E4000 air quality probe KNX and LON database setting

Ver	Date	Modification
V1		Initial Version
V2		Passage COV en ppm
V3		Ajout statut Z8
V4		Nouvelle base de données avec 255 paramètres possibles
V5		Ajout sondes annexes et passerelle EnOcean
V6		UK version created
V7		LON added
V8	18/04/2012	Renumbering data points
V9	06/11/2012	Comfort zone details
V10	Nov. 2012	LON details
V11	Jan 2013	Felt temperature data point added
V12	Dec 2013	Typing mistake corrected on Windows sate
V13	Feb 2014	Improved felt temperature details
V14	Oct 2015	Details of RH set point and T° exemption
V15	Sept 2018	NG Version, VOC in µg/m^3

Summary

1 E4000 Application Program

1.1 Selection in the product database

The probe appears as follow

Manufacturer	NanoSense
Product Family	Physical Sensors
Type of product	E4000 air quality probe
Program Name	E4000

KNX
The KNX database for ETS can be downloaded at the following address:
http://www.nano-sense.com/Soft/E4000/E4000-NG-ETS3-DB.rar

LON
The LON Plug-In can be downloaded at the following address:
http://www.nano-sense.com/Soft/E4000/E4000-NG-LNS-Plugin.rar

Number of parameters used	240
Number of communication objects used	245
Number of group addresses	254
Number of associations	255

1.2 Communication Objects

1.2.1 List of communication objects

N°	Function	KNX			LON		
		Object Name	DPT Type	Format Data	NV Name	NV Type	Format Data
1	Physical value	CO2 concentration	9.008	2 Bytes	nvoCO2ppm	SNVT_ppm	2 bytes
2	Switch	CO2Command	1.001	1 Bit	nvoCO2FanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoCO2FanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
3	Physical value	COV concentration	9.008	2 Bytes	nvoFloatVOC	SNVT_ppm_f	4 bytes
4	Switch	COV Command	1.001	1 Bit	nvoVOCFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoVOCFanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
5	Physical value	Humidity Relative Value	5.001	1 Byte	nvoHVACRH	SNVT_lev_percent	2 bytes
			5.004	1 Byte			
			9.007	2 Bytes			
6	Physical value	Absolute Humidity Value : Indoor	9.007	2 Bytes	nvoHVACAH	SNVT_abs_humid	2 bytes
7	Physical value Input	Absolute Humidity Value : Outdoor	9.007	2 Bytes	nviOutdoorRH	SNVT_lev_percent	2 bytes
		Relative Humidity Value : Outdoor	5.001	1 Byte	nviOutdoorAH	SNVT_abs_humid	2 bytes
			5.004	1 Byte			
			9.007	2 Bytes			
8	Physical value Input	Temperature : Outdoor	9.001	2 Bytes	nviOutdoorTemp	SNVT_temp_p	2 bytes
9	Physical value	Dew Point Value	9.001	2 Bytes	nvoIndoorDewPt	SNVT_temp_p	2 bytes
10	Switch	Relative Humidity Command	1.001	1 Bit	nvoHumFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoHumFanCmd	SNVT_switch	1 byte

	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
11	Alarm	Stop Ventilation	1.005	1 Bit			
12	Physical value	Temperature Value	9.001	2 Bytes	nvoHVACTemp	SNVT_temp_p	2 bytes
13	Switch	Heater Command	1.001	1 Bit	N/A	N/A	N/A
	Value from 0 to 255		5.001	1 Byte	nvoHeatPrimary	SNVT_lev_percent	2 bytes
14	Cooling Command	Cooling Command	1.001	1 Bit	N/A	N/A	N/A
			20.102	1 Byte	nvoCoolPrimary	SNVT_lev_percent	2 bytes
15	Input	Temperature set point	9.001	2 Bytes	nviSetpoint	SNVT_temp_p	2 bytes
16	Input	Select Operating Mode Heater & cooler	20.102	1 Byte	nviHVACMode	SNVT_hvac_mode	1 byte
17	Input	Select Operating Mode Ventilation	20.102	1 Byte	nviVentMode	SNVT_hvac_mode	1 byte
18	Input	Presence	1.018	1 Bit	nviOccSensor	SNVT_occupancy	1 byte
19	Input	Night Mode	1.001	1 Bit	nviNightEnable	SNVT_switch	1 byte
20	Input	Window State 1	1.019	1 Bit	nviHoldOff1	SNVT_switch	1 byte
21	Input	Window State 2	1.019	1 Bit	nviHoldOff1	SNVT_switch	1 byte
22	Input	Window State 3	1.019	1 Bit	nviHoldOff1	SNVT_switch	1 byte
23	Input	Window State 4	1.019	1 Bit	nviHoldOff1	SNVT_switch	1 byte
24	Input	Window State 5	1.019	1 Bit	nviHoldOff1	SNVT_switch	1 byte
25	Input	Complementary T° sensor 1	9.001	2 Bytes	nviIndoorTemp1	SNVT_temp_p	2 bytes
26	Input	Complementary T° sensor 2	9.001	2 Bytes	nviIndoorTemp2	SNVT_temp_p	2 bytes
27	Input	Complementary T° sensor 3	9.001	2 Bytes	nviIndoorTemp3	SNVT_temp_p	2 bytes
28	Switch	Bypass Heat exchanger	1.001	1 Bit			
29	Switch	Combined Ventilation Command	1.001	1 Bit	nvoMixFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoMixFanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A

If annexes Modbus RS485 sensors are connected to the E4000probe, they are handled if the gateway function for these sensors is enabled in the KNX database.

30	Switch	Bypass Canadian well	1.001	1 Bit			
31	HVAC Command	Overpressure	20.106	1 Byte			
32	Physical value	Radon Value	9.010	2 Bytes	nvoRadon	UNVT_radon	1 byte
33	Switch	Radon Command	1.001	1 Bit	nvoRadonFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoRadonFanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
34	Physical value	1µm Particles Mater Value	9.001	2 Bytes	nvoPM1	UNVT_particle_matter	1 byte
35	Physical value	2.5µm Particles Mater Value	9.001	2 Bytes	nvoPM2_5	UNVT_particle_matter	1 byte
36	Physical value	10µm Particles Mater Value	9.001	2 Bytes	nvoPM10	UNVT_particle_matter	1 byte
37	Switch	Particles Command	1.001	1 Bit	nvoPMFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoPMFanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
38	Physical value	Ozone Value	9.008	2 Bytes	nvoOzone	SNVT_ppm_f	4 bytes
39	Switch	Ozone Command	1.001	1 Bit	nvoOzoneFanCmd	SNVT_switch	1 byte
	Priority		2.001	2 Bits	N/A	N/A	N/A
	Value in %		5.004	1 Byte	nvoOzoneFanCmd	SNVT_switch	1 byte
	Value from 0 to 255		5.001	1 Byte	N/A	N/A	N/A
40	Physical value	Felt Temperature Value	9.001	2 Bytes	nvoHVACTemp	SNVT_temp_p	2 bytes

Communication objects of EnOcean Gateway are described in the document call "E4000 EnOcean-KNX or LON Gateway Setting Manual UK"

1.2.2 Description of the KNX communication objects

• Object 1 "CO2 Value"
This object sends the CO2 value measured in real time by the probe (If authorized by the sending setting).

• Object 2 "CO2 Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON control if ventilation with one speed motor (Depending on the command setting).
This object is used when the ventilation system must be operated solely for the CO2 value.
The command depends on CO2 levels and hysteresis limits setting.

• Object 3 "Value VOC"
This object sends the VOC value measured in real time by the probe (If authorized by the sending setting).

• Object 4 "VOC Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON control if ventilation with one speed motor (Depending on the command setting).
This object is used when the ventilation system must be operated solely for the VOC value.
The command depends on VOC levels and hysteresis limits setting.

• Object 5 "Air Relative Humidity value"
This object sends the Relative Humidity of air measured in real time by the probe (If authorized by the sending setting).
According to the needs, the communication object can be selected between 9007 (standardized) or the generic percentage byte number 5001 or 5004 (used in some units). Only one of these three objects is sent depending on the setting.

• Object 6 "Indoor Air Absolute Humidity value "
This object sends the absolute humidity of indoor air calculated from measurements of Relative Humidity and temperature in real time by the probe (If authorized by the sending setting).

• Object 7 "Outside Air Absolute Humidity value"
This object is an input for an outdoor air humidity sensor. It calculates if the outside air through the ventilation is likely to dry or humidify the indoor air.
The telegram type varies depending on whether absolute or relative humidity depending on the setting.

• Object 8 "Outdoor Temperature"
This object is an input for an outdoor temperature sensor. It is helpful to calculate the outdoor absolute humidity of outdoor air if the sensor of the communication object 10 is a Relative Humidity Sensor.

• Object 9 "Dew Point value of indoor air"
This object sends the temperature of the Dew Point based on the absolute humidity of indoor air calculated from measurements of Relative Humidity and temperature in real time by the probe (If authorized by the sending setting).

• Object 10 "Air Relative Humidity Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON control if ventilation with one speed motor (Depending on the command setting).
This object is used when the ventilation system must be operated solely for the air Relative Humidity value.
The command depends on Relative Humidity levels and hysteresis limits setting.

• Object 11 "Stop Ventilation"
This object in receiving an Off ventilation order (fire, maintenance ...)
0: No Stop
1: Stop

• Item 12 "Temperature value"
This object sends the temperature measured in real time by the probe (If authorized by the sending setting).

• Object 13 'Heating Control "
Size of the control for the Heating actuator (1 byte telegram) or ON / OFF control if electric heating or not controllable in continuous (Depending on the command set).
The order depends on the measured temperature and the temperature setpoint.
This command uses a PID (steering with Proportional Integrals Differential with self-adaptive coefficients,) that limits the oscillations around the setpoint while reaching this point as soon as possible. When selecting the ON / OFF control, the PID is replaced by a PID like using of gradual hysteresis reduction method.

• Object 14, "Air Conditioning Control"
Similar to the heating control with a similar PID.

• Object 15 "Temperature Setpoint"
This input is used to derogate to nominal temperature setpoint set in ETS.
This is typically from a Room Operating Panel.

• Object 16 "Select Operating Mode for Heater and Air Conditioner"
This input is used to control heating and air conditioning and set the mode as:
0: Auto,
1: Comfort
2: Economy (Standby)
3 : Night
4: Protection building (used for frost protection)

• Object 17 "Select Operating Mode for Ventilation"
This input is used to control the ventilation and is similar to the previous one.
Protect mode building is used as stopping ventilation.
This telegram is typically from window handles state.

• Object 18 'Presence'
This input can switch the ventilation, heating and cooling from Comfort mode to Economic mode according to absence or presence.
This is typically an infrared or ultrasonic presence detector.
0: Absence
1: Presence

• Object 19 "Night Mode"
This input can switch the ventilation, heating and cooling from Comfort mode to Economic mode overnight.
This is typically a clock or external light sensor that generates a Boolean.
0: Day
1: Night

• Object 20 to 24 "Window State"
This entry can associate up to five window switches or handles to the ventilation control, heating and air conditioning.
It is thus possible to reduce, increase (not recommended) or shut down the ventilation, heating and air conditioning depending on the setting.
0: Closed
1: Open

• Object 25 to 27 "Complementary Temperature Sensors"
These objects are inputs for additional temperature sensors located nearby and for controlling the same heating and air conditioning.

• Object 28 " Heat Recovery Bypass"
Output object to disengage the double flow ventilation exchange of calories system to cool down the building with cool outside air without using air conditioning or to assist it (if authorized by the sending setting).
This way is commonly used at night during summer time and is called "free cooling"

• Object 29, "Combined Ventilation Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON if ventilation control with one engine motor (Depending on the command set).
This object is used when the ventilation system must be operated according levels of CO2, VOCs air relative humidity, particles, ozone and Radon activity combined.

The Command values of object 3, 6, 14, 248, 252 and 254 are monitored and it is always the highest command value that is sent.

• Object 30 "Bypass Canadian Well"
Output object to order the ventilation to pick up incoming air directly instead of from the Canadian well. This strategy is applied when radon is suspected to come from the Canadian Well.
0: No bypass
1: Bypass

• Object 31 "Overpressure"
Output object to order the double-flow ventilation to permanently overpressure the inside of the building. This command is not usable by simple flow ventilation that only extracts air. It could possibly be used by a simple ventilation flow insufflation if they can close air registers once the desired pressure is reached. This pressure is used as a remediation strategy for the penetration of radon in buildings. This object is only supported when the E4000 probe is equipped with an Annex radon sensor and dilution strategies of radon have failed.
0: No overpressure
1: Overpressure

• Object 32 "Radon Value"
This object sends the activity of radon measured in real time by the annex probe (If authorized by the sending setting).

• Object 33 "Radon Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON if ventilation control with one motor speed (Depending on the command set).
This object is used when the ventilation system must be operated solely for the activity of radon.
The command depends on the Radon activity limit and hysteresis setting.

• Object 34 to 36 "Particles Value"
These objects send PM1, PM2.5 and PM10 Particle Mater values measured in real time by the annex probe (If authorized by the sending setting).

• Object 37 "Particulate Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON if ventilation control with one motor speed (Depending on the command set).
This object is used when the ventilation system must be operated solely for the fines particles.

The command depends on PM1, PM2.5 and PM10 particle density limits and hysteresis setting.

• Object 38 "Ozone Value"
This object sends the content of ozone measured in real time by the annex probe (If authorized by the sending setting).

• Object 39 "Ozone Control"
Size of the control for the ventilation actuator (1 byte telegram) or ON if ventilation control with one

motor speed (Depending on the command set).
This object is used when the ventilation system must be operated solely for Ozone.
The command depends on ozone concentration limits and hysteresis setting.

• Item 40 "Felt Temperature value"
This object sends the felt temperature calculated in real time by the probe (If authorized by the sending setting).

1.2.3 Description of the LON Network Variables

Lon Network variables are similar to KNX communication objects.
Please refer to the table of chapter 1.2.1 for details

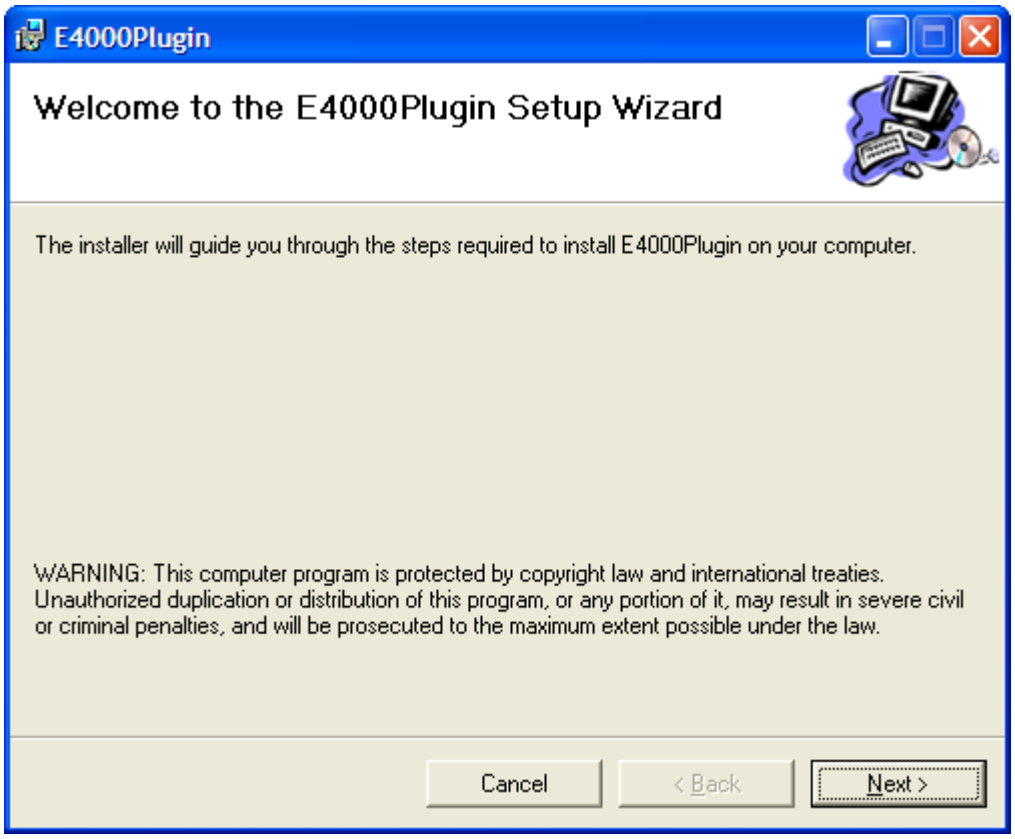
1.3 KNX & LON commissioning tool

The ETS tool is universal for KNX.

