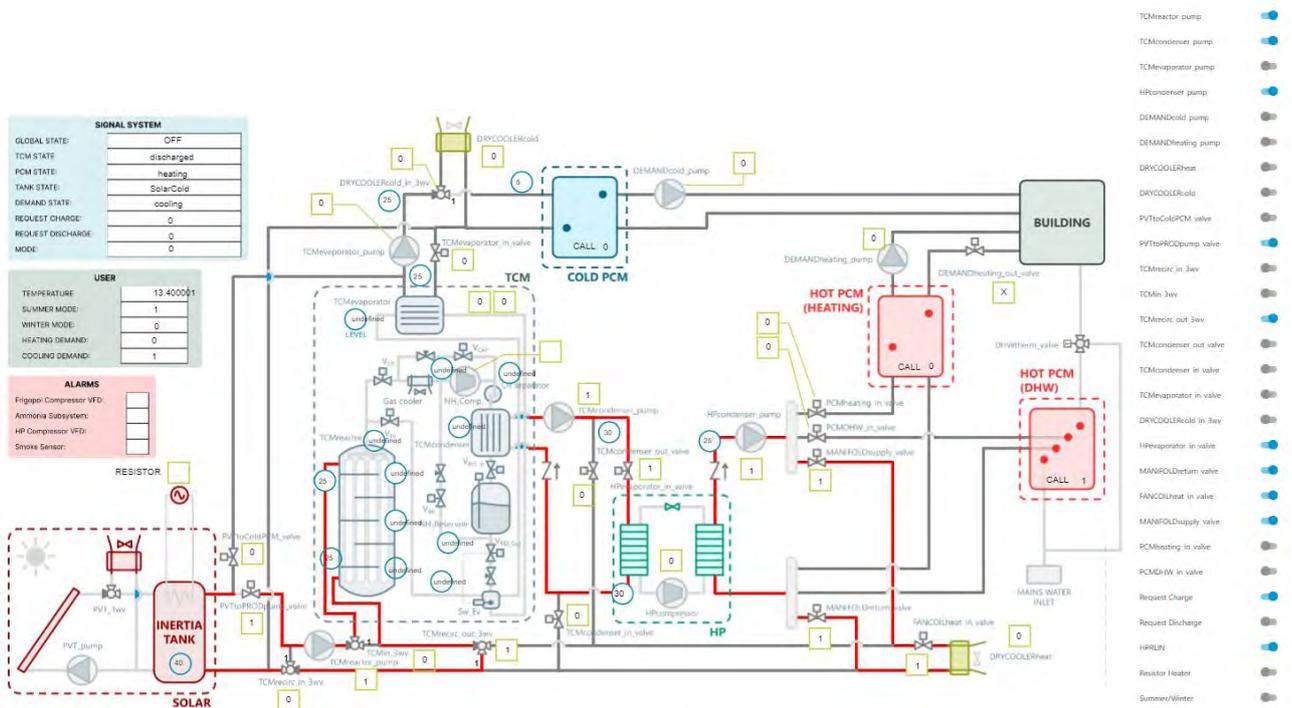


Figure 11: Appearance of the SCADA in the no-demand charge transition mode of operation.

All these actuators have the function of recirculating both the TCM and HP inlet and outlet but with both still off waiting for the TCM to pressurize and in the case of the HP waiting for a recirculation time of at least 1 minute to elapse.



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2.3 Operation Mode: TCM charge without PCM demand

This mode starts when the TCM goes to state 2 (charge) to pass to this state the user does not have to do anything. If the pressure and temperature conditions are maintained, to receive that 2 it is enough to wait.

