Manual. *NatVent* ™ IAQ office ventilation program NaVIAQ V1.3

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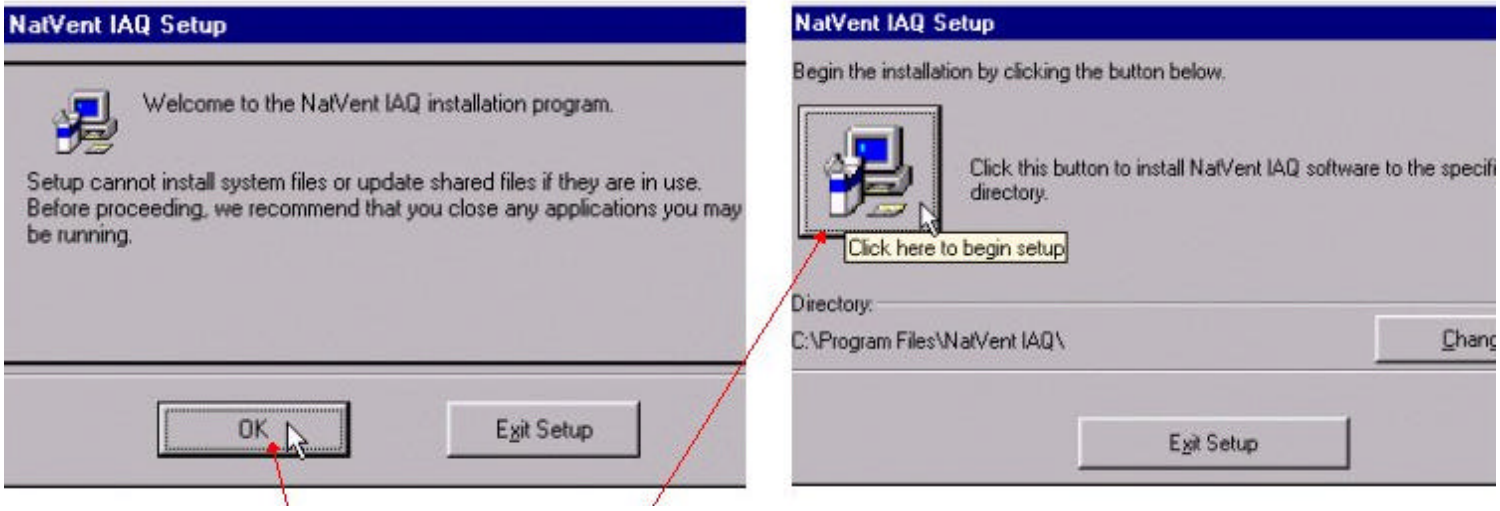
1. Installation

Here follows a short description of the installation on a PC with Windows locally installed. Setup will install a number of *.dlls in the windows system directory if no Visual Basic 5.0 program had been installed before. For systems that have Windows shared at a network drive, the systems operator must install the program first to update the system *.dlls.

- Close all programs, also stop virus checkers that prevent writing in the Windows directories.
- If earlier versions of NaVIAQ exist, see 1.1. Removal of earlier versions of NaVIAQ.
- Place the NatVent IAQ CD-Rom or floppy disk 1 in the drive.
- Open that drive in the Explorer
- On the CD-Rom open the folder \Design Tools\NavIAQ\Installation files
- Double click the setup(.exe) program



- Click OK to confirm that no other programs run . Click the large NatVentIAQ icon.

Read further at 2 Run NatVent IAQ.

1.1 Removal of earlier NatVent IAQ versions.

From the windows taskbar: | Start | Settings |Control panel |Add-Remove Programs.
Select NatVent IAQ in the list. Click Add-Remove. There may be an error that the program group NatVent could not be removed. Ignore this. The NaVIAQ icon will stay in the Start Menu until the next boot of the PC.

1.2 Old system files

It is possible that the Setup program asks confirmation to replace system files. Setup.lst contains a list of the (dll-)files to be replaced. It may be safe to make a copy of the original files and to run ERD.EXE (see Windows CDROM) before installing NaVIAQ.

2. Run NatVent IAQ.

From the windows taskbar click: | Start | Programs, look for NatVent and then NatVent IAQ in the programs list and click it.
Click the Start button or press the Enter key.