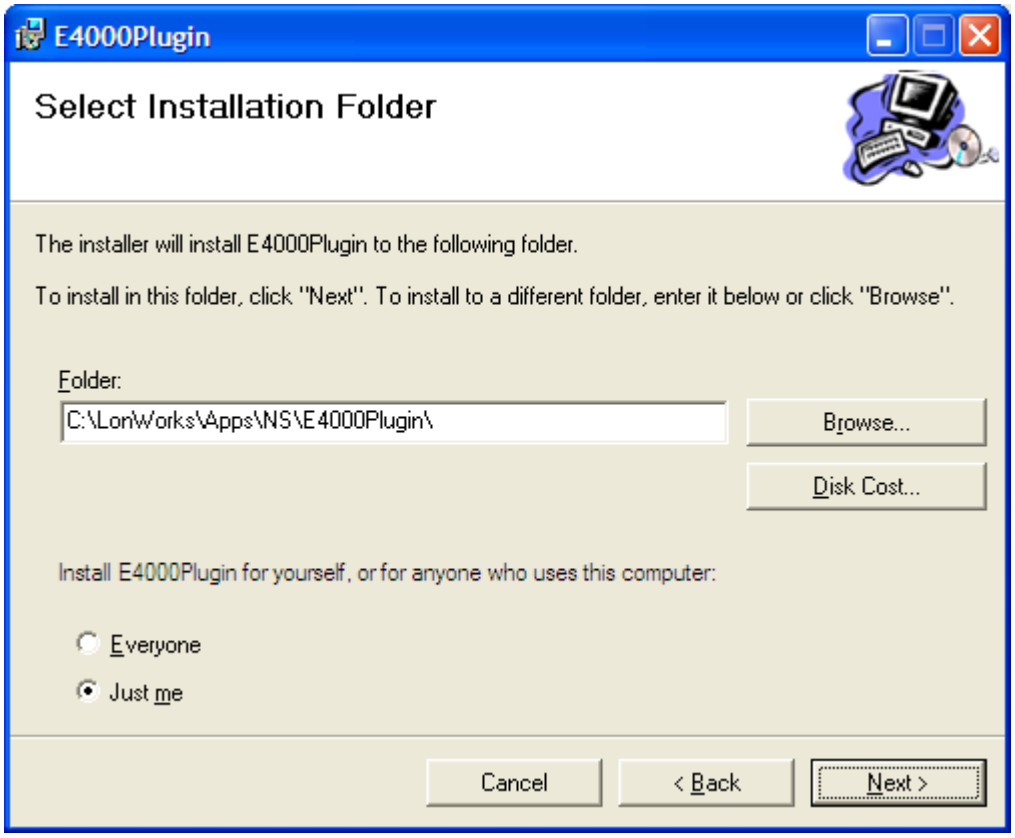
LonWorks can use various commissioning tools. Nevertheless we have developed a proprietary LNS Plug-In that looks similar to the KNX database.

To use this LNS Plug-In it is necessary to install the files available from the web site http://www.nano-sense.com/Soft/E4000/E4000-LNS-Plugin.rar. The file must be unrared to get two installation files and one file for W7.

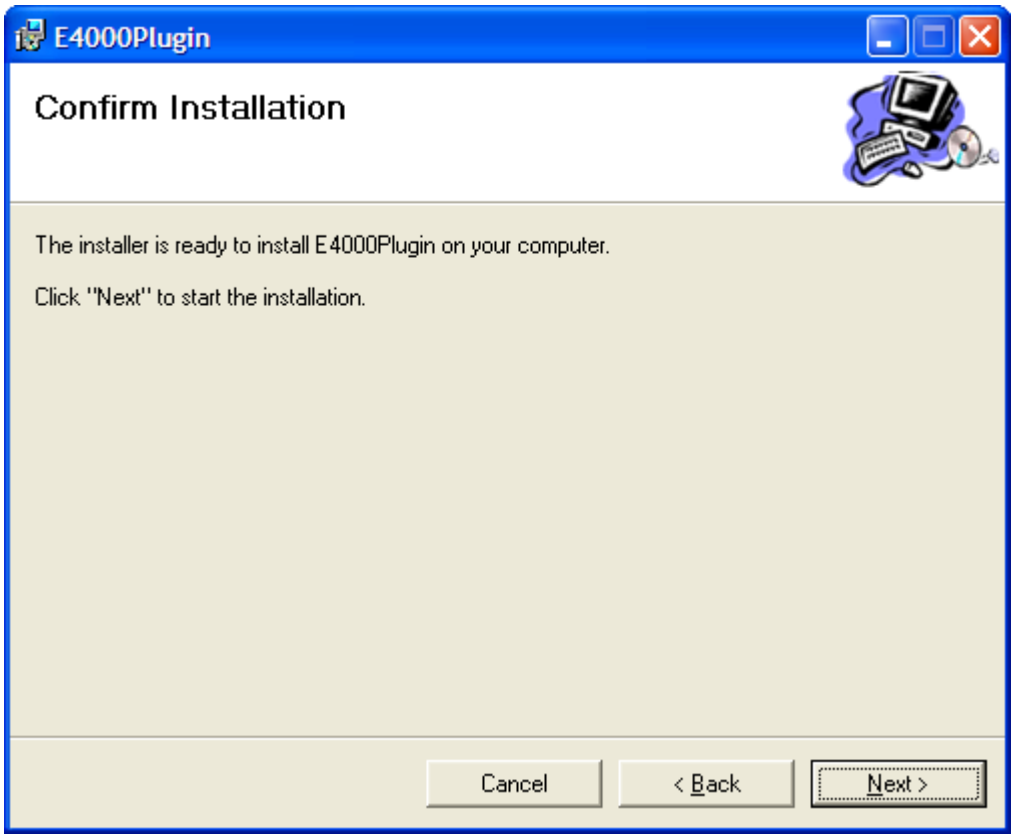
Double click on setup.exe. The following window opens:



Click on “Next”.

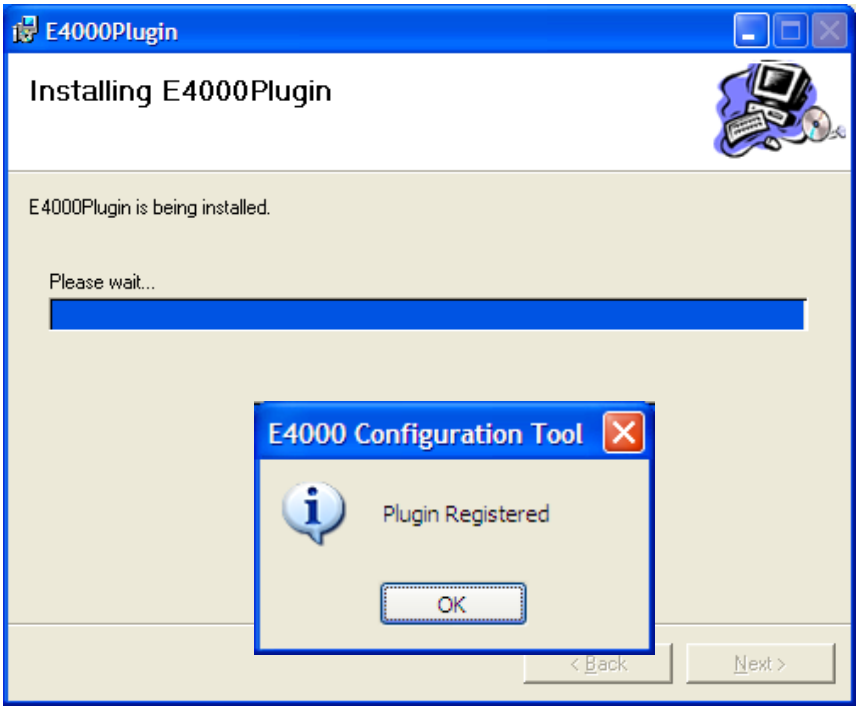


Do not change the installation directory. Click "Next"

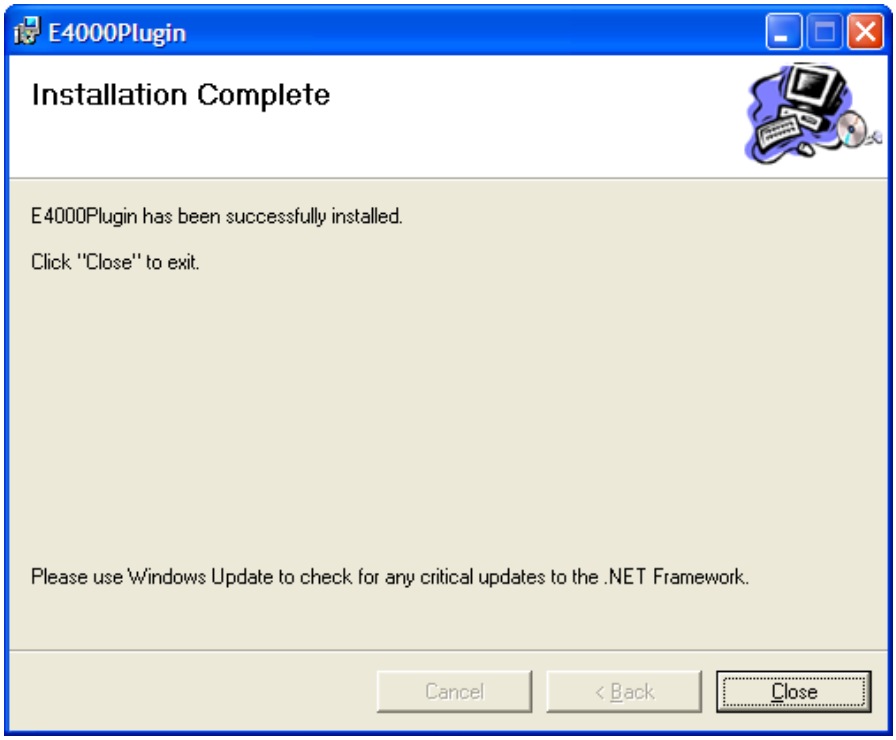


Click "Next"

This message confirms the success of the Plug-In installation. In case of failure, an error message will be displayed. In this case, check the access rights to the installation directory. Click on "OK".



This message confirms the success of the Plug-In installation. In case of failure, an error message will be displayed. In this case, check the access rights to the installation directory. Click on "OK".

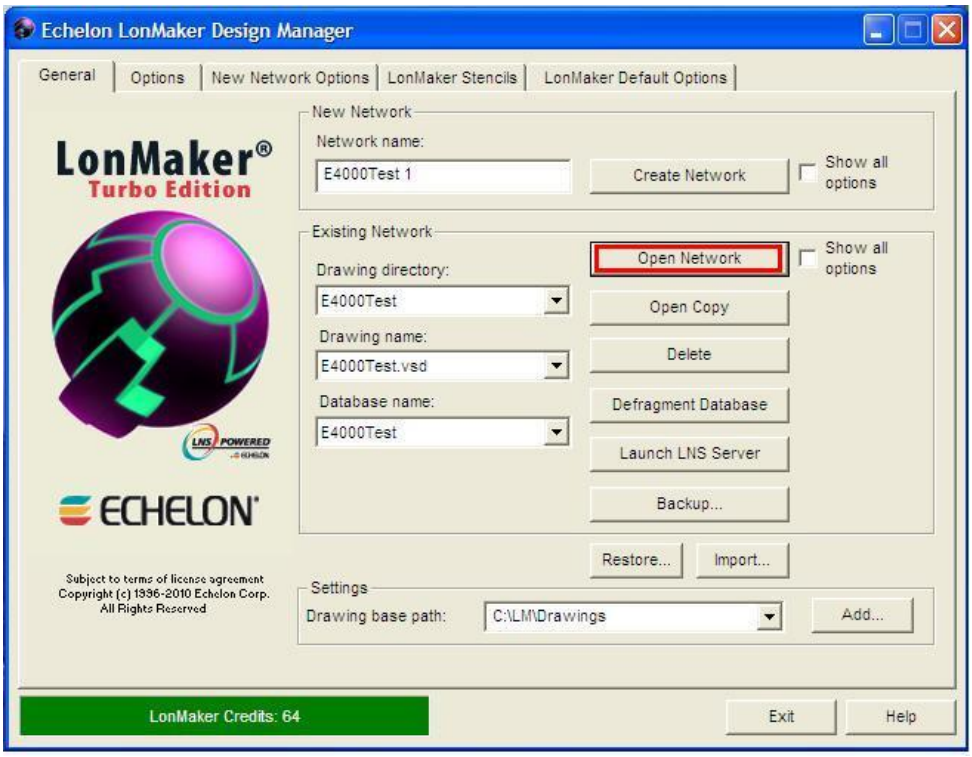


To complete the installation, click "Close".

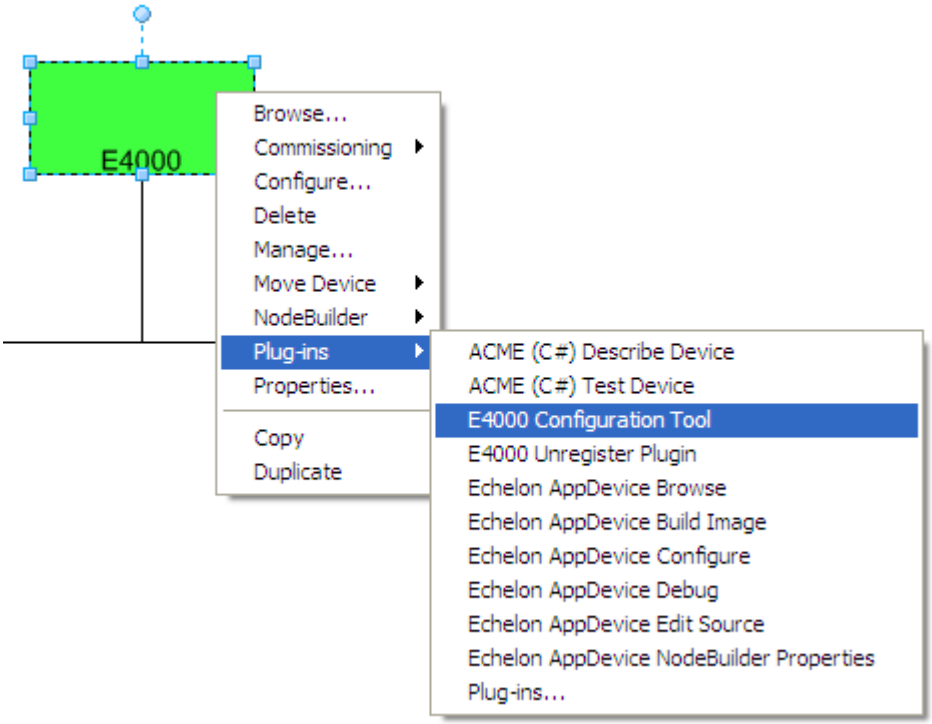
Running **Windows 7** you must replace the file:
$LonWorksPath\Apps\NS\E4000Plugin**E4000ConfigPlugIn.exe**
by the same named file found in the download.

We must also take into account that the operation of plugin depends on the proper installation of the resource files, which normally must be in $LonWorksPath\Types\User\NanoSense,
It is recommended to do a "Refresh of the catalog" on NL220 before adding the node on the network

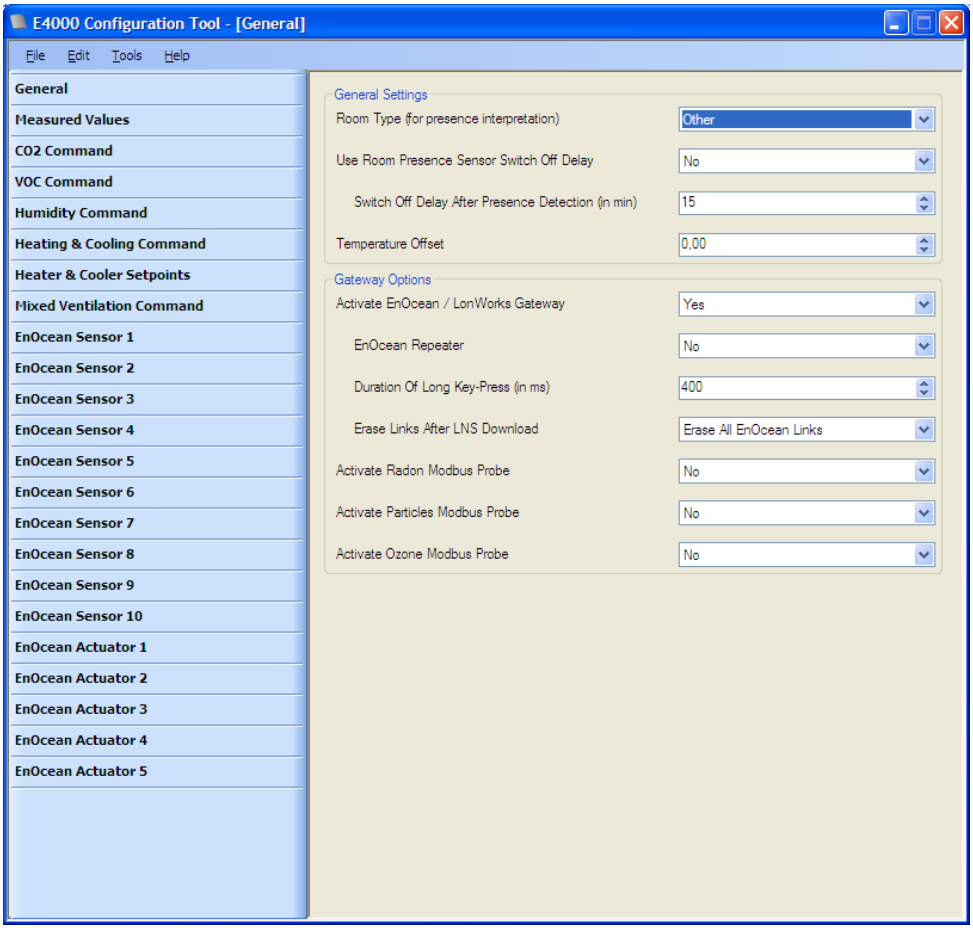
In order to launch this LNS Plug-In, first, open the LonWorks network with your preferred LNS tool; in this example, we used LonMaker Design manager with Visio 2010.
This Plug-In is universal and will work with all LNS tools supporting LNS Plug-Ins (minimum version 3.23).



Then, proceed to a right-click on the E4000 LonWorks Device to access the menu where to select "Plug-Ins" and then "E4000 Configuration Tool".



