PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

The Philosophy of Control of Air Pollution in the United Kingdom [and Discussion]

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Phil. Trans. R. Soc. Lond. A 1979 **290**, 625-637
doi: 10.1098/rsta.1979.0018

Phil. Trans. R. Soc. Lond. A. **290**, 625–637 (1979)
Printed in Great Britain

The philosophy of control of air pollution in the United Kingdom

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The United Kingdom uses an air pollution control system based on the best practicable means (b.p.m.) philosophy. The philosophy recognizes that a degree of air pollution is inevitable in present-day industrial society, and strives to optimize this pollution so that the total interest of society is best served. Account must be taken of health and amenity effects, of the capabilities of pollution arrestment techniques, of the finances of industry and effects on employment, and of the national need for the product.

This paper describes the operation by H.M. Alkali and Clean Air Inspectorate of the four basic components of the b.p.m. philosophy: the setting of emission limits and other requirements which will give acceptable levels of ambient air pollution, prior approval of works' air pollution control equipment, continuing inspection and testing of the operation of control equipment, and prosecution of works managements where requirements are not met. It is shown that the b.p.m. philosophy compares favourably with alternative philosophies based on systems of statutory air quality standards or statutory emission standards. It is suggested that the b.p.m. philosophy can be developed and, with its involvement of workers, management, local interests and control authorities, is the system best able to meet the needs of air pollution control in the future.

1. Administration of air pollution control legislation in the U.K.

(*a*) *Emissions from general industrial operations*

Atmospheric pollution in the U.K., other than any from traffic and nuclear installations, derives historically from two categories: general industrial operations and burning of fuels. Emissions from both categories are subject to legal control. Control is vested either in H.M. Alkali and Clean Air Inspectorate, which is a central government organization, or in Local Authorities, but the split between the two is not in terms of the industrial and fuel-burning categories mentioned. The position can be understood by first considering the situation on emissions from industrial operations, where control is applied by the Alkali Inspectorate through the Alkali Act and by Local Authorities through the Public Health Acts (see appendix).

Traditionally, the Alkali Inspectorate has been responsible for administering control of emissions to atmosphere from industries with a greater potential for pollution, perhaps because the process is new and the emission arrestment problems novel, or because the potential dangers from the emissions have only recently been recognized, or because individual plants are very large and can cause large-scale pollution. The Inspectorate strives always to solve emission control problems posed by industrial processes and for this reason seeks to assume responsibility for administering control of emissions where technical problems arise, and to relinquish responsibility where problems have been overcome. A high quality of scientific knowledge is necessary for continued control. The Alkali Inspectorate deals only with a small segment of industry, and is responsible for approximately 2200 works. Administration of control of emissions to air from

the remainder of industry is the responsibility of Local Authorities; perhaps 50000 works in this category may need special attention.

(*b*) *Emissions from burning of fuels*

Controls on emissions from general industry derive from the situation which led up to the 1863 Alkali Act. Controls on emissions from the burning of fuels are more recent, and were precipitated by the famous London smog of 1952. The outcry at that time was followed by the setting up of the Beaver Committee, whose report (Committee on Air Pollution 1954) in turn led to the Clean Air Acts of 1956 and 1968. These Acts put restrictions on emissions of smoke, grit and dust from certain classes of boilers and furnaces, restrictions on the heights of chimneys against smoke, grit, dust, gases or fumes, and allowed establishment of smoke control areas. The Clean Air Acts are enforced by Local Authorities and apply only to premises which are not under the Alkali Act. Smoke, grit and dust emissions from industries already otherwise controlled by the Alkali Inspectorate were brought under the control of the Inspectorate in 1958, thus continuing the principle that either the Inspectorate or a Local Authority but not both should have responsibility for a given works location. The best practicable means (b.p.m.) approach of air pollution control has been evolved by the Alkali Inspectorate, and a similar approach has often been appropriate for Local Authorities.

2. The best practicable means approach to air pollution control

(*a*) *Basic considerations*

A report of the World Health Organization (1972) defined air pollution as 'limited to the situations in which the outdoor ambient atmosphere contains materials in concentrations which are harmful to man or his environment'. Any pollution control system must have scientific information on the effects of pollutants and their levels in the environment, and must be flexible enough to respond to emerging knowledge. Science should be concerned to bring its findings and their implications to the attention of those responsible for operation of the control system, but it is as important to know the levels of pollution that society will tolerate as to know the damage these levels will cause. Should pollution be eliminated with a probable shut down of industry, or merely abated and controlled? Society's expectation of a full life for each of its members is involved. Once basic needs for food, shelter, clothing are met, attention will turn to less pressing needs, to health care and to care for the environment and amenity. A satisfactory control system must accommodate society's expectations.