To start a simulation press the |Start button at the ventilation frame or /and afterwards the CO_2 button.

For help press F1 or open the manual from the menu |Help |Open manual

The tool tips can be switched on/off with the check box in the lower left corner.

The name NaVIAQ means Nat Vent Indoor Air Quality.
NaVIAQ simulates ventilation flow rates and concentrations of human exhaled CO_2 in one floor of an office building.

The program runs best at a screen resolution of 1024*768 or 800*600 16 million colors and small system characters.

The program always starts with the input from the last closed run.

3. Top of the screen.

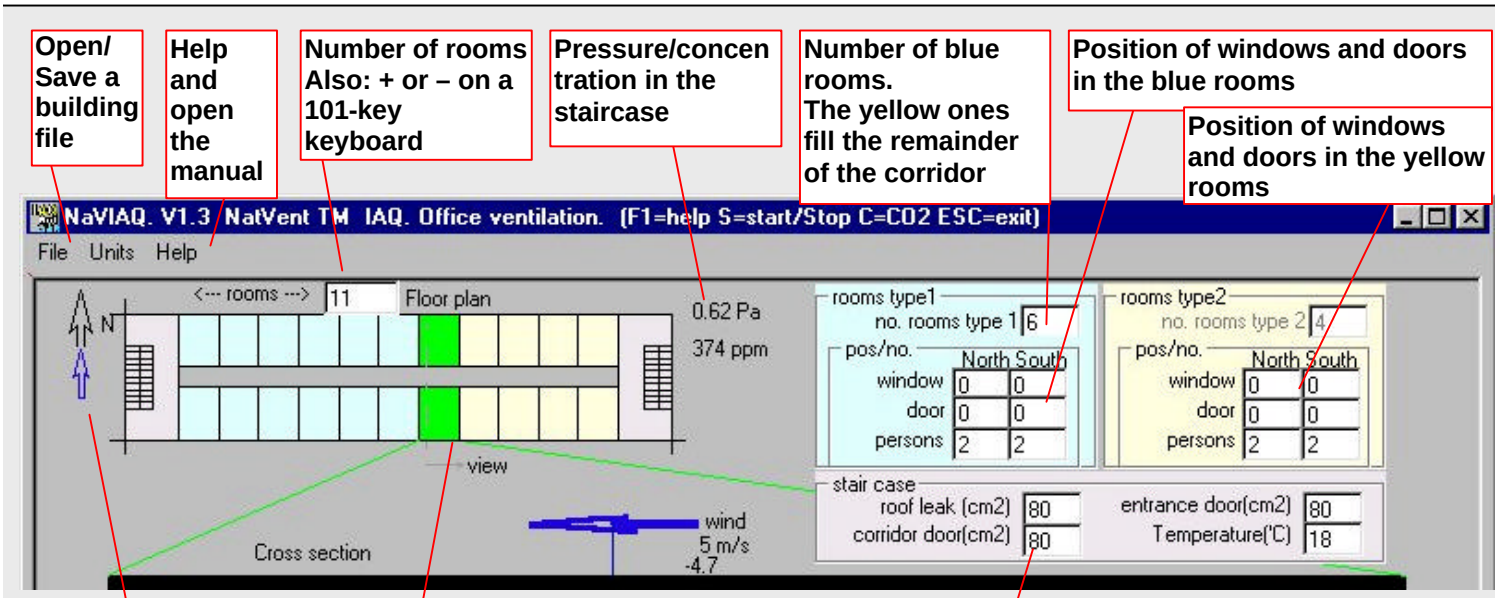


Figure 1

At the top of the screen is the menu to open/save the building data, change units and get help and open this manual.
The white text boxes (except the one for the number of yellow rooms) can be edited to modify the building.

At the left hand side is the floor plan of the office building. The number of rooms (counted along one side of the corridor) is 1 to 50.
The two green rooms are shown in detail below as a cross section (90° rotated, viewed towards East).

Left and right from the green rooms are the blue and yellow rooms of type 1 and type 2. Those may have different settings for window and door positions (0=closed…100=open). Their input is in the frames with the same color at the right hand side of the floor plan.
All other input is copied from the input given for the green rooms shown as cross section in the middle of the screen.

The staircase is only simulated at the East side and duplicated in flows and volume to account for the West-staircase.

