RHEONIK.

RHE4X
Desktop Reference Statistics

GET FLOW MEASURED

Rheonik Messtechnik GmbH
Rudolf-Diesel-Straße 5
D-85235 Odelzhausen
Germany

Tel + 49 (0)8134 9341-0
info@rheonik.com

LEARN MORE

Document No.: 8.2.1.28
Version 1.00
October 2020

RHE4X Transmitter

Addendum Desktop Reference Statistics

RHEONIK.

Table of Contents

Baseline reference:

Version 0.11 of this document reflects the properties of the RHE4X firmware version 1.78 and later.

Version 0.20 of this document reflects the properties of the RHE4X firmware version 2.00 and later.

1 Introduction

When ordered with the Statistics Feature RHE4X the transmitter collects data important to the performance of the flow, temperature, and other measurements and calculates statistical relevant information which may help a customer to optimize his processes or the use of the RHM sensor.

Since the handling of the Statistics Feature and its related data is rather complex its description is not included in the "RHE4X Desktop Reference Manual", Document Number 8.2.1.14, but it was decided to create a separate document for it.

This document describes the Statistics Feature on several detail levels from user handling up to the level needed to write own software handling the potential huge amount of data. This does not seem necessary since the RHECom program is able to perform standard operations with the recorded data like writing a CSV file from a selected range of recorded data.

2 Principles of the Statistics Feature

2.1 Sample Interval

The statistics data is sampled in a sample interval of which the duration is defined by the period of the RHM sensor oscillation multiplied by the value in the StatisticCycles (0x60D0) register:

Modbus Address	Register Name	Description
0x60D0	StatisticCycles	(UINT32) **Statistic Cycle Base:** Number of RHM sensor cycles for data sampling. Default is 5000.

Table 1: Modbus Holding Registers for the Administration of the Statistics

The smaller RHM sensors will have an oscillation frequency of about 220 Hz which corresponds to a period slightly less than 5ms. With the default of 5000 cycles in the StatisticCycles (0x60D0) register a sampling period will last around 23 seconds.

When a sampling period is started the statistics data such as mean, minimum, and maximum values as well as the standard deviation is reset. Whenever a respective new value is generated in the RHE transmitter it is included in the calculation of the statistic. When the sampling interval terminates the statistics data set is finalized, timestamp and administrative information is added, and the data is copied to the Modbus input register data set containing the statistics data. The access to this data set is described in section 2.2.

It should be noted that the different data items of which the statistics data set is based are generated with different sampling frequency. The flow oriented data items such as the phase difference and the mass flow are generated at a 1 kHz frequency. This is also true for the RHM frequency and pickup amplitude data. The temperature data is generated at 4 Hz, the CPU Load at 1 Hz, and the RHM drive output at 100 Hz.

2.2 Modbus Input Registers for Statistics Data

Since the amount of statistic data is greater than 256 bytes two Modbus telegrams are needed to read all data items. Therefore, the administrative data such as time stamps and statistic cycle identifications are structured around the data items to form two data records which each can be read in one telegram.

The data of the first record is found in the Modbus input address range of 0x4100 to 0x4176. The second records uses the address range from 0x4180 to 0x41F6. Following Modbus input registers are defined in these ranges:

Modbus Address	Register Name	Description
0x4100	DateTimeRecord1	(UINT32) **Date and Time for Record 1**: Date and Time for Record 1 in seconds since January, 1st 1980.
0x4102	SystemTime	(UINT32) **System Time Stamp for Record 1**: System Time in ms since system start.
0x4104	StatisticRecord1IdStart	(UINT32) **Start Id number for Record 1**: This should be equal to StatisticRecord1IdEnd (0x4176) in order to ascertain that all data items in the record origin from the same sampling.
0x4106	MeanAmplitudeRightCoil	(FLOAT64) Mean Amplitude of Right Pickup Coil in mV the range of 0 to 1250mV.
0x410A	SDAmplitudeRightCoil	(FLOAT64) Standard deviation of amplitude of Right Pickup Coil expressed in percent.
0x410E	MinAmplitudeRightCoil	(FLOAT64) Difference between mean and minimum amplitude of Right Pickup Coil expressed in standard deviation units.
0x4112	MaxAmplitudeRightCoil	(FLOAT64) Difference between maximum and mean amplitude of Left Pickup Coil expressed in standard deviation units.
0x4116	MeanAmplitudeLeftCoil	(FLOAT64) Mean Amplitude of Left Pickup Coil in mV the range of 0 to 1250mV.
0x411A	SDAmplitudeLeftCoil	(FLOAT64) Standard deviation of amplitude of Right Coil expressed in percent.
0x411E	MinAmplitudeLeftCoil	(FLOAT64) Difference between mean and minimum amplitude of Left Pickup Coil expressed in standard deviation units.
0x4122	MaxAmplitudeLeftCoil	(FLOAT64) Difference between maximum and mean amplitude of Left Pickup Coil expressed in standard deviation units.
0x4126	MeanFrequency	(FLOAT64) Mean Sensor Frequency in Hz.
0x412A	SDFrequency	(FLOAT64) Standard deviation of the sensor frequency expressed in percent.
0x412E	MinFrequency	(FLOAT64) Difference between mean and minimum sensor frequency expressed in standard deviation units.
0x4132	MaxFrequency	(FLOAT64) Difference between maximum and mean sensor frequency expressed in standard deviation units.
0x4136	MeanPhaseDifference	(FLOAT64) Mean phase difference in 8ns units from which the zero phase already has been subtracted and to which no filtering has been applied.
0x413A	SDPhaseDifference	(FLOAT64) Standard deviation of the phase difference (not expressed in percent!).
0x413E	MinPhaseDifference	(FLOAT64) Difference between mean and minimum phase difference expressed in standard deviation units.
0x4142	MaxPhaseDifference	(FLOAT64) Difference between maximum and mean phase difference expressed in standard deviation units.
0x4146	MeanTubeTemperature	(FLOAT64) Mean tube temperature in °C.

Modbus Address	Register Name	Description
0x414A	SDTubeTemperature	(FLOAT64) Standard deviation of the tube temperature expressed in percent.
0x414E	MinTubeTemperature	(FLOAT64) Difference between mean and minimum tube temperature expressed in standard deviation units.
0x4152	MaxTubeTemperature	(FLOAT64) Difference between maximum and mean tube temperature expressed in standard deviation units.
0x4156	MeanTorsionTemperature	(FLOAT64) Mean torsion temperature in °C.
0x415A	SDTorsionTemperature	(FLOAT64) Standard deviation of the torsion temperature expressed in percent.
0x415E	MinTorsionTemperature	(FLOAT64) Difference between mean and minimum torsion temperature expressed in standard deviation units.
0x4162	MaxTorsionTemperature	(FLOAT64) Difference between maximum and mean torsion temperature expressed in standard deviation units.
0x4166	MeanMassFlow	(FLOAT64) Mean mass flow in kg/min.
0x416A	SDMassFlow	(FLOAT64) Standard deviation of the mass flow (not expressed in percent!).
0x416E	MinMassFlow	(FLOAT64) Difference between mean and minimum mass flow expressed in standard deviation units.
0x4172	MaxMassFlow	(FLOAT64) Difference between maximum and mean mass flow expressed in standard deviation units.
0x4176	StatisticRecord1IdEnd	(UINT32) **End Id number for Record 1.** This should be equal to StatisticRecord1IdStart (0x4104) in order to ascertain that all data items in the record origin from the same sampling interval.
0x4180	DateTimeRecord2	(UINT32) **Date and Time for Record 2**: Date and Time for Record 1 in seconds since January, 1st 1980.
0x4182	SystemTime	(UINT32)) **System Time Stamp for Record 2**: System Time in ms since system start.
0x4184	StatisticRecord2IdStart	(UINT32) **Start Id number for Record 2.** This should be equal to StatisticRecord2IdEnd (0x41F6) in order to ascertain that all data items in the record origin from the same sampling interval.
0x4186	MeanDensity	(FLOAT64) Mean density in kg/min units.
0x418A	SDDensity	(FLOAT64) Standard deviation of density expressed in percent.
0x418E	MinDensity	(FLOAT64) Difference between mean and minimum amplitude of density expressed in standard deviation units.
0x4192	MaxDensity	(FLOAT64) Difference between maximum and mean amplitude of density expressed in standard deviation units.
0x4196	MeanDriveCurrent	(FLOAT64) Mean drive current in mA.
0x419A	SDDriveCurrent	(FLOAT64) Standard deviation of drive current expressed in percent.
0x419E	MinDriveCurrent	(FLOAT64) Difference between mean and minimum amplitude of drive current expressed in standard deviation units.
0x41A2	MaxDriveCurrent	(FLOAT64) Difference between maximum and mean amplitude of drive current expressed in standard deviation units.
0x41A6	MeanDriveGain	(FLOAT64) Mean Drive Gain in percent.
0x41AA	SDDriveGain	(FLOAT64) Standard deviation of the drive gain expressed in percent.
0x41AE	MinDriveGain	(FLOAT64) Difference between mean and minimum drive gain expressed in standard deviation units.

