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HAZARDS OF THE WORKING ENVIRONMENT

The history of occupational safety legislation in Great Britain is largely one on legal control of the manufacturing industries. Its roots lie in the industrial revolution when the exponential increase in the use of powered machines brought with it exploitation of the workforce so blatant that reform was inevitable. Attention was first focused on the worst excesses; limits were imposed on working hours and general standards were laid down to control heating, lighting and ventilation. Since that time improvements have continued to be made as new threats to health or safety have been recognised.

It is generally recognised that very few improvements are absolute. As one evil is corrected so another, hopefully lesser problem will be introduced. This seems particularly so in matters related to modern ventilation practice. One consequence of energy efficiency is a greater control over air movement and heat loss; one possible consequence is that substances not previously recognised as hazardous can build up in the working environment. Another is that organisms can thrive within equipment designed to improve air quality and prejudice the health of susceptible members of the workforce. There is a general lack of understanding regarding the significance of some of these matters. This article seeks to review a number of topical issues which are of general concern.

LEGIONNAIRES' DISEASE

Legionnaires' disease is a form of pneumonia caused by the bacterium *Legionella pneumophila*. It was first recognised in 1977 following an outbreak in Philadelphia. The lung is the main organ to be affected by the disease although other symptoms can be produced. The disease is more common in elderly men, especially smokers or patients whose resistance to disease is impaired. Of 1295 cases reported in the period 1979-86, 49 per cent were aged 50-69 and 70 per cent were males. It is estimated that about 2 per cent of all cases of pneumonia in the community are caused by *Legionella pneumophila*. Since 1979 there have been several hundred cases in England and Wales with about 20 deaths each year. Between 1979 and 1986 962 sporadic cases have been reported; 359 from overseas hotels and 39 acquired from hospitals. There are known to have been 21 outbreaks in England and Wales and a further 35 where the source of infection was from overseas.

The bacterium favours both natural and artificial aquatic habitats, which include hot water systems, water based industrial coolants, whirlpool spas, and water cooled air conditioning systems. A recent survey of hot and cold water and cooling systems in hotels, hospitals, and business premises isolated legionella in up to 70 per cent of water samples. Although *L pneumophila* is frequently present in water, conditions must be right for its multiplication. The water must be warm, 20-45°C, and stagnant; the presence of iron, nitrogen or algal growth is said to promote multiplication.

There is no evidence to suggest health risks associated with the drinking of water contaminated with legionella. Danger only arises if contaminated water is released as droplets which evaporate before reaching the ground; this will leave very light particles of bacteria small enough to be inhaled deeply into the lungs. Cooling towers, sprays, disc humidifiers, showers, taps, and wind lift of standing water can all create this effect. It does not follow that illness will always occur; infection is dependent on the survival of the organism, its virulence, and the susceptibility of the host. No information is available on the minimum dose to cause infection.

Because of the ubiquitous nature of *Legionella pneumophila* its presence must be assumed in water systems. Precautions must therefore be taken to prevent its multiplication and to reduce the generation of aerosols. It is important that the potential for problems is recognised at the design and commissioning stages of new plant, and that management adopt and implement adequate procedures to ensure safe operation and maintenance.

Basic guidance has been offered on the fundamentals of good design. The following points should be borne in mind;

(a) **Sufficient space for building services** — Unless adequate space is allowed for the installation of building services equipment there is a real danger that subsequent maintenance will be impeded;

(b) **Use of modular systems** — in large buildings the use of modular units reduces long pipe runs, large storage tanks, dead ends and blind loops. Although costs may be marginally increased, the health benefits are tangible and maintenance may also be easier.

(c) **Avoidance of aerosols** — as far as possible equipment likely to generate aerosols should be avoided.

(d) **Use approved materials** — Certain materials have been found to favour the multiplication of legionella *e.g.* rubber grommets. Advice is available on suitable materials.