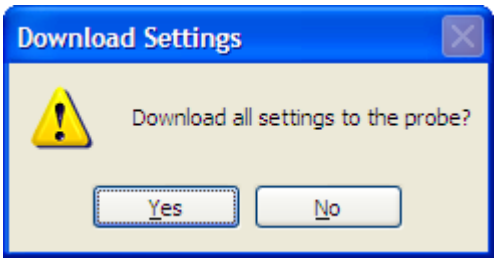
The E4000 Configuration Tool will look like as follow to configure the device (it may takes few seconds to appear).



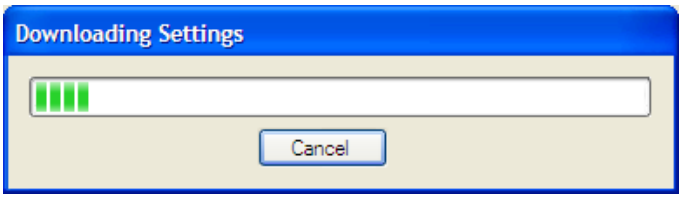
The Plug-In looks like the KNX database under ETS but presents some specificities.

Plug-In specificities:

- Go to Edit to change the language.
- Go to Tools -> Download to download the configuration settings in the probe. The following window appears.



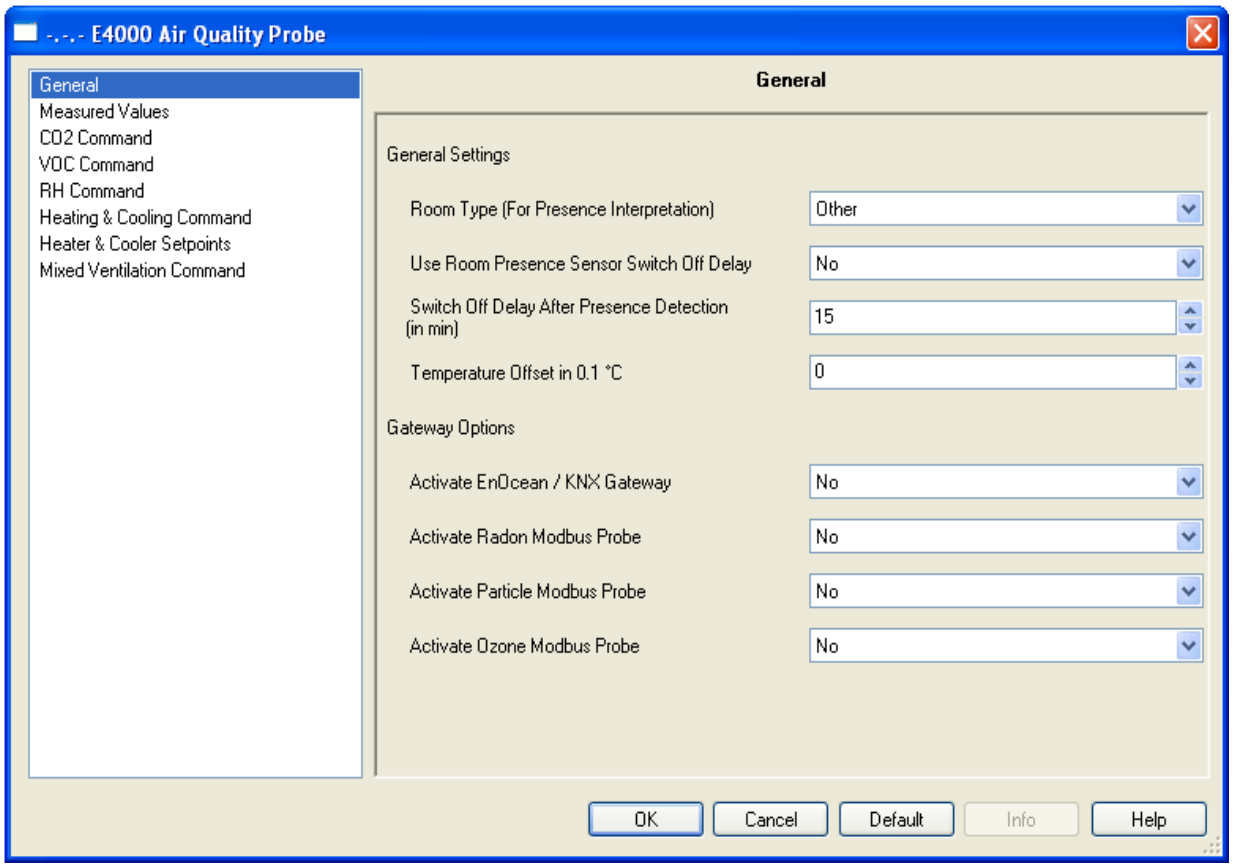
Click "Yes" to start downloading. While downloading, a progress window appears.



During this phase it is always possible to cancel without consequence.
As the LON Plug-In looks like the KNX database under ETS, the remainder of this document will only describe the KNX database.

1.4 .Setting up the database

1.4.1 General



General settings

Type of rooms: Select the type of room so that the presence generally allocated to lighting and also used for ventilation, heating and air conditioning control be prioritized or not over the night mode. Indeed in a bedroom, the presence sensor can react to small movements during sleeping time without having to switch from economic mode dedicated to night time. In other words, for a bedroom, the night mode is priority over the presence.

Uses the embedded Presence Sensor delay: The presence sensor is allowed to shut down lighting after an embedded delay of absence or immobility. It is therefore possible to use this timer to control ventilation, heating and air conditioning (economy mode). By selecting "No", the delay is adjustable.

Switch off delay after presence detection: Delay used for the presence sensors to control heating, ventilation and air conditioning.

Temperature Offset: This setting adjusts a small shift in temperature measurement of the probe without having to recalibrate.

Gateway option

EnOcean KNX Gateway: When the gateway is enabled by selecting "Yes" (This option is only functional when EnOcean module is installed on the motherboard), additional fields appear with EnOcean sensors and actuators.

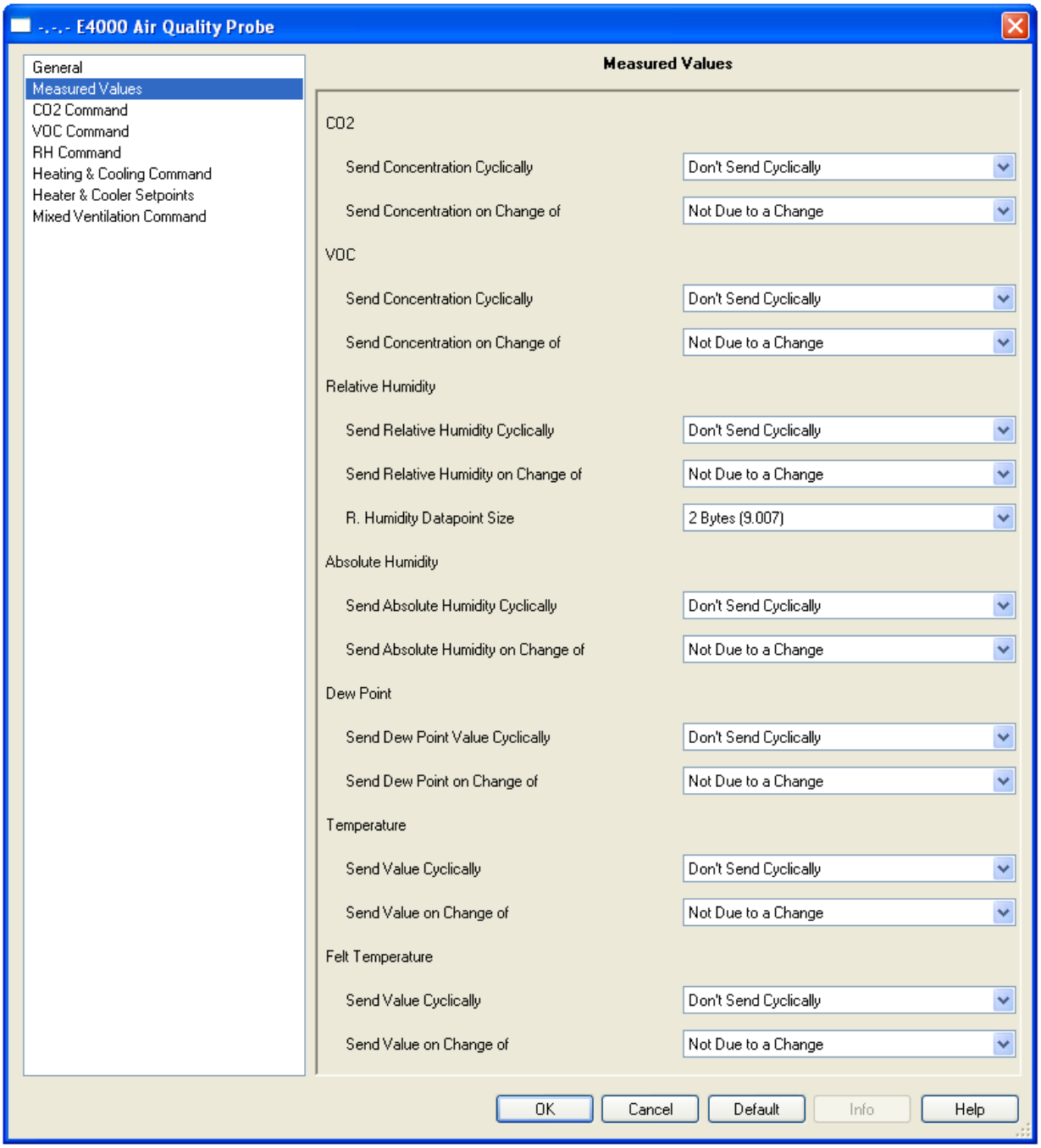
Enable Modbus Radon probe: Selecting "Yes" measurement data of an annex Radon probe

are transferred to the KNX bus and this probe can contribute to ventilation control criteria (appears in "Mixed Ventilation Command"). Note that the Canadian wells can become a significant source of radon in particular by their condensate sump.

Enable Modbus particles probe: Selecting "Yes" measurement data of an annex particles probe is transferred to the KNX bus and this probe can contribute to ventilation control criteria (appears in "Mixed Ventilation Command")

Enable Modbus Ozone probe: Selecting "Yes" measurement data of an annex Ozone probe are transferred to the KNX bus and this probe can contribute to ventilation control criteria (appears in "Mixed Ventilation Command"). Note that ozone can be generated significantly by laser printers and photocopiers. In this case the Ozone probe and air extractor should be placed near the Ozone source.

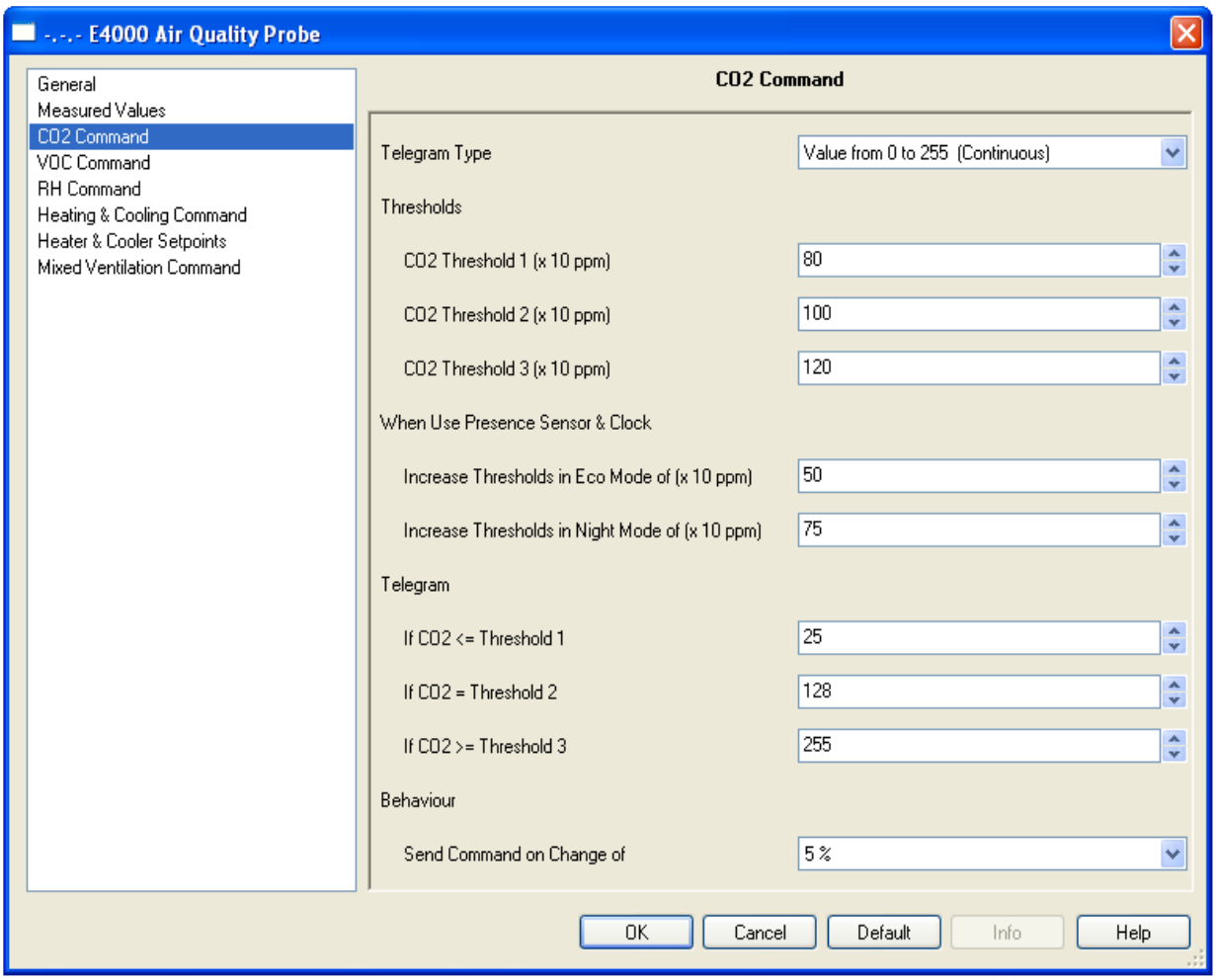
1.4.2 Measured values



For each measured or calculated value, it is possible to choose how to send data on the bus.
• Either it does not send it.
• Or it sends it cyclically by selecting the rate (from one minute to one hour).
• Or it sends it on value change by selecting it from a list.

Note that humidity can be sent in different formats, the default type being the standardized one but not always compatible with some devices that use the generic percent.
If generic percent is selected, it must specify whether it will use the 0-100% or 0-255.

1.4.3 CO2 Command



Ventilation Control based on CO2 requires first to determine if the control is switched or continuous type.

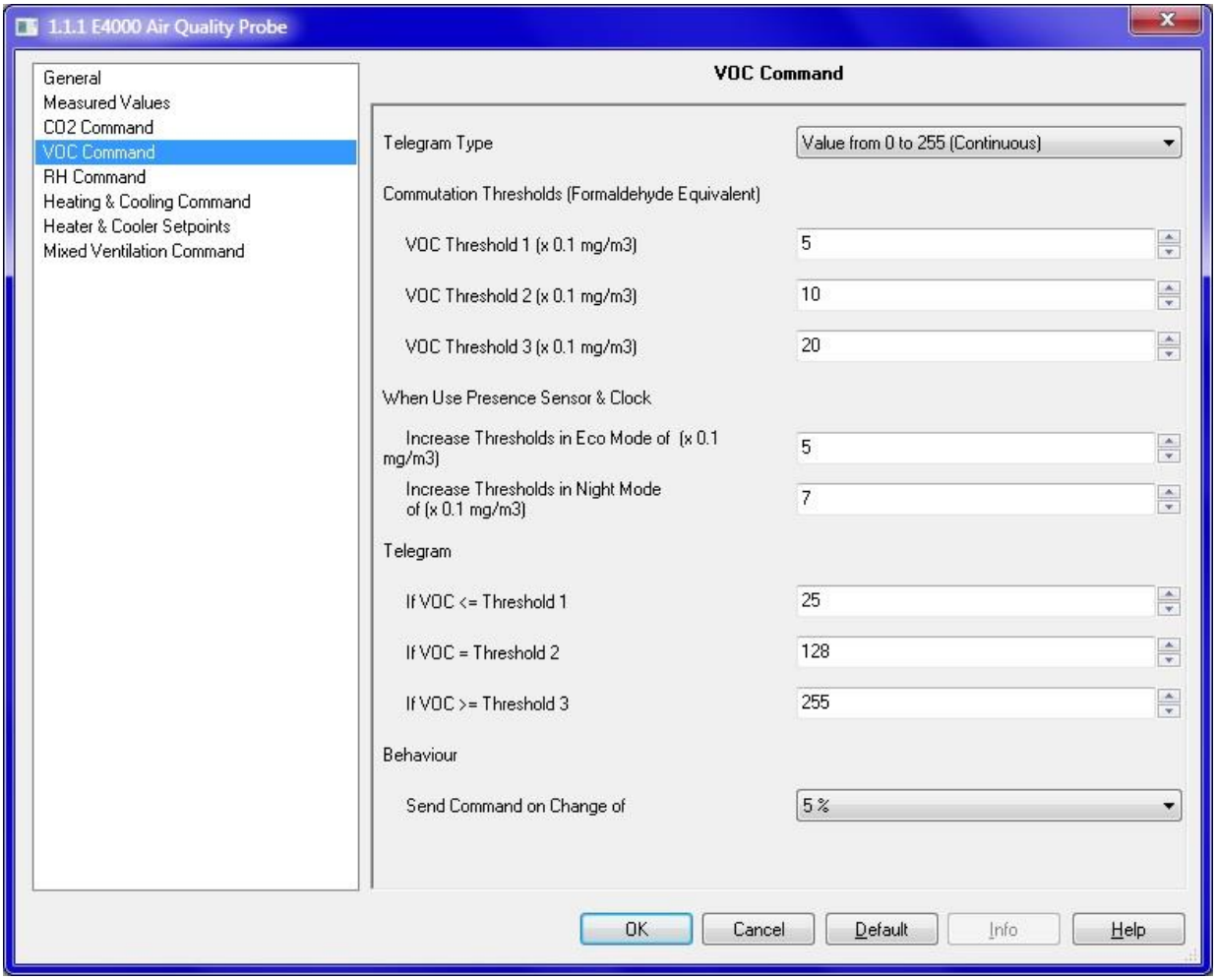
When in switched mode, set three thresholds and associated hysteresis.

