

Instruction Manual

for

gSKIN[®] U-Value Kit

Content

1. The gSKIN U-Value KIT – delivery overview	1
2. General overview of the gSKIN® U-value software	2
3. Ready to measure in five minutes by following these steps	3
4. Six-steps summary	6
Appendix A: U-Value software introduction	7
Appendix B: Data Logger Characteristics	10

1. The gSKIN U-Value KIT – delivery overview

By post:

- 1 gSKIN® Heat Flux Sensor
- 1 gSKIN® DLOG Data Logger with 2 temperature sensors
- 1 USB cable (PC to data logger)
- 1 Adhesive tape
- 1 MOUNT 1214 (3 x thermal conductive pad)
- 1 Calibration sheet
- 1 Instruction manual

By email:

Download link and password for the software.



Figure 1: U-Value KIT in transportation box

2. General overview of the gSKIN® U-value software

The gSKIN® U-value software is built upon a home screen with 5 functional buttons and 2 top-menu buttons (see Figure 2).

5 functional buttons in the centre of the home screen:

1. **Real time measurement:** This button allows the user to review in real-time all data points measured by the sensors of the U-value KIT (temperature, heat flux, calculated U-value). With this menu-screen, one cannot start a new U-value measuring process, it can only be used for reviewing once all sensors are working and to show their real-time values.
2. **Start logging:** From here, you can start your measuring process. Before starting, please select the frequency at which you would like to log your data points and when you want to start the measurement process (logger stores up to two million data points; for details, please refer to Appendix B).
3. **Read record:** Via this button, you can select measurement files which have been saved on your logger for further analysis (e.g. export raw data, print PDF reports).
4. **Analyse record:** Here, you can search for other logger protocol files (*.msr) which have been saved on your computer.
5. **Exit:** This button will close the program.

Two top-menu buttons:

1. **Menu-button “File“:** This button can be used to end the program (“Exit”), to export data while you review data points in the “Read record” tab or change the language.
2. **Menu-button “Logger“:** This button can be used to stop your measurement process and to delete all measurement files from the data logger (“Delete all stored data!”).