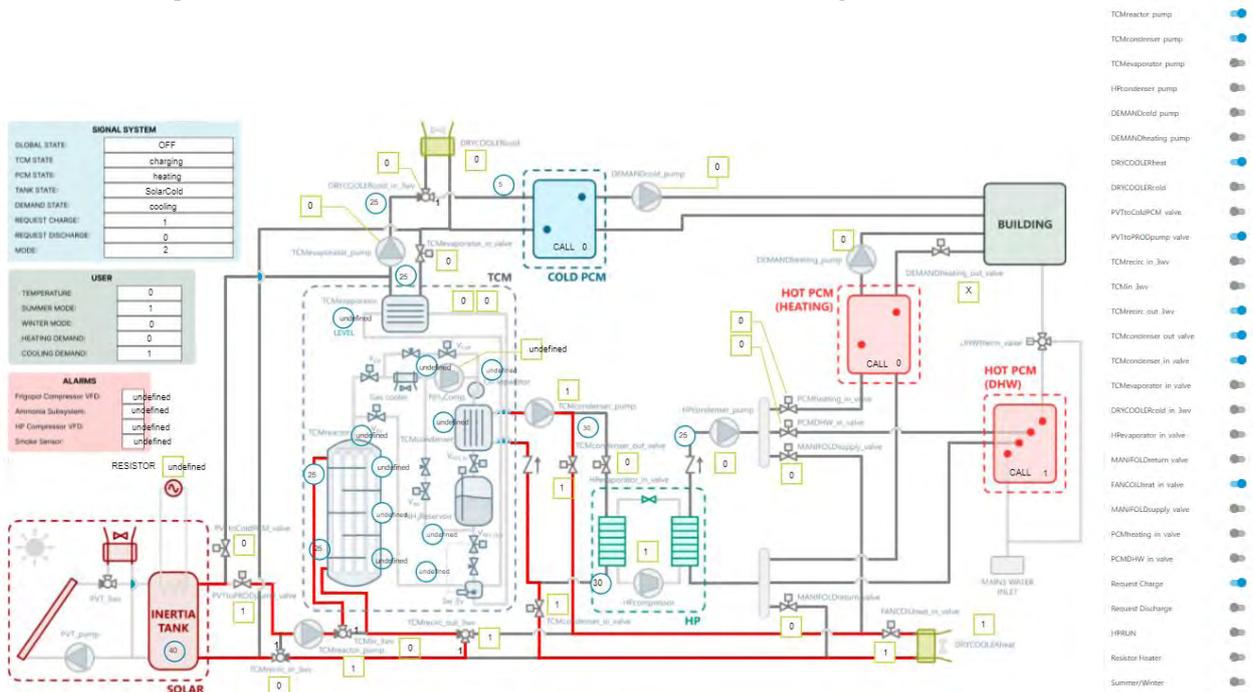


Figure 12: SCADA appearance in the TCM charge mode of operation without PCM demand

After reaching this state, if you do not want to charge any of the hot PCM units, the heat can be expelled by a Fancoil to the ambient to prevent the temperature from rising. If you do not want to throw it out, the only thing to do is to close the fancoil ('DRYCOOLERheat').

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2.4 Operation Mode: TCM charge with PCM demand without HP

This mode charges one of the two PCM heat batteries but without using the HP. The TCM mode is still 2, and the only difference is that the HP is turned off and the system is recirculated to one of the PCM units. This mode is not common and when it occurs it is because the HP cannot operate or the temperature at which the condenser water leaves the TCM condenser is high. In this case, the ‘Heating PCM’ unit will be charged, as displayed in the following figure.

