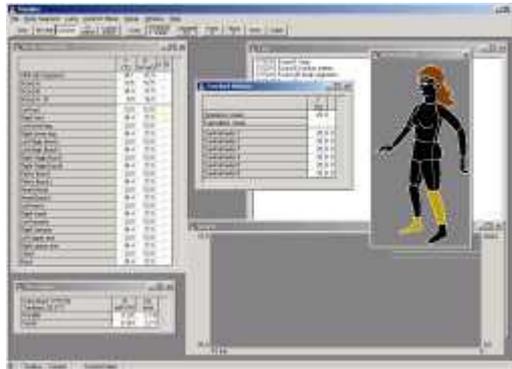


Manikin



Version 3.1 for Windows

August 2008

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Introduction

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This document describes the MANIKIN program. The MANIKIN computer program controls the manikin from the computer via the standard serial port or USB. The program transfers the necessary power to each part of the manikin in order to maintain the wanted body temperature. MANIKIN is a measuring program that present the various temperatures and powers and saves the measurements to a file. Clo-values for the manikin can also be calculated, either based on a constant chosen ambient temperature, or based on the temperature as measured by a connected Comfort Meter.

Additional, the MANIKIN software controls the following equipment which can be connected to the system:

- Lung function
- Comfort Meters

System requirements:

- PC (min 1 GHz pentium recommended)
- Windows 98/2000/XP (english version recommended), Vista is currently being testet
- USB-port
- About 250 MB free diskspace for program files, plus additional free diskspace for log files

Changes to this manual, program updates and other information will be available on the internet at the following address:

<http://manikin.dk>

IMPORTANT: By installing, copying or otherwise using the manikin software, you agree to be bound by the terms and conditions of the [license agreement](#). If you do not agree to these terms and conditions, do not install, copy or otherwise use the manikin software.

Installation

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Installation from CD

- Insert the CD in the CD-drive

The installation program should start automatically, otherwise:

- Choose Start / Run
- In the Run-window, type d:\setup.exe and press Ok (where d is assumed to be the drive-letter for the CD-drive)

Installation from the internet

Programfiles, upgrades and installation instructions are available on the internet:

<http://manikin.dk>

Starting

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Starting Manikin

To connect and start the manikin:

- Connect the manikin and (if any) the comfort meters to the USB port (via the USB-RS485 converter)
- Turn on the power to the manikin and (if any) the comfort meters and/or lung
- Start the program by selecting the Manikin icon in the Windows Start-menu

During start-up the program will detect the manikin by scanning the serial-port.

Selecting the serial port

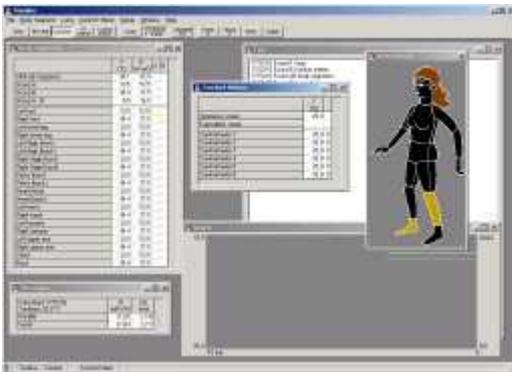
The first time you start the program (or after changing serial port) you should choose the correct serial port to which the manikin is connected in the pull down menu Setup / Port / COM 1-32. When selecting one of the ports the selected port will be scanned to see if the manikin is connected to the actual port. The serial port specifies the port that the USB-RS485 converter has mapped.

Program window

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The programwindow consists of the main window where one or more child windows can be placed as you please:

- Body Segments
- Comfort Meters
- Clo Values
- Body Picture
- Graph
- Constants
- Log



Body Segments

Here the manikin's instant temperatures of each part of the body and the transferred power are shown. Additionally two columns are displayed. Column A and B indicate if the bodypart is included in the mean calculation for group A and B respectively.

By selecting *Voltage* and *ADC-values* in the *Window*-menu you can toggle whether current voltage and ADC-values also are shown for each body segment.

