Sick building syndrome

By: World Health Organization Regional Office for Europe

Summary

Sick Building Syndrome (SBS) describes a medical condition where people in a building suffer from symptoms of illness or feel unwell for no apparent reason.

The symptoms tend to increase in severity with the time people spend in the building, and improve over time or even disappear when people are away from the building.

Sick Building Syndrome results in substantial disruption of people's work performance and personal relationships, and considerable loss of productivity.

Sick Building Syndrome is wide spread and may occur in offices, apartment houses, nurseries and schools, resulting in substantial costs to the community. Even though the cause effect relations are unclear it is possible to remedy buildings with SBS problems, and for new buildings the chances of avoiding SBS problems are also good.

Local Government actions can be both for implementing curative measures and for taking preventive actions. These measures and actions range from simple to radical.

In recent years it has become apparent that occupants of buildings suffer a number of relatively minor illnesses where there is no apparent cause, yet it has been established that these are caused in some way by the building. The symptoms are varying degrees of irritation of the eyes, nose, throat or skin plus general symptoms such as lethargy and headaches. Because these illnesses may happen in the building or elsewhere, it was initially difficult to show that they could be caused by the building.

While these symptoms may seem trivial at first sight, together they are a substantial problem.

It was not until the medical condition of "Sick Building Syndrome" was identified that the actual size of the problem could be established and actions taken to improve the incidence of illness. It now appears that Sick Building Syndrome (SBS) is wide-spread, with an estimated proportion as high as 30% of new, remodelled or renovated buildings having occupants with SBS.

SBS may occur in most kinds of building: offices, apartment houses, nurseries and schools. It causes reduced work performance and increased absenteeism, resulting in a total cost which may well be in the range of 0.5-1.0% of GNP.

Even though the cause-effect relations are unclear, experience shows that it is possible to take measures to remedy established buildings with SBS problems. For new buildings, the chances of avoiding SBS problems are also good if sufficient attention is given at an early stage. A local authority can take actions which will make a big contribution to reducing the number of people with Sick Building Syndrome in its area.

Sick Building Syndrome symptoms

Modern people spend most of their time indoors in houses, day-care centres, schools, offices and other building facilities. This means that if they are unwell, they will suffer symptoms and discomfort while indoors, only some of which may be related to the buildings they occupy.

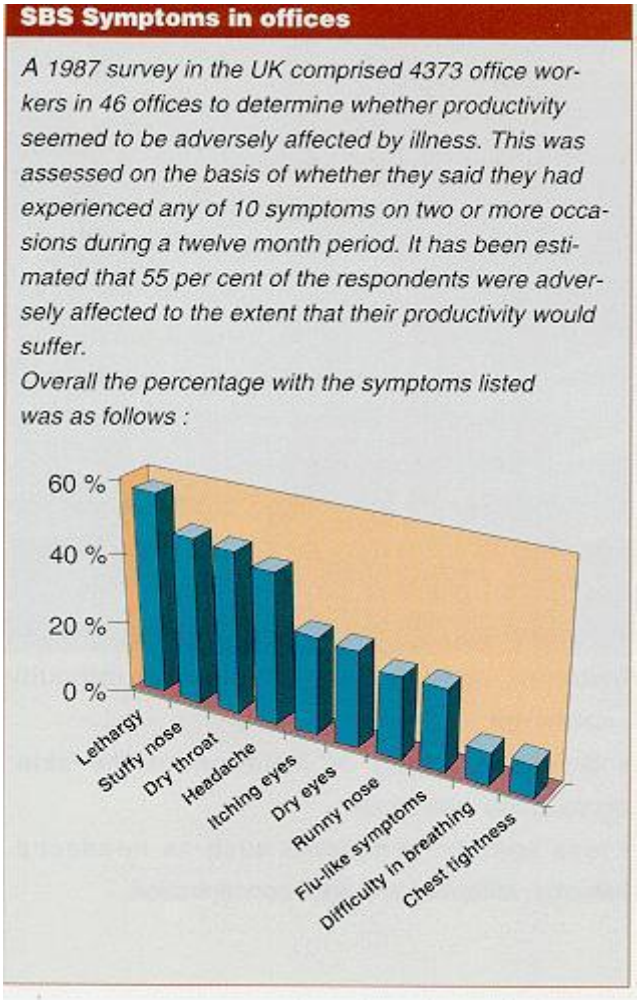
Sick Building Syndrome can be identified where people in a building experience, more frequently than expected, a range of common symptoms causing discomfort and a sense of being unwell.
The most common symptoms are the following:

- irritated, dry or watering eyes (sometimes described as itching, tiredness, redness, burning or difficulty wearing contact lenses),
- irritated, runny or blocked nose (sometimes described as congestion, nosebleeds, itchy or stuffy nose),
- dry or sore throat (sometimes described as irritation, upper airway irritation or difficulty swallowing),
- dryness, itching or irritation of the skin, occasionally with a rash,
- less specific symptoms such as headache, lethargy, irritability and poor concentration.

Typically several of these symptoms are experienced simultaneously and they are often accompanied by complaints about stuffiness, poor air, dry air, noise, light or temperatures which are too hot or too cold.

For some illnesses clear-cut connections to the building have been recognized. These are not included in SBS:

- infections such as colds and those that emanate from sanitary equipment,
- chronic illness caused by tobacco smoke
- poisoning from building materials such as lead in paint,
- legionellosis,
- effects of pollutants from industrial processes,
- cancer from radon
- asbestos-related diseases,
- general effects of dampness,
- thermal comfort effects
- hearing loss from noise.



