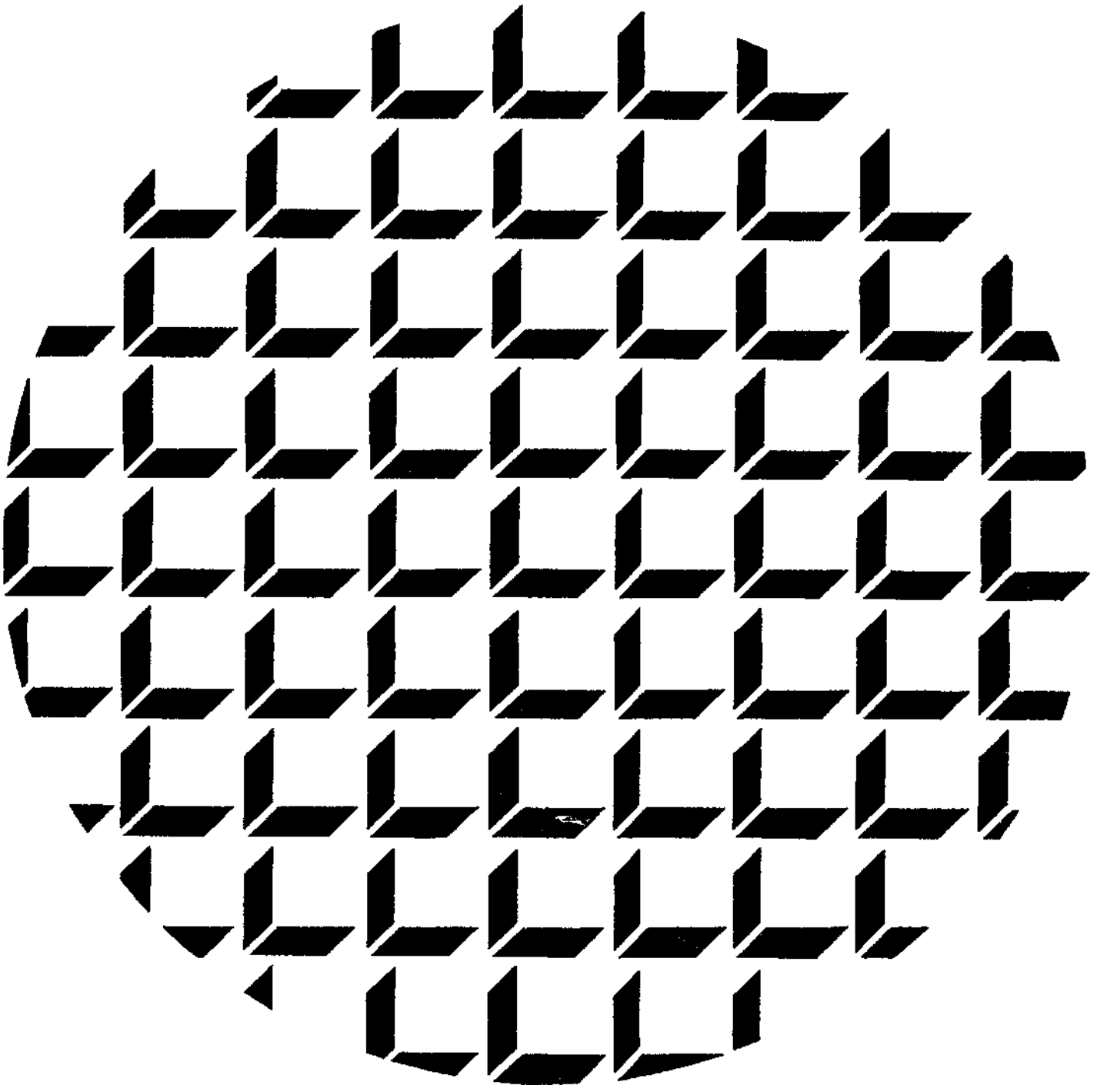
Volume 26, No.3, August, 1992.

Print Post No. PP 38166 71 00037

CLEAN AIR



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SUBSCRIPTIONS
Annual Subscription rates (Inc. postage) for non members and libraries

Australia and New Zealand $A35.00

Elsewhere $A39.00
Single copies $A10.00
Enquiries about subscriptions, payment of invoices and requests for back numbers should be directed to the Circulation Manager

Publication is quarterly in February, May, August and November.
CLEAN AIR is listed in *Current Contents*

CONTENTS

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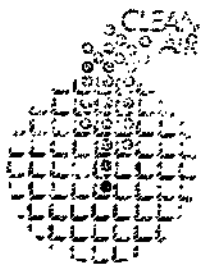

GUEST EDITORIAL

INTRACTABLE WASTE DISPOSAL

Dr Ben Sellinger is Chair, Independent Panel on Intractable Waste, Juniper Hall, 248-250 Oxford Street, Paddington, NSW 2021.

The issue of intractable waste disposal generates strong views: some argue that it is a city not a country problem: others that it is an industry not a consumer responsibility. In reality, of course, the issue affects the whole community and requires the broadest acceptance of responsibility. There remains a clear need, however, to build community understanding and acceptance to a point where an effective resolution is possible.

Media and public attention must continue to be directed to the nature and extent of the problem - especially to findings such as those of the Snowy Mountains Engineering Corporation which has sampled the disposition and quantity of intractable waste in the community.

It is critical that the issue be kept alive. Interested parties must continue to be involved in social and technical argument, to debate each other and to have dialogue with the Independent Panel on Intractable Waste. The alternatives to third party resolution of the matter seem likely to be no resolution at all or an imposed political solution.

In addition and further to its terms of reference, the Independent Panel wants to ensure that, when a resolution is forged, its potential to be implemented is maximised.

The key elements of the intractable waste issue are:

- It is a serious environmental threat
- By the time the threat is tangible, it may be too late to fix it
- The goal is to resolve this matter for all time
- Public consent is required to reach an effective resolution

The Independent Panel has established these objectives for community consultation:

- To ensure that Independent Panel members are appraised of the range and intensity of community opinion on the intractable waste issue and options for its resolution
- To provide organisations, interest groups and individuals with the opportunity to inform members on technical, environmental and all other relevant matters
- To use the consultative process as a means for further informing and educating the community about the intractable waste issue and options for its resolution
- To derive from the consultative process a general view of how best the intractable waste issue may be resolved in a way that is broadly acceptable to the community.

The community in this context refers to government, industry, research and scientific bodies, representative or sectional organisations, and individual citizens.

The Independent Panel's community consultation policy is based on the logic of its overall strategic approach in coming to grips with an issue which has so far defied successful resolution in Australia.

The strategic approach is straightforward: first to define the nature and extent of the intractable waste problem: secondly to examine and test alternative solutions: finally to propose a resolution.

Throughout this process, the Independent Panel is encouraging submissions representations and dialogue with interested parties.

In order to harness the required knowledge and opinion, the Independent Panel adopted a three-step approach involving:-

- The identification of key interest groups and interested citizens and the initiation of dialogue with them, augmented by opinion polling to determine overall community understanding and attitudes.
- Following the publication of the community consultation paper, a second round of meetings with selected groups which need to be party to a satisfactory resolution of the issue.
- A third step in which the Independent Panel will introduce and negotiate the proposed resolution before finalising its Report to the Commonwealth, NSW and Victorian Governments.

It should be added that this process is pragmatic, flexible and iteractive rather than preordained and highly structured. It seems a successful outcome will require the capacity to manage the ambiguity of the issue, not to engineer a predetermined solution.

The need to manage ambiguity derives from the contrasting positions held on the intractable waste issue. There are serious divisions and contradictions within the bureaucratic, commercial, environment and broader communities about the nature of its resolution.

One reason for this is that the issue exists in two forms in the community: the first physical, posed by the properties of the waste itself, its impact on the

environment and the means of disposal: the second ultimately political, flowing from disagreement about how the solution to the problem should be processed and implemented.

The Independent Panel first publicly articulated its processes at the time of the release of its Terms of Reference in September 1991. It was announced then that the process would initially operate at three levels:-

- Consultation with key interest groups
- Consultation with interested citizens
- Exploration of general attitudes and understandings through community opinion polling.

Just as the intractable waste issue is in fact a complex group of issues, the evidence to hand indicates that it is necessary to look to a range of solutions rather than seeking one simple answer.

It has been said that war is too important to be left to the generals. The Independent Panel believes that the range of issues concerning intractable and non-BAT waste are too important to be left to politicians or experts to solve.

Nor should the resolution of the intractable waste issue be seen as a matter of 'who wins' in terms of the protagonists of various options for waste disposal or waste management.

The immediate benefit of community consultation has been that it has illustrated that there are a number of issues, many points of view, a number of fixed positions and no current scenario for resolution.

There are strong indications that the ultimate mix of solutions will be characterised by:-

- Different solutions for different waste streams
- More active encouragement for the development of alternative technologies
- A clear plan for more imaginative and comprehensive waste management
- A shared understanding of the dimensions of the problem and a social and political environment which encourages industry, the community and government to collaborate in finding the implementing solutions.

A special newsletter published early July 1992. canvassed options in greater details initiated the first tentative steps towards defining a resolution.

INDUSTRY PERSPECTIVE

"A Manufacturing Industry Perspective on Environmental Policies" by Anita Roper, Representing Australian Chamber of Manufactures. Clean Air May 1992. Volume 26 2 pages 62-64.

I feel that I must respond to the comments expressed by Anita Roper on behalf of the Australian Chamber of Manufactures in her recent perspective paper published in Clean Air. May 1992. Roper would seem to be implying that the Air Quality Review undertaken by myself on behalf of the Environment Protection Authority, Victoria, demonstrates a "very cavalier attitude towards provision of scientific evidence of the need for any change in air quality objectives", and goes on to imply that the review amounted to "an arbitrary re-setting of environmental objectives, with neither scientific, medical or economic arguments offered".

If this were true, I would agree with Roper's further comment that "this is no way to achieve a balance of views". However the reality is far removed from this scenario, and whilst it is agreed that my brief from EPA specifically excluded consideration of the economic implications of the recommendations that I have made, I would like to reassure both Roper, as well as your readership in general, that a very extensive and full review of world literature, such as it was up until mid-1990, was undertaken. Furthermore, the various draft sections of the review were forwarded to various independent scientific reviewers for comment, and the final report was reviewed in detail by a number of independent consultants both here in Australia and even more particularly overseas. The overseas reviewers included Dr. David Bates of Vancouver, Dr. Jonathan Samet of New Mexico, Dr. Dean Shepherd of San Francisco, Dr. John Spengler of Boston, and more latterly, Professor Peter Barnes of London. All have responded in a very positive and supportive manner, and have been most helpful in providing further additional research information which is now only just starting to appear in the medical literature, and which entirely supports the general tenor of recommendations made in my report as published in September 1990. Of local reviewers, Dr. Michael Abramson submitted an editorial leader in the Medical Journal of Australia (Med. J. Aust., 1991, 154, 716-717) and other workers in Australia have also concurred with his comments.