Besides values for each body segment, mean values are also shown. The mean values are calculated on the basis of the above temperatures and power values. Three mean values are stated: All, A and B. The mean values are weighted according to the area of each body part. All include all bodyparts, while A and B only include the body segments indicated by the actual Group-settings. The difference between Group A and B is stated as well.

Comfort Meters

If Comfort Meters are present this window will show the instant temperature for each Comfort Meter. A column will indicate whether each comfort meter is running in operative (O) or equivalent (E) mode.

By selecting *Voltage* and *ADC-values* in the *Window*-menu you can toggle whether current voltage and ADC-values also are shown for each comfort meter.

Besides values for each comfort meter, mean values are also shown. The mean values are calculated on the basis of the above temperatures. Two temperatures are stated: Operative and Equivalent. Operative will be the mean value of these comfort meters running in operative mode, while equivalent will be the mean value of those running in equivalent mode.

Clo Values

This window will show the calculated heat resistance and clo-values. Both values are calculated using the parallel- and serial-method. Please refer to [Appendix - Clo Calculation](#) for a description of the different methods.

Furthermore the time for the calculation will be displayed along with the ambient temperature used for the calculations.

Body Picture

On the picture of the manikin the different bodyparts are coloured according to their instant temperature. The temperature range of colours is shown to the left. The temperature interval and colors can be changed by [Setup - Body Picture](#).

Graph

Temperatures and/or power values are shown as a graph over a given period. The graph is rolling from right to left, in that way the instant values are shown to the right (time equal to 0). Please refer to [Graph Setup](#) for a description on the different graph-settings.

Constants

Displays various constants and other values for each controller. This is only used for debugging purpose.

Log

The Log-window displays error messages and other messages during runtime.

Program functions

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The different program functions are available from the pulldown-menus. The availability of some of the functions will depend on the state of other functions. Some of the most used functions will be available through the toolbar, and some again through hot-keys.

Start filelog



The filelog saves data in to a file. Data is printed for all body parts. Filename gives the name of the data file. Interval specifies the time-interval in seconds for saving the data. The data will be a mean-calculation over this period. Fileformat specifies whether data are saved in Comma Separated Values (CSV) format or tabulator separated format. Both format should easily be imported by fx spreadsheets and database programs. The decimal settings follows the standard Windows settings.

Exit

To quit MANIKIN, select this menu-item. If the file-log is active, you will be prompted to deactivate this. The manikin and comfort meters will be put in *no heat*-state and the lung (if any) will be powered off

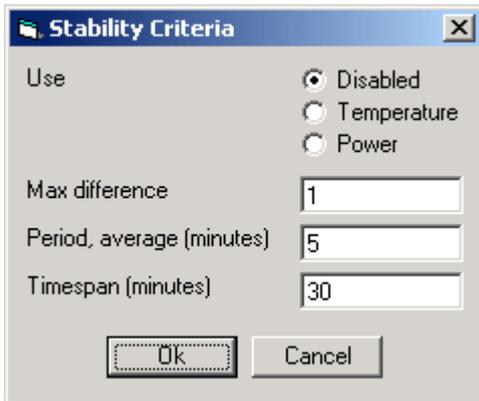
Body Segment - Control



Used for managing the control method of the manikin. No Heat / Comfort / PI / Locked Power specifies the actual method for controlling the fired power (for a description of the different types of control available refer to [Appendix - Methods of control](#)).

When No Heat is selected, no power is fired. Use this mode when calibrating the manikin.