Domestic water systems must be designed to minimise storage of hot and cold water by achieving high throughputs. Temperature control is important; water should be heated to 60°C and delivered at not less than 50°C. (If there is a risk of users being scalded the solution is to use thermostatically controlled taps.) Waste heat recovery designed to pre-heat water will not impose unacceptable risk provided that water temperature is immediately raised to above 60°C. Cold water systems should be protected to prevent water being heated to a temperature above 20°C.

Although air conditioning plants have traditionally made use of wet systems there is a clear need to consider the use of air-cooled condensers. If this is not practicable then all other precautions should be taken, including the siting of plant away from air inlets for ventilation and air-conditioning. Access for maintenance and water sampling must also be easy.

Commissioning of new or refurbished plant must be carried out in an efficient manner. If there is to be a delay in the use of any component then it should be drained of water until immediately before it is brought into use. Adequate information must be available on site to enable the continued operation of all plants; such advice should include the proper consideration of steps to prevent the growth of legionella organisms.

Engineering responsibilities do not end when plant has been commissioned. Various codes of practice have been produced which are specifically designed for building service engineers. Codes of practice should not be seen as being sufficient in themselves. Adequate procedures should be produced which relate specifically to individual pieces of plant. Copies of these documents should form the basis of all service operations; it is therefore desirable for them to include adequate space for comprehensive maintenance records to be made.

There is a commonly held view that water systems should be cleaned on a regular basis, usually every six months. This period is not of any biological significance to the life of the bacterium; more regular, perhaps monthly, checks are necessary in order to detect the presence of biological fouling. When found the system should immediately be cleaned — biocides are only able to work effectively if the biological load is not too great.

Information of biocide effectiveness is limited at present; most knowledge is based on laboratory tests. Hypochlorite based compounds are known to be effected by the alkalinity of water. Therefore if it rises above pH8 chlorine ions combining to form salts, it follows that any significant emission of alkali material (such as cement dust) can render this range of compounds ineffective at normal concentrations. These effects can be minimised by the use of dosing plant controlled by some form of continuous monitoring. However the use of intermittent dosing which does not take account of varying environmental conditions can result in a depletion of available chlorine.

Regardless of the method used for dosing a system with biocide some programme for water testing is necessary. When this is done it is vital that personnel understand the associated risks and follow safe methods of working. The chemical quality of water should be measured on a regular basis and the results of analysis interpreted by a competent person. Similarly measurements for the presence of biocide can be made although the means of carrying out this test will depend on the chemical used for treatment. Finally, it is possible to test water for the presence of legionella. There is controversy over the value of this test because of the ubiquitous nature of the organism. However, if all aspects of installation, maintenance and treatment are satisfactory the presence of the bacterium is an indicator of some unrecognised problem. When results of any form of analysis are received they require the interpretation of a competent person, for that reason they must be immediately available for consideration. Mechanisms must exist to activate investigation and/or remedial measures when unacceptable findings are discovered. Response should not be limited to calling for the test to be repeated on the off-chance that the original result was wrong.

If water testing is to be fully utilised as an investigatory technique a number of steps must be taken:

(a) advice is needed on the number of Legionella in a water sample which are felt to constitute a health hazard,

(b) standard techniques for determining the concentrations of biocides must be developed,

(c) biocide efficiency should be tested in operational conditions,

(d) further information is required on the use of chlorination in circulating water systems,

(e) training on water sampling is required,

(f) technical representatives of water treatment companies require training.

