When Ealing Council employees moved into the prestigious Great Western Centre offices in 1987 they did not imagine that failure to maintain the complex building services would land several workers in hospital with severe allergic reactions; many more have chronic, debilitating ailments.

A unique case? Not according to the London Hazards Centre's inquiry records which show that increasing numbers of office workers are suffering from a group of symptoms which have come to be known as sick building syndrome.

The office development boom of the last 25 years has been followed by an architectural revolution geared to designing energy saving buildings at all costs. The result: the modern, often sealed, open plan, fluorescent lit, synthetically furnished, artificially ventilated office in which individual workers have virtually no control over their working environment. In 1990, increasing numbers of office workers are reporting symptoms ranging from dryness of the skin, eyes, nose and throat, to tiredness, headaches and allergic and asthmatic conditions.

With costs pared to the bone, essential maintenance work on air conditioning, heating, cooling and ventilation is often neglected. In the most serious cases, the failure of maintenance has led to outbreaks of the potentially fatal legionnaires' disease.

*Sick Building Syndrome,* the fourth book in the London Hazards Centre's informative series on office hazards, will help all those concerned - office workers and their representatives, planners, architects, surveyors, maintenance engineers, hazards centre workers, occupational health specialists and environmental scientists - unravel the maze of technical and medical information and find practical remedies to the problem of sick buildings.

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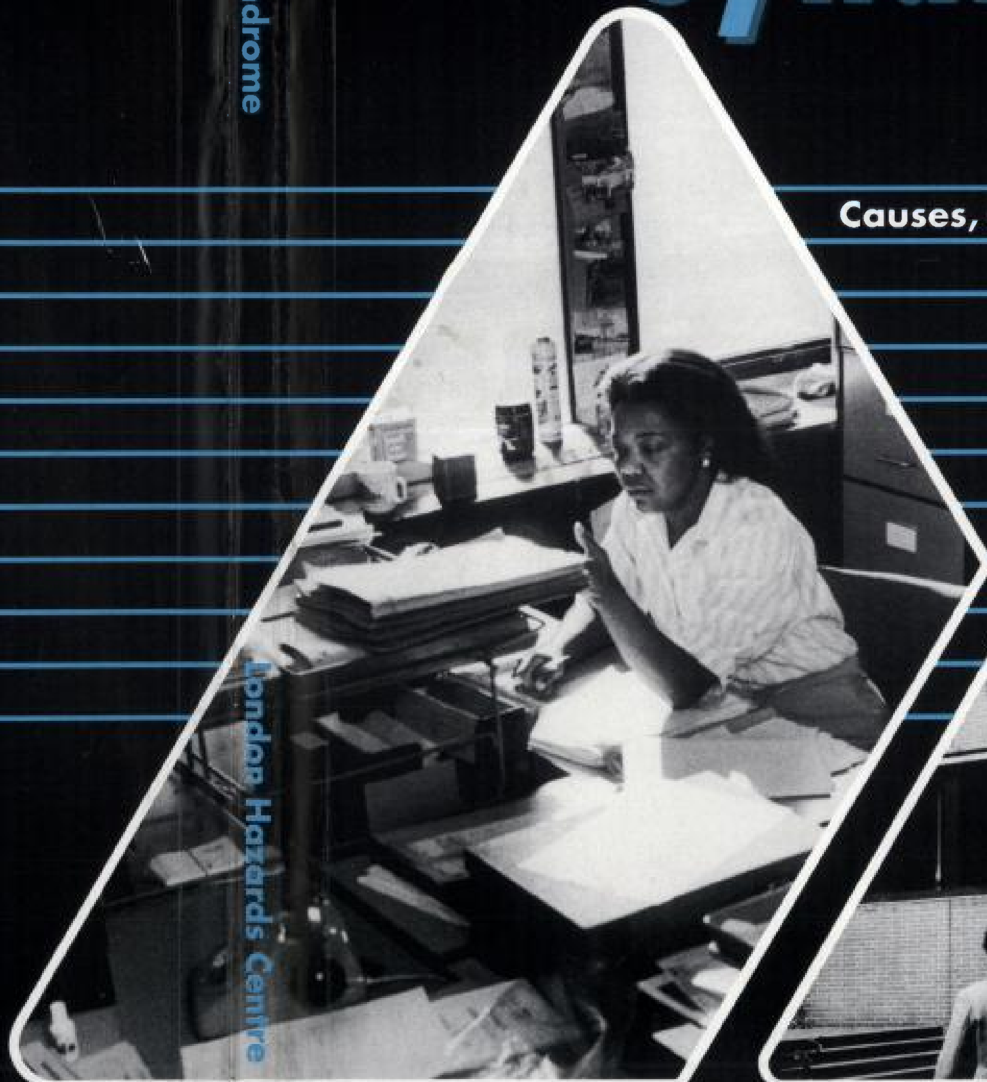
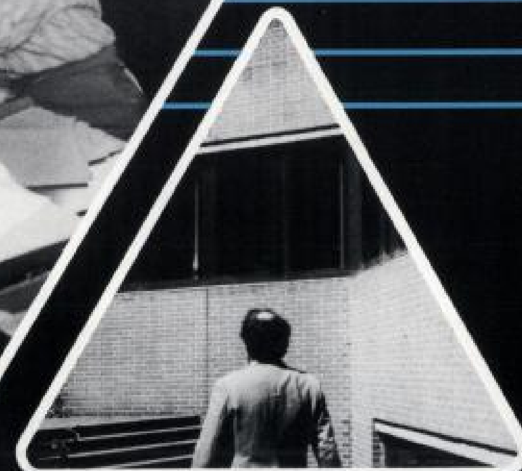
Sick Building Syndrome

London Hazards Centre

# Sick Building Syndrome





## Causes, effects and control

A LONDON HAZARDS CENTRE HANDBOOK

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# Sick Building Syndrome

## Causes, effects and control

**A LONDON HAZARDS CENTRE HANDBOOK**

## Acknowledgements

*Thanks are firstly due to the hundreds of people working in unhealthy buildings and offices who have approached the London Hazards Centre for help over the past six years and whose requests for advice and information stimulated the production of this book.*

*We are especially grateful to those groups of workers whose stories have contributed to highlighting some of the problems of sick buildings and ways of tackling them.*

*We would also like to thank Alex Balsdon for her invaluable work in writing most of this handbook.*

*London Hazards Centre*
*June 1990*

# Contents

*NALGO members suffering from sick building syndrome at Hammersmith and Fulham Town Hall negotiated the right to select consultants whose report they subsequently used to persuade management to implement improvements in their poorly designed and ventilated offices.*

Alan J P Dalton

# Introduction

# 1

**'I work in a clean area in a sealed building with air-conditioning. I am always ill and tired, with headaches and sore eyes. We have no windows and all fluorescent lights. There are about 90 of us who work in this place, and we are all stuck in this atmosphere since there is no other work on the island.'** (Cowes, Isle of Wight)

This letter to the London Hazards Centre requesting information on sick building syndrome is typical of complaints received from people around the country. What must it be like to go to work knowing that you'll feel lousy by the end of the day, drained of energy and perhaps with sore eyes, respiratory problems and a headache to cap it all? Yet this is just what happens to an increasingly large number of workers in supposedly 'clean' jobs and industries, such as office workers and those in the micro-chip electronics industry. Problems of fluctuating temperatures, draughts, stuffiness, bad lighting and noise have always been found in offices but the energy-saving measures introduced in the 1970s with the rise in oil prices have exacerbated them.

## Re-circulation of air and pollutants

Many buildings are now designed to reduce the intake of 'fresh' outside air because it is cheaper to re-circulate air that has already been warmed up in winter, or cooled in the summer, than to take in outside air and heat or cool it. Doors, window frames and other seals in the building are made as air-tight as possible, windows cannot be opened, and the amount of outside air brought into the ventilation system may be reduced - perhaps to zero, so that only re-circulated air is being breathed. Such buildings are known as 'sealed' or 'tight' buildings. Sometimes air inlets have been found to be bricked up. And the power of fans that distribute air from the air handling unit into the distribution ductwork may be reduced, or some fans may be turned off altogether for periods of time to save on energy costs.

Other changes have also taken place in the past two decades. More synthetic materials are used in construction, insulation and furnishings. Synthetic materials may release a variety of toxic chemicals, the best known being formaldehyde. The increasing use of machines also adds to indoor pollution, for instance the ozone from photocopiers, the noise from printers, and the electromagnetic radiation from visual display units. With the lack of fresh air resulting from energy-saving measures, chemical pollutants are not diluted and are continually re-circulated throughout the building. And, of course, 30 per cent or so of the workforce may be smokers... Air-conditioning systems themselves can harbour pollutants and micro-organisms and so add to the contamination of the workplace. For example, dirt enters with the air supply and builds up in the ductwork over time, or may have been lying in the system since it was installed. Often there is no-one in an organisation who really understands how the systems work. In addition, maintenance and cleaning of systems seem to be the exception rather than the rule, through negligence or because the various parts of the system are inaccessible (Wilson et al 1987; Jones and O'Sullivan 1988; Robertson 1988). The possible causes of sick building syndrome are discussed more fully in Chapter 4.

In the following chapters, much emphasis is placed on air-conditioning and ventilation systems since inadequate ventilation has been considered to be a causal factor in 50 per cent of sick buildings in the United States and in 68 per cent of Canadian investigations (Melius 1984; Collet and Sterling 1988). However, precise causal factors are rarely found in sick building investigations. Many reports conclude that inadequate ventilation was the cause of sickness because no other factor could be found, and improving the ventilation helped to remedy the situation. But improving the ventilation would in turn reduce the amount of contamination with chemicals or micro-organisms, so that increased ventilation can be seen as an effective treatment rather than a cause (Jones 1989).

## Taking symptoms seriously

The symptoms of sick building syndrome are discussed in Chapter 2. They include eye and nose irritation, runny or stuffy nose, fatigue, headache, nausea, sore throat and general respiratory problems. Environmental tobacco smoke is often blamed for these symptoms, particularly since it can be seen or smelt, but many other less visible pollutants, as well as environmental conditions, can cause similar problems. For example, identical symptoms to those described above are suffered by people who are exposed to formaldehyde, ammonia, nitrogen oxides, cotton dust and fibreglass particles; by those who are allergic to dusts and microbial spores; and by those exposed to low relative humidities for long periods of time (Robertson 1988).

Sick building syndrome is often not taken seriously by the management since managers are less likely to suffer the symptoms. Managers often have larger offices, furnished with more expensive materials such as natural wool and real wood which are less likely to give off noxious gases, less equipment such as photocopiers and word-processors, and the freedom to move about and out of the building. Since the symptoms of sick building syndrome are common in any population, managers may wrongly treat the complaints as mere whingeing by workers. One example is given of a building where people working in the basement had been complaining for some time that the atmosphere was hot and stuffy with no fresh air and with heat and odours emanating from an adjacent kitchen. It wasn't until a senior executive fell asleep during a meeting in the basement that the employers decided to do something about the problem (Tong 1989). The two main reasons why sufferers of sick building syndrome know that it is not an individual problem but one connected with the workplace are, first, that a substantial proportion of fellow workers will be suffering from similar symptoms (hysteria, the management might say) and, second, the timing of the symptoms. A cardinal feature of sick building syndrome is that symptoms become worse after the person has been in the building for a few hours, particularly after the weekend or a break away from the workplace, and improve after leaving the building and at weekends. Humidifier fever, another building-related illness, also follows this pattern, and for this reason humidifier fever is considered together with sick building syndrome; the two may well be interconnected.

## Air monitoring

Getting management to take the problem seriously may be the first hurdle, but other pitfalls can arise when 'experts' are brought in to monitor the air. There may be literally thousands of chemicals in the air, so the cost of measuring the levels of all of them is out of the question. Consequently, a few of the more common pollutants may be looked for, depending on the situation and likely causes of pollution. The levels of pollutants that are considered 'acceptable' are derived mainly for industrial exposures (and are in any case considered by many to be too high) and rarely in cases of sick building syndrome are these levels exceeded. So, say the experts, our results show that the levels of ozone, nitrous oxides, formaldehyde etc. are well below toxic levels, and chemical exposure is not the problem here. However, such an approach ignores the fact that effects of chemicals are additive or may even be synergistic, i.e. the combined effect of being exposed to two (or more) agents may be greater than the sum of their individual effects. The health risks of long-term exposures to low levels of a variety of pollutants are poorly understood.

### *Camden Housing Aid Centre*

The following story of conditions at Camden Housing Aid Centre in London gives a good example of the pitfalls - and delays - that can occur when piecemeal testing for chemicals is carried out.

For some years in the early 1980s, NALGO (National and Local Government Officers' Association) reps at the Housing Aid Centre complained to the management that workers were suffering from headaches, sore throats, muscular

*Siting ventilation inlets next to the car park at Camden Housing Aid Centre ensured that air polluted with petrol fumes was circulated around the office.*

London Hazards Centre

aches, sinus problems and cold and flu symptoms. The workers believed that their problems were due to a combination of poor fluorescent lighting and a faulty ventilation system. In particular, the air inlet drew in fumes directly from a car park at the rear of the building.

In 1984, the Council's Environmental Health Department was called in to measure the levels of various components of vehicle exhaust fumes. The survey showed that levels were below those required for 'safety' in Health and Safety Executive Guidance Notes. However, these surveys did not take account of the peak exposures or of possible synergy between the various contaminants - lead, carbon monoxide, carbon dioxide, nitrogen oxides, sulphur dioxide and hydrocarbons.

In 1985 the union contacted the London Hazards Centre and in early 1986 independent surveys of the ventilation system and lighting were arranged. These showed that complete overhaul and improvement of the ventilation system was needed and that lighting should be totally re-designed. Eventually, later in 1986, the office was relocated to another Council building while refurbishment was carried out.

As this story shows, measuring potential pollutants in isolation can be pointless. It also shows how 'scientific' results may be used to undermine the position of workers whose common sense tells them what is likely to be amiss in their environment. These workers suffered for years - a situation that is not unusual in cases of sick building syndrome.

## How do buildings get to be sick?

In the UK speculative office building prevails: the office is seen as a device for multiplying the cost of land and as much office space as possible is squeezed into a building to increase the lettable area (Duffy 1988). Particularly in the 1950s and 1960s property developers dominated the UK office market. Their interest was in the exchange value of the building - what it would sell for in the short term. This resulted in speculative office building of very low quality (Marriot 1979). In such a system, the use value of the building is given little priority, since the building is for profit first and for consumers second. Often more attention is paid to the outside 'look' of the building than to its internal use: most offices are not user-friendly and do not incorporate in their planning the changing needs of the organisations that will occupy them.

In the 1970s, following the development slumps of the 1960s, financial institutions took over the market and there was a shift to longer-term criteria of providing more adaptable spaces and building services to accommodate changing occupational needs (Wilson and Ellis 1985). Investors were forced to pay more attention to tenants' needs because of the over-supply of office space and also to allow for the introduction of new technology.

In the late 1980s, the shell-and-core approach, in which as little fitting out as possible is done before the first tenant or owner takes up occupation, became more common. In theory, this approach should provide a better environment since it allows end-users to organise the interior in their own way, but in practice problems of poor air quality are just as likely. The experience of local authority workers around the country who have been moved into vast new civic centres pays testimony to the fact that purpose-built and designed office complexes have their share of problems:

> **'Mansfield District Council have been moved into a new fully air-conditioned Civic Centre for about two years now. There are about 350 people employed within the building. The old office accommodation we vacated had no air conditioning. Shortly after moving into the new centre I began to receive complaints from members of staff about the working environ-**

**ment within the new building. Complaints about dry eyes, sore throats and headaches etc.'** (Director of Central Administration and Legal Services, Mansfield District Council)

In fact it has been shown that people who work in public sector buildings tend to have more building sickness than those in the private sector (Wilson and Hedge 1987).

***Chain of events***

The number of different people and professionals involved in the design and construction of an average building provides much scope for poor decision-making leading ultimately to unhealthy working conditions (Vischer 1989). The developer might assign 'quality control' decisions to the architect, who is then at the mercy of the engineers brought in to design heating and ventilation systems and lighting. Architects are not engineers, so they have to rely on engineers' design specifications. Routine formulae are used to calculate air distribution systems throughout a building, and standard systems are cheapest to design and install. If specific user requirements are not known, or are not taken into account because of cost constraints, a standard system is installed which turns out to be inappropriate to the ultimate users of the building. In a similar way uniform lighting is often fitted, with little attention paid to the need for local lighting for particular tasks.

Architectural and engineering decisions may be made with little reference to each other. For instance, an attractive architectural space such as a high, glassed-in sunny atrium may have no means of exhausting the heated air that collects at the top of it. Once building starts, responsibility for quality control shifts by default to the contractor. Many changes are made as the building is constructed, so that design specifications are altered. For instance, chunks of concrete in the air mixing chamber of the ventilation system may be left there if the cost of their removal is too high. Concrete may not be given enough time to dry out before a screed coating is applied. Plastic parts may be substituted for metal ones in the ventilation ductwork if the specified parts cannot be obtained in time or are too expensive. Waiting for parts costs time and money, so short-cuts are taken.

Once the building has been constructed, the space is prepared for office use. Walls and partitions are put up and finally equipment and machines are installed, often with no notice being taken of the siting of ventilation inlets and outlets or assumed pathways of air flow across a space. So printing equipment and photocopiers are installed without any special ventilation. An office may be walled in with a supply air vent but no extract outlet. And to make matters worse the air-conditioning system may never be properly 'commissioned' by the installation engineer once the building has been occupied so that the system is not correctly balanced. A catalogue of errors and poor decisions may mean that problems are 'built in' to the structure, only to be added to by incorrect operation and poor maintenance.

In some European countries - Sweden, Germany and Holland - workers have a statutory right to be involved with employers' plans for changes in the workplace. Building regulations stipulate, for example, that everyone has the right to a window, that no-one should work in deep space below ground, and that the thermal environment must be of good quality. These rights lead to elaborate negotiations about environmental matters: 'before the northern European architect draws a single line, the users are already crowding around the drawing board' (Duffy 1988).

## About this book

This book is written primarily for office workers since most reported cases of sick building syndrome are associated with office buildings, but workers in schools, nurseries, hospitals and factories - in any industry - may be affected. The sickness depends on the workplace not on the worker. Humidifier fever, for instance, is more common in industrial premises than in offices.

Humidifier fever is quite distinct from sick building syndrome but the two problems are considered together here since problems of humidifier fever often come to light only during investigation of sick buildings. There is also some overlap between humidifier fever and another building-related illness, legionnaires' disease, since both arise from breathing in contaminated water droplets and both are readily preventable. However, the cause of legionnaires' disease and the measures that need to be taken to prevent it are specific, so it is discussed separately in Chapter 3. As the reader will by now be aware, there is often no simple solution to the problem of sick building syndrome. However, buildings can always be made more habitable - if money is spent on doing so.

All buildings and building services are different. This book aims to help people to look with a critical eye at the building they work in, to ask appropriate questions about design, construction and maintenance, and to take steps to improve their working environment.

# 2 A-Z of symptoms and illnesses

Not everyone who works in a sick building will become sick, just as the whole population does not succumb to a bout of flu during an epidemic. There are many factors that determine a person's physical response to their environment, although the response in sick building syndrome is rarely so severe that the person needs to take sick leave.

A syndrome is a group of symptoms that characterise a particular medical condition. Every person suffering from the condition may not have all the symptoms. Table 1 shows four syndromes that have been identified as being related to buildings. The symptoms that make up these syndromes are fairly common in any group of people, so it is their association with a particular building, and the fact that they improve after the person has left the building, that show the symptoms to be building related. It is often useful to keep a diary of symptoms, perhaps recording their severity on a scale of 1-7 every two hours for a week at work and throughout a weekend away from work.

Some of the symptoms are found in more than one syndrome, for instance lethargy and chest tightness,and the symptoms can be divided into four categories:

▲dryness, of the skin, eyes, nose and/or throat
▲ allergic symptoms, such as watery eyes or runny nose
▲ asthmatic symptoms, such as chest tightness
▲ general feelings, such as lethargy, headache or malaise

Table 1 shows two types of sick building syndrome; one is a probable allergic response. Not everyone would agree with this classification into allergic and non-allergic responses. For instance, Jones (1989) believes that sick building syndrome may consist of sub-syndromes based on reactions to chemicals or microbes:

> **'The symptoms particularly associated with the proposed chemical sub-syndrome include fatigue, headache, and dry and irritated eyes, nose and throat sometimes with nausea or dizziness. Those most common to the proposed microbial sub-syndrome include itchy, congested or runny nose, itchy watering eyes, sometimes with wheezing, tight chest or flu-like**

**symptoms...These symptoms fit with a presumed trigeminal nerve irritation mechanism in the case of chemicals, and an infective or allergic mechanism in the case of microbes.'**

When more is understood about the causes of sick building syndrome, the issue of classification into medical syndromes may be resolved.

Humidifier fever and occupational asthma are illnesses related to buildings but they are considered to be separate from sick building syndrome because their causes can more usually be identified. These syndromes are not as common as sick building syndrome, and it is not yet known whether some of the underlying causes might be common to all four syndromes.

Similarly, legionnaires' disease, which is discussed separately in Chapter 3, is a building-related illness with a clearly identifiable cause (the bacterium *Legionella pneumophila*), unlike sick building syndrome which usually has non-specific causes.

**Table 1: Medical syndromes associated with buildings**

| *Syndrome* | *Symptoms* |
|---|---|
| Sick building syndrome (type 1) | Lethargy and tiredness<br>Headache<br>Dry blocked nose<br>Sore dry eyes<br>Sore throat<br>Dry skin and/or skin rashes |
| Sick building syndrome (type 2) | Watering/itchy eyes and runny nose i.e. symptoms of an allergy such as hay fever |
| Humidifier fever<br>(1) Flu-like symptoms | Generalised malaise<br>Aches and pains<br>Cough<br>Lethargy<br>Headache |
| (2) Allergic reaction in sensitive individuals | Chest tightness<br>Difficulty in breathing<br>Fever<br>Headache |
| Occupational asthma | Wheeze<br>Chest tightness<br>Difficulty in breathing |

*Sources:* World Health Organization 1983; Morris 1987; Wilson and Hedge 1987

The various symptoms and illnesses are described in more detail below, in alphabetical order. Cross-references are in italics.

**Allergy**

People who have become sensitised to a particular allergen (such as the house dust mite which provokes an attack of asthma in sensitive individuals) can be affected by very small amounts of that agent. Some substances are more likely than others to cause allergy, but any organic substance is a potential allergen.