4. Middle of the screen.

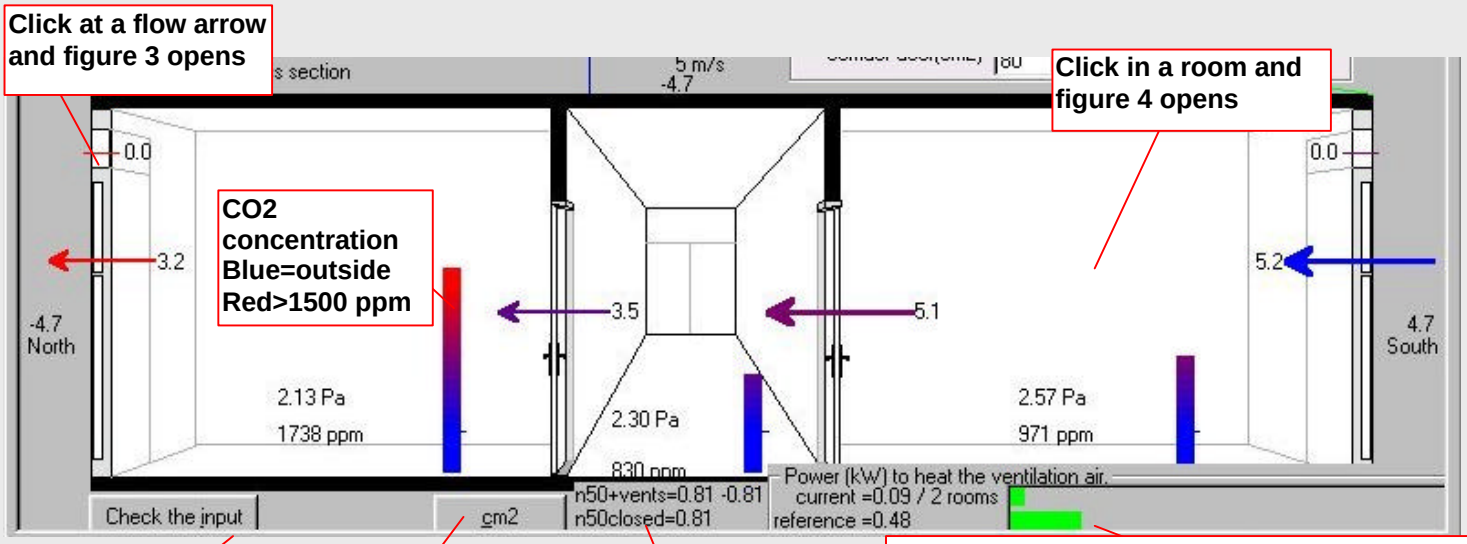


Figure 2

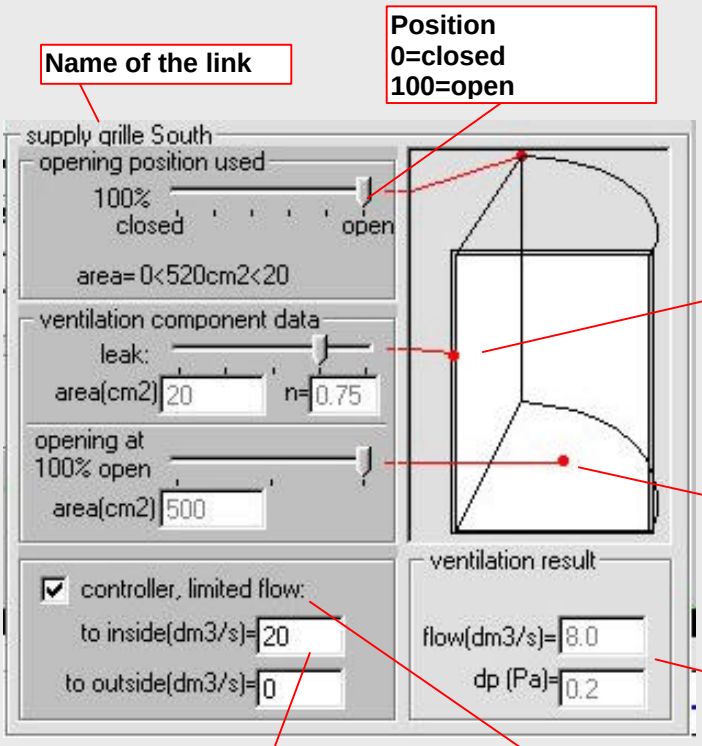
Expert opinion on a few aspects of the input