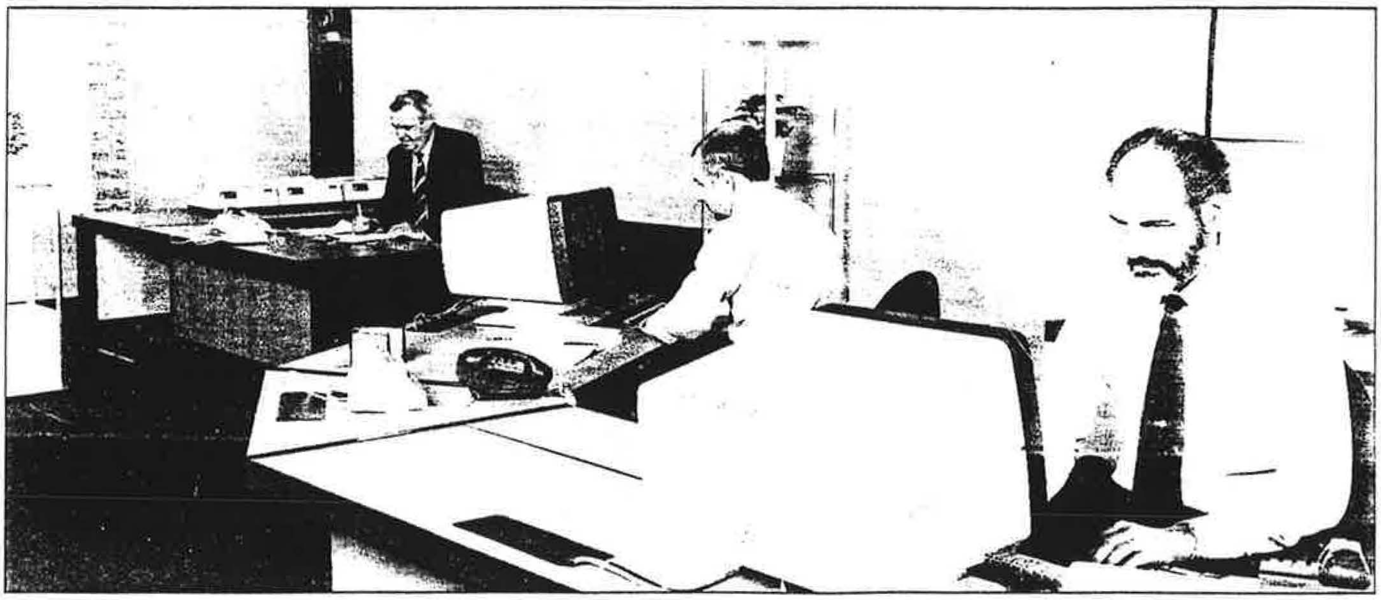
The problems posed by Legionnaires' disease make heavy demands on the engineering and safety professions; unless the challenge can be met, the unnecessary loss of life will continue unabated.

PONTIAC FEVER

This is a non-pneumonic form of Legionella infection. It was the name given to an outbreak which occurred in Pontiac in 1968 in an air conditioned building when 144 people were affected. Investigation and remedial works are the same as in the case of Legionnaires' disease.

HUMIDIFIER FEVER

Another illness which has its origins in water systems is humidifier fever. It is said to be caused by the inhalation of aerosols from cold water in ventilation systems which have been fouled with biological material. Although the exact cause is not known, amoeba, bacteria and endotoxins have all been proposed as worthy of further investigation. Unlike



Legionella such organisms can develop at temperatures below 20°C. Contaminated humidifiers have also been implicated in allergic reactions such as asthma. When humidifiers have been properly cleaned the symptoms are said to have disappeared.

SICK BUILDING SYNDROME

Sick building syndrome is a generalised non-specific malaise; symptoms include irritation of the nose, throat and eyes, lethargy, dry skin and headaches. It seems most likely to occur in office workers, especially those who are employed in larger buildings.

It is important to distinguish between temporary problems associated with newly constructed or refurbished buildings — where symptoms disappear in time — and permanently sick buildings where symptoms persist for years. Some common factors have been established such as:

(a) forced ventilation systems serving all or most of the building with partial recirculation,
(b) light construction,
(c) general use of textiles including wall-to-wall carpets,
(d) eneregy efficient buildings, kept relatively warm with a homogeneous thermal environment
(e) air tight envelopes.

Experience suggests that the syndrome is in part triggered by psychological forces, but that there are also clear physiological manifestations. Investigations of 'sick buildings' is complex because symptoms do not fall into a clear pattern. Remedial action is not easy because removal of specific exposures does not always reduce complaints.