The first Alkali Act was passed in 1863 to control pollution by hydrochloric acid from the Leblanc process for sodium carbonate. Until then, the acid was emitted untreated to atmosphere. The Act required 95 % of the acid to be removed before emission of the gases to atmosphere, but it quickly became clear that the need to achieve a statutory arrestment efficiency was too rigid. Technology able to achieve lower emissions was available, yet the law did not allow these levels to be required. Hydrochloric acid discharges were limited by the 1874 Alkali Act to the more useful concentration limit of 0.2 grain/ft^3 [*ca.* 0.46 g/m^3] and the apparently innocuous requirement on alkali makers to use the best practicable means to prevent the escape of noxious gases other than hydrochloric acid was introduced. The Alkali Act was revised again in 1881, 1892 and 1906, and there have been several Orders to the Act, but no statutory limit on any emission has been added since 1881. Rather there has been an attempt to consolidate flexibility

into the system by using the requirements that industries in the ambit of the Act shall use the best practicable means firstly to minimize emissions to atmosphere, and secondly to render harmless and inoffensive those emissions which do occur. This requirement is at the heart of the b.p.m. philosophy of air pollution control. The requirement never asks more than available pollution control equipment can achieve, but can always be tightened when better equipment or techniques become available.

Industrial processes change continually as time passes, new industries appear and expand, old industries become obsolescent and vanish. Flexibility in the ease with which new industries can be controlled is necessary and comes from the practice of scheduling industries under the Alkali Act rather than revising the Act itself, because changes in the list of scheduled industries are more easily accomplished than changes in the Act.

In implementing the requirements of the Alkali Act, it is the Chief Alkali and Clean Air Inspector who determines the tolerable level of pollution, and in turn what is the best practicable means of pollutant arrestment and what levels of the pollutant shall be deemed harmless and inoffensive.

The concept of practicability is still evolving. A start to understanding the principle of b.p.m. is to be found in recent legislation related to the Alkali Act. The Control of Pollution Act 1974, on noise pollution, states that '"practicable" means reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications. The means to be employed include the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings'. The Chief Inspector's aim is to use the best practicable means available to control pollution in such a way that an optimum blend of costs and benefits of pollution abatement is obtained for society. To do this realistically, he needs to be sensitive to society's expectations, both now and in the foreseeable future, to respond to scientific findings, to base his requirements of industry on available pollution control technology and to deal with changing industrial patterns.

(*b*) *Setting targets*

The cardinal consideration is society's expectation of the degree of air pollution which is tolerable. The target is always moving towards lower levels. Public health is the most important factor, and accordingly no emission which might cause a known health hazard can be permitted. The Chief Inspector strives to keep abreast of the latest knowledge on toxicity and aims always to achieve atmospheric concentrations which allow a wide safety margin. After health is guarded, attention must be given to amenity and aesthetic effects, and here additional complications arise in setting targets because not only will the criterion change with time, it will also vary around the country and from pollutant to pollutant. People in established industrial towns and cities are frequently more tolerant of pollution than those living in commercial or residential areas. Shall there be no damage to buildings, no smell, no visible or coloured emissions, shall grazing animals not suffer from eating polluted vegetation, etc.? Decisions here also are difficult because the relation between the costs of pollution abatement and its benefits cannot easily be established. What basis is to be used to decide whether the clouds of iron oxide fume emitted by steelworks are acceptable, or whether increasing sums of money should be spent in abatement? There is a risk that decisions may become subjective.

Recalling the definition of the word 'practicable', every decision by the Chief Inspector on

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pollution control requirements has to take into account the state of the work, the finances of the industry, the morale of the operatives and any likely effect on their employment, the national need for the product and the amenity of the public. A balance needs to be struck and pollution optimized so that the total interest of society is best served (Ashby 1975).