Change air leakage units

Air leakage of the building expressed as the number of air changes per hour at 50 Pa, the so called n50 value

Energy by ventilation. The current value is the energy to warm up the ventilation of the two rooms in the cross section. The reference is to warm up 40 dm3/s. This frame can be scaled by dragging the left side

The 6 arrows indicate the ventilation flow rates in the cross section of the building. The size of the arrows is the relative size of the flow. During the CO_2 simulation the arrows are colored from blue =



5 selectable leakage values s for the link in closed position. The flow exponent is a function of the leakage and can't be changed by the user.

Area of the ventilation component if it were in full open position (100%). The actual area in the simulation is the product of the here input area and the opening position percentage.

Results from the ventilation simulation

Figure 3

Limitation of the flow rate to inside (direction of the arrow at start up) and to outside.

Switch for the flow controller/limiter

outside concentration to red=1500 ppm. A click at an arrow yields the input frame of figure 3. The mouse can drag these frames. The top edge border is the best place to drag the frame. You can't drag the frame by clicking on the internal elements(sliders, internal frames and textboxes)

The input areas are the 'free cross section' of the openings (opening corrected for frame and grilles, and other obstacles) of a sharp edged opening that would lead to the same capacity (dm^3/s at 1 Pa). An opening of 12 cm^2 leads to 1 dm^3/s at 1 Pa.

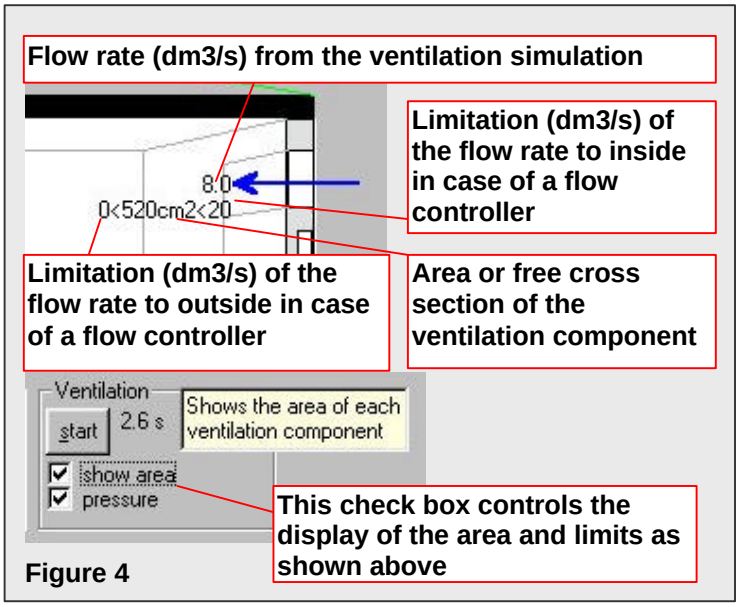


Figure 4

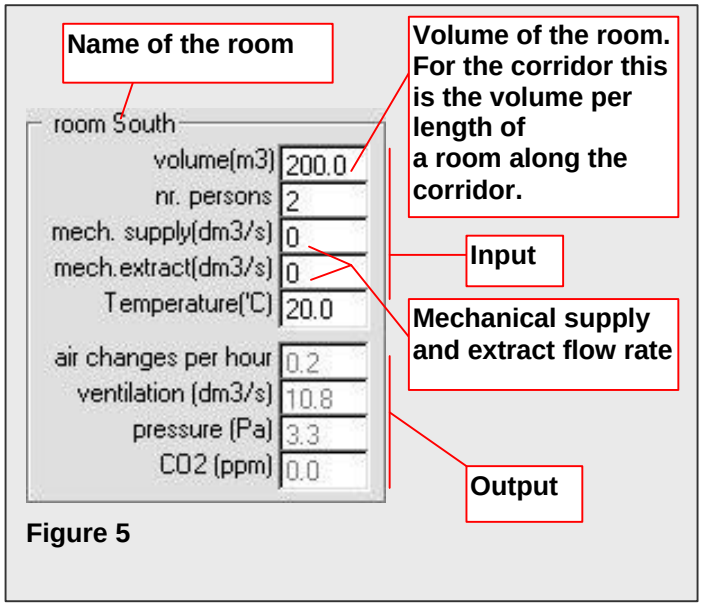


Figure 5

The input for the adjoining blue/yellow rooms of type 1 and 2 are copied from the 6 links in the cross section. However the window and door positions, are taken from the blue and yellow frame, top right. The staircase is derived from the leaks in the room at the same side of the building. The staircase has twice the width of a room.