Modbus Address	Register Name	Description
0x41A2	MaxDriveGain	(FLOAT64) Difference between maximum and mean drive gain expressed in standard deviation units.
0x41B6	MeanCPULoad	(FLOAT64) Mean CPU load of all critical tasks in percent.
0x41BA	SDCPULoad	(FLOAT64) Standard deviation of the CPU load expressed in percent.
0x41BE	MinCPULoad	(FLOAT64) Difference between mean and minimum CPU load expressed in standard deviation units.
0x41C2	MaxCPULoad	(FLOAT64) Difference between maximum and mean CPU load expressed in standard deviation units.
0x41C6	MeanValue1	(FLOAT64) Mean of value 1 assigned to this statistic slot.
0x41CA	SDValue1	(FLOAT64) Standard deviation of value 1 assigned to this statistic slot expressed in percent.
0x41CE	MinValue1	(FLOAT64) Difference between mean and minimum of value 1 assigned to this statistic slot expressed in standard deviation units.
0x41D2	MaxValue1	(FLOAT64) Difference between maximum and mean of value 1 assigned to this statistic slot expressed in standard deviation units.
0x41D6	MeanValue2	(FLOAT64) Mean of value 2 assigned to this statistic slot.
0x41DA	SDValue2	(FLOAT64) Standard deviation of value 2 assigned to this statistic slot expressed in percent.
0x41DE	MinValue2	(FLOAT64) Difference between mean and minimum of value 2 assigned to this statistic slot expressed in standard deviation units.
0x41E2	MaxValue2	(FLOAT64) Difference between maximum and mean of value 2 assigned to this statistic slot expressed in standard deviation units.
0x41E6	MeanValue3	(FLOAT64) Mean of value 3 assigned to this statistic slot.
0x41EA	SDValue3	(FLOAT64) Standard deviation of value 3 assigned to this statistic slot expressed in percent.
0x41EE	MinValue3	(FLOAT64) Difference between mean and minimum of value 3 assigned to this statistic slot expressed in standard deviation units.
0x41F2	MaxValue3	(FLOAT64) Difference between maximum and mean of value 3 assigned to this statistic slot expressed in standard deviation units.
0x41F6	StatisticRecord2IdEnd	(UINT32) **End Id number for Record 2.** This should be equal to StatisticRecord2IdStart (0x4184) in order to ascertain that all data items in the record origin from the same sampling interval.