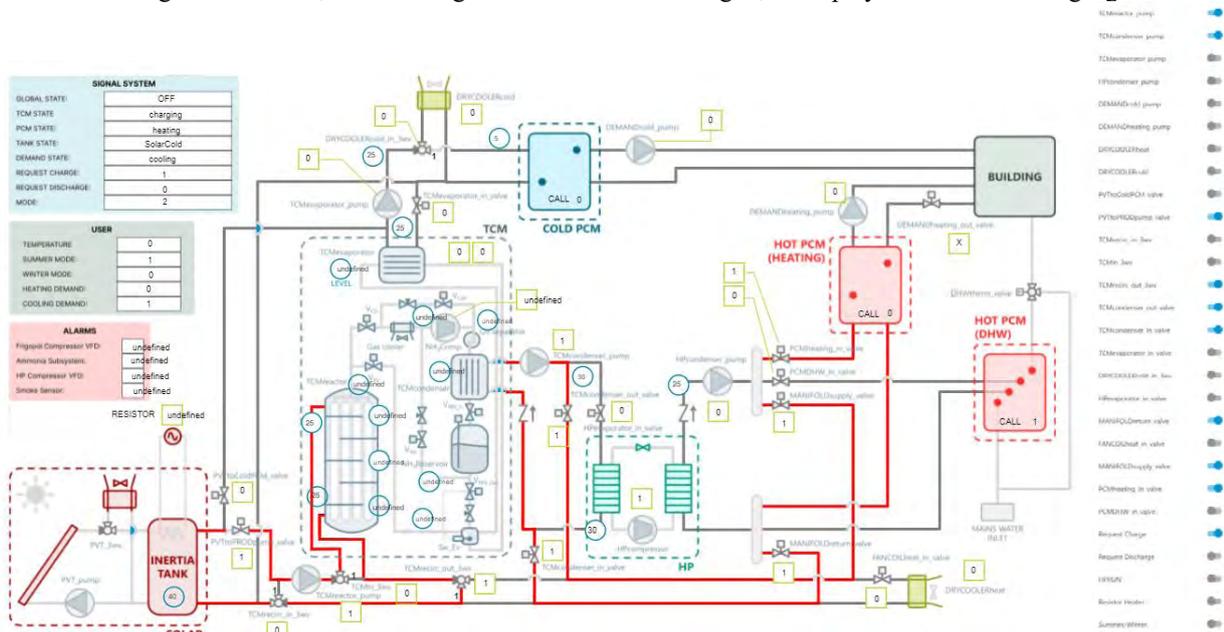


Figure 13: SCADA appearance in TCM charge mode of operation with PCM demand without HP

A variation of this mode is to open *PCMDHW_in_valve* and close *PCMheating_in_valve* if you want to charge the *DHW* battery instead of the *Heating* battery.

2.5 Operation Mode: Transition to charge TCM with demand from PCM

Same as mode 2.2, the difference is that one is the previous step to charge the PCM and the other is not. They differ in two different modes because the strategy of the automatic mode requires it, but here it is not relevant and it is enough to know that the **same actuators are opened as in mode 2.2.**



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2.6 Operation Mode: TCM charge with PCM demand

This mode charges either of the two PCM heat batteries but using the HP. The TCM mode is still 2 to switch to this state.

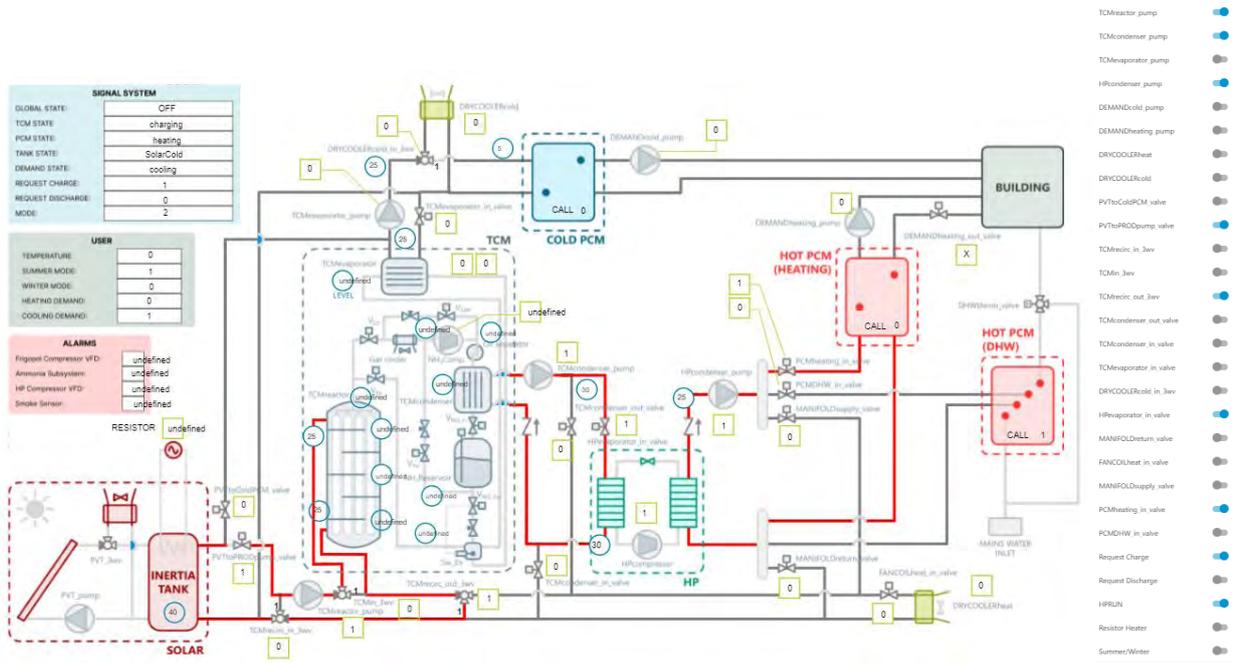


Figure 14: SCADA appearance in the TCM charge mode of operation with PCM demand



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2.7 Operation Mode: PCM demand without using the TCM

This mode of operation is when the tank temperature is very high and sufficient to charge the PCMs (without requiring any additional energy input). This mode will be detailed but is meaningless from a laboratory testing point of view as it does not use the TCM which is the key element of the system.

