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'Comfortable conditions' -a target for climatic research workers

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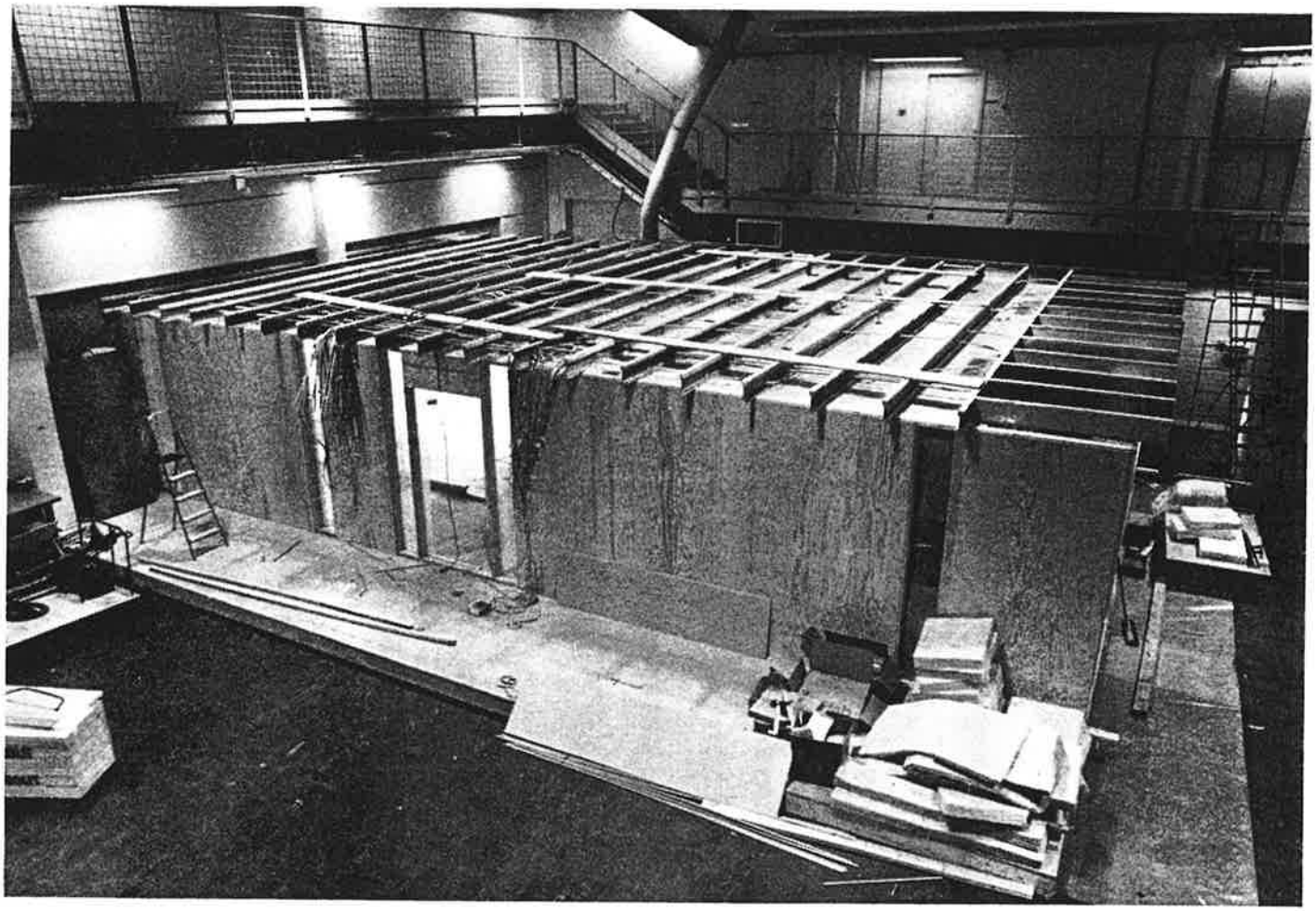
Many different factors influence temperature in our buildings. Their siting in the terrain, wind conditions, solar irradiation, building design, building materials, heating systems and ventilation. . .
The Department of Climate and Building Services at the National Swedish Institute for Building Research (SIB) in Gävle conducts research throughout this entire spectrum. The Institute also investigates the influence of climatic factors on building occupants and the requirements imposed by various activities and users.