Chief Inspectors over the years have attempted to develop a system which enables the various interests to contribute to the setting of pollution control requirements. Cooperation is sought with all parties. To help maintain contact with the views of the public, Alkali Inspectors foster close relationships with Local Authority staff, take a leading rôle in local works liaison committees – whose other members are drawn from the public, from works managements and from Local Authority officials – cooperate with members of the public when complaints are made of pollution, and meet workers during routine factory visits. Equally, close collaboration is maintained with industry to find economically acceptable solutions to problems of pollutant arrestment. Working groups are set up between the Inspectorate and industry, with the latter carrying out any research and development and meeting the costs. Outside specialist bodies may be consulted, and Inspectors often travel abroad, sometimes with industry representatives, to assess foreign technology. Developments in the scientific world are always under review. Close contact between industry and the Inspectorate ensures uniformity of control demands across industry, and, most importantly for the system, ensures that the Inspectorate itself remains in touch with the latest technical developments. This involvement of the public, industry and others is a valuable feature of the b.p.m. approach because all parties then know acceptable requirements have been set and so become committed to the outcome. The Chief Inspector, however, remains responsible, and makes the final decision on all requirements. The requirements for each industry scheduled under the Alkali Act are published and easily available to interested parties.

(*c*) *Presumptive Limits*

It will be recalled that no further statutory limit on an emission has been added to the Alkali Act since 1881, yet today 60 industries with many potential pollutants are controlled. To guide works managements in the design and running of plant and to assist Inspectors in the execution of their duties, Chief Inspectors have set their own standards of emission for many of the scheduled industries. These standards represent the result which may reasonably be expected if the requirements of b.p.m. are applied satisfactorily, and are known as Presumptive Limits. Presumptive Limits have the force of law, because works which fail to meet them are presumed not to be using b.p.m. and may be prosecuted accordingly. The system is strong because Presumptive Limits can be changed easily by the Chief Inspector to meet changing pollution control needs. Presumptive Limits are uniform within an industry across the country, but can be varied to meet particular circumstances at individual works. There are scheduled works, such as coke ovens, where standards of emission cannot be set, and in these cases codes of practice may be written to help those concerned with atmospheric pollution control.

(*d*) *Prior approval*

The inspectorate maintains close contact with each industry in the broad, nationwide sense, and also seeks close involvement with developments in the individual works of each industry. This reflects the stipulation under the Alkali Act that works must obtain from the Inspectorate prior approval of the air pollution control plant before production may legally begin. Inspectors, engineers and designers cooperate fully throughout plant design and installation, and

aim to develop mutual understanding of the required emission standards and of suitable means to achieve these. The Alkali Act requirement to minimize emissions is met by installation of the best practicable arrestment plant, while the requirement to render harmless and inoffensive those emissions which do occur is generally met by atmospheric dispersion from stacks sufficiently high to keep derived ground level concentrations of the critical pollutant within safe limits. The Inspectorate keeps dispersion theory and practice under scrutiny, and is alert to the possibility that pollutants for which self-purification mechanisms do not exist may cause build-up effects in the environment. Acceptable arrestment plant and, when appropriate, a stack of suitable height are integral parts of b.p.m. demands on works managements. Involvement of the Inspector from the design stage allows prior approval of the plant to be given. Inspectors do not define the precise type of plant to be used, but rather the performance to be achieved. Critics comment that this involvement with industry handicaps the Inspectorate should the plant not meet expectations, but the Inspectorate does not accept this criticism, because it is confident that plants approved are the best practicable and that if problems appear in operation every effort will be made by the company concerned to overcome them. The Inspectorate will promote and cooperate in all these efforts, but, of course, during difficulties of this kind, would never allow emissions hazardous to health to continue.

Works must also obtain from the Inspectorate approval of plant maintenance and supervision procedures, and by this means b.p.m. requirements also cover the training of operators, keeping of plant spares and standby equipment, good housekeeping, materials handling, etc.

(*e*) *Enforcement*

The close cooperation between the Inspectorate and industry in the prior-approval process has produced trust and understanding. Industry discusses its problems frankly during meetings, and in general attempts to meet its obligations towards the environment. However, the Inspectorate knows that the b.p.m. approach must be stiffened by legal sanctions against erring works. The Inspectorate is entitled to pay as many visits, unannounced, to works as may be necessary to make observations, carry out inspections and test emissions to confirm that requirements are being met. The Inspectorate frequently requires works themselves to monitor emissions to atmosphere and to record the results for examination by Inspectors on routine visits. As a general requirement, works must advise the local Inspector immediately pollutant arrestment problems arise, when production may be allowed to go ahead under conditions acceptable to the Inspector. Works which break the law are liable to be prosecuted, and Inspectors do not shrink from prosecuting when they feel it is deserved by, for instance, frequent offence, obstructionist tactics or flagrant disobedience. It is not the policy of the Inspectorate to prosecute merely because an offence has been committed by breakdown of equipment or because something has gone wrong, unless it is due to repeated carelessness, lack of maintenance or slack supervision. It is far more important to find permanent solutions to prevent a recurrence. Prosecution will not solve technical problems. The Inspectorate believes that involving industry in the problem-solving process gives the best and speediest results.