In other situations, however, they are health problems which seem to be building-related, but where there is no apparent cause requiring attention. The recent identification of the Sick Building Syndrome as a medical condition has provided the focus to allow local government to deal with the problem. A building where there are a substantial number of people with SBS symptoms is referred to as a "sick building".

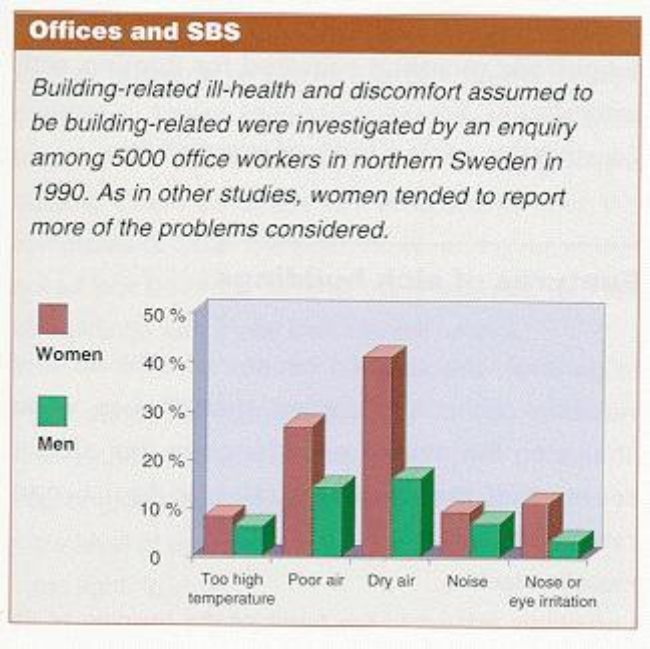
Sick Building Syndrome in Europe

The common feature of sick buildings is that their occupants suffer, or appear tu suffer, a measurably higher incidence of symptoms of illness or discomfort than can reasonably be expected. A sick building may result from the way in which the building is designed and constructed or from the way it is operated, maintained and used. Since the causes of SBS have not been identified, the best way of finding out if there is a problem is to look at the frequency of complaints or symptoms of illness.

SBS reports from various European countries show that this is a widespread problem. According to a WHO expert group in the mid-1980s. up to 30% of new or remodelled buildings may have unusually high rates of complaints. This conclusion has been supported by many other studies.

The recognition of SBS as an illness varies from country to country and the characteristics that are included in reports also vary considerably between countries. However, it is apparent that the sumptoms

occur in various kinds of building: offices, apartment houses, nurseries and schools. For example, a recent enquiry among 10,000 people living in Stockholm, Sweden, revelated that 13% of those living in apartment buildings complain about health problems which they relate to the indoor environment. Other Swedish studies indicate still more frequent malfunctions, for example complaints in some 25% of all kindergartens in Stockholm and 20% of all kindergartens in Stockholm and 20% of all municipal buildings in the city of Malmö.



A major survey of the indoor climate in more than 3000 Swedish homes, in both single units and buildings containing multiple dwellings, has recently been carried out. The report from this project reveals that one in ten residents in buildings containing multiple residences complains about stuffy air, dry air, noise, dust and dirt. The situation appears to be considerably better in single family homes that were constructed after 1975. In this study the most frequent symptom was tiredness. In every third or fourth case the sumptoms are presumed to be related to the residential indoor climate.

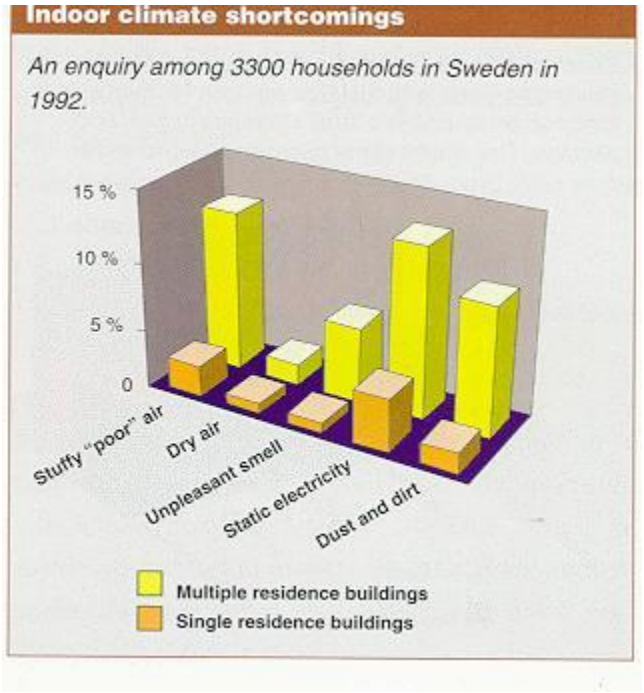
Health implications

SBS is a problem which can be removed or prevented. It is an unnecessary cause of ill-health with considerable loss of productivity and quality of life for those affected.

For people affected by SBS the symptoms can cause substantial disruption to both their work performance and personal relationships. This will have a major impact on productivity in the work place, which is shown in reduced performance, increased absenteeism, reduced overtime, increased staff turnover and demands on management and trade unions trying to resolve the problem. British estimates from various studies indicate that up to 8% of the working population regularly experience SBS symptoms tu such an extent that their health and productivity are seriously affected. It is important to remember, however, that the symptoms of SBS can be regarded as minor, since recovery is usually quite rapid as soon as the problem is identified and remedial measures taken.

When sick building problems occur in kindergartens, schools and hospital where the individuals are more sensitive and spend a large amount of time, the situation should be regarded as of great concern.