Table 2: Modbus Input Registers for the Statistics Feature

As it can be seen all administrative data items are 32-bit unsigned integers (UINT32) whilst the statistics data itself are 64-bit IEEE floating point numbers (double precision). A data source, e.g. the RHM sensor frequency, generates following statistics data set:

- a mean value, MeanFrequency (0x4126) in the example;
- a standard deviation in most cases expressed in percent, SDFrequency (0x412E) in the example;

- the minimum value encountered in the sampling interval, MinFrequency (0x4152) in the example, expressed in standard deviation units;
- the maximum value encountered in the sampling interval, MaxFrequency (0x4156) in the example, expressed in standard deviation units.

All data items in the statistic records which are based on measurements are also based on the RHE standard units

Unit	Measurement
°C	Temperature
hPa	Pressure
kg	Mass
kg/min	Mass flow
m^3	Volume
m^3/min	Volumetric flow
kg/m^3	Density

and will not be converted to user defined units when transferred. A conversion can be done in Excel after the CSV file was imported.

The records feature two different time stamps. One type found in the SystemTime registers consists of a counter which counts the milliseconds beginning from the start of the system.

Another time stamp in the records is DateTimeRecord1 or DateTimeRecord2, an unsigned 32-bit numbers which contains the number of seconds since midnight 1980-01-01. This time stamp format will result in unique numbers until 2116 and may be converted to other time stamp formats, e.g. to the format used by Excel which features an integer part based on midnight 1900-01-01.

Such an Excel time stamp is obtained from e.g. DateTimeRecord1 by adding a new column to the Excel sheet in which the time stamp value is divided by 86400 and thereafter the number 29219 added to the result.

The read-out of these records is not guaranteed to be atomic, i.e. a part of a record may origin from one statistics cycle whilst the other part of the record is based on the data of the next cycle. In order to facilitate a test for consistent data sets the fields StatisticRecord1IdStart, StatisticRecord1IdEnd, StatisticRecord2IdStart, and StatisticRecord2IdEnd contain a 32-bit counter which is incremented whenever a new data set is generated by the statistics feature. Thus, a data record obtain by a sequential read which contains identical start and end identifications contains data from the same statistics cycle.

In order to get all statistic records correctly it is recommended to read the statistic records three times in one statistics time span and discard all records with inconsistent start and end identifications and all duplicates.

3 Using RHEComPro to Generate a Statistics History in CSV File

This section is intended for users who want to use the RHEComPro program to handle the Statistics Feature and to generate a CSV file out of the recorded data.

3.1 Setting a Data Read-Out Interval

Following the advice given in section 2.2 three read-outs should be done in one statistics sample interval. The data read-out interval is specified in the field “Measurement Rate” in the RHEComPro Connection window.

Assuming that the statistic sample interval is about 25 seconds the read-out interval should be set to 5 or 10 seconds as indicated in the figure below.

