TÜV
CERT
EN ISO 9001 : 2000

Severe hot environments microclimate (PHS)

User's Manual
Updated on 27/12/2007

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1.Introduction

LSI LASTEM Microclima for severe hot environments (PHS) is the LSI LASTEM program that implements the European Norm UNI EN ISO 7933: "Ergonomics of the thermal environment – Analytical determination and interpretation of heat stress using calculation of predicted heat strain (PHS Predicted Heat Strain Model)".
With this program it is possible to calculate the heat stress on individuals operating in severe hot environments.

2. Severe hot environments and the PHS method

The European Norm UNI EN ISO 7933: "Ergonomics of the thermal environment - Analytical determination and interpretation of heat stress using calculation of predicted heat strain (PHS Predicted Heat Strain Model)" replaces the previous UNI EN 12515 norm: 1999 "Hot environments. Analytical determination and interpretation of thermal stress using calculation of required sweat rate".

The new norm includes a method to evaluate the exposure of individuals who operate in hot environments and features several new diversified elements, while keeping a similar reference base as in the previous norm.

2.1.Main differences with the calculation included in InfoGAP for severe hot environments

It is important to emphasize that the UNI EN ISO 7933 norm: "Ergonomics of the thermal environment - Analytical determination and interpretation of heat stress using calculation of predicted heat strain (PHS Predicted Heat Strain Model)" substantially modifies the calculation for the evaluation of heat stress in severe hot environments.

Referring to the norm as far as the details of the calculation methods are concerned, the main differences with the calculation included in InfoGAP are:

- The calculation determines, minute after minute, the evolution of two parameters, the rectal temperature and total liquid loss in every environment where individuals are working;
- It is therefore possible to define several environments, including rest areas, each characterized by a set of individual's parameters and data that describe, minute after minute, the gradual change of the environmental parameters;
- For the SR determination (protection against excessive dehydration) alarm and danger thresholds have been eliminated, as well as the possibility to determine the effect from the recovery of the liquids lost through sweating while working.

2.2. Limit values for different stress methods

Below is a list of the limit values for different stress methods:

Method	Limit values	
	Non-acclimatized individual	*Acclimatized individual*
Wmax	0.85	1.00
SWmax [g/h]	2.6•(M-32) •Adu	1.25•2.6•(M-32) •Adu
Tremax [°C]	38	38

Method	Limit values	
	Access to liquids	*No access to liquids*
Dmax50 [kg]	7.5% body mass	3% body mass
Dmax95 [kg]	5% body mass	3% body mass

Where:

- Wmax = max. share of wet skin;
- SWmax = max. sweat level;
- Tremax = max. rectal temperature;
- Dmax50 = max. liquid loss related to 50% of the population;
- Dmax95 = max. liquid loss related to 95% of the population;

2.3. Applicability limits of the norm

The norm limits of the environmental quantities and of individuals are:

Quantity	Applicability limit
M•A_{du}	$1.72 \div 7.74$ met•m^2 ($100 \div 450$ W)
I_{cl}	$0.1 \div 1.0$ clo ($0 \div 0.155$ m^2°C/W)
ta	$15 \div 50$ °C
tr – ta	$0 \div 60$ °C
va	$0 \div 3$ m/s
pa	$0 \div 4.5$ kPa

Where:

- M = metabolic waste [W/m2];
- Adu = total body surface calculated according to the Du Bois formula;
- Icl = static thermal insulation of clothing [clo];
- ta = air temperature [°C];
- tr = average radiant temperature [°C];
- va = air speed [m/s];
- pa = partial vapour pressure [kPa].

3.Using the program

3.1.Starting the program

The program *LSI LASTEM Microclima for severe hot environments (PHS)* can be directly started from InfoGAP; select menu *Microclimate -> Severe hot environment (PHS) -> New (or Open)*; you can also start the wizard to configure the microclimate.