Furthermore, a number of the aspects of the report, in particular recommendations relating to pollutants which derive from motor vehicle emissions were discussed at some length at a recent World Health Organisation working party held in Sydney in April 1992. Not only were the health effects as detailed in my report confirmed by some of the leading air pollution authorities in the world, but there was seen to be evidence coming to hand which might suggest a need for consideration for a proposition to further tighten some pollutant guidelines over and above my recommendations of September 1990. In particular, nitric oxide is now the centre of very intensive assessment from a number of different biological aspects, and should be kept under close observation in view of its demonstrated cytotoxic effects, and ability to lead to the production of oxygen free radicles in certain vulnerable lung tissues such as pulmonary capillary endothelium.

I would therefore like to conclude by saying that I believe that Anita Roper's comments are ill advised and misguided. I know nothing of the composition of the medical advisory panel to the Australian Chamber of Manufactures, however I would strongly urge that organisation to reconsider the current health effects situation in the light of published material.

Thank you for your consideration of this letter for publication in "Clean Air".

Yours sincerely,
J.A. Streeton

Dear Sir,

The article by Anita Roper of the Chamber of Manufactures in the May 1992 issue of Clean Air was a very disappointing one.

Its unexpectedly negative attitude appears to be at variance with the strongly expressed views on environmental responsibility by industry leaders. More importantly it ignores the enormous progress made by many sectors of industry in finding innovative ways of meeting that responsibility without undue cost penalty. This is a great pity because, as has been recognised through our domestic ESD process and through the Earth Summit at Rio, the answers to our environmental and our economic problems are intertwined. The Cleaner Production Conference held in Melbourne earlier this year carried the same message and many delegates from around the world demonstrated that a win win outcome was frequently possible.

Of equal concern is the section on the review process for the State Environment Protection Policy (The Air Environment). Many of your readers may have been confused or even misled by this. The 'Streeton Report' (which was the first stage of the process) was a review of the Victorian ambient air quality objectives in the context of the scientific research that had taken place in the decade since the objectives were established. Far from taking a 'cavalier' attitude to the science, the report is about the science. It has received favourable comment from leading researchers in the field both here and overseas.

The second stage of the process consisted of a series of discussion papers on particular objectives. These are public policy papers produced to stimulate discussion on the issues. ACM appears to be unaware of the difference between a science base for public policy and public policy itself which requires consideration of a much broader range of factors. Prominent among the issues canvassed in the discus-

Continued page 90

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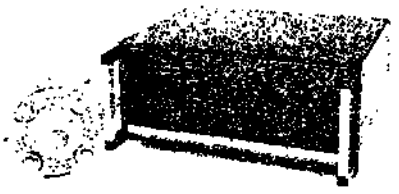

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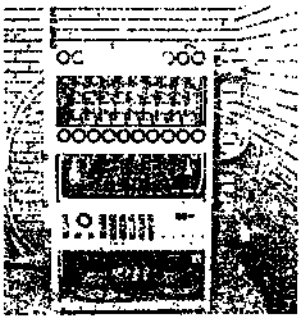

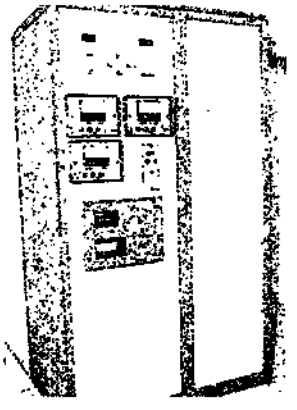

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sion papers are the economic aspects. As has been pointed out at the seminar on Class 1 Indicators, in the Summary Report on the seminar, and at the Workshop on Setting an Oxidant Objective, a rigorous assessment of costs and benefits has to be completed before the revised Air SEPP can be issued for public comment. ACM has been made aware of this in response to its submissions on this matter.

The next step in the process will be the issue of a formal draft policy based on the comments received on the discussion papers and on the Streeton Report. This will be accompanied by an explanatory document and will include an impact statement. Once again this will be subject to public comment and to discussions with specific interest groups including ACM.

The final step is the presentation to Government of a proposed new policy with the arguments for its adoption. This will include a review of the public comments and the costs and benefits. Our experience has been that all such proposals are closely scrutinised by other agencies with detailed evaluations being provided to Ministers before the policies are acopted by Government.

The ACM article calls for balance but regrettably displays little in the cavalier way it treats the very extensive and exhaustive process for the review of the Air SEPP.

If we are to get our environmental and economic policies right in this country we do need to work together. EPA and ACM have enjoyed a solid and robust working relationship for a long time. I hope that the Clean Air article does not represent a weakening of our mutual understanding.

Yours sincerely,
PHIL MORGAN
MANAGER AIR SEPP REVIEW

(A) OTHER THE SOCIETY

Dear Editor,

I wish to make a few comments regarding the name of the society, particularly in the light of my recent experience in being part of the organising committee for the 11th Clean Air Conference in Brisbane.

I believe the current name is inappropriate, it does not reflect the interests of its members and worse the name conveys an entirely inappropriate impression of what the society is all about.

In trying to interest non members in participating in the conference, attracting sponsorship and trade displays, it quickly became apparent to me that many people when confronted with the current name, conjure up visions of either the anti smoking lobby or an ultra green conservationist group. This reaction has also been apparent when trying to recruit members for the society.

The recent conference did not attract the numbers expected, due in part the current economic climate and perhaps other organisational factors, but also due to the falling active membership level facing the society. There are many other environmental organisations, and to survive CASANZ has to be relevant. Part of this must be its name.

I believe that the name should encompass a theme of air quality management. There seems to be a body of opinion that the name should also include waste management. I have no strong feeling on this either way

I have no time for the argument that CASANZ has an established and recognised name and thus should be kept. The name should only be kept if it serves its purpose. Overseas they have not been afraid to change the name to keep up with the times. Tradition is not a reason.

Should the society chose to keep the current name then I am very afraid it will slowly disintegrate. Certainly a number of people at the conference expressed very strong views on resigning and even secession. I certainly will not remain a member of a Clean Air Society for much longer if it is not relevant to its environment.

I commend to you the statements made in closing the conference by Neville Bofinger, the Queensland Branch President, and conference chairman. The whole membership must assess what it wants and decide, not a "select" few.

Yours sincerely,
DAVID CLIFF

BACK-ISSUES OF CLEAN AIR

Our Committee has recommended to members of the South Australian Branch that they consider donating copies of CLEAN AIR that they no longer require to public libraries or to libraries associated with secondary schools or tertiary institutions in their areas. In this way community awareness of air pollution, and of CASANZ, would be raised.

Our Committee suggests that you include, in the next issue of CLEAN AIR, a note recommending the same action to members of CASANZ in all states.

Yours Sincerely,
Ken Webb,
Secretary South Australian Branch.

GENERAL NEWS ITEMS

SUPPORT FOR NEW TECHNOLOGY

Over the past year the CSIRO Division of Coal and Energy Technology has received considerable support for its new initiative on Integrated Gasification Combined Cycle (IGCC) compustion. IGCC is seen as the most likely contender for a new power generation plant and a means of improving the efficiency and economic accessibility of coal-based power generation.

A $403,000 grant from NERRDC last year plus an allocation of over $300,000 from CSIRO priority funding means the project is underway. Chief of the Division, Dr Peter Alfredson and leader of the project Mr Ian Smith, visited Japan last year to develop collaborative studies with Japanese research organisations. Also, early this year, the Division signed a Memorandum of Understanding with the Korea Institute of Energy Research, initiating collaborative studies.

"We believe IGCC systems will be selected for the next generation of power stations built in Australia and overseas," says Mr Smith. "They offer more efficient and environmentally acceptable way of using coal for power generation."

At the moment, Australia's coal-fired power stations, and most overseas stations use pulverised-fuel technology. This involves using the heat from the coal combustion to raise steam to drive a turbine and generate electricity. The energy efficiency of this process is, at best, 35%, i.e. 65% of the energy held in the coal is lost. And, whilst electricity utilities continue to make improvements, the efficiency increases and resultant decreases in emission levels, are limited.

Combined cycle power generation uses both gas and steam cycles to drive the turbines and can raise the energy efficiency to almost 45%, reducing CO_2 production by at least 20% and practically eliminating emissions of SO_2 and particulates.

Whilst it is unlikely that IGCC power plants will be built in Australia until after the year 2005, they will be introduced sooner overseas. Australian coal exports are currently worth over $6 billion per year: to maintain or expand on this coal exporters will need to assure their buyers that Australian coal is suitable for the new systems.

The CSIRO study is aimed at testing a number of Australian coals to provide information on how they will behave. Coal qualities required for efficient coal gasification are quite different to those required in the traditional pulverised-fuel boiler.

John Patterson, a senior research scientist, points to the high ash-fusion temperatures of Australian coals as being a potential problem.

"Recent tests on Australian coals by the Japanese in their entrained-flow gasifiers, have indicated some problems with discharging the waste slag. We will be looking at whether fluxes, added to the coal, can lower the temperature at which ash will melt and produce mobile slags."

Other work at CSIRO will build on previous work on pulverised-fuel technology to look at the pyrolysis and reactivity of coal in the high pressure conditions within the gasifier.

The University of New South Wales is also involved in the reasearch, undertaking mathematical modelling

of gasifiers, which will link the laboratory results with full-scale operations and also identify other key areas for investigation.

Equally important will be studies of the environmental aspects of coal use, namely the type of flyash produced, its heavy metal content and leachibility and whether it can be reused.

Contact: Mr Ian Smith, CSIRO Division Coal and Energy Technology, P O Box 136, North Ryde, NSW 2113; Telephone (02) 887 8869 or, Dr John Patterson, Telephone (02) 887 8707
Dr David Harris, Telephone (02) 887 8886.

1992 WORLD AIR POLLUTION MARKET TO REACH $14 BILLION

Suppliers of air pollution control equipment and services will enjoy 1992 sales of $4.5 billion in the Americas, $4.7 billion in Equrope, East Block, Africa, and $4.4 billion in Asia, this forecast was just issued in Air Pollution Management by The McIlvaine Company.

Asia is the fastest growing market due to expanding production and greater environmental awareness. Japan spends more per capita on air pollution control than any other country. Purchase of scrubber systems for power plants has spread from Japan and Taiwan to other Asian countries. A big scrubber project is under construction in Thailand.

The need for particle control for coal fired boilers will result in $1.2 billion of electrostatic precipitators in Asia in 1992. The world precipitator sales in 1992 will be $2.4 billion. So Asia is 50 percent of the total market.