A US company that specialises in remedying sick buildings carried out research which showed that allergenic fungi were the main pollutants in 34 per cent of mechanically ventilated buildings (*Guardian* 1988).
See also *Asthma, Humidifier fever*

**Asthma**

Symptoms that are suggestive of work-related asthma include chest tightness, difficulty in breathing, shortness of breath and wheezing. Someone who is told by their general practitioner that they have recurrent bronchitis may in fact have occupational asthma. Breathing difficulties that improve on days away from the workplace could be due to occupational asthma.

> **'I teach computer studies in a room which, I feel, has made me develop asthma and which, latterly, has given me severe headaches. A colleague has suggested that I should use an ioniser in the room. If you know of any medical evidence that would substantiate my claim I would appreciate it. At the moment I am just told to keep taking the Becotide (for the asthma) and Paracodol (for the headaches).'** (Ballyclare, County Antrim)

In one study, up to 10 per cent of workers in air-conditioned offices with humidification experienced chest tightness compared with about 2 per cent of those in buildings with natural ventilation (Finnegan et al 1984). Work-related asthma may be caused by an allergic reaction to inhaled micro-organisms or their toxic products (Morris 1987).
See also *Allergy, Humidifier fever*

**Breathing difficulties** See *Asthma*

**Chest infections**

A high frequency of airways infection is one of the features of the *sick building syndrome* described by the World Health Organization (1983).
See also *Respiratory infections*

**Colds** See *Respiratory infections*

**Cough** See *Chest infections, Humidifier fever, Sick building syndrome*

**Eye problems**

The sensitivity of the eyes to the atmosphere means that they are easily irritated, and symptoms such as soreness, itchiness, grittiness, watering and redness are common in buildings with indoor climate problems. Some of these symptoms are due to dryness, whereas others (watery eyes) may be an allergic response. Tests for 'dry eyes' have shown that people who report building-related eye symptoms may have unstable tear-films and damaged conjunctival epithelium (Franck 1986). Eye problems often occur together with *nasal* and *throat* problems.
See also *Sick building syndrome*

**Dizziness** See *Nausea*

**Extrinsic allergic alveolitis**

The alveoli are the tiny airways at the bottom of the lungs where exchange of gases takes place. In extrinsic allergic alveolitis, these airways become inflamed as a result of an allergic response to an inhaled allergen. The illness is similar to farmers' lung, where the allergen is fungal spores. Symptoms are similar to those of humidifier fever - fever, chills, cough, malaise, chest tightness and shortness of breath - except they do not disappear because tolerance does not develop. Additional, long-term symptoms include loss of appetite, weight loss and a persistent cough with sputum which can lead to permanent lung damage due to scarring (fibrosis).

Extrinsic allergic alveolitis due to organisms from humidification systems has been reported in a few people (Robertson and Burge 1985).

**Headache**

The headaches associated with *sick building syndrome* are most often felt across the forehead, above both eyes, and also at the back of the neck. They are not usually throbbing or associated with visual symptoms, as in migraine (Robertson and Burge 1985), and were described as 'usually mild' in one study (Finnegan et al 1984). The headache, like the *lethargy* which often accompanies it, usually gets worse as the day progresses and starts to improve quite quickly once the person has left the building. Headache has many possible causes, including working all day under fluorescent lighting or spending too many hours in front of a visual display unit. It may be useful to keep a diary of when headaches occur to see if they are related to time spent in the building.
See also *Humidifier Fever*

**Hypersensitivity pneumonitis**

This is the American term for *extrinsic allergic alveolitis.*

**Humidifier fever**

Humidifier fever is caused by breathing in water droplets from humidifiers (or sometimes from other components of a ventilation system such as air filters) that have become heavily contaminated with micro-organisms. Such contaminated water can cause various illnesses, including *respiratory infections* and allergenic illnesses such as *asthma* and *extrinsic allergic alveolitis*. Humidifier fever is the most common and best documented of these illnesses (Sykes 1988). Sometimes a diagnosis of humidifier fever is made by testing sufferers for their reaction to extracts of the water or organic material taken from a contaminated humidifier.

Humidifier fever is a non-infective (that is, you can't 'catch' it from anyone else) building-related illness for which a specific cause can often be found, if it is looked for, unlike *sick building syndrome* which usually has non-specific causes. The disease has been reported more often in industrial buildings than in offices or public buildings, and is a particular problem in printing works where humidification needs are high and paper dust provides a good source of nutrients for microbes in the air-conditioning system. The acute symptoms are very like those of flu - fever, cough, aching limbs, headache, tiredness and lethargy - although the symptoms don't usually last for quite so long. Some people who are particularly sensitive to the causative agent may also have asthmatic symptoms of tight chest and difficulty in breathing (see Table 1). Symptoms usually develop on the first day back at work after the weekend or other break (the disease is sometimes called 'Monday fever'), and they are often worse after a longer break or after a period of air-conditioning plant shutdown. They start only after the person has been back in the guilty environment for some hours, perhaps in the late afternoon of the first day, and often become severe in the evening and night after the person has left work, lasting for 24-48 hours. Despite the fact that the person may continue working in the contaminated environment, the symptoms do improve, indicating that an allergic reaction may be involved.

Cold water humidification systems can become contaminated with a wide range of micro-organisms (algae, amoebae, bacteria and fungi) and the response may be to the organism itself or to toxins produced. Humidification systems that spray tepid water into the air are most prone to cause humidifier fever. The treatment of humidification systems with biocides or other chemicals can make the situation worse, since the chemicals may also be toxic. Humidifier fever is said to occur in about 3 per cent of people working in offices where a humidifier in the air-conditioning system is in operation (Robertson and Burge 1985). Permanent lung damage does not occur, although a few reports have been made of people who have developed the more serious condition *extrinsic allergic alveolitis* due to organisms from humidification systems (Robertson and Burge 1985).
See also *Asthma*

### Hysteria

Problems associated with poor air quality at work are often put down by bosses as a hysterical reaction, particularly since clerical staff are more likely than managerial staff to suffer from *sick building syndrome* and more women than men are clerical workers (Wilson and Hedge 1987). Since *sick building syndrome* has been accepted as a 'definite entity' by the Health and Safety Executive and the World Health Organization, the label of 'hysteria' can be seen as evidence of ignorance.

### Influenza

The influenza virus, like other airborne infectious agents, can be spread around a building by the recirculation of air in a ventilation system. Symptoms of flu are similar to those of *humidifier fever*, although their expression is not work related and they tend to last longer. People working in sick buildings tend to suffer more from respiratory infections.

### Lethargy

Lethargy, described in dictionaries as 'morbid drowsiness', might also go under the headings of tiredness, lack of energy, apathy, mental fatigue and sleepiness. The feeling that it is a great effort to concentrate tends to develop

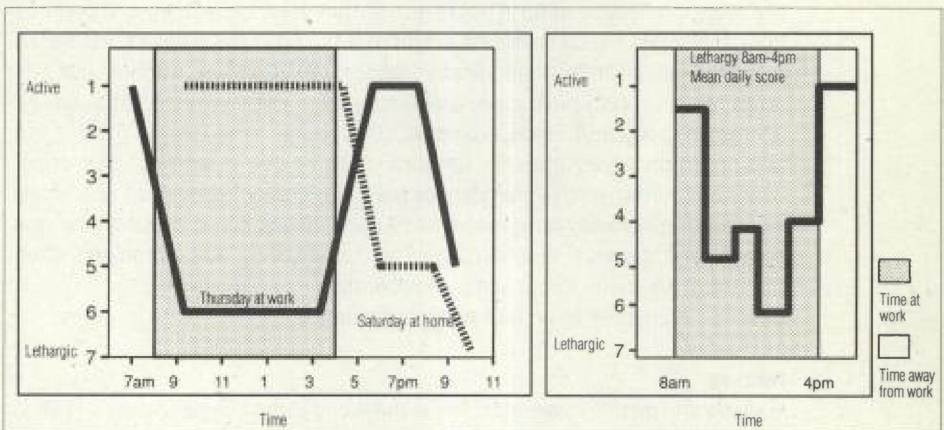



***Figure 1*** *An office worker in an air-conditioned building kept a diary of her lethargy every two hours from waking to sleeping. The scale runs from 1 (active) to 7 (lethargic). Left: the two-hourly readings on a Saturday at home show lethargy starting at 6.30pm, progressing in the evening. On a Thursday at work lethargy starts within an hour of coming to work, improves on leaving work and recurs before bedtime. Right: the same results have been plotted as the average lethargy score for the hours at work (8am to 4pm). There is progressive lethargy from Monday to Thursday, with some improve-ment on the half-day worked on Friday and clearing up over the weekend. The record shows clear work-related lethargy.*

*Reproduced from* Robertson A S and Burge P S (1985), Building Sickness, *The Practitioner* Vol 229 June 1985, p534 in the afternoons but improves once the person goes outside the workplace, sometimes within minutes, sometimes within 2-3 hours (Robertson and Burge 1985).

For lethargy to be taken seriously as a work-related condition it may be best to keep a diary, scoring the lethargy on a scale from 1-7 every 2 hours. The lethargy experienced in *sick building syndrome* is often also accompanied by a *headache*. Lethargy may be experienced by about 50 per cent of workers in buildings that are air-conditioned, with or without humidification systems, although about 15 per cent of people working in naturally ventilated buildings also complained of this symptom in the same study (Finnegan et al 1984). Many causes have been suggested for the symptoms of headache and lethargy: lack of negative ions, lack of air movement, low humidity, ozone and carbon monoxide, formaldehyde from furniture and furnishings, too much time spent at a visual display unit, fluorescent lighting.
See also *Humidifier fever, Sick building syndrome*

**Nasal problems**
If the air is dry, the mucous membranes of the nose will also be dried and the nose will feel 'stuffy'. Or the membranes may be irritated and inflamed (as in the allergic response seen in hay fever), so that the nose is runny and perhaps itchy or blocked. Nasal problems are more common in mechanically ventilated buildings with chiller or humidification systems than in those without such systems, which in turn have more problems than naturally ventilated buildings (Finnegan et al 1984; Robertson et al 1985; Burge et al 1987). Stuffy nose and dry *throat, eyes* and *skin*, are thought to be due to working in an atmosphere with low relative humidity or moisture content. However, one study showed that humidity levels were adequate, casting some doubt on the reasons for the 'dryness' reaction (Robertson et al 1985). Nasal problems often go hand in hand with *throat* and *eye problems.*
See also *Humidifier fever, Sick building syndrome*

**Nausea**
Nausea and dizziness are included in the World Health Organization's (1983) list of symptoms associated with *sick building syndrome*, but not all researchers have found these problems to be any more common than in the general population (Wilson and Hedge 1987).

**Respiratory infections**
A dry atmosphere leads to an increased incidence of respiratory infections since the mucous membranes are dried out too. Upper respiratory tract infections, such as colds and *influenza*, are more common in air-conditioned offices than in naturally ventilated ones (Ruhemann 1985). This may be partly due to the fact that re-circulation of air in the system will spread viruses around the building and partly due to the debilitating effects of *sick building*

*syndrome*. The inhalation of contaminated water from humidification systems may also cause respiratory infections.

> **'I work in a building that has a second-hand air-conditioning system and I don't think it works properly. All of us have had cold after cold and sore throats and coughs galore. We all feel very tired and lethargic at the end of the day. The boss won't allow us to have the windows open - even in the summer. I always feel headachy and my lungs are craving for fresh air at the end of the day. It feels very claustrophobic in there sometimes.'**
> (Electrical wirer of audio equipment, Salisbury, Wiltshire)

See also *Humidifier fever, Sick building syndrome, Stress*

**Sick building syndrome**

Since the symptoms of sick building syndrome are common in the general population, it is the pattern of their expression that points to the diagnosis: in sick building syndrome, symptoms are associated with being in a particular building and are relieved by leaving or staying away from that building. Table 1 shows two types of syndrome; one is a more allergic response in sensitive individuals. In addition, the World Health Organization (1983) lists the following symptoms of malaise:

▲ eye, nose and throat irritation
▲ sensation of dry mucous membranes and skin
▲ erythema
▲ mental fatigue
▲ headache
▲ high frequency of airway infection and cough
▲ hoarseness, wheezing, itching and unspecific hypersensitivity
▲ nausea, dizziness

In a study of 4,373 people working in 46 buildings (Wilson and Hedge 1987), 80 per cent had symptoms of ill-health which they associated with being in their place of work. Twenty-five per cent experienced one or two symptoms only, but 29 per cent had five or more symptoms. Lethargy was the most common complaint (57 per cent), followed by stuffy nose (47 per cent), dry throat (46 per cent), headache (43 per cent), itching eyes (28 per cent), dry eyes (27 per cent), runny nose (23 per cent), flu-like symptoms (23 per cent), difficulty in breathing (9 per cent) and chest tightness (9 per cent).

This study also showed that people with clerical/secretarial jobs have 50 per cent more symptoms than those with managerial posts, and 30 per cent more than 'professionals'. The likely reasons for this are that clerical workers most often work in open-plan offices where there is less control over environmental conditions than in cellular offices; they are more tied to their desks, so that they are exposed to the same conditions for most of the working day, unlike managers who are usually more mobile; and they often do repetitive, visually demanding jobs that stress the body physically. (Clerical/secretarial work comes high on the ladder of stressful occupations.) Women report symptoms more frequently than men, a difference that may be due to the fact that women are employed predominantly in clerical/secretarial jobs and men in professional/managerial posts. Also, women tend to be more aware of how they are feeling than men. Another suggestion for this gender difference is that women may be more prone to sick building syndrome because a dose-response relationship exists: women need a lesser dose of a chemical or pollutant to become ill (Jones 1989).

People working in air-conditioned buildings consistently show higher rates of sickness than those working in buildings that are naturally ventilated or that have mechanical systems of ventilation supplying ducted air but not cooling or humidifying it, although it may be pre-heated (Finnegan et al 1984; Robertson et al 1985; Burge et al 1987; Wilson and Hedge 1987; Wilson et al 1987). For all ventilation categories, workers in public sector buildings have consistently higher rates of building-related sickness than those in the private sector (Wilson and Hedge 1987).

**Skin problems**

Dryness of the skin affects exposed areas such as the face, lips, arms and hands. In one study it was found to be commoner in women, who found they had to use more moisturising cream after moving from a naturally ventilated to an air-conditioned building (Finnegan et al 1984). Other reported problems include rashes, blotches (erythema) and itchy skin.
See also *Sick building syndrome*

**Stress**

The acute problems associated with stress include headaches, digestive disorders, fatigue and lethargy, sleeping problems, skin disorders and a reduced immunological response (i.e. a decreased resistance to infection). Many of these symptoms are similar to those seen in *sick building syndrome,* so stress due to environmental and other factors should also be considered as a cause of *sick building syndrome.*

**Throat problems**

Dry throat and hoarseness are symptoms that indicate drying of the mucous membranes and are often found together with a stuffy nose and sore eyes. Throat and *chest infections* are more common in buildings with air quality problems.
See also *Eye problems, Nasal problems, Sick building syndrome*

**Wheezing**

See *Asthma*

# Legionnaires' disease

# 3

On 27 April 1988, two people - one with suspected food poisoning, the other with suspected pneumonia - were admitted to the same Essex hospital. Two days later, tests had confirmed that both people had legionnaires' disease and doctors noticed that both had been working in Broadcasting House in London. This chance observation led to an immediate alert of the public health authorities and to searches for the source of infection and for potential victims.

Eventually, 58 people were confirmed as suffering from legionnaires' disease; 18 worked for or at the BBC and the rest were members of the public who had happened to pass by or who lived close to Broadcasting House. Three people died.

The source of the infection was a cooling tower which had stood idle for 2-3 months in the autumn of 1987. As we shall see, such a situation is a potential recipe for disaster.

## *Legionella* bacteria

In July 1976, 182 delegates to an American Legion convention in Philadelphia were struck down with a mysterious acute respiratory illness. The search began for what was, six months later, found to be the bacterial species *Legionella pneumophila*. Twenty-nine people died in this outbreak.

The *Legionella* organism is a particularly small bacterium (bacteria are single-celled organisms that multiply by dividing into two) which doesn't grow in conventional laboratory growth media - which is why it took so long to find it.

Outside the lab, *Legionella* thrives in any warm, non-sterile water, particularly if the water contains sludge, iron, algae and amoebae. The bacterium is found everywhere in nature - in rivers, lakes, ponds and streams, and in wet soil. It is probably found in low concentrations in all open water systems, including those of building services such as hot and cold water systems (CIBSE 1987). *Legionella* has probably been around for hundreds of years but has been isolated only recently because the new environments that support its growth have the potential to cause outbreaks (two or more cases) of disease rather than sporadic (single) cases. Typical disease-causing environments are air-conditioned buildings with poorly maintained or sited cooling towers. As John Rimington, Director General of the Health and Safety Executive, has said:

> **'Legionnaires' disease is an illness which we have managed to create for ourselves. In designing and constructing systems to control our environment, we have created conditions which can be ideal for the propagation of Legionella. Those systems must be properly monitored and maintained. That is the key to controlling this disease.'** (Health and Safety Executive 1989)

However, *Legionella* is a threat to human health only under certain circumstances - when conditions are such that the bacteria multiply to reach high numbers and become airborne in highly contaminated droplets (see *Sources of infection* below).

By 1988, at least 23 different *Legionella* species had been identified, with 12 different serogroups (a serogroup causes a particular immunological response in infected people) (Winn 1988). The organism responsible for causing legionnaires' disease is *Legionella pneumophila* serogroup 1 sub-type Pontiac. The species name *pneumophila* indicates the bacterium's fondness for the human lung. Outbreaks of acute respiratory disease from as far back as 1959 are now known to have been caused by *Legionella pneumophila.*

## *Legionella* infections

Legionellosis is the collective term used for clinical conditions caused by bacteria from the Legionellaceae family. The species *Legionella pneumophila* can cause two distinct clinical syndromes: full-blown legionnaires' disease and Pontiac fever. Legionnaires' disease is quite separate from sick building syndrome or humidifier fever. Between 100 and 200 cases of the disease are reported each year. It is a type of pneumonia, with symptoms that come on abruptly 2-10 days after exposure (but more usually 3-6 days) in a susceptible person. Only about 1 per cent of those exposed go on to develop legionnaires' disease. Susceptible people include the elderly; those who are already ill from respiratory or heart disease; people on renal dialysis and with kidney disease; those taking immunosuppressant drugs (such as anti-cancer agents); diabetics; alcoholics; and smokers. Men are more vulnerable than women: only three out of ten sufferers are women. Most cases have been in people aged between 40 and 70 years.

Legionnaires' disease is thought to account for 2-10 per cent of all cases of pneumonia in Europe (Badenoch Report 1987). From the figures on the annual number of deaths from pneumonia, between 1,000 and 5,000 deaths from legionnaires' disease would be expected in the UK each year. In fact, only 161 legionnaires' disease deaths were reported between 1979 and 1986, suggesting that a very large number are not diagnosed or reported as such (*Occupational Health Review* 1988).

The symptoms of legionnaires' disease are high fever, chills, headache and muscle pains, followed by a dry cough and breathing difficulty. As Table 2 shows, about a third of sufferers also develop diarrhoea or vomiting, and nearly a half become confused or delirious. The disease is fatal in up to about 18 per cent of cases, which is a mortality rate similar to that seen for other types of pneumonia. Antibiotics are usually an effective treatment. However, it is important that the correct diagnosis is made so that an antibiotic to which *Legionella pneumophila* is sensitive can be used. Complete recovery from legionnaires' disease takes several months, even for people previously in good health. It is not yet known whether people who have had legionnaires' disease are then immune to re-infection.

**Table 2: Symptoms of legionnaires' disease and Pontiac fever**

| | Percentage of patients | |
|---|---|---|
| *Symptom* | *Legionnaires' disease* | *Pontiac fever* |
| Cough | 75 | 46 |
| New sputum production | 45 | - |
| Coughing blood (haemoptysis) | 21 | - |
| Breathing difficulty (dyspnoea) | 50 | - |
| Muscle pains (myalgias) | 38 | 95 |
| Upper respiratory tract symptoms (nose, throat) | 13 | - |
| Headache | 32 | 88 |
| Confusion | 45 | 19 |
| Nausea or vomiting | 30 | 10 |
| Diarrhoea | 33 | 21 |
| Abdominal pain | 8 | - |
| Fever | - | 86 |
| Fever above 39°C | 70 | - |
| Slowed heart rate | 40 | - |

*Source:* Winn (1988)

Pontiac fever, named after an unsolved outbreak of acute respiratory disease affecting 144 people in a health department in Pontiac, Michigan, USA, in 1968, differs from legionnaires' disease in that symptoms of pneumonia are not involved (see Table 2) and the disease is not fatal. The incubation period averages 36 hours, and 95 per cent of those exposed develop the disease. It has been suggested that Pontiac fever is an allergic reaction (Rowbotham 1980).

The mortality rate in the BBC outbreak was low: only 5 per cent of those who contracted the disease died. This may have been because of the relatively good health of the population exposed, unlike in the world's worst outbreak, probably also from a contaminated cooling tower, at Stafford General Hospital in April 1985, when 30 people died - a mortality rate of about 30 per cent.

## Sources of infection

Most cases of legionnaires' disease are not associated with outbreaks (two or more cases from a single source): 75 per cent of reported cases in the UK are sporadic, i.e. single cases (Badenoch Report 1987). The source of infection is often not identified although most sporadic cases are associated with hot water systems (Employment Committee 1986).

Legionellae enter hot and cold water systems, cooling water systems or process water systems in industry through contamination of exposed water or through the mains water supply. It has often been stated that more than 90 per cent of known outbreaks of legionaires' disease arising from cooling towers are associated with nearby building works. The suggestion is that the dust neutralises the biocides in the cooling water or helps to sustain the droplets released into the environment.

A survey carried out by the Public Health Laboratory Service in the aftermath of the Stafford General Hospital outbreak showed that 70 per cent of water systems in hospitals and 75 per cent of systems in business premises were contaminated (Bartlett et al 1985). However, very low numbers of *Legionella* in a water system are unlikely to cause problems. Disease occurs when conditions favour the growth and multiplication of bacteria so that high concentrations are reached. Stagnant water favours growth; contamination (and outbreaks of disease) occurs when new water systems are brought into operation or when systems are started up after a period of shut-down, since under these circumstances water may have been lying around in the system for weeks or even months. Stagnant water zones such as dead-legs where dirt, sludge, rust or scale can accumulate may also shelter bacteria. In addition, the materials used in the systems may affect the organism's ability to multiply: some pipes, washers, grommets, sealants and jointings are more likely than others to support surface growth.

