HOT

There are few computer programs available to assist occupational hygienists, particularly in teaching hygiene. In evaluating the thermal environment, students often are confused between heat stress and thermal comfort. They cannot get a feel for the different concepts. The program "HOT" was developed to give an interactive interface to evaluate heat stress and thermal comfort. It was also used as an excuse to learn Visual Basic!

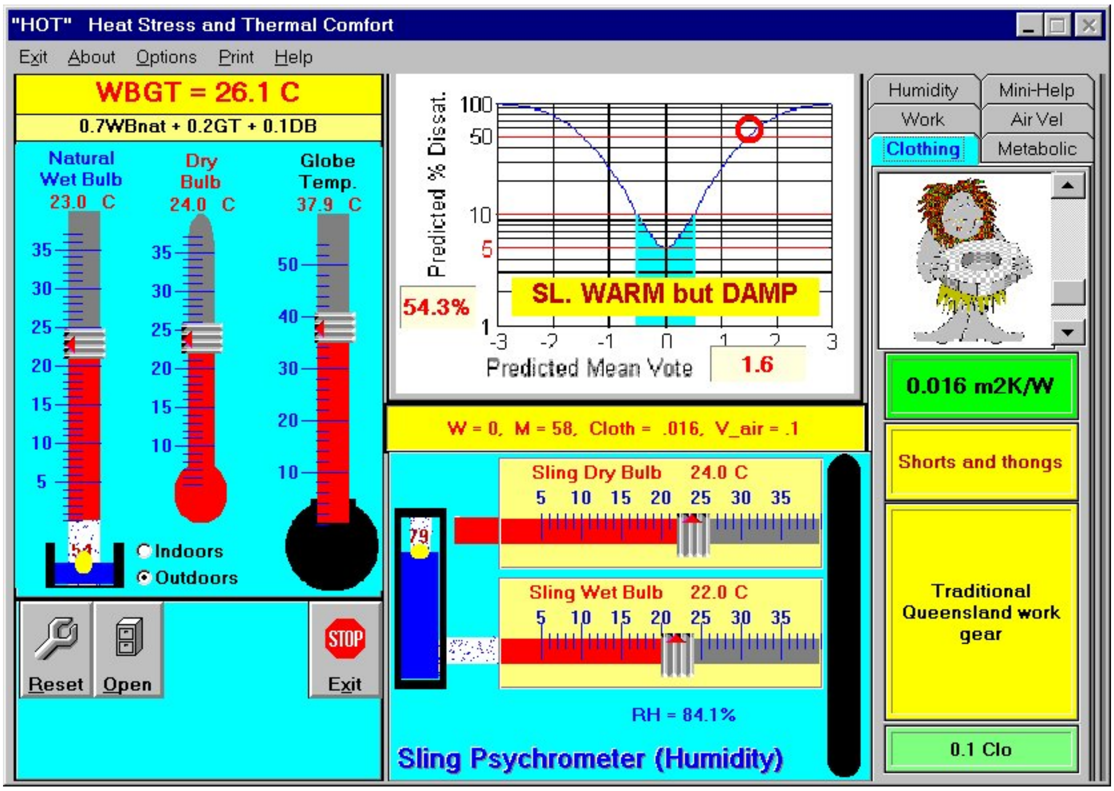
• *Visual Basic*

Visual Basic is upside down programming. The human interface for a program is generally considered to take up about 70% of the time to develop a program. Code is written in a language like C or Fortran to solve the data manipulation parts of the problem, then the input interface - boxes prompting keyboard entry, a mouse click or movement, are constructed. Simultaneous output of data as graphs or numbers or text allows feedback to the user. A program that is not "user friendly" will not sell.

Visual Basic starts with the visual interface from a menu of boxes, buttons graphs and controls. Each element may have dozens of attributes like text size, colours, default values or text strings for gauges or boxes and the like. This allows rapid program development. Code is then written to link all the elements to make the program. Other tools allow the code to be compiled to an executable file and distribution disks to be made. The look and feel of even a complex program can often be constructed in hours. It is also a relatively simple to link the programs to interact with other programs, including Microsoft Word, Excel and Access. A cut down set of Visual Basic is the macro language for these three programs. Use of Visual Basic in another project gave the impetus for me to develop "HOT" using Visual Basic Professional version 3.0.

• *HOT*

A frame grab from the beta release of "HOT" for Heat Stress and Thermal Comfort is shown below.



(the picure above has been updated from the version published)

The design of the interface went through a number of changes, each to make the use of the program more intuitive. A good program should not need a manual. Colour, placement and grouping of controls (sliders) and other elements are all very important. To reduce clutter, the messages on some of the controls only stay visible for about 10 seconds after a control is used. Even less clutter and better presentation of information will improve the program.

