A productive environment for production personnel

Whitepaper

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A productive environment for production personnel

It is well known that people's behaviour and attitude to work is very much influenced by the quality of their working environment and this has been proven by numerous academic studies and experiments. An uncomfortable working environment leads to low productivity. Comfort depends on several factors, including temperature, air quality, humidity, air movement, what clothing is worn and what activity is being performed. The ISO 7730 standard provides guidance on defining and setting thermal comfort criteria for normal working environments.

A good working environment

It is essential that a good environment is created where people work. High internal temperatures combined with body odours, over moist air or too little air movement can be problematic. The human body will always seek to maintain an equilibrium temperature (37°C). The body absorbs heat through radiation, convection, and carrying out work. It releases heat by evaporation through the skin, convection and radiation. The normal ratio for human heat transfer is:

- 45% by radiation
- 30% by convection
- 25% through evaporation.

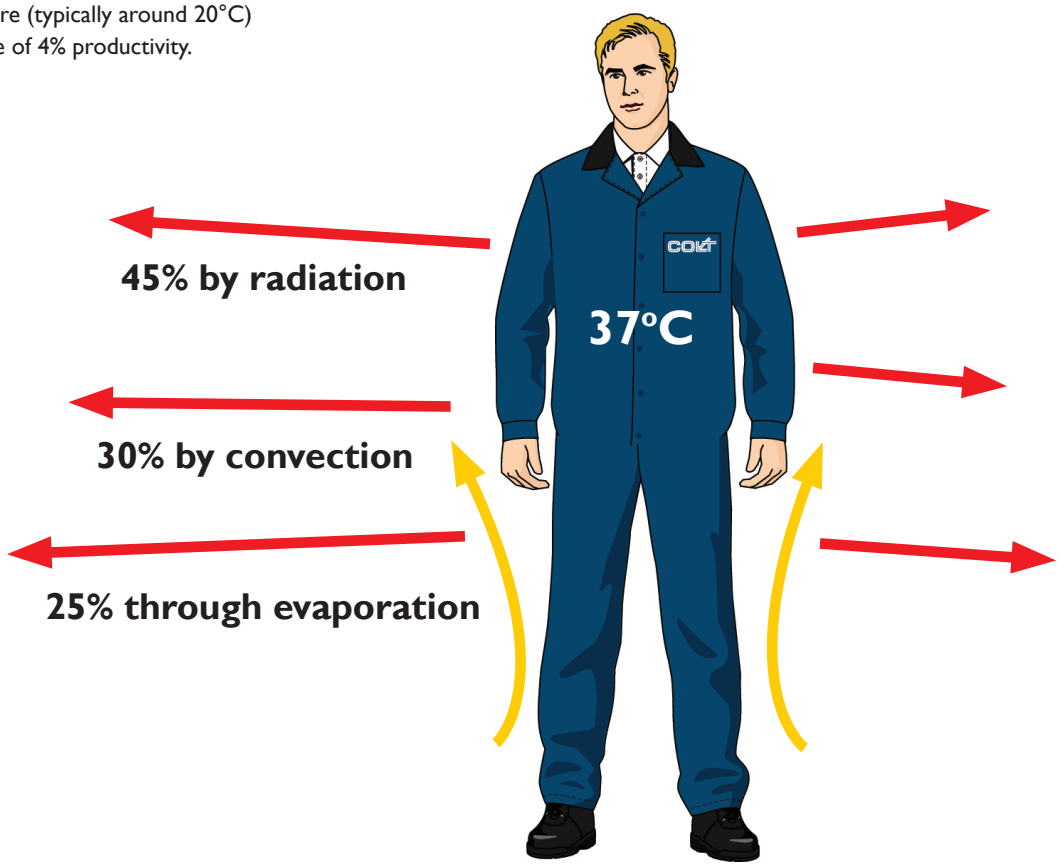
Thermal comfort is achieved when the absorption and release of heat are in balance. However if, for example, the radiation transfer is reduced, the body seeks other ways to maintain a balanced temperature. As a consequence, the body sweats to increase evaporation and under these conditions people feel uncomfortable and listless. Experiments, practical tests and measurements show that every degree above the most comfortable working temperature (typically around 20°C) gives rise to an average decrease of 4% productivity.

But how can we define what conditions are really comfortable? A person who is exerting them self will want different conditions compared to the person who is doing light work.

Several academics have researched this. One of the best known is Professor P. O. Fanger. His work forms the basis for the ISO 7730 standard.

To assess thermal comfort in a particular place it is important to quantify the various influencing factors and analyze them. ISO 7730 is a good starting point.

Safety
Higher temperatures are not only uncomfortable and therefore detrimental to the efficiency of people. If the temperature exceeds certain limits it has implications for people's safety and responsiveness and the probability of accidents increases.