The temperature of the water is a very important factor. Temperatures of about 37 degrees Celcius (37°C is normal human body temperature) are best for growth of *Legionella*. Growth rates decrease at lower temperatures and cease altogether below 20°C. Above 37°C the rate of multiplication also decreases, until at 46°C it is zero. At higher temperatures the bacteria are eventually killed off, more quickly as the temperature rises.

## Aerosols

Water cooling towers, certain kinds of humidifer, air-conditioning systems, showers, spray taps, and other water systems produce small droplets in the course of their normal operation (see Table 3). The main mechanisms by which aerosols are created are water streams breaking up or striking a surface, or bubbles bursting at a water surface. Air movement can spread these aerosols hundreds of metres from their source: in the BBC outbreak, one victim lived 500 metres from the contaminated cooling tower.

**Table 3: Possible sources of *Legionella* bacteria**

| |
|---|
| Air-conditioning equipment (cooling water systems, humidifiers, cooling coils, condensers) |
| Air washers |
| Cold water systems |
| Condensers (e.g. evaporative, steam turbine) |
| Fire sprinklers |
| Hot water systems |
| Humidifiers (atomising, spray, portable) |
| Jacuzzis |
| Nebulisers and humidifiers (for medical use) |
| Showers |
| Spray taps/mixer taps |
| Swimming pools |
| Ventilation bags (for medical use) |
| Water-based coolants (lathes, diamond wheels and other rotating machines generate aerosols) |
| Wet cooling towers |
| Whirlpool baths/spas |

Inhaling tiny droplets of contaminated water is the only proven way of catching legionnaires' disease: it is not contagious and cannot be passed from person to person. The organism is not thought to be harmful if swallowed, although guinea pigs who were fed large doses of contaminated water developed pneumonia and died (Winn 1988).

Danger arises when contaminated water becomes aerosolised and the droplets evaporate before they reach the ground, so creating particles that are so small they can be inhaled into the lowest part of the lungs - the alveoli, where exchange of gases takes place.

The factors that determine whether or not a person who has inhaled contaminated aerosol will go on to develop disease include the susceptibility of the individual, the number of bacteria that have been inhaled, and the length of exposure time. For instance, exposure to a contaminated shower-head may be brief, whereas exposure in a building where the ventilation system is taking in contaminated air from a nearby roof-top cooling tower may be continuous.

## Wet cooling towers

In both the BBC and the Stafford General Hospital outbreaks, cooling towers were believed to be the source of infection. It is surprising that more outbreaks of legionnaires' disease haven't occurred, particularly in connection with the air-conditioning water cooling towers of office blocks or public buildings. The maintenance of many cooling towers on London office blocks is atrocious, according to evidence given to the inquiry into the Stafford outbreak (Badenoch Report 1987).

***How cooling towers work***

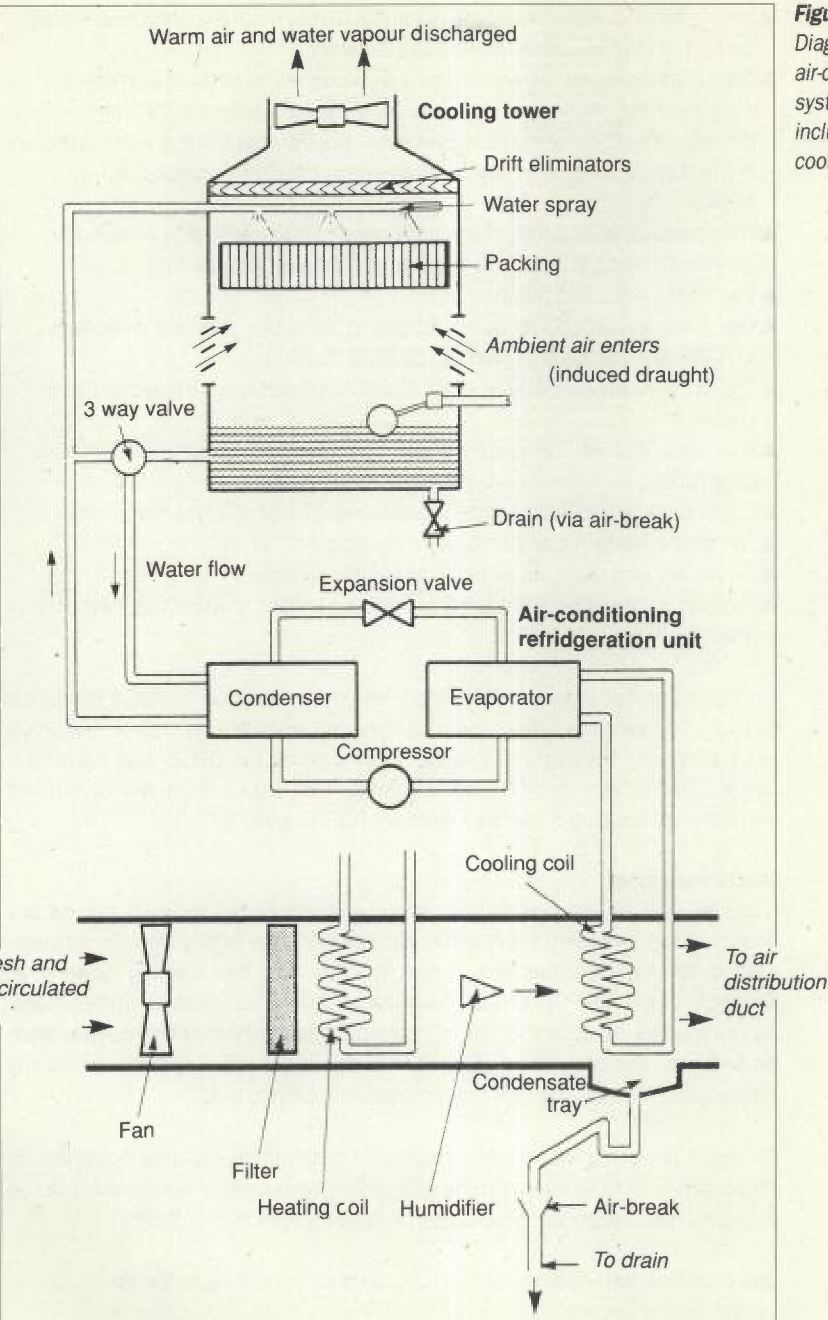
There are several types of cooling tower, but they all work on the same principle. Cooling towers are designed to remove unwanted heat from air-conditioning plant (see Figure 2) or from process cooling in industry. Before the ducted air is circulated through the building it is cooled by the cooling coil through which water chilled by a refrigeration unit is circulated. Heat from the refrigeration cycle is removed at the condenser, which may be cooled by air or, more commonly, by water circulating through the cooling tower.

The cooling water is drawn from the pond at the base of the tower and pumped through the refrigerant condenser where it gains heat. It is then pumped to the top of the tower and sprayed on to a filler pack before draining back into the pond. Air is blown or drawn through the filler pack and gains moisture and heat in the process of cooling the water by evaporation. The purpose of the filler pack is to increase the rate of evaporation, and hence cooling, by providing a large area of wetted surface.

***Design of cooling towers***

Cooling towers need to be designed in such a way that growth of *Legionella* is minimised:

▲ The tower must be sited so that air from the discharge does not enter open windows or air-conditioning or ventilation intakes. Prevailing wind direc tions should be taken into account.




*Reproduced from*: Health and Safety Executive (1987), Guidance Note EH48: *Legionnaires' disease*, HMSO, London

**Figure 2**
*Diagram of an air-conditioning system, including the cooling tower.*

▲ High efficiency eliminators are essential to minimise the amount of water carried out in the airstream leaving the tower.
▲ Construction materials should be non-porous with a smooth surface for easy cleaning. All non-metallic components such as seals, 'O'-rings, washers, etc. should be of a type known not to support bacterial growth, as listed in the *Water Fittings and Materials Directory* (Water Research Centre 1990).
▲ Filler packs should not be made from organic materials such as wood or cardboard which are more likely to support microbial growth.
▲ The filler pack must be cleanable.
▲ The water circuit should be as simple as possible, avoiding dead-legs and awkward loops that may be difficult to drain.
▲ The system should be able to be dismantled easily for inspection and cleaning.
▲ The water distribution system should be designed to minimise aerosol generation.
▲ Sump design should promote the removal of sludge from the system.
▲ The entire system must be able to be drained.
▲ Air-breaks and traps must be provided for all drains.
▲ The pond should be shielded from direct sunlight to minimise microbial growth.

Further technical details on cooling tower design can be found in Guidance Note EH48, which is being updated, from the Health and Safety Executive (HSE 1987); in the Code of Practice published by the DHSS and the Welsh Office (1989); and in Technical Memorandum TM13 from the Chartered Institution of Building Services Engineers (CIBSE 1987).

***Water treatment***

However well designed a cooling tower is, it still poses a threat unless the quality of the water in the system is good. Before the BBC outbreak, arrangements for treating the water and maintaining the cooling towers at Broadcasting House had broken down completely. There was no written statement on water treatment policy, no schedule listing necessary maintenance procedures, record-keeping was inadequate, and no one person was clearly responsible for ensuring that procedures were carried out.

For every cooling tower, a water treatment programme must be designed for that system, both to maintain the efficiency of the system and to prevent the growth of micro-organisms including *Legionella*. It should include:

▲ a bleed or blow-down to prevent build-up of impurities in the re-circulating water
▲ scale and corrosion control

▲ biocidal treatment
▲ chemicals to control sludge build-up
▲ a filtration system or strainer system to prevent the accumulation of sludge

Prevention of the build-up of scale is important since biocides cannot penetrate under scale where legionellae may be harbouring. The cooling tower water must be kept free from organic debris since this 'uses up' the biocide and prevents it from combining with its intended target, the *Legionella* bacterium.

***Use of biocides***

While the Badenoch Committee was carrying out its inquiry into the outbreak of legionnaires' disease at Stafford General Hospital it recommended that another committee be set up to review the use of biocides to control the growth of *Legionella* (Committee of Inquiry 1986). The Expert Advisory Committee on Biocides reported in 1989 (Department of Health 1989). It found that hardly any proper research had been carried out into the use and effectiveness of biocides in cooling towers, and was unable to recommend any one biocide over the others. However, it considered that most biocides on the market would be effective provided that the water system was already 'clean', that the biocides could reach all parts of the system, and that they could remain there for a sufficient time. The committee made the following points:

There is little evidence to support any particular dosing system: as long as cooling towers are kept in good condition, *intermittent dosing* with biocides is adequate. *Continuous dosing* may be needed for towers in a poor condition.

There is no such thing as a 'safe' level of *Legionella* in a cooling water system, and there is little point in routine testing for the organism. In any case, however rigorous the maintenance procedures are, there will always be some legionellae in cooling water systems; bacterial counts are often inaccurate; and there is a delay in getting back the results. (The London Hazards Centre recommends that samples of water, sludges and, perhaps, air should be taken if there is any doubt, and before and after any major clean-up. Of course, tests must be done if the tower is thought to be associated with human infection.)

Towers that are used all year round should be cleaned and disinfected twice a year. When chlorine is used as the biocide after twice yearly cleaning, a free chlorine level of 5-15 milligrams per litre (or parts per million) should be maintained for five hours before the tower is brought back into use.

As yet, there is no firm evidence that legionellae readily develop resistance to biocides. The Committee recommends that different biocides be used to prevent resistant strains from being selected. (The London Hazards Centre advises, however, that use of more complex biocides should be avoided because of increased toxic risk to engineers and building occupants.)

### *Cleaning and disinfecting*

The Code of Practice published by the DHSS and the Welsh Office (1989) is the most comprehensive document available in the UK for those whose job it is to keep buildings free from *Legionella* bacteria. For cooling towers, it recommends that cleaning and disinfecting of the *entire* system is needed at the following times:

- ▲ when the system is first brought into use after installation;
- ▲ before start-up, mid-way through, and at the end of short 'cooling seasons'. After final cleaning, towers should be left 'dry' during the winter months;
- ▲ twice yearly for systems that are operated all year round. The water quality should be carefully monitored;
- ▲ after a shut-down period of five days or more;
- ▲ if the system or part of it has been altered or otherwise disturbed;
- ▲ when the 'cleanliness' of the system is in doubt.

Workers cleaning towers must have protective clothing and respirators to protect them from both bacteria and chlorine (or other biocides). Water lances should not be used since they create aerosols.

The best way to disinfect by chlorination is to add a solution of sodium hypochlorite rather than slow-releasing tablets (Department of Health 1989). Chlorine is one of the most deadly gases in existence, and sodium hypochlorite is a dangerous chemical: undiluted solutions are caustic, causing burns to the eyes and skin, and poisonous. It and any other chemicals used for cleaning purposes - comes under the Control of Substances Hazardous to Health (COSHH) Regulations (1988) which came fully into force on 1 January 1990.

*COSHH Regulations*

Under the COSHH Regulations an employer has to assess all work that is liable to expose any worker to hazardous solids, liquids, dusts, fumes, vapours, gases or micro-organisms. Assessment means evaluating the risk and taking appropriate action to prevent people from being exposed.

The COSHH Regulations also apply to workplaces where there is a risk of legionellosis, since they cover micro-organisms that create a hazard to the health of any person (Health and Safety Commission 1989). COSHH leaflets can be obtained free from Health and Safety Executive Area Offices. The revised HSE Guidance Note EH48 on legionnaires' disease will give practical guidance on assessments under the COSHH Regulations and the sort of action that will be necessary. Most trade unions have produced guidance on COSHH for their members.

Chlorinated water is hazardous to aquatic life when discharged directly into water courses. In the USA, biocides are classed as pesticides and their use is more strictly controlled than in the UK. Similar regulations apply in other countries, e.g. Holland and Canada. In the UK, biocides are less regulated but a licence to discharge chlorinated water is needed under Section 34 of the Control of Pollution Act 1974. The licence application includes information on the nature and flow-rate of the discharge: bleed water should be discharged at a steady rate to the sewer to dilute the chlorine.

***Replacement of wet cooling towers***

There are large numbers of wet cooling towers in the UK that are about 20 years old, and the estimated useful life of a tower is about 10-20 years (Employment Committee 1989). The contaminated tower at the BBC, for example, was installed in 1972.

The policy within the NHS is now to use equipment such as air-cooled condensers when a wet cooling tower needs replacing, so that wet towers will be phased out. At the very least, older towers, which are more likely to harbour legionellae, should have wooden components replaced with plastic ones. The aim nationwide must be to replace all wet towers with air-cooled systems as soon as possible.

## Air-conditioning equipment

Wet cooling towers are often implicated in outbreaks of legionnaires' disease, but other parts of the air-conditioning system may also provide ideal conditions for growth and dispersal of legionellae, i.e. water temperature of 20-45°C; the presence of sludge, scale, rust, algae and organic particles which provide food for the bacteria; and the production of small droplets or aerosols that can travel along the ductwork into rooms where people are working.

No one air-conditioning system is the same as another, but you should be able to work out where potentially hazardous sites and components lie in your system. Several of these components can be seen in Figure 4.

***Air inlets***

Air inlets are potential sources of entry of contaminated droplets from the drift of cooling towers and evaporative condensers sited on nearby roof-tops. Sometimes, air inlets are placed right next to cooling towers on the roof. The outbreak in Pontiac, which gave rise to the illness known as Pontiac fever, is believed to have arisen from contaminated exhaust from an evaporative condenser being drawn into the air- conditioning system (Dept. of Health 1989).

### *Humidifiers*

Humidifiers can become heavily contaminated unless they are kept scrupulously clean. Atomising and spray-type humidifiers spray water into the ductwork (or directly into the workplace in some industrial applications).

Spray humidifiers use recycled water: spray water is collected and returned to a tank from which water is reused. The tank provides ideal conditions for the growth of a range of micro-organisms and the spray mechanism could easily contaminate the air as it passes through the system.

Steam injection is the preferred method of humidification since it doesn't involve recycling water and the high temperature reached is probably biocidal. Steam injection humidifiers should be used to replace the spray type wherever possible. Care must be taken to ensure that the source of the steam does not contain toxic amines, which are often added to the main plant boiler steam as anti-corrosion agents (Binnie 1988). A second best is to use water direct from the mains supply, with no re-circulation.

All types of humidifier should be cleaned regularly, at least every 2-3 months, with a final rinse with a mild disinfectant. However, biocides and chemical water treatments to prevent the build-up of sludge and scale and to stop corrosion should not be used since these chemicals would then be discharged into the building.

*Portable humidifiers* have been responsible for cases of legionnaires' disease. They work by producing an aerosol via a high speed pump placed above a basin of water, and so create ideal conditions for *Legionella* growth. The Chartered Institution of Building Services Engineers (1987) recommends that such units be kept very clean, with daily washing and draining of the unit. Distilled water should be used in sensitive areas such as hospitals.

### *Air cooling mechanisms*

The *cooling coil* is maintained at a low temperature by the refrigeration unit, which produces chilled water to circulate round the hollow coils placed in the air flow. The water in the warm air is condensed onto the cooling coil, and the drops collect in a drip tray. Condensed water is initially below 20°C but will be warmed as it stands in the condensate tray, so providing a source of infection. Water droplets may sometimes be picked up by the air flow in the duct as it 'scours' the stagnant water surface. Contamination may arise directly from micro-organisms drawn through the air inlet or indirectly from the drain if there is no air-break between condensate discharge and drain (Health and Safety Executive 1987).

Another cooling mechanism is the use of *air washers*, which spray water into the airflow and collect it again by means of eliminator plates. The recycled water is a source of infection, as described above for spray humidifiers, and inevitably the eliminators fail to collect all the water.

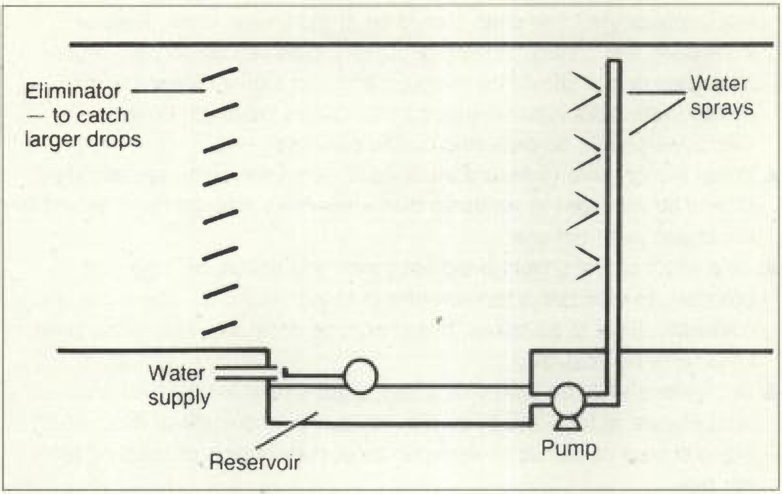



***Figure 3***
*Diagram of an air washer*

*Reproduced from:* Sykes J M (1988), *Precautions against illness associated with humidifiers*, Specialist Inspector Reports No. 11, Health and Safety Executive Technology Division, Bootle

***Ductwork***
Water can enter ductwork from various sources, such as leaking equipment and pipes, and can stagnate at room temperature. Again, the air flow may scour the water surface, so spreading contaminated droplets.

## Hot and cold water services

In April 1989, 30 people at a nursing home for the elderly in Surrey were struck down by legionnaires' disease. The bacteria were isolated from the water system. Four people died - luckily no more than 13 per cent of this vulnerable population. In fact, hot water systems are the source of most outbreaks of legionnaires' disease in the UK.

The 'domestic' water systems of most hotels and hospitals are probably positive for *Legionella*, and occasionally systems in these and other large buildings give rise to outbreaks or to sporadic cases of infection (Department of Health 1989). Showers and taps with spray heads are most commonly implicated in dissemination of contaminated water droplets (Health and Safety Executive 1987).

Mains water is normally free from significant levels of bacteria since it has been chlorinated. However, a potential hazard arises when it becomes tepid after standing for a long period. *Legionella* may colonise water storage tanks, calorifiers, pipework, filters and certain fittings and materials. Systems should be designed and maintained with the following points in mind:

- ▲ Cold water storage tanks should hold only a day's supply and should be sited in well-ventilated spaces, out of direct sunlight.
- ▲ Tanks should be fitted with tight lids or covers, and lagged to maintain a low temperature. The drain should be at the lowest level. Regular inspection and annual clearing of tanks should be carried out. Sludge, scale and debris should be removed and rust pitting cleaned and painted with paint recommended by the Water Research Centre. Overflows should be protected by fine mesh screens.
- ▲ When two or more tanks are installed to serve the same system, they should be arranged in series so that water flows through them all and is not drawn just from one.
- ▲ Cold water piping should avoid hot zones and should be lagged, if possible, to maintain a temperature of less than 20°C. Where hot and cold water have to be mixed, this should be done as close to the point of delivery as possible.
- ▲ Hot water should be stored at a temperature of at least 60°C, and the temperature at taps and other draw-off points should be at least 46°C. Signs should be put up to warn people of the dangers of scalding from hot taps.
- ▲ The design of water systems should be as simple as possible, with no stagnant water zones (dead-legs) where dirt, sludge, rust or scale can accumulate. Blind ends that have resulted from modification of the system should be removed wherever possible.
- ▲ Water fittings with the highest usage should be located at the end of a dead-end spur to ensure the best water throughput in the spur.
- ▲ Shower-head supply pipes should be self-draining.
- ▲ Non-metallic parts such as sealants, washers and jointings should be of a type known not to support bacterial growth. The *Water Fittings and Materials Directory*, published by the Water Research Centre (1990), lists fittings and materials that are acceptable under by-laws for connection to the mains water supply, and which are neither toxic nor provide nutrients for micro-organisms.
- ▲ Calorifiers (vessels in which water is heated to a thermostatically controlled temperature) should have re-circulation pumps fitted if they have a zone of lukewarm water at the bottom, beneath the heating elements. They must also be readily accessible for draining (at the lowest point), dismantling and cleaning, which should be carried out at least every year and more often in hard water areas. Periodic discharge of water from the calorifier should minimise the build-up of sediment.
- ▲ Water service systems should be disinfected after installation or refurbishment.

The main measures to prevent the growth of *Legionella* in water systems are cleanliness, maintenance of cool conditions for cold water and of hot temperatures for hot water services, and regular use of water to prevent it from remaining static. Further guidance on the design and maintenance of water systems can be found in Technical Memorandum 13 (CIBSE 1987), Guidance Note EH48 (Health and Safety Executive 1987) which is currently being updated, and the code of practice *Control of Legionellae in Health Care Premises* (DHSS and the Welsh Office 1989).