Body Segment - Stability Criteria

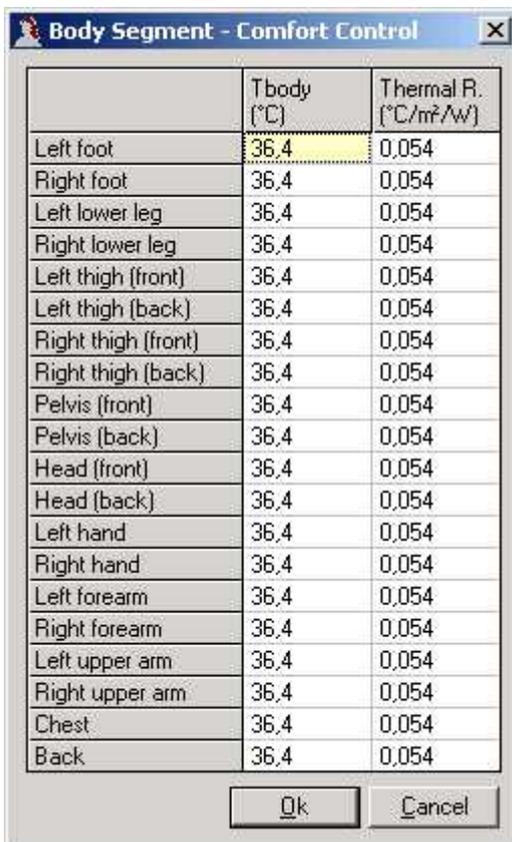


The dialog box titled "Stability Criteria" contains the following settings:

- Use: Disabled, Temperature, Power
- Max difference: 1
- Period, average (minutes): 5
- Timespan (minutes): 30

Buttons: Ok, Cancel

Body Segment - Comfort



The dialog box titled "Body Segment - Comfort Control" displays a table with the following data:

	T _{body} (°C)	Thermal R. (°C/m ² /W)
Left foot	36,4	0,054
Right foot	36,4	0,054
Left lower leg	36,4	0,054
Right lower leg	36,4	0,054
Left thigh (front)	36,4	0,054
Left thigh (back)	36,4	0,054
Right thigh (front)	36,4	0,054
Right thigh (back)	36,4	0,054
Pelvis (front)	36,4	0,054
Pelvis (back)	36,4	0,054
Head (front)	36,4	0,054
Head (back)	36,4	0,054
Left hand	36,4	0,054
Right hand	36,4	0,054
Left forearm	36,4	0,054
Right forearm	36,4	0,054
Left upper arm	36,4	0,054
Right upper arm	36,4	0,054
Chest	36,4	0,054
Back	36,4	0,054

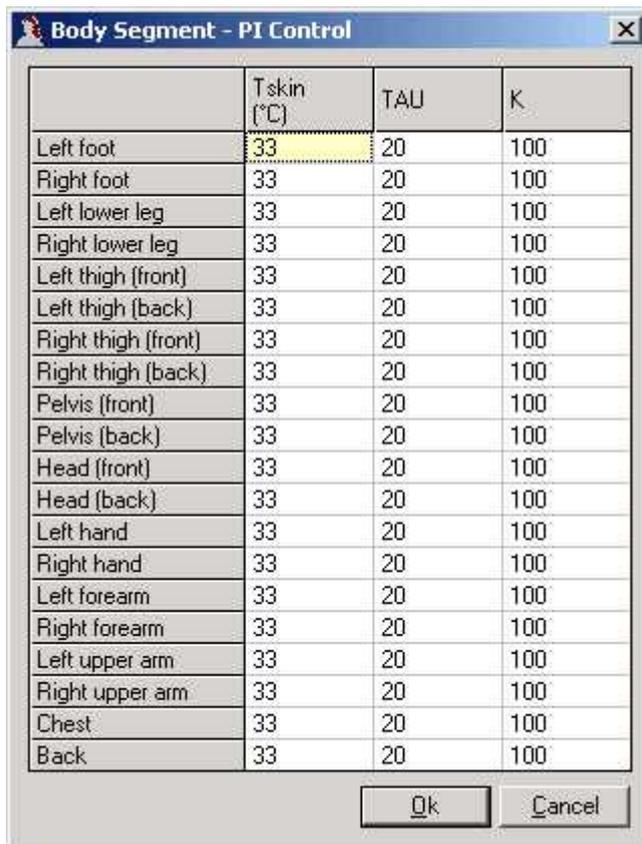
Buttons: Ok, Cancel

The Comfort Control-settings are used when you have selected Comfort as controlling method for the manikin (for a description of the different types of control available refer to [Appendix - Methods of control](#)).

Deep Body - Specifies the wanted deep body temperature of the manikin.

Thermal Resistance - The power-coefficient specifies the transmitted power as a function of the temperature below the wanted deep body temperature (default 0.054 m²*C°/W).