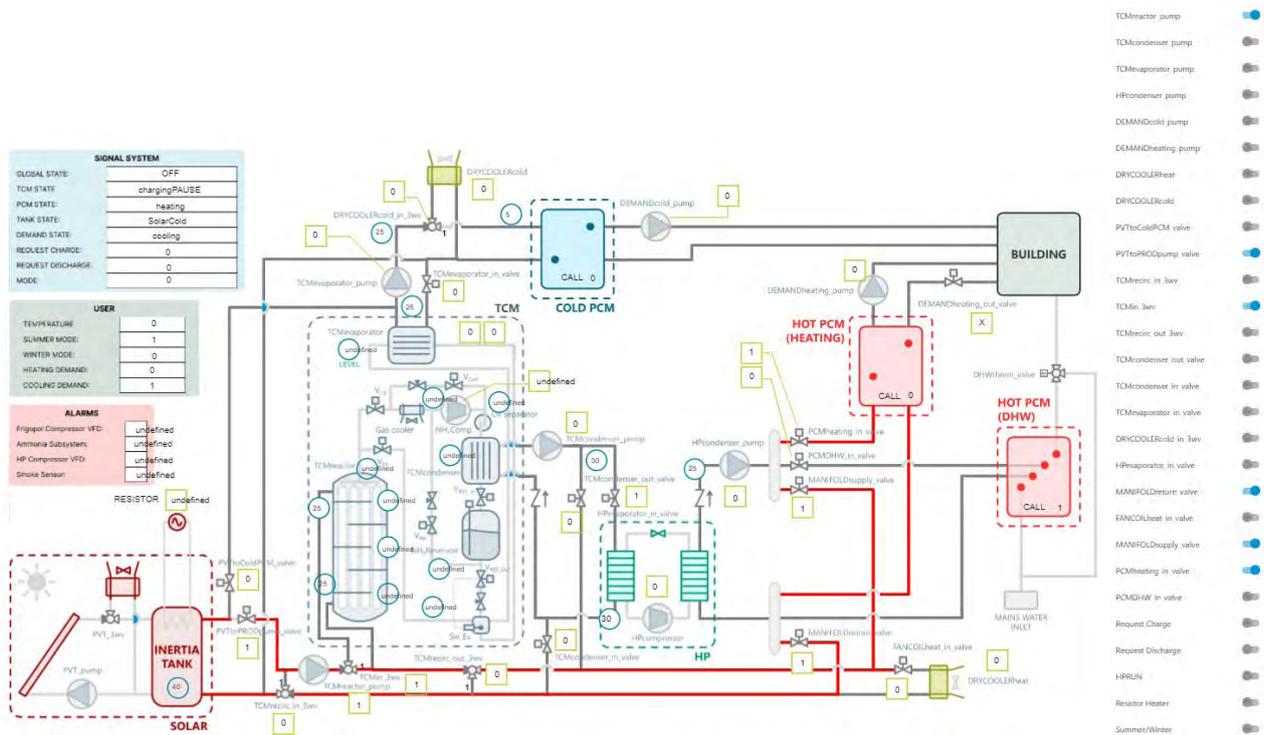


Figure 15: SCADA appearance in PCM charge mode of operation without using the TCM



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2.8 Operation Mode: Transition to discharge TCM on demand from PCM

When the TCM is in mode 0 having been charged (it is not necessary that it is fully charged but it would be advisable that it is a high value to prolong the charge cycles of the PCMs), the discharge can be started. Discharge versus charge has the particularity that both cold and hot batteries can be charged.