## Other equipment

*Legionella* can grow in other equipment and fittings, for instance in the water that stands in fire sprinklers (the initial water-fill should be treated with chlorine). Jacuzzis (whirlpool spas) use warm water which is constantly re-circulated through high velocity jets, or air is injected to agitate the water. This agitation creates an aerosol above the surface of the water. Both fire sprinklers and jacuzzis have been associated with legionnaires' disease, so careful cleaning and maintenance is essential. Bacteria can grow in shower-heads where the fitting is made from a material that can be used as a nutrient source. When the shower is turned on, a spray of contaminated droplets is created. All shower fittings, whether used regularly or not, should be run for 5 minutes each week, passing hot water for the first 2 minutes. Other possible sources of *Legionella* are given in Table 3.

## Responsibility and record-keeping

Detailed records are needed for all water systems or other plant or equipment that might give rise to legionnaires' disease, to include the following points:

- ▲ the layout of the system, including parts that are temporarily out of use
- ▲ what constitutes correct and safe operation, as determined during design and commissioning
- ▲ procedures for maintenance, monitoring, cleaning and disinfection and their frequency; details of work done and when
- ▲ safety precautions for carrying out this work
- ▲ the name of the person(s) responsible for all aspects of control

Some useful checklists and examples of records can be found in Technical Memorandum 13 (CIBSE 1987) and the Code of Practice from the DHSS and Welsh Office (1989).

## Training

Training is needed for service engineers in the maintenance of water systems and in the use of biocides. The Expert Advisory Committee on

Biocides was concerned that no acknowledged qualifications or training existed for such workers. The training given to outside maintenance contractors and water treatment suppliers should be checked.

## What to do in an outbreak

It is important that procedures are developed for dealing with an outbreak, suspected outbreak or discovery of high levels of contamination with *Legionella* before it occurs, so that panic doesn't reign. The following checklist outlines the actions that might form the basis of a contingency plan:

- ▲ Inform the relevant public authorities immediately. In England and Wales, this is the Health and Safety Executive and the local authority Medical Officer for Health. In Scotland, the Community Medicine Specialist (Communicable Diseases and Environmental Health Group) or the Designated Medical Officer should be contacted.
- ▲ Develop procedures to seal off infected areas and close buildings where *Legionella* has been or may be found.
- ▲ Shut down all possibly contaminated systems while the source of infection is being identified.
- ▲ Inform the workforce.
- ▲ Make arrangements for medical tests for people who may have been exposed.

## The law and legionellosis

In January 1989, the BBC was fined £3,600 for criminal negligence in the outbreak at Broadcasting House in London which cost three people their lives. In May 1989, British Aerospace was fined £4,000 for an outbreak at its factory in Bolton which affected 30 people. Both of these cases were heard in magistrates' courts and both organisations were charged under Section 2(1) of the Health and Safety at Work Act 1974 with failing to ensure the safety of their employees and under Section 3(1) for failing to protect the safety of people not in their employment.

Another section of the Act that is relevant to legionnaires' disease is Section 4, which requires that premises and plant or substances are safe and without risk to health. The Control of Substances Hazardous to Health (COSHH) Regulations 1988 are also applicable (see p.30). For more information on the law and health and safety in the workplace, see Appendix 5.

***Changes in legislation***

Following the various committees of inquiry and anger about the outbreaks of legionnaires' disease in the 1980s, particularly those at the BBC and Stafford General Hospital, the Health and Safety Commission reached the conclusion that clearer and more comprehensive legislation is needed to control the disease. At the end of 1989, the Commission published a consultative document which suggests that either a set of Regulations or an Approved Code of Practice should be drawn up. Regulations will be needed if it is decided to ban or modify all wet cooling towers. However, a code approved under Section 16 of the Health and Safety at Work Act seems a more likely prospect: failure to comply with its provisions could be used in court as proof that the law had been broken.

Such a code would probably outline measures to be taken to assess foreseeable risks of legionellosis from plant and equipment and indicate action to prevent or control such risks. These actions are already needed under the COSHH Regulations (see p.30), and the code would include detailed guidance on the control of legionnaires' disease.

***Registration or licensing of cooling towers***

In Scotland, where legionellosis is a notifiable disease, all wet cooling towers and whirlpool spas (jacuzzis) are supposed to be registered, although this is not a statutory requirement. The Health and Safety Commission's consultative document considers whether registration should be extended to the rest of the UK, but the case for doing so is not argued very strongly: '...those who are most likely to ignore any requirement to register are likely also to be those who have inadequate or non-existing preventive and maintenance regimes' (Health and Safety Commission 1989).

Other possible options for control proposed by the Commission include the licensing of wet cooling towers or of other potential sources of infection, or banning the installation of new towers with phase-out of existing ones. None of these options seems likely to be instituted.

## Punishing the offenders

So far, cases against employers who have caused outbreaks of legionnaires' disease have been heard only in magistrates' courts, where the maximum fine is £2,000 for each offence. The Health and Safety Executive has been strongly criticised, particularly by trades unions whose members have developed legionnaires' disease, for not taking such cases to the Crown Court, which could impose up to 2 years' imprisonment and unlimited fines. One trade union officer at the BBC said: 'Clearly three people being killed is not sufficient to go to the Crown Court for action these days' (*Labour Research* 1989). It is not only trade unionists who are concerned about the apparent laxity with which prosecutions have been brought. In March 1989, the House of Commons Employment Committee published a report *Legionnaires' Disease at the BBC*, in which it criticised the Health and Safety Executive for ignoring its advice to apply for Crown Court trial:

> **'We regard the penalties imposed by the Magistrates' Court as totally inadequate to reflect the seriousness of the offences and of their consequences in a case where negligence had caused three deaths and much suffering, where the infection could (as we were told) have spread so much more widely, and where it resulted from the inexcusable and admitted criminal acts of the BBC. The maximum permitted penalties should have been imposed.'**

The Employment Committee believed that the Health and Safety Executive should also have prosecuted the individuals responsible, and perhaps the main board or other individual directors who had responsibility for safety matters. It further recommended that legionnaires' disease and Pontiac fever be made notifiable diseases (legionellosis is already notifiable in Scotland), that more inspectors be employed by the Health and Safety Executive and local authorities to carry out inspections of wet cooling towers, and that regulations be introduced to control legionnaires' disease.

## Checklist for legionnaires' disease

Each workplace should have:

- ▲ a written scheme for preventing or controlling the risk of legionellosis,to include:

  (a) details of the source(s) of risk and results of assessments

  (b) precautions to be implemented

  (c) the name of the person(s) responsible for overseeing and implementing precautions, with clear lines of responsibility laid down

  (d) an outline of the procedures to be taken to carry out the precautions

  (e) monitoring of the procedures

- ▲ detailed inspection and maintenance schedules
- ▲ detailed records
- ▲ training programmes
- ▲ a policy on the replacement of wet cooling towers
- ▲ a written plan of action to be taken in the event of an outbreak, suspected outbreak or heavy contamination
- ▲ a system for reviewing the above

# 4 Causes of sick building syndrome

Despite numerous investigations, journal articles and conferences, little has actually been proven about the causes of sick building syndrome. Different experts have different theories - some say the main cause is chemicals, others that fungi are primarily to blame, or physical factors such as humidity, temperature or lighting, or the air-conditioning system itself.

In the USA, investigations carried out up to the end of 1983 by the National Institute for Occupational Safety and Health (NIOSH), a governmental organisation, showed 'inadequate ventilation' to be the causal factor in about half of buildings with health complaints (see Table 4). Inadequate ventilation was often given as the cause when no other, more precise, cause could be found.

What is certain is that symptoms are more common in buildings with air-conditioning or mechanical ventilation. Six building features are strongly associated with symptoms of sick building syndrome (McIntyre and Sterling 1982):

- ▲ a hermetically sealed, airtight shell
- ▲ mechanical heating, ventilation and air-conditioning systems
- ▲ use of materials and equipment that give off a variety of irritating and sometimes toxic fumes and/or dust
- ▲ fluorescent lighting that may produce photochemical smog
- ▲ application of energy conservation measures
- ▲ lack of individual control over environmental conditions

The rest of this chapter looks in more detail at some of the effects of these features.

**Table 4: Types of problem found in 203 indoor air quality investigations carried out by NIOSH**

| *Problem* | *No.* | *%* | *Notes* |
|---|---|---|---|
| Contamination (inside) | 36 | 18 | Exposure to chemical or other toxic agent generated within the office space, e.g. methyl alcohol from spirit duplicator, methacrylate from a copier, sulphur dioxide from a heating system, amines used in a humidification system, chlordane used as a pesticide |
| Contamination (outside) | 21 | 10 | Exposure to a chemical or other toxic substance originating from a source outside the building, e.g. motor vehicle exhaust fumes, construction activity, underground petrol spillage |
| Contamination (building fabric) | 7 | 3 | Problems from the material used to construct the building (figure excludes asbestos), eg. formaldehyde, fibreglass |
| Inadequate ventilation | 98 | 48 | Symptoms may be due to low levels of multiple contaminants and/or poor ventilation |
| Hypersensitivity pneumonitis | 6 | 3 | Problems due to a reaction to micro-organisms in the building environment |
| Cigarette smoking | 4 | 2 | |
| Humidity | 0·9 | 4 | |
| Noise/ illumination | 2 | 1 | |
| Scabies | 1 | 0·5 | |
| Unknown | 19 | 9 | |

*Source*: Melius 1984

## Airborne pollutants

Nearly everything we use sheds particles or gives off gases, particularly when new. People shed dead skin and hair all the time. Clothing, furnishings, curtains, carpets etc. contribute fumes, fibres and other fragments. Cleaning processes such as sweeping, vacuuming and dusting may remove the larger particles but often increase the levels of smaller, respirable, particles in the air. Chemicals used for cleaning are often toxic, and office supplies and equipment may also give off harmful chemicals. Buildings are complex environments which can trap and concentrate pollutants as well as generate them. Outside pollutants find their way into buildings through air intakes and inadequate filtering systems. As long as ample ventilation ensures a constant supply of fresh air, indoor pollution problems may be kept to a minimum. But general ventilation is often inadequate and office equipment may have no local exhaust system venting fumes to the outside.

The **A-Z list** below contains some of the more common pollutants that may be found inside buildings and is compiled mainly from information supplied by the Queensland and Lidcombe Workers' Health Centres (1984) and the Northern Trade Union Health and Safety Centre (1989). It is not an exhaustive list of the many thousands of chemicals present in the environment. When air monitoring for any of these substances is carried out, levels are likely to be below those considered to be 'acceptable' or 'safe'. However, little is known about the health effects of long-term exposure to low levels of a variety of chemicals and some people are sensitive to extremely low concentrations of toxic agents.

***Ammonia*** Cleaning solutions, blueprint machines (plan printers) and cigarette smoke are sources of ammonia. This gas irritates mucous membranes and so affects the respiratory system and eyes.

***Asbestos*** There are many sources of asbestos in buildings (e.g. pipe lagging, ceiling and roof tiles, asbestos cement sheeting) particularly in buildings constructed in the 1960s and early 1970s. In the air-conditioning system, asbestos may be used as duct insulation, as mounting for heating elements, or sprayed as insulation in the air-conditioning plant room. The inevitable deterioration of these asbestos products with time means that respirable fibres will be released into the air. Asbestos - blue, brown and white types - can cause cancer and fibrosis of the lung and mesothelioma (cancer of the lining of the chest and abdomen).

***Benzene*** This cancer-causing chemical is released from synthetic fibres and plastics, and is found in cleaning solutions and tobacco smoke. It damages the central nervous system and skin, and causes respiratory irritation.

***Biocides*** Biocides are added to air-conditioning systems to control the growth of micro-organisms. They are also toxic to humans; the effect depends on the biocide. Biocides and other chemical water treatments such as anti-scaling agents should not be used in humidifiers or in any part of the air-conditioning system where they may be picked up in the airstream and so breathed by workers.

***Carbon dioxide*** Carbon dioxide is present in the unpolluted atmosphere at a concentration of about 0.03 per cent but since about 5 per cent of the air we breathe out is carbon dioxide the level increases in inadequately ventilated occupied rooms. The level of carbon dioxide is therefore often used to assess the efficiency of ventilation, although NIOSH investigators did not find it useful for this purpose (Melius 1984). Levels higher than 800 parts per million (ppm) indicate that the ventilation rate is inadequate. Outside sources include vehicle exhaust fumes, nearby smoking chimneys or other exhausts. The effects of too much carbon dioxide are headache and lethargy; then breathlessness, sweating, visual impairment and tremor. Finally unconsciousness develops as the level increases.

***Carbon monoxide*** Any process of combustion can produce carbon monoxide, so this gas is produced by tobacco smoking, gas cookers, and gas or oil heaters. We all exhale a small amount of carbon monoxide in our breath. A major source of carbon monoxide is vehicle exhaust fumes. Carbon monoxide harms the body by replacing oxygen in the haemoglobin of red blood cells and so starving the body - and the brain in particular - of oxygen. Less than 1 per cent of the haemoglobin of non-smokers is normally bound to carbon monoxide rather than oxygen but this increases to 4-6 per cent in smokers (Hoover 1982). Non-smokers who spend their 8-hour working day in an atmosphere containing 30 parts per million (ppm) of carbon monoxide will also develop a 5 per cent concentration and possibly the early symptoms of carbon monoxide poisoning such as headache. Smokers would not be affected since their bodies have become habituated to such a high level. At levels of 50-250 ppm dizziness may accompany the headache, and above 500 ppm nausea and vomiting occur and collapse is possible. Long-term exposure to carbon monoxide is associated with heart disease. It has been recommended that carbon monoxide levels be kept below 9 ppm in offices because of the potential for health effects associated with long-term exposure to low levels of this gas (Queensland and Lidcombe Workers' Health Centres 1984). In the UK the occupational exposure limit for carbon monoxide is 50 ppm.

***Detergent dust*** Detergent residues from carpet cleaning may cause respiratory irritation such as cough, dry throat, breathing difficulty, nasal congestion and headache. Effects depend on the type of detergent used and its formulation.

***Ethanol (ethyl alcohol)*** Ethanol is found in duplicating fluids and can cause dermatitis, liver damage and intoxication.

***Fibreglass*** Fibreglass is used for insulation. Large fibres can cause itching and skin irritation; smaller fibres are suspected of causing lung diseases and cancer in a manner similar to asbestos.

***Formaldehyde*** Formaldehyde is found in hundreds of different products, including insulation material, ceiling tiles, particle board, plywood, office furniture, carpet glues, various plastics, synthetic fibres in rugs, upholstery and other textiles, pesticides, paint and paper. It is also emitted from electric stencil-cutting machines and is present in tobacco smoke. Levels of emission increase with temperature. Formaldehyde is a colourless gas with a pungent odour. At 2-3 parts per million (ppm) it will irritate the eyes, nose and throat of most people exposed to it, but many are affected at much lower levels. At 4-5 ppm the irritation is worse and is accompanied by drowsiness, loss of memory, sneezing and skin rashes. At 10-20 ppm there is severe breathing difficulty and burning eyes, nose and throat. Formaldehyde increases the risk of several types of cancer, and has also been shown to cause poor sleep, impaired memory, lack of concentration, nausea and menstrual irregularities. The occupational exposure limit in the UK is 2 ppm, twice as high as the permissible level in the USA of 1 ppm, which has an action level of 0.5 ppm. In Sweden and Germany the maximum permissible indoor level is 0.1 ppm. People who have become sensitised to formaldehyde have adverse reactions

## Carpet blamed for BT illness

**Keith Harper**
**Labour Editor**

BRITISH Telecom has temporarily closed a telephone exchange in Plymouth after operators complained of "a mysterious smell", sore throats and eyes, and skin rashes.

The symptoms had come and gone since video display units and cabling were installed last November, and an environmental scientist has blamed low humidity, triggered by weather conditions reacting with the carpet.

Carpet tiles have been taken away and humidifiers and ionisers installed to bring the atmosphere back to normal.

Miss Sally Davis, a local officer of the Union of Communication Workers, said yesterday: "At one time we had as many as 10 people off sick because of it. People's faces would start burning within a couple of hours of starting work."

A national union official, Mr John Dingle, said he was pleased that BT was taking the problem seriously, and had responded to staff demands for tests on the switchroom.

Mr Lawrence Taylor, an environmental consultant, commented that buildings should be considered as machines that broke down if not carefully maintained.

*Formaldehyde in the carpet tile glue may have been responsible for this outbreak of sore throats and skin rashes at British Telecom*

*Guardian*, p6, 13 February 1989

whenever it is present, even in very small amounts. Concentrations as low as 0.01 ppm have been associated with eye irritation (HSE 1981).

***Hydrocarbons*** Chemicals composed of hydrogen and carbon are found in various sources including paints, solvents, synthetic materials, floor and furniture polishes, and vehicle exhaust fumes. Their effect on health depends on the type of hydrocarbon but can include respiratory, skin and eye irritation, nausea, headache, central and peripheral nervous system damage, and cancer.

***Hydrogen chloride*** Hydrogen chloride is emitted by electric stencil-cutting machines. It irritates the mucous membranes of eyes, nose and throat.

***Methanol (methyl alcohol)*** Methanol is used in spirit duplicating machines, and causes irritation to the eyes, respiratory system and skin.

***Micro-organisms*** Not much research has been carried out on indoor pollution with microbes such as bacteria and fungi (mould). In the USA, investigation of more than 200 governmental, hospital and commercial buildings showed that 34 per cent had high levels of fungi and 9 per cent had high levels of bacteria which could potentially cause disease or allergy (Robertson 1988). The fungal species *Aspergillus* and *Cladosporium* were found growing to excess in the ductwork of many of the buildings where workers had high levels of symptoms. In some cases, 'challenge' tests were carried out which showed that these workers had severe allergic reactions to the spores of these fungi. Subsequent cleaning and removal of the sources of contamination apparently cleared up the symptoms (Robertson 1988). Micro-organisms are probably responsible for humidifier fever and extrinsic allergic alveolitis, which are discussed elsewhere, and for legionnaires' disease (see Chapter 3).

***Motor vehicle exhaust*** Exhaust fumes contain carbon monoxide, nitrogen oxides, lead particulates, sulphur oxides and hydrocarbons. Sources include basement car-parks which don't have their own separate ventilation system and outside traffic. The siting of ventilation intakes is therefore important in determining the intake of exhaust fumes into the building.

***Nitrogen oxides*** Like carbon monoxide, nitrogen oxides are produced as products of combustion, so sources include vehicle exhausts, tobacco smoke and gas heaters. These chemicals cause irritation to the respiratory system and eyes.

***Ozone*** Ozone is naturally present in the air since it is produced from oxygen by ultraviolet radiation. However, it can also be produced by electrical discharges and is emitted by some items of electrical equipment such as photocopiers and electrostatic precipitators (devices used to 'clean' the air by removing dust). A single photocopying machine can produce more than 0.1 parts per million (ppm), which is the recommended limit for exposure to ozone in the UK and Australia. Ozone is a dangerous gas since it mimics the effects of ionising radiation (X-rays and gamma-rays) and can cause genetic damage. It is also very irritating to mucous membranes in eyes, nose and throat (at 0.1 ppm), causing lung damage at higher exposures. It can also cause headache (at 1 ppm), dizziness and severe fatigue.

No one should work in the same room as a photocopier which is in constant use or employed for long runs, particularly if unvented. Ozone is sometimes added to the air-conditioning system to 'sweeten' the air and counteract smells. This should never be done: an adequate supply of fresh air is what is needed.

***Paint*** Paint fumes, depending on the formulation, may cause headache and irritation to the eyes and respiratory system, damage to the nervous and reproductive system, cancer, and kidney and bone marrow injury at high exposure levels.

***PCBs (polychlorinated biphenyls)*** Use of these dangerous chemicals, which include dioxin and dibenzofuran, is now banned in the UK, but they may still be found in electrical appliances and may leak from ageing visual display units and fluorescent lights. PCBs cause skin rashes, cancer, fetal defects, and damage to reproductive organs, liver and kidney.

***Pesticides*** Pesticides may be used inside buildings for many reasons: to kill fungi, beetles, fleas, ants, booklice, silverfish, rodents, and plant and timber pests. Although all pesticides are harmful to humans (some more than others), treatment is sometimes carried out during working hours, with little apparent concern for the health of the people working at their desks. Or spraying may be carried out overnight or over the weekend so that the chemical is still circulating in the atmosphere when workers return to the building. The pesticides used as wood preservatives often leach out into the air over a number of years. Pesticides may be added to air-conditioning and ventilation systems to reduce biological contamination. This is not the way to effect control: proper cleaning and maintenance are what is needed, or the chemicals will be circulated around the building. The hazards of pesticides depend on their chemical constituents (often a 'cocktail' of chemicals is used) and include cancer, fetal damage, liver and neurological damage, skin problems, and irritation to the eyes and respiratory system.

***Photochemical smog*** It is possible that the various individual pollutants may combine to form new hazards, and it has been suggested that ultraviolet light from fluorescent tubes provides energy for reactions to occur between ozone and other chemicals.

***Radon*** Radon is a decay product of uranium and is present in varying amounts in the soil. It moves from the soil by diffusion into the soil's air pockets and into soil water, from where it can migrate through building foundation cracks etc. into the indoor space. Building materials such as concrete and stone may also contain radon. Out-gassing from these materials, and from radon in the water supply, adds to the indoor air levels derived primarily from the soil below the building. The effects of high levels of radon on humans are those associated with ionising radiation (X-rays and gamma-rays): cancer and damage to the reproductive organs and to the fetus.

The effects of low levels of exposure are not known but the Institution of Environmental Health Officers recently recommended a 50 per cent reduction in the levels considered to be 'safe' for homes in the UK *(Environmental Health News* 1989*).*

***Solvents*** Solvents such as toluene, acetone and trichloroethane are found in white-out fluids and thinners. They may cause headaches and dizziness or eye, throat and skin irritation. Solvents are also found in adhesives, glues, cleaning fluids, paint and felt-tip pens. Trichloroethylene, which can cause liver cancer and damage to the lungs and central nervous system, is used in spray adhesives and some types of stencil machine.

***Sterilant gases*** Gases such as ethylene oxide are sometimes used in an attempt to sterilise humidification and air-conditioning systems. The effects will depend on the gas used, and may range from irritation of mucous membranes to cancer. Such gases should not be used.