A complete apartment has been built in the Institute's laboratory hall in order to study the design of efficient ventilation systems. Photo: Tommy Landberg, J-Berg Studio.

The outdoor climate determines the conditions under which a building must operate. The siting and orientation of a building in the terrain affects not only the amount of light and insolation that it receives, but also the ambient temperatures and wind conditions around the building. Insolation, air temperature and wind influence the energy balance of the building. The wind and pressure distribution around the building influence uncontrolled ventilation through gaps in the building envelope, and also influence the performance of mechanical ventilation.

Wind conditions also affect the spread of pollutants from chimneys, vehicles, etc. and can therefore play a part in determining the quality of air entering the building.

Research into outdoor climate and the built environment is carried out both by measurements under real conditions and on a model scale in wind tunnels. The objective is to be able to provide advice and information on what the local climate is likely to be like in a given area, or on how it might be modified if problems are encountered. In the longer term, this work is intended to accumulate knowledge to improve the accuracy of design calculations. In the short term, work may be devoted to specific problems relating to a particular area which is planned, or which is to be redeveloped.

Indoor climate

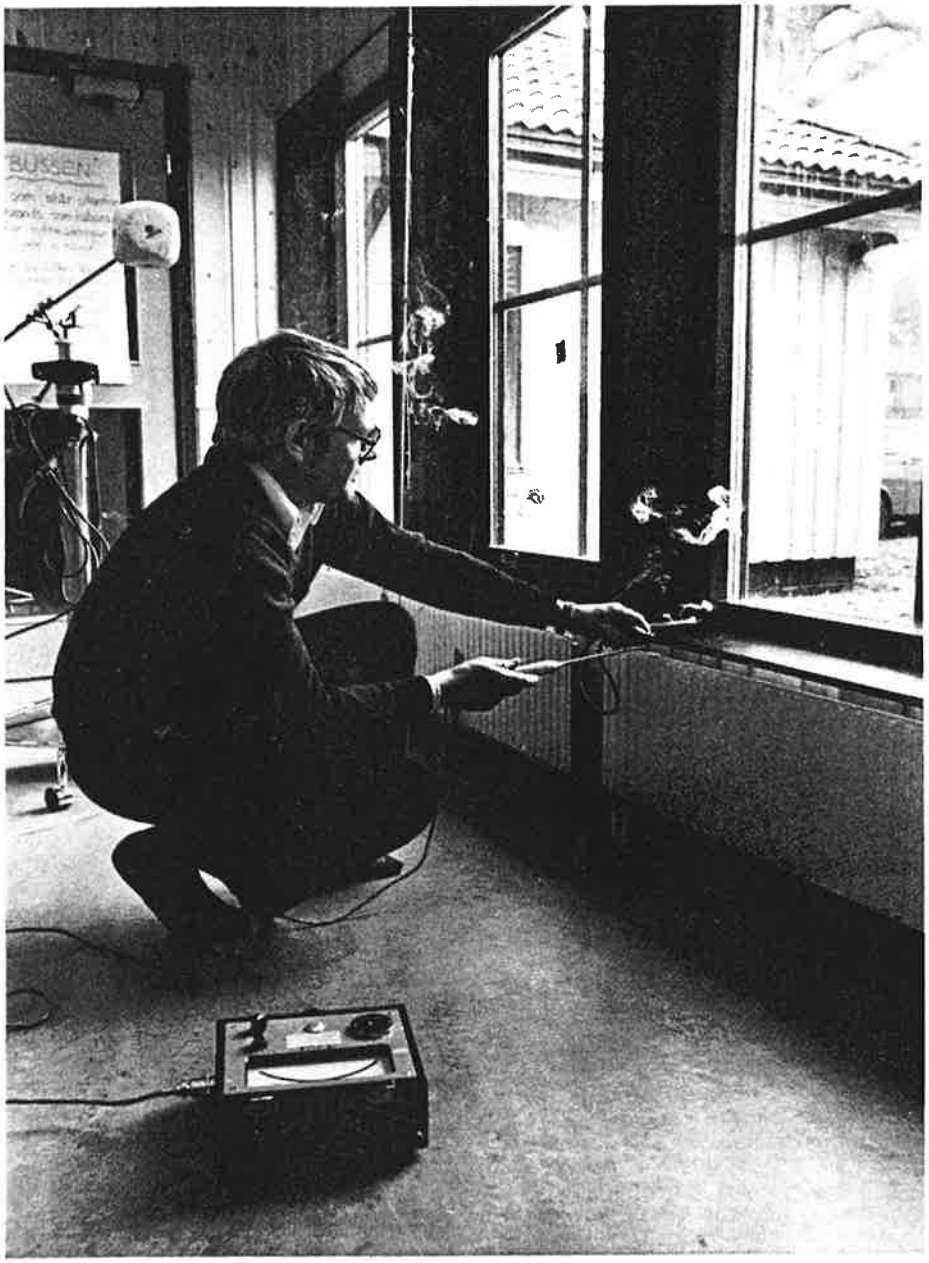
Indoors, we are concerned with establishing a climate which feels comfortable and which facilitates work to the greatest degree possible. The main emphasis of the Department's research is on good ventilation and a thermally correct indoor climate. This means that ventilation must be efficient, to ensure good air quality, while air temperature, room surface temperatures and air velocity must be such that the building occupants experience the overall impression as comfortable.