Co-ordinated research is needed to develop a better understanding of this subject. It should include measurement of the levels of a wide range of air contaminants and seek to correlate findings with patterns of distress. Studies should also include electromagnetic fields and ion concentrations as some literature identifies them as influential factors. Surveys should consider other causes of stress in the workplace, including those associated with management and personal relationships. If necessary means may have to be found to reduce dissatisfaction caused by poorly maintained plant and premises; lack of individual control of the working environment and the insensitivity of building service systems.

OFFICE-EYE SYNDROME

This is said to be a form of eye irritation identified in clerical workers. The source of the problem has been attributed to poorly maintained ventilation plant, but definitive information seems lacking.

CABLE-BUG PHENOMENON

This problem has been found in a wide range of offices throughout the country. Complaints are associated with large offices, using a large amount of electronic equipment, and serviced with combined heating and ventilation systems. Often the source of the complaint is said to be some unidentified source of insect bite but evidence of infestation is non-existent and treatment ineffectual. The term 'cable-bug' was first coined when telephone cables had an outer fabric covering surrounding a multitude of fine wires which is a clue to the cause of the problem. Irritation is caused by a variety of sharp particles, paper, fibre from carpets, or fragments from low current wires. Discomfort is worsened during periods of high humidity when the particles adhere more easily to the skin. Improvements can be achieved by better housekeeping, replacement of rogue carpeting and the cleaning and improvement of ventilation.

SMOKING

It is unrealistic to review hazards in the working environment without mention being made of smoking. The World Health Organisation has recently carried out a study of this subject as part of its evaluation of carcinogenic risks of chemicals to humans. It concludes that tobacco smoke affects not only people who smoke but also people who are exposed to the combustion products of other people's tobacco. The effects produced are not necessarily the same as the constituents of smoke vary according to source. Three main sources exist:

- mainstream smoke,
- sidestream smoke,
- smoke exhaled to the general atmosphere by smokers.

Smokers are exposed to all three to a greater extent than non-smokers. Examination of the smoke from the different sources shows that all three types contain chemicals that are both carcinogenic and mutagenic. The amounts absorbed by passive smokers are, however, small, and the effects are unlikely to be detectable unless exposure is substantial and very large numbers of people are observed. Observations on non-smokers are compatible with either an increased risk from 'passive' smoking or on absence of risk. Knowledge of the nature of sidestream and mainstream smoke, of the materials absorbed during 'passive' smoking, and of the quantitative relationship between dose and effect leads to the conclusion that passive smoking gives rise to a cancer risk.

RADON

Radon is a chemically inert gas which is produced from the decay of uranium and radium (both of which occur in the soil). The short lived decay products, called radon daughters are ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po. They become attached to aerosols and if inhaled can be deposited in the respiratory system. The radiation dose caused by inhalation of radon daughters constitutes the main part of natural radiation dose to man. Levels of radon daughters in air depend on their source and on dilution factors. Reduced ventilation may cause radon to accumulate in enclosed spaces. The National Radiological Protection Board has estimated that there are some 20000 houses in the United Kingdom where radon concentrations are high enough to give a dose of 20mSv or more. In such circumstances it is recommended that remedial action is taken. Most of the houses so far identified are in Devon and Cornwall because of the nature of the local strata. More recent studies have suggested the estimate of affected premises to be on the low side.

Research in the UK has focused on dwellings because that is where the population spends the greatest part of its time. The working environment cannot, however, be ignored. There are likely to be buildings in various parts of the country where radon can accumulate because of the effects of reduced ventilation and air conditioning. In such cases remedial work may be necessary. Therefore in order to prevent radon migration it is vital to seal all routes by which gas can find its way from the ground into working spaces. Once this has been achieved further testing is necessary. The only problems are the sheer scale of the operation and the fact that, currently, financial assistance is not available.