***Sulphur oxides*** Sulphur oxides, such as sulphur dioxide which is emitted from coal-burning power stations, chimneys and vehicle exhausts, form acidic solutions when in contact with moisture. Exposure to sulphur dioxide causes respiratory irritation, runny nose and cough. Long-term exposure can lead to chronic bronchitis, lung damage, altered sense of smell and may have a cancer-causing effect in the presence of other chemicals (co-carcinogenesis).

***Tobacco smoke*** Cigarette smoking is a considerable source of airborne contamination. Amongst other things, tobacco smoke contains carbon monoxide, carbon dioxide, nicotine, formaldehyde, acetaldehyde, acrolein (a strong irritant), ammonia, hydrogen cyanide, nitrogen oxides, coal tars and particulates. Many of these substances have toxic or irritant properties causing symptoms similar to those of sick building syndrome - eye and nose irritation, coughing, breathing difficulties, sore throat and hoarseness, headache, nausea and dizziness - in both smokers and non-smokers. The long-term effects of smoking include lung cancer and heart disease.

***Vinyl chloride*** Vinyl chloride is found in plastic products such as pipes and light fixtures and in upholstery and carpets. It is a cancer-causing agent and causes skin and lung irritation.

## Air-conditioning systems

Air-conditioning is the process of treating air to control its temperature, moisture content (humidity), purity and distribution. Early proponents of air-conditioning believed that they could produce an atmosphere like a 'perpetual spring'. In practice, the air is often not so sweet.

In buildings with no air-conditioning, fresh air enters by natural ventilation or infiltration - through open windows and doors and gaps in window and door frames. Outside wind pressure makes the air circulate inside, and air also rises as it is warmed. In contrast, the windows of buildings with air-conditioning often cannot be opened because the system is so designed that its controls may be 'thrown out' by even one opened window. These buildings are 'sealed' or 'tight'. Air-conditioning systems rely on mechanical ventilation for air distribution.

There are many different types of air-conditioning and ventilation system. The simplest, which is described as 'mechanical ventilation', only filters and distributes ducted air; the air is not 'conditioned' by heating, cooling or humidity control. Table 5 gives an idea of the range of air-conditioning systems. Not all offices have systems with a plant room and ductwork. Some use domestic-style wall units which take in air through the outside wall, condition it and deliver it straight to the office space.

Despite the wide variety of types of system, they all work along similar basic principles (see Figure 4): an air handling unit draws air into the plant (or unit) where it is treated (filtered, cooled, heated, and perhaps humidified or washed) and then blown through ductwork, entering the office space through supply air vents.

In all-air systems, all plant is centralised and the conditioned air is distributed throughout the building by a network of ducts. These systems are inflexible and the ducting for supply and return air is bulky. The other extreme is the local air handling system. Each room may have its own induction or fan-coil unit, perhaps with a fresh air intake through the wall. These systems are more flexible, often with individual controls in each room. In between comes the decentralised system, which is similar to the local system except that a whole zone (a group of rooms, a wing or a floor of a building) is served by one air handling unit.

**Table 5: Air-conditioning systems**

| *Type of system* | *Notes* |
|---|---|
| **All-air systems** | |
| Conventional | Central plant filters, heats/cools and humidifies air. Systems are usually low velocity and are either constant air volume (CAV)/variable temperature or variable air volume (VAV)/constant temperature. |
| Terminal re-heat | Central filtration and humidification. Local heating in room unit. |
| Multi-zone | Central filtration, heating/cooling and humidification. At central plant the required proportion of cold and hot air is mixed for separate ducting to each zone of the building. |
| Dual duct | Central filtration, heating/cooling and humidification. Two parallel ducts convey cold and hot air at high velocity to room unit which mixes air under thermostatic control. |
| Variable air volume | VAV allows reduction in air supply when operating under partial load, so reducing energy costs. May employ dual duct, single duct or re-heat terminal units, all in same building. System operation may be unstable. |
| Dual air | Central filtration, heating/cooling and humidification. Employs two high or medium velocity airstreams: one is constant air volume/variable temperature and the other is variable air volume/constant temperature. Mixing unit allows individual room temperature control. |
| **Air and water systems** | |
| Induction | Useful for perimeter zones of deep buildings. Two airstreams: central filtration, heating/cooling air humidification of primary airstream; secondary air-stream is heated/cooled locally using air re-circulated from the room, and perhaps with a fresh air inlet through the wall. |
| Fan-coil | Generally used for perimeter zones. Similar to induction system above, except for mechanics. |
| Three-pipe and four-pipe | |
| Panel air | |
| **Direct expansion refrigerants** | |

*Source:* Croome-Gale and Roberts 1975

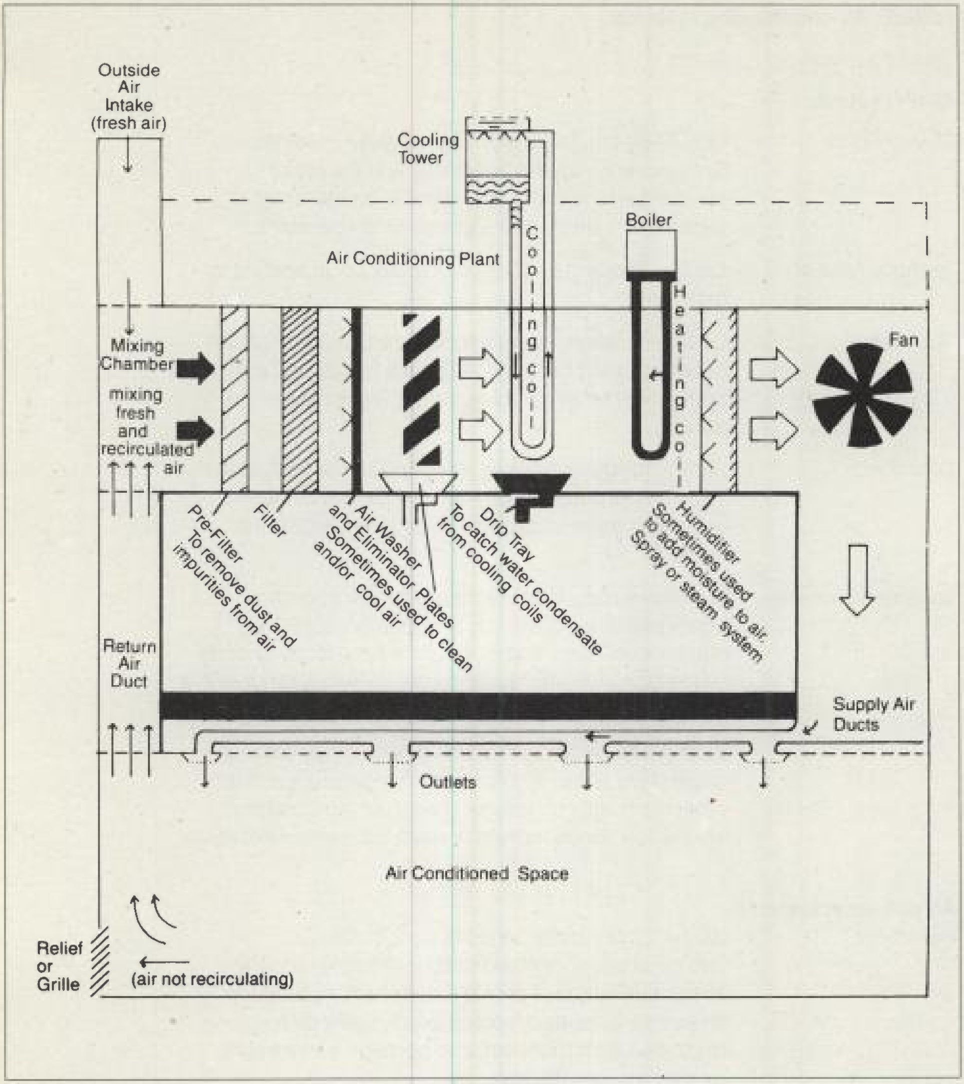



***Figure 4***
*Components of a basic air conditioning system*

*Reproduced from:*
Queensland Workers Health Centre and Lidcombe Workers Health Centre (1984), *Air Conditioning - Health and Comfort at Work,* Administrative and Clerical Officers Association, Sydney

In practice, the humidification part of the process may not be in operation to save money on energy costs. Ask for a plan of the air-conditioning system or systems operating in your workplace. Trade union safety representatives are entitled to this information under the Safety Representatives and Safety Committees Regulations (see Appendix 5).

***Outside air inlets***

The supply air fan draws fresh air into the building through the outside air inlets. The siting of this intake may be critical in determining how 'fresh' the air actually is. City air can hardly be called fresh, but it may be additionally polluted if the inlet is located in the basement car-park, at pavement level along a busy main road or next to a flowerbed (where pesticides may be sprayed), downwind of a hospital incinerator or chemical plant, or next to a cooling tower or exhaust on the roof. The positioning of fresh air inlets must take into account prevailing wind directions and wind patterns caused by nearby buildings. Inlets should be louvred or wired to prevent birds, large insects and wind-blown debris from entering, and should slope so that rainwater drains away and does not enter the mixing chamber.

***Mixing chamber***

Here the outside air is mixed with return air from the building. It is usually intended that 10-20 per cent of the air mixture is fresh, but the fresh air dampers may be closed completely so that 100 per cent recycled air is being circulated. In the USA, ACVA, a commercial organisation that specialises in sick buildings, found that over 35 per cent of 223 buildings it investigated were taking in no fresh air and 64 per cent had inadequate fresh air intake (Robertson 1988).

***Filters***

Filters are supposed to remove dust and other impurities from the air but are often inefficient or so poorly maintained that they actually pollute the air. In many air-conditioning systems the filters are designed only to stop large insects such as moths and butterflies. There are several different types of filter which vary in their efficiency. A good filter system will have more than one filter, perhaps including a coarse pre-filter, and the selection will be based on:

- ▲ anticipated dust load
- ▲ type of dust (e.g. soot, ashes, earth, sand, fibres, animal, vegetable and mineral matter, mould spores, bacteria. viruses, pollen, industrial pollutants)
- ▲ size of dust particles (larger particles settle out on desks etc., smaller particles remain airborne or 'stick' to other surfaces due to electrostatic attraction)
- ▲ degree of cleanliness required

Filters in common use are dry filters, wet filters and electrostatic filters:

▲ *Dry filters* are usually disposable and made from a fabric or paper-type material which can trap larger dust particles in the airstream. There are two types: the roller type works like a film in a camera, automatically moving on to the next 'frame' when loaded with dirt.
The panel type needs to be cleaned and reused or discarded once soiled.

▲ *Wet filters* are relatively coarse filters made from fibres, wire mesh, metal turnings or plates and coated with a viscous substance such as oil or grease. Again, there is a self- cleaning roller type and a fixed panel type. They are often washable and reusable.

▲ *Electrostatic filters* are much more efficient than wet or dry filters for both large and small particles. They work by passing the air through an ioniser which gives particles a positive or negative charge. These charged particles then go through a collector where they are attracted to plates of the opposite charge. Older models of electrostatic filter may produce ozone, as may newer models if they are left in operation with no airstream passing through them. (In one office building, workers received a 'blast' of ozone each morning when the air-conditioning system was turned because the electrostatic filter had not also been switched off overnight.)

Filters will not work if they are clogged up with dirt: they must be regularly maintained, cleaned or replaced. Only electrostatic and HEPA (high efficiency particulate air) filters will remove bacteria. Beware of HEPA filters that contain asbestos; these should not be used.

### *Cooling and biological contamination*

As well as removing heat, the cooling coil incidentally dehumidifies the air: moisture in the warm air is condensed out on the cold coil and drops collect in a drip tray. Wherever there is water, particularly if it is left standing for a long time, micro-organisms will grow. And wherever micro-organisms will grow, the potential for *humidifier fever* and *extrinsic allergic alveolitis* exists. Despite the name, humidifiers are not the only source of the organic dust believed to be the cause of humidifier fever - any dirty, dusty, damp place such as drip trays, ductwork, evaporative cooling systems, spray cooling devices (air washers) and baffle plates may be a source. These parts of the air-conditioning system are also where the legionnaires' disease bacterium may grow, and more details on biological contamination are given in Chapter 3 (pages 31-33).

### *Control systems*

There are as many different systems to control the temperature, humidity and delivery rate of the air as there are air-conditioning systems - each building will be unique, and some computer-controlled systems are very complex. The siting and number of thermostats, humidistats and other sensors is crucial to the functioning of the system.

In a variable air volume (VAV) system, when the temperature of the office deviates from the 'set' temperature (perhaps because more people are present) the thermostat automatically controls baffles in the ducting to allow more or less air into the space to maintain the set temperature. Thermostats need to be re-set monthly depending on the average monthly temperature outside since people's bodies acclimatise to different temperatures in different seasons and they dress for the weather.

Temperature problems in buildings may result from:

- ▲ Wrongly placed thermostats. Sometimes thermostats are located in a passage or at the periphery of an open-plan office where there is solar gain, so that the core of the office remains cold.

- ▲ Rearrangement of office partitions may place the thermostat outside the area it is meant to serve.

- ▲ Faulty thermostats.

- ▲ Faulty air-conditioning equipment

Some thermostats are really only 'dummies'. They have no actual effect on ambient temperature but are cynically introduced to give workers the impression that they have some control over the system.

In the UK the use of carbon dioxide monitors to control the amount of fresh air being drawn into the system is luckily not common. Such monitors may be set to operate at levels of carbon dioxide that are never reached, e.g. 2,500 parts per million, so that outside air is never introduced.

***Delivery and circulation of air***

Fans deliver the air to the office space via supply vents (diffusers) sited on the wall or ceiling. The number of fans depends on the size of the building, zoning, etc. An air-conditioned building may be 'zoned' so that varying amounts of air are delivered to different parts of the building. For example, the west side may be given more air in the afternoon to counteract the effects of the sun on room temperature.

Supply air vents control the volume, velocity and direction of air flow into the workspace. Although an adequate amount of air may be delivered to the office, this does not guarantee that the air will circulate to reach everyone equally. Tall furniture such as filing cabinets and acoustic screens, especially those that extend to the floor even if they are no higher than 5 feet, may prevent the air from circulating. Walls and partitions put up to enclose workstations or cellular offices in an area originally designed to be open plan can mean that air delivered at the perimeter never reaches into the open-plan core. To allow air flow, partitions should clear the floor by 1-2 inches. If full-height partitions are used, there must be at least one supply vent (diffuser) and one return or exhaust vent.

The air-conditioning system must be checked once the office floor has been filled up with furniture, partitions and people to ensure that it still delivers and returns air in the way it was designed to. This is called 'balancing' the system. Balancing is often carried out inadequately, or not at all. All air handling systems should be re-balanced after a year or two, depending on how much reorganisation of the floor space there is, and after changes of occupancy.

### *Exhaust air*

Air removal is as important as air supply. Air that has circulated through the office space is returned through ceiling vents, often combined with light fittings, into ducts or plenums. The majority of the exhaust air goes back to the mixing chamber, but a small amount leaves the building through ventilation grilles. Fans in the return air duct draw in the exhaust air. It is possible for air to be drawn directly from the supply to the exhaust vent so that people sitting at desks don't receive any fresh air at all.

In some systems, heat exchangers are used to reclaim heat that would otherwise be exhausted from a space. The wheel of a rotary heat exchanger passes from the exhaust to the supply airstream, alternately absorbing and giving up heat, so heating supply air in the winter and cooling it in summer. Pollutants are transferred to the supply air by these devices (Schaeffler et al 1988).

To maintain air movement, air-conditioned buildings usually operate under slight positive pressure, which means that the pressure inside the building is greater than that outside and there is a tendency for air to move outwards. If the air-conditioning system is faulty and the building is under negative pressure, the efficiency of exhaust fans will be reduced and outside air will infiltrate anywhere it can, perhaps 'rushing in' when windows are opened. The effect of this is that pollutants will not be ventilated out of the building.

### *Types of problem found*

Youle (1986) has found that air-conditioning systems giving rise to symptoms of sick building syndrome can be put into four categories:

▲ *Under-designed systems.*
Examples include no extraction fan, faulty design of fresh air/return air damper, poor temperature control due to centralised plant and inadequate terminal re-heaters, no provision for humidification.

▲ *Poorly installed, operated and maintained systems.*
Typical problems found in buildings where systems have not been set up and tested properly include: incorrect function of local control systems, tolerances on temperature control sensors set too wide, incomplete closure of valves to local re-heater batteries, faulty setting of diffusers, malfunctioning humidifier, corrosion of fresh air damper bearings, illogical control system, inadequate operator training.

▲ *Equipment problems.*
Sometimes problems related to one particular item of equipment can lead to overall problems of control. For example, air handling units may not be capable of delivering the required amount of air, electronic temperature controls may be malfunctioning, heating or cooling batteries may be the wrong size, diffusers may be of poor quality causing noise and poor control of air flow.

▲ *Poor control of fresh air.*
Reduced levels of fresh air input and build-up of contaminants can be due to: closing fresh air dampers to 'save energy', faulty operation of automatic dampers, inadequate purging of the building before occupancy, inadequate overall ventilation, poor air circulation, and low air flow rates in variable air volume systems.

## Air quality and thermal comfort

In a comfortable environment there are no noticeable fluctuations in temperature, no stuffiness, draughts, odours, etc. The main factors influencing comfort include temperature, humidity (moisture level) and air movement. These factors interact. For example, if the air is very humid, the temperature appears to be warmer than it would be in drier air. If the air is circulating rapidly, the temperature seems to be cooler than it would be in sluggish air. People don't usually notice comfortable and constant conditions. Problems arise when fluctuations occur such as sudden blasts of cold air.

As all office workers know, different people feel comfortable under different conditions; one person will be too hot when another is 'just right'. In general, women tend to like slightly higher air temperatures than men. But many problems in offices arise because of lack of personal control over the conditions - windows can't be opened, heating can't be locally controlled, lighting is uniform and not task-oriented, table fans aren't allowed in hot weather, etc.

Table 6 gives the levels of various parameters recommended by the Chartered Institution of Building Services Engineers (CIBSE).

**Table 6: Comfort levels recommended by the Chartered Institution of Building Services Engineers (CIBSE 1986)**

| *Parameter* | *Recommended level* |
|---|---|
| Temperature (dry bulb) | 19-23°C |
| Relative humidity | 40-70 per cent<br>More than 55 per cent RH is needed in carpeted buildings with underfloor heating to avoid electrostatic shocks |
| Ventilation | |
| Delivery of fresh air | 8 litres per second per person (minimum)<br>16 litres per second per person where some smoking<br>25 litres per second per person where heavy smoking |
| Total air supply | 4-6 air changes per hour |
| Air speed | 0.1-0.3 metres per second. Less than 0.1 m/sec causes stuffiness . More than 0.3 m/sec causes draughts.<br>For air speeds higher than 0.1 m/sec CIBSE recommends an increase in air temperature to take account of air movement |
| Sound | 46 dBA is upper limit for general office work |
| Lighting | 500 lux for general office work<br>750 lux for deep-plan offices and work at drawing boards, proofreading, etc. |

***Temperature***

Complaints about the temperature in offices are common, particularly if the building is air-conditioned. Some parts of the building might be too cold, while others are too hot, or the air does not circulate properly so that people's feet are always cold even though their faces are warm enough, or the temperature might vary dramatically during the day.

CIBSE recommends a temperature of between 19 and 23°C for offices, although temperatures at the lower end of this range (19-21°C) have been suggested to be better since people feel less fatigue at cooler temperatures, which in turn feel 'fresher' (Vischer 1989). Conversely, air that is too warm is experienced as 'stuffy' and possibly as being polluted. Temperatures in offices are often too high, particularly in summer due to the effects of solar gain and heat generated by equipment (thermal radiation). Air-conditioning systems use more energy in cooling the air than heating it.

Air temperature can be checked with an ordinary dry bulb thermometer to see whether it falls within a comfortable range but for a more accurate measurement of comfort, humidity and the speed of air movement also need to be taken into account.

***Humidity***

Humidity is the amount of moisture in the air. Air at a given temperature can hold only a certain amount of moisture, and no more. This is called 'saturation humidity'. Humidity is measured as a percentage of this saturation humidity (100 per cent) and is referred to as 'relative humidity'.

The higher the relative humidity, the less able the body is to evaporate moisture (sweat) from the skin. At high humidity (above 60-70 per cent) and in warm temperatures, the body produces sweat but is unable to evaporate it so that the air temperature feels hotter than it actually is and you feel 'sticky'. When the relative humidity is low, the air is dry and moisture evaporates easily from the skin. However, when the relative humidity is very low (below about 20 per cent) the skin and mucous membranes of the nose and throat dry out. Dry skin becomes itchy, and scratching can lead to dermatitis. Dry mucous membranes mean a greater susceptibility to infection. Other symptoms of low humidity include headaches, a feeling of stuffiness, sinus troubles and sore eyes.

Dry air also increases problems with static electricity such as skin irritation, minor shocks and face rashes. (Workers at Kensington and Chelsea Town Hall in West London had to water the carpets every morning to cut down the static!)

There is controversy in the UK about the need to humidify the air. Some UK studies have shown that humidified buildings have slightly higher rates of sick building syndrome than non- humidified buildings (Wilson and Hedge 1987) or those with natural ventilation (Harrison et al 1987). But others, carried out in Finland where the air in winter may be extremely dry with relative humidities below 10 per cent, have shown a different association: workers in humidified rooms had fewer symptoms of sick building syndrome than those with no humidification (Jaakkola et al 1988; Reinikainen et al 1988).

Those who oppose humidification in the UK say that relative humidity in this country rarely reaches very low levels and that most people cannot tell whether the air is humidified or not since human beings cannot 'sense' moisture content (McIntyre 1980; *Office Secretary* 1988). However, a UK study that looked at how well people's ratings of air quality compared with readings from monitoring instruments showed that ratings of 'too dry' correlated well with low measured relative humidities (Wilson et al 1987).

Despite these opposing views, and because of the problems associated with dry air, it seems reasonable to adhere to the CIBSE recommendation of a minimum relative humidity of 40 per cent and to try to maintain a relative humidity of 40-50 per cent. At relative humidities higher than this, the growth of bacteria and moulds in the ventilation system is encouraged because of condensation in the ductwork (Vischer 1989), although higher humidities may be needed if static build-up is a particular problem. Humidifiers can certainly do more harm than good if they are not properly cleaned and maintained.

It must not be forgotten that temperature and relative humidity should be combined to obtain optimal thermal comfort: the higher the relative humidity the lower the air temperature can be for an equivalent sensation of warmth.