Body Segment - PI



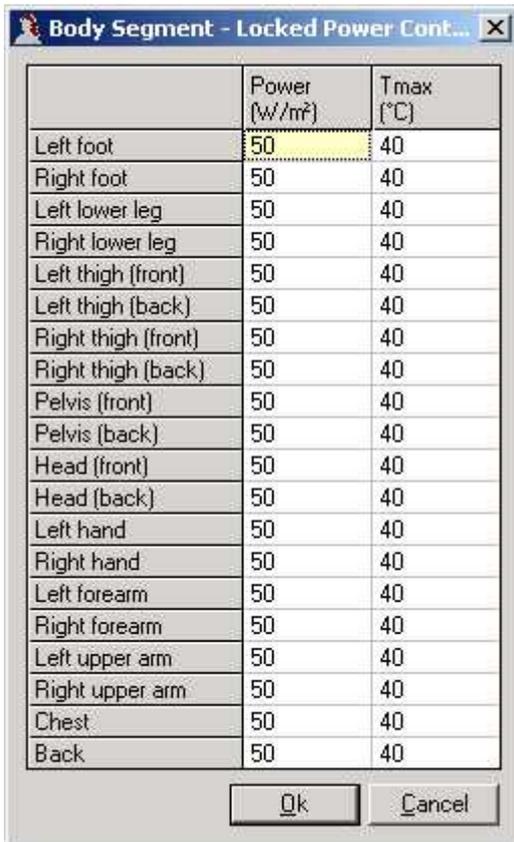
	T _{skin} (°C)	TAU	K
Left foot	33	20	100
Right foot	33	20	100
Left lower leg	33	20	100
Right lower leg	33	20	100
Left thigh (front)	33	20	100
Left thigh (back)	33	20	100
Right thigh (front)	33	20	100
Right thigh (back)	33	20	100
Pelvis (front)	33	20	100
Pelvis (back)	33	20	100
Head (front)	33	20	100
Head (back)	33	20	100
Left hand	33	20	100
Right hand	33	20	100
Left forearm	33	20	100
Right forearm	33	20	100
Left upper arm	33	20	100
Right upper arm	33	20	100
Chest	33	20	100
Back	33	20	100

The PI-settings are used when you have selected PI as controlling method for the manikin.

Skin Temperature - Specifies the wanted skin temperature of the manikin.

K and Tau - Constants for the PI-control.

Body Segment - Locked Power



	Power (W/m²)	Tmax (°C)
Left foot	50	40
Right foot	50	40
Left lower leg	50	40
Right lower leg	50	40
Left thigh (front)	50	40
Left thigh (back)	50	40
Right thigh (front)	50	40
Right thigh (back)	50	40
Pelvis (front)	50	40
Pelvis (back)	50	40
Head (front)	50	40
Head (back)	50	40
Left hand	50	40
Right hand	50	40
Left forearm	50	40
Right forearm	50	40
Left upper arm	50	40
Right upper arm	50	40
Chest	50	40
Back	50	40

Specifies the wanted power to be transmitted to the manikin if controlling method Locked is selected. If the temperature reaches Max temperature for one or more parts of the manikin, the heat will be turned off in this/these part(s) to prevent overheating of the manikin.

Body Segment - Calibrate Temperature A/B

When selecting this function, you will be prompted for the current ambient temperature of the manikin. When pressing Ok the digital values will be logged, and new constants will be calculated. For further information on how to calibrate the manikin please refer to [Appendix - Calibration](#).

Lung

To control the lung (if connected) the following functions can be used:

- Lung Control
- Lung Interval or Lung Setup

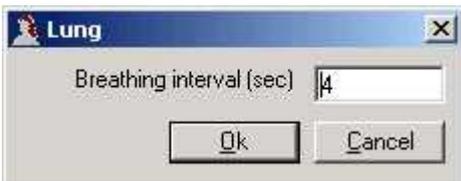
The functions varies depending on the type of lung (with or without heating- and flow-capabilities). Please note that these functions will only be available if the necessary hardware are present.

Lung - Control (no heat or flow)



Used for managing the attached lung (if any). If the checkbox is checked breathing will be active.