For each threshold the percentage of control or status shall be determined.

To ensure a good building health, minimum ventilation is ensured by continuous control with a minimum command of 10% and it is not possible to go below this value.

Note: There is no system for air treatment to reduce CO2, therefore the setting of this command, dedicated to CO2, is mainly designed for the mixed ventilation command.

1.4.4 VOC Command



Ventilation Control and air treatment on the basis of VOC requires first to determine if the control is switched or continuous type.

When in switched mode, set three thresholds and associated hysteresis.

For each threshold the percentage of control or status shall be determined.

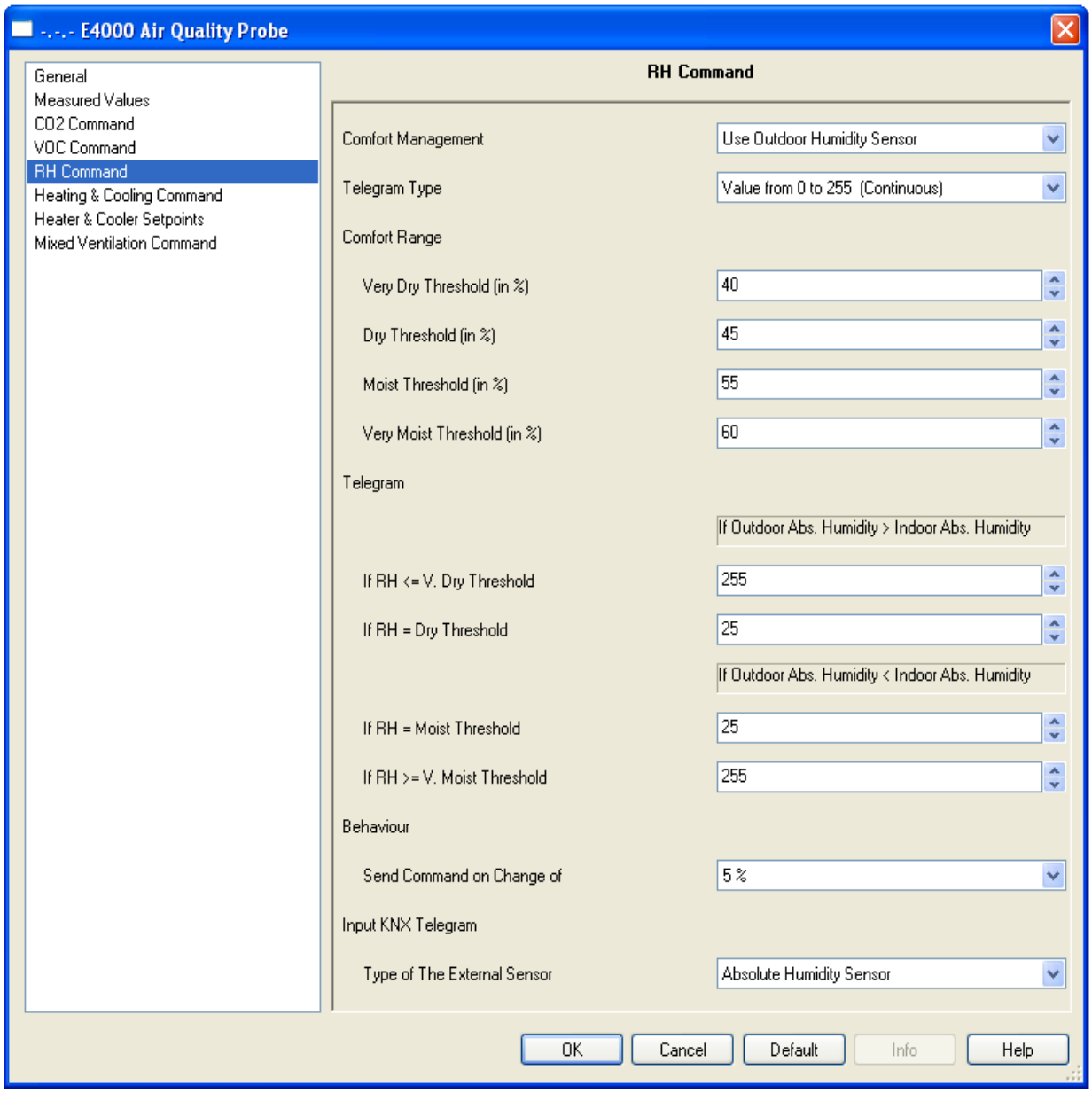
To ensure a good building health, minimum ventilation is ensured by continuous control with a minimum command of 10% and it is not possible to go below this value.

Note: There are air treatment systems for VOC directly controllable by this command. If case of air treatment this minimum command of 10% cannot be canceled and the VOC treatment system operated in continuous must have a minimum trigger threshold.

If no air treatment system is used, the setting of this control will be mainly for controlling the mixed ventilation command.

The measurement of VOC for ventilation control requires an auto zero based on the healthiest air seen in the context of ventilation or aeration. Indeed the outdoor air is never ideal and it would be futile to want to reach a level of VOC lower than that of the fresh air, at the risk of over ventilating unnecessarily.
The absolute measurement of VOC uses the factory zero. This zero is obtained after hours of fresh air cleaning. In this configuration, there is no auto zero. Factory zero drift cannot be fully guaranteed for years and will depend mainly on possible sensor contaminations.
By default, the VOC measurement is in relative measurement mode. It is possible to choose between absolute VOC measurement and relative VOC measurement using the LCD tool (see installation manual).

1.4.5 RH Command



The ventilation control based on the Relative Humidity needs to first determine whether or not it use an outdoor humidity sensor in order to control if ventilation can dry or humidify the indoor air. Indeed if the indoor air is too humid and the outdoor air is even more so, ventilation is useless because it would aggravate the situation.

We can get rid of an outdoor sensor if it controls an air humidification and or drying system (see Appendix 2.4) and not ventilation.

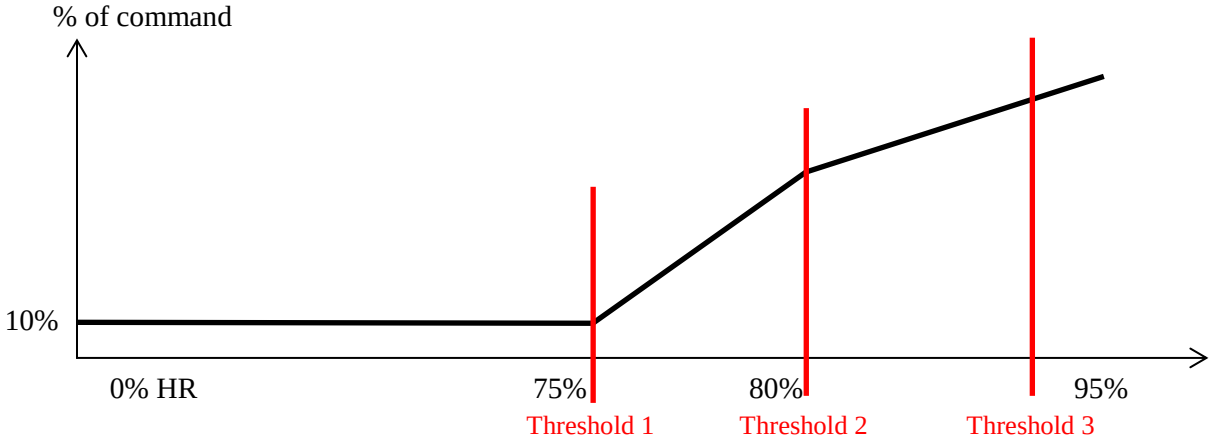
This does not avoid this command to be taken into account in the mixed ventilation command.

Then determine if the control is switched or continuous type.

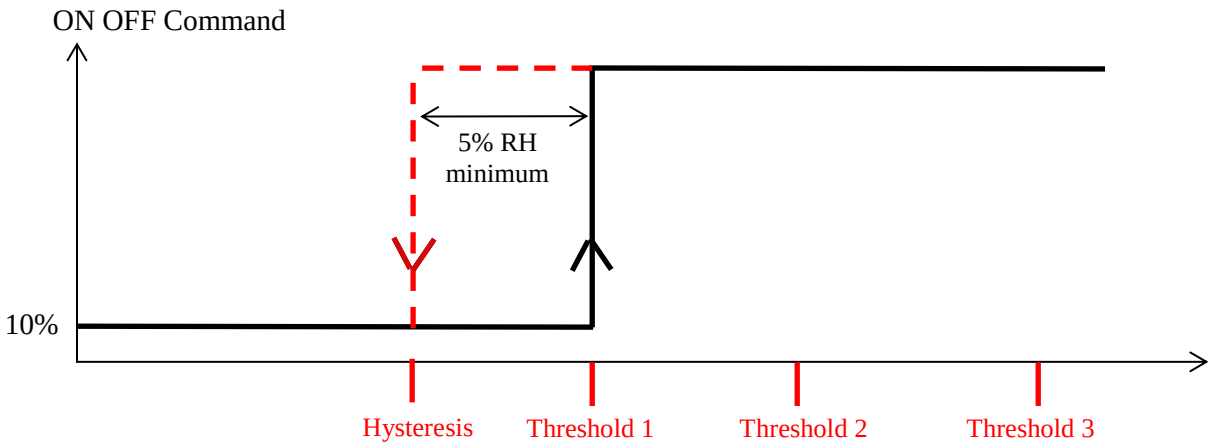
Switching thresholds: Without an external humidity sensor, only the case of humid indoor air is managed and three thresholds must be defined: Threshold 1 wet, Threshold 2 very wet and Threshold 3 extremely wet.

In continuous control mode, the 3 thresholds are necessary to take into account the performance graph of the installed fan.
In switched mode, it is also necessary to determine the associated hysteresis.

Example in continuous

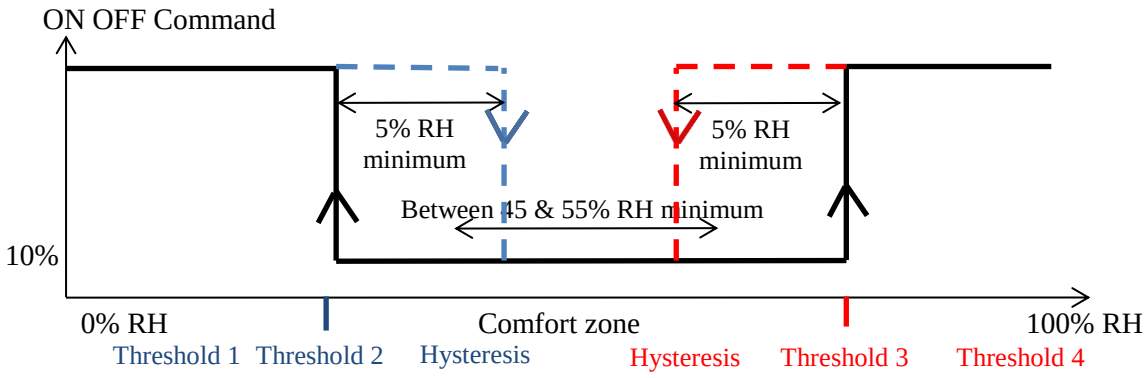


Example in Switched:

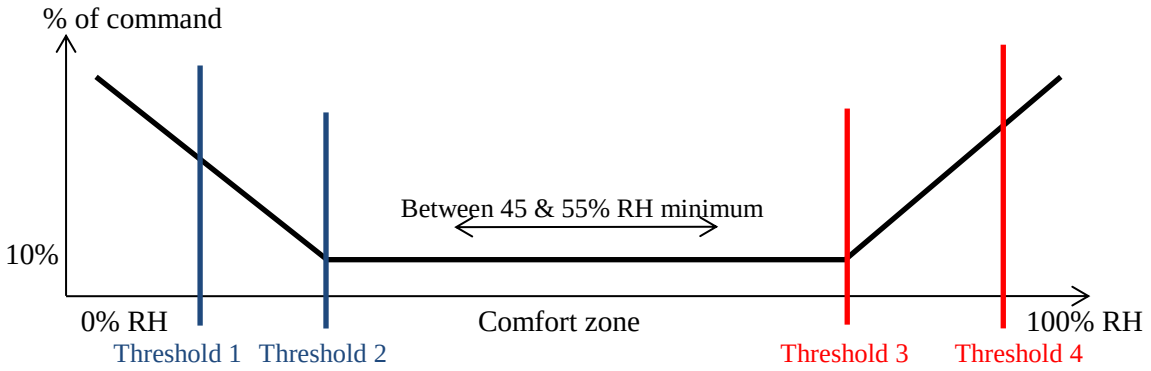


With an external humidity sensor, the case of indoor air that is too dry or too humid is managed and four thresholds must be defined: Threshold 1 very dry, Threshold 2 dry, Threshold 3 wet, Threshold 4 very wet. This makes it possible to determine a comfort zone situated between dry and wet. Be careful this comfort zone is at least between 45 and 55% RH.

Example in Switched:



Example in continuous:



Two thresholds correspond to a ventilation intended to humidify the air if this one is too dry.
Two thresholds correspond to a ventilation intended to dry the air if it is too wet.

If the air is too dry, the mucous membranes and skin may be irritated.
If the air is too humid, mites and molds can grow.

For the extreme thresholds and for the comfort zone, the percentage of command or the state must be determined.

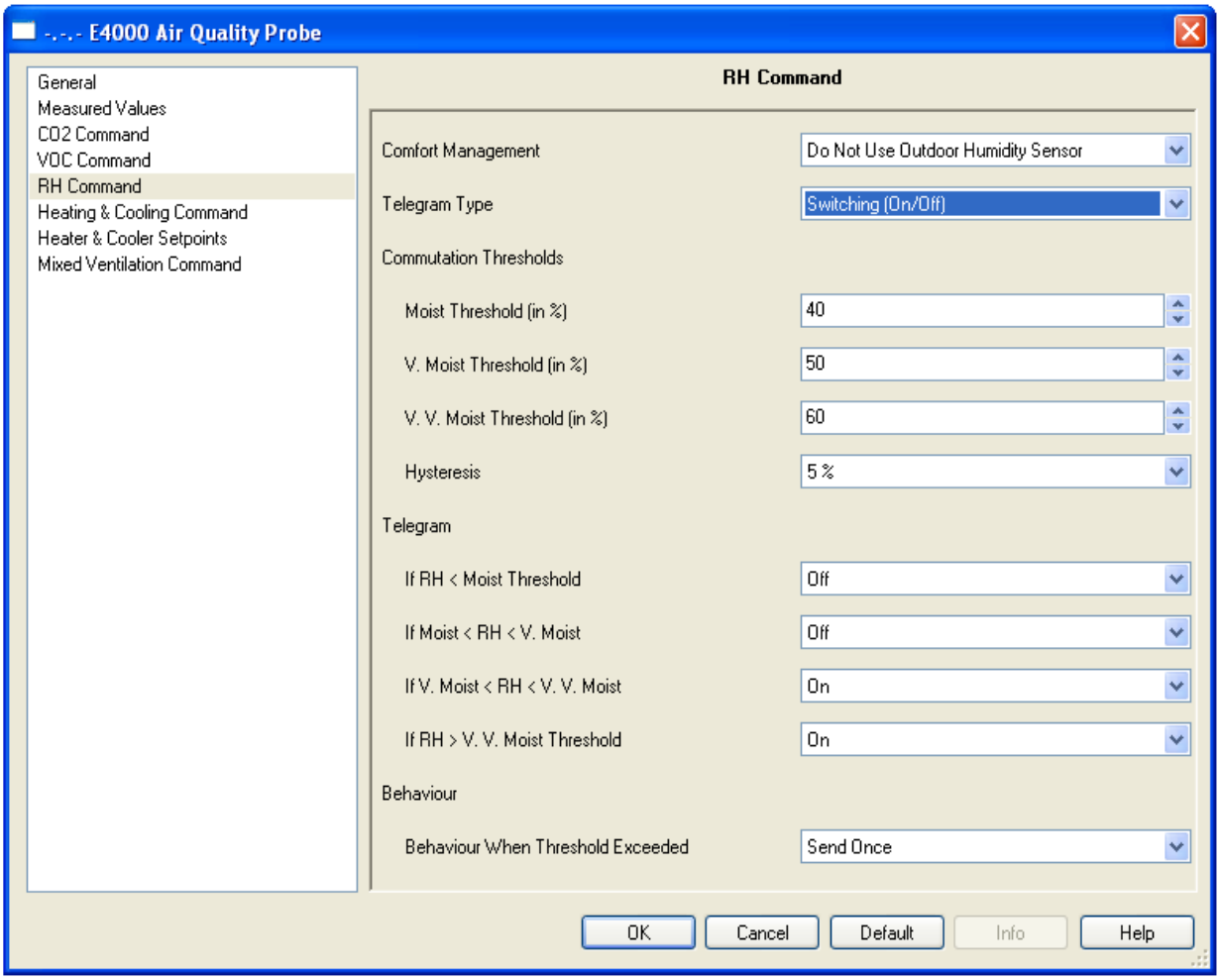
In order to guarantee the sanitary state of the building, a minimum ventilation is ensured in continuous order with a minimum order of 10% and it is not possible to go below this value.