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3. Alternative air pollution control philosophies

(a) *Air quality standards*

For most of the period from 1863 to the present the U.K. was free to use whichever air pollution control philosophy it chose. Now, however, the U.K. must expect increasing pressure to conform to air pollution control philosophies in use elsewhere, and it is in the interest of all that the best system be chosen. Alternative systems must be examined. Modern air pollution control philosophies are often based either on a system of air quality standards or on a system of emission standards (de Nevers 1977) and both are frequently applied, outside the U.K., on a statutory basis. The air quality standards approach has the seemingly logical premise that acceptable levels of pollution can be defined and steps then taken to ensure that actual pollution never rises above these levels, but in practice there are many difficulties (Scorer 1973). The acceptable level for each pollutant has to be established, on bases which are likely to vary from pollutant to pollutant as the critical exposed species (child or aged person, human or animal or plant, etc.) varies, as the critical mode of action (short- or long-term exposure, accumulation, etc.) varies, as the presence of synergistic effects from other pollutants varies, and so on. Precisely because the system is statutory, any standard proposed must cover each of these factors and will be complicated. The complication is likely to be such that legal enforceability must be open to doubt, but, disregarding this, there are further problems. Any law can only be enforced when information on how well the requirements are being met is available. An air-quality-standards law demands an efficient monitoring system to determine pollutant concentrations in the ambient atmosphere, and the technical and economic problems in setting up such a system are immense. In turn, if such a system could be established and then did show that the required standards were not being met, further difficulties would follow, because the statistical nature of atmosphere dispersion and practical monitoring techniques is such that it would be impossible to assign responsibility to any specific works. The probable action would be a demand that all sources decrease their emissions by a specified amount, but this is extremely inefficient because there is no good way of selecting the works which must act. Are only 'nearby' works involved, or only those 'upwind'? The method will allow little suitable action against individual sources which are emitting excessive pollution and will disregard the economic and political considerations at the various works affected by the restriction. The system seems unnecessarily complicated and impracticable.

(b) *Emission standards*

Problems arise with the air-quality-standards approach because it attempts to base action directly on events in the atmosphere at large. Pollution can only be controlled by restricting emissions to air, and so a system of emission standards must be considered. Emission standards set limits to emissions of specified pollutants from particular processes. On occasion, standards which have not related to the performance of existing pollutant arrestment plant have been set, sometimes unintentionally but at other times in reflexion of a conscious policy of establishing ambitious targets to encourage satisfactory arrestment plant to be evolved and installed. Frequently this plant has not appeared, the law in general and pollution control in particular have been brought into disrepute, and pollution has continued unabated. Many types of emission cannot be quantified and so cannot be controlled by a system of emission standards.

It will be recalled that in the early years of the Alkali Inspectorate, air pollution control

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suffered because the rigid demand for arrestment of 95 % of the hydrochloric acid rapidly became a licence for plants to pollute up to this level although equipment able to achieve better levels was available. Systems which operate statutory limits generally risk granting licences to pollute. This remains true today of statutory air quality or emission control systems.

(*c*) *Relation of the b.p.m. approach to the air quality and emission standards approaches*

The various criticisms above of the so-called air-quality standards and emission control standards approaches are over-simplified, but they highlight real difficultes which any satisfactory air-pollution control system must overcome. The air-quality standards and the emission control standards approaches each describe only aspects of air pollution control. A truly satisfactory system must seek to combine the strengths of both, while avoiding the failings.

The objections to a statutory emission control system concern primarily the inflexibility imposed by the statutory nature of the system and the theory that over-tight requirements will be met by the appearance of more efficient plant. The b.p.m. approach works through emission control but avoids rigidity and overambition in the arrestment standards required. Again, the Chief Alkali Inspector, when he takes note of the best scientific opinion on toxicity, etc., and tempers this with what he learns in feedback from the public, industry and his various other sources of advice in deciding tolerable atmospheric pollution levels, is actually operating an air-quality system which avoids the rigidity of statutory standards. The b.p.m. system does not propose immediate enforcement action if the levels of pollutants in the ambient atmosphere exceed specified limits, and thereby does not become caught in the self-defeating events which follow such action. In the b.p.m. approach, realistic emission standards are linked to amply sufficient air quality requirements by means of sufficient stack dilution of pollutants. The b.p.m. approach does combine the strengths of the emission control and air quality control systems while avoiding the failings, and yet has additional strengths in the need for prior approval of plant, approval of maintenance and supervision procedures, training of operators, etc.