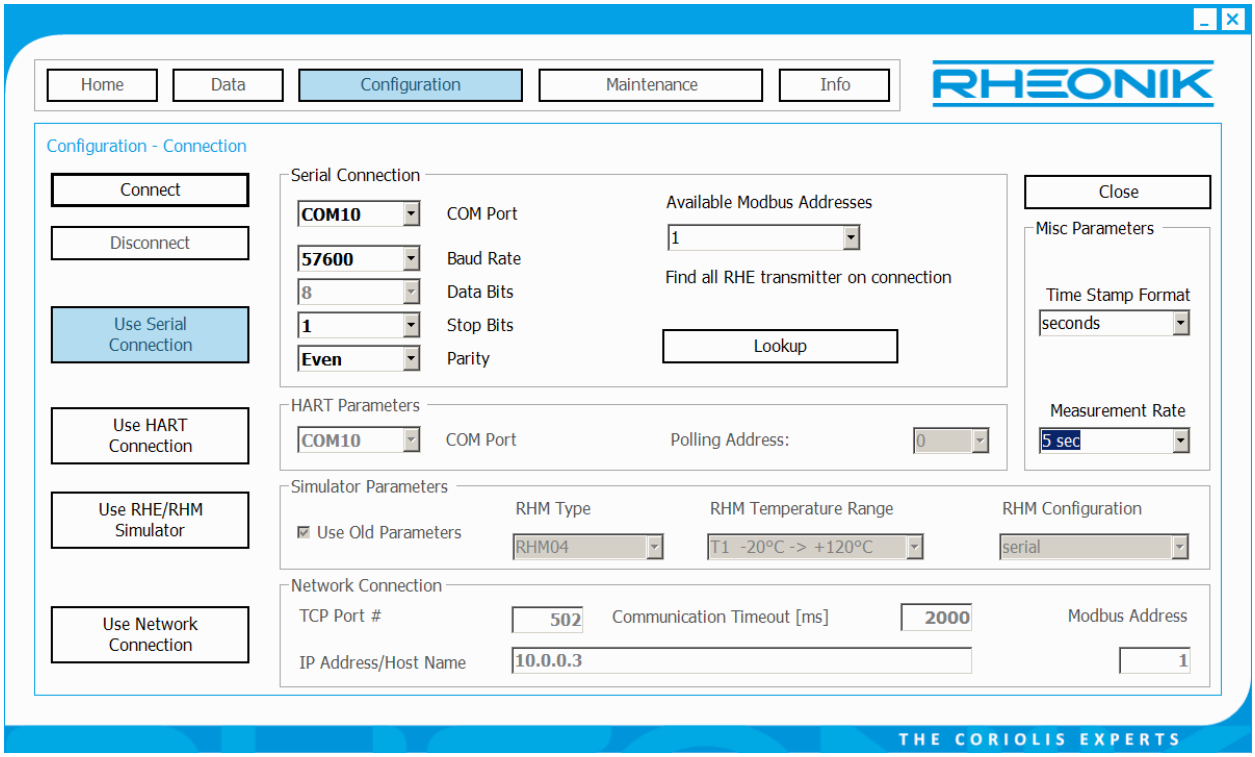

Figure 1: RHEComPro Connection Window

This should be done when the connection to the RHE transmitter is established. When this is done later the measurement cycles of the RHEComPro should be stopped and restarted in order to render the rate change effective. See the tool-strip at left side of the RHEComPro dashboards for a “Stop” symbol which automatically turns into a “Start” symbol when the measurements are stopped.

3.2 Data Selection Dialog Box

When the RHEComPro program detects that is connected to an RHE4X series transmitter it offers an additional “Statistics” tab in the “Data Selection” dialog box. In this tab the data items of interest can be checked for logging. It is strongly recommended to include the first three administrative data items DateTimeRecord1, SystemTime, and StatisticRecord1IdStart as well as the last data item StatisticRecord2IdEnd.

The “Statistics” tab together with data items check for logging is shown in Figure 2.