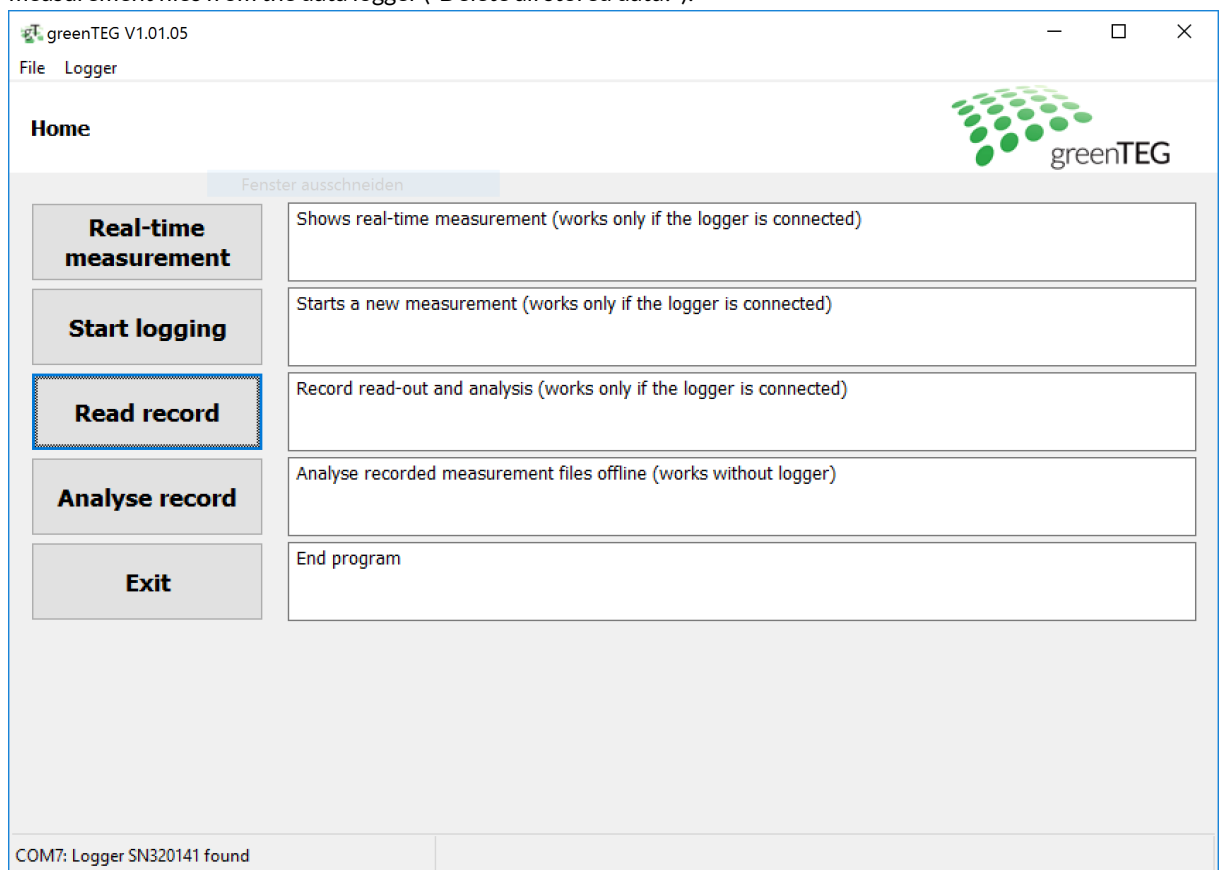


Figure 2: Home screen view with data logger connected to your laptop.

3. Ready to measure in five minutes by following these steps

1. Connect the data logger to your computer via the delivered USB cable.
2. Allow all drivers to be installed.
3. The necessary read-out software can be downloaded from <http://www.greenteg.com/contact/software-u-value-kit/> (use the password provided to you by greenTEG). Follow the instructions to install the software on your computer. You need to have admin rights to follow all necessary steps (right click on option "Execute as Administrator").
Currently the software is compatible with Windows® only. If you use a different operating system, e.g. MacOS®, UBUNTU® etc., please, have a look at our FAQ for some hints and additional information: <http://u-value.greenteg.com/faq-u-value-measurement>.
4. When you open the software, the home screen will appear (See Figure 2). Under "File" > "Language" you can change the language settings from English to German or vice versa.
5. Mount the heat flux sensor onto the surface you would like to investigate. For detailed instructions on mounting the gSKIN® Heat Flux Sensors, look up the case studies and application notes, which can be found at www.u-value.greenteg.com. In the following box, we will briefly describe the mounting process.

Short guideline on how to mount the sensors:

- I. Heat flux sensor placement
 - a. Install the heat flux sensor on the indoor surface with the side showing the gSKIN logo facing towards you. The thermal conductive pad has to be placed between the wall and the sensor to compensate for potential irregularities at the wall. Stick the sensor to the wall with an adhesive tape and ensure that the sensor is protected from direct heating, convection, and solar radiation. Adhesive tape to fix the sensor is included in your U-Value KIT.
 - b. Optional: For mounting the heat flux sensor, use thermally conductive paste (can be purchased in our online shop. Caution: hard to remove from walls).
 - c. Optional: Use thermographic imaging to help identifying representative/interesting spots for the heat flux sensor placement on your building element.
 - d. Optional: Cover the heat flux sensor with the same material as its surrounding material.
 - e. Optional: Use several sensors to obtain an average value for highly inhomogeneous building elements.
- II. Temperature sensor placement
 - a. Place the two temperature sensors at roughly opposite sides of the building element at the position where the heat flux sensor is placed.
 - b. For U-value measurements, make sure that the ambient air temperature is measured (i.e. by measuring the temperature more than 5 cm away from the building element and avoid direct solar radiation).

Note: The cables are typically used in aerospace and therefore meet highest requirements.