4. Implications of long-range transport of pollutants for b.p.m.

The recent findings (O.E.C.D. Programme 1977) on long-range transport of sulphur dioxide from Europe to Scandinavia may seem to call in question the b.p.m. approach because of its dependence on atmospheric dilution, but this is to overlook the fact that the approach seeks always to optimize pollution. Since the time of the 1956 Clean Air Act approximately, the pattern of domestic heating in the U.K. has shifted from open fires to indirect methods which very often have been electrically powered. The shift has lowered ambient sulphur dioxide levels in the U.K.'s urban areas and has led to improved health for the population, yet the total sulphur dioxide from the burning of fuel in the U.K. has changed little. Estimates based on the O.E.C.D. study suggest that the change from open fires to central power-stations is equivalent to an increase of 1–2 % in the sulphur dioxide received in Scandinavia. Methods for lowering the sulphur dioxide content in power station exhaust gases are available but expensive, and often involve secondary problems such as the disposal of calcium sulphate. To date, the optimum cost effective application of the b.p.m. approach in the U.K. interest has been dispersal of sulphur dioxide untreated in the atmosphere. The b.p.m. approach will not have been negated if this ceases to be acceptable. There will simply have been a shift in the optimum, and b.p.m. then perhaps will entail desulphurization.

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5. Uniformity in presumptive limits

Before leaving the more technical aspects of how the b.p.m. approach may be expected to meet the demands of the future, it is worth noting that there will be bounds to the size of the area over which uniformity in presumptive emission limits is possible. Presumptive limits are part of the equilibrium between the performance which arrestment equipment can reasonably attain, the atmospheric dispersion which a stack policy can achieve, and the air-quality target which must be met. Considering the wider area of the E.E.C. only, it is probable that the countries involved could agree a set of uniform air-quality targets for the important pollutants, but uniformity in pollutant arrestment, given the varying wealth of the countries, and in dispersion performance, given the climatic variations of the countries, would be difficult to achieve. Again, of course, failure to establish uniform presumptive limits across an area as large as the E.E.C. is not a negation of the b.p.m. approach, since there is no technical reason why a regional b.p.m. approach, with regions each operating a separate set of presumptive limits, could not be devised.

6. Widening the decision process in U.K. air pollution control

There is no doubt that the b.p.m. approach can arrive at the optimum solution that air pollution control requires. This is not to say that air pollution control in the U.K. does not merit criticism or that it cannot be improved, only that on examination the criticisms are not of the approach itself but of the way it is implemented. For example, outcries occasionally occur about emissions from specific works, and the claim is made that the air pollution control system has failed. Certainly this will seem so to the housewife whose washing is soiled by black particulates. Here there might have been failure by the Alkali Inspectorate correctly to assess the tolerable pollution level, or failure in the information system through which the Inspectorate assessed the tolerable pollution level initially. Again, the local employment situation or the wider national need might justify the existence of the offending works and so on. However, none of these explanations would point to failure of the b.p.m. philosophy itself.

Improvements must continually be sought in air pollution control, but it seems unlikely these will be through a philosophy other than best practicable means. They are more likely to be an evolution of the b.p.m. approach, and in the mechanics of how it operates. There is a need for greater appreciation by the public of the types of input – scientific, economic, etc. – to b.p.m., and for greater confidence by the public in the control authority's ability to weigh these inputs satisfactorily. The decisions required in air pollution control cannot avoid being political, in the non-party sense, and it may be that the public's confidence will only increase as its political involvement increases.

The public must be involved in such a way that a positive gain results. The Control of Pollution Act 1974 gives Local Authorities the right to acquire and publish information on works' emissions to air, and this is certainly to the good. Beyond this, however, the prospects are unclear. Decisions by the Government on the recommendations (Royal Commission on Environmental Pollution 1976) in the Fifth Report of the Royal Commission on Environmental Pollution are awaited. The recommendations are many: that b.p.m. should be defined precisely for individual works, that air-quality guidelines should be explicitly formulated and publicly declared, that works' plans for improved pollution control systems should be published and

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publicly justified, that the control authority should develop expertise in economics, etc. Many of these suggestions are clearly valuable, but it would be wrong to comment specifically in this paper. It is pertinent, however, to remind all that the need is to introduce a format for beneficial consultation without defeating the purpose by clogging the system, and that the Alkali Inspectorate already has long sought means, for instance through Local Liaison Committees, etc., effectively to involve the public in the air pollution control process.