In the Europe, East Block, Africa region, the bulk of the sales of air pollution control equipment will be in Western Europe countries. But sales of selective catalytic reduction and flue gas desulfurization equipment have peaked. The needs of Eastern Europe and the former USSR are huge. Despite the economic problems of the region, substantial investment in air pollution control equipment will take place in 1992. Funding comes from barters with Finland and Austria, German investment and other international funding. South Africa is the largest purchaser of air pollution equipment on the African continent.

The Americas (North and South) will invest less in flue gas desulfurization, but more in all other categories of equipment than in 1991. The market for stack sampling services continues to expand rapidly. Orders for continuous emissions monitors continues at a level greatly exceeding any year in the 1980s. The South American market will expand in 1992. Chile has just implemented stringent air pollution controls and will show the greatest growth rate in 1992, although Brazil remains the largest South American market.

For more information on Air Pollution Management contact: The McIlvaine Company, 2970 Maria Avenue, Northbrook, Illinois 60062 USA; Telephone (708 272-0010; Fax (708. 272-9673.

WATER BOARD TRIALS

The Environmental Group, specialists for the past 15 years in the field of gas and vapour emission control, have been awarded a contract by the Sydney Water Board for the supply and installation of a pilot carbon adsorption system.

The Environmental Group's carbon adsorption technology will be trialled by the Water Board for approximately 3 months as part of their ongoing programme to evaluate various technologies for the control of sewage odours.

The adsorption system employs a new type of activated carbon developed by Norit specifically for sewage gas odour control.

For additional information contact: Mr Glen Jelich, The Environmental Group Pty Ltd, 9 Packard Avenue, Castle Hill, NSW 2154; Telephone (02) 899 3499; Fax (02) 899 3463.

FREDERICK GARDNER COTTRELL INDUCTED INTO INVENTORS HALL OF FAME

Branchburg, New Jersey, May 1, 1992 - Dr Frederick G Cottrell, founder of Research- Cottrell, Inc. and inventor of the electrostatic precipitator, was inducted into the Inventors Hall of Fame on April 25, 1992. He joins such prominent inventors as Thomas A Edison, Gugliemo Marconi, Eli Whitney, and the Wright brothers. Only 98 inventors have been honored by membership in the hall of fame. Research-Cottrell is a subsidiary of Air & Water Technologies (AMEX.AWT)

At the turn of the century, paper mills, power plants, smelters, and industries were facing opposition of municipalities because of escaping gases and sometimes-poisonous dust and fumes. One copper company was sued for $3 million because of damage caused by smoke and fumes from a smelter. Determined to alleviate this pollution problem and to prevent valuable raw materials from being released in the atmosphere, Dr Cottrell began experimenting with electric precipitation.

In 1907, he applied for a patent on the first electrostatic precipitator, a device that passed high-voltage direct current through a conductor or electrode, which leaked the charge onto particulates in the passing fumes. The charged particulates were then electrically attracted to another nearby electrode, where they collected and could be retrieved as valuable minerals or chemical compounds.

The electrostatic precipitator known as the Cottrell, removed between 90 and 98 percent of all particles from escaping smoke and gases. In 1912, Dr Cottrell founded the Research Corporation, a nonprofit corporation that returned money from inventions back into the advancement of science. Research-Cottrell was spun from this organisation in the 1950s.

"We are proud of the important role that Dr Cottrell played in the origin of Research-Cottrell," said Donald A Deieso, president and CEO of Research-Cottrell. "ESP is used throughout the world at power plants, oil refineries, and other facilities and it continues to be an integral part of our series of products to control air and thermal pollution. Through our research and development efforts, we continue to improve on the original Cottrell, adding numerous enhancements and obtaining additional patents.

"Demand for this technology has increased in response to the Clean Air Act Amendments of 1990. To meet this demand, we are upgrading our ESPs to include wide plate spacing, pulse energization, gas conditioning, humidification, and the use of taller plates."Research-Cottrell has a worldwide installed base of more than 5,000 ESPs and has performed more than 2,500 rebuilds.

The subsidiaries of Research-Cottrell - Air Pollution Control Division, Custodis, Ecodyne Cooling Tower Services, Flex-Kleen, KVB Analect, R-C Environmental Services & Technologies, R-C Europe, and

Thermo Environmental Instruments Inc.

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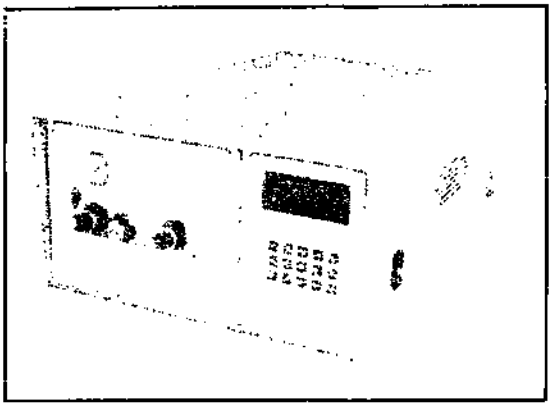

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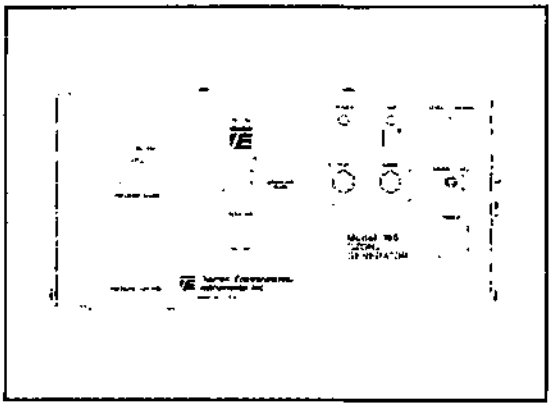

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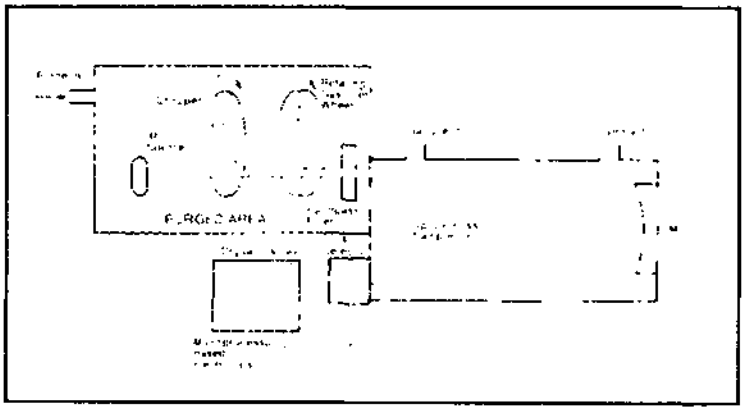

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EPA SMOG MODEL

EPA Victoria's, Smogwatch service started on Channel 10 news towards the end of April. Smogwatch, otherwise known as a Pollution Animation Dispaly uses a computer model to generate an animated image of the development and movement of smog over Melbourne and Geelong over the previous 24 hours.

Information from a known database of motor vehicle and industrial emissions, and information about wind speed, direction and pollutant concentrations from the 11 air quality monitoring network stations, is updated hourly and fed into the model to create the animated display.

Smog is represented on the display as colours which change as concentration varies. For example, light blue may represent background levels of smog, and black may represent the heaviest concentrations of smog.

Apart from providing up-to-date information about the movement and concentrations of smog over homes and work places, the model clearly shows variations in smog during the day and how the use of cars increases smog concentration.

Motor vehicles are the largest contributor to urban smog, and if conditions are right, it is possible to 'see' peak-hour emissions from motor vehicles travelling between Melbourne and Geelong, and along other major arterial roads.

Apart from using the model to demonstrate the development and movement of smog, the model will allow EPA to examine the likely concentrations of smog in areas where there are no air monitoring stations and will help to evaluate the effectiveness of various pollution control strategies.

The smog model does not predict the development of smog, but smog forecasts are issued by EPA based on weather forecasts.

EPA hopes the visual demonstration of motor vehicles' negative effect on the air environment will encourage people to keep their cars well tuned and use them less, particularly on days when a smog alert has been issued. It's also hoped that Smogwatch will discourage people from using backyard incinerators and from burning garden clippings since these activities also contribute to urban smog.

ODOUR REDUCTION IN PLASTICS MANUFACTURE: A CASE STUDY

R.J. BROWN, MARPLEX AUSTRALIA.

ABSTRACT

Marplex has adapted the latest technology available to convert airborne volatile organic compounds (VOCs), hydrocarbons and odour causing constituents arising from its manufacturing processes into carbon dioxide and water vapour at its Hammond Road, Dandenong South, plant. The problem and the steps taken to resolve it are discussed.

As a member of the Australian Chemical Industry Council and of the Plastics Institute of Australia, Marplex Australia Limited responds to the "Responsible Care" program of self-regulation and better communication with the community. The company acknowledges and responds to community concerns about chemicals and its operations, it complies with the statutory requirements that affect operations and products, and manages its activities in a manner that protects the environment and the health and safety of employees, customers and the public.

The company recognises that a purified air emission stream is an important element in living in harmony with the community and is pursuing this objective through waste management and better control of diffuse emissions.

Marplex is Australia's leading manufacturer of ABS engineering thermoplastics. It is the only one with totally integrated operations, and specialist ABS thermoplastic technology that extends from the initial monomers - acrylonitrile, butadiene and styrene - to the finished range of engineering thermoplastics, marketed under the registered trade names of Astalac (ABS) and Astaloy (ABS, Polycarbonate alloys). These pre-pigmented pellets are packaged and sold in basic moulding grades of ABS as well as sophisticated flame retardant and plating alloys to the automotive, electrical, communications, white goods, safety equipment, agriculture, mining and other prominent industries.

For the past three years Marplex has been working with the community and industry seeking to establish a climate of trust and co-operation through forums whereby environmental problems engaging the attention of both residents and industry can be discussed with a free interchange of information. The major environmental concern in these discussions has always been odour, as the acrylonitrile, butadiene, styrene monomers used in manufacturing ABS plastics produce obvious odours. Because of the low ambient concentrations involved, the odours should not cause health problems but a

continual strong odour can be an intrusion upon pleasant living conditions.

The Environment Protection Authority is obliged to investigate the circumstances of community odour complaints, trace the suspected sources, and require corrective action to be taken to prevent recurrence. In many ways Marplex feels it has been criticised unfairly in the area of environmental problems because, with its location, it is seen to be the "last factory in the row". Community forums have revealed that a lot of the criticism of the company is based on lack of knowledge and understanding of what happens in a chemical plant.

EPA licences allow the emission of air to atmosphere from a number of points around the plant provided the discharges do not exceed authorised odour limits under the State Environment Protection Policy -SEPP(Air). Some residents have persistently regarded the company with suspicion and linked the plant to the fear that their long term health and the amenity of the community could be affected by odours.