A click at one of the three rooms in the cross section opens figure 5 with : Volume, temperature, mechanical supply and extract flow rates and the number of persons per room. The frame can be dragged at the (top)edge.

5. Bottom of the screen.

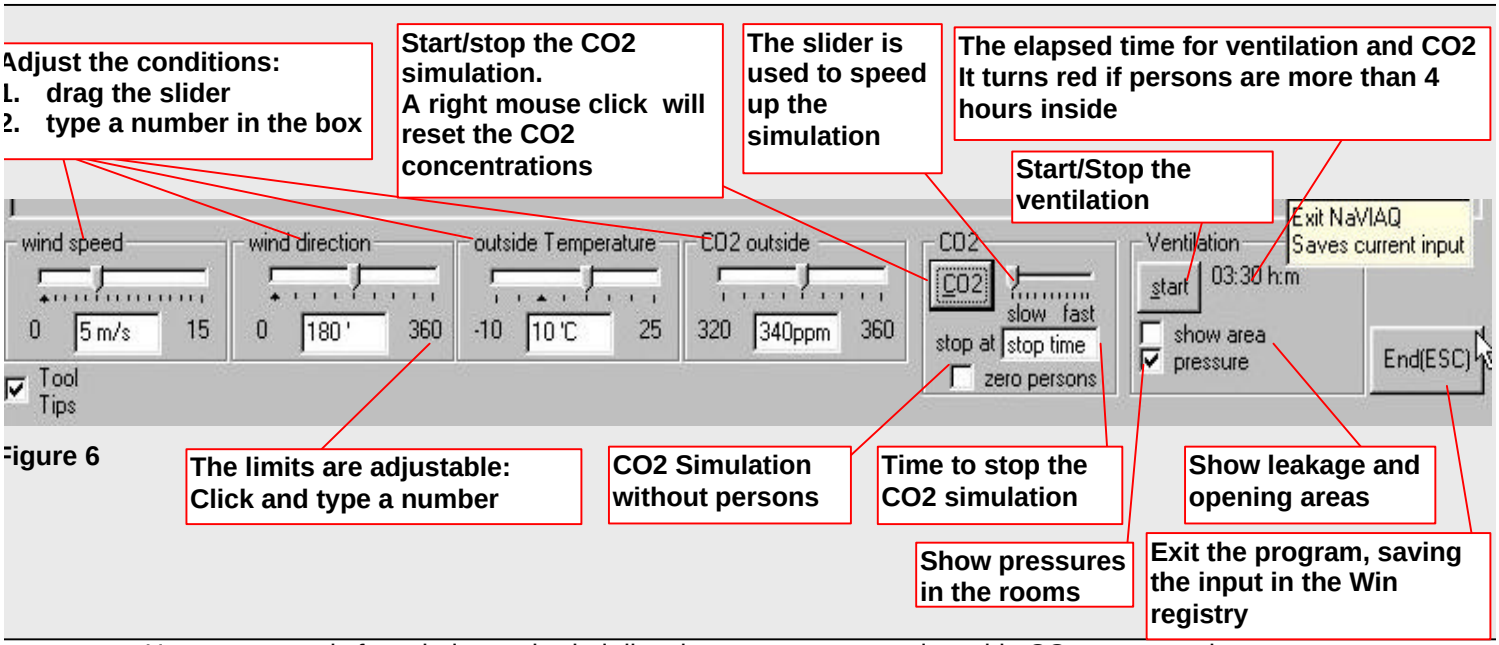


Figure 6

Here are controls for: wind speed, wind direction, temperature and outside CO_2 concentration

The minimum and maximum is also adjustable by clicking. This input is not limited and exotic results may follow at odd values.

In the frame 'Ventilation calculation' the button | Start, starts a series of dynamical calculations of all flow rates and stops at a certain accuracy or 10 simulated seconds.