7. Appendix. Air pollution control legislation in the United Kingdom

1. Legislation enforced by H.M. Alkali and Clean Air Inspectorate:

The Alkali Etc. Works Regulation Act 1906.
The Alkali Etc. Works Orders 1966 and 1971.
The Health and Safety at Work Etc. Act 1974.

2. Legislation enforced by Local Authorities:

The Public Health Acts 1936 and 1961.
The Public Health (Recurring Nuisances) Act 1969.
The Clean Air Acts 1956 and 1968.
The Control of Pollution Act 1974.

3. H.M. Alkali and Clean Air Inspectorate became part of the Health and Safety Executive in 1975. The Executive contains bodies such as H.M. Factory Inspectorate, H.M. Mines and Quarries Inspectorate and H.M. Nuclear Installations Inspectorate, and is charged with protecting persons throughout the U.K. against hazards from work activities. The intention is that the Alkali Etc. Works Regulation Act 1906 and the 1966 and 1971 Orders will be subsumed by the Health and Safety at Work Etc. Act 1974. Section 5 of the 1974 Act replaces the main provisions of the Alkali Act and contains the philosophy of b.p.m. The section will be enforced by the Alkali Inspectorate. Section 3 of the 1974 Act is a general section dealing with the effect of work activities on the public so far as health and safety are concerned and includes air pollution from processes not scheduled under the Alkali Act. The section is enforced by the Factory Inspectorate.

4. H.M. Alkali and Clean Air Inspectorate operates only in England and Wales. Equivalent controls are operated by H.M. Industrial Pollution Inspectorate for Scotland, and by the Alkali and Radiochemical Inspectorate for Northern Ireland. These Inspectorates each use the b.p.m. philosophy.

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Discussion

W. J. Megaw (*Department of Physics, York University, 4700 Keele Street, Downsview, Ontario M3J 1P3, Canada*). While Mr Ireland and Dr Bryce have demonstrated that the 'best practicable means' approach is an effective method of emission control, I would suggest that this only addresses half the problem for it makes no attempt to prevent or control the potentially disastrous short-term air pollution episode which depends not only on the sources, but also on weather and local geography. I am not a Canadian so perhaps I may be forgiven for boasting a little about the air pollution control system operated by the Ministry of the Environment in Ontario which I believe to be one of the most effective in existence. The Ministry operates the 'best practicable means' of control of emissions both in regard to existing and proposed factories but, in addition, the 'Air Pollution Index' (a function of the sulphur dioxide and particulate content of the atmosphere) (see *Ontario's Air Pollution Index* (1977), Toronto: Ministry of the Environment) is measured continually at a large number of places in Ontario. Values of below 32 are considered acceptable but when a value of 32, combined with an unfavourable weather forecast for the next 6 h, is reached, the Minister warns specified industrial concerns that they may be required to close, further factories are closed down at an A.P.I. of 75 and at a value of 100 all sources not essential to public health and safety are required to shut down. In practical terms it is expected that people with chronic respiratory disease may experience accentuation of symptoms in SO_2 concentrations of 0.21 parts/10^6 combined with particulate concentrations of 300 $\mu g/m^3$ (Lawther, P. J. 1958 *Proc. R. Soc. Med.* **51**, 262–264) and at this level the Ontario A.P.I. would be 58. At an A.P.I. of 100 it is expected that mild effects would be experienced by healthy people and that those with severe cardiac or respiratory disease would be seriously endangered. Had the Ontario A.P.I. been measured during the London smog of 1962 (which caused a 20 % increase in mortality) its value would have been 586.

The effectiveness of the 'best practicable means' method of emission control has been demonstrated in Ontario by the progressive annual reduction in areas exposed to specified mean annual concentrations of sulphur dioxide. The episode prevention system also works. The number of times per year in which the A.P.I. in Toronto exceeds the value 32 is generally between 0 and 3. I can remember only one occasion in the last five years on which the value 50 was exceeded and some factories were shut down. The Ontario system thus prevents the build-up of the short-term episode and I should like to ask Dr Bryce whether he does not consider that such a system would be of advantage in the United Kingdom?