Citizens Action Groups have influenced government, local government and district health services. As a result, health localities projects, clean air enquiries, and publicity support through community newspapers have kept the questions of industry and clean air very much alive. The Groups have sought to ban industrial incineration practices and, preferably, to have chemical plants removed from Dandenong South.

Marplex is not the only chemical plant in Dandenong South manufacturing similar products but it is closest to the residential area and became a major target. The company, therefore, decided to raise its public profile and tell the community of its activities in preserving clean air. An Open Door policy was introduced, embracing the local community, City of Dandenong Councillors, and any interested parties.

THE PROBLEM:

In 1968, when the current ABS Resin Plant commenced operations, the Marplex site was situated in a remote location with mainly farm land and isolated industry in the nearby surrounds. The addition of the Latex Plant in 1971 had little effect on still very remote neighbours.

Commencement of operations in the new Compounding Plant built in 1984 followed a period under a now obsolete Planning Authority which allowed residential housing to within 300 metres of the site's northern boundary. It was only saved from closer proximity of residences by the declaration of the Dingley by-pass road reservation.

By 1988, when the capacity of the Compounding Plant was doubled the local community became aware of the company's operations and perceived that the operations were associated with odourous atmospheric discharges. The discharged odours were distinct and characteristic of the processes being operated and the materials handled. On warm days with southerly or westerly winds the odours were carried toward residential areas including the nearby school and sports ovals.

THE RESIN PLANT:

The main sources of odour from atmospheric discharge were the resin dryer exhaust, the resin reactor ventilation, and the latex reactor flashing and stripping processes for removal of residual VOCs. Both the ABS resin reactor and the resin dryer contributed to styrenic vapour discharges at low concentrations.

In the case of the dryer there was little buoyant effect because of very high humidity levels and low discharge temperatures, although dispersion was aided by the height of the dryer fan discharge on the roof of the building. The discharge volume from the dryer exhaust was significant at 400 m³ min.

THE LATEX PLANT.

Discharges form the SBR Latex plant were more of a problem both in terms of discharge quantity and the rate of release. Two separate processes are operated in this plant - the SBR Latex rubber for carpet backing, and the polybutadiene process which is the first step in the ABS plastic manufacturing process.

In the batch SBR process, unreacted butadiene and styrene monomer are removed by a steam stripping process under vacuum conditions through a steam vacuum jet via condenser to the atmosphere. The more volatile butadiene is released first and would essentially be completely driven off within the first 45 minutes but, because of its very low boiling point, there is little opportunity for capture with the equipment installed. Higher boiling point styrene is driven off over the remaining hours of the stripping process with a high proportion of vapour knock-out through a condenser and a steam jet inter-stage condenser.

A quantity of unreacted butadiene is liberated from the polybutadiene process at the batch transfer stage at completion of the reaction.

These discharges constitute major short duration odour problems and substantial treatment problems

THE COMPOUNDING PLANT:

Another large volume of odorous air was discharged from the ABS Compounding Plant. The source was essentially fume extraction from the extrusion process itself with contributions at the die-head and the vacuum ports on each extruder. Odours again characteristic of the process, coming from styrenic compounds and dimer and trimer decomposition products. Although the concentration of organic contaminants in the discharge stream is low, the high air volumes result in a large odour volume release.

POSSIBLE SOLUTIONS:

THE LATEX PLANT:

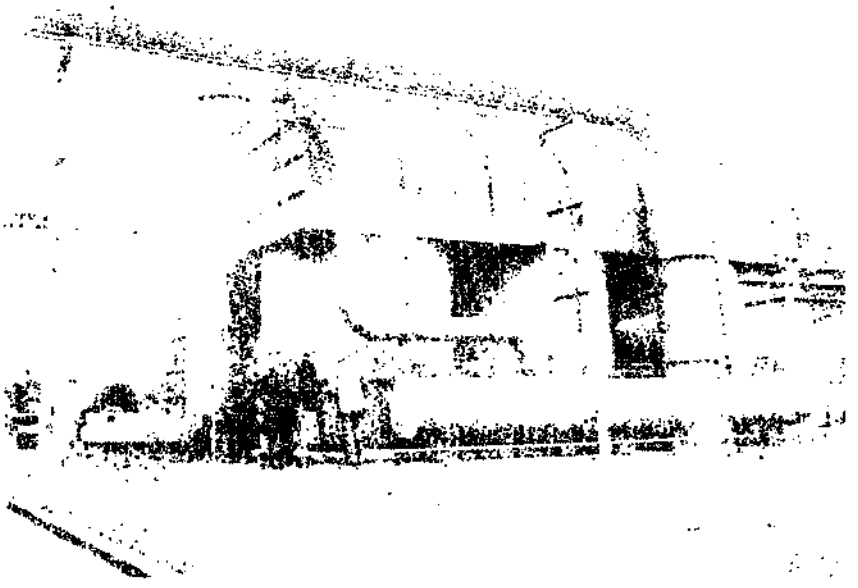
Possibilities examined by Marplex - in consultation with the Environment Protection Authority - for treatment of the butadiene and styrene discharges included point-of-discharge incineration through a flare or enclosed after-burner or vapour recovery. A recovery system would involve very high capital outlay and low to moderate operating costs, but the value of the recovered material, if re-used, would not provide an economic payback. Local incineration would provide a moderate capital-cost solution, but running costs would be high even with the most optimistic utilisation of recovered heat, bearing in mind the short-duration high-rate discharges. The EPA was not particularly happy with these options.

COMPOUNDING PLANT:

Scrubbing the discharge stream with a suitable solvent such as di-octyl phthalate was a possibility but with low concentrations and potentially low solubility rates, a high probability of success could not be assured. Liquid disposal would then become a problem.

RESIN PLANT:

The Resin plant, with its dryer exhaust and low contaminant loadings, virtually made thermal oxidation the only viable option. Given that thermal oxidation was the choice for the resin plant it could easily be extended to the compounding plant, so it was decided that the latex plant emissions would be treated in the one central unit. The amount of air to be treated would be quite large - over 500 Nm3 min - and the combustion temperature was required to be approximately 760 deg C with a residence time of 0.5 seconds. Heat recovery becomes extremely important when installing a system of this size. Although normal recovery units were examined, a regenerative rather than a recuperative system was eventually chosen



The 70 tonne Reeco thermal oxidiser converts airborne organic compounds (VOCs) into carbon dioxide and water vapour in the grounds of Marplex Australia Limited, Dandenong South

because of its reported higher recovery efficiency.

THE CHOICE:

Fortuitously, a second- hand unit came on the market at the time Marplex was considering the purchase of a unit manufactured by the Regenerative Environmental Equipment Company Inc., (Reeco). The unit was a Re-Therm Model VF designed to treat 34,000 Nm3 hr but with provision to be extended to 68,000 Nm3 hr by the addition of further equipment.The advantages of the regenerative heat recovery incinerators were seen to be:

- Rugged construction with very few moving parts,
- Ability to run normally without operator intervention,
- Good economy with high heat recovery, and
- Capability of extension in the future.

The Re-Therm VF is a vertical flow model consisting of three or five chambers (or lobes) and stands seven metres high, exhausting clean air to atmosphere through a nine metres high stack.

As the unit operates, the lobes are sequentially switched from preheat to recovery mode, then back to preheat. Flow control valves direct the incoming stream of contaminated fumes or odours into and through the selected recovery lobe that is in preheated mode, then into the purification chamber.

The fumes are progressively heated as they pass through the recovery bed moving towards the incineration chamber. They leave the preheat beds at a temperature very close to the incineration temperature. They are then destroyed in a fraction of a second, with little auxiliary fuel consumed in addition to the fuel value of the contaminants. The superheated clean air then passes through another lobe which is in recovery mode. Here, most of the heat energy is given off and stored in the heat exchange elements. Thus, a back and forth cycle is established.

THE MARPLEX REECO:

The Marplex Reeco has three lobes. At any one time, one lobe is in inlet mode, and one is in outlet mode. The odd chamber is either in inlet or outlet mode, or is being switched between inlet and outlet. This ensures there is always at least one chamber in both inlet and outlet modes so that the flow is maintained through the unit without interruption.

When fume concentrations reach the self-sustaining level, all the required energy is obtained from oxidation of the contaminants and the gas burner reverts to pilot operation. The temperature at any point within the lobe is stable, varying by no more than 10 deg C or 15 deg C. It is the air that changes temperature as it passes through the recovery beds. There is no problem of thermal stresses due to changing conditions.

Since the recovery bed temperature range extends through the autoignition range of most solvents, autoignition occurs, raising the temperature of the solvent laden air stream as it passes through the preheat chamber. Once the air leaves the preheat chamber it enters the purification chamber where it is held at a temperature of approximately 760 deg C for about one second - well above the 0.5 second generally considered adequate for complete combustion.

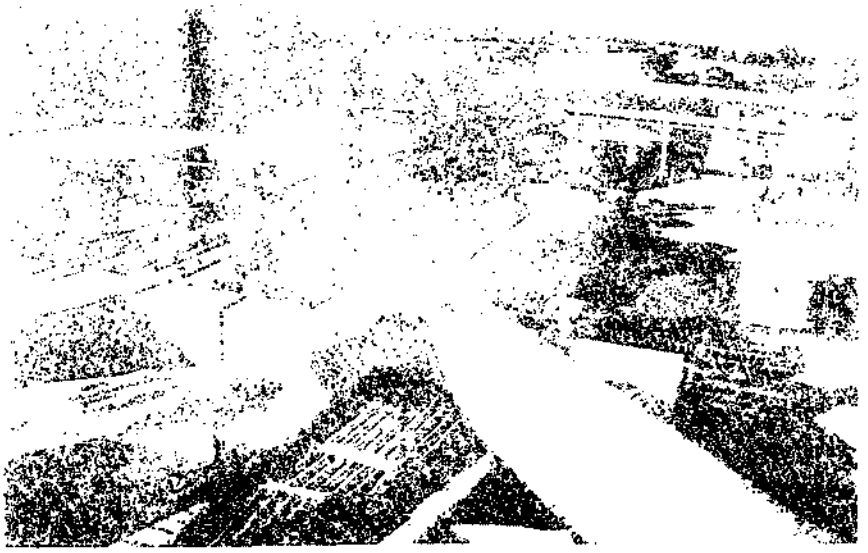
The 70 tonne unit had to be completely dismantled for shipment to Melbourne from Sydney and cut into four pieces for transport by road. This involved the significant logistical exercise of dismantling all ancillary items of equipment and instrumentation including the control system. The incinerator and all of its associated ducting was carefully matchmarked prior to the top incineration chamber being separated from the regeneration chambers and then the separation of these three sections.

It was decided to transport the ceramic-filled, refractory-lined regeneration chambers with the ceramic fill still in place within the chambers, to minimise the damage to the ceramic from handling and minimise the potential for damage to the eighteen-month-old castable

refractory.