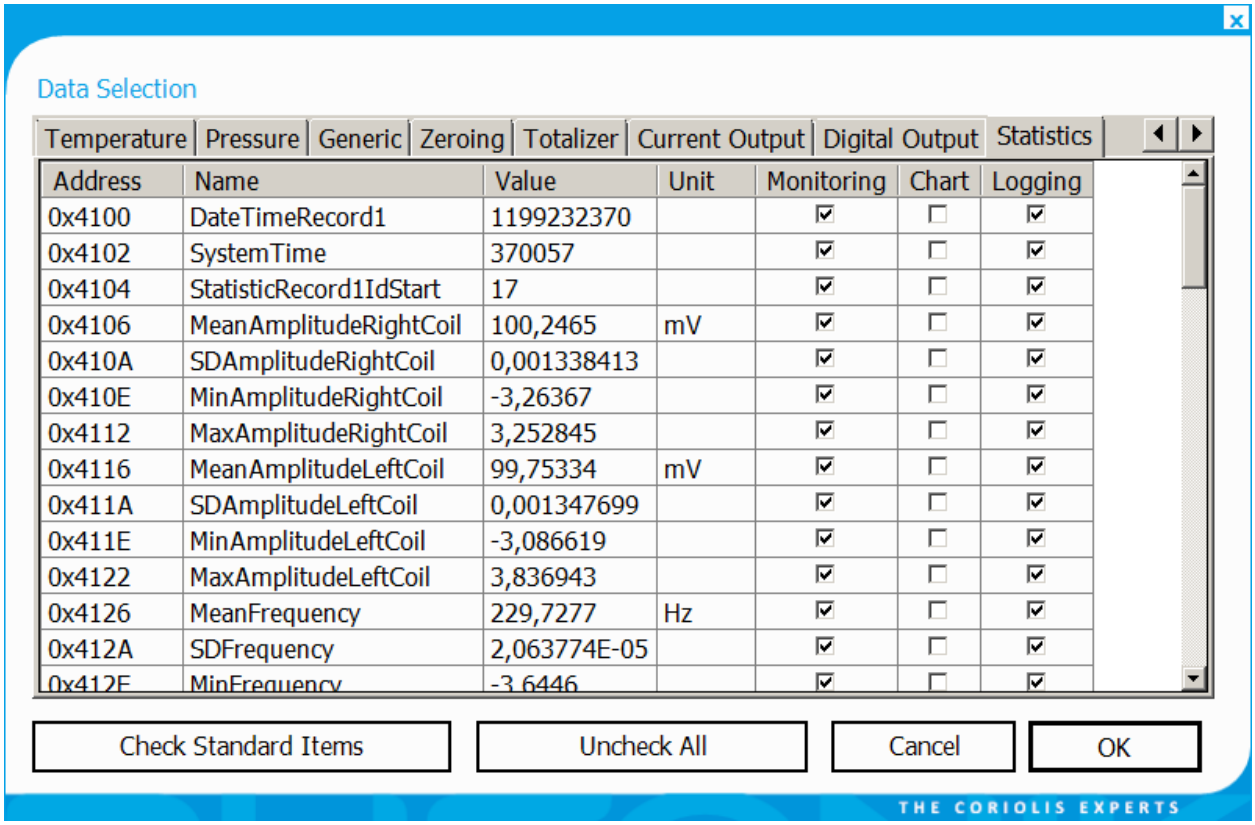

Figure 2: RHEComPro Data Selection Dialog Box

3.3 Start the Recording of the CSV File

Before starting the RHEComPro data logging the target directory and the file name should be checked with the help of the “Data” / “Data Logging Configuration” dialog box which can be activated via the “Data” / “Data Logging Configuration” menu item as indicated in Figure 3: Menu Tree to the “Configure Data Logging” Dialog Box.