6. Please verify that all sensors (temperature and heat flux) are displayed correctly by reviewing their graphs under "Real-time measurement". Here you can also directly review the approximate U-value (the U-value will still fluctuate).
7. On the home screen, push the "Start logging" button and then do the following steps:
 - Check the sensitivity¹
 - Select the frequency for data logging (under "Sampling rate", e.g. 10 min or 30 min²)
 - Select start time (under "Start mode", e.g. "immediately")
 - Add a comment e.g. specifications about measurement location

After you push the "Start measurement" button, your data logging process begins. In the lower part of your screen, you will see the text switch from "save settings.." to "Measurement running..". While logging, the

¹ You can adapt the sensitivity of your sensor by selecting the "calibrate" function. Please make sure that the sensitivity shown here matches the sensor's sensitivity on your calibration sheet. **Please change these settings only if you use another heat flux sensor**; the value stored here should match with the sensor's sensitivity shipped to you.

² ISO 9869 indicates that data acquisition intervals should be less than 30 min. (1 data point per 10 min. can easily be handled with a fully charged data logger – the battery will be charged automatically via the USB cable when connected to your laptop). Ensure that you have connected the data logger to your computer for some hours, before you start with your first measuring trial, as for longer measuring times you need to have a fully charged battery.

LED of the logger flashes in blue (while charging in yellow; the logger is fully charged when there is no yellow light flashing anymore while having a connection to the computer).

NOTE: If the LED of the logger is red, no connection with your computer is established. In this case, please make sure that all cables are connected correctly and that there is no problem with the USB port you use.

8. After logging data for **72 hours**, you should receive an exact U-value according to ISO 9869. You can stop the measurement process by selecting the “Logger” tab and there the “Stop measurement” function. We recommend that you first review your current measurement process (as indicated in step 9) before you stop your ongoing measurement. The following box outlines the conditions, which should be fulfilled for a successful measurement according to ISO9869:

Short outline of the measurement conditions regarding ISO9869:

- I. Duration of the measurement > 72h (+ an integer multiple of 24). The software automatically calculates the appropriate time frame (see Appendix A)
- II. R-value obtained at the end of the test does not deviate more than 5% from the value obtained 24h before (dR24)
- III. The R-value obtained during the first 2/3 of the overall measurement period does not deviate more than 5% from the values obtained during the last 2/3 of the overall measurement period.
- IV. The change in heat stored in the wall is $\leq 5\%$ of the heat passing through the wall

While test conditions I. – III. are validated by the software, condition IV. is not tested. greenTEGs measurement system does not allow measurement of heat storage changes of the wall. Appendix A explains the test conditions in detail.

9. To analyse your logged data and to verify if you really should stop the logging, please select “Read record” (on home screen). In the next window, you need to select the data set you want to be displayed and analysed (the latest data set will be preselected, all data sets are ordered by the measurement start time).
10. By selecting the latest logging file, you can review the logged data set. In the newly opened window named “Analysis”, you will find the last measured data points (see Figure 3). The values stated in the header of the window are explained in detail in Appendix A. A graphical review of the measured data is given in the chart:
 - Blue line: Heat flux (corresponding to primary y-axis)
 - Red line: Indoor temperature T1 (corresponding to primary y-axis)
 - Yellow line: Outdoor temperature T2 (corresponding to primary y-axis)
 - Green line: Calculated U-value (corresponding to secondary y-axis)
 - Dotted vertical line: Start of analysis period

The section “comments” shows the comments made regarding your latest measurement activity (see step 7), comments can be changed afterwards³.

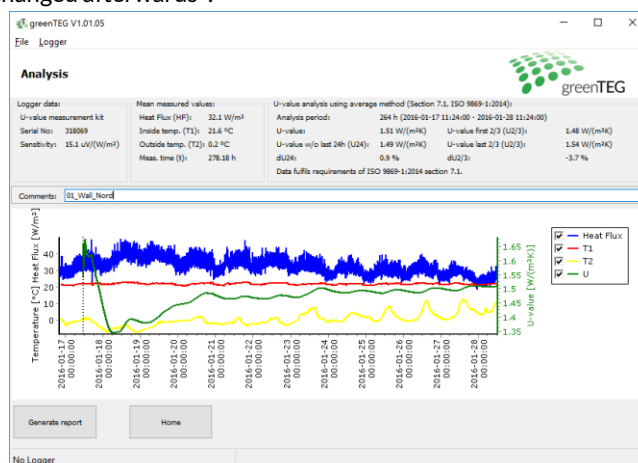


Figure 3: Analysis window showing U-value output and sensor data graphs.