ISO 7730

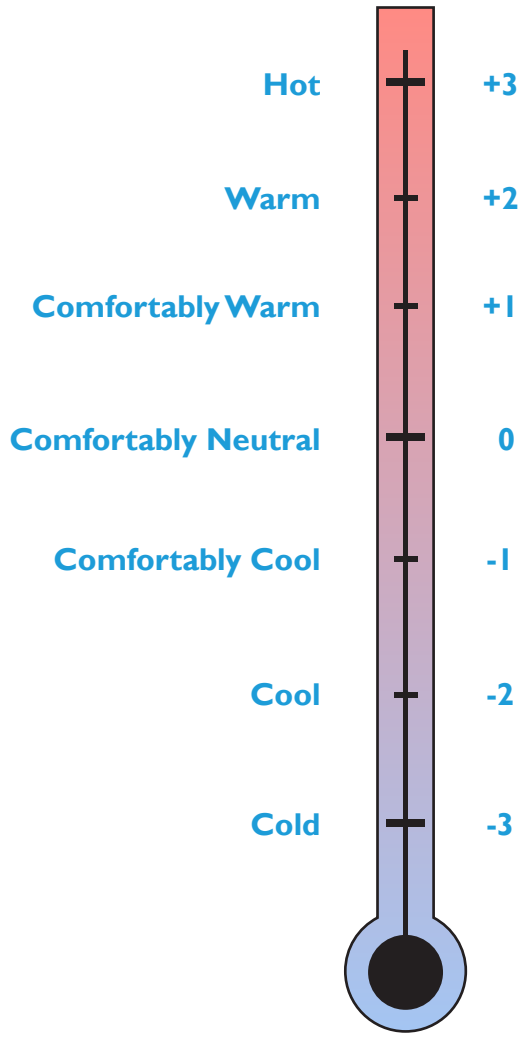
ISO 7730 gives recommendations for a comfortable thermal environment for normal indoor conditions. This international standard provides methods of calculation of recorded PMV and PPD values (see box). The benefits of PMV and PPD are that they allow the level of comfort of any set of conditions to be assessed and they also allow comparison of different or combined methods (cooling, humidification, dehumidification, increased air movement, etc) of improving comfort.

Assessment of PMV takes place using a 7-point scale as described below.. This is only suitable for reasonably "normal" conditions. For very hot or very cold conditions different standards apply.

ISO 7730 is important for anyone responsible for designing and maintaining the internal climate in buildings or other situations where people live or work.

The Fanger Model

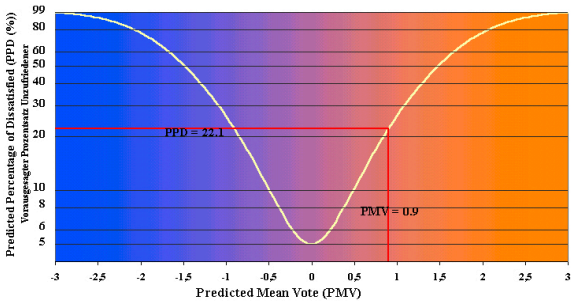
Fanger's theory was developed in the 1970s and is based on studies in the laboratory and in environmental chambers. Participants were dressed in standard clothing, they carried out different kinds of activities, and were exposed to different conditions. Participants were asked to indicate how hot or cold it felt on the ASHRAE 7-point scale.



PMV and PPD values

PMV is an abbreviation for Predicted Mean Vote. It is assigned an objective value that lies between -3 and 3 in which zero can be considered as thermal balance.
A positive value is "hot" and a negative value is "cold".
PPD stands for Percentage of Persons Dissatisfied, and it is derived from the PMV value. A PMV value of "0" has an associated PPD value of 5% (you can never expect to satisfy everybody).

A common objective is to maintain the internal environment to give a PMV between the values -0.5 and +0.5, which correspond to a PPD value of 10% (see illustration). This range is needed because conditions rarely remain totally constant, either the internal heat load changes (e.g. lights are switched on) or the weather changes (e.g. the sun moves behind the clouds) through the day.



Existing workplace comfort levels

Research by TNO in the Netherlands (by Houtman and Van den Berg, 2005) demonstrated that 24% of employees consider their workplace as "unpleasant", while 32% believe that temperature control is bad and around 16% suffer from annoying drafts.

Fanger's theory combines four physical variables:

1. Air temperature
2. Relative humidity
3. Air speed
4. Surface radiation temperature

with two personal variables:

5. Clothing
6. Activity level

These are incorporated into a model that can be used to predict the average thermal comfort of a large group of people in an internal space.

Toxins, odours and dust in the air, light, noise, and the psychological condition of a human being also play a big part in defining the level of comfort. These need to be considered but are not covered by ISO 7730. Thermal comfort is mainly determined by the physical and personal variable listed above. Under normal conditions heat is generated by physical activity and the other variables affect the rate and methods of heat loss as the human body exhausts the three possibilities to release heat (by radiation, convection or evaporation) simultaneously.

Temperature
Man constantly exchanges heat with his surroundings by radiation and convection. The ratio of these depends upon the temperatures of exposed surfaces and the surrounding air. Comfort is easiest to achive when these temperatures are reasonably balanced. High asymmetric radiation, for example from a hot surface or a sunny window, can cause discomfort even when the overall heat balance is acceptable.