3.2.Main features of the program

The main window of the program is displayed below:
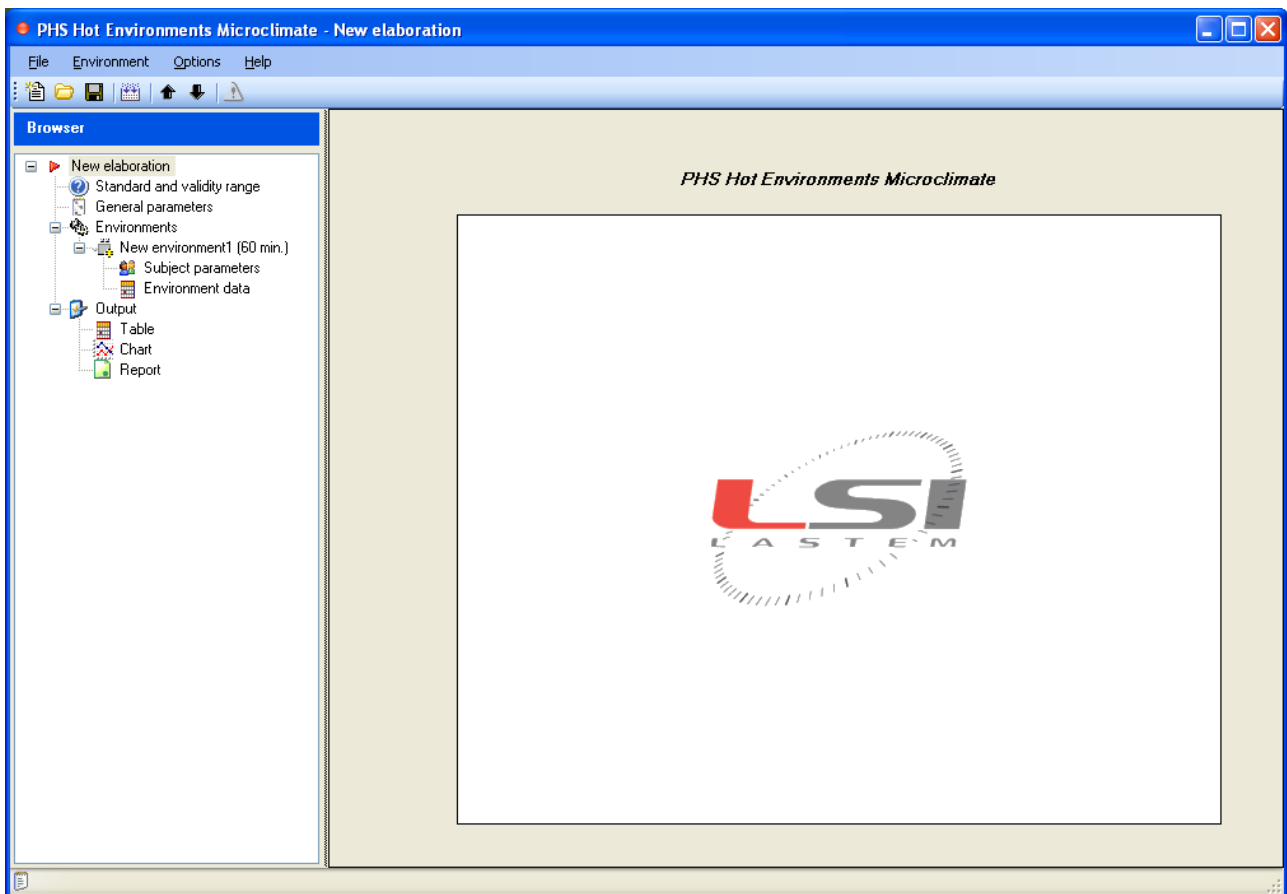
The *Browser* is located on the left of the window and gathers all the elements of the current elaboration. The details of the item currently selected in the *Browser* are displayed on the right.

3.2.1.Menu structure

Use the menu and the tool bar to select all the functions available in the program.

The menu *File* includes:

- *New*: opens a new elaboration;
- *Open*: opens an existing elaboration;
- *Save*: saves the current elaboration;
- *Save as*: saves the current elaboration with another name;
- *Run*: carries out the calculation;
- *Quit*: quits the program.

The menu *Environment* includes:

- *Add*: adds an environment to the environment list;
- *Copy*: copies the selected environment in a new environment which is then added to the environment list;
- *Remove*: deletes the selected environment from the environment list;
- *Move up*: moves the position of the selection environment upwards;
- *Move down*: moves the position of the selection environment downwards;

The menu *Options* includes:

- *Chart settings*: sets the options to personalize the results chart.

The menu *Help* includes:

- *Contents*: shows the current document.
- *Check for Updates*: checks for program updates available on the LSI LASTEM site;
- *About this Applications*: shows information about the application, including the version.

3.3.The elaborations

All data related to the settings of an elaboration are saved on a file with a default extension (.phs). Phs files contain all settings of the environment and the individual, as well as the environmental data loaded when using the program.

## 3.3.1.Creating or opening an elaboration

To create a new elaboration select *File -> New* or click on ▤. To open an existing elaboration, select *File -> Open* or click on 📁 and select the desired file.

3.3.2.Saving an elaboration

To save a current elaboration on the same file it was loaded from select *File -> Save* or click on 💾. To save the elaboration as a new file select *File -> Save as...*.