Note: There are drying systems and / or air humidification directly controllable by this command. In case of air treatment this 10% minimum order cannot be canceled and it is appropriate that a continuously controlled humidity air treatment system has a minimum triggering threshold.

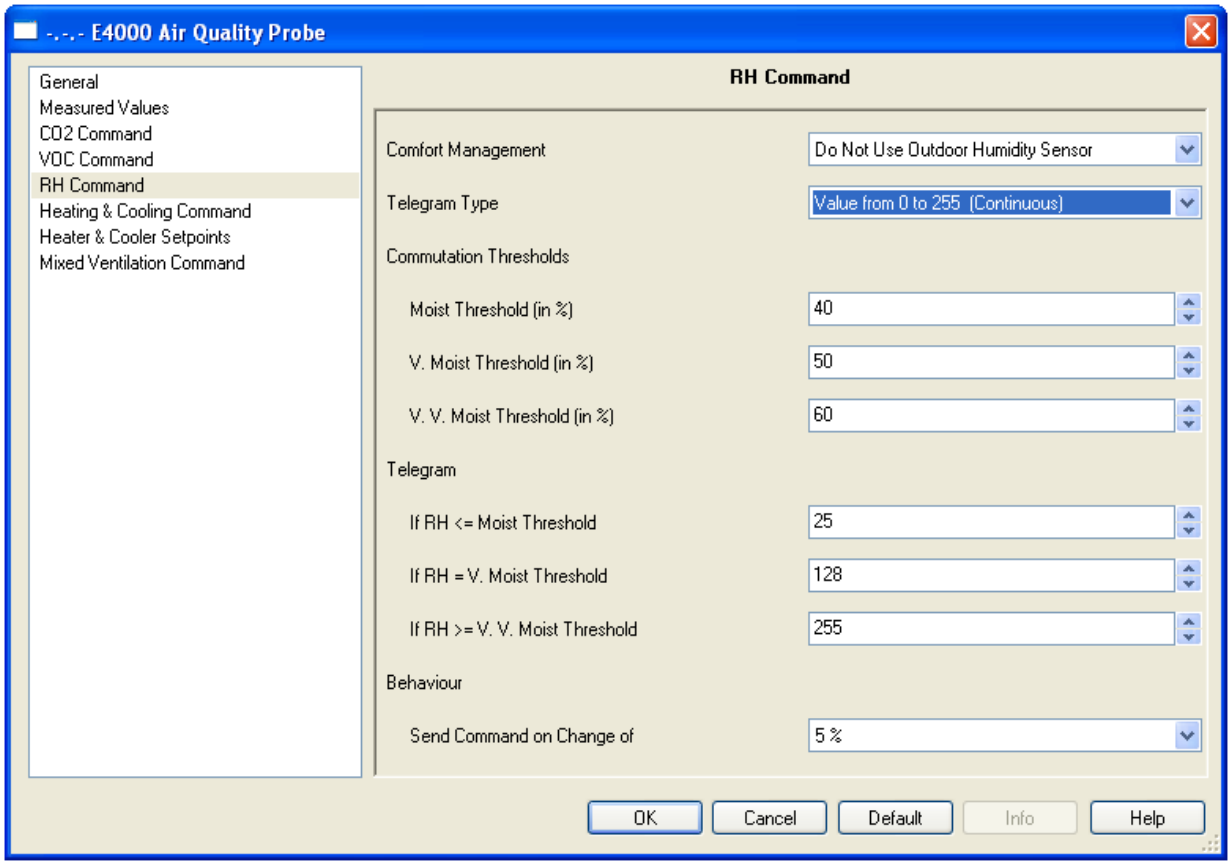
If no air treatment system is used, the setting of this command will be mainly for the combined ventilation control.

For the determination of the comfort zone, see Appendix 2.3

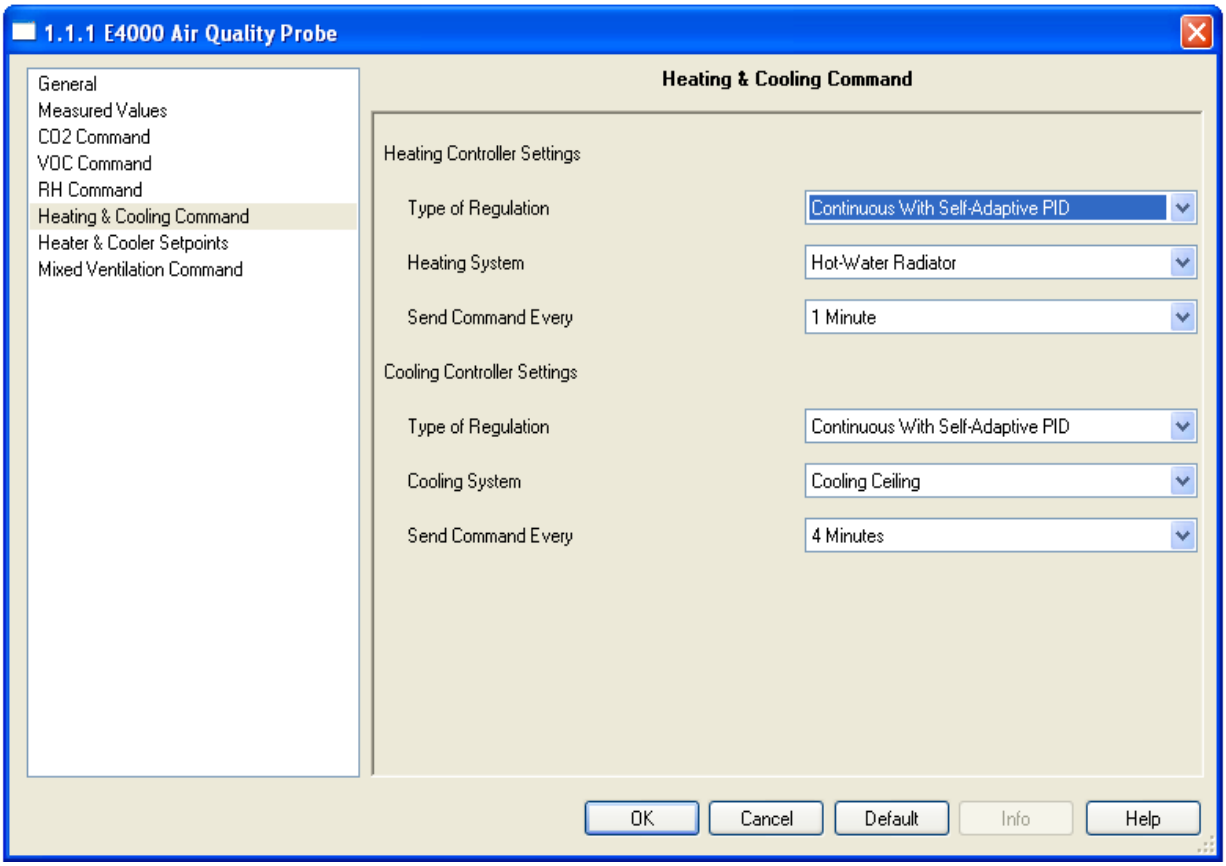
If no external humidity sensor is used and the ventilation is On / Off mode:



If no external humidity sensor is used and the ventilation is in continuous mode:



1.4.6 Heating and Air Conditioning Control in continues with self-adjusting PID



Heating and air conditioning control requires first to determine if the control is switched or continuous type.

In continuous mode, the control uses a self-adjusting PID[1].
For the PID to be efficient the category of inertia of the heating and cooling must be specified in defining the type of device.

The control command may be sent at a rate to be determined.

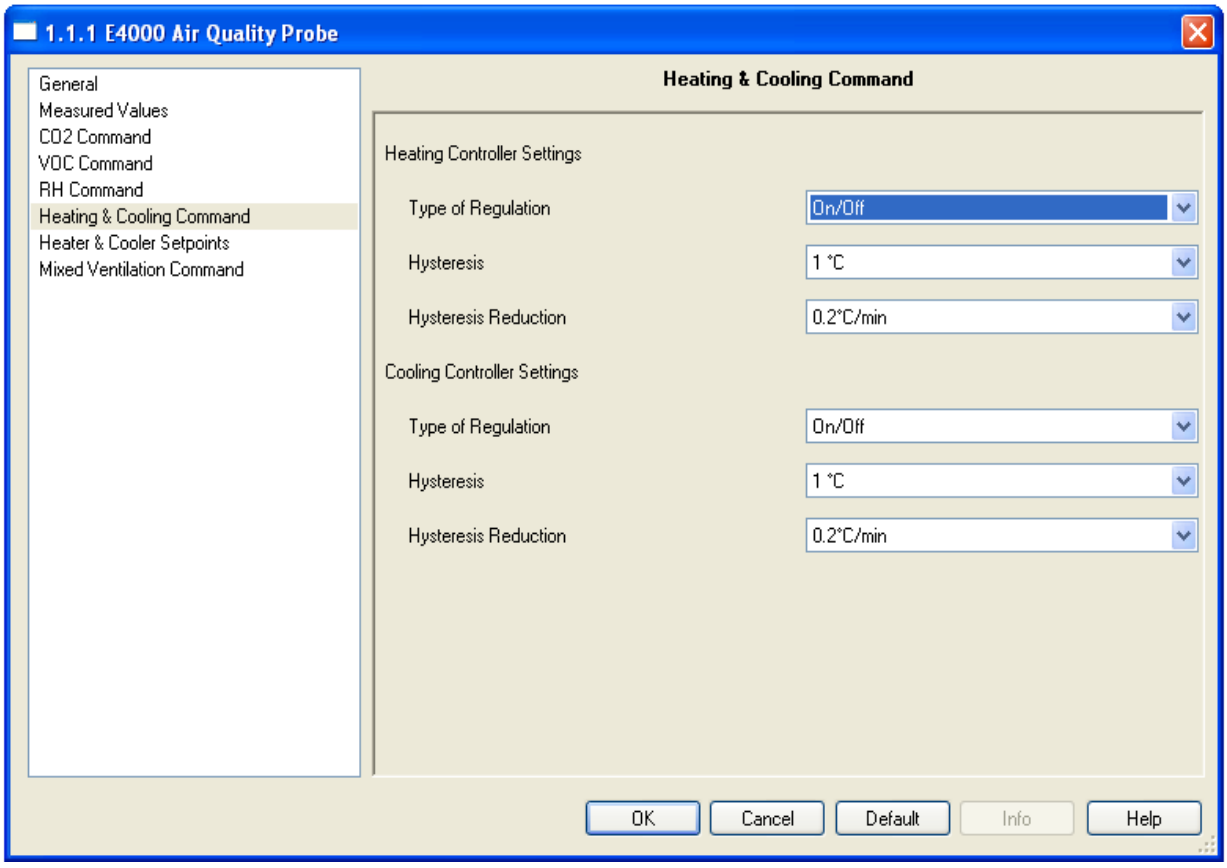
[1] A Regulation is to require a system to follow an instruction. Considering heating a room with a variable power heater (controlling its flow).
The closed-loop control monitor the room temperature at all times and compares it with the setpoint. So, depending on the temperature difference between room and setpoint, it will generate an output signal (intensity of the radiator) which will be:
Proportional to the difference (Room temperature- setpoint) (to reach it faster and turn the heating up if necessary).

As the temperature approaches the setpoint according to the type of room and heating, it is very likely to exceed this set (inertia of the heating that will not stop immediately ...). So the regulator is monitoring the increase in forecasting what will happen if it keeps the same intensity (**I**ntegration). The integrator forecasting the future will force the system to gradually adjust the power output (flow radiator) so that the room is slowly coming to temperature setpoint without overshoot. Nevertheless, this operation strikes the speed of obtaining the set.

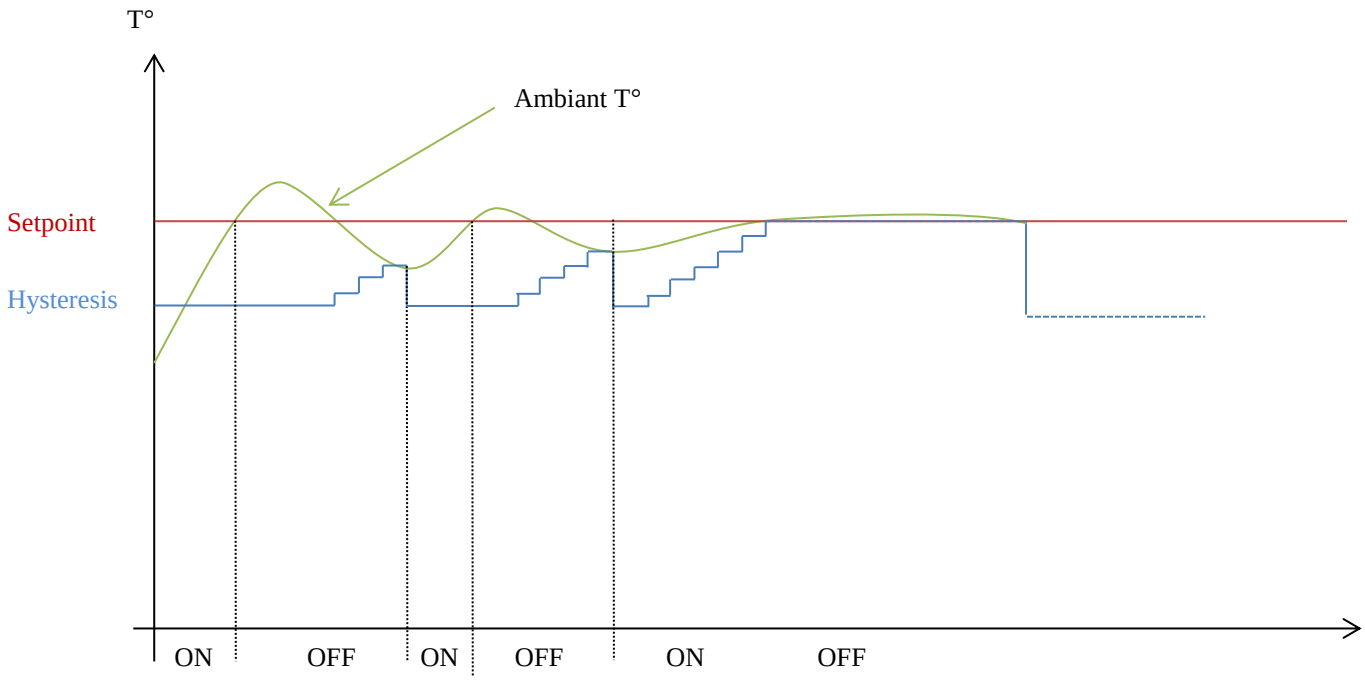
To overcome this slow progress, it monitored the progress (**D**erivative) to estimate the excess over the reference. In case of an overshoot risk it introduced a correction.

This process is called a **PID** controller.

1.4.7 Heating and Air Conditioning Switched Control



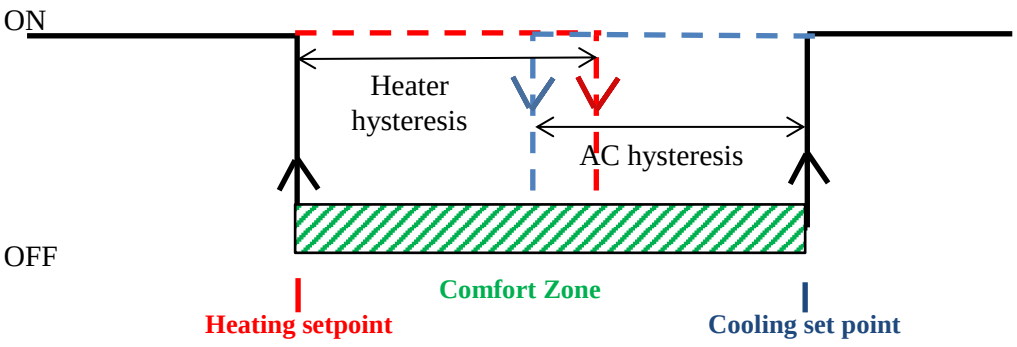
Heating and air conditioning control requires first to determine if the control is switched or continuous type.
In Switched mode, the controller uses a method for reducing the temperature oscillations around the desired value using a gradual hysteresis reduction.
The setting is the reduction of the hysteresis per unit of time. This setting depends on the thermal inertia of the heating or air conditioning.