D. J. Bryce. The b.p.m. approach is such that an attempt is made, when setting the presumptive emission limits for different industries, to ensure that the emissions are set at a level which makes it unlikely that pollutant concentrations in the atmosphere will ever build up to the levels needed for an episode to occur. However, industry can only reasonably be asked to meet emission requirements which will be satisfactory in weather conditions which are likely to arise. Clearly, abnormal weather conditions over large industrial areas may call for special emergency arrangements, but this is within the spirit of the b.p.m. approach. A system does exist to deal with pollution episodes in the U.K.

F. E. Ireland. Many years ago an interdepartmental working party was set up to decide on a plan of campaign in case of another serious High Pollution Episode. The working party considered what could be done in advance to reduce the risk and also what procedure should

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be adopted if and when an Episode occurred. Expert opinion was that more people were at risk today because medical science kept seriously ill people alive who in the past would have died. These people needed only an extra stress to push them over the brink and among these stresses could be abnormal pollution. Further, weather conditions had not changed significantly since the 1952 and 1962 Episodes and the same conditions could recur, although the results would not be expected to be so dramatic as in the past because of the reduction of pollution. Briefly, a careful watch is kept by the Meteorological Office on weather forecasts to identify critical conditions. The continuous pollutant monitoring instruments operated by Warren Spring Laboratory and the Medical Research Council are watched for significant rises of sulphur dioxide and suspended particulates. When a High Pollution Episode is suspected, extra monitors are brought into play and certain Departments and individuals are alerted to watch the situation. If it looks like becoming serious, the public, especially those predisposed to bronchial trouble, are given advice through the media. If an advanced stage were reached, by consultation some industries would be asked to moderate their production programmes. The situation would be treated in a flexible manner by discussion between the small team of experts involved.

B. Page (*Science Division, Polytechnic of Central London, 115 New Cavendish Street, London, W. 1, U.K.*). Although the Alkali Inspectorate is responsible for the industries thought to constitute a great pollution risk, the majority of industrial premises in the U.K. are unregistered. I became aware of this problem when I was recently involved in a survey which revealed air levels of up to 11 μg cadmium/m^3 air outside a London factory. Cadmium levels of up to 387 parts/10^6 were found in household dust from nearby flats. The pollution had apparently been occurring for the last five years, and had the survey not been carried out, it would presumably still be occurring now.

Many small firms, such as scrap metal companies, may be reticent about bearing the cost of expensive equipment to contain invisible pollutants. The local authority officers have no legal standards against which to compare the potential danger of the pollution, and may be hampered in their action. At what level in the environment does cadmium, for example, constitute a health hazard on which they should act?

Perhaps more important is the question of how such incidents of pollution can be discovered in the first place. Pollutants are so diverse, and sampling techniques so difficult and therefore expensive, that local authorities do not have the facilities to monitor emissions from the tens, possibly hundreds of thousands of unregistered premises they are mandated to control. Such unregistered premises may be situated in the heart of residential areas. Pollution is discovered when:

(1) A survey for the correct pollutant in the correct locality is undertaken. A simultaneous survey for lead in the area polluted by cadmium described above indicated that pollution levels were not abnormally high for such an urban area.

(2) The pollution reaches a sufficiently high level for it to become noticeable to local people. Noise attracts many complaints, and levels are often rigorously enforced. Unfortunately, even the high levels of the toxic metal cadmium remained invisible to the local community and factory workers throughout the 5-year period of pollution. Since cadmium has a biological half-life of up to 30 years, cessation of production does not immediately eliminate their problem.

The chances of early discovery of toxic pollutants from Britain's unregistered industries are

not good. In the absence of a coordinated monitoring system, how can the authorities be confident of meeting the needs of air pollution control? I feel it is imperative that the question of pollution control from unregistered premises should be considered, for failure to recognize the problems precludes the search for an answer. How can pollution from Britain's unregistered premises be controlled?

F. E. IRELAND. We identify four questions from Mr Page, three of which, dealing with discovery of pollution incidents, monitoring and the control of air pollution, are interrelated.

The first question concerns levels of cadmium in the environment which constitute a health hazard. This should properly be addressed to the medical authorities. Nevertheless it can be said that no simple answer is possible since the particular sector of the environment, the route of exposure and the exposed population group will all influence the conclusion. However, in general, as far as human health is concerned, what matters is the *total* absorption of cadmium from all sources. For most people, food is the most important source and cigarette-smoking can be equally important. Respiration of airborne cadmium normally plays a very minor rôle in exposure. An expert working group convened by the E.E.C. has concluded that *continuous* exposure to a concentration of 2 $\mu g/m^3$ of cadmium in air might be expected to lead to kidney damage after 70 years exposure, 24 h a day. Long-term average values in the U.K. are normally less than one hundredth of this.