3.4. The Browser

The *Browser* gathers all the elements of the current elaboration.
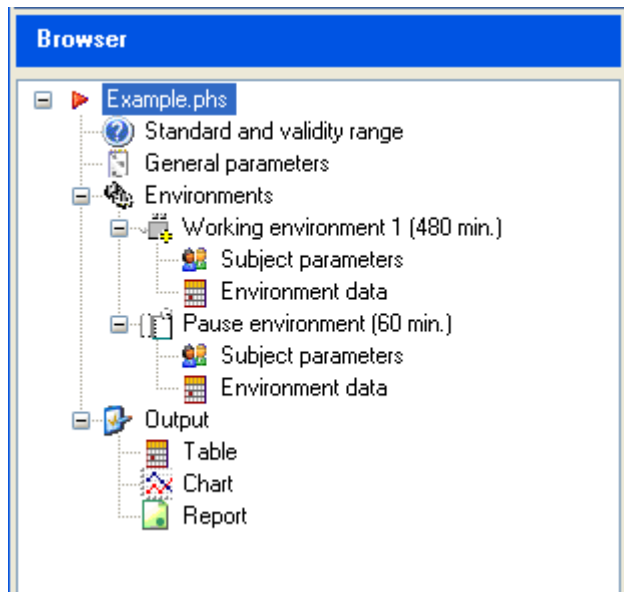
The details of the item currently selected in the *Browser* are displayed on the right. The main item contains the name of the elaboration; the other items are:

- *Standard and validity range*: displays the applied norm and the reference limits for all the quantities; the information is only displayed here and is used as reference; the values cannot be modified;
- *General parameters*: contains the general parameters of the elaboration and psychrometry;
- *Environments*: contains the list of the environments used for the calculation; There are two items for each environment: *Individual's parameters and Environmental data*. Besides, the name of the environment includes information about the length of the operator's stay;
- *Output*: contains the results of the elaboration. It also contains the items *Table, Chart, Report*.

All data modified in a selected item are memorized each time another item is selected, when the elaboration is saved or when the program or the calculation is terminated.

3.5. General parameters

This item contains the general parameters of the elaboration and psychrometry:

- *Description*: brief description of the elaboration
- *Subject height* in meters;
- *Subject weight* in kg;
- *Acclimatized subject*: if selected indicates that the individual has been acclimatized to the environment in which he/she operates;
- *Psychrometric standard*: indicates the norm selected for the calculation of the humidity (ISO 7726 or VDI 3786);

- *Psychrometric constant*: used for the calculation of the psychrometric quantities. This constant's value depends on the physical characteristics of the psychrometric sensor. Reference values are:

  - Standard ISO 7726 K=0.000667;
  - LSI LASTEM sensor mod. BSU102 (portable line) K=0.000735;
  - LSI LASTEM sensor mod. BSU102 (line for fixed installations) K=0.000735.

3.6. The environments

Since the reference norm specifies the need to carry out calculations in every environment where the individual is located, the definition of the elaboration can contain several environments. Remind that:

- Each environment is characterized by the length of the operator's stay, individual's parameters and environmental data measured in the environment;
- The environmental data must be elaborated every minute during all the time the operator remains in the environment;
- The calculation determines the variation of the parameters of the individual's rectal temperature and max. liquid loss and is carried out in a sequence from the first minute of stay in the first environment to the last minute of stay in the last environment; therefore, the sequence of the many environments must correspond to the actual sequence of the individual's stay;
- The environments can be rest or work areas: in this case, consider that the norm might not be adequate to describe the evolution of the parameters subject to calculation.

To insert a new environment select *Environment -> Add.*
To insert a new environment copied from an existing one, select an environment and use the menu *Environment -> Copy.*
To eliminate the environment definitively select *Environment -> Remove.* It is also possible to exclude an environment from the calculation by disabling it (without actually being forced to delete it).
To move the position of the selected environment use *Environment -> Move up* or *Environment -> Move down*.

3.6.1. General data of an environment

To define the general data that characterize an environment select the environment in the *Browser*. The data are divided in two panels:

Environment general data

- *Name*: name of the environment (must be univocal);
- *Enabled to computations*: if selected indicates that the environment will be used for the calculation, otherwise it will be ignored;
- *Activity type*: indicates whether the environment is a rest or work area;

- *Duration*: indicates the length of the individual's stay expressed in minutes;
- *Remarks*: possible notes about the environment.