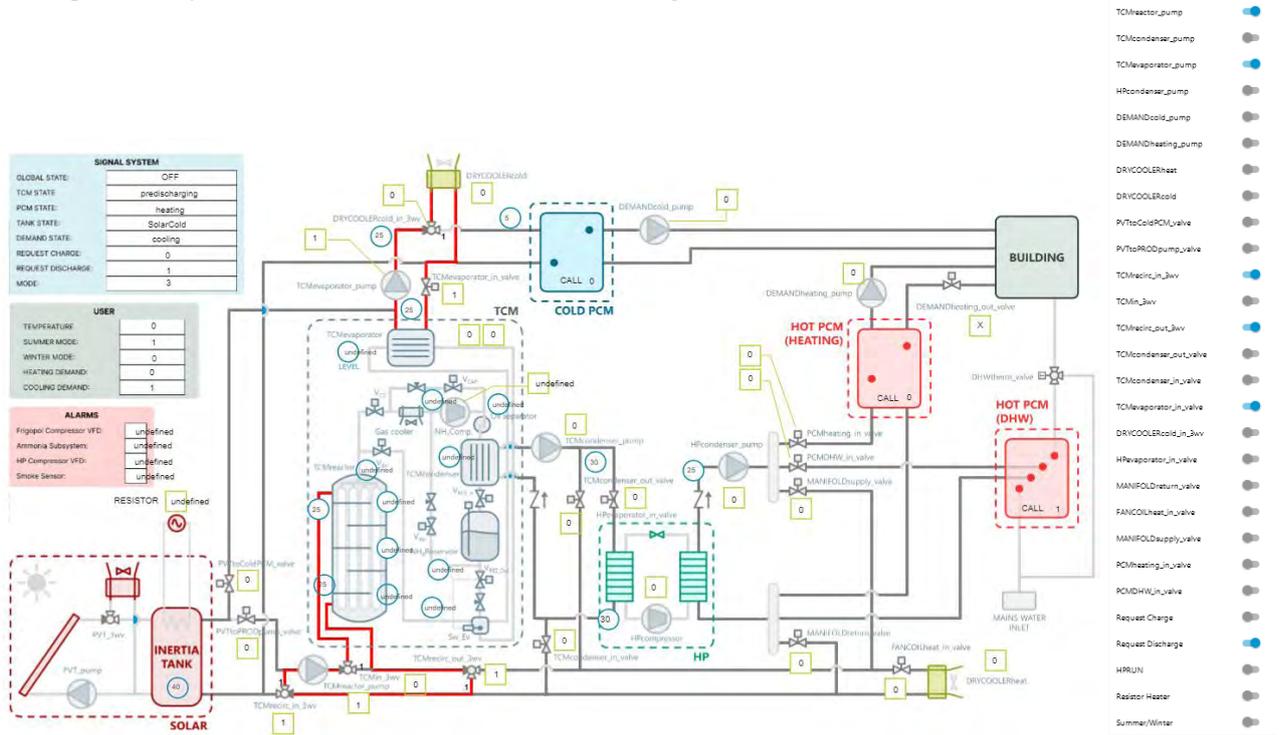


Figure 16: Appearance of SCADA in TCM discharge transition mode of operation charging PCM

In this state the TCM mode has to go from 0 to 3 (pre-discharge).

2.9 Operation Mode: TCM discharge with PCM Demand

This mode charges one of the two heat PCM batteries and there is a cold production, therefore it is also possible to charge the cold battery. The TCM mode has to be 4 to reach this state, which is when the TCM can discharge. To get to 4 it is enough to wait in the transition mode to discharge.