Certain work settings are more likely to induce Sick Building Syndrome

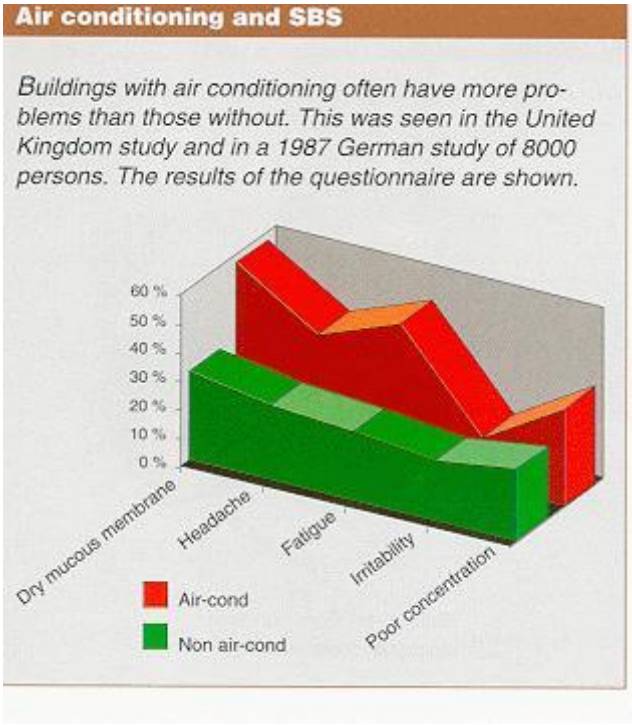


Economic aspects

The total cost of SBS on a country's economy has not been comprehensively studied, although estimates indicate it is likely to be substantial. Extreme cases of buildings being closed or demolished are rare. The most obvious costs of SBS are due to increased absenteeism and increased staff turn-over. Economic costs, which are very difficult to assess, are those due to reduced work performance, the use of management time to deal with complaints, and time and costs involved in trying to establish and eliminate the problems.

In a British study of a particularly troublesome large office building, the loss of productivity is subjectively estimated to range from 3% for staff taking "sick leave" up to 33% for staff who are "sometimes less productive".
An American study estimated that the total cost of SBS may range from US$5 billion up to several tens of billions for the USA. If the costs for health care, social security and building works are added, the total may be 0.5-1.0% of GNP.

A moderate assumption from these figures is that 1 day per person per year is lost through sick leave, productivity loss,



extended breaks, etc. Another 1 hour per month is required for dealing with problems.
Together this adds up to 1% of total staff time.

Features of sick buildings

In general, the specific causes of SBS for any individual cannot be identified. Nevertheless, when analysing the overall experience in this area it seems that the problems fall into four broad categories:

- location factors,
- problems related to the fabric of the building or its contents and building services. These include chemical emissions from building materials and furniture as well as things like lighting and heating.

Structurally unrelated factors, like pollen, may exarcerbate Sick Building Syndrome

- problems unrelated to the structure of the building but which occur while in the building. The best example of these is allergy where the cause may be pollen, dust or mould,
- problems which can be described as psychological.
  These may be caused by organizational or social conditions or even physical objects or the work space.

The following list provides a set of building characteristics which are often found in sick buildings. These should be considered for both houses and other buildings when investigating a building where a number of the occupants have the symptoms of SBS. It should, however, be noted that not all sick buildings have all these features, and not all buildings with these features will be sick.

- built during the 1960s or later
- air conditioning with cooling capacity
- lighting causing high glare and/or flicker
- low level of user control over ventilation, heating and lighting
- large areas of soft furnishing
- large amount of open shelving and filing
- new furniture, carpets and painted surfaces
- poor standards of maintenance and repair
- insufficient cleaning
- high temperature or excessive variations in temperature during the day
- very low or very high humidity
- chemical pollutants such as tobacco smoke, ozone or volatile organic compounds from building materials and furnishing
- dust particles and fibres in the air
- computer display screens

Bad house keeping increases the risk of Sick Building Syndrome

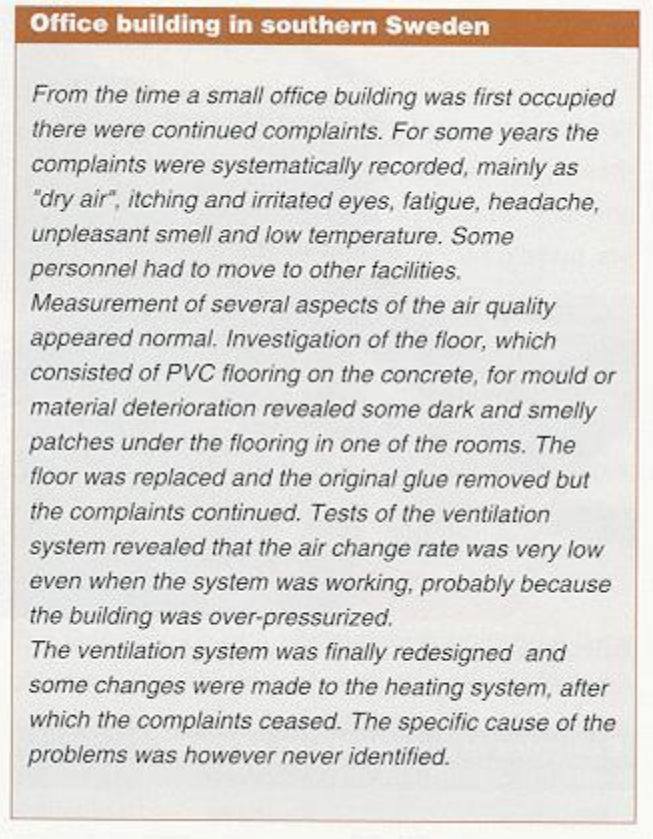
Examples of combinations of factors causing a problem are :

Problem	Factors
Common feeling of "dryness"	• low humidity • high temperature • chemical pollutants • dust
Irritation of the eyes	• chemical pollutants in air • draughts • heat radiation • inadequate lighting • allergenic particles

If the building being investigated is an office building with SBS problems, the following characteristics can also be significant:

- deep plan or oper plan offices of more than about 10 work stations
- many people working with display screens
- workers most affected by the symptoms tend to be those in routine clerical jobs

It should be noted that single factors are unlikely to cause the symptoms and that complicated interactive causes are highly probable. It may be extremely difficult to identify all the causes, and in some cases the cause may never be identified even when the problem is fixed.