Compute of partial water vapour pressure

Select the calculation method used to calculate the partial vapour when the corresponding channel measured by the instrument is missing. There are two methods available:

- Uses the ambient temperature, the humid bulb temperature and the atmospheric pressure;
- Uses the ambient temperature and relative humidity.

3.6.2.Parameters of an individual

To define the individual's parameter of an environment select *Subject Parameters* in the *Browser*. The data are divided in two panels:

Environment subject parameters

- *Activity*: sets the value of the metabolic activity in met or in W/m^2; by setting the values in a measurement unit the program converts it automatically into the other;
- *Clothing*: sets the value of the static thermal insulation of clothing in clo or in $m^2°C/W$; by setting the values in a measurement unit the program converts it automatically into the other;
- *Mechanic performance*: sets the value of the mechanic performance in %;
- *Body posture*: Sets the posture of the individual.

Click on *Load* to display the individual's parameters library defined by InfoGAP. To add individual's parameters to this library using the composition functions of InfoGAP start InfoGAP and use the menu *Microclimate --> Subject parameters settings*.

Environment supplementary subject parameters

This panel sets the additional individual's parameters requested by the calculation method. Usually, the default values are to be kept. To modify the values check the box *Select to change default values and edit environment supplementary subject parameters*.

- Body fraction with reflective clothes;
- Thermal static isolation of the limit coating [clo]; default value 0.111;
- Static permeability index [adimensional]: default value 0.38;
- Emission power of the reflective clothes [adimensional]: default value 0.97;

When available, it is moreover possible to set a value for the individual's movement speed and a value for the relative movement direction; by default, these values are not included.

3.6.3. The environmental data

To define the environmental data of an environment select *Environmental Data* in the *Browser*. This panel contains a table that displays the selected environmental data.

Environment Data

Environment duration (min): 480   Load data

Minutes	Air temp. (°C)	Rad. temp. (°C)	Air speed (m/s)	Part. wat. vap. (kPa)	Globe temp (°C)	Rel. humidity (%)
1	40,00	6,39	0,10	3,69	22,00	50,00
2	40,00	6,39	0,10	3,69	22,00	50,00
3	40,00	6,39	0,10	3,69	22,00	50,00
4	40,00	6,39	0,10	3,69	22,00	50,00
5	40,00	6,39	0,10	3,69	22,00	50,00
6	40,00	6,39	0,10	3,69	22,00	50,00
7	40,00	6,39	0,10	3,69	22,00	50,00
8	40,00	6,39	0,10	3,69	22,00	50,00
9	40,00	6,39	0,10	3,69	22,00	50,00
10	40,00	6,39	0,10	3,69	22,00	50,00
11	40,00	6,39	0,10	3,69	22,00	50,00
12	40,00	6,39	0,10	3,69	22,00	50,00

Color data legend: Acquired values;   Calculated values;

Click on *Load data* to load the data.

The table displays the necessary data for the calculation of every minute the individual remains in the environment and indicates whether the channel is acquired or calculated. The data necessary for the calculation are:

- Ta: air temperature [°C];
- Tr: average radiant temperature [°C];
- Pa: partial vapour pressure [kPa];
- Va: air speed [m/s].

The table also display channels not used directly for the calculation but possibly used to calculate the channels necessary for the calculation.

Use the contextual menu or the key combination CTRL + C to copy the selected cells to the Windows clipboard and then paste the results in another application (for example Word or Excel).

ATTENTION
It is necessary to reload the environmental data after modifying the psychrometry settings or the length of the operator's stay in the environment.