Lung - Interval (no heat or flow)

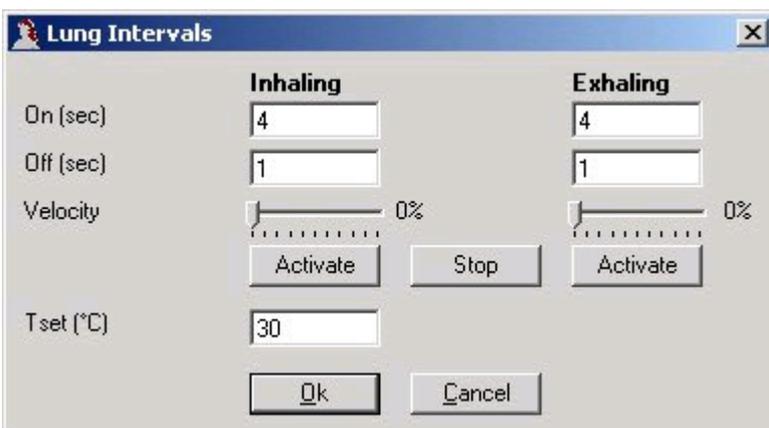


Settings for the attached lung (if any). *Interval* specifies the interval (in seconds) for breathing in and out.

Lung - Control (heat and flow)



Lung - Settings (heat and flow)

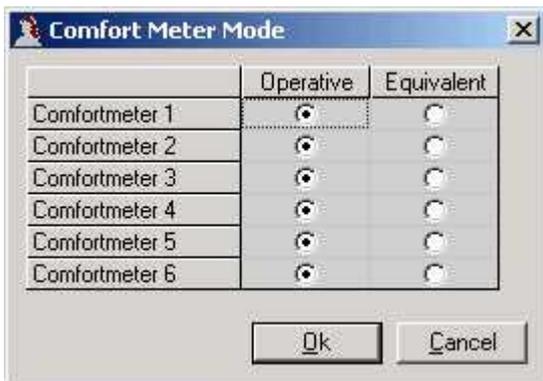


Comfort Meter - Control



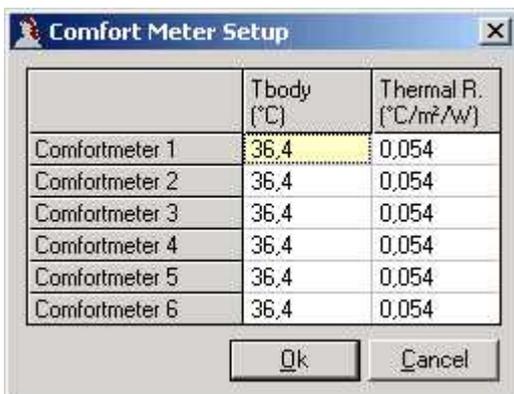
Used for managing the attached comfort meters (if any). If the checkbox is checked the comfort meters will be active, and operate according to there *mode*-settings.

Comfort Meter - Mode



Specify wether each comfort meter will run in operative or equivalent mode.

Comfort Meter - Setup



Specify the settings for the comfort meters when running in equivalent mode.

Comfort Meter - Calculate Clo



Used to calculate new Clo-values.

You can specify which ambient temperature to use in the calculations. If there are any comfort meters attached to the system (and one or more are running in operative mode) the temperature will be prefilled with the mean operative temperature from these.

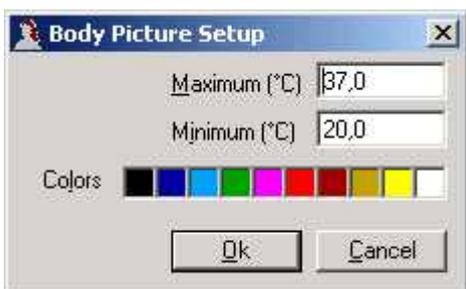
If *Auto* is checked, new clo-values will be calculated every 2.5 seconds. Again, if a operative temperature based on comfort meter measurements are present, this value will be used. Otherwise, the last specified ambient temperature will be used.