WHO Position

Many different terms have been used to describe the phenomenon of reported high incidence of illness or unwellness suffered by people for no apparent reason in certain buildings; these include "building sickness", "sick office syndrome", "tight-building syndrome" and "office-eye syndrome".
In 1982 the World Health Organization agreed the term "Sick Building Syndrome" (SBS), and this is now the most widely used.

WHO has produced some very useful publications on indoor air quality which are available from the Regional Office for Europe.

Recommendation 1

Local Government action to improve sick buildings

Sick building syndrome may become a local governmet issue, either because of problems in a building owned or occupied by local governmet staff or because of complaints that the owner of a building in the area is not responding to complaints by the occupiers or tenants of a building.

If there may be SBS problems in a building, a suggersted plan would be to:

- **Design a procedure and give one member of staff overall responsibility for collecting and classifying complaints** about indoor climate and symptoms of ill-health. It is often better for an autside organization to carry out staff surveys
- **Establish a systematic approach to dealing with problems,** which should involve identifying possible causes and dealing with them without delay. The key areas are:
  - looking for simple causes such as breakdown in the ventilation system
  - considering changes in work environment or processes employed
  - paying particular attention to cleaning the building
- **If simple measeures do not work, then seek expert help.**

Recommendation 2

Local government action to prevent the construction of new sick buildings

In approving or agreeing to a building plan, the local government priorities should be to:

- **Ensure the proposed building site does not have hidden problems,** such as water close to the surface or contamination from previous uses.
- **Make sure that designers ensure known risk factors are taken into account**. This will require professionals to work as a team when determining facility layout, use of materials, machinery and thermal properties, and ensuring the building is designed for easy cleaning.
- **Check local air quality** before deciding or approving standards of ventilation and air tightness.
- **Check the building and its services before it is brought into use.**

Further reading

Indoor Air Quality Research. Copenhagen, World Health Organization, 1986. (EURO Reports and Studies N°. 103).

Indoor Air Quality : Organic Pollutans. Copenhagen, World Health Organization, 1989. (EURO Reports and Studies N°.111).

Indoor Air Quality : Biological Contaminants. Copenhagen, World Health Organization, 1990. (WHO Regional Publications, European Series N°.31).

Technical Annex

Table of content

Improving sick buildings

Continual complaints about indoor climate or about symptoms of ill-health will often mean that there are problems with the building of the type which are associated with SBS.
Neglecting complaints will in the long run result in the problems growing worse, increased losses in production and increased lossess in production and increased costs of remediation.
Furthermore, the absence of action may cause irritation, suspicion and distrust amog the workers or occupants.

Changes in an existing building will at best take considerable effort and in the worst case may require replacement of the building. It is therefore well worth using a systematic approach to ensure that action is likely to be effective in solving the problems. The general approach is autlined.

Good practice is to appoint a staff member with overall responsibility for collecting and classifying complaints and for planning all actions. All staff occupying the building should know who the responsible person is and how to lodge complaints.

Recording complaints should include every complaint related to indoor climate, even those which are vague or diffuse. Symptoms of ill-health, particularly minor ones, will usually not be reported. Reports about reduced efficiency should also be recorded. The person responsible for recording complaints should regularly review the situation.

When te review of complaints suggests that a problem exists, **an investigation to identify the extent and nature of the problem should be carried out.** Normally the first part of the investigation will comprise visiting the facilities in question and talking to people about the situation.

Questions about both the complaints and symptoms of ill-health should be asked.
Important questions at this stage are the following:

- what are the symptoms?
- how frequently and when do symptoms occur?
- do symptoms decrease after leaving the building?
- do variations between parts of the building exist?

People's answers often may indicate one or more probable cause of the problems. Look first for the most common explanations:

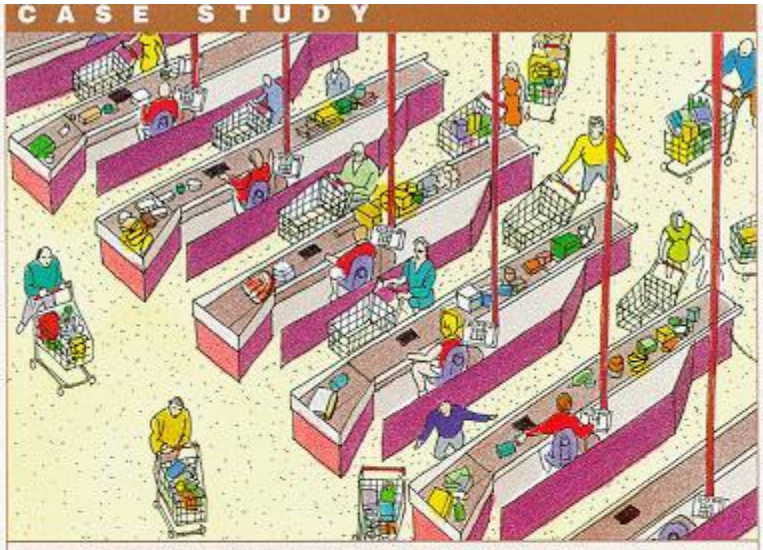
- new or increased pollutants
- ventilation breakdowns
- epidemics of colds

- changes in work processes

If **simple solutions** are indicated, these **should be applied without delay**, e.g. to repair or change ventilation components, to adjust temperatures, or to improve cleaning.
These issues are discussed in more detail below.