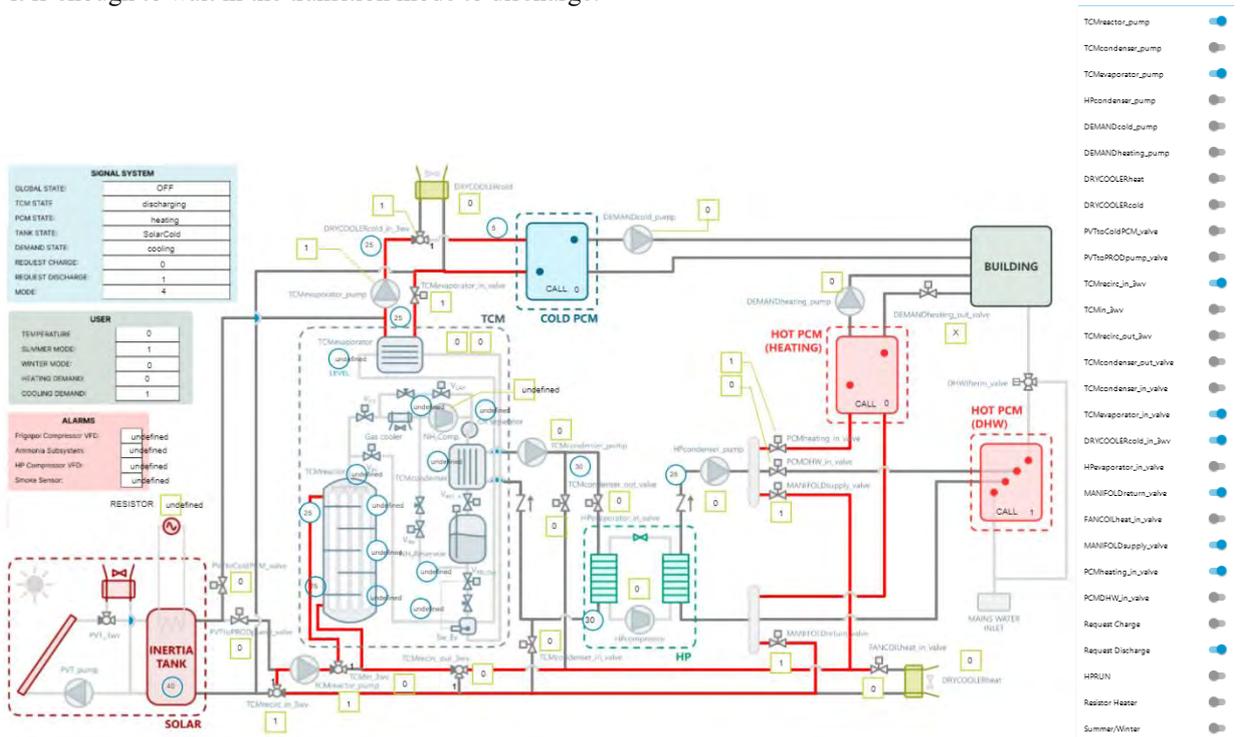


Figure 17: Appearance of SCADA in TCM discharge mode of operation charging the PCM units

On the other hand, if you do not want to charge any of the two PCMs, it is enough to open the valve 'DRYCOOLERcold_in_3wv' and the fancoil 'DRYCOOLERcold' in the case of cold. And in the case of heat, the valve 'DRYCOOLERheat_in_valve' and the fancoil 'DRYCOOLERheat', while the rest of the valves that go to the PCMs are closed.

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2.10 Operation Mode: Heating the cold battery

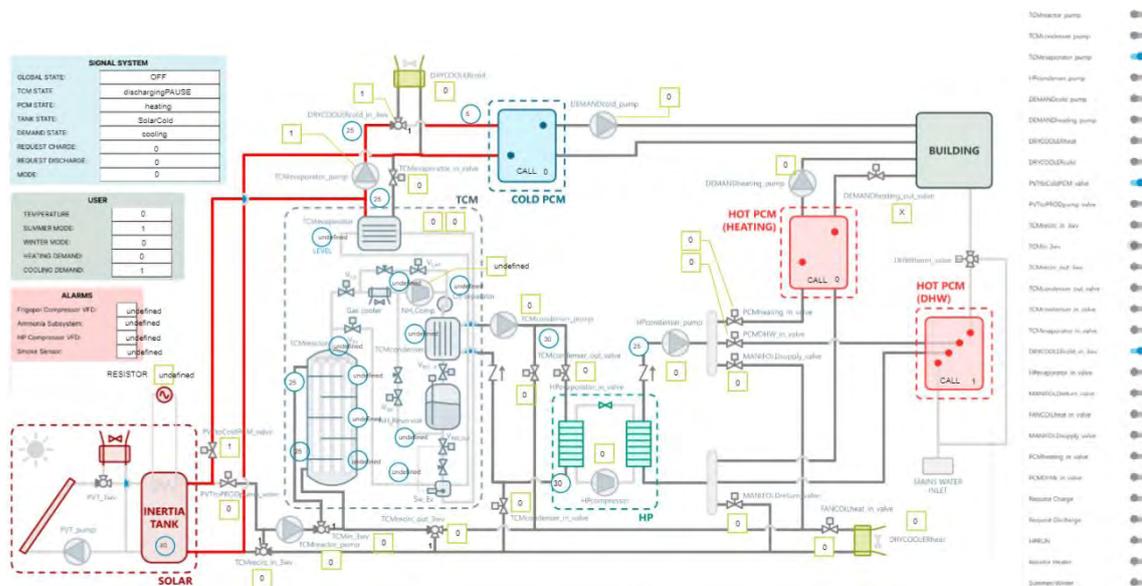


Figure 18: Appearance of SCADA in TCM discharge mode of operation charging the PCM units