- On an average PC the simulation is a few times faster than real time.
- A second click starts calculations with a greater accuracy.
- Click | Stop to end these calculations at a sufficient approximation of the equilibrium value
- The total elapsed real time in the building is displayed.

The dynamical CO_2 simulation starts at a click at the CO_2 button. The bars show the concentration.

- The slider (slow.. fast) can speedup the simulation.
- The number of persons can be set to zero temporarily with a click in the check box (zero persons).
- If a simulation with persons takes more than 4 hours, the elapsed time will be displayed in a red label to show that normally a break would occur. If the number of persons is set to zero, this red is cleared again.

6. Step by step

After installation click |Start |Programs |NatVent |NatVent IAQ.
Click OK or press Enter.

6.1 First start

Press F1. Click 'Reset all input'. Click OK. Press ESC to return to the NaVIAQ screen.
Press S (or click on start in the frame Ventilation calculation) to start the ventilation calculation.
This stops at a reasonable value or after 10 s simulation in the office building.
Press C (or click on CO_2 in the frame concentration calculation)
The simulation does not stop. Press an other time on C or click on CO_2 to stop the calculation.

6.2 Results

The ventilation calculations are dynamical. The course of flows and pressures at the indicated time approximates that in the real building.
The flow rate is displayed in dm^3/s, internally mass flow rates are used.
The concentrations are calculated for CO_2 which is produced by the persons in the building and depend also on the outside concentration.

At the bottom of the cross section is a frame with the heating power. This is the power for two rooms. Calculated from the ventilation heating loss of the whole office building and divided by the number of rooms along one side of the corridor. The heating loss of the staircase is thus added to that of the rooms. Below is as reference the power to warm up 40 dm^3/s from outside to room temperature. The left edge of this frame can be dragged to be large enough for losses at low outside temperatures up to 9 kW.

6.3 Help text

Press F1 to show a short help text. Press ESC to return to the NaVIAQ screen.
At the bottom of the help screen is a button to reset all input to the default input.

6.4 Manual

At the left below the cross section of the building is a button | Manual that opens this manual (NaVIAQ Manual.doc) if Microsoft Word is present at this PC as WINDOWS program. Search via CTRL+F or the menu | Edit | Search.

6.5 Check the input

Stop the calculations. Press I or click on the button 'Check the input' below the cross section. An overview follows with checks of the input.

- There may be proposed changes that can be applied automatically with the button at the bottom of this screen 'Apply changes'. This is followed by a new check of the input.
- Suggested changes to be applied manually are indicated by '***'.

At dm^3/s@1Pa and g/s@1Pa, the reported values may be non integer numbers as they are derived from integer cm^2 values.
Press ESC to return to NaVIAQ .

6.6 Edit input of the building

Stop all calculations.
The ventilation-area of a ventilation component is given here as free area. That is: 12 cm^2=1dm^3/s at 1Pa.
Most data is limited within a certain range. For instance:

- room volumes 20 .. 200 m^3
- air leaks up to 500 cm^2.

After every change of the input the whole building blower door value, n50 (=number of air changes at 50 Pa) is recalculated. If there are flow controllers n50 is ill defined. At lower pressure flow controller flow rates usually don't decrease.

6.7 Input that is not in the cross section.

All non-grayed fields can be edited.

6.8 Clicking on an arrow / ventilation component

By clicking an arrow a movable input frame opens Position
The most important, most frequently changed data is the opening position of a window/door, which can be changed by the top slider in 5 positions: 0=closed to 100=open.

6.9 Size of the ventilation opening

In the second sub frame are the ventilation areas of the components in:

- closed position (this may be the leak)
- opened position.

The open position is not a large opening, but meant as a provision for ventilation. Real open windows and doors would be in the range of 10000 cm^2.
The flow exponent n is here a fixed function of the size of the leak.
NaVIAQ does the following:

Closed
A ventilation component that is closed has only its leak, the area given by the top slider in the 'ventilation component' frame in **Error! Reference source not found.**. The flow rate is calculated with the displayed flow exponent.

mass flow rate = (A_{leak})*0.63*SQRT(2*rho) * SGN(dp) * ABS(dp) ^ n

as shown here: A is in m^2 and the flow rate in kg/s.