When the problem seems more complicated or when the simple actions are not sufficient, more comprehensive studies are needed.

CASE STUDY



Supermarket in southern Sweden.
In the food department, the cashiers had complained for several summers about high temperatures.
An investigation found that within an air conditioning unit a throttle control had been broken from the time of installation. The result was that hot air from cold boxes was recirculated. The cooler was set at 15°C while the heater was set at 18°C. Both machines were consequently continuously working.

These should include a general enquiry among the users, preferably using one of the models developed by a number of expert organisations.
Technical surveys should include measuring air humidity, temperature, air supply rates, air velocities and the concentration of carbon oxides.

Again some rather simple actions may possibly solve the problems, for example balancing the ventilation system or arranging separate extract ventilation from office machinery and smoking rooms.

Careful dust removal helps reduce the risk of Sick Building Syndrome

It is essential that information about the investigation is given to all the people concerned. When the solutions will take time to implement, user involvement by a project group is often useful. Monitoring of complaints and symptoms during the investigation must be carried out.

If the problems remain unsolved, **expert help should be sought.** It is very probable that specific chemical and biological measurements are needed or that substantial changes in the building are required. Doing the wrong thing may result in high costs and even increase the problems.
Suitable professionals may be building service engineers, medical experts, occupational hygienists and management specialists.

Cleaning

There is growing evidence that indoor surface pollution is one of the main causes of SBS. The surface pollution is more than settled dust; it is also made up of all the contaminants given off by the building's users, its contents and services. This includes chemical and microbiological contaminants which settle on surfaces, as well as skin scales, debris from shoes and products from food, smoking and drinking.

A survey by the UK Building Research Establishment found that reducing indoor surface pollution helped to reduce SBS.

Good cleaning should pay special attention to areas which are damp or wet and where papers and books are stored. If possible, methods that do not raise dust should be used.
Ventilation systems (ducts, filters and grills) and hidden areas (above false ceilings and below false floors) should be regularly cleaned. Where large areas of solt surfaces occur, chemical methods may be needed to kill dust mites if they are found to be present.

However, the need for enhanced or specialized cleaning, which is very expensive, can be reduced and the task of cleaning made easier by paying attention to design, furniture selection and general layout. Managing the source of pollution is better than continually removing the pollution as it occurs, e.g. by avoiding open storage areas and the use of excessive furniture fabrics. Measures should also be taken to facilitate the access of the cleaning staff to all areas.

Ventilation

Ventilation has two purposes, to provide fresh air and to remove or dilute pollution. This requires adequate air flow while excessive flow will cause draught, noise and other comfort problems. Heavily polluted air may therefore be difficult to manage.

Shortcomings of the ventilation system are apparent in many instances of SBS. The most common problem is that the ventilation system has been wongly adjusted, creating an imbalance between the rooms in the building, which may lead to pollution being disseminated or insufficiently diluted in some rooms.

Another cause of low air flow and pollutants in the air is dirt in the ventilation ducts. This may depend upon the design of the sistem, for example if installations are difficult to reach, inspection panels are missing or components are poorly designed.

Modern ventilation systems are usually complicated and demand precise instructions for operation and maintenance. In fact, several studies show that adequate documentation is uncommon, and that SBS symptoms are less frequent where the users themselves can control the ventilation.

Office building in the UK

The building had four occupied floors and a basement car park. It was built in 1975 and had approximately 1300 occupants with a design capacity of 1525. Most of the office areas were open plan, demarcated with partitions and cupboards up to 2.5 m in height. There was generally inadequate storage space, with the result that papers were stored on desks, on top of cupboards and on the floor.

Comfort cooling was provided by a mixture of fresh and recirculated air. Distribution of air was through ceiling mounted fan coil units and perimeter induction units. Room air was extracted through the light fittings into a plenum and from there via the service core ducts to the atmosphere.

After identifying a set of likely causes, the building was divided into areas, in which different actions were implemented.

Cleaning the ventilation nozzles and grills did not bring about a reduction in symptoms - even if it was probably needed to avoid future problems. A complete cleaning of ducts and plenum might have been more effective but did not fit into the available timescale.

Nor did air filtration result in a reduction of symptoms.

A full office cleaning programme significantly reduced the symptoms (hard surfaces were wiped down and all other surfaces, including paper files, were vacuum cleaned; carpets and chairs were additionally cleaned with hot water extraction). Still better results were achieved by treatment of office chairs with liquid nitrogen to kill dust mites, followed by vacuum cleaning.