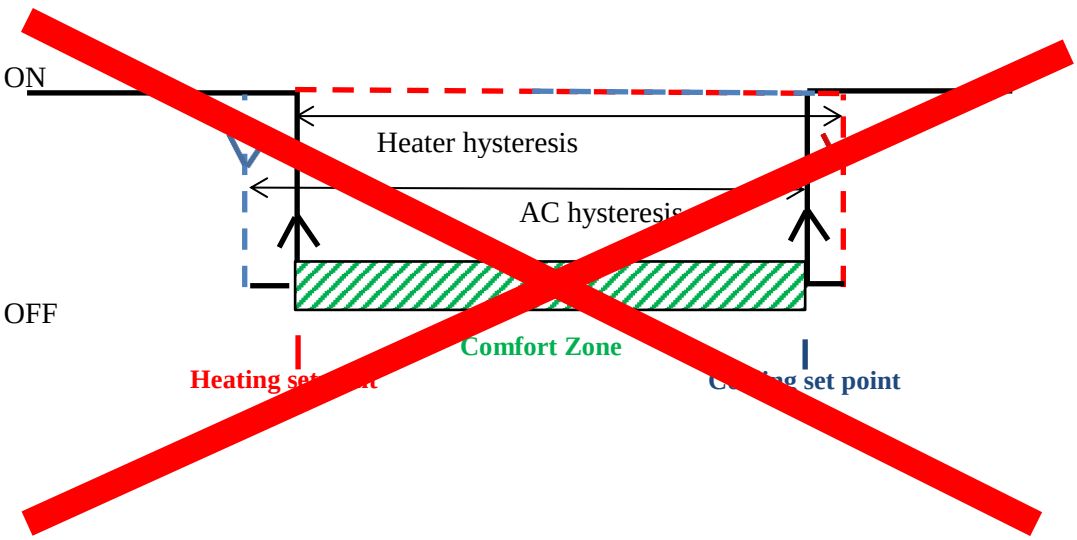


Hysteresis parameter limits in ON OFF command

The hysteresis set here will be used with the set point and the comfort zone in the heating and cooling setpoint parameter tab.

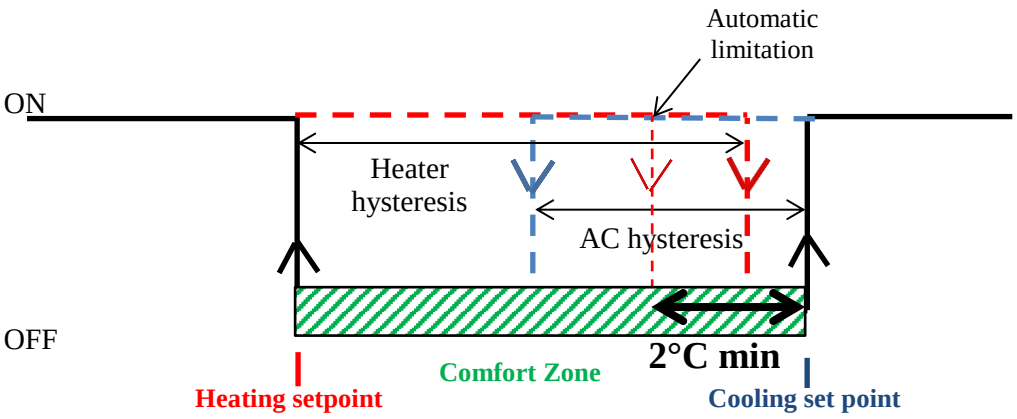
Each hysteresis being used to shut down heating or air conditioning in one direction only (exceeding the set temperature for heating and exceeding the set temperature for cooling), it is possible to cross the hysteresis but in no case it can be greater than the comfort zone.



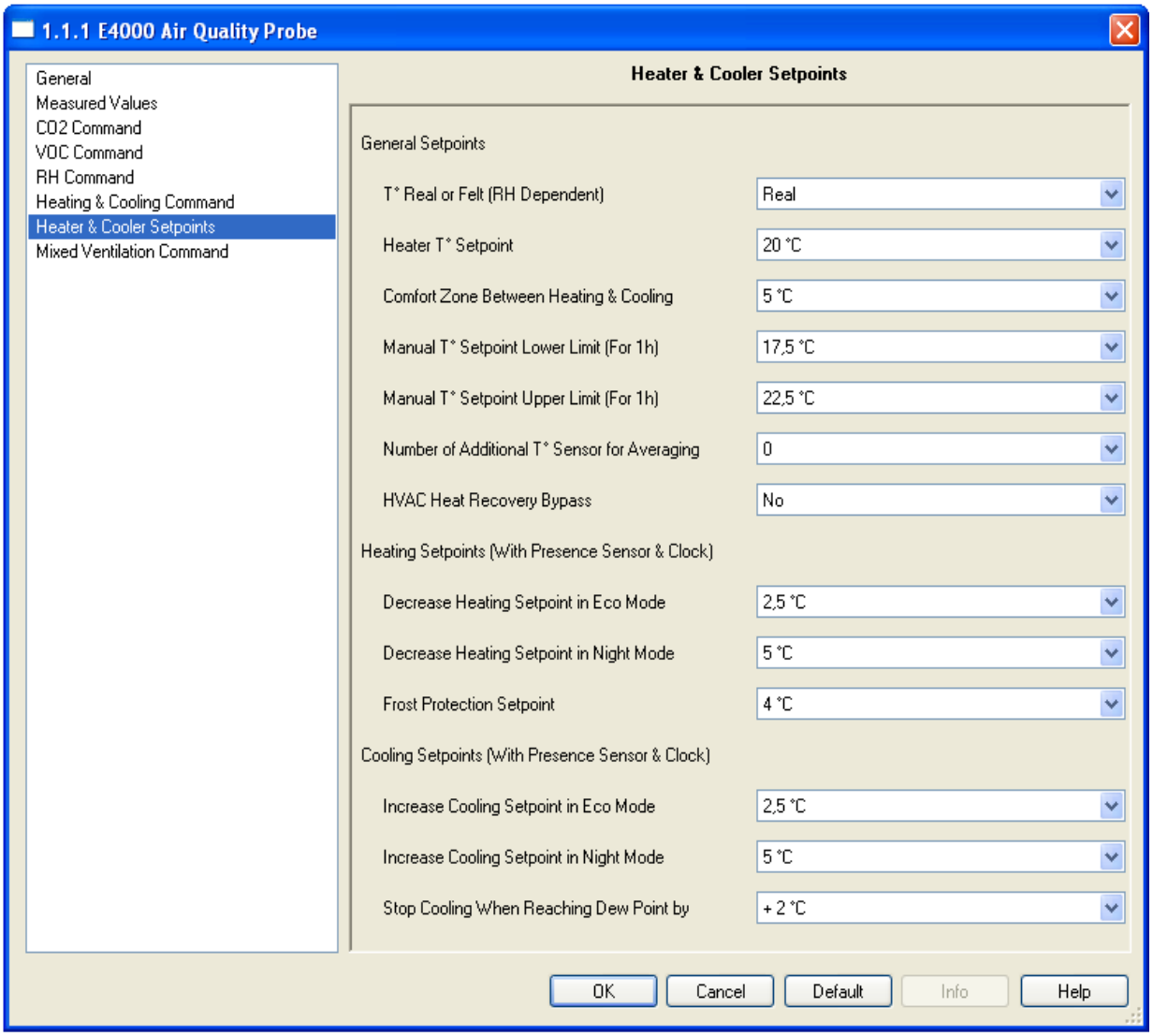


Attention, ETS does not have functions to limit a parameter value according to another. It is the responsibility of the installer to ensure these limitations.

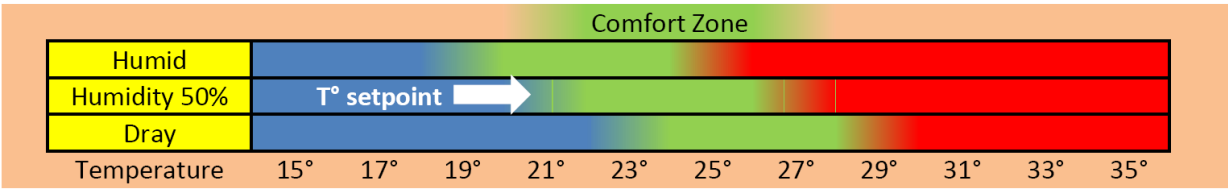
If the setting of a hysteresis exceeds the comfort zone, the unit will reduce it to leave a comfort zone of at least 2 ° C. If this proves to be insufficient (a hysteresis cannot be lower than 0.5 ° C), the comfort zone will be enlarged automatically.



1.4.8 Heating and Cooling Setpoints

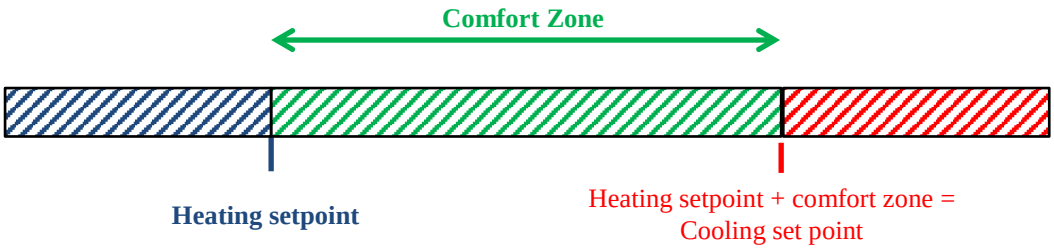


It is possible to regulate heating and cooling on a real or perceived temperature setpoint. The choice of the felt temperature takes the ambient relative humidity into account. See Appendix 2.6 for details.



The nominal temperature set point is the minimum comfort temperature (heating) and shall be set.

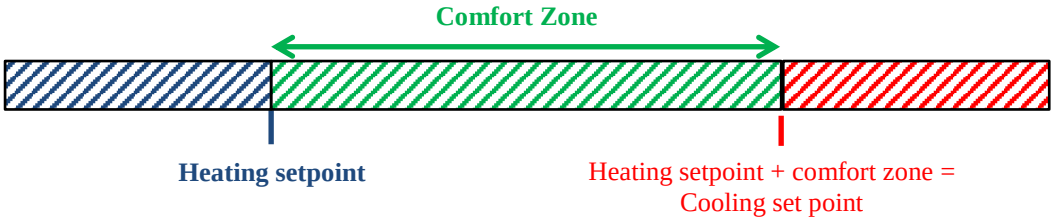
From this temperature setpoint, the comfort zone between heating and cooling can determined. The minimum is 5°C to avoid running simultaneously heating and cooling because of thermal inertia.



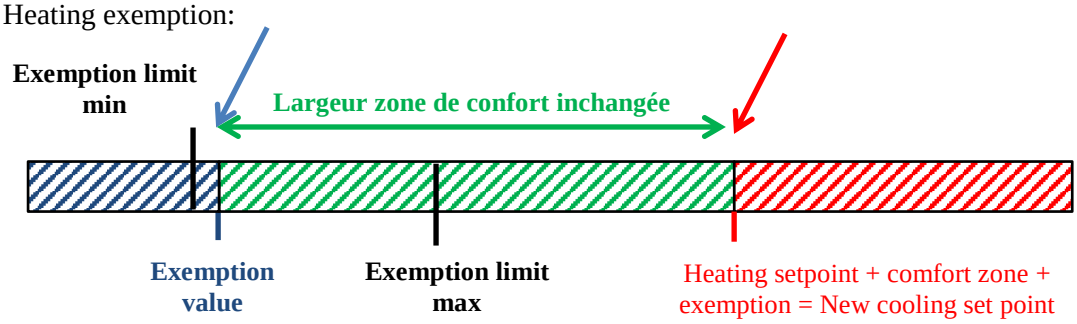
Exemption: It is possible to add a temperature control panel to override manually the nominal setpoint value. This override value will be valid during one hour if not sent again.
So, a temperature control panel shall send the temperature set point at least every hour for them to be taken into account permanently. (also possible with a smartphone in case of a gateway).

Exemptions are instructions in °C to modify the low and high values of the thermal comfort zone.

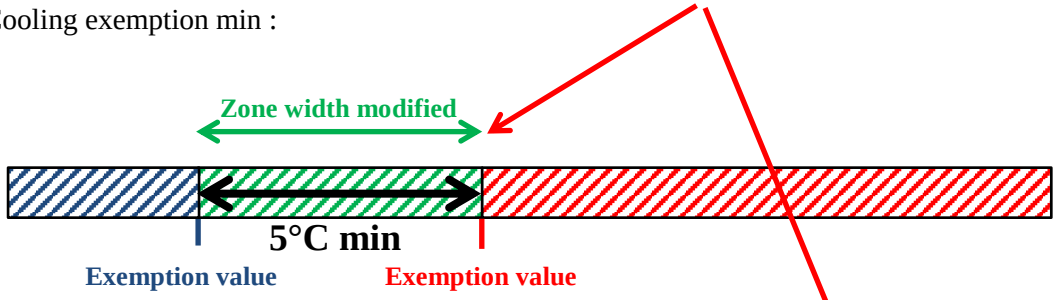
It is possible to limit min and max temperature derogations by entering the limit values.



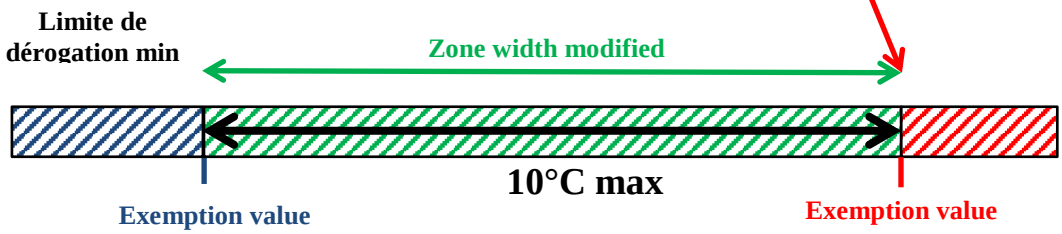
Heating exemption:



Cooling exemption min :

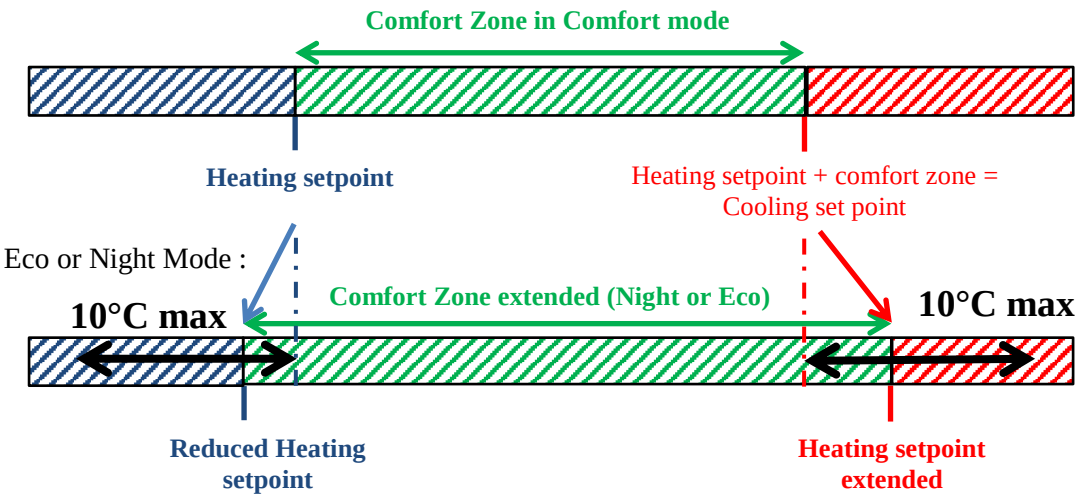


Cooling exemption max :



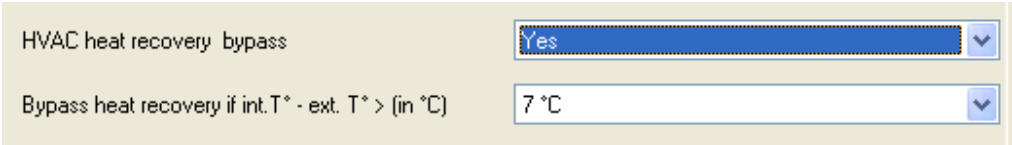
Be careful: At least 5 °C must be kept and at most 10 °C between the exemption limit values. (New comfort zone). **The user will see his limited exemption automatically and the value applied can be read for display.**

Offset of setpoints
The nominal temperature setpoint can be differentially adjusted for heating and cooling for the ECO (absence) and Night modes.