As far as cadmium in dust is concerned, no data are available on which to set hazardous levels. The group most likely to be at risk is very young children who might suck contaminated fingers or toys; clearly the degree of hazard will be a function of the individual child's behaviour. We know of no evidence of either acute or chronic health effects from this source of exposure.

To turn now to the other three questions, perhaps we can best illustrate how liaison between local authorities and the Alkali and Clean Air Inspectorate is helpful by referring to the 'incident' with which Mr Page was concerned. A programme of monitoring by the local authority indicated an undesirable degree of contamination by cadmium in a certain area, though its source was not unequivocally identified. The local authority consulted the Inspectorate who gave advice on the need for abatement equipment on the unregistered process operated at a nearby non-ferrous metal works and on the need for improvements in general housekeeping. Action was taken by the company to reduce emissions and to improve housekeeping.

This is clearly a perfectly proper way for matters to be handled when the local authority is responsible for control; the Alkali Inspectorate is always ready to help. In certain circumstances it has become apparent in the past that particular types of works caused an unacceptable degree of contamination and that local authorities have not had the necessary technical expertise to develop solutions. The Alkali Inspectorate has then assumed responsibility by scheduling the class of works under the Alkali, etc., Works Regulation Act 1906; an example here is mineral works where dust emissions were unacceptable.

The value of the liaison between local authorities and the Alkali Inspectorate was recognized in the Fifth Report of the Royal Commission on Environmental Pollution. Indeed, the Royal Commission considered that the present division of responsibilities should continue, with greater powers being afforded to the local authorities and more flexible arrangements for the transfer of control between central and local authorities. The Commission also proposed that local authorities should adopt a system of control by 'best practicable means', seeking guidance from the Alkali Inspectorate.

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Finally, a word on monitoring. Monitoring surveys are carried out for a variety of reasons including, *inter alia*, prospective assessments of what is present and in what concentrations, specific checks on emissions from works and assessments of the efficiency of abatement equipment. Some major cities have carried out extensive programmes and a 'national network' of 20 sites is being operated by the Warren Spring Laboratory for a range of trace elements, in addition to the national survey of smoke and SO_2. Levels in country areas are also being assessed. But it remains a fact that most monitoring has been and will probably continue to be carried out specifically to look for certain substances which are expected, on the basis of local industry, to be present. This seems entirely sensible; it would be a waste of resources to monitor all parts of the country for a wide range of substances as a means of identifying sources of pollutants; it is far better in general to concentrate resources on dealing with areas expected or known to be contaminated. A comprehensive report on the present arrangements for monitoring our environment, *The monitoring of the environment in the United Kingdom*, Pollution Paper No. 1, has been prepared by the Department of the Environment and is available from Her Majesty's Stationery Office.

There are a few general points that I should like to make:

1. We can estimate that industry registered under the Alkali Act for England and Wales spends something of the order of £200M to £300M per year to meet the Inspectorate's requirements on air pollution control. We can guess that the remainder of industry probably spends a similar sum, giving a total for England and Wales of about £500M per year.

2. The Inspectorate has long appreciated the inadequacies and cost of spot-sampling of chimney emissions, especially for particulate matter. During the last decade it has sought to encourage the development of continuous monitoring instruments and has given research contracts to suitable organizations. Only by the use of continuous monitors can emissions be properly controlled by the owner.

3. The philosophy of the Alkali Inspectorate is to make industrial emissions to air safer than safe. Is 'best practicable means' good enough to achieve this end? I believe it is, and can exemplify this by our attitude towards airborne radioactive emissions, where we act as agents of the Secretary of State for the Environment under the Radioactive Substances Act 1960.

The International Commission on Radiological Protection has made recommendations on the doses of radioactivity to which the public can be exposed. From these can be calculated Derived Working Limits (d.w.l.) for individual factories. When 'best practicable means' are applied the actual working level of emission which is achieved is usually of the order of 1 % of the d.w.l. When incidents occur which raise the emission of radioactivity to 5–10 % of the d.w.l., the Inspectorate carries out an investigation to assess what caused the increase, with a view to preventing a recurrence. The same philosophy and policy is applied to works registered under the Alkali Act.

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