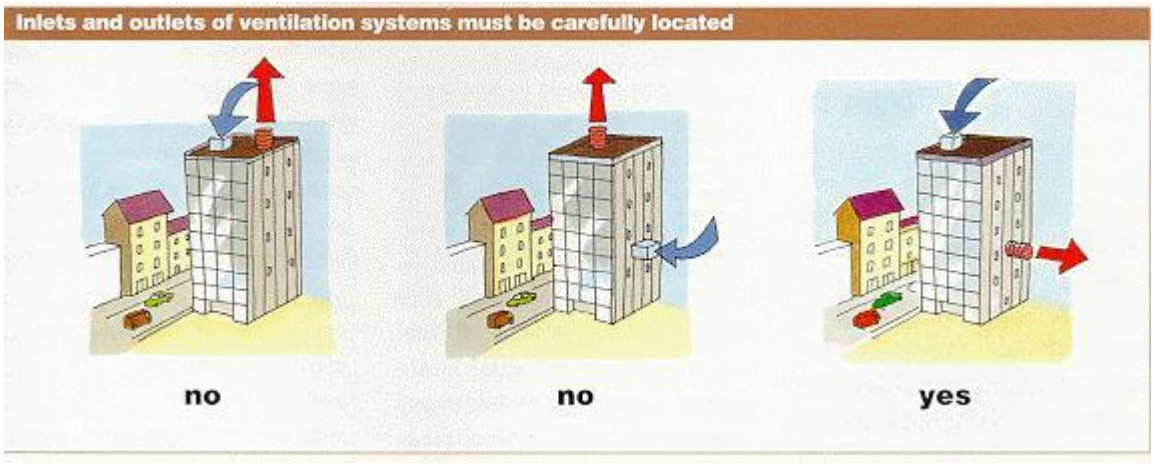
Contributing comfort factors

A number of interrelated physical factors such as noise, uncomfortable temperatures, low relative humidity, and poor lighting may have acumulative effect and make SBS more likely.
Noise may play a complex role. High levels disturb communication and concentration and hence contribute to lethargy, headache, etc. The effects of low frequency noise, e.g.from ventilation systems, are not sufficiently known but have been associated with SBS symptoms.

Higher temperatures are unlikely to directly cause symptoms but may stimulate material emissions and growth of bacteria, fungi and dust mites. Field studies have shown that SBS symptoms can increase as the temperature rises above 21°C.

Case studies and controlled tests have shown that humidification which increases relative humidity to above about 30% can reduce symptoms. This has, however, to be balanced against increased humidity promoting growth of micro organisms.

Lack of natural light may also be a contributory factor and tests have shown those seated near a window tend to suffer less from SBS, although the link is not clear. Subliminal flicker from fluorescent tubes has been shown to contribute toward headaches and eye-strain and elimination of the flicker has been shown to reduce the symptoms.



Management and use of buildings

In general, buildings with poor maintenance (hygiene and operation) and insufficient cleaning are more likely to show SBS symptoms.

Modern indoor climate technology is often complicated. In order to ensure the proper temperature and air supply, the operation staff should receive proper training to maintain the systems and have access to comprehensive instructions on how maintenance, function tests and adjustments should be carried out.

In many cases, user activities have been proven to expose the buildings to strains that they were not designed to endure. Changes of use of the building - e.g. changed office partitioning or adding new equipment such as computers, printers and photocopiers - may heavily increase the load of heat and pollution. Every major change should therefore be discussed with the building managers and professionals familiar with building problems.

Psychological factors

It appears that stress may increase the susceptibility of individuals to SBS, which is shown by increased complaints about discomfort or illness. The cause may be general job stress or inadeaquate management of the work or living environment by those responsible for the building. However the symptoms are caused, they do result in problems for the individual and will result in reduced productivity and loss of quality of life. Until there is more knowledge about human reactons to substances, or to the combination of factors which individually do not cause ill-health or discomfort, SBS must not be dismissed "due to psychological causes" and no further action taken.

Several studies imply that there is a relationship between SBS symptoms and poor general management, poor management of staff complaints or low general staff satisfaction with job or organisation. Organisational changes may therefore be an effective way to deal with SBS problems.

Studies have also shown that women and staff in routine and low paid jobs are more likely to suffer from SBS than others. This may be because lack of personal control tends to decrease people's tolerance of poor indoor environments.

CASE STUDY

Ventilation systems in use

The following is a selection of observations by two comprehensive Swedish studies of ventilation systems in use between 1986 and 1988.
Air flows were on average 20% lower than specifications and test records stated.
Of 67 kindergartens only one met the requirements for air change.
10 to 20% of the fans did not work and one fan out of three was not properly functioning. In some cases the fans worked backwards.
9% of all air filters were missing.

Avoiding sick buildings

Reducing the hazards before a new building is occupied can greatly reduce the losses in time and well-being resulting from SBS. Until SBS is better understood as the result of further research we must rely on things which have been shown to work in the past. It is essential that every new building and refurbishment project is carefully planned and managed.

Local authorities may play various roles in the building process : as planning bodies, as educartors, as controlling bodies, as purchasers, and as owners and managers. These roles differ from country to country, which means the following general advice must be used when applicable in the local situation.

Local Planning

Local planners should be throughly aware that not all land is suitable to be built upon. Problems that are likely to be caused by type of ground or climate can be avoided. Building plans should always be based on geotechnical investigations, with areas containing high levels of radon gas or high sub-soil water levels avoide. Similarly, landfill sities, highly containated land and noisy areas should be avoided.

Concern should also be given to the air quality of the surroundings.
Locations near industrial areas or heavy traffic will generally need more stringent requirements on ventilation systems and air tight buildings.

General building design

There is an obvious relation between the activities within a building and the technical requirements that the building must satisfy. It is therefore essential that each building project is described by specifications which identify what the activities are, how they relate to one another, and what the generation of heat, moisture and pollutants is likely to be. The project specifications should also define what skills and competences are needed in the project and demand a plan for organised interaction between the various professionals.

Often too little attention is paid to the long-range characteristics of the building. The building specifications should explicity require that desing teams consider, document and explain the expected life-cycle of systems and components. the need for maintenance and how operation and monitoring should be carried out.
From the evidence to date, there are some risk factors which have been identified and which should be avoided if possible. These include:

- open plan offices of more than about ten work stations,
- lightweight thermal properties and/or poor insulation,
- poor provision for daylight and/or uncontrolled solar gain,
- sealed windows,
- large areas of soft furnishing, open shelving and filing,
- use of inadequately tested materials, paints, joining mastics, and glues,
- luminate type lighting and position giving glare and flicker,
- services and areas not designed for easy cleaning and maintenance.