Careful re-positioning of the regeneration chambers onto the new concrete footing at the Dandenong site was necessary to ensure matching-up of the separated components. This aspect of the relocation was carried out with a great deal of precision and full credit is paid to the tradesmen involved. Subsequent reassembly of the ancillaries proceeded smoothly with no major problems encountered.

Once assembled, the job of conveying the fumes to the unit was started.



Half a kilometre of ducting had to be designed and erected around the plant to connect the manufacturing processes to the Reeco

MAJOR ENGINEERING PROBLEMS:

Conveying the large air volumes with low concentrations of contaminants from the resin and compounding buildings was relatively easy. Large diameter steel ducts with control dampers and in-line fans were used. The whole installation was subjected to Hazop studies where the main concern was a flash-back to the operating facilities. The flow of unreacted butadiene from the latex building was to provide the major technical problems.

Marplex, having decided to incinerate the butadiene in the Reeco system, had to prevent detonations in the butadiene delivery line to the Reeco, or in the Reeco inlet manifold. This presented a major challenge as the piping required to convey the butadiene to the burner had to be 180 metres in length. Calculations had shown that, in the event of an initiation of combustion in this pipe, the combustion could be expected to turn into a deflagration in a relatively short length pipe, and that the deflagration would transform into a detonation within around 20 metres of pipe.

The flammability limits of 1, 3-butadiene are:

* Upper Explosive Limit, 12.44% v v in air, and
* Lower Explosive Limit, 1.94% v v in air.
* The flame speed in free air is 0.55 m sec, and
* The Autoignition Temperature, 418 deg C

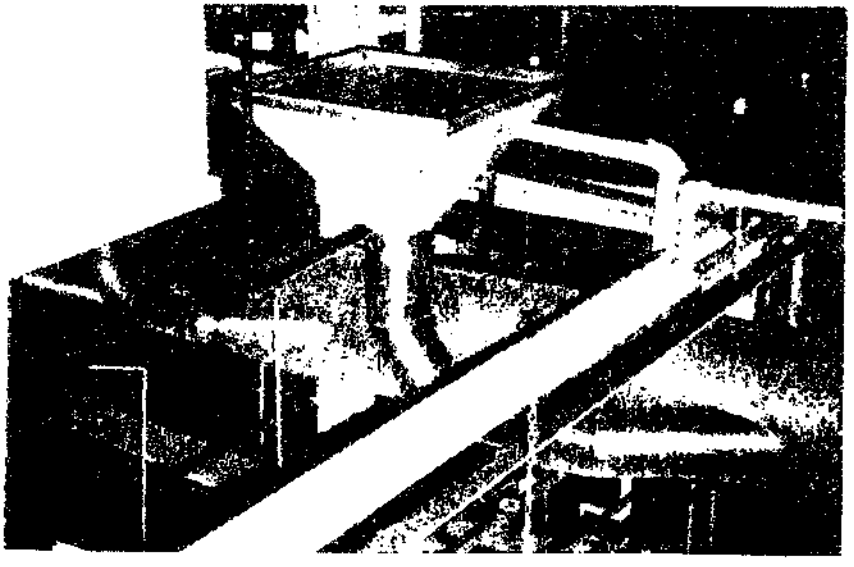
From these properties it could be seen that, at a safety margin of four selected, operating the pipeline in the region above the Upper Explosive Limit (UEL) would require operation of 49.8% v v, (say 50% v v) in the air, and in the region below the Lower Explosive Limit (LEL) would require operation of 0.49% v v (say 0.5% v v) in the air, representing a dilution of 200:1 v v.

The tendency for butadiene to form peroxides in the presence of air and the potential for the accumulation of static electricity in places where a latex coating is formed, could initiate combustion in the pipework if the mixture ever strayed into the explosive range. The formation of peroxides and other active groups are known precursors to the onset of spontaneous combustion.

The basic control philosophy of conveying butadiene to the Reeco was to design the system so that the butadiene could be conveyed to a mixing point at above the UEL, then to mix it rapidly with air to reduce it to below the LEL. The butadiene is maintained above the UEL in the transfer line by operating the line as a totally sealed system. This system can be swept with nitrogen.

When the system is operational three oxygen meters constantly monitor the oxygen content with a control limit of 2%. If the oxygen content in this line rises above 4%, the line automatically trips to by-pass. The oxygen meters are monitored by a process control computer which, in essence, allows the units to vote so that two out of three oxygen meters give a particular level as a safeguard.

Another problem with the evolution



Odorous process fumes are vacuumed from discharge points and conveyed through ducting to the thermal oxidiser.

of butadiene to the Reeco is that the quantities of butadiene cannot be left uncontrolled because the fuel value is such that the unit will quickly exceed its design temperature. A complex control system of butadiene extraction rate from the latex had to be devised to prevent this happening.

The temperature of the Reeco purification chamber is controlled by a maximum of 820 deg C. and butadiene flashing is controlled by the supervising computer.

Nitrogen is used to pressurise the reactors because of the need to prevent ingress of air into any parts of the system. The state of the reactor can be determined by a nitrogen "break through" which indicates that the reactor is empty. This triggers a shut off of the nitrogen supply to the reactor, and at the same time closes the latex flow control valve.

Because of the inherent problem of the latex system with carry over of latex droplets and the tendency of butadiene to polymerise, the transfer line has been equipped with pigging facilities to allow for regular cleaning of the line. Although the original design called for short flanged sections to make cleaning easier, the line is of one piece fully welded, as flanges could increase the probability of an unacceptable level of leaks.

COMPLEX CONTROLS:

The control system for this particular line has 269 instrument items including hardware and software. To protect the inlet manifold to the Reeco from accidental deflagration, 14 magnetically-bonded panels, each approximately one and a half square metres in size, were installed to relieve pressure should this occur. The design of these panels was developed in-house. The Marplex installation, to the company's knowledge, is the only Reeco Re-Therm in Australia which is being used for such a concentrated VOC gas stream.

SUMMARY:

In summary, the Reeco regenerative type of fume incineration is an excellent system where large volumes of air with low levels of contaminants need to be treated.

It can also be used to incinerate highly concentrated streams of contaminants provided that the technological problems can be overcome.

Odorous process fumes pass through the heat recovery beds into the purifying chamber on top and are emitted to atmosphere as clean air.

Having installed and commissioned the Reeco Re-Therm burner, Marplex's next major project is to harness the waste heat for re-use in their ABS resin drying process.

If this were to be achieved, the running costs of the unit, other than fan power, would be totally recouped and significant utility savings could be realised.

CONTRIBUTIONS RECOGNISED:

Marplex Australia Limited's commitment to "Responsible Care" has brought about wider community recognition of the company as a responsible citizen and employer in the Dandenong-Western Port region, prepared to invest in air cleaning processes to preserve the environmental amenity of its neighbourhood, and ready to respond to the concerns of the community.

Marplex's efforts have been recognised by the presentation of the Dandenong-Western Port Environment Protection Award of 1991.

ACKNOWLEDGEMENTS:

Many individuals, both Marplex and external, contributed to this project, and to list names of individuals is to risk not acknowledging particular contributions. While noting the contributions from the following people, the individual efforts by all who have been involved are greatly appreciated and hereby ackrowledged:

Phil Evans, project manager, The Environmental Group Ltd,
Harry H. Simmons, consultant, H.H. Simmons and Associates.
Anthony R. Vanstor, manager, Procor Engineering Pty Ltd,
Graeme R. Durrant, senior systems engineer, Fischer and Porter Pty Ltd,
Joseph Turrisi, director, Chemical Manufacturing Technology.

Robert J. Brown is Plant Engineer, Marplex Australia Limited.
163 Hammond Road,
DANDENONG,VIC.3175

HUMAN HEALTH AND tfQTOR VEHICLE FUELS R EXHAUST EMISSIONS

Sydney Jn vers ty Union 6-10 Apr 1992.

Phillip Callan, Meeting Rapporteur

The Clean Air Society of Australia and New Zealand (NSW Branch) hosted an internat ona. Workshop on Human Health and Environmental Effects of Motor Vehicle Fuels and their Exhaust Emissions with partic pation from 15 countries. The Meeting, timed to coincide with World Health Day 7 Apr 1992, was co- sponsored by a number of Commonwealth and State Environmental Agencies and the ILO UNEP WHO International Programme on Chemical Safety. Support for developing country participants was provided by the Australian International Development Assistance Bureau, the United Nations Environment Programme and Car. Deutchberg Gesenelsnaft of Germany

Len Ferrari, President, New South Wales Branch, Clean Air Society of Australia and New Zealand, in welcoming Dr Michel Mercier, Director IPCS and overseas participants indicated that the aim of this Workshop was to improve the understanding and public awareness of human health and environmental effects of motor vehicle emissions.

The outcomes of the Workshop was the preparation of a well defined document which will form the basis of the IPCS Environmental Health Criteria documents on Human Health and Environmental Effects of Gasoline Engine Exhaust Emissions; Human Health and Environmental Effects of Diesel Engine Exhaust Emissions; and Human and Environmental Effects of Ethanol and Methanol based Fuels and Exhaust Emissions.

A number of technical reports were tabled during the meeting which examined the impact of emissions on air quality in Australia (Mr L. Ferrari), Japan (Dr J. Kagawa), United States (Professor P. Flachsbart) health and environmental effects of gasoline (Dr A. Sivak, USA) and diesel engine exhaust emissions (Dr R. Herte.. Germany) and ethanol and methanol based fuels and exhaust emissions (Professor F.G. Reyes, Brazil).

The ambient environment impact of motor vehicle emissions and national responses including regulatory standards and guidelines were covered in papers provided by Professor A. McMichael, Adelaide University, Dr L. Grant, USA Environment Protection Agency Dr P. Anyon, Department of Transport and Communication and Mr D. Munro, Victorian Environment Protection Authority.

Examination of the fundamental health impacts and the chemical mechanisms of atmospheric pollution were detailed in papers given by Dr V. Bencko, Czechoslovakia, (immunological effects), Dr I. Farkas, Hungary (biological markers) and Mr G. Johnson, CSIRO. Developing country presentations were provided by national participants from Philippines, Indonesia, Malaysia, Thailand and the Peoples Republic of China.

The Plenary presentation by Mr Ferrari, outlined statistics concerning population, motor vehicles and fuel consumption in Australian States. Australia's per capita fuel consumption was third highest after the United States and Canada in 1989. However, ratios of diesel fuel and gasoline varied markedly between States perhaps reflecting distributions of population between capital cities and more rural areas. Comparisons were presented for Sydney and other major cities overseas showing that while particulate material concentration were in the lower range of polluted cities, maximum one-hour ozone concentrations were comparable with other middle order cities such as Houston (USA), Anaheim (USA) and London (UK).