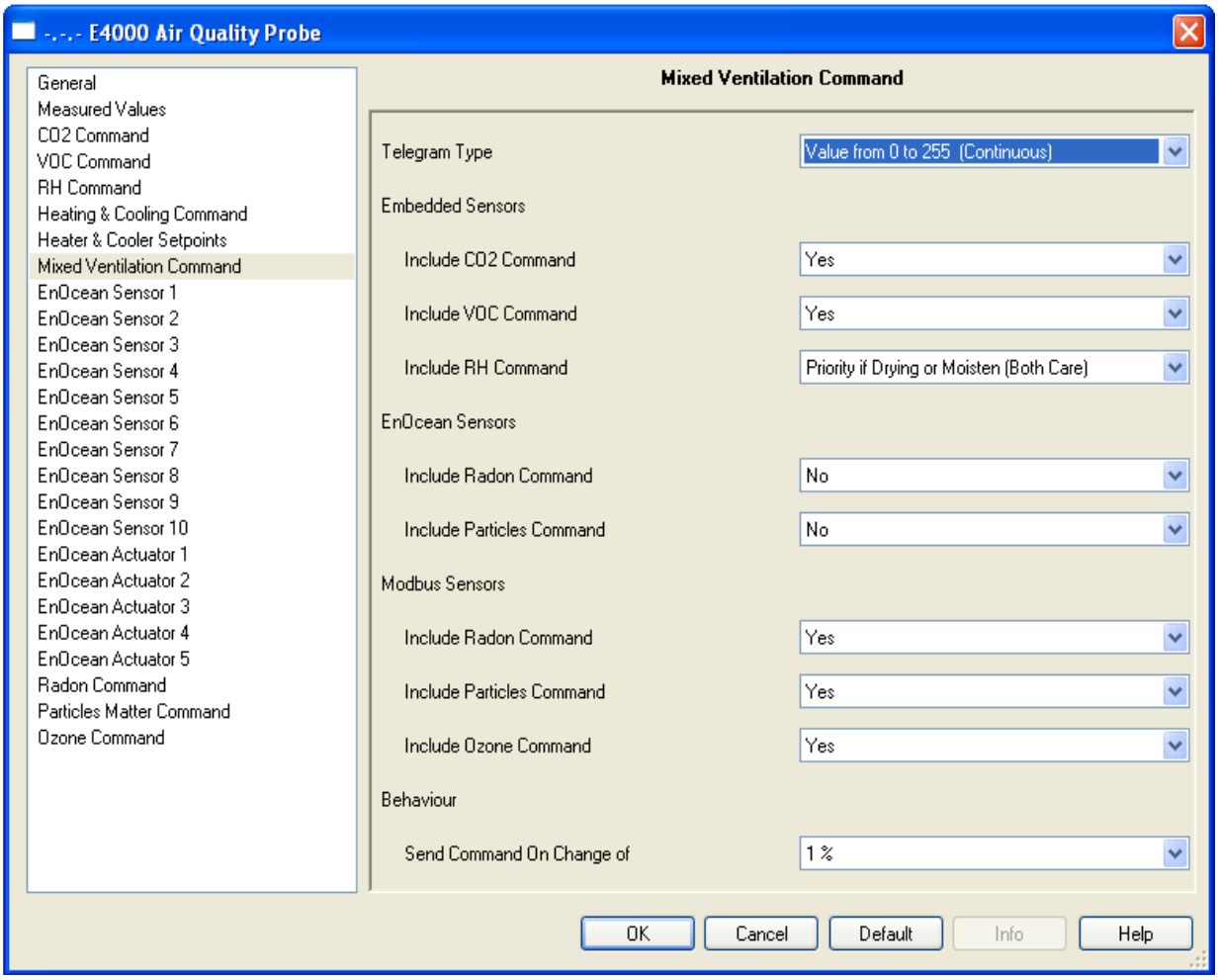
Additional sensors: Up to 3 additional temperature sensors can be added. The probe will then average these sensors. However, to be used, the measurement of these sensors must not be different from that of the E4000-NG probe by plus or minus 2 °C. Additional sensor data is only taken into account for 20 minutes. A sensor that transmits its data every 5 minutes will be taken into account permanently; a sensor that transmits its data every hour will be taken into account only during the 20 minutes after transmission.

Free Cooling: The disengagement of the heat exchanger of the double flow ventilation makes it possible to cool the building with outdoor fresh air without using the air conditioning or to assist it. This means is commonly used at night during summer time and is called "Free Cooling"
The setting relates to the difference between the indoor ambient temperature and the outdoor ambient temperature. The minimum fan speed (apart from IAQ considerations) allows for cooling without over-consumption.



Frost protection and dew point: The frost protection trip temperature must be determined for the heating and the shutdown value of the air conditioning according to the temperature difference with respect to the dew point.

1.4.9 Mixed Ventilation command



Air quality sensors of the E4000 probe as well as annexes air quality EnOcean and ModBus sensors can be combined together to a single overall ventilation command to control the ventilation for air renewal.

The command can be continuous or switched and the type of command should be selected.

Each sensor can be associated. When used in combination, commands from each sensor are compared and the highest value is applied.

The association of EnOcean sensors does not pass through objects group. Simply indicate the number of EnOcean sensor from the list.

However, the humidity control can lead to limit the air renewal. Indeed, if it takes into account outdoor humidity (If selected in RH command) and, for example, the absolute outdoor humidity is greater than the absolute indoor humidity and we wish to dry the air, it should not ventilate.
Choices to take into account humidity are as follows:

- **No**: Humidity is not taken into account in ventilation control.

- **Yes, No Priority**: The control of indoor humidity takes into account outdoor humidity to stay in the comfort zone (Higher humidity by ventilation if too dry if the difference between indoor and outdoor can allow it and vice versa). However, there is a risk of exceeding the threshold of humidity comfort when ventilation on other criteria. (Example: ventilation on CO2 or VOC.. and air intake more humid than the comfort threshold).

• **Priority if drying (Health)**: Ventilation is minimized on a priority basis if the outdoor humidity dries the indoor air below the humidity comfort threshold. This setting is detrimental to air quality, but is recommended for people suffering from diseases of skin and mucous membranes associated with dry air (eczema, dermatitis...).

• **Priority if Humidification (Building):** Ventilation is minimized on a priority basis if the outdoor humidity humidifies indoor air above the humidity comfort threshold. This setting is detrimental to air quality, but is recommended to prevent mold growth. A health aspect shall be considered by limiting the proliferation of mites.

• **Priority if drying or humidification**: Ventilation is stopped on a priority on the two above criteria. Caution: This setting is detrimental to air quality.

In case of excess of radon, ventilation is a priority on restraining ventilation due to humidity.

For each type of command, select the behaviour for sending telegrams.

Note that mixing different types of commands is possible (continuous and switched). However it is best combines commands of the same type. Indeed an Off or low priority command will be interpreted as a minimum order (10%) and an On or high priority command will be interpreted as 100% command.

Conversely if the combined control is of Switched type, continuous command under 50% will be interpreted as an Off command or low priority and an On or high priority if more than 50%.

Examples

Outdoor Air too humid:

<table>
<tr><th rowspan="3"></th><th rowspan="3">Value</th><th rowspan="3" colspan="2">individual Command</th><th colspan="5">Mixed Command</th></tr>
<tr><th rowspan="2">Without outdoor sensor</th><th colspan="4">With outdoor humidity sensor</th></tr>
<tr><th>No priority</th><th>Health</th><th>Building</th><th>Priority</th></tr>
<tr><td>CO2</td><td>1000ppm</td><td colspan="2">30%</td><td rowspan="5">60%</td><td rowspan="5">50%</td><td rowspan="5">50%</td><td rowspan="5">10%</td><td rowspan="5">10%</td></tr>
<tr><td>COV</td><td>10ppm</td><td colspan="2">50%</td></tr>
<tr><td>Radon</td><td>50Bq/m3</td><td colspan="2">10%</td></tr>
<tr><td>RH ind</td><td>80%</td><td rowspan="2">60%</td><td rowspan="2">10%</td></tr>
<tr><td>RH out</td><td>H out > H ind</td></tr>
</table>

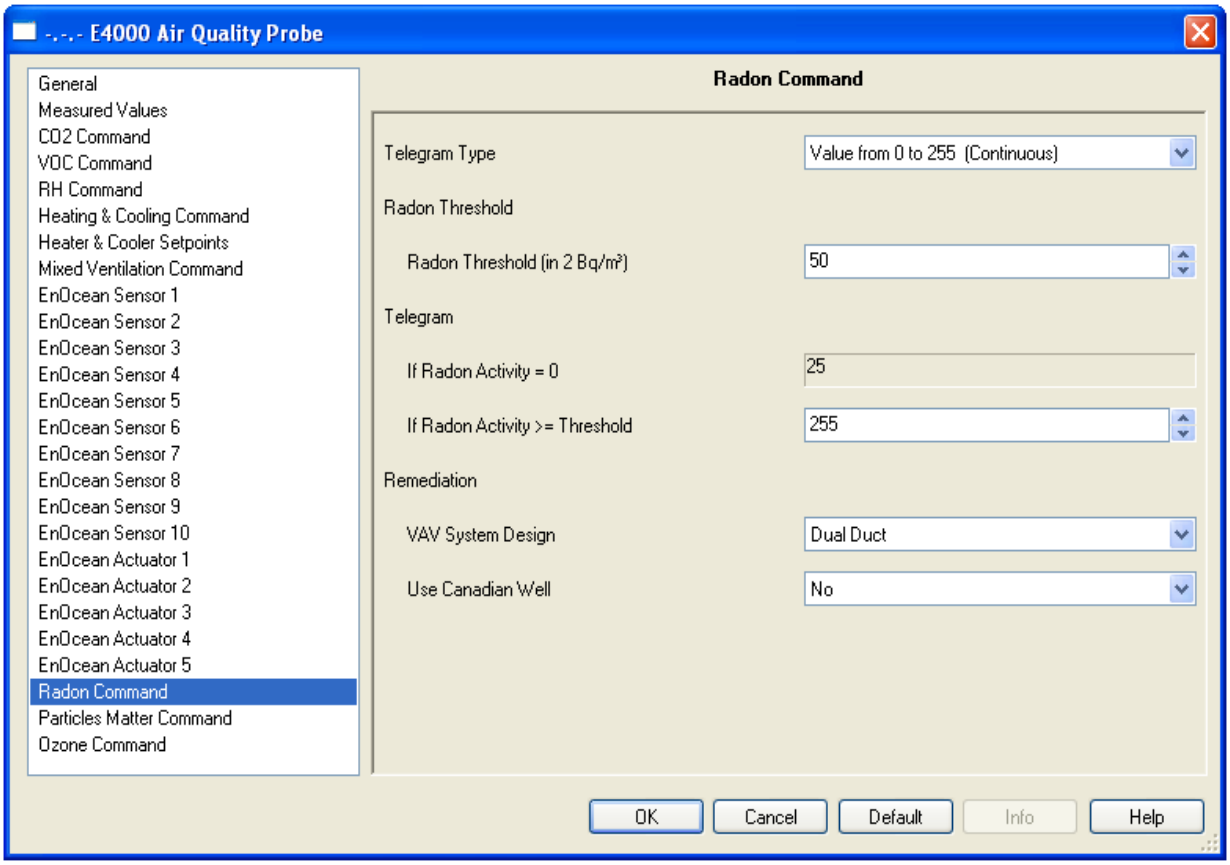
Outdoor Air in the range of humidity comfort:

<table>
<tr><th rowspan="3"></th><th rowspan="3">Value</th><th rowspan="3" colspan="2">individual Command</th><th colspan="5">Mixed Command</th></tr>
<tr><th rowspan="2">Without outdoor sensor</th><th colspan="4">With outdoor humidity sensor</th></tr>
<tr><th>No priority</th><th>Health</th><th>Building</th><th>Priority</th></tr>
<tr><td>CO2</td><td>1000ppm</td><td colspan="2">30%</td><td rowspan="5">60%</td><td rowspan="5">60%</td><td rowspan="5">60%</td><td rowspan="5">60%</td><td rowspan="5">60%</td></tr>
<tr><td>COV</td><td>10ppm</td><td colspan="2">50%</td></tr>
<tr><td>Radon</td><td>50Bq/m3</td><td colspan="2">10%</td></tr>
<tr><td>RH ind</td><td>80%</td><td rowspan="2">60%</td><td rowspan="2">10%</td></tr>
<tr><td>RH out</td><td>H out > H ind</td></tr>
</table>

Outdoor Air too dry:

<table>
<tr><th rowspan="3"></th><th rowspan="3">Value</th><th rowspan="3" colspan="2">individual Command</th><th colspan="5">Mixed Command</th></tr>
<tr><th rowspan="2">Without outdoor sensor</th><th colspan="4">With outdoor humidity sensor</th></tr>
<tr><th>No priority</th><th>Health</th><th>Building</th><th>Priority</th></tr>
<tr><td>CO2</td><td>1000ppm</td><td colspan="2">30%</td><td rowspan="5">60%</td><td rowspan="5">50%</td><td rowspan="5">10%</td><td rowspan="5">50%</td><td rowspan="5">10%</td></tr>
<tr><td>COV</td><td>10ppm</td><td colspan="2">50%</td></tr>
<tr><td>Radon</td><td>50Bq/m3</td><td colspan="2">10%</td></tr>
<tr><td>RH ind</td><td>30%</td><td rowspan="2">60%</td><td rowspan="2">10%</td></tr>
<tr><td>RH out</td><td>H out < H ind</td></tr>
</table>

1.4.10 Radon Probe



Radon Control Section appears only if the RS485 ModBus Radon Annex probe gateway has been activated in the General Chapter.

It is first necessary to determine if the control is a witched or a continuous mode.

Then determine a threshold triggers (hysteresis is not configurable. It is 10% in switch mode).

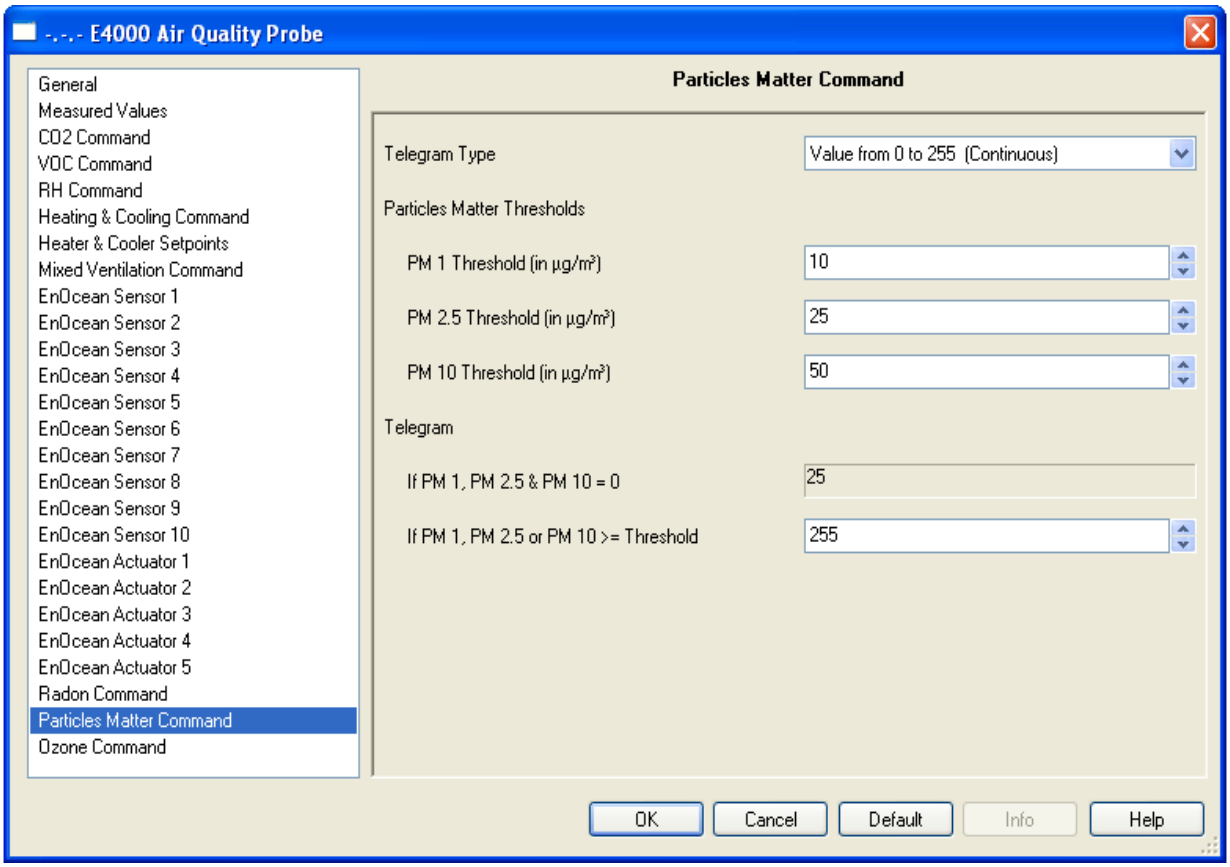
If the measure exceeds the threshold, a percentage of control or the status has to be to be determined.

Switched mode, the rate of transmission of telegrams must be set. In continuous mode, you need to set the percentage threshold is exceeded.

To ensure the building health, minimum ventilation is ensured by continuous control with a minimum of 10% and it is not possible to go below this value.

Note: There is no treatment system to remove Radon from air; therefore the setting of this command specifically dedicated to Radon is mainly designed to the mix ventilation command.
However, if the remediation is ineffective by dilution, after several unsuccessful dilution attempts, an overpressure telegram is sent.
Only some double flow ventilation can handle overpressure command.
The overpressure prevents the radon from entering the buildings through cracks in the basement structure or pipe passages.
In case of Canadian well, if the overpressure is ineffective, the last chance is to bypass the Canadian well. The depression of the ventilation into the Canadian pipe is usually a source of incoming radon.
See the Radon probe manual for details.

1.4.11 Particles Probe



Particles Control Section appears only if the RS485 ModBus Particles Annex probe gateway has been activated in the General Chapter.

It is first necessary to determine if the control is a witched or a continuous mode.
Note there are three control telegrams (one for each particle mater thinness) and this setting is common.

Then determine a threshold triggers for each type of particle (hysteresis is not configurable. It is 10% for the switch mode).

If the measure of each type of particle exceeds its threshold, a percentage or a status command has to be determined.