Installation systems

Among the requirements on modern buildings is that of energy efficiency, which is met by more insulation, increased air tightness and controlled air flows. It is very important that the interaction between air tightness, ventilation and emissions is understood. A relatively small mistake in one area may be reinforced elsewhere and create a substantial problem. Key factors in this area are the following:

- provision of sufficient fresh air (at least 8 litres per second per person in non-smoking areas and up to 30 in smoking areas)
- air inlets that are not close to exhaust or outdoor pollution sources and that are supplied with adequate filtration
- removal or dilution of airborne pollutants (e.g.separate extract ventilation from office machinery and smoking rooms)
- provision of a comfortable temperature, related to the activities in the building

- prevention of air stagnation and draughts (air flow rates 0.12-0.3 m/s)

Control, evaluation and feedback

It is essential that the critical functions of the building and its sub-systems are tested before a new building is occupied. Experience shows that delayed completion often leads to occupancy without adequate testing.

An essential part of the building programme is therefore a control plan, where relevant checkpoints are defined. This plan should include how inspections are to be undertaken, and how these should be documented.
Procedures for changes of materials and designs during design and construction should be defined.

In areas where dampness is believed to contribute to SBS problems, allowing sufficient drying time for concrete constructions is issential as well as control of how moisture protection is carried out. Proper storage of materials at the building site should also be specified.

Building designers rarely get feedback from the building in use. One way to achieve improved feedback is to set up a meeting between designers, contractors and the operations and management staff within about 12 months of the building coming into operation. The meeting should be based on a systematic documentation of problems and errors as well as the good features.

C A S E S T U D Y

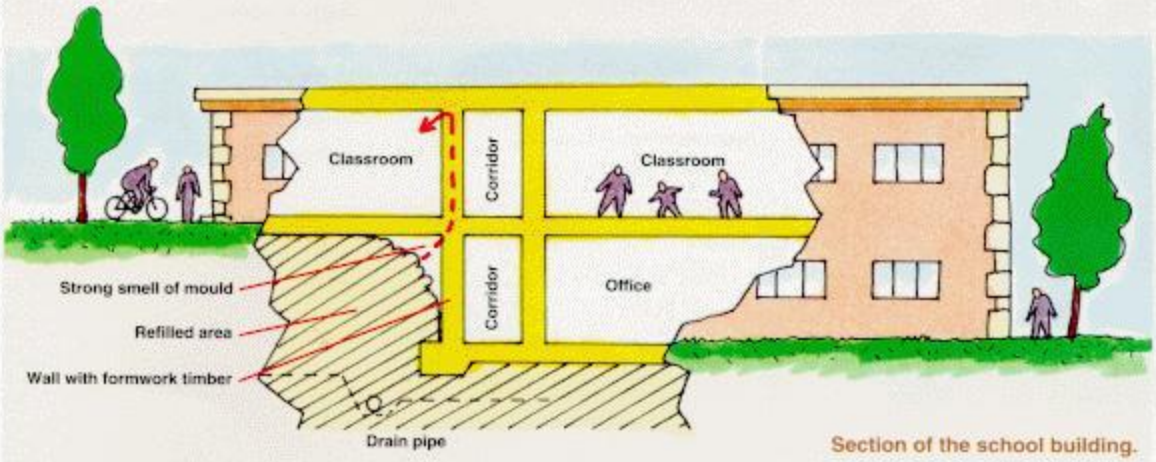
Elementary school in southern Sweden.

The school was built in 1970 on a slightly water-logged site that needed extensive filling. In 1984 complaints about bad smell and "stale air" were common particularly in cold weather, when heated air was recycled. One teacher and one pupil were forced to change schools by allergic reactions. Another teacher suffered more frequent asthma attacks at school. Many teachers and pupils complained about tiredness.

Emissions from the flooring were suspected but measurements did not reveal high levels of any substance. Tests of the ventilation system showed that the air exchange rate was low but not to the extent that this could explain the problems. Mould tests gave low results. The moisture content of the basement slab and of the haydite filling underneath appeared however to be high.

When a small section outside the foundation was dug out, a pronounced smell of mould appeared. Further investigation revealed that formwork timber had been left at the foundation and was now affected by mould. The smell could be traced along a wall up to the attic, and into the classroom due to negative air pressure within the building.

Ventilation of the foundation and a change of the air pressure balance in the ventilation system has since removed the acute problems. However, the moisture level in the concrete slab remains and it has not been possible to remove the formwork timber.



Section of the school building.

Background information on microbiological and chemical pollutants

Microbiological pollutants

People who suffer from allergy and hypersensitivity generate a substantial part of the complaints. Recent studies have shown that the number of people suffering from an allergy or other hypersensitivity has increased. In a couple of decades the frequency of asthma has doubled among 19 year old Swedish men.

Hypersensitivity reactions are twice as common among pre-school children as among adults. A similar development has been reported from other countries.

Most hypersensitivity reactions can be related to organic substances. A certain part of these are always "imported" into the building from its surroundings, which means that the input of fresh air to the building needs to be filtered. Another substantial part resides and develops in room dust.

Dust mites are very small spider-like animals that mostly feed on skin scales. They are known to trigger hypersensitivity reactions.

A certain amount of alga is always present in dust. Of the wide variety of species some are known to cause illness. Even algae grown in damp environments can create severe health problems when spread to the inside air.

Mould growth is often associated with fresh and damp building materials. Water leaks and excessive showering are also known to create suitable environments for mould.