### *Ventilation*

#### *Air movement*

The faster the movement of air, the cooler it will seem because heat is lost as sweat evaporates into the cooler airstream - as long as the air is not warmer than the body (37˚C, which is unlikely in the UK) or the relative humidity is not extremely high. As Table 6 shows, if the air speed is too low the room will feel stuffy and if it is too high the office area will be draughty. Air movement greater than 0.8 metres per second will disturb office papers. Workers sitting next to supply air vents (diffusers) may be annoyed by fast air movement, particularly a ceiling-mounted diffuser that blows air down the back of their necks.

#### *Fresh air*

The four main reasons given by the Health and Safety Executive in its Guidance Note EH22 (HSE 1988) for supplying air to buildings are:

- ▲ for respiration, ie. to provide oxygen and to dilute carbon monoxide.
- ▲ to dilute and remove airborne impurities created by the occupants of the room.
- ▲ to remove excess heat and maintain comfortable conditions.
- ▲ to dilute other airborne impurities present in the room such as dust and fume.

Several standards have been set for ventilation rates in offices, and they are usually based on the amount of air needed to dilute cigarette smoke or body odour. CIBSE's standard ranges from a minimum of 8 litres of outdoor air per second per person in a general office to 25 litres per second per person where there is heavy smoking in a meeting or conference room. So, if there are 20 workers in an office, the minimum amount of 'fresh air' required is 20 x 8 = 160 litres per second. Fresh air means air from outside the building, not air that has simply been re-circulated without any treatment to remove odours, fumes and other contaminants. If the air has a constant odour, smells stale, or workers are suffering from headache or tiredness, then lack of fresh air or lack of air movement could be the cause. To find out whether the fresh air intake meets the CIBSE recommendations, the building services engineer or other person responsible for maintenance of the ventilation system would need to be consulted. These ventilation rates are rarely found in naturally ventilated offices.

In the USA, ventilation standards are based on 80 per cent of occupants failing to 'express dissatisfaction' with the air quality. This means that at acceptable ventilation rates up to 20 per cent of workers could be affected by contaminants from office equipment, new furnishings and outdoor sources and yet the building would still remain within the standard. In many buildings in the UK it is likely that fresh air input is below recommended values (Youle 1986).

### *Thermal radiation*

The radiation of heat from various sources has an important effect on room temperature. Solar radiation through windows and heat from equipment such as lights and visual display units (VDUs) increases the temperature. A person doing clerical work gives out about 140 watts of energy as heat, whereas the heat output of a VDU can be as much as 500 watts. When new equipment is introduced, often no thought is given to upgrading the ventilation to meet the new demands placed on the system; an additional local air-conditioning system may be needed. Devices such as internal blinds made from translucent material that allows the transmission of light but not heat may be used to counteract the effect of solar radiation.

### *Noise*

Noise is rarely mentioned in connection with sick building syndrome since it has not been found to be significantly associated with reports of building sickness (Wilson et al 1987). Yet noise is a facet of office life that people find particularly stressful and which certainly affects their concentration.

Noise that is too loud for comfort is intrusive whether it is a single, unexpected sound or a continuous one. But noise can also be too soft so that workers experience stress from being too easily overheard; a continuous soft noise can also be distracting.

There are several sources of noise in buildings: building-related noises such as buzzing lights, noises from air-conditioning equipment; noise from outside the building; noise from office equipment; and 'people noise'. People's tolerance to building noise may be different from their tolerance to people noise since these are separate acoustical experiences.

Air-conditioning equipment may be noisy if it is functioning poorly or is badly maintained or designed. A rapid flow of air through supply air vents is also noisy; by making ducts larger, the required amount of air can still be supplied through the vent. Ventilation ductwork can also transmit noise around the building, and proper insulation of noisy areas and machinery is needed to reduce these sources of noise.

CIBSE recommends 46 dBA (decibels, 'A' refers to a particular decibel scale on the sound level meter) as the upper sound limit for general office work. Sometimes the background level of noise in a building, i.e. before occupation, reaches this level. During the working day all eight buildings in one study had average sound levels above the CIBSE limit (Wilson et al 1987).

***Lighting***

Unlike noise, lighting is significantly associated with reports of sick building syndrome (Wilson et al 1987; Vischer 1989). If the workplace is not suitably lit, visual disturbance can occur. Tiredness, dry and gritty eyes and headaches can be caused by glare, flicker, lack of contrast, inadequate illumination or unsuitable spot lighting. Conventional white fluorescent lighting in particular is likely to cause eyestrain and headaches (Wilkins et al 1988) and should be replaced with non-fluorescent lighting and as much daylight as possible. Workers who are unable to negotiate to get rid of their fluorescent tubes should at least press for regular maintenance of lights and for full-spectrum fluorescent tubes to be used since these seem less likely to cause symptoms of sick building syndrome (London 1987; Wilkins et al 1988). (Read the booklet *Fluorescent Lighting: A health hazard overhead* by the London Hazards Centre for more detailed information.)

CIBSE gives recommendations for the levels of light needed to carry out different types of work (see Table 6). Since a range of activities takes place in offices, an important aspect of lighting design is that individual workers have control over the lighting in their immediate environment. This means that local task lighting is needed as well as good general overhead lighting, particularly where VDUs are in use.

***Ions***

Many claims have been made about the effects of air ions on health but little 'scientifically acceptable' research on ions has actually been carried out. There is even controversy over the exact nature of ions, although they are usually described as positively or negatively charged forms of the molecules that make up the atmosphere.

It seems that all living things need ions to survive. Scientists in the USSR tried to raise small animals in air containing no ions at all and found that all the mice, rats, guinea-pigs, rabbits, etc. died within a few days. Similar experiments on plants produced stunted growth. One of the few controlled experiments carried out on humans in the UK showed that increasing the number of negative ions in a computer-operating area reduced complaints of headache, nausea and dizziness, and resulted in a significant improvement in the rating of environmental quality. The workers also felt more comfortable and alert. Effects were most marked for those on the night shift (Hawkins 1984). Other workers have failed to reproduce these findings.

The number of negative ions in the atmosphere seems to be more important than the number of positive ions. Research worldwide has associated lack of negative ions with a range of diseases including thrombosis, haemorrhage, asthma and bronchial diseases, difficulty in breathing, aching joints, migraines, insomnia and increased susceptibility to infections. It has also been connected with depression, lethargy, anxiety, mental hospital admissions, suicides and crimes of violence. In contrast, an excess of negative ions is reputed to be associated with feelings of calmness, alertness and well-being, with quicker recovery from exhausting exercise, more appetite, sounder sleep, fewer bodily aches and pains, and fewer respiratory complaints.

Not everyone is sensitive to changes in air ion concentration: about 25 per cent of people notice no difference when the proportion of positive to negative ions is changed. Women seem to be more sensitive to ion depletion than men and respond more favourably to an ion-enriched environment (Hawkins 1984). Negative ions seem to become less effective as the ambient temperature increases above 22°C and at high relative humidities.

The typical air-conditioned office in the city has only 50 negative ions per millilitre of air (and 150 positive ions) compared with 1,000 negative ions (and 1,200 positive ions) in the same volume of clean, outdoor, country air. Hawkins (1984) gives the reasons for low air ion levels indoors as:

- ▲ *Ducted air conditioning.* Metal ducting attracts charged particles so that ions are stripped out of the air as it passes through the ductwork. (Electrostatic filters would similarly reduce ion levels.)
- ▲ *Static electricity.* In an air-conditioned building, especially one with low humidity, static charges build up on carpets, furniture, wall fabrics, workers' clothing and, particularly, on electrical equipment such as VDU screens. Ions in the room are then attracted to these static charges.

▲ *Smoke and contamination.* Smoke and dust particles act as a sponge, mopping up ions.

▲ *High density of individuals.* Each person removes ions from the air while breathing and each carries an amount of static electricity.

No-one knows how or why air ions may exert their effects. Many of the symptoms of negative ion depletion are similar to the effects of stress on the body, so it may be that the body's hormonal system is affected.

So how can the effects of low levels of negative ions be counteracted? It is clear that ion depletion can be minimised by taking steps to reduce the amount of static electricity in the environment, using natural rather than synthetic fibres wherever possible, making sure that all VDUs and other equipment likely to build up a static charge are properly earthed, controlling humidity and temperature, removing pollutants and dust at source, and ensuring that offices are not overcrowded. Negative ionisers help to clean the air by precipitating dust, fibres and particles out of the atmosphere - as can be seen by the enormous amount of dirt streaking the area that immediately surrounds the ioniser. So, if ionisers are to be introduced as a means of giving workers individual control over their immediate working environment, ensure that proper cleaning arrangements are made to cope with the resulting dirt. This may involve the cleaners working extra time.

### *Radiation and visual display units*

The possible involvement of electromagnetic radiation in sick building syndrome is probably even more controversial in the UK than the effects of air ions, but some people do believe it to be a factor (Best 1989).

The term radiation is used to describe electrical and magnetic energy travelling in the form of waves. These waves differ enormously in frequency (how many go past a given point in a second), and range from the extremely low frequencies given off by electrical appliances operating at high voltages through the visible spectrum of light to the very high frequencies of X-rays and gamma-rays of nuclear fall-out. Radiation of different frequencies has different biological effects.

There are various items of equipment in offices that emit electromagnetic radiation, but the item of most concern in the 1990s is the visual display unit (VDU) which gives out low levels of radiation across a wide range of frequencies. Pulsed low-level radiation at 'biological' frequencies (those that coincide with frequencies used by the body's own electrical systems - nerves) has been shown to affect the behaviour of monkeys and cats, making them lethargic and sleepy at some frequencies and hyperactive at others.

Exposure to low levels of ionising radiation (X-rays and gamma-rays) can cause a disease of the thyroid gland, hypothyroidism, which results in lethargy, loss of IQ and an increase in weight (Bertell 1985). In the USSR, several effects have been observed in people exposed to large doses of low frequency radiation, including listlessness, excitability, headache, drowsiness and fatigue. More about the hazards of radiation from VDUs can be found in the *VDU Hazards Handbook* published by the London Hazards Centre.

One study showed that increased building sickness symptoms occurred only when people spent more than six hours a day working at a VDU (Wilson and Hedge 1987). However, if exposure to radiation is a factor in sick building syndrome, this figure is open to question since, depending on the layout of the room, people who spend no time at all at a VDU may actually have higher exposures than those working on the screen: many VDUs emit more radiation from the side and back than from the front.

Of course, quite apart from the radiation question, work at a VDU is well known to produce some of the symptoms associated with sick building syndrome - eyestrain, sore eyes, skin rashes, headache and fatigue. Other complaints made by VDU workers include an increase in colds, flu and other viral infections; asthma, bronchitis, sinusitis and other respiratory disorders; digestive upsets; angina and other heart and circulatory problems; migraine attacks; irregular or painful periods; miscarriages and birth defects; depression, sometimes suicidal; irritability; exhaustion; going off sex; nausea, loss of appetite or compulsive eating; and insomnia (London Hazards Centre 1987).

It may well be that workers reporting such symptoms are working in sick buildings as well as spending far too much time in front of the VDU screen.

> **'My office is open plan and very crowded. This has been reported to our health and safety officer, but as yet with no results. We now have VDU terminals on one in four desks and by Christmas there will be a terminal on each desk. We use laser printers which are in the middle of the office and smell awful. I suffer from sinus headaches. At home, I get very few headaches but at work they increase, and I know this occurs with others. Colds spread round the office like a non-stop event, summer and winter.'**
> (Bradford, West Yorkshire)

For ways to improve conditions of VDU work, read the *VDU Hazards Handbook*.

## Stress

As this chapter has shown, almost every aspect of the work environment may contribute to the symptoms of sick building syndrome. Figure 5 shows how the various stressors to which people are exposed can affect health, morale and productivity. Chemicals in the building, lack of ventilation, thermal conditions, acoustics and lighting, the nature of the work and other factors all contribute to the stress load on an individual or group of workers.

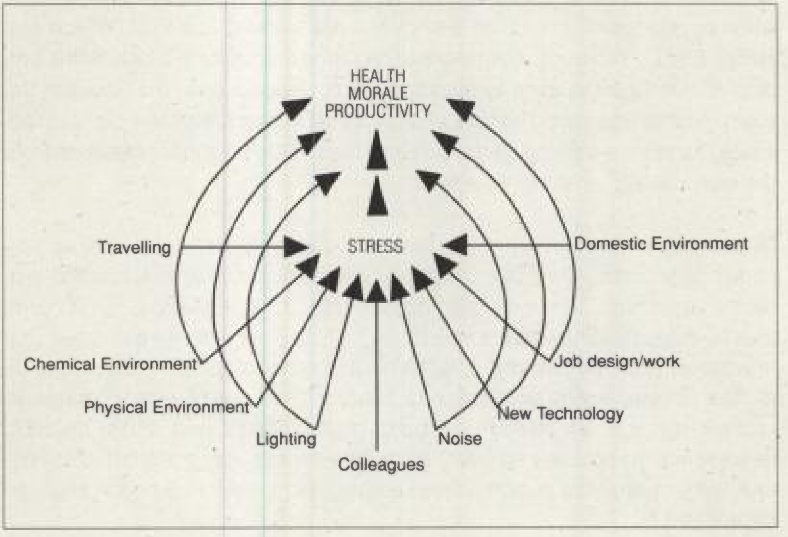



***Figure 5*** *Diagram showing the role of stress in sick building syndrome*

Reproduced from Morris L (1987), Sick building syndrome and the office environment, *The Safety Practitioner,* March 1987, p5

Some environmental stressors have a direct action (e.g. temperature, humidity, light and noise) causing a physiological response in the body as it tries to regain its equilibrium. But other stressors act in a more subtle, indirect way. For instance, a person may become tense or anxious if they cannot control the environment around them. Being unable to control the temperature to suit your own needs, to change the level of lighting, to open a window for fresh air, to reduce noise, or to eliminate cigarette smoke from the atmosphere is likely to affect your behaviour, causing stress that ultimately takes its toll on your health. Study after study on sick building syndrome has shown that the amount of control that people have over their environment is critical. Only 4 per cent of people in air-conditioned buildings feel that they have any control over ventilation and over temperature, compared with 33 per cent and 17 per cent respectively in naturally/mechanically ventilated buildings (Wilson and Hedge 1987). However, none of these figures is particularly encouraging, and it is clear that architects and heating, ventilation and lighting engineers have a long way to go before they start creating buildings that are geared to the needs of those who work in them.

# Investigation, remedies and prevention 5

For six years in the 1980s, members of the Civil and Public Servants' Association (CPSA) at the job centre in Milton Keynes suffered from working in a sick building. The job centre occupies two floors of a glittering mirror-glass building designed by the Development Corporation. Soon after the sealed, air-conditioned building opened in 1980, staff began to complain about heating, lighting and ventilation. They suffered from the typical symptoms of sick building syndrome - itching eyes, chest problems, coughs, colds and sinusitis, and a general lethargy in the afternoons. A distinctive symptom was the 'three o'clock flush' - a reddening of the face experienced by many of the workers.

After four years of complaining, with no action by management, a union meeting held in March 1984 made demands for something to be done. Two years later, and after much struggle by union members, £10,000 had been spent on piecemeal repair-work to the air-conditioning system and on other alterations, but there was no improvement in workers' health. The CPSA members finally managed to persuade their management to commission a survey by a compe-

*A deceptive appearance: this Milton Keynes building was the cause of building-related illness in CPSA members for over six years until improvements in air quality and circulation were finally carried out in 1986*

Richard Davies

tent and independent heating and ventilation engineer. His main findings (in July 1986) were:

▲ Incoming air was going straight up through the Formalux 'egg-crate' louvre false ceiling instead of circulating in the room.
▲ The louvre also allowed fibreglass particles to pollute the air of the room.
▲ Humidity was much too high because the ventilation system's humidity control was not working.
▲ Lighting was poor and glare levels were unacceptable.

Management had no option but to accept in full the recommendations made in the report, which included complete replacement of the ceiling to allow air circulation and sealing in of the fibreglass insulation. Once this work had been carried out, conditions improved and the sickness level dropped dramatically. The final cost was estimated at £30,000. These workers were organised but, despite walking out when conditions became intolerable and having to threaten industrial action to get things done, they were not taken seriously. Most importantly the management continuously refused an independent assessment of the situation which could have highlighted the problems at the outset. Such dragging of the feet is typical in cases of sick building syndrome, and a piecemeal approach to the problem without a proper diagnosis can mean that money is spent uselessly and that people's health continues to suffer needlessly.

## A systematic approach for trade unionists

As the previous chapters have shown, the main factors contributing to symptoms of building sickness are:

▲ ventilation
▲ temperature and air movement
▲ humidity
▲ airborne pollution
▲ biological contamination
▲ work-related stress

A systematic approach is needed to determine which of these factors, or combination of factors, is likely to be responsible in a particular building. As the above example shows, it is easy to throw money at a building without improving things at all. Therefore, the following steps, which are discussed in more detail below, might be taken by trade unionists trying to solve sick building syndrome:

▲ Obtain information on sick building syndrome and circulate it to members.
▲ Carry out a questionnaire survey of members' symptoms and of their assessment of environmental conditions in the workplace.
▲ Do a visual inspection of the building.

▲ Obtain relevant information from management.
▲ Determine objectives and action that members are prepared to take.
▲ Negotiate with management for obvious remedial action to be taken and for independent surveys and/or air monitoring to be carried out.
▲ Re-survey the membership after any remedial or 'curative' work has been carried out.

You may choose to set up a union working party to ensure that things get done as quickly as possible, involving ordinary members as well as committee members.

**In the summer of 1987, Ealing Council in West London moved 1,000 employees into the Great Western Centre, a prestige office development which promised a 'new era' of luxury for local authority workers. Within weeks, staff began to complain of headaches, sore eyes, sore throats and stomach upsets.**

**It took several months of trade union pressure before the management commissioned London Scientific Services (an ex-GLC body) to conduct a survey of environmental conditions and a staff questionnaire. The survey was incon-clusive but did find the bacterium responsible for legionnaires' disease in the air-conditioning system. Internal documents - describing pools of stagnant water in the ductwork and plant-room - pressed for cleaning and improved maintenance of the system. But these were ignored. By 1989, two years later, the staff had had enough. Mass meetings were organised by the trades unions, and union members walked out when it was revealed that there were major defects in the building that breached fire regulations as well as hygiene standards.**

**The final straw came when the majority of staff in the switchboard room were struck down by severe allergic reactions, landing some in hospital. The cause turned out to be a breach in the internal ductings of the building that allowed a direct connection between a leaking sewage pipe, a laboratory where hazardous chemicals were used, a service duct contaminated with fungal growth and the room occupied by the switchboard staff. Trade union reps demanded an immediate repair of these defects and an undertaking from management that the environmental problems would be investigated properly and immediately. These demands were met and a joint union-management committee was set up to monitor the progress of the investigations and repairs. Consultants were commissioned to design an effective maintenance programme.**

***Obtain information on sick building syndrome***

You should obtain as much information as possible, particularly examples of other cases of sick building syndrome that your union has had to deal with. Talk to as many members as possible to elicit their opinions on the working conditions, symptoms and possible causes.

### *Provide members with information*

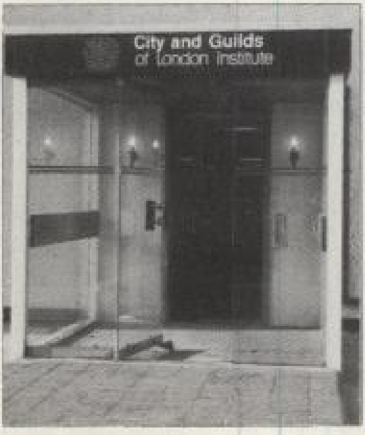
Disseminate information to members by means of leaflets, newsletters, noticeboards, speakers at union meetings, etc. It is particularly useful to invite people who have been involved in combating sick building syndrome themselves to speak at a meeting. As negotiations with management proceed, ensure that members are kept fully informed of objectives and progress - or lack of it - so that they can decide on appropriate action to take.

### *Conduct a questionnaire survey*

In order for your case to be taken seriously by management, it is likely that you'll need some statistics in support. Appendix 1 gives a sample survey that can be adapted to suit your needs. It is based on a survey carried out in 1987 by the National and Local Government Officers' Association (NALGO) in Kensington and Chelsea Town Hall in West London, a typical municipal complex with air-conditioning, sealed windows, fluorescent lights and tinted glass. Workers there had suffered for many years with sick building syndrome, and the survey showed that the percentage of people who usually or always suffered from a particular symptom was: stuffy nose, 42; dry skin, 41; lethargy, 40; headaches, 30; eye irritation, 30; irritated throat, 30. A far higher percentage experienced problems on occasion.

A health and safety survey undertaken by the Manufacturing, Science and Finance Union (MSF) at the City and Guilds Institute in London in 1990 asked for members to rate the office environment. Fifty-eight per cent said that the temperature was usually unsatisfactory; 71 per cent criticised humidity levels; 81 per cent said that air circulation was poor; and a staggering 94 per cent did not get enough fresh air. The levels of headache (90 per cent), lethargy (74 per cent), dry eyes (61 per cent), sore throat (58 per cent) and other symptoms amongst these workers point to a major problem with ventilation in this six-storey, sealed, air-conditioned building.

*A survey of workers at the City and Guilds Institute building in London clearly highlighted the ventilation problems in this sick building.*




London Hazards Centre

Some members might prefer not to give their names in a survey. This doesn't matter, although it is useful to know who is experiencing problems. The most important thing is to get as high a response rate as possible, including people who say they find no problem with the environment. Make sure members understand that individual questionnaire forms are confidential and won't be shown to the management.

***Inspect the building***

If you are lucky, one of the building services engineers may be a sympathetic union member and happy to help you with your inspection of the air-conditioning/ventilation system. But, anyway, trade union safety reps have the legal right to carry out inspections (see Appendix 5). Appendix 2 provides a comprehensive checklist for building inspections. The whole building needs to be covered, so draw up a methodical plan and timetable for carrying out the inspection.

***Obtain information from management***

Some points on the checklist cannot be answered by inspection, but rely on information from management. Union safety reps have the right to this information under the Safety Representatives and Safety Committees Regulations (see Appendix 5). Ask any additional questions that have emerged so far. You might also ask management to check the comfort parameters of temperature, relative humidity and air speed at various specified sites in the office during working hours.

***Determine objectives***

By now, you should have a good picture of the extent and nature of the health problems experienced by members, the possible environmental causes, and whether the management is likely to be co-operative and assume its responsibilities under the Health and Safety at Work Act. You need now to determine both long-term and short-term objectives, and decide how these will be raised with the management - perhaps at a Safety Committee meeting if these operate effectively within your organisation, or at a regular union-management meeting. You also need to be clear about what action your members are prepared to take if management refuses the union's requests or takes no action.