Full-scale trials

When the target objectives have been established, the next step is to find technical means of realizing them. The building and building services designers must be able to determine the effect of various designs, and of various combinations of properties of walls and windows, heating systems and supply and exhaust ventilation systems. All this represents a complicated interaction, which is still not fully understood, which means that it is sometimes necessary to test new ideas in full scale before they can be applied. For several years, the Institute has had its own laboratory facilities for full-scale tests of indoor climates under varying external weather conditions, providing a simple means of plotting the temperature and air velocity conditions in a room. Over the years, many ideas have been tested for designers and consultants, invariably resulting in suggestions for improvements.

Field measurements

It is not, however, sufficient to rely on laboratory tests alone: it is also necessary to check that the performance in the completed building turns out as planned. The Institute has a special mobile laboratory which carries out tests of this type in the built environment. Field work can embrace everything from thermography (thermal imaging), airtightness evaluation and measurement of air change rate to detailed measurements of air temperatures and air velocities in rooms. The mobile laboratory service is also used for work carried out for other research workers, organisations etc. outside the Institute, often in connection with energy conservation projects.



Measuring the indoor climate in a child day-care centre. The use of smoke enables draughts and air movements to be made visible. Photo: Roland Rygin.

Measurement technology and methods

It is often found, in connection with laboratory trials and site problems that the Institute has been called in to investigate, that there is uncertainty on how the particular property is to be measured. Over the years, the Department, working jointly with other Nordic organisations, has developed methods of measurement, instrument specifications etc. so that unnecessary disputes can be avoided. When the owner or operator of a building wants to check system performance, he should naturally carry out system measurements in the same way as the contractor did when checking performance during the building or installation stage.

Unfortunately, insufficient attention has been paid to adjustment and checking the performance of building system services, and it is hoped that training and the adoption of common rules and methods will improve standards in the longer term.

Measurement of air velocity is a typical example of the type of problems that are encountered. First of all, indoor air flows are at a low velocity, which introduces difficulties, and secondly, they vary more or less irregularly all the time. Air flows are said to be turbulent. If measurements are made for only a short time, there is a risk of obtaining too low or too high values as a result of turbulence. On the other hand, the response of the measuring instrument must not be too slow, for this always results in an incorrect mean value. In order to obtain reliable readings, it is necessary to use accurate, high-performance instruments, and to measure over relatively long times, normally three minutes at each point. It is therefore

necessary to specify the measurement time and instrument response rate when deciding how air velocities are to be measured.