³ In order to save this comment, you need to save the report as a PDF (see step 11), otherwise this comment will be overwritten by your next comment. So, be aware that if you are reviewing an old data set, it doesn't show the original comments anymore. You can correct this again by simply revising the text in the box after “Comments” (see Figure 3).

- To save the graph as a PDF or printing it directly, press the “Generate report” button. The “Generate PDF” button generates a PDF file (see Figure 4), “Print” leads you to your printing settings. The PDF gives more details about the measurement values than the window “Analyse record”. A detailed explanation of the parameters used in the report is given in Appendix A.

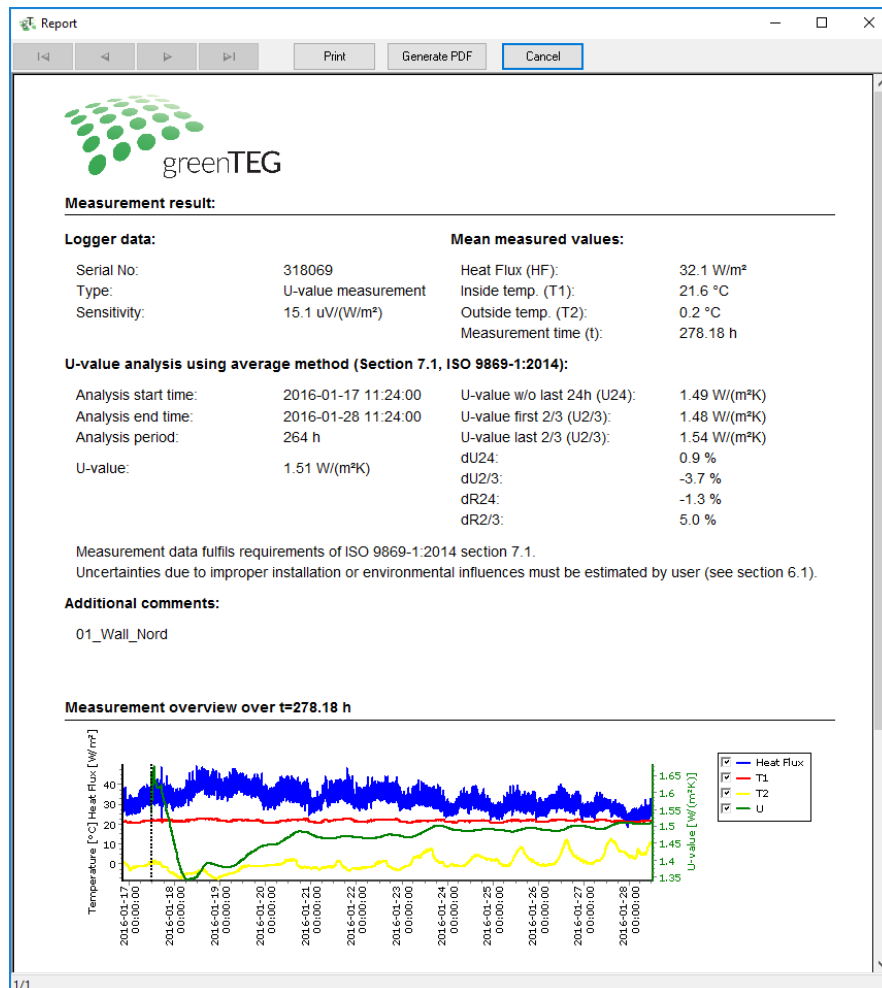


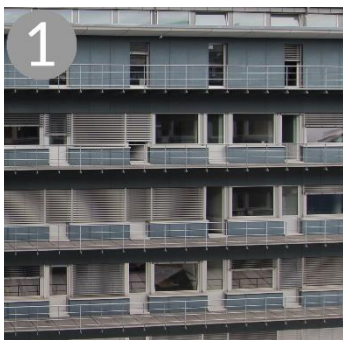
Figure 4: Software screen for saving data as a PDF file.