3.6.4.Loading the environmental data

Click on *Load data* in the *Environment Data* panel of an environment to load the data.
From the window from which the data are loaded it is possible to select the origin survey of the data as well as to define quantities and the extraction and elaboration options of the data.
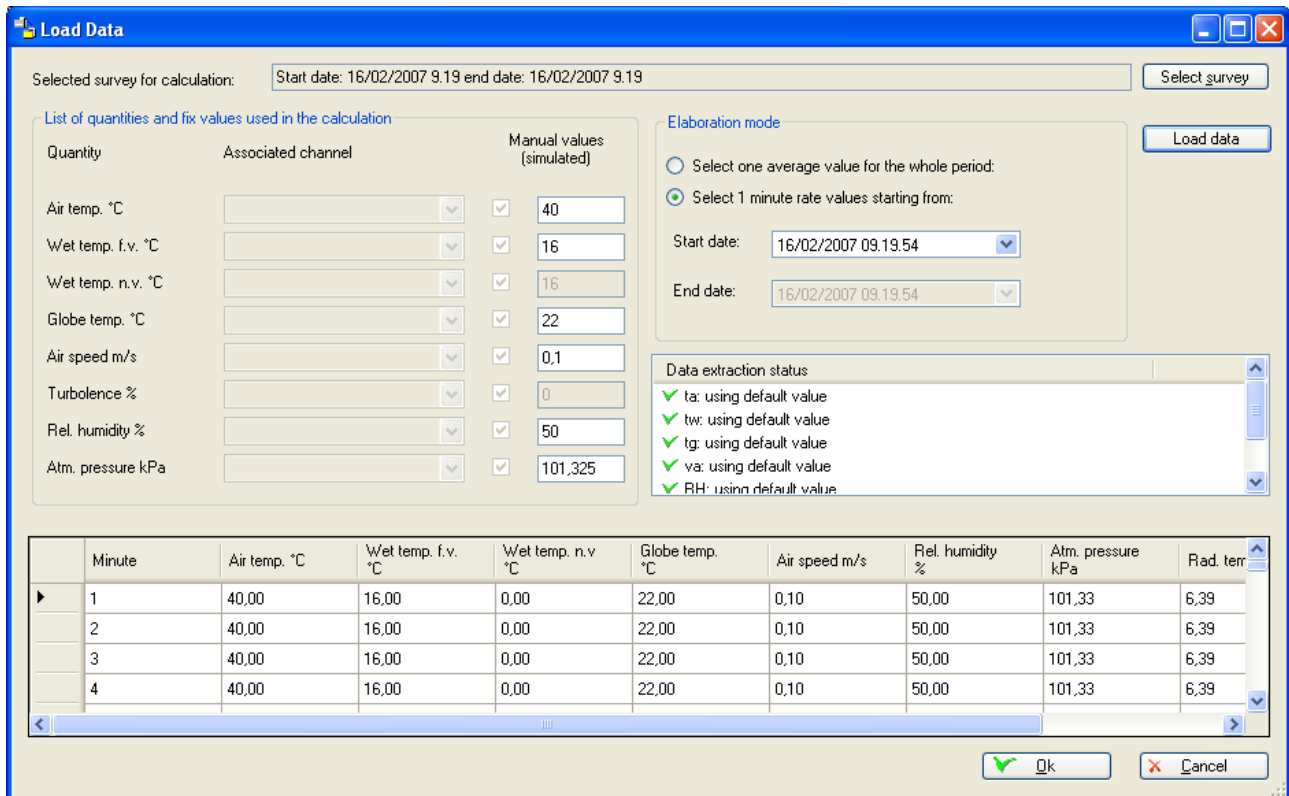
Once the survey is selected, from which the data are extracted when clicking on *Select survey*, the channels of the survey available for the many necessary quantities will be listed (disabled quantities are not used for the calculation); the user can decide whether to:

- Use the channel present in the survey;
- Choose the channel in case the survey contains more channels fit to represent a certain quantity;
- Set an alternative value to use if the channel is missing or to replace the indicated channel; to use the alternative value check the box beside the channel to activate the field in which it can be entered.

After choosing the mode of the survey channel proceed to set the elaboration mode. The user can choose whether to:

- Select an average value for the whole period;
- Re-elaborate the data with a fixed one-minute rate.

If only one average value for the whole period is chosen it will be necessary to select the time period for the elaboration of the data; if the fixed one-minute rate is chosen it will be necessary to select only the initial date.

If the one-minute rate is chosen bear in mind that:

- If the original data are available with a higher elaboration rate (for example: 10 minutes) the intermediate data will be interpolated between two extremes;
- If the survey and the initial date chosen for the re-elaboration are not enough to cover all the period scheduled for the individual's stay in the environment, the data will be extended replicating the value of the last valid data;
- If there are no data in the selected period or in case of errors the default values will be used.

Upon termination of the settings click on *Load data* to load the data. The *Data extraction status* panel displays useful information on the data load procedure. The table located in the lower part of the window displays, instead, the loaded data.

Click on *Ok* to import the data in the calculation.

ATTENTION
After returning to this window, from the panel "Environment data" of the selected environment, once the data are loaded, only the settings will be visible and not the loaded data.

3.6.4.1.Selecting the survey

Click on *Select survey* in the data load window to select the survey to load the data from. The window for the selection of the survey displays all the tools and the surveys memorized in the database of InfoGAP listed according to the instrument's serial number.

ATTENTION
When selecting the survey, the license for the activation of the calculation module "Microclimate for hot environments model PHS" is verified: in case the selected instrument is not activated it is

possible to enter the license key directly, otherwise it won't be possible to select the survey. The calculation module "Microclimate for hot environments model PHS" uses a different license that that of the previous module "Microclimate for hot environments".