Control strategies for photochemical smog and "brown haze" (fine particles) were outlined including control on industrial sources, solvent substitution, and controls on motor vehicles and open burning. The introduction of Australian Design Rules (ADR) for motor vehicle emissions, has resulted in the introduction of catalysts and unleaded gasoline on new passenger cars in 1986.

Trend data showed that ozone exceedances of both the NHMRC goal (0.12 ppm) and a proposed Victorian Environment Protection Authority criterion of 0.08 ppm had decreased since 1952 in both Sydney and Melbourne. Levels of brown haze have also decreased steadily during the 1980s. However, projections based on emissions inventory data and population statistics have foreshadowed increasing problems of particle and photochemical pollution in some areas of Sydney over the next two decades as a result of the development of new population centres with associated changes in traffic and industry distributions.

Professor J. Kagawa, (Japan) outlined problems associated with environmental pollution encountered by Japan following World War II, due to the delayed implementation of countermeasures to protect against environmental pollution.

After multiple pollution events, the Japanese government and private sector made joint efforts to reduce environmental pollution including the introduction of specific legislation. As a result of new legislation, pollution related disease have declined, however localised health effects of automobile exhaust on people living near busy roads is increasing because of a marked increase in automobile numbers and their high concentration in urban areas. These problems were being addressed through more efficient transportation of goods based on analyses of city structure and lifestyles of city dwellers and socio-economic factors.

Dr P. Flachsbart, USA described a conceptual model of exposure to

emissions from motor vehicles, and reviewed studies of co-variants of exposure identified in the model. These included volume and speed of traffic, vehicle emissions, distance from roadways and their classification and design, in vehicle self-contamination and ventilation, ambient air quality, and meteorological factors including temperature, atmospheric stability, and wind speed and direction.

A review of several studies that were used to develop methods and models to estimate or predict exposure to automotive air pollutants were presented to the Workshop. The studies attempted to estimate numbers of people exposed to air pollutants in excess of air quality standards, while others sought to develop models which predicted exposure in terms of typical concentrations. Personal monitoring combined with carefully designed diaries could estimate exposures in a number of micro-environments throughout a given day, supported by information about types and intensity of physical activity undertaken in each area. This detailed information was necessary to adjust for respiratory rates and hence real exposure to pollution in any micro-environment.

It was concluded from these studies that fixed-site monitoring tended to over estimate frequency of low exposures, and under estimate frequency of high exposures. Some modelling approaches using personal monitoring data, and their relative merits were also discussed.

Dr A. Sivak, (USA) outlined the current US National Ambient Air Quality Standards (NAAQS), in particular carbon monoxide, hydrocarbons, nitrogen dioxide and ozone. There were concerns in the US regarding the detrimental effects to agricultural crops, including large economic losses due to exposures to ozone and sulphur dioxide at levels below NAAQS.

Mean particle levels from diesel generated sources in American cities are in the range 0.4-0.5 ug m^{-3}. Carbon monoxide reduction required control of gasoline motor vehicles. Introduction of catalysts to motor vehicles has reduced the emission of hydrocarbons, carbon monoxide and oxides of nitrogen. The option of introduction of traps and catalyst systems to diesel engines was being considered in the USA to meet 1990 standards.

In his second presentation, Dr Sivak outlined current knowledge of metabolic pathways, toxicology, biological detoxification systems, difficulties in extrapolation of animal data to man and the health implications of motor vehicle emissions and photochemical oxidants. Details of observed effects in animals were noted including nephropathy in rats caused by binding of trimethylpentane to alpha-2-globulin in the kidney. Epidemiology studies did not show evidence for renal cancers in populations exposed to gasoline. It was indicated that through properly designed and controlled epidemiology studies, a strong correlation between human leukemia and exposure to benzene resulting from gasoline exposure could be identified.

Dr R. Hertel (Germany) discussed diesel exhaust components which differ markedly from those found in gasoline exhaust, in that they include a much greater proportion of particulate material and associated organics, such as polycyclic aromatic compounds and nitro-arenes, which are considered to be carcinogenic.

Also, carbon monoxide emissions are lower than in gasoline exhausts. Diesel fuel contains higher-molecular weight hydrocarbons (with approximately 8 to 30 carbon atoms) with high density. Other important quality criteria, which also influence the emission characteristics of diesel vehicles, are ignition performance, distillation range, viscosity and flash point. Compared with gasoline, the sulfur content in diesel fuel is between 7 and 14 times higher.

It is unclear whether the carcinogenic effect of high concentrations of diesel particulates is due to the particles or to absorbed organic compounds, as exposures to both carbon black alone and carbon black doped with small amounts of benzo[a]pyrene may also induce tumours in rat lungs. Two large epidemiological studies on American railroad workers have been undertaken, in which a significantly increased lung cancer frequency was found in the exposed population when compared with control groups. Because of uncertainties in confounding factors such as tobacco smoking, the results are not regarded as evidence for carcinogenic effects of diesel emissions in humans.

Professor F. G. Reyes (Brazil) provided an outline of the history of the introduction of alcohol based fuels to Brazil. It was indicated that the alcohol gasoline was superior in reducing carbon monoxide and hydrocarbons, although an increase in aldehydes in emissions resulted. Due to a temporary shortage of ethanol, mixtures comprising 60% ethanol, 33% methanol and 7% gasoline was successfully introduced in 1990 91 to replace neat ethanol, without engine modification and without increasing carbon monoxide emissions.

A description of the toxicology and metabolism of both ethanol and methanol indicated that there was sufficient evidence that ethanol as an alcoholic beverage was a possible human carcinogen but available evidence showed that methanol was not known carcinogen in humans. However, possible central nervous system effects may result from chronic low level exposure to methanol.

A future programme in Brazil to reduce motor vehicle emissions would include the introduction of catalyst technology and fuel injection systems. The use of alcohol based fuels are strongly subsidised through fuel pricing and through tax incentives.

Professor A. McMichael (Australia) outlined the urban environment where mobile sources, primarily motor vehicles, have the greatest impact on ambient pollutant concentrations. Lead emissions, despite reduced use of lead in petrol, occasionally exceed health guidelines in areas adjacent to roads of high traffic density. Exhaust emissions of hydrocarbons and oxide of nitrogen are the major contributors towards photochemical oxidants.

An outline of the current areas of research into priority air pollutants being undertaken by the National Health and Medical Research Council (NHMRC) was provided to the Workshop. The NHMRC is currently reviewing the goals for sulfur dioxide, photochemical oxidants (ozone), nitrogen dioxide, lead , blood lead levels, carbon dioxide, and indoor air pollution

Dr L. Grant (USA) discussed recent findings of health related studies on the criteria air pollutants, focussing on major aspects of relevance to the US EPA review of the National Ambient Air Quality Standards (NAAQS), for which new revised standards could be anticipated by early 1993. Lead in air and lead in blood were also being re-examined following the Center for Diseases Control Report in 1991.

Mr P. Anyon and Mr D. Munro (Australia) outlined future emission control options for motor vehicles in Australia. The preferred approach was to adopt overseas standards to meet national requirements. This applied particularly to diesel controls as diesel engines are not manufactured in Australia.

For diesel engines, hydrocarbons, nitrogen oxides and particulate materials will be regulated. Australia will probably adopt a consensus standard in 1996. It was noted that the projected Japanese standard is some ten times less stringent than the US and European targets. In Australia, control will be applied through complete auditing of production systems, quality control feedback, standards and calibration.

While new vehicle standards are important, effective control will need to focus on the lifetime emissions performance of existing vehicles. A testing system will need to be simple, effective, based on the relevant Australian Design Rule (ADR), and be no more stringent than the ADR. A prime target will be vehicles which have been deliberately adjusted to change emission controls.

Dr V. Bencko (Czechoslovakia) indicated that several studies had shown that the immune system of mammals, including man, may be a sensitive indicator of the exposure to harmful substances from the environment. Motor vehicle exhausts have irritant effects on the mucous membranes of the respiratory system which are a part of the barrier of the pulmonary defence mechanisms. Data have indicated that diesel emissions can alter the cellular defence responses to viral induction of interferons.

There are studies that show that exposure of mice to diesel engine exhaust may increase the in susceptibility to infection. Other data indicate that exposure of mice and rats to the exhaust of gasoline engines with catalytic converter show less susceptibility to infection than mice exposed directly to diesel emissions.

Dr I. Farkas (Hungary) outlined recent research directed towards biological monitoring of health indicators. It was stressed that health-relevant exposure is better assessed in this manner as the impact on internal exposure of personal behaviour, choice of foodstuffs, biological characteristics such as age, sex, inter-individual differences in absorption and metabolism, disease states, and anthropometry are taken into account.

Studies conducted in Budapest in which biological markers were used to monitor environmental exposure from motor vehicle exhaust were reviewed. Urinary aminolaevulinic acid excretion was used as a biological marker for lead exposures and hippuric acid renal excretion was also used as a marker of the early damage of the haematological and immune systems in children. It was proposed that this marker could be utilised routinely as an indicator of vehicle exhaust emission in areas adjacent to heavy traffic.

Mr G. Johnson (Australia) provided an overview of the interaction of reactive organic compounds with sunlight. Emissions arising from the use of motor vehicles are generally accepted as being the prime cause of most ozone (O_3) and nitrogen dioxide (NO_2) pollution episodes. NO_2 and O_3 pollution events result from a single atmospheric chemical process, namely the photochemical oxidation of NO. The speed at which

this oxidation progresses is proportional to the amount of sunlight exposure and quantity of reactive organic compounds (ROC) which have been emitted into the air.

ROCs are emitted both in motor vehicle exhaust and as gasoline vapour from moving vehicles and also from refining and fuel distribution networks. Nitric oxide is produced in the motor by the combustion process and is emitted through the tailpipe.

Recent research has shown that photochemical oxidation can be described as: the quantity of nitric oxide consumed plus the quantity of ozone produced (i.e. quantity of smog produced). Also that smog production is a linear function of exposure to sunlight up until some limit at which point smog production is terminated because the available NO and NO_2, essential to the chemistry of the process, has been consumed by side reactions (the NOx limited regime).

It follows from these considerations that so long as there is significant unreacted NO present in the air, the NO_2 concentration is controlled by the emission of ROC and sunlight exposure.

Dr P. Abbott (Australia) outlined the deficiencies in the existing data base on carcinogenicity of motor vehicle exhausts. He highlighted areas such as identifying target and control groups, and variability in emissions due to fuel composition and engine design. Given the high variability, the validity of comparing results obtained from one study to another was questionable.

There have also been clear indications of carcinogenicity in animal studies using exhaust condensates. No reliable data is available from human inhalation studies.

There is sufficient data, however, to show that some individual components of motor vehicle emissions are carcinogenic, for example, benzene in humans and 1,3- butadiene in mice. Polycyclic aromatic compounds with three or more rings have been shown to be mutagenic and or carcinogenic in animal studies.