- On the “Read record” > “Analysis” window, you can select under the “File” menu-button “Export data...” to save the raw data as a CSV file to your laptop (note: If you need further advise in exporting data please have a look in our FAQ: <http://u-value.greenteg.com/faq-u-value-measurement>).
- To review other data logger files stored on your laptop, you can select these files via your home screen by using the “Analyse record” button (see Figure 1).⁴
- For erasing stored data on your data logger, you can ONLY erase/delete all data saved on the data logger by selecting in the top menu “Logger” and “Delete all stored data!”. There is no option to retrieve deleted data, unless you have stored it before as a CSV/msr file on your desktop (see step 12).
- To close the U-value software, you can select the “Exit” button on your home screen or the tab “File” and “Exit” function. In case you have already started a U-value measuring process, this activity will not be stopped. Only by selecting the “Logger” function on your home screen and there selecting “Stop measurement” one can end a U-value measuring process (see step 7).

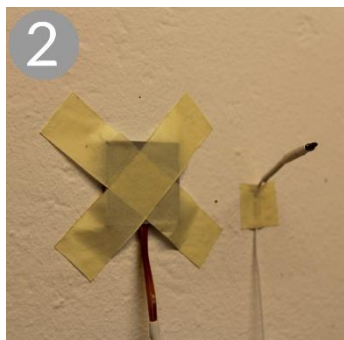
⁴ Every stopped measurement will automatically be saved on your computer under C:\Users\

4. Six-steps summary

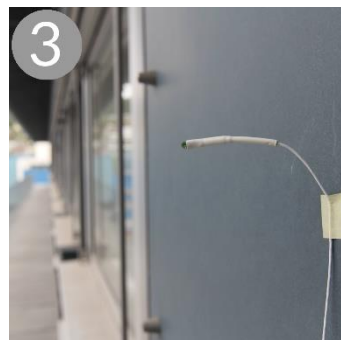
The following six pictures describe the whole measurement process. To get detailed instructions, please visit our homepage (www.u-value.greenteg.com) and watch our U-Value KIT video.



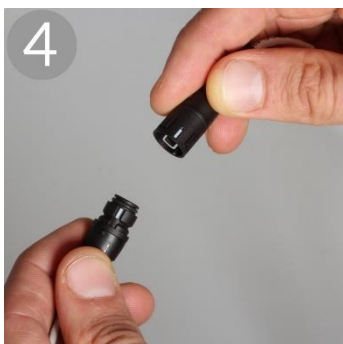
1 Choose an optimal measurement spot on the building element of interest.



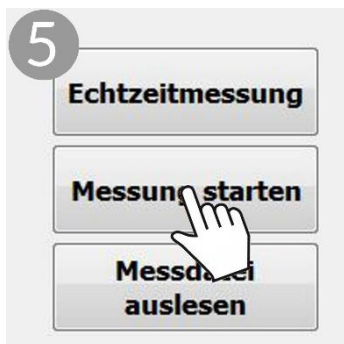
2 On the inside of this spot place the heat flux sensor and one temperature sensor.



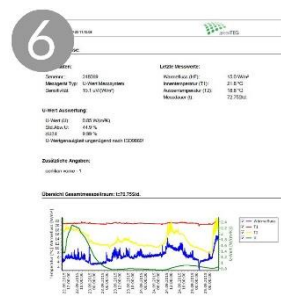
3 On the outside of this spot place the second temperature sensor.



4 Connect all three sensors to the data logging unit.



5 Start the measurement process (via your laptop).



6 Evaluate the U-value of the building element with the software included

Figure 5: Six-steps to start the measurement

Appendix A: U-Value software introduction

The appendix highlights key elements of the ISO 9869-1:2014 on which the data analysis of the software is based. Even though the software is capable of analysing the measurement data, it is the user of the system who has to ensure applicability of the ISO test conditions to measurement data.

Requirements according ISO 9869-1:2014

The standard ISO 9869-1:2014 details in section 6 how a measurement apparatus has to be installed for proper measurement and in section 7 how the measurement data must be analysed.

The ISO standard highlights the following important points for the **installation**:

- Heat flux meters (HFM) and temperature sensors shall be mounted at a **location that is representative** of the whole element (previous inspection using thermography cameras are mentioned).
- HFMs shall **not** be
 - installed close to **thermal bridges, cracks** or similar sources of error
 - under direct influence of a **heating or of a cooling device** or under the **draught of a fan**
- The outer surface of the element should be **protected** from
 - **Rain**
 - **Snow**
 - **Direct solar radiation**
- Protection of the outer surface may be achieved through **artificial screening**.
- Data acquisition intervals should be less than 30min.