Setup - Group A/B



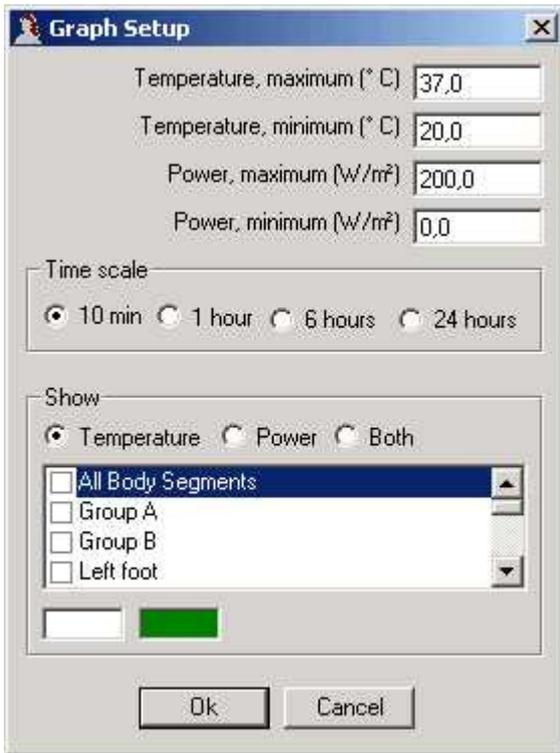
Group A and Group B indicates if a specific part of the body is to be included in the mean calculation of temperature and power value for group A and B respectively. The mean calculation is performed as a weighted mean according to the areas of the different parts of the manikin.

Setup - Body picture



Setup of the span for temperature/colour legends for the picture of the manikin. The colors can be customized by clicking one of the 10 colorboxes.

Setup - Graph



The following settings are available for configuring the screen-image of the graph:

- Temperature and Power - specifies the minimum and maximum for temperatures and powers respectively. Also the actual drawing colour can be specified.
- Time scale - The x-axis range, from 10 minutes to 24 hours.
- Show - Select temperature, power or both to be displayed.
- Elements - Selection to draw the graph on the basis of the weighted means for Group All, Group A, Group B, an selected body segment or operative/equivalent temperature.

Furthermore, the colors can be customized: Select an element in the listbox, and click on the temperature- or power-colorbox.

Setup - Rescan

Will scan the selected COM-port to detect the manikin. The result of the scan will be logged in the Log-window. When using this function the Manikin will be scanned for all connected body-parts, and other devices such as comfort meters, lung etc.

Please note: The result of this scan will be saved and reused during startup. If you add or remove body-segments or external devices please use this function to detect your changed.

Setup - Port COM 1-32

Will select one of the eight COM-ports, and scan this port for devices.

Window

Select one of the windows listed in this pulldown-menu to open and/or focus the actual data-window.

Window - Voltage

Select this to toggle whether voltage are shown in the different datawindows or not.

Window - ADC-values

Select this to toggle whether ADC-values are shown in the different datawindows or not (mainly used for debugging purpose).

Help - About



Displays copyright information and version numbers for the program, and name and license information for the attached manikin.

Appendix - Calibration

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To obtain exact measurements the manikin must be calibrated frequently by making measurements at known temperatures of the manikin. To calibrate the manikin the following steps must be taken:

1. Log a data-record when all parts of the manikin have uniform temperatures e.g. 20 °C by selecting the function Body Segment / Calibrate Temperature A
2. Item 1 is repeated with Calibrate Temperature B at another temperature e.g. 30 °C
3. The new temperature constants are calculated automatically

Make sure that the temperatures of all body parts are the same, e.g. by placing the manikin in a climate chamber. Log the data-records with the function Record A or Record B where you will be prompted for the instant temperature of the manikin.

Please note: It is important that the hot wires of the manikin are not activated during calibration. Therefore, calibration is only possible when the manikin is in No heat-mode.

Appendix - Methods of control

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Three different methods of controlling the heat transfer to the manikin are available:

- Comfort control
- PI (Proportional Integral) control
- Locked Power

Comfort control

The Comfort control is simulating the thermal resistance in the skin. The power is calculated as follow:

$$P = \frac{T_{db} - T}{R_t}, P \geq 0$$

P Power (W)

Tdb Deep body temperature (oC)

T Actual temperature (oC)

Rt Thermal resistance (m2*oC/W), by default 0.054

PI control

The PI controller also performs an integration. The power is calculated as follow:

$$P = K(\Delta T + \frac{1}{\tau} \int \Delta T dt), \Delta T = T_{skin} - T, P \geq 0$$

Tskin Skin temperature (oC)

K Constant (default 100)

TAU Constant (default 20)

By adjusting K and tau a combination of speed and stability in your system is chosen.