As far as temperature measurement is concerned, it is not so much absolute temperature that is of interest as the human subjective experience of temperature. Air temperature alone is not a sufficient criterion, as the human body receives or emits heat by radiation from or to surrounding surfaces. Instead, a function known as operative temperature is measured, which is arrived at by consideration of both air temperature and the temperature of surrounding surfaces. The thermal balance of the human body is discussed elsewhere in this article.

Airtight buildings

Many older buildings have been draught-proofed, and new buildings are made as airtight as possible from the beginning, in the interests of energy conservation. This changes the operating conditions for ventilation systems. Previously, air could infiltrate through the building envelope at many points, and a fan maintained a slight sub-atmospheric pressure in order to extract air. However, with an airtight envelope, it is necessary either also to have a supply air fan or to arrange means of air entry through the envelope. The Institute tested the inlet devices available on the market some years ago, with results that showed that further development was required. Such development is still needed.

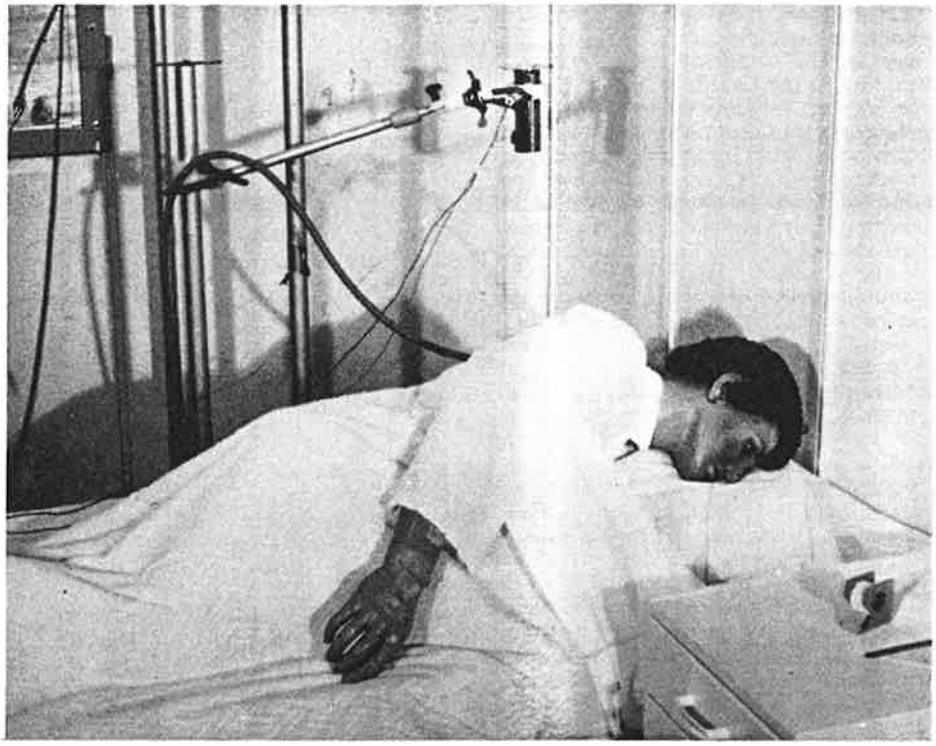
Radon

More airtight buildings have also brought new problems of air quality in their train, often caused by an overall reduction in ventilation rate. New building materials and new designs, sometimes carelessly or improperly used, can result in mildew and condensation problems. SIB has been involved for several years in the radon problems which can arise if ventilation is inadequate. In particular, it has been found that radon emitted by the ground can be inducted into the house if exhaust air fans or natural ventilation create an internal sub-atmospheric pressure. A number of simple methods of dealing with the radon problem are now being tried out jointly with consultants. So far, experience is promising, and it may often even be possible to ventilate radon out of the ground before it enters buildings.

Air quality and efficient ventilation

SIB maintains close contact with the Swedish National Institute for Environmental Medicine (SML). Among the work carried out by SML is investigation of the effect of air pollutants on humans. SIB's part in this work is to describe how pollutants originating in a room can be removed as quickly as possible.