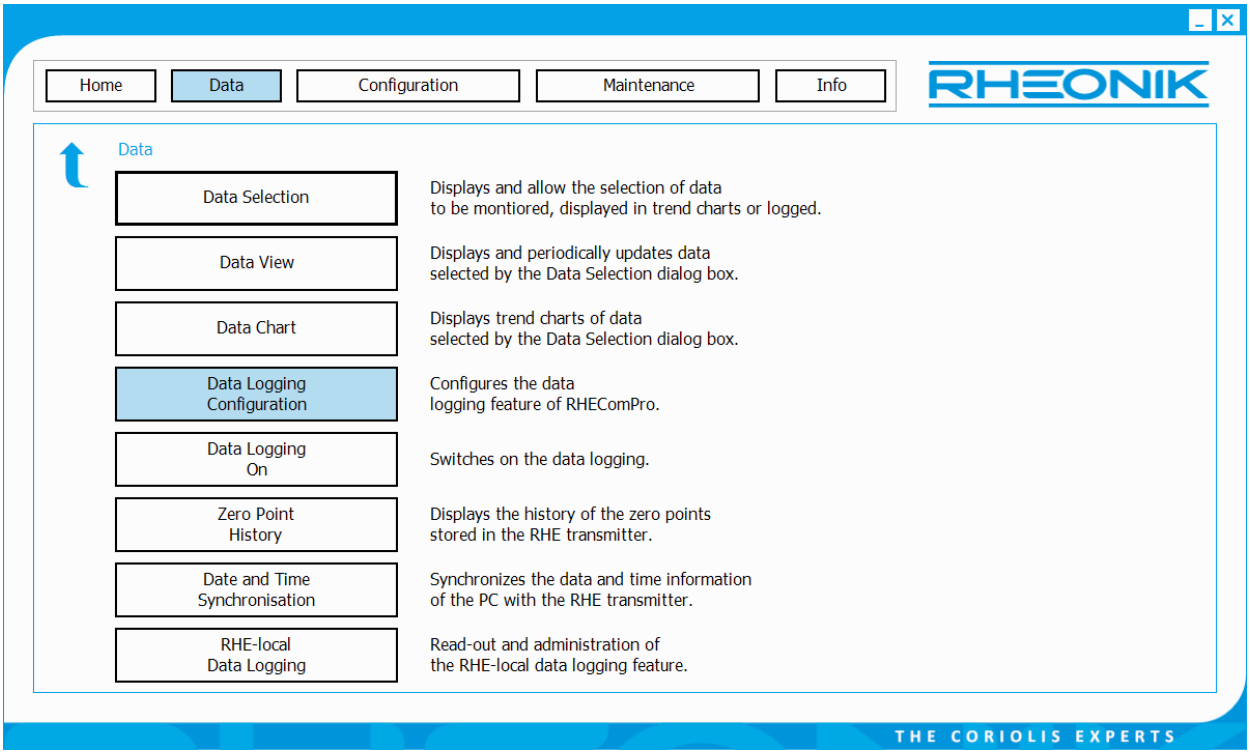

Figure 3: Menu Tree to the "Configure Data Logging" Dialog Box

In the "Configure Data Logging" dialog box the directory and name of the CSV file can be specified, see Figure 4. Note, that the specified file name will be amended by the current date and time information.