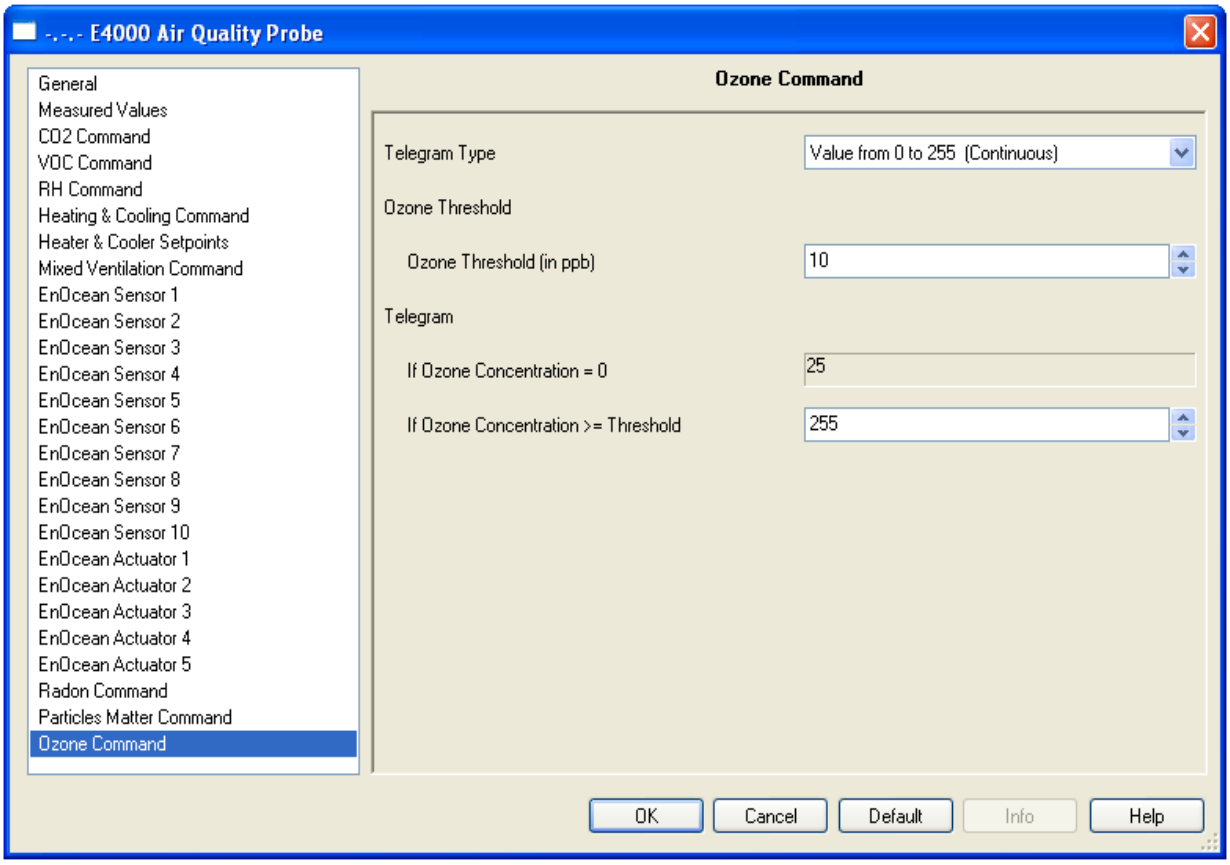
In Switched mode, the rate of transmission of telegrams must be set. In continuous mode, by setting the send command on change of a percentage of the threshold.

To ensure the building health, a minimum ventilation is provided in continuous control with a minimum of 10% and it is not possible to go below this value.

Note: there are air treatment systems for particles directly controllable by these commands. If case of air treatment the minimum of 10% commands cannot be canceled. Air treatment system (filtering) operating in continuous should have a minimum threshold trigger.

If any of air treatment system is used and the source of fine particles is indoor, the setting of this control will be mainly for mix ventilation command. If the source of particles is outdoor, the command can be used to warn of the need to change filters.
See the manual probe Fine Particles for details.

1.4.12 Ozone probe



Ozone Control Section appears only if the RS485 ModBus Ozone Annex probe gateway has been activated in the General Chapter.

It is first necessary to determine if the control is a witched or a continuous mode.

Then determine a threshold triggers (hysteresis is not configurable. It is 10% in switch mode).

If the measure exceeds the threshold, a percentage of control or the status has to be to be determined.

Switched mode, the rate of transmission of telegrams must be set. In continuous mode, you need to set the percentage threshold is exceeded.

To ensure the building health, a minimum ventilation is ensured by continuous control with a minimum of 10% and it is not possible to go below this value.

Note: There are systems for air treatment for Ozone directly controllable by this command.
If case of air treatment the minimum of 10% commands cannot be canceled. Air treatment system operating in continuous should have a minimum threshold trigger.

View Ozone probe manual for details.

2 Annexes

2.1 Hysteresis

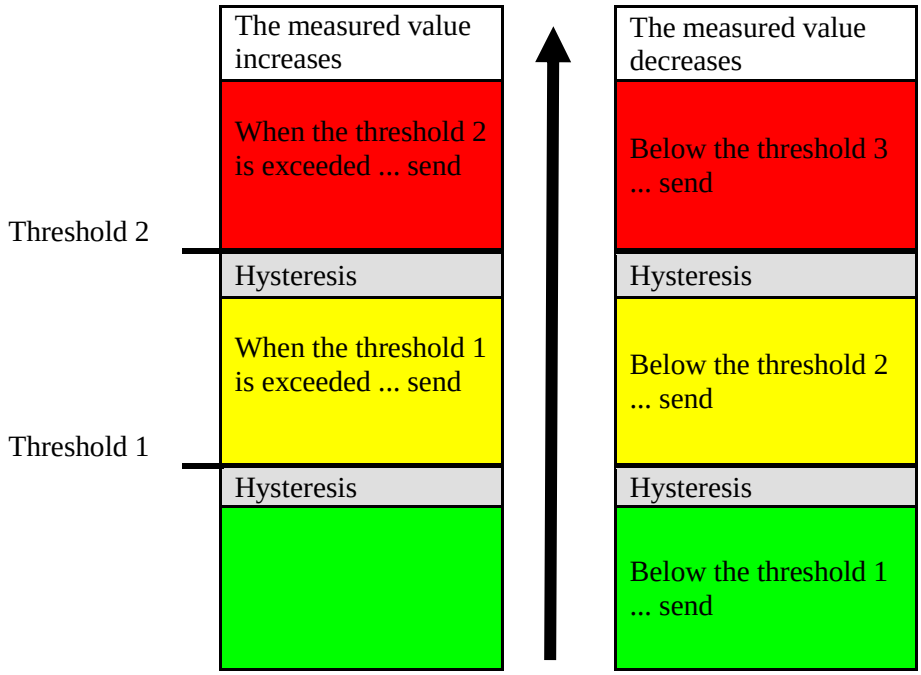
Hysteresis is the difference between the value of the activation and deactivation.
For the E4000probe, it is exclusively negative.

Without hysteresis, the regulator with thresholds would turn ON and OFF continually if the real value remained in the range of the setpoint.

Example of CO_2 Threshold

Threshold 1= 600 ppm, hysteresis = 100 ppm.
The threshold is exceeded when the actual value becomes greater than or equal to 600 ppm.
It leaves the exceeded when the actual value falls below the " threshold - hysteresis" value.
So here 600 ppm - 100 ppm = 500 ppm.

2.2 Behavior of switching thresholds for VOC, CO2 and humidity



The telegram of the last threshold exceeded is always sent.
If multiple thresholds are exceeded from one measurement cycle to the next, the corresponding telegrams are also sent (threshold 1-2) when the value is increasing; while in case of sending cyclically, only the last telegram that exceeded threshold is sent cyclically. This behavior applies exactly the same in case of decreasing values.

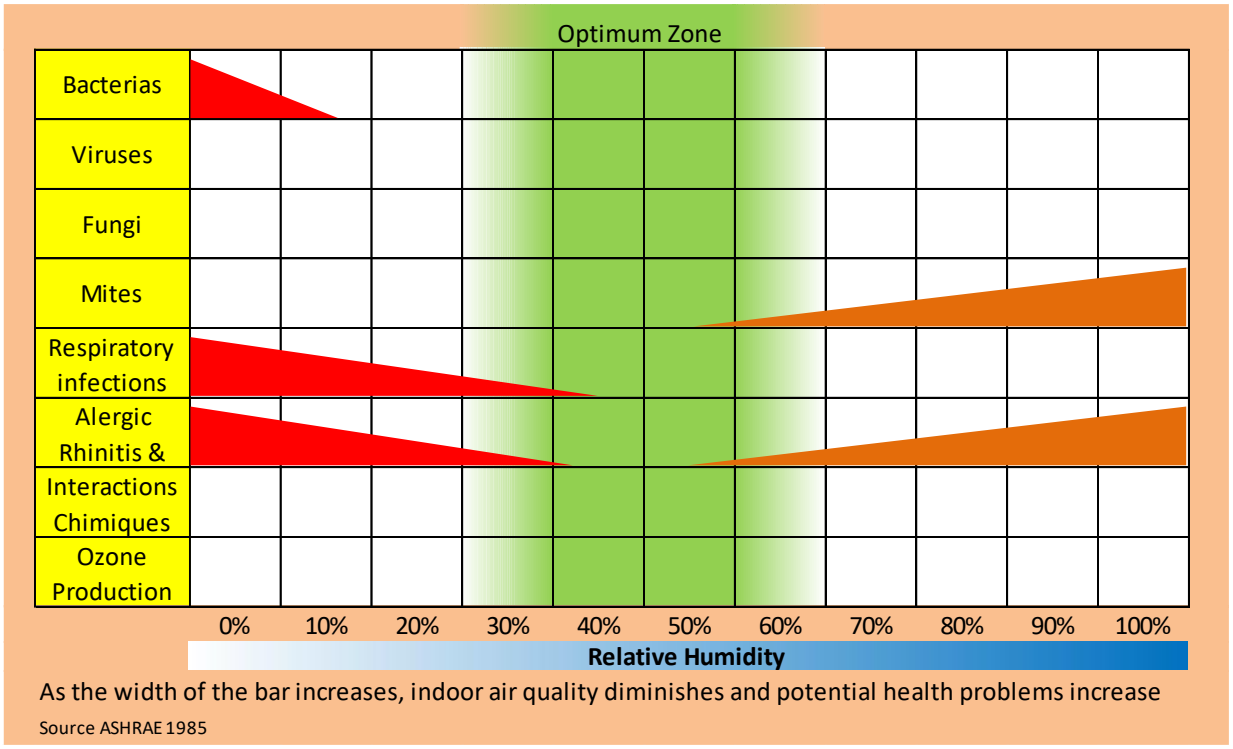
2.3 Relative Humidity

The relative humidity is the degree of saturation of air in water vapor.
It is expressed as a percentage of absorptive capacity of maximum water vapor at a given temperature.

Example: A relative humidity of air of 60% means that the air is saturated to 60% of its capacity of maximum absorption of water vapor.
At 100%, the air is completely saturated and can no longer absorb more moisture.

If the degree of saturation exceeds the limit of 100%, there is condensation, and therefore fog.
The ability of air to absorb water vapor varies with temperature.
Warm air can absorb more water vapor than cold air.

The following table shows that keeping relative humidity in the optimum zone limit many side effects.



Humidity and Building
When control of the air in buildings is provided by mechanical ventilation, the key is to control the relative humidity in a comfortable range: low enough to be comfortable, but high enough to avoid the inconvenience associated with very dry air.

When temperature is high and relative humidity is low, the water evaporation is rapid, materials dries, wet clothes dry quickly, and body sweat evaporates easily. Wooden furniture and frames can shrink and crack the paint on their surfaces.

When the temperature and relative humidity are high, the water evaporation is slow. When relative humidity approaches 100%, condensation can occur on the coldest walls, leading to problems with mold, corrosion, rot and other moisture-related damage.

Technical processes of production and processing in factories, laboratories, hospitals and other institutions require relative humidity levels to be maintained using humidifiers, dehumidifiers and related control systems. These systems can be driven directly by the command related to humidity.

2.4 CO2 Thresholds of reference

CO2 is mainly derived from animal or human breathing.
Rates found in non-airproof buildings are rarely dangerous.
Although CO2 is odorless discomfort can be seen starting from 1000 ppm.
Note that above 1000 ppm intellectual faculties start to deteriorate.
It is therefore necessary to adapt the requirements to desired comfort but also to the activity in each room.
A classroom or office for example will have an allowable limit of 1000 ppm while the requirements for a bedroom may be looser.

200 000		Lethal (fatal) to humans
100 000		Extinction a candle
40 000		Threshold of irreversible effects on health
5000		Maximum concentration on workplace (8h)
4000		Stuffy bedroom
1000		Sensation of foul air, a factor of asthma or building syndrome
390		Outdoor Air

All these values are expressed in ppm (Parts Per Million)

2.5 VOC Thresholds of reference

Currently, there is no specific standard for VOCs in non-industrial settings outside Publicly Available Establishments (PRAs) in some countries. There are thousands of different VOCs but some are recognized as a specific health risk and are subject to specific regulations.

However, thresholds can be used for buildings classified as High Environmental Quality with regard to VOCs.

Leadership in Energy and Environmental Design (LEED) initially used a threshold of 200 µg / m^3 of TVOC but it proved difficult to implement and was eventually raised to 500 µg / m^3. The European Community has attempted to circumvent the problem by using a 300 µg / m^3 TVOC limit without a single compound contributing more than 10% of the total.

The literature generally seems to agree that 200µg / m^3 represents an "acceptable" level of TVOC and that 3000µg / m^3 represents a "dangerous" level of TVOC.
However, some would like to raise the threshold between 300 and 3000µg / m^3. Part of this problem lies in the fact that some occupants appreciate fragrant VOCs of perfumes (cleaning products, scented candles, potpourri, so-called deodorants, essential oils, etc.) and try to increase the threshold while other occupants are not inclined and may actually experience nausea, headaches, and other associated symptoms.

The following table is recognized by many consultants:

Housing and offices	
TVOC levels in µg/m^3	meaning
< 200	Ideal
200-300	Good
300-400	Acceptable
400-500	Marginal
> 500	Bad

Symptoms above 3000µg / m^3 usually include drowsiness, eye and respiratory irritation, general malaise, headache, nausea and exacerbation of respiratory symptoms. Some data suggest that elevated levels of COVt amplify the harmful effects of specific harmful VOCs (cocktail effect).

	COVT	**Formaldehyde**	**Benzene**	**4-PCH***
HQE (French)	300 µg/m^3	10 µg/m^3	2 µg/m^3	NA
DGNB (German)	<500 µg/m^3 : 50 marks <1000 µg/m^3 : 25 marks <3000 µg/m^3 : 10 marks	<60 µg/m^3 : 50 marks <120 µg/m^3 : 10 marks	NA	NA
BREEAM (UK)	300 µg/m^3	100 µg/m^3	NA	NA
LEED (USA)	500 µg/m^3	33 µg/m^3	NA	6.5 µg/m^3

* 4-phenylcyclohexene

<u>A ventilation threshold set between 0.3 and 0.5 mg / m3 therefore seems recommended for TVOC (300 µg / m^3 and 500 µg / m^3) for certified sustainable buildings.</u>

Thresholds for specific VOCs and known carcinogens such as formaldehyde and benzene are well below that of the TVOC and would require selective detection. Unfortunately, the current technology does not yet make it possible to specifically measure these carcinogenic VOCs. However, the TVOC load includes some of these carcinogenic VOCs and a low TVOC threshold contributes to reduce these as well.

2.6 Felt temperature

Humans and warm-blooded animals control their body temperature by perspiration. Indeed, the sweat evaporation leads to cooling of nearby ambient air which cools the skin. The relative humidity of ambient air will affect the evaporation of sweat, and thus cooling the body. If Humidity is too low, it will increase the cooling and amplify the sensation of cold, while a too high humidity will limit the cooling and thus amplify the sensation of heat. Because humans perceive the transfer rate of body heat rather than temperature itself, we feel warmer when relative humidity is high than when it is low.
It is recommended to maintain a relative humidity between 30% and 60% (below 50% if we want to limit the proliferation of mites.

However on workplace, humidity below 50% may cause discomfort by drying out the mucous membranes and contribute to skin rashes.

The **heat index** (**HI**) or **humiture** or **humidex** (not to be confused with the Canadian The heat index (HI) or humiture or humidex (not to be confused with the Canadian humidex) is an index that combines air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature—how hot it feels. The result is also known as the "felt air temperature" or "apparent temperature".

The heat index has been adopted by the NWS (National Weather Service) and NOAA (National Oceanic and Atmospheric Administration) in the United States.

NOAA / NWS heat index

Relative Humidity (%) \ Temperature (°F)	**80**	**82**	**84**	**86**	**88**	**90**	**92**	**94**	**96**	**98**	**100**	**102**	**104**	**106**	**108**	**110**
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

- Caution
- Extreme Caution
- Danger
- Extreme Danger

Its formula is calculated from degrees Fahrenheit (° F) by:

$$\mathrm{HI} = c_1 + c_2 T + c_3 R + c_4 T R + c_5 T^2 + c_6 R^2 + c_7 T^2 R + c_8 T R^2 + c_9 T^2 R^2$$

Where

HI= heat index (in degrees Fahrenheit)
T= ambient dry-bulb temperature (in degrees Fahrenheit)
R= relative humidity (percentage value between 0 and 100)
$c_1 = -42.379, c_2 = 2.04901523, c_3 = 10.14333127, c_4 = -0.22475541,$
$c_5 = -6.83783 \times 10^{-3}, c_6 = -5.481717 \times 10^{-2}, c_7 = 1.22874 \times 10^{-3},$
$c_8 = 8.5282 \times 10^{-4}, c_9 = -1.99 \times 10^{-6}.$

This formula is valid only if the actual temperature is above 27 °C (80 °F), dew point temperatures greater than 12 °C (54 °F), and relative humidity higher than 40%

Temperature and humidity control

In order to reduce energy consumption it is preferable that the temperature comfort setpoint (in theory at 50% RH) be not used as a control setpoint but be replaced with the felt temperature (depending on humidity).

According to the indoor air humidity setpoint for (comfort zone), it is possible to act according to the outdoor air humidity. This requires comparing the partial pressures of water vapor between indoor and outdoor.

Other means than outdoor air can be implemented as humidifiers, but it is necessary to calculate and compare the energy impact. Indeed, the evaporation of a water fog produces a decrease in air temperature while increasing the perceived temperature.
In winter for example, when the outdoor air is dry, it is not possible to increase indoor humidity by air exchange.