Opened
As soon as the position slider is not 'closed' and in position 20 .. 100, the sum of the areas of the leak and the full open area times the position fraction is used with a flow exponent of n=0.5 .

mass flow rate = (A_{leak} + position / 100 * $A_{fullopen}$)*0.63*SQRT(2*rho) * SGN(dp) * ABS(dp) ^ 0.5

The abrupt change of the flow exponent, n, may lead to small discontinuities in the actual flow and the n50 value when opening/closing a small window with a large leak.

6.10 Flow controllers

In the lower frame is a check box to make the ventilation component a flow controller. The flow rate to inside or to outside can be limited. (interpret 'to inside' as the startup direction of the arrow) . Don't zero both limits, as a constant zero flow rate will result.

6.11 Clicking on a room

Clicking a room opens a movable input frame with: the volume, the temperature and the mechanical flow rates (see **Error! Reference source not found.**).

6.12 Changing the Conditions

Stop the calculations. The sliders at the bottom of the screen adjust the wind speed, direction, temperature and outside CO_2 concentration. The limits are also editable by clicking.

6.13 Ventilation calculation

The following controls also active during a calculation.

- The Check box 'show area' displays the number of cm^2 at all links. Flow controllers also show their limiting values.
- The Check box 'room pressure' controls the display of the room pressures. CO_2 Concentration calculation.

6.14 CO_2 calculation.

The following controls are also active during a calculation.

- The slider 'slow..fast' can speed up the concentration simulation.
- The Check box 'zero persons' toggles the number of persons in the whole building to 0 and back to the original number, thus simulating a lunch break.
- The text box with 'stop time' can be used to stop the CO_2 calculation at a predefined time (hh:mm). An input of zero, like 0:0, is interpreted as :don't stop.
- A right mouse click on the CO_2 button will zero all CO_2 concentrations. If stopped, the zero concentrations will be shown at the next start.

The CO_2 source strength is 5E-6 m^3/s per person.

7. Compare two versions of a building.

NaVIAQ can only work with one building at a time. You may open the program more than once.
From the File menu you can open a previously saved building.
To start the subsequent run with the current office press F1 and click 'Save input', after that the building may be changed. The next instance of the program uses the just 'Saved' input. Input is also saved when NaVIAQ is closed.
If more than one instance of NavIAQ is running, the last closed one determines the input at a next start of the program.
Keep in mind which program is the first on the Windows taskbar.

8. Limitations

NaVIAQ is meant to demonstrate office ventilation. Real simulations and design issues would require much more detailed input, such as wind, wind pressures, surrounding buildings, detailed floor plan of the building, other levels.

- Wind direction is faked by a cosine and will deviate from an actual course.
- Pressure coefficients are fixed, shielded or exposed buildings must be simulated by an adapted wind speed.
- The volume of the rooms is limited between 20 and 200 m^3.
- The flow exponent has a fixed dependency with the input area. For opening positions>0 n=0.5 .
- The flow rates are linearized below 1 Pa.
- The CO_2 production per person is an average human production value of 5E-6 m^3/s.
- The CO_2 concentrations are not calculated if rooms with less than 1.5 dm^3/s per person exist.
- The open windows and doors are still small areas, meant as provision for ventilation. They are at '100%' open in the program some 20 to 50 times smaller than actual fully opened windows and doors.