Ventilation must be efficient, but this is often not the case today. Some of the incoming ventilating air flows directly from the air inlet to the exhaust point without benefiting the rest of the room. The efficacy of a ventilation system depends on both the design and positioning of supply and exhaust fittings as well as on the temperature of the supply air in relation to the room air. Earlier quantifications of ventilation performance, known as the air change rate, assume that performance is correct if the incoming air is completely mixed with the room air. This also means that any pollutant, e.g. cigarette smoke, must first be diffused throughout the room before it can be removed. Ventilation would be more efficient if smoke was instead drawn directly to the extraction point. Various methods of describing the efficiency and different practical designs of ventilation systems are being tested under laboratory conditions, both in single rooms and in a complete apartment which has been specially built in the laboratory hall.



The SIBMAN dummy being used to establish the thermal balance of a sleeping body in a hospital environment.

Requirements set by the occupants

It can be seen from the above that one of the purposes of buildings and building services is to create an indoor climate which is suitable for the needs of the user. The fact that these requirements differ in residential buildings, hospitals and industries is to be expected, as activities differ, occupants vary in age and so on.

The Institute's work on climatic criteria has been primarily concerned with the thermal climate, i.e. how air temperature, draughts etc. influence human thermal balance. However, indoor climate must also take lighting and noise into account. As all these factors influence us, it is quite probable that there are combination effects which should be investigated. Unfortunately, this has not yet been done systematically and, what is worse, the effect has, if anything, been ignored in the applied research that has been carried out for many years in the individually isolated fields of lighting, noise and heating.