3.6.4.2.InfoGAP database update

When the contents of the InfoGAP database are updated during an elaboration (by importing instruments and/or surveys, or by unloading new data), it will be necessary to save the current elaboration, close it and open it again to gain access to the new updated data.

3.7.The calculation

To carry out a calculation select *File -> Run* or click on [icon]. This procedure will check the integrity of the data: in case of failure the panel below will be displayed:
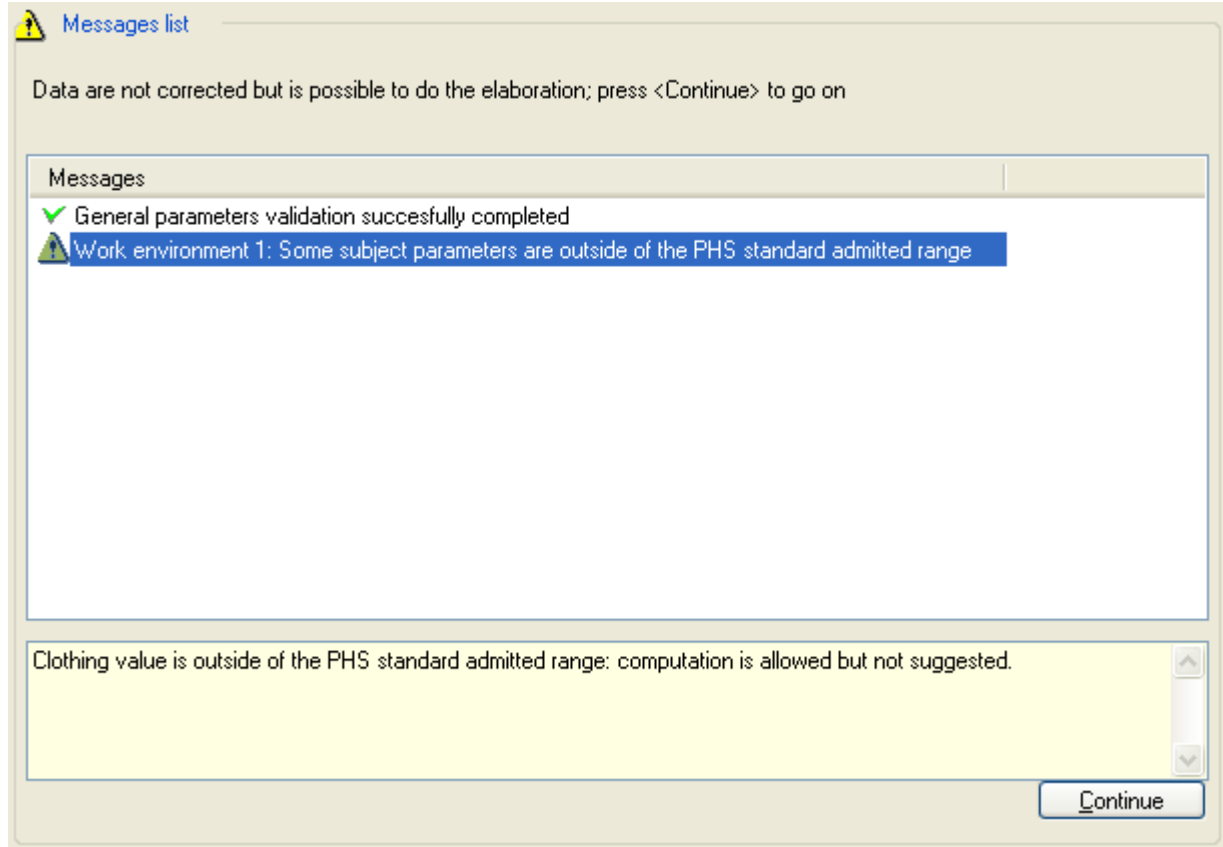
This procedure may generate error messages that will block the calculation or warnings that will advise to proceed with attention; however it is not advisable to continue if there are values outside the limits set by the norm. Select an item from the list to display additional information in the text box below the list.

To display the message panel again select the [icon] icon in the icon bar.

3.7.1.Checking data integrity

The program will check the data integrity before carrying out the calculation. More specifically, it will check if:

- The many entered parameters are consistent with the limit values set by the norm;
- The total length of the individual's stay in the many environments is not over 24 hours;
- The environmental data have been set with values consistent with the limits set by the norm.

Disregarding the limits of the norm on environmental parameters and individual's parameters will only produce a warning message; the user can anyway decide to carry on with the calculation.