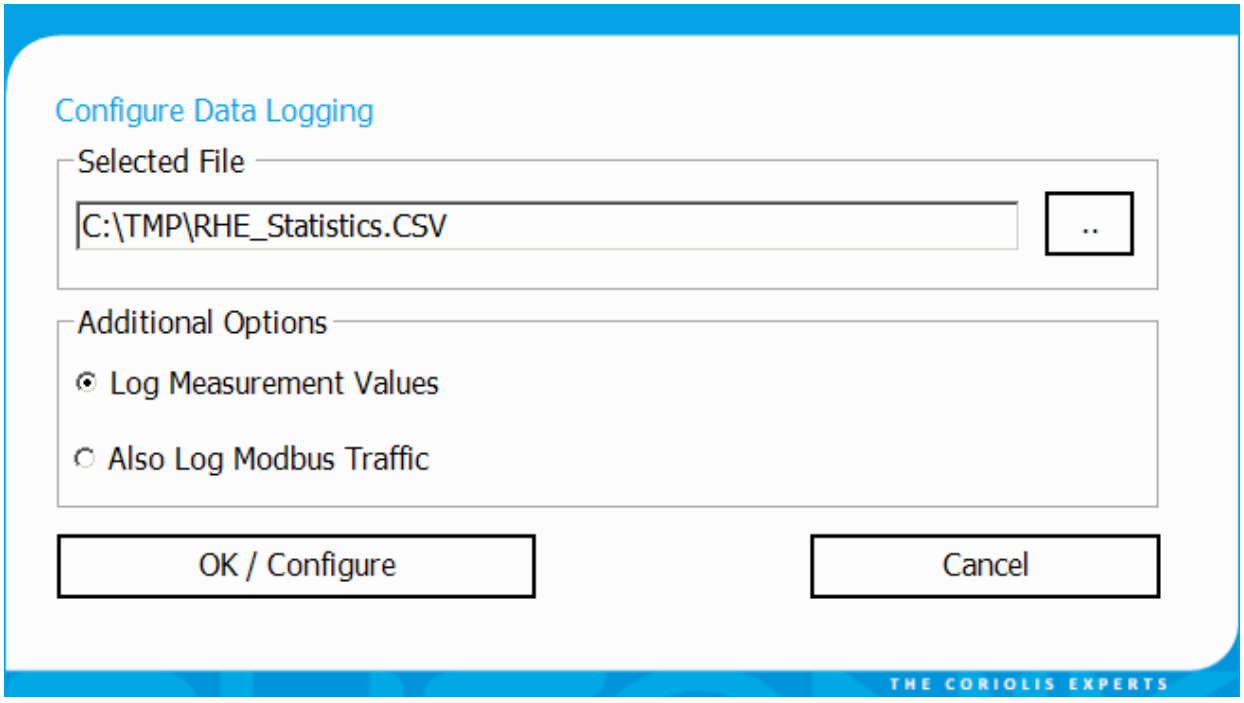

Figure 4: RHEComPro Configure Data Logging Dialog Box

Thereafter, the recording of the statistics data can be started via the "Data Logging On/Off" menu item or icon. The menu item and the icon change their appearance depending on the status of the recording. The recording can be stopped anytime. A restart of the recording will create a new file with different time stamp in its file name.

3.4 Preparing the Data Evaluation

The amount of data columns in the CSV file depends on the number of data items checked in the “Logging” column in the tabs of the “Data Selection” dialog box.

The data items in the CSV file are separated by ‘;’ characters and the floating point numbers will feature a decimal point or a decimal comma depending on the “locale” settings of your windows operating system. Please check this with a text editor before importing the file into your Excel version. Whether the file format is accepted by your Excel installation also depends on the “locale” settings and options in the “Extended” tab of the Excel “File”/”Options” dialog box.

If these settings don’t match the format your Excel installation requires use a text editor first to replace all the decimal point characters and thereafter the data field separator characters. Both cannot be identical. Do this on a copy and keep the original file for further reference.

Next all rows should be deleted where the values in the StatisticRecord1IdStart and StatisticRecord2IdEnd are not identical. Then all rows with duplicate StatisticRecord1IdStart values can be deleted.

When the SystemTime column needs to be converted to a human readable date and time information this can be done by adding a new column with the following formula

```
=B3/86400 + 29219
```

where B3 is a value in the SystemTime column. The resulting cells then can be formatted in a standard or non-standard Excel date/time format.

About Rheonik

Rheonik has but one single purpose: to design and manufacture the very best Coriolis meters available.

Our research and engineering resources are dedicated to finding new and better ways to provide cost effective accurate mass flow solutions that provide value to our customers. Our manufacturing group care for each and every meter we produce from raw materials all the way to shipping, and our service and support group are available to help you specify, integrate, start-up and maintain every Rheonik meter you have in service. Whether you own just one meter or have hundreds, you will never be just another customer to us. You are our valued business partner.

Need a specific configuration for your plant? Don't compromise with a "standard" product from elsewhere that will add extra cost to your installation. If we can't configure it from our extensive and versatile product range, our exclusive **AnyPipeFit Commitment** can have your flow sensor customized with any size/type of process connection and face to face dimension you need.

No matter what control system you use as the backbone in your enterprise, with our **AnyInterface Commitment**, you can be sure that connection and communication will not be a problem. Alongside a wide variety of discrete analog and digital signal connections, we can also provide just about any network/bus interface available (for example: HART, ProfibusDP, ProfiNet, EtherCAT, PowerLink, EtherNet/IP, CAN, ….) with our RHE 40 Series family of transmitters. Rheonik RHE 40 Series transmitters can connect to your system – no headache and no conversion needed.

Rheonik Messtechnik GmbH
Rudolf-Diesel-Straße 5
D-85235 Odelzhausen
Germany

Tel + 49 (0)8134 9341-0
info@rheonik.com