The **analysis** of the measurement data is separated into two methods. The first analysis method (the average method) is introduced in section 7.1 of the standard. It is the method used in the current software. The average method is valid if certain conditions are met:

- The **heat content of the element is the same at the beginning and at the end** of a measurement (same temperatures and moisture distribution)
- The HFM is **not** exposed **to direct solar radiation**.
- False results might be obtained if the **external face** of the element **is exposed to solar radiation**
- The thermal conductance of the element is constant during the test

If the above conditions are not met, misleading results can be obtained. It is the responsibility of the user to ensure that the conditions are met.

Data analysis (average method) for heavier elements with a specific heat per square meter greater than $20\text{kJ}/(\text{m}^2\text{K})$ according to section 7.1 shall be carried out over a **period of integer multiple of 24h**.

The measurement shall be ended only when **the conditions are fulfilled** as follows:

1. Duration of the measurement **> 72h**
2. R-value obtained at the end of the test does not deviate more than 5% from the value obtained 24h before (dR24)
3. The R-value obtained during the first 2/3 of the overall measurement period (which needs to be an integer of 24h, too) does not deviate more than 5% from the values obtained during the last 2/3 of the overall measurement period (also an integer multiple from 24h).
4. The change in heat stored in the wall is $\leq 5\%$ of the heat passing through the wall

While test conditions 1 – 3 are validated by greenTEG's software, the condition 4 is not tested. greenTEG's measurement system does not allow measurement of heat storage changes of the wall.

Data analysis details

Figure 6 shows an example from the analysis section of the generated report (the original report is shown in appendix 1).

U-value analysis using average method (Section 7.1, ISO 9869-1:2014):			
Analysis start time:	2016-01-17 11:24:00	U-value w/o last 24h (U24):	1.49 W/(m ² K)
Analysis end time:	2016-01-28 11:24:00	U-value first 2/3 (U2/3):	1.48 W/(m ² K)
Analysis period:	264 h	U-value last 2/3 (U2/3):	1.54 W/(m ² K)
U-value:	1.51 W/(m ² K)	dU24:	0.9 %
		dU2/3:	-3.7 %

Figure 6: Excerpt from the U-value report as generated by the U-value software V1.01.05

Figure 7 shows a visualization of the measurement data from a measurement run over 8.5 days. The analysis period of the U-value is calculated by taking the integer multiple of 24h from the measurement period (i.e. 8*24h). The U24 period is the same as the U-value analysis time without the last 24h. U2/3s and U2/3e periods are the integer multiple of 24h of the first and the last 2/3 of the analysis period.

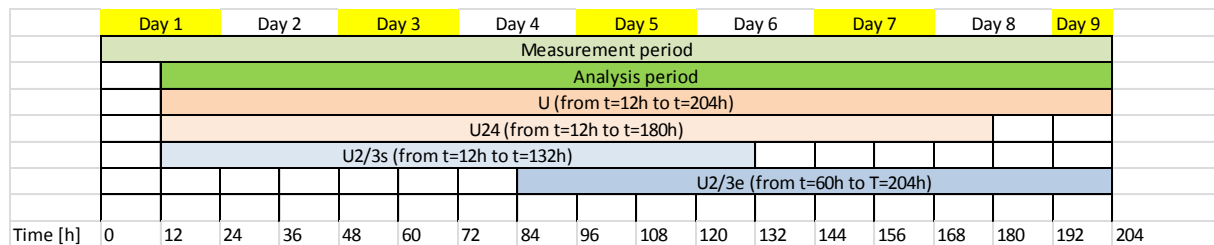


Figure 7: Visualized structure of the measurement data and the analyzed data periods

Detailed explanations of the parameters shown in Figure 6 are given in Table 1.