3.8.Results of the calculation

After the calculation it is possible to see the results, which can be selected in the *Browser* in *Results*, in four different ways:

- Page with a review of the main results;
- Table with a review of data calculated each minute;
- Chart;
- Report.

3.8.1.Main results page

The main results page is displayed automatically upon termination of the calculation and includes the data below:

To activate this page go to *Output* in the *Browser*.

3.8.2.Results table

The results table, for each minute of elaboration, displays the following values;

- The operator's rectal temperature compared to the maximum admissible value;
- The operator's liquid loss compared to the maximum admissible value expressed for both the fiftieth and ninety-fiftieth percentile of the population, whether the operator can have access to liquids or not.

Moreover, a sub-division of all data for each environment is also displayed. A green symbol indicates that the calculated value falls within the limits set by the norm; a red symbol indicates that the calculated value exceeds the limits set by the norm.

To activate this table go to *Results -> Table* in the *Browser*.

Use the contextual menu or the key combination CTRL + C to copy the selected cells to the Windows clipboard and then paste the results in another application (for example a word or spreadsheet processor).

3.8.3.Results chart

The chart with the results displays, for each minute of elaboration, the flow of the following values:

- Operator's rectal temperature;
- Operator's liquid loss

Moreover, it displays the sub-division of the data in the many environments and shows the values related to the position of the mouse pointer.

To activate the chart go to *Results -> Chart* in the *Browser*.
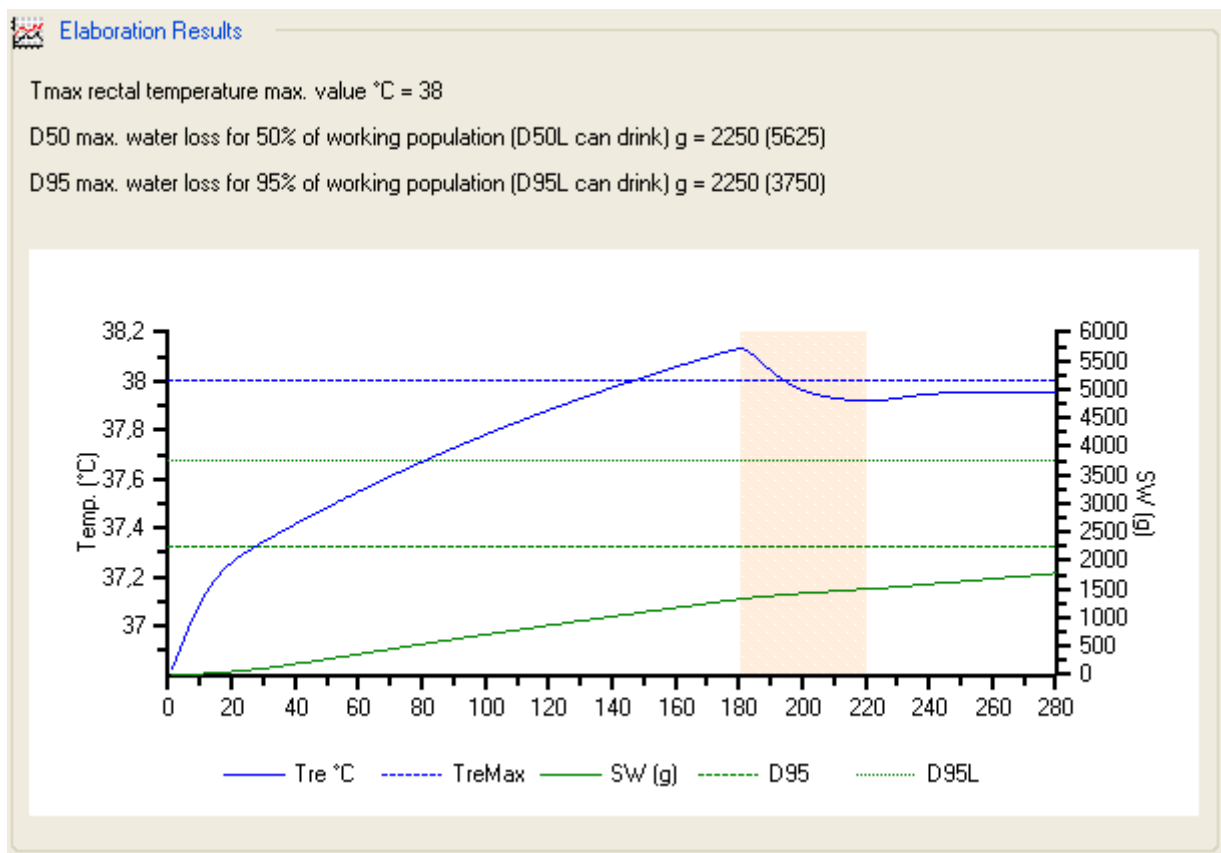
Select *Option -> Chart settings* to define:

- Style, thickness and color of the lines representing both variables;
- Style, thickness and color of the lines representing all limits set by the calculation;
- Which variables and limits should be displayed;
- Whether to display the legend for the data:
- Whether to display the sub-division of the chart in environments:

Click on the right button of the mouse to activate a contextual menu on the chart to be able to:

- Save the chart as a file;
- Print the chart;
- Copy the image to the Windows clipboard to be able to paste it in other applications.