Humidity
Air humidity should ideally be kept within a limited range. Excess humidity interferes with heat loss by evaporation and can cause a feeling of "clamminess" or excess sweating. Too low a humidity can cause drying out of mucous membranes and respiratory organs. Their ability to function is considerably reduced if they dry out, producing feelings of discomfort.

Air velocity
Air velocity should be low enough to prevent people suffering from draughts. People sitting still generally need lower velocities than people who stand up to work. People who are active can generally tolerate a higher velocity than sedentary people. In high ambient temperatures a high air velocity can be beneficial to improve convective and evaporative heat loss.

Clothing
Clothing can be a significant factor, particularly if safety gear, uniforms or company dress codes force people to wear heavier clothing than they would otherwise choose for the environmental conditions.

Activity Level
The activity level is measured in terms of metabolic rate. The most common method is to measure the heat or oxygen delivery from people doing a specific activity. An alternative method is to measure the heartbeat of a participant. For design purposes generic standard data is usually used.

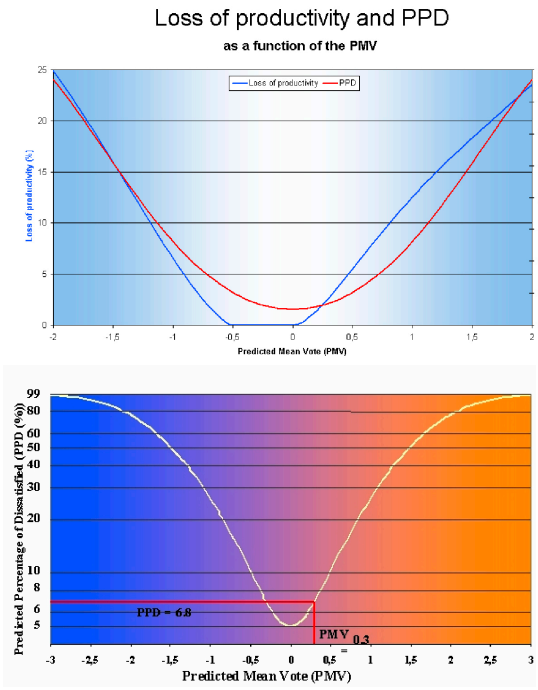
0.04 clo **0.61 clo** **0.76 clo** **0.89 clo** **1.37 clo**

Complaints

Complaints about thermal comfort include::

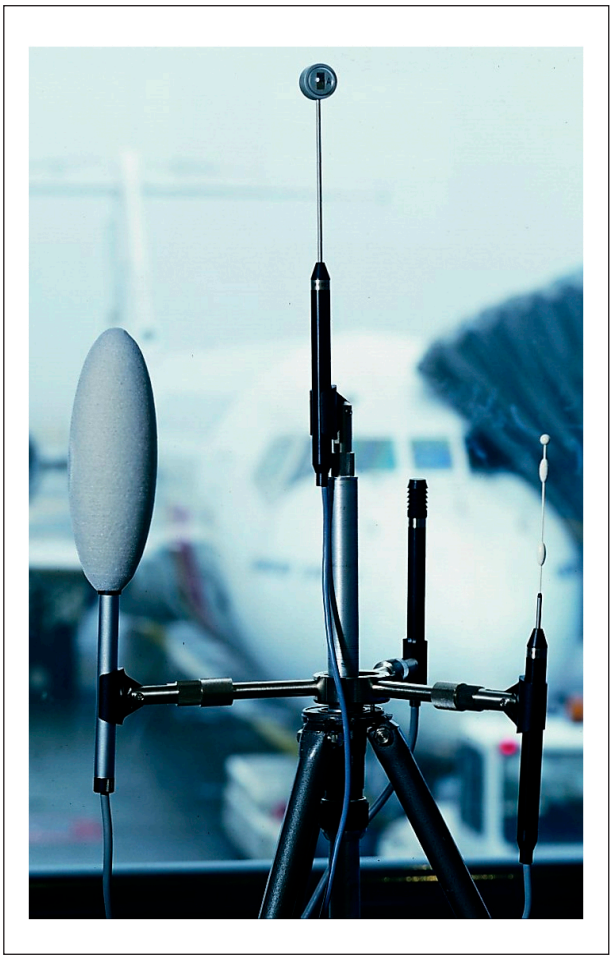
- too cold;
- too hot;
- widely varying temperatures;
- draughts;
- cold radiation;
- excessive direct heat;
- cold feet;
- hot feet;
- too large a temperature gradient between head and feet.

This diagram shows relationship of productivity to the internal environment.



Measuring instruments

In the past, the tools for measuring thermal comfort were not always reliable. Nowadays there are new techniques available which include using a climate analyzer. This is an instrument which has sensors measuring all the relevant parameters, and which records these and calculates the PMV and PPD values. In the absence of a climate analyzer individual readings can be taken and combined using the standard.



Summary

Based upon the work of Professor fanger and experiments carried out in many countries, ISO 7730 effectively allows assessment of comfort levels and potential improvement strategies using the PMV/PPD value.