Table 1: Detailed explanations of the parameters used in the report

Designator	Description	How to calculate / formula
Measurement time	Total length of the measurement period	(measurement end time) - (measurement start time)
Analysis period	Duration of the period used for data analysis (must be a multiple of 24 h)	Measurement period rounded down to a multiple of 24h. corresponds to: (analysis end time) - (analysis start time)
Analysis start time	Since analysis period is shorter than measurement period a part of the measurement data must be discarded. The first part is discarded in our software since it is usually more prone to fluctuations than the last part of the measurement period	-
Analysis end time	Always corresponds to the end of the measurement period	
U-value (U)	U-value calculated by using the data of the full analysis period	$U = \frac{\sum_{j=1}^n q_j}{\sum_{j=1}^n (T_{ij} - T_{ej})}$ <p>Where q_j = heat flux at time j T_{ij} = inside air temperature at time j T_{ej} = outside air temperature at time j</p>
U24	U-value calculated by using the data without the last 24h	See calculation of U-value
U2/3s	U-value calculated by using the first 2/3 of the analysis period in days	Number of days of this period is calculated using $\text{INT}(2/3 * D)$, where D stands for the duration in days of the analysis period
U2/3e	U-value calculated by using the last 2/3 of the analysis period in days	Number of days of this period is calculated using $\text{INT}(2/3 * D)$, where D stands for the duration in days of the analysis period
dU24	Deviation between U and U24	$dU24 = 2 * (U - U24) / (U + U24)$
dU2/3	Deviation between U2/3s and U2/3e	$dU2/3 = 2 * ([U2/3s] - [U2/3e]) / ([U2/3s] + [U2/3e])$
R (not shown in report)	R-value calculated from U-value by assuming standardized heat transfer coefficients of 0.13 (inside) and 0.04 (outside)	$R = 1/U - 0.13 - 0.04$
R24 (not shown in report)	R-value calculated by using the data without the last 24h	See above
R2/3s (not shown in report)	R-value calculated by using the first 2/3 of the analysis period in days	Analogous to U2/3s
R2/3e (not shown in report)	R-value calculated by using the last 2/3 of the analysis period in days	Analogous to U2/3e
dR24	R-value deviation calculated from R24-value by assuming standardized heat transfer coefficients on 0.13 (inside) and 0.04 (outside)	$dR24 = 2 * (R - R24) / (R + R24)$
dR2/3	R-value deviation calculated from R2/3-value by assuming standardized heat transfer coefficients on 0.13 (inside) and 0.04 (outside)	$dR2/3 = 2 * ([R2/3s] - [R2/3e]) / ([R2/3s] + [R2/3e])$

Test criteria:

1. Measurement time ≥ 72 h
2. $\text{Max}(\text{abs}(dR24, dR2/3)) \leq 5\%$

Appendix B: Data Logger Characteristics

The table below shows the maximum measurement time for the adjustable measurement intervals

Measurement interval	Duration [days]	Duration [years]
1s	8,1	0
1min	485,5	1,3
10min	4854,5	13,3
30min	14563,6	39,9
1h	29127,1	79,8

Important Technical Notes

- 1) If the memory of data logger is full, the oldest data is being overwritten until the current measurement takes up the whole available memory of 8 MB. Then data logging stops automatically.
- 2) If the battery is fully charged, it is possible to log the data up to 5 weeks with 10 min interval.
- 3) A USB-charger can be attached to the MSR logger to keep the battery fully charged and, thus, to use data logger for a longer time.

Please note that we are currently still improving minor layout and functional aspects of this software. Let us know if you have any suggestions for improvements. We will send you all software updates and a detailed installation guideline by email and free of charge.

Disclaimer

The above restrictions, recommendations, materials, etc. do not cover all possible cases and items. This document is not to be considered to be complete and it is subject to change without prior notice.

Revision History

Date	Revision	Changes
30. October 2014	0.1 (preliminary)	Initial version
25. November 2014	1.0	Full-software package, incl. new PDF functions
5. December 2014	1.1	Enhanced pictures
15. December 2014	1.2	Additional information on saving files
5. January 2015	1.3	Additional information software version 1.00.01
5. February 2015	1.4	New software screenshots, small updates
25 February 2015	1.5	Text revision
16 March 2015	1.6	Screenshots for full English version
28. October 2015	1.7	Formatting and enhanced pictures
19. April 2016	1.8	Adaption to software update
12. July 2016	1.9	Figure updates and data logger characteristics