Approximately 70-80% of mould fungi an develop toxic substances (mycotoxins) Generally, however, the mould contents in buildings are not high enough to constitute a risk of causing allergies in health individuals. Persons who are already allergic to mould may experience asthma, hay fever, hives or eczema at normal mould levels. The amount to which mould fungi in the indoor air may cause other problems is not known.

All biological growth requires a suitable combination of humidity and temperature - for dust mites 75-80% relative humidity and for mould fungi more than 50%, both stimulated by higher room temperature. To disrupt mite and mould growth, the indoor air should be kept under that level for at least a couple of months a year, which in many countries is difficult to achieve. Since dust mites can survive at 45-50% relative humidity or even lower, specialist cleaning of soft surfaces may be required.

Chemical emissions

Chemical emissions from materials and equipment may account for some sick building problems. Well known sources of such emissions are various building and decorating materials, furniture, office machinery and soft furniture. The vast majority of building materials do not, however, give rise to any

known negative health effects, providing that they are used properly. On the other hand, improper use, for instance in an excessively damp environment, is likely to cause dramatically increased emissions.

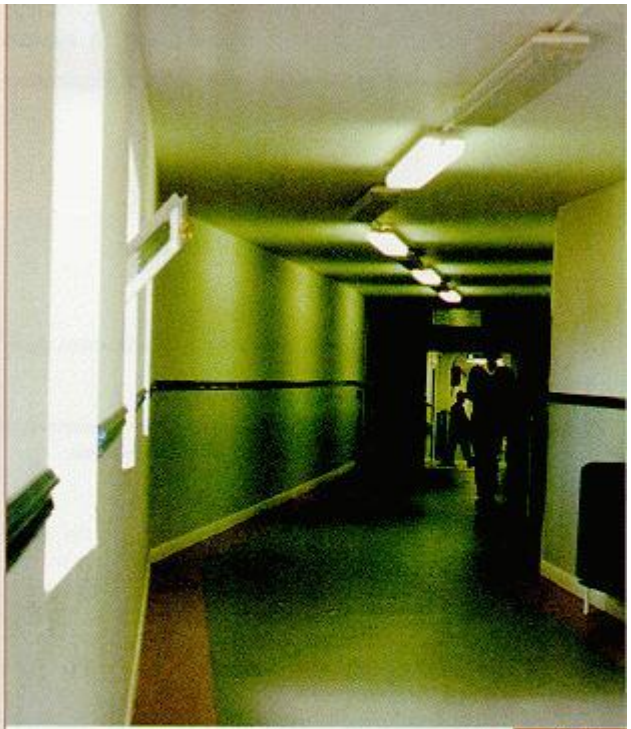
The largest and most important group of emitted substancs is volatile organic compounds, primary compunds that are used in glue, paint and joining mastics. This group comprises several thousand substances of which most may irritate mucous membranes.

More than 300 different chemical substances have been identified in normal office air, most in very small concentrations. The general rule is that no specific substance can be identified as the source of SBS problems. Reliable conclusions are however difficult to reach, since the interaction between substances are suggested to cause problems in such small concentrations that they are difficult to identify.

The emissión rate is high when materials are new, and decreases with time. For most materials the emissions will be acceptably low after 2-6 months. This process is affected by adsorption - substances taken up by other materials and particles in the air and thereafter again emitted to the air. Pollutants from replaced materials may therefore stay for a considerable time.
In Swedish practice some harmul emissions have been identified during the past 15 years. Around 1980 bad smell and tissue irritation could be traced to formaldehyde from ceiling elements, where a certain type of glue had been used. Simultaneously, some self-levelling moulding compounds containing caseis caused discolouring of flooring and bad smell, and in some cases also caused eye and nose irritation. Later on several cases of glued PVC flooring with a sweet pungent smell were found.
Investigations have proved that this was caused by damp from insufficiently dried concrete sub-floors that dissolved softeners.

PVC flooring in a Swedish hospital

A hospital building was rebuilt. Both staff and patients in one department complained soon afterwards about bad smell, headache, and tissue irritation. Measurements showed high content of various alcohols in the air.
The problem was traced to vinyl flooring, which could be shown to be deteriorating by laboratory tests. The same type of mat had been used in other parts of the building where the sub-floor was considerably less damp without causing problems.



Hospital corridor c19

References

The material presented has been derived from many sources and in general has not been referenced in the text. All of these sources ar gratefully acknowledged but the following were particularly useful.

- **Gustafsson, H.** Building materials identified as major sources for indoor air pollutants. A critical review of cases.
  Swedish Council for Building Research D 10:1992.
- **Johnson, B. Kronvall, J. Lindvall, T.Walling, A. & Weiss Lindencrona, H.** Buildings and health. Indoor climate and effective energy use. Swedish Council for Building Research D3:1991.
- **Norlön, U. & Andersson, K.** Bostadsbeståndets inneklimat (Indoor climate in the housing stock), ELIB-rapport nr 7.Swedish National Institute for Building Research, TN 30.
- **CIB Healthy Buildings 88. Vol.2.** Planning, Physics, and Climate Technology for Healthier Buildings.
  Swedish Council for Building Research D20: 1988.
- **CIB Healthy Buildings 88. Vol.3** Systems, Materials, and Policies for Healthier Indoor Air. Swedish Council for Building Research D21:1988.
- **Hus & Hälsa. Kunskapsbas.** (Buildings $ Health, the Knowledge Base). Seven state-of-the-art booklets concerning Man and indoor climate, Building physics, Building materials and emissions, Ventilation, Building design, Building client requirements, and Use and management of buildings. Swedish Council for Building Research U4-10:1992.
- **Sick Building Syndrome:** a review of the evidence on causes and solutions. Health and Safety Executive, UK, 1993.