***Negotiate with management***

Depending on what your investigations so far have shown and the objectives you have drawn up, you will have specific demands to make of the management. These obviously depend on so many factors that it is impossible to identify more than a few of the more obvious ones here:

▲ an immediate, thorough overhaul of the existing air- conditioning system (see Appendix 3)

▲ appointment of competent and independent consultants to carry out surveys of heating, ventilation, lighting, building construction, biological con-

tamination, health, etc. or to monitor the air for pollutants and measure comfort parameters (see p. 88)
- ▲ a written agreement that the recommendations of any such report will be implemented and their effects will be monitored
- ▲ formulation of a smoking policy
- ▲ establishment of an ongoing complaints procedure
- ▲ a timetable for specific actions to be carried out

You may need to keep reminding management of their obligation and duties under health and safety legislation (see Appendix 5), particularly if the solution to problems is likely to be an expensive one. If your management refuses to co-operate, call in the Environmental Health Officer from your local council who is legally responsible for ensuring that employers of people working in offices, shops and similar places do not neglect their duties under the Health and Safety at Work Act.

***Re-survey the membership***
If your inspection showed, for instance, that humidifiers were full of slime, filters were clogged up, and ductwork was dirty, the union's first demand might be for a complete overhaul of the system and the instigation of a regular cleaning and maintenance programme (see Appendix 3). After such work has been carried out the membership should be re-surveyed to see whether their health has been improved by this action. If not, you will need to negotiate with management for further action to be taken.

## Relocation/new building

If your employer plans to relocate, you should use your rights under health and safety legislation to obtain information on the heating, ventilation and lighting systems in the new building and on other factors relating to sick building syndrome such as office layout/partitioning and furnishings. You might need to negotiate improvements to proposed alterations, refurbishments and installations. Appendix 4 provides a checklist for those involved in planning an air-conditioning system for a new building or a new system in an existing building.

## If there is no union

If there is no recognised union in your workplace, your employer still has a legal responsibility to provide a healthy and safe workplace (see Appendix 5). However, you will need to think carefully about the best way of approaching your management to get them to assume their legal duty. You might start by joining the appropriate trade union and seeking advice from the union's organiser. If you are unsure about which union to join, contact your local Trades Council, Regional TUC, or the Trades Union Congress (TUC, Congress House, Great Russell Street, London WC1. Tel: 071-636 4030).

No doubt people will have been complaining for some time about conditions at work: the building might for years have had a 'reputation' for causing sickness. Pass literature on sick building syndrome around the office so that as many people as possible become familiar with the causes and possible remedies - particularly those who are prone to develop symptoms. If you work in a building occupied by other organisations which share an air-conditioning system, ask these workers whether they are also suffering from ill-health. Some of you might then organise an informal meeting after work to discuss the issue. You can then decide which of the steps outlined above for trade union members you might take - setting up a working party, arranging a questionnaire survey, drawing up plans of the office, carrying out inspections, using the law, approaching the management, etc. But remember, unless you are an elected trade union safety rep you don't have any legal right to inspect the workplace and management doesn't have to give you information you ask for.

If a meeting of workers decides to inform management of survey results, do so in writing, making sure that the management is clear that the people presenting the results are representing all the workers. Never go alone to a meeting with management. If your management ignores the problem, or you find the management impossible to approach, you could get the ball rolling by contacting the authorities responsible for enforcing the Health and Safety at Work Act - the local authority's Environmental Health Officer, who is responsible for offices. This can be done anonymously and EHOs have a duty to follow up any complaints made in this way.

## Surveys and air monitoring

When negotiating with management for competent and independent consultants to be commissioned to carry out surveys, make sure you are calling in the right 'expert' for the job and that she or he is given the right brief. In the example of Camden Housing Aid Centre, described in Chapter 1, workers believed their symptoms were due to traffic exhaust fumes being drawn into the air-conditioning system. In an early survey an occupational hygienist was asked to assess the health risk from airborne lead and carbon monoxide and to make recommendations on the basis of his findings. The hygienist did just this and, not surprisingly, he measured levels well below recommended exposure limits and concluded that no action was necessary by the management to prevent ill-health amongst its employees. He failed to recommend that other causes of ill-health should be investigated, for instance that a thorough inspection of the ventilation system be undertaken to try to find the reasons for the complaints. It was another three years before NALGO members at this workplace managed to get their management to pay for the correct surveys to be carried out.

The occupational health and safety resource centre at Canada's University of

Western Ontario has devised a routine five-point survey for occupational hygienists to follow when investigating air quality complaints (Ruhemann 1985). Features include:

- ▲ a walk-through inspection to look for sources of contamination, such as photocopiers, insulation and cleaning materials
- ▲ measurement of temperature, humidity, air movement and other comfort parameters
- ▲ measurement of carbon dioxide to assess ventilation efficiency
- ▲ measurement of formaldehyde, carbon monoxide, ozone and respirable particles
- ▲ examination of the ventilation system for causes of poor distribution, including tests for biological organisms in any water in the system

From these measurements it may be possible to predict the health complaints of people working in the building; conversely, people's rating of environmental conditions usually correlates well with the measurements obtained with instruments (Wilson et al 1987). But this is not always the case: air monitoring tests may show nothing 'abnormal'. This doesn't mean, however, that people are not sick or that their symptoms aren't real! Instruments don't measure things in the same way as humans: they can only measure the 'here and now' and cannot provide a summary of the long-term performance of the building environment as humans can. Also, instruments cannot measure interactions between the various parameters that determine environmental comfort.

A major problem can arise when people look to instruments to validate health complaints (Vischer 1989). If people are too hot and the thermometer shows the temperature to be 25°C, then they are 'right' in complaining. But if a sound level meter gives a reading of only 32 decibels in an office where people complain about noise levels then they are 'wrong' and are told to stop complaining. The assumption is that the instrument tells the 'truth' and people's experience is dismissed as 'subjective' and 'unreliable'. Instead of trying to relate people's judgements to instrument readings, the two should be treated as separate but equally valid measures. In her book *Environmental Quality in Offices* Jacqueline Vischer (1989) develops a new approach in which human judgements alone are used to diagnose problems in the building environment. Called 'building-in-use' assessment, this systematic, ongoing approach might be taken by managements who seriously want to improve the working environment.

Some of the techniques and instruments used to monitor the air are described below.

***The thermal environment***

To assess the thermal load on workers, temperature, relative humidity and air speed need to be measured. This is done by taking four different measurements: wet and dry bulb temperature, air speed and globe temperature. Ambient temperature can be measured more accurately using the wet bulb-globe thermometer (WBGT) method than with an ordinary mercury or alcohol thermometer. Readings should be taken in various different parts of the office/building. An instrument that is capable of measuring the moisture content of the air is called a hygrometer. Relative humidity can be measured by use of a whirling hygrometer (sling psychrometer), which consists of both wet and dry bulb thermometers, and psychrometric charts. Air speed is often measured using a Kata thermometer (which allows air velocity to be measured by determining the cooling power of the air), although many other instruments are available for measuring air velocity. Air speed (movement) measurements should be made about 1 metre above the floor in positions where room occupants would normally be working. Attention should be given to those areas where circulation is likely to be blocked by partitions or other barriers.

### *Ventilation*

To assess the performance of the ventilation system, the hygienist will need to measure air flow rates (the number of cubic metres of air that pass per second, or air changes that occur in one hour), air speed (the number of metres that the air travels in each second), air pressures inside ductwork and air flow patterns.

*Air flow*

Air flow rates inside the ducting deteriorate with time for a variety of reasons, but mainly because of dirt and other deposits on fan blades, duct walls and other parts of the system. If regular records are kept trends can be spotted and remedial action can be taken (Gill and Ashton 1982). Vane anemometers or heated head air meters may be used to measure air flow in ducts.

*Pressure*

A pressure difference needs to be maintained between the inside of ducts (negative pressure) and the outside room-space (positive pressure) so that air can flow. This is achieved by means of a fan with its suction and discharge effects. Pressure is absorbed by the ducting, fittings and obstructions such as dampers and filters, particularly when they are dirty. Routine pressure measurements can therefore indicate deterioration in the system. Manometers and diaphragm gauges are used to measure pressure.

*Natural ventilation and circulation*

In order to assess the rate of air infiltration in buildings without mechanical ventilation or to see how well the air is actually circulating in a mechanically ventilated space, a tracer gas such as nitrous oxide can be used. A known quantity of the gas is released into the room, and its distribution and dilution rate are measured.

### *Lighting*

Sources of illumination deteriorate with time: windows and light fittings accumulate dirt which reduces the amount of light emitted, and surfaces become dirty so reducing the amount of light reflected from them. The correct level of illumination does not necessarily mean that the workplace is properly lit: measurement of illumination takes no account of glare from unshielded lights or windows or of the position of the worker in relation to the light source.

Photometers are used in lighting surveys to measure illuminance levels, but a visual assessment of such factors as lighting adequacy, suitability to the work being done, shadows, reflections, glare, colours, cleanliness, flicker and light distribution is equally important. A person doing a thorough lighting survey should also talk to people occupying the room about what they feel about the lighting levels.

### *Noise*

Sound level meters are used to measure the intensity of sound in units called decibels (dB). A reading in dB(A) cuts out those sound frequencies that the human ear is not sensitive to and boosts the sensitive frequencies. Even so, the use of sound level meters is a fairly crude way of measuring the experience of the human ear. The meter measures a sound between two points, assuming an emitter of sound and a receiver who hears it. A person sitting at a desk, however, has sound coming from all directions and the ear selects sound from a number of different directions at once (Vischer 1989).

### *Dust*

Although the amount of dust in offices is unlikely to reach the 'nuisance' levels found in many industrial processes, the level can be considerable. If lots of paper is being used, paper dust is generated; new carpets shed particles of different sizes; movement stirs up the dust; cigarette smoking produces respirable particles; and asbestos and fibreglass particles may be shed from deteriorating insulation material. Large particles lodge in the nose and throat while smaller ones are deposited increasingly further down into the lungs as their size decreases.There are two main methods for sampling airborne dust. Filtration sampling involves drawing a known volume of air through a preweighed filtering device by means of an air pump. The device is then weighed to determine the mass of dust collected during the sampling period (which may be the working day). The pore size of the filter will determine the size of dust particles that are collected. The second method involves direct reading of the dust concentration at a particular point in time, using bulky, expensive instruments.

### *Gases and vapours*

There is such a vast range of gases and vapours that a wide variety of monitoring and detection techniques has been developed. Instruments can be used to measure directly the concentration of the airborne chemical or - more often - the air is collected from the workplace and examined in the laboratory. You need experience in analytical chemistry to carry out many of these assays, but anyone can use the simple detector tubes and paper type monitors relying on colour changes which have been developed for some chemicals, e.g. carbon monoxide. Carbon monoxide, formaldehyde and ozone are three chemicals that are routinely monitored for in office surveys.

***Air ions***

Air ion analysers are available which can selectively measure ions of a particular size and mobility. Values are likely to be affected by the weather, time of day and fluctuations in air pollution levels, particularly outside the building.

***Radiation***

Electromagnetic radiation at either ionising or non-ionising frequencies is virtually impossible to measure accurately in the office and at the low levels concerned. Different frequencies need different methods of measurement, and at extremely low frequencies the instruments themselves can interfere with and distort the fields that they are measuring.

***Microbiological contamination***

More than 30 different types of organism have been identified in the water from one humidifier. The skills of a microbiologist are needed to sample, grow in the laboratory and identify microbial species such as bacteria, viruses, spores and amoebae.

## Smoking in offices

When Volvo moved to a new building, it introduced a smoking ban for its 630 white-collar workers. British Telecom has introduced a piecemeal policy on smoking: workers can vote to designate their area 'no smoking' if they wish (Leadbeater 1989).

The contribution of tobacco smoke to indoor pollution was outlined in Chapter 4, and it is now indisputable that passive smoking causes ill-health in the short term, with effects on the respiratory system, and produces a likely increase in the risk of lung cancer in the long term. Over the past few years non-smokers have become increasingly vocal in their demands for the right to work in a smoke-free environment, and have pointed to the law to support their case. Under Section 2 of the Health and Safety at Work Act, employers are required to provide a safe and healthy working environment as far as is reasonably practicable. It is argued that the banning of smoking in the workplace or the restriction of smoking to designated areas away from workstations are actions that employers should, and reasonably could, take to comply with the law.

It is important for non-smokers to understand the enormous stress placed on smokers who are faced with the ultimatum: 'There's no smoking in this building from Monday morning'. Many smokers do want to give up their habit, but they need help in doing so. For this reason, designated smoking areas, ventilated so that tobacco smoke is not distributed around the building, offer the best compromise - as long as managers aren't allowed to smoke in their offices. A policy on smoking should be incorporated into the employer's safety policy (see Appendix 5).

## Conclusion

An 18-month study into the causes of sick building syndrome, carried out by the government's Building Research Establishment and costing 'hundreds of thousands of pounds', is due to report at the end of 1990. The researchers hope to provide a method for studying sick buildings (Barrick 1989). Study is all very well, but there is plenty that can be done now to improve conditions for workers whose health is suffering, such as giving air-conditioning systems a thorough overhaul, checking the adequacy of the system, and increasing the amount of fresh air delivered per person.

One lesson that has already been learned is that sick building syndrome can result from placing too much emphasis on centralised efficiency and control, overlooking the individual and variable needs and responses of people to their environment. The best way to prevent sick building syndrome is for buildings and ventilation systems to be better designed in the first place so that people have plenty of natural light and individual control over heating and ventilation.

# APPENDIX 1
## Office work environment survey questionnaire

### Part 1: Demographic information

Name: (please leave blank if preferred)
Building/Floor/Room: (as appropriate)
Job type:
Smoking habits:
Hours per day spent in building:
Office equipment used:

### Part 2: Subjective evaluation of working environment

Do you experience the following conditions in your working environment?

| | *Always* | *Often* | *Sometimes* | *Never* |
|---|---|---|---|---|
| Too little air | | | | |
| Too much air | | | | |
| Too dry | | | | |
| Too moist | | | | |
| Too hot | | | | |
| Too cold | | | | |
| Too bright | | | | |
| Too dim | | | | |
| Glare on surfaces | | | | |
| Too noisy | | | | |
| Too quiet | | | | |
| Smoky | | | | |
| Stuffy | | | | |
| Unpleasant odours | | | | |

## Part 3: Health-impaired symptoms

Do you experience any of the following complaints in your workplace? Also, please indicate if the problem is consistently more common in the afternoon than in the morning.

| | *Always* | *Often* | *Sometimes* | *Never* | *More common in the afternoon* |
|---|---|---|---|---|---|
| Dry or sore throat | | | | | |
| Skin dryness | | | | | |
| Skin rashes | | | | | |
| Eye irritation | | | | | |
| Contact lens problem | | | | | |
| Runny nose | | | | | |
| Stuffy nose | | | | | |
| Difficulty in breathing | | | | | |
| Chest tightness | | | | | |
| Flu-like symptoms | | | | | |
| Headache | | | | | |
| Dizziness | | | | | |
| Nausea | | | | | |
| Drowsiness | | | | | |
| Lethargy | | | | | |
| Aches in arms | | | | | |
| Chest pain | | | | | |
| Backache | | | | | |
| Menstrual problems | | | | | |
| Impotence | | | | | |

## Part 4: Degree of control over environment

| | None | A little | Some | Mostly | Complete |
|---|---|---|---|---|---|
| Temperature | | | | | |
| Ventilation | | | | | |
| Humidity | | | | | |
| Lighting | | | | | |
| Noise | | | | | |

Please add any additional comments:

# APPENDIX 2
## Checklist for building inspection

This checklist is aimed mainly at people working in air-conditioned buildings, but those in buildings with natural or simple mechanical ventilation can easily adapt it for their own use.

### Toxic fumes, gases and dust

- ▲ Conduct a walk-through survey to identify possible sources of air pollution. Are there photocopiers or other equipment giving off potentially harmful gases/fumes? If so, is the equipment supplied with separate exhaust ventilation? Does the exhaust vent air to the outside of the building or into corridors or into the air-conditioning system? What is the position of the fume extractor in relation to supply and return air vents?
- ▲ Is ozone added to the air-conditioning system to 'sweeten' the air?
- ▲ Are biocides added to the system to control growth of micro-organisms?
- ▲ Is there urea-formaldehyde insulation in the walls? Or are there furniture, furnishings, carpets, etc. that are likely to give off formaldehyde gas?
- ▲ Have wood preservatives or other chemicals been used in the building?
- ▲ Are renovations being done in any part of the building? Are they done during working hours?
- ▲ Is there any asbestos in the building?
- ▲ Is there a kitchen or canteen where cooking is done? Is exhaust ventilation provided here?

### Vents

- ▲ Obtain or draw a plan of the office space. Check the number of supply air and return air vents in each room/area and mark them on the plan.
- ▲ Is there at least one supply air and one return air vent in each room? NB: Vents may be difficult to find. There may be a false ceiling which is perforated to allow air to diffuse from the space above it. Supply and return air vents may also be combined with light fittings.
- ▲ Are vents located in positions that will allow the best air circulation?
- ▲ Are supply or return air vents blocked in any way, by partitions, files or other structures that obstruct air flow?

### Dust

- ▲ Has dust collected around the return air vents? This indicates the need for improved maintenance or better filters; vents should also be cleaned.
- ▲ What type of filters are used? Are they adequate? Are they being bypassed?
- ▲ Check the state of the filters. How often are they cleaned/replaced?
- ▲ Samples of dust from vents or filters could be analysed for hazardous substances such as asbestos and fibreglass.
- ▲ Where ductwork can be seen, is it clear of dirt and debris?

### Fresh air

- ▲ Mark on the plan the number of people working in each area. Give numbers of workers on different shifts.
- ▲ What hours are workers in the building?
- ▲ Does the system get turned off during the day? This can be checked by attaching a thin piece of paper to the edge of the vent and checking at regular intervals that it is moving.
- ▲ Does the system get turned off after 5pm? Are workers still in the building then?
- ▲ Does the system get turned on to a different cycle at night? For instance, is outside air closed off at night so that all air is recycled? NB: The system should continue to function and draw in air from outside at all times that there are workers in the building.
- ▲ Where is the air intake/outside air drawn from? Is it near the cooling tower on this or nearby buildings? Is it at street level or drawing from a car park? Is it blocked up? Is there heavy industry nearby? Or construction work?
- ▲ Are fresh air dampers working correctly so that fresh air is actually getting into the building? The greater the percentage of fresh air rather than recycled air the better. Try to achieve 100 per cent fresh air.

### Fresh air requirements

- ▲ How many smokers work in each room/area? How many non-smokers? (for each shift)
- ▲ Calculate the minimum fresh air requirements

for each room on the basis of 8 litres per second per person. To find out if enough outside air is brought into the building to meet these requirements, you will need to consult the building services engineer. Increasing the amount of fresh air often helps in sick building syndrome.

## Humidification

▲ Is there a humidification system? If so, what type of humidifier/dehumidifier is used? Is it actually operating? Is it in working order? Is it clean and free from contamination with micro-organisms?

## Comfort

▲ Is temperature regulated by thermostats? Where are they located? Have they been correctly positioned following building alterations? Are they working correctly? Measure the air temperature with an ordinary dry bulb thermometer in various locations.

▲ Is there discomfort from heat radiation from visual display units?

▲ Is there discomfort due to local cooling from cold window surfaces?

▲ Are temperature, relative humidity and air flow rates checked regularly during working hours?

▲ Does air reach all parts of the office or are there dead spaces? This can be measured with a smoke tube. If air is circulating well, the smoke will drift to a return air vent. If circulation is poor, the smoke will stay in one place.

▲ Is the building still used as the designer envisaged? Have partitions/walls been added or removed? Have occupancy levels changed? When was the air-conditioning system last 'balanced'? Professional advice may need to be sought to find out whether the system can still meet its design criteria.

▲ Are there any flickering fluorescent tubes? Are fluorescent tubes regularly replaced before there are obvious signs of wear? Are lights fitted with diffusers? If so, are these made from glass, which is better than plastic at cutting out ultraviolet radiation? Are the diffusers clean? Are daylight full-spectrum tubes used? Is non-fluorescent lighting used wherever possible?

## Cleaning and maintenance

▲ Is the building adequately cleaned? Is regular damp dusting of office furniture, ledges, shelves, etc. carried out to help keep dust to a minimum?

▲ Are there staff responsible for cleaning and maintenance of the air-conditioning/ventilation system in the building?

▲ Is a regular procedure for maintenance followed? (See Appendix 3)

▲ Are all necessary components (cooling towers, evaporative cooling systems, drip tray, ductwork, filters, humidifiers) cleaned regularly and inspected for leaks, breaches, etc.?

*Main source:* Queensland and Lidcombe Workers' Health Centres 1984

# APPENDIX 3
## Cleaning and maintenance of air-conditioning systems

Workers should be employed specifically to ensure that regular maintenance is carried out on a routine basis. But where maintenance and cleaning are contracted out, tenders and contracts should be checked to ensure that all aspects are covered. Maintenance workers should be given full information about the prevention of hazards associated with air-conditioning (eg. humidifier fever, legionnaires' disease, toxic chemicals). Records should be kept of all maintenance work - when and what was done.

## Preventive maintenance programme

***Mechanical operation***
This needs to be checked regularly so that it continues to operate at maximum efficiency and breakdowns are prevented.

***Re-balancing***
After the first year of operation the system should be checked and adjusted to ensure correct air flow, temperature and humidity. Similarly, checking is needed after renovations or changes in office layout that might affect air flow.

***Air handling unit***
The state of the air handling unit can be critical because this is where incoming fresh air (and re-circulated air) is filtered and treated. Contamination here could result in contamination everywhere else in the air system. The components of air handling units such as fans and baffles should be cleaned every 3-6 months, depending on the condition of the incoming air and use of the system.

***Filters***
Filters should be cleaned or replaced regularly. The frequency of cleaning depends on the type of filter. However, maintenance should occur before the filters become totally clogged so that they are performing properly at all times.

***Cooling coils, condenser trays and water trays***
These should be checked regularly for signs of sludge, algae or rust build-up and for leaks where water could enter the airstream. Coils should be cleaned at least every 6 months. The trays should be cleaned regularly (every 2-3 weeks) to ensure that contaminants do not build up. Any ferrous metal surface should be treated with an acceptable anti-corrosion paint. Re-circulating water should also be treated to prevent rust - but that treated water must not be allowed to enter the airstream.