• *Heat Stress (WBGT)*

There are about 70 different heat stress indices, most not in common use. The most well known index is probably the WBGT as it is documented in the ACGIH TLV documentation and ISO standards. Two forms of the WBGT are used - for indoors and outdoors. Outdoors, a Globe Temperature reading would overestimate the radiant heat contribution as the sun sees half of a Globe Thermometer but mainly the head and shoulders of a person. In the figure, the indoor WBGT is shown. A symbolic representation of the Natural Wet Bulb and the Globe Temperature assist the user to identify the appropriate control. Sliders were placed next to gauges, shown as thermometers with a moving mercury column. As with Windows programs, the sliders can be dragged for rapid movement, clicked on the arrows for fine changes, or between the slider and the arrow for an intermediate size change. The position of the slider has been programmed to correspond to the top of the mercury to make their use intuitive. Default values are used when the program is first run to make the program more intuitive. In the figure, the indoors WBGT is shown with the Dry Bulb faded and its slider not visible. A rule prevents the Natural Wet Bulb from exceeding the Dry Bulb. The Globe Temperature can take any value. The WBGT could be calculated manually, but it is there to contrast the more complex Thermal Comfort Calculation.

Future versions of HOT will show the WBGT value graphically on a WBGT- Metabolic Rate graph. This will be linked to Metabolic Rate control. Acclimatisation will also be added. The desired Work-Rest regime will also be displayed. Other heat stress indices will also be added, but this will mean that clutter will be a problem.

• *Thermal comfort*

The trend towards office work will continue, so thermal comfort can be expected to become a bigger issue. Hygienists spend more time in offices than the field, so being able to evaluate the local thermal environment, particularly when there are complaints that it is too hot or cold, can be invaluable. Few can afford the Thermal Comfort Meters that are available, but with little more than a humidity measurement, a smoke tube estimate of air velocity and a Globe temperature and sensible air temperature measurement.

The calculation of Thermal Comfort is easy with a computer as the calculation has to iterate the solution. The calculations are based on Turbo Basic code published by Parsons (1993). The variables are:

- **Globe Temperature.** The value is often close to the Dry Bulb, but can be much higher of lower than the sensible air temperature. In an office, a black pig pong ball could serve as a Globe Thermometer as convective heat trnsfer is usually low.
- **Humidity.** . A rule prevents the Natural Wet Bulb from exceeding the Aspirated Wet Bulb. If the measurement is done with an electronic thermometer, then the Aspirated Wet Bulb is adjusted to give the right relative humidity reading. Absolute Humidity - the partial pressure of water vapour, rather than Relative Humidity is used in the calculations.
- **Dry Bulb** is made the same for the Sling and WBGT dry bulb. In practice, there is often a small difference in the readings due to thermometer quality or radiant heating of alcohol in cheap thermometers. Aluminium foil around the bulb reduces this difference.
- **Thermodynamic work**. This may be changed, but for practical purposes it is zero. HOT automatically resets the value to zero after 10 seconds. It is there for completeness.
- **Metabolic Rate** using discreet tabulated values and a description of the type of activity. The display showing the type of work is only shown for 10 seconds after setting a new value to reduce clutter.
- **Clothing**. A picture shows the type of clothing and a description of the clothing from naked to polar. Clothing is insulation from hot or cold, but also reduces evaporation of sweat and convective heat and radiative gains or losses. With some research, values for PPE could be

included to show the effect of overalls and other PPE. The graphics are currently from Microsoft Powerpoint, so may appear familiar.

- **Air Velocity**. This value is particularly interesting when it is used to evaluate the effect of introducing greater air movement to solve a heat stress problem. Little effect is seen when the problem is radiant heat.

Every time a value is changes, Fanger's thermal comfort equation is solved for the Predicted Mean Vote (PMV) and the Predicted Percentage Dissatisfied (PPD). Here a PMV of 1.6, PPD of 58.5% and evaluation as "SLIGHTLY WARM" are shown on the graph. A circle moves along the curve, instantly showing the degree of change. When the PPD value less than 10%, the circle changes colour and the message "THERMAL COMFORT!" is displayed. This corresponds to a PMV or ± 0.5. A PPD of less than 10% is the target, and this accounts for the shaded area under the curve.

The curve bottoms out at 5% dissatisfied, as in optimal conditions, 2.5% could be expected to be warmer and 2.5% would want it cooler. Some students do have some problem understanding that this is a model, and workplace expectations have a major influence on the level of complaints.

No corrections have yet been programmed to account for published suggestions for modifying the index, or known changes between summer and winter.

Code for calculating Fanger's Thermal Comfort Index is in ISO 7930 as Fortran. A modified version of this code has been used for the past five years at Griffith University. The code in this program is based on Turbo Basic code in an Appendix to Parsons (1993). If there are sufficient requests for the program it will be released as "freeware" on the Internet via my FTP site.

ftp://plato.ens.gu.edu.au/sys/xfers/hygiene/HOT08.ZIP (this link is now dead)

The program fits onto a 3.25" floppy and installs into a directory of your choice. The source code will not be made available.

• References.

ISO 7730. 1984. Moderate Thermal Environments - Determination of the PMV and PPD indices and specification of the conditions for thermal comfort, Geneva: International Standards Origination.

Parsons K C. 1993. "Human Thermal Environments. The effects of hot, moderate and cold Environments on Human health comfort and performance" Taylor & Francis

Olesen B W. 1982 "Thermal Comfort" Technical Review No 2, Bruel & Kjaer, Denmark ISSN 0007-2621

ACGIH, 1994. Documentation of Threshold Limit Values and Biological Exposure Indices. 6th Ed. American Conference of Governmental Industrial Hygienists, Cincinnati.

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This was originally published in the Australian Institute of Occupational Hygienist's Newsletter July 1996