It was concluded that if gasoline is carcinogenic, its potency is extremely low and should be treated as a whole compound, rather than attempting to assess individual components.

Mr R. Walter (United Kingdom) provided a historical overview of the air pollution situation in London from the smog episodes in the early 1950's to the present. He drew attention to the fact that whilst the early episodes were due to extremely high concentrations of particles and sulphur dioxide from coal combustion, current air pollution in London is primarily due to motor vehicle emissions. He discussed early studies on particles and carbon monoxide from diesel buses and their effect on depot maintenance workers.

Professor A. di Lorenzo (Italy) outlined current research on automotive emissions from both gasoline spark ignition and diesel compression engines, which focused on the roles of fuels and lubricating oils and their quality on exhaust emissions.

Methods are currently being developed to sample exhaust emissions for analysis of condensable material, including polycyclic aromatic compounds as a function of fuel composition, and sampling of material from within engine combustion chambers at various points during the operating cycle. This has allowed a detailed understanding of reactions occurring within chambers, and processes which generate and combust PAC and soot. This is important from the point-of- view of particle emissions from diesel engines.

Mr T. Kahn (Australia) informed the Workshop that motor vehicle numbers provide a broad indication of per capita energy use and the potential intensity of human impact on the environment. The number of motor vehicles is growing at a faster rate that the human population. There are 500 million motor vehicles and it is predicted that there will be 1 billion by next century.

Motor vehicles are an energy intensive and inefficient form of transport, but with enormous counterveiling advantages of flexibility and other user benefits, particularly in the care of the private motor car, not easily provided by any other form of transport.

While there has been an increase in knowledge about atmospheric pollutants and their widespread dispersion, this has not been matched by a similar increase in knowledge of their biological and ecological effects, let alone in the understanding of the significance of the effects currently known.

COMPANY NEWS

NEW APPOINTMENT

Peter Williams has been appointed Principal Consultant in the Melbourne office of the specialist environmental consultancy company, ICF Pty Ltd, with specific responsibilities for air quality management services.

ICF Pty Ltd, with offices in Melbourne, Sydney, Perth and Brisbane is part of the world wide group ICF International Inc., and provides specialist environmental services in the areas of air, water and natural resources covering policy, assessment, pollution control and management.

For further information contact:
Peter Williams, ICF Pty Ltd.,
424 St. Kilda Road, Melbourne.
(03) 867 2400.

ADDITION TO CONSULTANTS LISTING

ICF Pty Ltd
Level 3 242 St Kilda Road
Melbourne Vic 3004
Telephone: (03) 867 2400
Fax: (03) 820 1940
Peter Williams B.Eng., MSc.
Areas: 1,3.5,6,7.8.10,12.13
The Listing of Consultants and key to 'Areas' will be found in November 1991 issue of Clean Air.

CONFERENCES

THE UNIVERSITY OF ADELAIDE

DEPARTMENT OF COMMUNITY MEDICINE

Four-Day Course on The Assessment of Health and Safety Risks under Workplace Hazardous Substances Regulations and Examination for the Award of Professional Development Certificate

Presented by:
The Australian Institute of Occupational Hygienists in conjunction with The S A Occupational Health and Safety Commission.
12-15 October, 1992. Adelaide. Fee: $500, including lunches, teas, course notes.
Contact for registration form and information leaflet:
Dr Dino Pisaniello, University of Adelaide. Telephone (08) 228 4637. Fax (08) 223 4075.

NATIONAL SHORT COURSE ON ENVIRONMENTAL HEALTH

29 Nov-9 Dec. 1992 Adelaide. Fee $650.
A NHMRC-supported, intensive nine-day course, designed for persons involved in environmental health risk assessment, management and communication.
Speakers include: Prof J Samet, University of New Mexico; Prof D Nebert, University of Cincinnati.

Presented by:
The University of Adelaide in conjunction with The S A Health Commission.
Contact for registration form and information leaflet:
Ms Louise Stafford, University of Adelaide. Telephone (08) 228 4637. Fax (08) 223 4075.

ENVIROPRO '92 MALAYSIA

October 28-31, 1992

International Conference & Exhibition on Environmental Protection and Control Technology
Organised by:
Environmental Management & Research Association of Malaysia in collaboration with:
Communication International Associates (S) Pte Ltd
In Association and Cooperation with:
Ministry of Science, Technology & The Environment and The Department of Environment, Malaysia.

OFFICIAL LANGUAGE

The official language of the conference will be English and will be used in all correspondence, presentations and publications.

SCOPE AND TOPICS

The six principal areas to be addressed during the conference are:
* Air Pollution - which is related to motor vehicle usage; haze formation; emissions from industries; and pollution caused by construction activities;
* Water Pollution - which is caused by sewage disposal, animal husbandry and waste discharges from industries;
* Noise - arising from traffic, construction works and industrial noise;
* Waste Management - which is related to waste minimisation and disposal of solid and hazardous waste materials;
* Health and Safety - assess impact from various forms of pollution and means of protection against these hazards; and
* Land use - such as soil erosion, loss of fauna and flora due to urbanisation and deforestation.

EXHIBITION

An international exhibition on Environmental Protection and Control Technology - Enviro-Pro '92 will be staged in parallel with the conference. This exhibition is organised by Communication Internation Associates (S) Pte Ltd and will be held at Hotel Istana, Jalan Sultan Ismail, Kuala Lumpur. Companies who are interested, please communicate directly with Communication International Associates (S) Pte Ltd, 44-46 Tanjong Pagar Road, Singapore 0208. Telephone (65) 226 2838. Fax (65) 226 2877.

REGISTRATION FEES

The Conference fees are:
Late Registration after 31 8 92

Local participants	
ENSEARCH members	MS700.00
Non-ENSEARCH members	MS800.00
Foreign participants	US$35 0.00

The full registration will include attendance at the 3-day conference, conference papers, morning and afternoon refreshments, lunches and selected technical visits. Reduced fees offered for early registration s before 31st August, 1992.

ACCOMMODATION

Arrangements will be made to reserve accommodation in city hotels by request. Please indicate in the reply form.
Please address all communications and enquiries to:
The Conference Secretariat, ENVIRO-PRO '92, C - ENSEARCH, 38A Jln SS21 58, Damansara Utama, 47400 Petaling Jaya, Malaysia. Telephone: 03-7177588 7173819. Fax: 03-7177596.

NOTICE OF MEETING!

Proposed Workshop — Air Pollution Modelling & Its Application

Information Circular.

We plan to hold a residential-type workshop in the week beginning March 21st, 1993 on the topic of Air Pollution Modelling and Its Application. The workshop will involve workers from Australia, New Zealand and south-east Asia: participation will be restricted, with total numbers limited to about sixty.

The workshop will most likely take place over a three day period at the Cape Schanck Convention Centre, some 50km south of Melbourne, with a fourth day given over to local institutional visits in Melbourne for overseas people (and those from interstate, if requested).

The main objectives of the workshop are as follows:

1. To provide up-to-date information on relevant work and activities.
2. To act as a forum for critical comment on current and planned activities.
3. To aid communication and interaction between groups and individuals.
4. To bring together workers in Australia, New Zealand and S.E. Asia.
5. To identify critical air-pollution issues requiring greater attention in the future.

Themes to be covered include.

1. Industry Perspectives & Problems.
2. Air Pollution Models.
3. Latest Developments in Theory and Modelling.
4. Critical air pollution issues in the south-east Asian region.

Proceedings will be published in a special volume of Clean Air (Australia).

Registration fees covering all-inclusive accommodation and meals, workshop participation, workshop abstracts, refreshments and transport between Cape Schanck and Melbourne (where required) will be in the vicinity of $750.00.

DITAC are to be approached for the funding of south-east Asian participants.

For further information, contact Dr John Garratt at the CSIRO Division of Atmospheric Research.

AIR POLLUTION CONTROL COURSE

You are invited to register for a 2 day course on air pollution control, to be held in **Adelaide on 28 - 29 October 1992**, at the **Air Quality Laboratories of the Department of Environment and Planning, 310 Richmond Road, NETLEY.**

Due to demand, a third 2 day air pollution control course will be conducted by the SA Branch of the CASANZ on 28-29 October 1992. The course has been modified in response to the changing demands being placed upon industry with environmental auditing and effective maintenance being added to the course subjects.

The course will provide sound practical advice for plant managers, engineers and operators to solve air pollution problems and to prevent air pollution events. A comprehensive training course manual will be provided.

Lectures will be presented by experts from the air pollution control industry. The venue will allow up to 30 people to be accommodated and the lectures will take the full 2 days including an inspection of an industrial plant exhibiting several forms of air pollution control.

The cost will be $350 for members and $400 * for non members of the society. This cost includes tuition fees, course manual, lunches, morning and afternoon teas and the course dinner.

The course meets the requirements for eligible training under the government training guarantees.

If you are interested in attending, please fill out and return the registration form as soon as possible, since numbers are limited to 30.

Registrations will be accepted when accompanied by payment.

* Registrants who join the Clean Air Society at a fee of $32.00 will be able to enrol for the course at members' rates - a saving of $50.

(Please detach and return)

Mr K Webb
Clean Air Society of Australia & New Zealand
PO Box 1902
ADELAIDE SA 5001

Tel: (08) 45 1681

Name: ..... **Affiliation:** .....

Address: .....

I wish to attend the Air Pollution Control Course 28 - 29 October 1992.

Member ($350.00) Non-member ($400.00)

Please find enclosed cheque for $ ..
please make cheque payable to CASANZ)

Signature .....

DEADLINE FOR REGISTRATION: 1 OCTOBER 1992

BACKGROUND ODOUR LEVELS IN SUBURBAN SYDNEY

DAViD G LAING-, ANDREW EDDY* AND CATHERINE JAMES

UNIVERSITY OF WESTERN SYDNEY. * CSIRO FOOD RESEASRCH LABORATORY

ABSTRACT

In order to determine whether residents of Glenfield who live adjacent to a sewage treatment plant are subjected to greater levels of odorous chemicals during their normal daily life than a community distant from a sewage plant iWahroonga). samples of air were collected over several months from both locations and assessed by a human panel who were not associated with either location. An eight channel air-dilution olfactometer and a forced choice triangle test were used to establish odour thresholds.

Statistical analyses of the data showed that there was no significant difference between the levels of odour to which communities at Glenfield and Wahroonga were exposed, the levels being 4.4 and 4.8 odour dilution units respectively. These odour levels were significantly higher than that of the control sample [Medical air, 2.8 odour dilution units). Thus, the study showed that during a normal day the residents of Glenfield living closest to the sewage plant are not exposed to levels of odorous chemicals that are higher than those found in an industry-free location at Wahroonga.