NB: When using chemicals to solve one particular hazard, care should be taken to ensure that no new health problems are created. The health of maintenance workers must be considered.

***Air washers/humidifiers and eliminator plates***
These should be cleaned regularly and thoroughly at least every 2-3 months to prevent build-up of sludge, algae and rust. Biocides and other chemicals should not be used since they would be discharged into the airstream. When humidification is necessary, a steam injection system should be used.

***Wet cooling towers***
Regular water treatment and cleaning/ disinfecting programmes must be drawn up. Towers that are used all year round must be cleaned and disinfected thoroughly twice a year. (For more details, see Chapter 3, pp.28-31.)

***Ducting***
Ducting can be difficult to keep clean since it is often not designed with openings - engineers should include regular openings in their designs. Nevertheless, methods of cleaning deep into ductwork have been developed by specialist cleaning companies, and deep cleaning should be carried out yearly. Parts of the ductwork that are more accessible should be cleaned at least every 6 months.

## Breakdowns

In case the air-conditioning system breaks down, there must be an alternative source of providing fresh air to all workers, for instance opening windows. If this cannot be done, perhaps because the building is sealed, you should leave the building until the system is operating again.

## Responsibility

There may be argument about who is responsible for maintenance, cleaning and proper functioning of the air-conditioning system - the employer, the contractor or the owner of the building (if it is leased). This will depend on the lease or contractual arrangements. However, as far as workers are concerned, the employer has a general duty in law to provide a safe and healthy working environment, so it is the employer's responsibility to ensure that work is carried out, by whomever.

*Main source:* Queensland and Lidcombe Workers' Health Centres 1984

APPENDIX

# Design of new air-conditioning systems

4

This checklist is for those who are involved in the planning of a new air-conditioned building or the installation of a new system in an existing building.

## Before appointing designers

▲ Spend time considering what the new building, or air-conditioning system, is going to be used for - as far into the future as possible.

▲ All those who are going to work in the building should be involved in discussions about the air-conditioning system as well as other aspects of the office environment such as lighting, flooring, furniture, colours, etc.

▲ Maintenance workers should give feedback on their experience with any existing air-conditioning system.

▲ Decide broadly on the conditions to be achieved for workers and for any special equipment or processes (e.g. computer suite) before consulting a building services design engineer and/or architect. Avoid late changes in the specification.

## Design of the system

▲ Ideally, the air-conditioning system in a new building should be designed by an architect together with an air-conditioning consultant or building services design engineer - rather than a conglomerate of interested parties including air-conditioning equipment manufacturers' 'free design services'. Priority should be given to health and comfort rather than cost alone.

▲ Check that the architect's brief allows sufficient space for building services, future maintenance and possible later additions. Does it strike the right balance between aesthetic and practical considerations?

### *Individual control*

▲The system should be designed with as much individual control over conditions as possible, and the building should be designed so that all workers have good access to natural light. Windows should be openable and temperature and air flow rates should be as locally controllable as possible. (These features of individual control should become more easily available in the future as long as demands to manufacturers and designers are made now.)

### *Ventilation*

▲ The system should have the flexibility for adjustment to be made to the amount of fresh air taken into the system and for the amount of fresh air supplied to different areas within the building to be altered. In the first few months of occupancy (and after renovations) it should be possible to push more fresh air through the system to ensure 'de-gassing' of fumes from new carpets, paints, furnishings, etc.

▲ The system must be able to deliver a minimum fresh air volume of 8 litres per second per person at full occupancy of the building.

▲ Separate exhaust ventilation must be supplied to equipment such as photocopiers and cookers.

▲ A policy on smoking at work must be established. Areas set aside for use by smokers should be well ventilated, perhaps designating a room with a separate ventilation system which exhausts the smoky air directly to the outside of the building. The system must be designed so that smoke is not circulated throughout the building.

### *Air vents*

▲ The positioning of supply and return air vents should encourage full circulation of air throughout the offices. Circulation patterns should be able to cope with changing placement of partitions and furniture, so all possible future subdivisions of space should be anticipated. This may mean a modular system (perhaps with a 3 x 2.5 metre grid) for all building services such as lighting, phones, electricity supply, and air.

▲ Any local perimeter heating/cooling units should be designed so that they cannot be used as makeshift shelves, thereby blocking air flow (e.g. use slanted-top units).

### *Humidity control*

Humidifiers should be of the steam injection type to avoid re-circulating water which can build up levels of micro-organisms.

***Water/dampness in the system***

▲ It is possible to design a system that does not produce wet areas in air handling units and ductwork: wetness provides a favourable environ-ment for the growth of micro-organisms. However, if wet or damp parts are anticipated, they should be readily accessible for regular cleaning.

***Thermostats***

▲ There should be a thermostat inside the office space (not in a corridor) on each floor of the building.

***Thermal gain***

▲ The building must be designed to take account of the heating effects of thermal radiation (and local cooling), for example the orientation of the building and window size. Tinted glass tends to disorient workers since it dissociates them from the weather conditions outside, but blinds, curtains, awnings or double glazing may be considered.

▲ The air-conditioning system must also be able to cope with the heat load from equipment such as visual display units.

***Outside air intake***

▲ Outside air must not be drawn from cooling tower spray, car parks, pavement level on busy roads, exhaust vents or other pollution sources.

***Filters***

▲ These must be carefully selected according to environmental conditions and the nature of the work carried out in the building and they must be positioned in the air handling unit for maximum efficiency.

***Ductwork***

▲ Ductwork must be designed with regular openings to allow cleaning and to ensure as little sound transmission and as quiet an air flow as possible.

***Materials***

▲ Materials that favour growth of micro-organisms, e.g. wood, should be avoided in the air-conditioning system. Hazardous fireproofing and insulation substances such as asbestos, fibreglass and urea-formaldehyde foam must not be used.

***Cooling towers***

▲ Air-cooled condensers should be used rather than water-cooled condensers, so dispensing with the wet cooling tower.

## Installation and commissioning

▲ The brief to air-conditioning contractors should not encourage low tenders at the cost of a healthy indoor environment. The proposed conditions of contract should encourage the contractor to suggest improvements based on practical experience. A reputable contractor should be used.

▲ Sufficient time in the schedule must be allowed for commissioning and testing of the completed installation and for fine tuning after commissioning. Commissioning should be extended into the period of occupation.

## After installation

▲ Operating and maintenance manuals and 'as fitted' installation drawings should be obtained and kept safely. Manuals and drawings should be updated when modifications are made.

▲ Maintenance workers should be taught all the intricacies of the system and its performance targets, and should go on relevant training courses.

▲ A service log book should be kept for analysis of defects etc., and the performance of the system should be audited.

***Complaints procedure***

It should be made easy for workers to give their views on the operation of the system so that necessary adjustments and alterations can be made and the designers can receive feedback on how well, or badly, the system is working. Problems may best be highlighted by carrying out periodic questionnaire surveys on environmental comfort to all workers.

*Sources:* Queensland and Lidcombe Workers' Health Centres 1984; Heating and Ventilating Contractors' Association 1989

# APPENDIX 5
## Sick building syndrome and the law

Under the Health and Safety at Work Act 1974 employers have a statutory duty to ensure the health and safety of their employees at work as far as is reasonably practicable (HASAWA Section 2). The HASAW Act places general duties on all employers; more detailed requirements can be found in the Offices, Shops and Railway Premises Act 1963:

***Heating***
(OSRPA Section 6): Offices must be kept at a 'reasonable' temperature. There is no legal maximum temperature, but a minimum of 16°C must be reached after one hour (the law falls short of acceptable standards of comfort here). The heating system must not emit injurious or offensive fumes into workspaces. A thermometer must be provided in each work area.

***Fresh air and ventilation***
(OSRPA Section 7): An 'adequate' supply of fresh air must be circulated to all offices. Rooms with no direct access to fresh air, such as opening windows, must be supplied by mechanical ventilation. Ventilation systems can deliver either fresh air from outside the building or 'artificially purified' air.

***Lighting***
(OSRPA Section 8): 'Sufficient and suitable' lighting by natural or artificial means must be provided in all areas. 'Sufficient' lighting is bright enough to do the work safely; 'suitable' means free from glare, shadows or flicker. Windows and skylights must be kept clean and free from obstruction unless shaded or whitewashed. All fittings for artificial lights must be properly maintained.

***Cleaning***
(OSPRA Section 4): The whole workplace, including ventilation and heating systems, must be kept in a clean state.

***Space for workers***
(OSRPA Section 5): No room should be so overcrowded as to cause risk to health. Each worker should have at least 11.3 cubic metres with 3.7 square metres of floorspace. The space occupied by workers' furniture (desks, chairs) is ignored but space taken up by other equipment, filing cabinets or machinery is subtracted from the space.

### Safety policies

To have a safe workplace there must be a clear plan for keeping the workplace safe. This is the safety policy. Every employer of more than five workers at a time must have a written safety policy (HASAWA Section 2). The policy must say in detail how safety is maintained. It must be kept up to date. And the employer must ensure that every employee knows what the policy says.

### Accident book

All workplaces with more than ten employees (and all factories) must have an accident book where details of all accidents can be recorded by the employee concerned, or by someone on their behalf (Social Security Act 1975). The book should also be used to record any sickness possibly caused by work. (All workers should log their symptoms of sick building syndrome here to help bring the point home to management.)

### Safety representatives' rights

The HASAW Act provided for the formation of safety committees and the election of trade union safety representatives. Regulations introduced under the Act in 1978 gave safety reps extensive legal rights in the workplace: they can undertake health and safety training, inspections and investigations in work time and are legally entitled to see any documents the employer holds relating to workplace hazards. The Safety Representatives and Safety Committees Regulations 1977 (SRSC Regs) provide the legal framework covering the role and rights of safety representatives.

***Becoming a safety representative***
In any workplace with more than two employees where a trade union is recognised the workers can appoint or elect as many safety reps as they decide are necessary to represent their interests on health and safety issues (SRSC Reg 3). (A safety rep is not a

safety officer: a safety officer is a member of management.)

### *Functions of safety reps*

These are outlined in SRSC Reg 4, and include investigating potential hazards and complaints from employees, carrying out inspections and representing members in talks with Health and Safety Executive inspectors and local authority Environmental Health Officers.

### *Facilities for safety reps*

An employer has a duty in law to provide safety reps with the facilities they need to operate effectively (SRSC Reg 5(3)). These should include a filing cabinet, access to a desk, rooms for meetings, access to a private telephone, internal and external post, typing and duplicating facilities, and notice boards.

### *Inspections and investigations*

Safety reps have the right to inspect the workplace at least once every 3 months (SRSC Reg 5(1)) and more often by negotiation or if there is a change in working conditions (such as the introduction of new equipment or working methods), a notifiable accident, disease or dangerous occurrence or new official information about a hazard (SRSC Reg 6). If management agrees, they can call in independent technical advisers.There is also a right to investigate hazards between formal inspections.

### *Information to safety reps*

SRSC Reg 7 requires an employer to make available to safety reps all the health and safety information 'within the employer's knowledge'. Reps have the right to see, and make copies of, any health and safety document the employer is required to keep by law (for example, manufacturers' and suppliers' hazards data sheets).

### *Training for safety reps*

Safety reps are entitled to take time off with pay in working hours to undergo trade union or TUC training courses. Reps should be trained in all aspects of the job, including the law, understanding hazards and how to eliminate them, using specialist information sources and conducting safety inspections and investigations. In addition, an employer should ensure reps are trained in the particular technical hazards of the workplace and on how health and safety structures operate.

## Safety committees

Under the HASAW Act (Section 2(7)) the function of a safety committee is described as keeping under review the health, safety and welfare of employees. New safety committees are easy to form: where two or more safety reps request in writing that an employer establish a safety committee it must be formed within 3 months of the request being received (SRSC Reg 9). The regulations also put a duty on an employer to consult with safety reps and trade unions as to how the committee shall function, who will sit on it, and what work the committee will do.

## Calling in a health and safety inspector

Where workers believe there is a health hazard or need information, they have the right to call in an inspector from the Health and Safety Executive or from the local authority's Environmental Health Department (which is usually responsible for offices) to make an investigation on their behalf and, if necessary, to instruct their employer to make changes.

## European Commission requirements

In January 1993, a European Commission (EC) Directive on minimum health and safety requirements in the workplace will come into force. As far as factors contributing to sick building syndrome are concerned, the provisions for ventilation, heating and lighting add little to requirements already existing in the UK under the Offices, Shops and Railway Premises Act, although in Article 6 special reference is made to the need for regular cleaning of air-conditioning and mechanical ventilation systems to an adequate level of hygiene.

The requirements on ventilation state that, in all workplaces, there must be sufficient fresh air and that forced ventilation systems must be maintained in good working order. Air-conditioning or mechanical ventilation systems in 'new' workplaces (those used for the first time after 31 December 1992) must operate in such a way that workers are not exposed to draughts which cause discomfort.

Article 7 of the Directive states that all workers and/or their representatives shall be informed of all measures to be taken concerning health and safety in the workplace.

# APPENDIX 6
## Resources and contact addresses

### Work hazard groups, local trade union health and safety groups and resource centres

**Birmingham Region Union Safety and Health Campaign (BRUSH)**, Unit 304, The Argent Centre, 60 Frederick Street, Birmingham B1 3HS. Tel: 021-236 0801.

**Coventry Workshop**, 38 Binley Road, Coventry CV3 1JA. Tel: 0203-27772/3.

**Greater Manchester Hazards Centre,** 23 New Mount Street, Manchester M4 4DE. Tel: 061-953 4037.

**Health and Safety Advice Centre,** Unit 304, The Argent Centre, 60 Frederick Street, Birmingham B1 3HS. Tel: 021-236 0801.

**Health and Safety Project, Trade Union Studies Information Unit**, Southend, Fernwood Road, Jesmond, Newcastle-on-Tyne NE2 1TJ. Tel: 091-281 6087.

**Hull Action on Safety and Health,** 31 Ferens Avenue, Cottingham Road, Hull HU6 7SY. Tel: 0482-213496.

**Isle of Wight Trade Union Safety Group,** Bob Davies, 12 Winston Road, Newport, Isle of Wight PO30 1RF. Tel: 0983-520439

**Liverpool TUC Health and Safety Committee and Trade Union Resource Centre**, 24 Hardman Street, Liverpool L1 9AX. Tel: 051-709 3995

**London Hazards Centre,** 3rd Floor Headland House, 308 Gray's Inn Road, London WC1X 8DS. Tel: 071-837 5605.

**Lothian Trade Union and Community Resource Centre,** 12a Picardy Place, Edinburgh EH1 3JT. Tel: 031-556 7318

**Milton Keynes Health and Safety Group** Vic Graves, Labour Hall, Newport Road, New Bradwell, Milton Keynes.

**Nottingham TUC Safety and Health Committee,** c/o 118 Mansfield Road, Nottingham. Tel: 0602-281898

**Portsmouth Area Health and Safety Group,** Norman Harvey, 32 Rowner Close, Gosport, Hants PO13 OLY. Tel: 0329-281898.

**Sheffield Area Trade Union Safety Committee,** 3rd Floor, Town Hall Chambers, Barkers Pool, Sheffield S1 1EN. Tel: 0742-753834.

**Sheffield Occupational Health Project,** Birley Moor Health Centre, 2 Eastglade Crescent, Sheffield S12 4QN. Tel: 0742-645691.

**South East Scotland Hazards Group,** 10 Fountainhall Road, Edinburgh. Tel: 031-667 1081 x 2932.

**Walsall Action for Safety and Health,** 7 Edinburgh Drive, Rushall, Walsall WS4 1HW. Tel: 0922-25860.

**West Yorkshire Hazards Group,** Bradford Resource Centre, 31 Manor Row, Bradford BD1 4PS. Tel: 0274-725046.

**VDU Workers' Rights Campaign,** c/o City Centre, 32-35 Featherstone Street, London EC1. Tel: 071-608 1338/9/0

**Women and Work Hazards Group,** London Women's Centre, Wesley House, 4 Wild Court, London WC2B 5AX.

### Further sources of information and help

**City Centre**, 32-35 Featherstone Street, London EC1. Tel: 071-608 1338. City Centre is an advice and information centre for office workers in London.

**Service Workers Action and Advisory Project** (SWAAP) Room 160, South Bank House, Black Prince Road, London SE1. Tel 071-587 1947

**Women's Design Service**, 18 Ashwin Street, London E8 3DL. Tel: 071-241 6910. Women's Design Service provides information and resources on women and the built environment.

### Information about trade unions

**Trades Union Congress** Congress House, Great Russell Street, London WC1B 3LS. Tel: 071-636 4030

J Eaton and C Gill, *The Trade Union Directory - A Guide to all TUC Unions*, Pluto Press (1983)

### White collar trade unions representing office workers

**Banking, Insurance and Finance Union (BIFU)**, Sheffield House, 1b Amity Grove, Raynes Park, London SW20 0LG. Tel: 081-946 9151.

**Civil and Public Services Association (CPSA),** 160 Falcon Road, London SE11 2LN. Tel: 071-924 2727.

**GMB,** Thorne House, Ruxley Ridge, Claygate, Esher, Surrey KT10 0TL. Tel: 0372-62081.

**Inland Revenue Staff Federation (IRSF)**, Douglas Houghton House, 231 Vauxhall Bridge Road, London SW1V 1EH. Tel: 071-834 8254.

**Manufacturing, Science and Finance Union (MSF)**, 79 Camden Road, London NW1 9ES. Tel: 071-267 4422.

**National and Local Government Officers' Association (NALGO),** 1 Mabledon Place, London WC1H 9AJ. Tel: 071-388 2366.

**National Communications Union (NCU),** Greystoke House, 150 Brunswick Road, London W5 1AW. Tel: 081-998 2981.

**National Union of Civil and Public Servants (NUCPS)**, 124-130 Southwark Street, London SE1 0TU. Tel: 071-928 9671.

**Society of Graphical and Allied Trades '82 (SOGAT '82),** Sogat House, 274-288 London Road, Hadleigh, Benfleet, Essex SS7 2DE. Tel: 0702-554111.

**Union of Communication Workers (UCW),** UCW House, Crescent Lane, Clapham, London SW4 9RN. Tel: 071-622 2442.

## Environmental and occupational hygiene consultants

We know that even when building sickness is suspected, workers and their employers often have difficulty in tracking down experts who can provide consultation on diagnosing and remedying the problem. We have therefore included the names and addresses of some consultants. We must emphasise, however, firstly that this list is not complete, and secondly, that inclusion here does not constitute a recommendation.

**Associated Scientific Laboratories** Paul Sutton, Laboratory Manager, 21 Humes Avenue, Hanwell, London W7 2LJ. Tel: 081-840 2200. Mainly occupational hygiene and analytical services including asbestos, dust, water, chemical and bacteriological contamination.

**Bartlett School of Architecture and Planning** Prof O'Sullivan, University College London, Wates House, 22 Gordon Street, London WC1H 0QB. Tel: 071-387 7050. Provides consultancy on health hazards in buildings.

**Building Research Establishment** Gary Raw, Garston, Watford WD2 7JR. Tel: 0923-894040. BRE provides technical consultancy on investigating and remedying sick building syndrome.

**Building Use Studies** 53-54 Newman Street, London W1P 3PG. Tel: 071-580 8848. Specialises in investigation of complaints including surveys, audits of management and organisational factors, briefing service for staff, trade unions and management.

**Environmental Monitoring Services** The Old Depository, Church Street, Warnham, Horsham, West Sussex RH12 3QP. Tel: 0403-69375. Monitoring of 'health of buildings', including water and air quality testing, microbiological and occupational hygiene testing and specifications for remedies.

**Institute of Environmental Engineering** South Bank Polytechnic, 103 Borough Road, London SE1. Tel: 071-928 8989. Investigation of office environment, heating and ventilation systems and specifications for remedies.

**Institute of Occupational Health** Dr Alistair Robertson, Birmingham University, P O Box 363, Birmingham B15 2TT. Tel: 021-414 6030. Specialises in investigation of medical problems associated with sick buildings including use of questionnaires and surveys.

**Robens Institute** University of Surrey, Guildford, Surrey GU2 5XH. Tel: 0483 572823. Provides complete range of analytical and occupational hygiene services and consultancy.

**Thames Water Utilities** Dr P J Dennis, Water and Environmental Services, New River Head Laboratories, 177 Rosebery Avenue, London EC1R 4TP. Tel: 071-833 6699. Adviser on water quality testing for building-related disease caused by chemical and microbiological contamination. Provides specifications for non-chemical remedies. Works with Water Quality Centre (below).

**Roy A Waller** 26 Salisbury Road, Carshalton, Surrey SM5 3HD. Tel: 081-647 5015. Environmental consultant specialising in diagnosis of building-related problems.

**Water Quality Centre** Martin Holden, New River Head Laboratories, 177 Rosebery Avenue, London EC1R 4TP. Tel: 071-833 6105.

Provides analytical services in co-operation with Thames Water Utilities (above).

**Winton Environmental Services** Group Air and Water Management, McMillan House, Worcester Park, Surrey KT4 8RH. Tel: 081-337 0731. Provide air, water, noise and lighting analysis services and non-chemical maintenance specifications.

## Videos and further reading

***General and office hazards***

London Hazards Centre, *Daily Hazard*, newsletter of the London Hazards Centre (five issues per year)

Hazards, *Hazards Bulletin*, a magazine for safety representatives, (five issues per year)

City Centre, *Safer Office Bulletin*, City Centre, (four issues per year)

***Health and safety law***

Trades Union Congress, *TUC guide to health and safety*, TUC Publications, 1985

***Lighting***

Health and Safety Executive, *Lighting at Work*, HMSO, 1987

London Hazards Centre, *Fluorescent Lighting - A health hazard overhead*, London Hazards Centre Trust, 1987

**New technology and VDUs**

U Huws VDU *Hazards Handbook - A workers guide to the effects of new technology*, London Hazards Centre Trust, 1987

Labour Research Department, *VDUs, Health and Jobs*, LRD Publications, 1985

Team Video, *Technology at Work*, Team Video Productions, (undated)

***Noise***

Trades Union Congress, *TUC Handbook on Noise at Work*, TUC Publications, 1986

***Sick Building Syndrome***

TV Choice, *Sick Buildings - the battle for healthier offices*, TV Choice, 1989

***Trade union and bargaining information***

Labour Research Department, *Labour Research* and *Bargaining Report*, LRD Publications, monthly magazines

***Women and work hazards***

Audrey Droisen and Women and Work Hazards Group, *Bitter Wages*, Video, Cinema of Women, 1984

W Chavkin, *Double Exposure - Women's health hazards on the job and at home*, New Feminist Library, New York, 1984

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