9. Wordlist

1 dm^3/s	flow rate. For one person ventilation flow rates of 7 to 10 dm^3/s are common.
1 Pa	pressure difference of 1 N/m^2
12 cm^2	area for 1 dm^3/s at 1 Pa
1500 ppm	unconfortably high CO_2 concentration, CO_2 bar is red
adjacent rooms	other rooms along the corridor (blue and yellow)
airing	Use of large windows to get a large amount of ventilation in a room for a limited period of time, for instance 1 to a few hours per day.
arrows	ventilation flow rates
bars	indicate CO_2 concentration
blue	other rooms along the corridor
Check the input	button at main screen that opens a form that may have advise on the input and allows for automatic adjustments.
climate	Meteo outdoor temperature during the year and wind speed
CO_2 concentrations	the result of human exhalation
Delft	in dutch the word Delft is related to digging. The main institute of TNO is in Delft. The relation between research and digging…
duct	Pipe though which the ventilation air is supplied or exhausted.
dynamical calculations	The ventilation and concentrations in this model are simulated as a true function of time and thus dynamical.
elapsed real time	time elapsed after pressing the start button
equilibrium value	steady state value
extract	exhaust
F1	open Help
F3	Search forward in report and help text
F4	Search backwards in report and help text
Flow controllers	devices that keep the flowrate constant
flow exponent	Power to which the ratio between two pressure differences across an air leak or opening has to be raised to get the ratio of the flow rates through the air leak/opening at those pressure differences. At laminar flow this exponent is 1, at turbulent flow this exponent is 0.5 . There is a relation between the size of leaks , the flow rate and the flow exponent, but this relation has wide deviations for individual leaks.
flow rate	Air flow rate here expressed in dm^3/s
frame	Computer term for a rectangular line. For example the frame that is opened after a click at an arrow or in a room in NaVIAQ.
IAQ	Indoor Air Quality
inlet	Opening, grille, flap or device, through which ventilation air can enter the building. This is for purpose provided, more or less continuous inlet of air. In contrast the air that enters through leaks is considered to be unintended or non-purpose provided.
Large windows	windows with openings in the order of 0.5 to 1 m^2.
leak, leakage	Openings, cracks, joints that are not perfectly air tight through which ventilation air can enter the building. These leaks are not-purpose provided.
mechanical ventilation	Ventilation by means of electrical fans.
Mechanical	(ventilation) driven by (electrical) fans
meteo conditions	wind speed, wind direction and outdoor temperature
n50	Index for the air leak of the envelope of a building. It is the number of air changes at a pressure difference of 50 Pa across the whole envelope of a building. This is commonly measured by means of a 'blower door'. A large fan placed in an external door or window, to create sufficient over/under pressure. The flow rate (through the fan) is measured and expressed in n50= flowrate*3600/buildingvolume.
Natural ventilation	Ventilation of buildings driven by wind and thermal stack effect (buoyancy)

natural ventilation	Ventilation without systematic use of fans, but mainly by means of wind pressures and thermal stack or buoyancy pressures.
NatVent	EC program into natural ventilation, giving guidance to overcome barriers
NaVIAQ	NatVent Indoor Air Quality simulation program for office buildings
number of persons	the number of persons per room in NaVIAQ
number of rooms	number of rooms along one side of the corridor
pressure in the rooms	Pressure in the office(difference with outside) is calculated by the ventilation model. If there are large under- or over pressures a warning is given. If there is mechanical extract ventilation and the leak is set to its minimum and inlets are all closed, then the pressure becomes unrealistically low. Normal fans would not be able to create such pressures, but in NaVIAQ the mechanical flow rate is independent of the pressure.
pressure	Air pressure difference with the outdoor pressure (without wind pressure) as reference, expressed in Pa (N/m^2)
show area	check box to display the open area of ventilation components (grilles, leaks windows)
supply	Air supplied by a fan and duct from outside to various rooms of the building.
supply	flow rate supplied to a room
system	System for ventilation, consisting of a one or more ducts and one or more fans. A natural ventilation system works without fans, by means of natural wind induced pressures and / or temperature driven pressure differences (buoyancy).
temperature (meteo)	Outdoor air temperature as given by meteo.
text box	Computer term for an input box for text or numbers
TNO Bouw	TNO is a research organisation for Applied Physics in Holland, The institute Bouw (means: Building) is involved in Building and Construction Research
ventilation energy	Energy used to warm up the ventilation air.
ventilation flow rate	air flow rate through a building component
ventilation model	Computer model that calculates the flow rates in a building. This is often done by iterative approximation of the indoor pressures, so that the mass flow rates that enter the building and rooms equal the outgoing flow rates.
ventilation system	System for ventilation, consisting of one or more ducts and fans could be used. A natural ventilation system works without fans, by means of natural wind induced pressures or temperature driven pressure differences (buoyancy).
Ventilation	Renewal of indoor air by outdoor air to dilute concentrations of aerosol pollutants like CO_2, H_2O, odors and to supply O_2.
volume	Internal volume of the building (m^3).
wind pressure	Pressure on the facade or roof, calculated from the dynamic pressure and the cp value.
wind speed	wind speed measured at a meteorological station
wind	Wind speed as given by meteo m/s
window	Large window used for airing.