This mode is not expected to occur frequently, like 2.4 and like 2.7 and may have no relevance in laboratory tests. It consists of pre-heating the cold battery so that the cold produced in the TCM evaporator can be transferred to the cold PCM in cases where the ambient temperature is too low and cannot be rejected into the ambient air using the fancoil.

Finally, to discharge the PCM units to cover the energy demand from the building is necessary:

- Open the DEMANDcold_pump in case you want to discharge the COLD battery, in addition to operating other elements related to cold production that may vary depending on the particular case of each demonstration site.
- Open the DEMANDheating_pump in case you want to discharge the HEATING battery, in addition to operating other elements related to heat production that may vary depending on the particular case of each demonstration.
- In the case of DHW battery discharge nothing needs to be done in the SCADA as this pump is integrated in the demo and therefore each demo will know how to operate.

These actuators are considered independent of the rest of the system as they do not influence the charging and discharging operations. Of course, if the PCMs are not charged, opening these actuators is inappropriate.

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3 Transitions

In this last section, a normal charging sequence and a normal discharging sequence will be detailed.

Charge

The most basic charging sequence, which will generally occur and which it is advisable to follow unless either the HP cannot operate or you do not want to charge any PCM is as follows.

1st Transition to charge the TCM with PCM demand (2.5)

When the TCM is in mode 2

2nd TCM charge with PCM demand (2.6)

With this, the system should raise the ammonia level (box A) in the TCM resulting in charging.

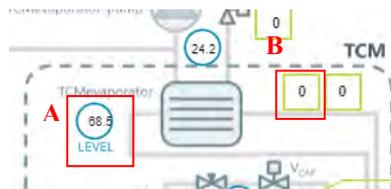


Figure 19: Signaling of TCM charge indicators on SCADA

Once the charge signal is received at 1 (box B) the TCM will be charged and the TCM mode will be 0.

That is all in general, but, as mentioned above, other external factors must be taken into account, such as that the TCM may switch modes if the conditions of its own control are met or that the PCM units are not charged because it is not wanted or because it is not possible to do so. In that case, you should switch to secondary operating modes 2.2, 2.3 or 2.4. If any abnormal behavior is observed or something unexpected occurs, go to mode 2.1 (OFF mode).

Note: To charge the TCM, the solar tank must be at a temperature of at least 60-65°C. In principle, it is not advisable for this temperature to be much higher, and it could never exceed ~98°C (under real conditions, but for this purpose, the solar system has an additional fan coil to prevent exceeding these values).

Discharge

The most basic discharging sequence, which will generally occur and which it is advisable to follow unless it cannot work or you do not want to charge any PCM, is as follows.

1st Transition to TCM discharge with PCM demand (2.8)

When the TCM is in mode 4

2nd TCM discharge with PCM demand (2.9)

With this, the system should raise the ammonia level (box A) in the TCM resulting in charging.

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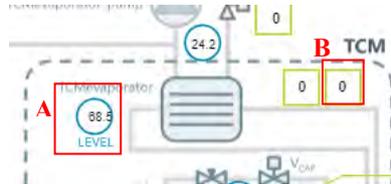


Figure 20: Signaling of TCM discharge indicators in SCADA

Once the discharge signal is received at 1 (box B) the TCM will be discharged and the TCM mode will be 0.

That is all in general, as mentioned above, other external factors must be taken into account, such as the TCM can switch mode if the conditions of its own control are met or that the PCMs are not charged because it is not wanted or because it is not possible. In the latter case it would be necessary to open the Fancoils ('DRYCOOLERheat' and 'DRYCOOLERcold') and expel the heat and cold. If any abnormal behavior is observed or something unexpected occurs, go to mode 2.1 (OFF mode).

Note: To charge with the residual heat from the discharge it should be noted that if it is too low it will discharge. This is not particularly critical in these tests where the intention is to evaluate the performance and not the efficiency of the system.