3.8.4.Results report

The results report displays a full report on the calculation and its results. It is based on the printing properties indicated by the default printer, which has to be defined in the system.
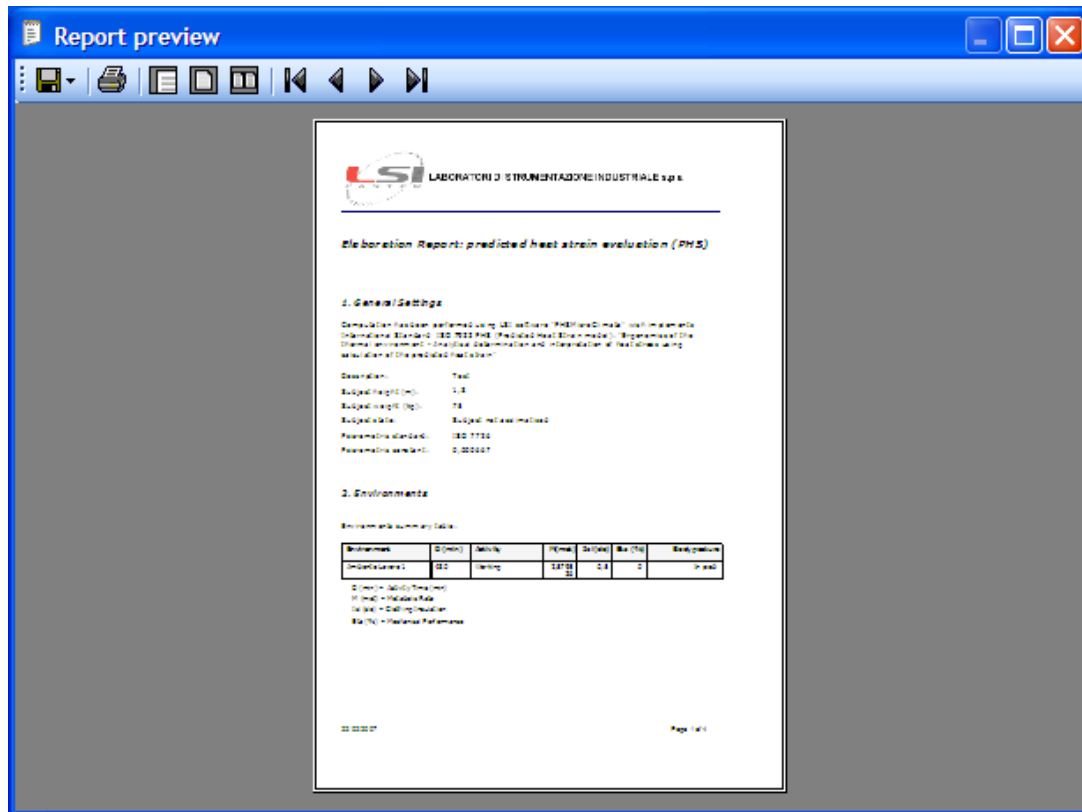
The report includes the following information:

- A brief written introduction (optional);
- The normative reference used to carry out the calculation (optional);
- The general settings used for the calculation;
- The individual's parameters for each environment;
- The environmental data for each environment (optional);
- The results chart
- The results table for each minute (optional);

After selecting *Report* in the *Browser* and the optional settings click on *Display Report* to open the preview window. In this window it is possible to:

- Modify the view in one page, two pages or actual size;
- Navigate throughout the report;
- Print the report;
- Save the report in several formats:
  - Pdf;
  - Html;

- Rtf.

3.8.4.1.Changing the logo

To change the logo located in the upper part of the report change the image;

```
C:\Documents and Settings\All Users\Dati applicazioni\LSI-
Lastem\LSI.PHSMicroClimate\ReportTemplate\it\PHS001\Logo.jpg
```

If the folder above is not available set the visualization of the hidden folder by using the option available in Windows *Explorer*.