Locked Power

The power is locked at a specific value, regardless of the actual temperature of the manikin. The values can be entered by the function Control / Locked Power. To avoid the risk of overheating, the power will be set to zero, if the manikin reaches a certain maximum temperature.

Appendix - Clo calculation

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The following is a summary of:

Memorandum - Calculation of manikin clothing data
George Havenith
Loughborough
4 September 2002

There are three main calculation methods for manikin clothing insulation (heat resistance R). There is ongoing debate on which should be used, with Umbach (D) pushing hard for the 'serial' approach detailed below. I think that we need all three calculations in the software, as the validity of each method changes with the measuring conditions (for Victoria it is different for the comfort setting [unequal skin temp.] than for equal skin temps over the body)

1 - Preliminary - Notations

T_i local skin temperature segment (i)

T_a ambient temperature

T_{sk} mean skin temperature

a_i area fraction of segment (i) related to whole body area A_{sk} ; a_i = A_{sk(i)} / A_{sk}

note that : T_{sk} = S a_i . T_i

note that : S a_i = 1 and therefore S (a_i . T_a) = T_a

H_{sk} whole body heat flux (W/m²)

H_i local heat flux of segment (i) in W/m²

note that total heat flux for whole body (W/m²) is H_{sk} = S (a_i . H_i)

R_i local resistance of segment (i)

2 - The general formula for defining whole body resistance (no consideration of parallel or serial here), which in my opinion meets best the definition of insulation in ISO 9920 is:

$$R = \frac{\overline{T_{sk}} - T_a}{H_{sk}} = \frac{\sum (\alpha_i T_i) - T_a}{\sum (\alpha_i H_i)} = \frac{\sum \alpha_i (T_i - T_a)}{\sum (\alpha_i H_i)}$$

(equation A)

3 - If you make the assumption that **skin temperature is uniform** over the body, i.e. T_i = T_{sk} = constant, then equation (A) becomes:

$$R = \frac{T_{sk} - T_a}{\sum (\alpha_i H_i)}$$

$$\frac{1}{R} = \frac{\sum \alpha_i H_i}{T_{sk} - T_a} = \sum \alpha_i \left(\frac{H_i}{T_{sk} - T_a} \right) = \sum \alpha_i \cdot \frac{1}{R_i}$$

(equation B)

This is adding up resistance according to a **parallel model**.

4 - If you make the assumption that **local heat flux is uniform** over the body, i.e. $H_i = H_{sk} = \text{constant}$, then equation (A) becomes:

$$R = \frac{\sum \alpha_i (T_i - T_a)}{\sum (\alpha_i H_i)} = \frac{\sum \alpha_i (T_i - T_a)}{H_{sk}} = \sum \alpha_i \frac{T_i - T_a}{H_{sk}}$$

or

$$R = \sum \alpha_i R_i$$

(equation C)

This equation (C) is adding up resistances according to a **serial model**.

Comments

For "clothing" comfort probably none of the methods represent what happens, the reality being local resistance, local heat loss and local skin temperature, coupled with body physiology.

Because we want to reduce this complex reality in a single global equation, we try to define a global resistance. Equation (A) is the definition you naturally think of. With assumption of uniform skin temperature, this is similar to adding up local resistances in parallel (equation B). With assumption of uniform heat flux, this is similar to adding up local resistances in serial (equation C).

Reality being usually in-between uniform skin temperature and uniform heat flux, equation A will result in a value in-between parallel (low side) and serial (high side).

When measuring on a manikin, we usually use a uniform skin condition (temperature / water vapour pressure); and this is now how the measurement is standardised. Therefore for manikins, general - and natural - equation (A) is similar to adding up local resistances parallel (up to a certain extent if heat transfer is truly uni-directional in the cross-section).

Appendix - License agreement

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