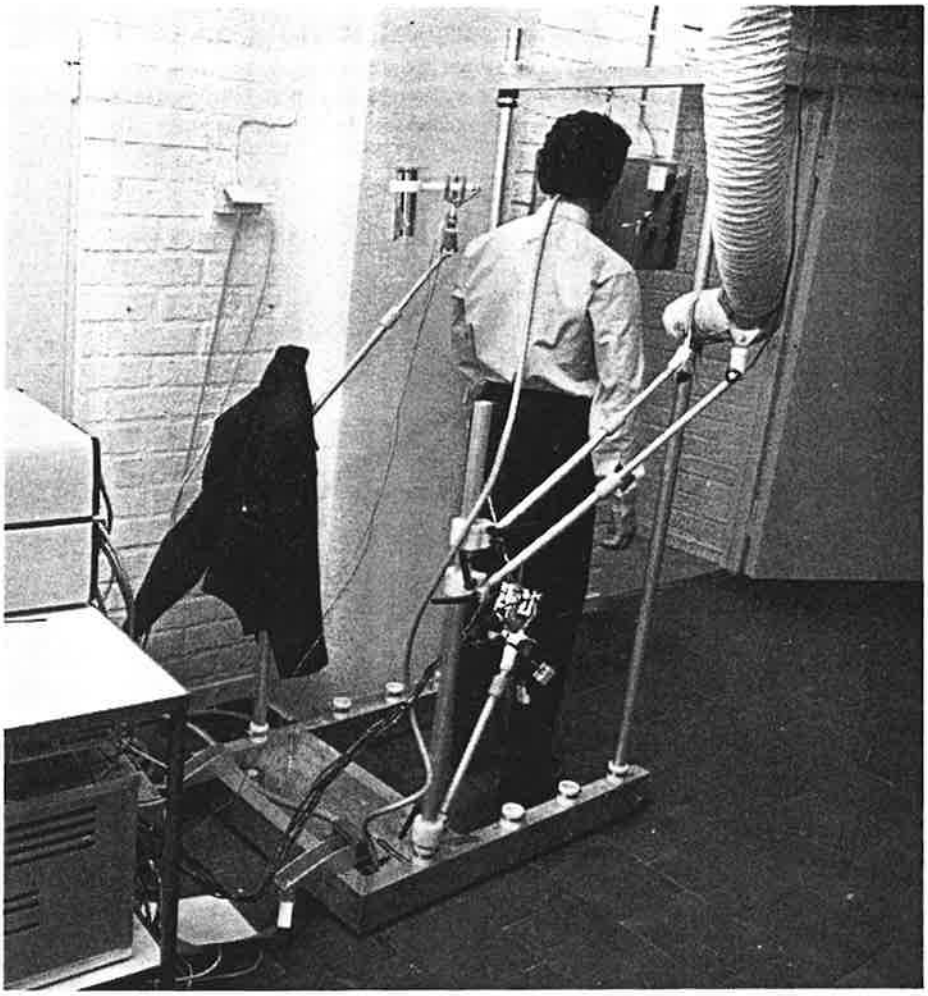
Effects on human performance

One of the objectives of the Department's work is to investigate, using the Institute's climate chambers, the effects of combinations of lighting and heating, noise and heating etc. on human performance. An investigation is at present in progress, for example, on how noise affects mental arithmetic ability, memory and attention at various temperatures. As working humans differ widely in their sensitivities to external factors, a very comprehensive series of experiments is necessary before any reliable results can be determined. An earlier investigation of the effect of various lighting levels on schoolchildren's performance at differing room temperatures indicated that higher lighting levels had an adverse effect if room temperature was somewhat higher than normal and if the children were tired towards the end of the day.

However, the major area of interest today relates to the effects that temperature reductions may have on comfort and performance. Reduction of indoor temperatures does not seem to have any adverse effect on mental performance, but it does adversely affect manipulative ability and, of course, bodily thermal balance. Changes in thermal balance can be countered by appropriate clothing and also by the insulating properties of furniture. A reduction in temperature is also accompanied by an increase in sensitivity to draughts. Air velocity becomes more critical than before, which influences the design of heating and ventilating systems.

Measurements on dummies

Although humans can express their feelings of discomfort caused by draughts – whether conditions feel chilly or warm, etc. – it is almost impossible to measure heat transport to or from parts of the body, or how this transport is influenced by the insulating effects of clothing etc. In order to complement subjective investigations, we have therefore designed full-scale dummies with which we can measure the effect of external climatic conditions on the thermal balance of every part of the



SIBMAN is exposed to a draught on one arm.

body individually. With these dummies, the original of which was known as SIBMAN, a wide range of different working situations has been investigated, ranging from occupation of a hospital bed to the draughty conditions under which bus and truck drivers work.

Humidy can be a problem

Problems were encountered at the offices of the National Land Survey of Sweden (LMV) in Gävle when it was found that some of the personnel felt excessively cold. The reason for this was found in due course with the help of another dummy, known as VOLTMAN. Employees moving between various parts of LMV, where different humidity levels were encountered, felt cold, in spite of the fact that LMV had been given a dispensation to increase room temperatures above those nationally permitted in public and office buildings. VOLTMAN indicated that, in moving from a higher humidity zone to a lower humidity zone, the body is cooled while the moisture in the clothes evaporates. The necessary latent heat of evaporation is taken from the body, inducing a sensation of coldness. Increasing the temperature in the higher humidity areas exacerbated the problem instead of alleviating it. It would have been better to reduce the temperature. Another way of dealing with the problem is to wear clothes of artificial fibres which do not absorb as much moisture.

The work carried out by the Institute with SIBMAN and clothing has resulted in close contact with textile research workers throughout the world who want to use the same method of research.

Wide field of activities

Research work carried out by the Department covers a wide range, as illustrated above. New technology, new building methods and living habits, energy conservation and other matters all result in new problems which must be solved before they get »built in» to the future. At the same time, earlier faults must also be rectified, and advice and instructions prepared for the major redevelopment projects that face us in the future. This work is being carried out in a stimulating environmental mixture of the Institute's own long-term strategic accumulation of knowledge and of projects being carried out on behalf of commercial organisations central and local government authorities etc., requiring help with specific problems or with the development of rules and methods.

The Institute has a wide-spread network of external contacts, which means that there is a constant stream of research workers from Sweden and abroad, either on brief visits or working temporarily with the Institute, and complementing the Institute's own experience and knowledge. In the same way, we have been able to contribute to knowledge and research elsewhere.

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Further information on published reports current research etc. is available from the National Swedish Institute for Building Research, Information Department, or from Hans Allan Löfberg, Box 785, S-801 29 Gävle, Sweden, telephone 026-10 02 20.