ASBESTOS

For many years a wide range of building products containing asbestos have been used because of their thermal insulation properties and resistance to fire. They are commonly found in many commercial and industrial buildings. In the general population, the risks of mesothelioma and lung cancer attributed to asbestos, cannot be quantified reliably and are probably undetectably low. The risk of asbestosis is virtually zero. Nevertheless it is prudent to develop a programme designed to identify the presence of asbestos in buildings, assess its condition, arrange removal or treatment when necessary, and ensure that other building works do not cause fibre release.

MAN MADE MINERAL FIBRE

Following upon concerns about the possible dangers associated with asbestos fibres has come worry about other fibres. A recent study indicates that levels of man made mineral fibre in typical general and indoor environments were lower, by some orders of magnitude, than occupational exposures. The conclusion is that the possible risk for the general population is very low, and should not be a cause for concern if current low exposure continues.

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REFERENCES

1. Health and Safety at Work. Report of the Committee 1970-72 Cmnd. 5034. London HMSO 1972.
2. Fraser, D. W., Tsai, T. R., Osenstein, W., *et al.* Legionnaires' disease; description of an epidemic of pneumonia. New England Journal of Medicine 1977; 297: 187-97.
3. Committee of Inquiry. Second Report of the Committee of Inquiry into the Outbreak of Legionnaires' disease in Stafford in April 1985. Cmnd 256 London: HMSO, 1987.
4. Lawson, T., Deep cleaning of water systems. Journal of Environmental Health 1988; 96 No. 7 7-10.
5. Committee of Inquiry. Second Report of the Committee of Inquiry into the Outbreak of Legionnaires' disease in Stafford in April 1985. Cmnd 256 London: HMSO, 1987.
6. The Chartered Institute of Building Engineers. Minimising the risks of Legionnaires' disease. London Chartered Institute on building Engineers, 1987. (Technical Memorandum 13.)
7. Lawson, T., Deep cleaning of water systems. Journal of Environmental Health 1988; 96 No. 7 7-10.
8. Water Research Centre. Water Fittings and Materials Directory. Unwin Bros.
9. Chartered Institute of Building Engineers: Code of Practice: Minimising the risk of Legionnaires' disease.
10. Health and Safety Executive: Guidance Note EH 48 'Legionnaires' disease'. HMSO 1987.
11. World Health Organisation: Environmental Aspects of the Control of Legionellosis: 1986.
12. Glick, T. H., Gregg, M.B., Berman, B., *et al.* Pontiac Fever: An Epidemic of Unknown Epidemiological Origin in a Health Department. I: Clinical and Epidemiological Aspects. American Journal of Epidemiology 1978; 107: 149-160.
13. Lawson, T., Deep cleaning of water systems. Journal of Environmental Health 1988: 95 No. 7 7-10.
14. Ibid.
15. Finnegan, M. J., Pickering, C. A. Burge, P. S. The sick building syndrome: Prevalent studies. British Medical Journal 1984 289; 1573-1575.
16. Ashley, S. Sick Buildings. Building Services February 1986.
17. Ibid.
18. Quale, V. New challenges on the horizon. Journal of Environmental Health 1988. 96 No 5 9-10.
19. Hutchinson, R. D. Cable-bug phenomenon. Journal of Environmental Health 86 No. 1 11.
20. World Health Organisation: International Agency for Research on Cancer: Monograph in the Evaluation of the Carcinogenic Risks of Chemicals to Humans: Volume 38. Tobacco Smoking. 1985 WHO Switzerland.
21. World Health Organisation. International Programme on Chemical Safety. Environmental Health Criteria 25. Selected Radionuclides. 1983 WHO. Switzerland.
22. Radiological Protection Bulletin. No. 79 Februay 1987 National Radiological Protection Board.
23. Blythe, A. Private Correspondence.
24. IPCS International Programme on Chemical Safety. Environmental Health Criteria 53. Asbestos and other natural mineral fibres. WHO 1986.
25. IPCS International Programme on Chemical Safety. Environmental Health Criteria 77. Man-made mineral fibres. WHO 1988.