INTRODUCTION

Odours from the Sydney Water Board's Glenfield sewage treatment plant have been the cause of complaints by nearby residents for a number of years. Although there has been a significant reduction in the frequency of complaints as a result of the upgrading of processes within the plant there is concern in the community that residents may be exposed to airborne odorous chemicals when they are downwind from the plant even when no odour can be perceived. Since lengthy exposures to an odorant can result in olfactory adaptation and reduce the sensitivity to odours, it is possible that residents could be exposed to odours without sensing their presence.

Accordingly, the objective of the present study was to determine if the usual background level of odour at locations in Glenfield approximately 500 metres from the plant, where complaints are frequently registered when emission rates are high, are higher than those at a location in a suburb free of industry, sewage plant, and exposed to minimal vehicle emissions.

Since it is very difficult to relate chemical analyses of complex odour mixtures such as those from sewage to odour thresholds, the procedure adopted in this study was to determine the level of odour by measuring odour thresholds using a group of panellists to assess air samples collected from the two designated suburban locations. By using panellists not resident at either location and therefore less I'kely to be affected by adaptation to odours encountered at those locations, it was proposed that this 'neutral' panel would be capable of establishing the odour thresholds of air collected from these distant locations. Furthermore, conducting the assessment at the relatively odour-free olfaction laboratory at CSIRO. a site remote from either collection location, enhanced the chances of measuring differences in odour quantity between the two locations.

The objective, there'ore, was to determine and compare the background odour levels in two suburbs representing a location adjacent to a sewage treatment plant and a location free of industry, sewage plant ana exposed to minimal venicle emissions.

METHODS

A. Panelists

The panellists were all staff of the CSiRO Division of Food Processing and most had some experience with sensory testing. A pool of 16 panellists aged between 23 and 50 years (10 females, 6 males; was used

facts 1 Odorants used for Screening Panelists

Odorant	Description
Mandarin aldehyde (Dragoco 0 11192; ;-Carvone (Fluka	Orange Citrus
Methyl salicylate (Dragoco) 3 954880	Spearmint
Ethyl butyrate (BDH;	Dencorub
Chamogrom (Dragoco 3 91962;	Fruity
Cis-3-hexenol (Dragoco 4 94911011	Mushroom
Benzaldehyde (May and Baker	Cut grass
Eugenol (Fluka;	Almond
Jasmine (Dragoco 0 21450.	Cloves
Coumarin (Bourney &.	Floral
	Chocolate

throughout the study, an aim being to keep th's pool size to a minimum to ensure that as far as was practicable the same panellists v/sra usee to assess sarnples from both locations.

All panellists underwent a prelirninary test of their sense of srnell. In this test each panellist was presented with to very different odours (Table 1). Each odour, in a gauze covered brown bottle, was number coded and presented singly along with a list of four odour descriptions (Table 2). A panellist was required to select the description from the list of words which best described the odour they had sniffed. For a panellist to bo accepted into the study at least 8 out of the 10 odours had to be correctly identified.

This form of test has been shown to correlate well with the outcome of odour threshold tests and is used routnely ,h the United States (Doty et al 1984 and Australia (Lewitt et al.1989) in clincal tests for smell deficiency.

In each assessment of a collected air sample 10 panellists were employed.

Table 2 Panellist Screening Test

Odour Descriptions

MUSHROOMS	ORANGE CITRUS
ORANGE CITRUS*	CUT GRASS
SPEARMINT	FLORAL
CLOVES	SPEARMINT*
COCOA	CLOVES
CUT GRASS	FRUITY*
DENCORUB*	CUT GRASS
ORANGE CITRUS	ALMOND
MUSHROOMS*	FRUITY
DENCORUB	COCOA
CLOVES	CUT GRASS*
SPEARMINT	FLORAL
CUT GRASS	FRUITY
ALMOND*	SPEARMINT
FLORAL	ORANGE CITRUS
MUSHROOMS	CLOVES*
FLORAL*	MUSHROOMS
SPEARMINT	DENCORUB
COCOA	CHOCOLATE*
DENCORUB	ORANGE CITRUS

Note Target odorant is marked here with an asterisk

B. Olfactometer

An eight-channel air dilution olfactometer was designed and constructed to deliver low levels of environmental odours and to measure human responses to these odours. The instrument provided dilutions of between 0 and 127 as shown in Table 3. A schematic diagram of the olfactometer is shown in Figure 1.

Flow of diluent air (Medical air) and odorous air to panellists was computer controlled (Sancom XT Turbo) with the computer directing these air streams through specific solenoid valves to the three sniff outlets. These outlets were constructed from cylindrical Plex.glas and Teflon. The final flow of air through each sampling outlet was 1.5L min $^{-1}$.

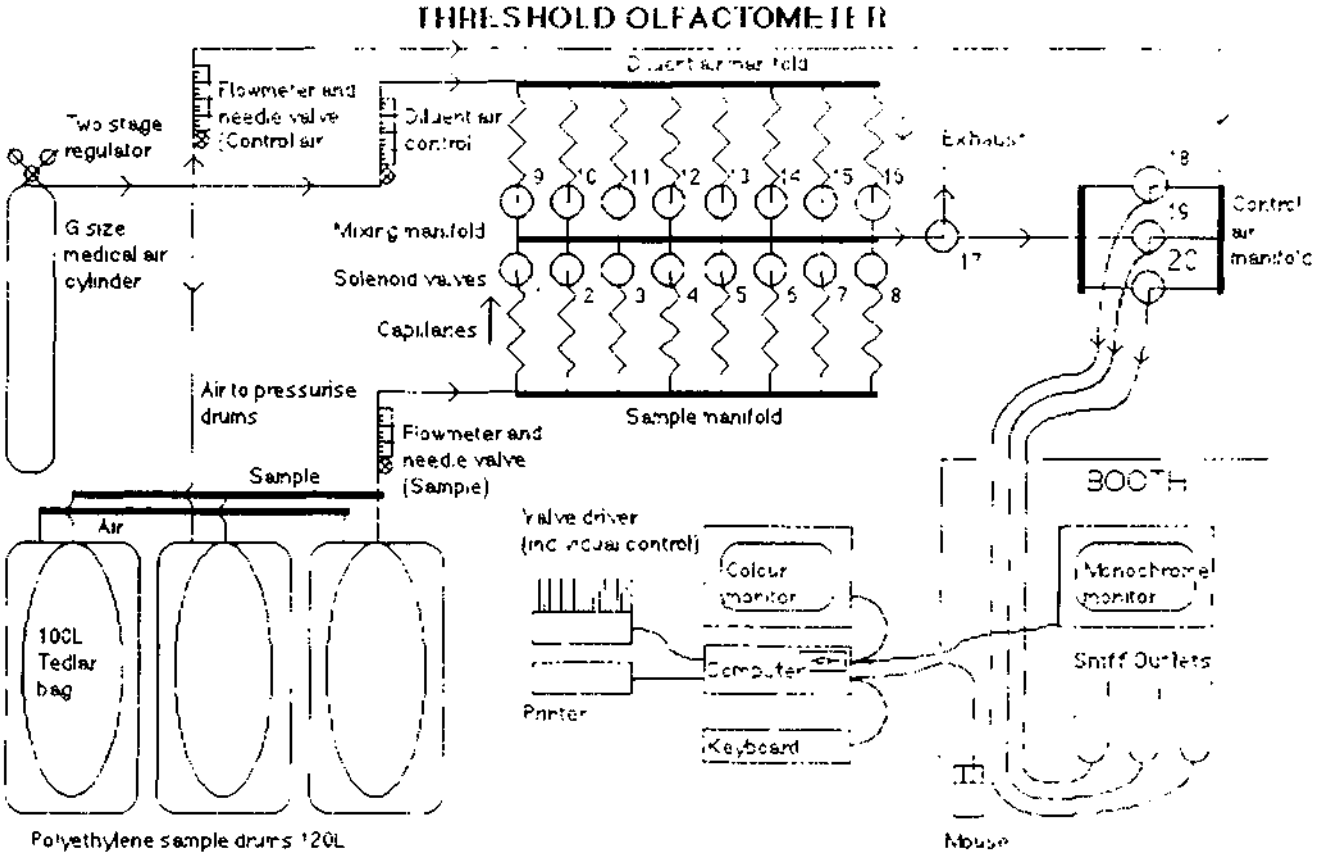


Fig.1. Shown is a diagrammatic representation of the olfactometer. 1-16 designate two-way Teflon solenoid valves connected to Teflon or stainless steel capillaries of different lengths and internal diameters, providing dilutions described in Table 3. Solenoids 1-8 control odorous air from the collection bags and 9-16 diluent air from the cylinder. 17 is a three-way solenoid valve normally open to exhaust except for 20 s during each sample presentation when it allows odorous air to pass to the flow switching valve - manifold complex containing the three-way solenoid valves 18, 19 and 20. Two of these valves deliver control air and the other odorous air to the three sniff outlets during a sample presentation. Selection of the valve through which odorous air passed during a sample presentation was computer-controlled.

Table 3 Odour Dilutions*

Dilution Step	Relative Quantity of Odorous Sample	Relative Quantity of Diluent Air	Odour Dilutions Units
1	1	127	128
2	1	63	64
3	1	31	32
4	1	15	16
5	1	7	8
6	1	3	4
7	1	1	2
8	1	0	0

* Note: The total volume at each step was constant regardless of the ratio of the odorous sample and diluent air.

C. Collection Procedure

Air from each location was collected in three Tedlar bags (100 L capacity. Air-Met Scientific Pty Ltd) contained inside three Polyethylene bins (120 L. Rheem Aust. Pty Ltd). The top of each bin was fitted with a Teflon-glass needle valve (Gilmont, USA) which allowed entry and exit of collected air to a bag, and for 'flushing' air [Medical air, ex CIG) when cleaning the bags. Each bin top was also fitted with a brass tail piece to which was attached PVC tubing (id), and the latter connected to a vacuum pump (Dynavac Eng. Pty Ltd. OD 2-12) to allow filling and evacuation of air from around the bag inside each drum.

Prior to collection of air samples, all three bags were flushed three times with Medical air. emptied by pressurising each bin with Medical air, and the needle valves closed. Once at the collection location the three drums containing the bags were connected by a common transfer manifold (glass), the Teflon tubing fitted to the needle valves and PVC tubing to the brass tail pieces. The PVC tubing was attached to the vacuum pump to evacuate air from the drums and allow the intake of sample air into the bags. To fill the sample bags, the needle valves were opened and the open end of the Teflon tube held at arms length into the air and the vacuum pump switched on. Bags were filled until they virtually filled the drums but not so that the bag wall was taut, to avoidstress and damage to the seams. Filling was monitored through a small window in the lid of one of the drums. Once the bags were filled the needle valves were closed, the pump turned off and the transfer manifold dismantled.

On returning to the laboratory from the collection location, the drums were re- connected via the transfer manifold, the PVC tubing connected to the cylinder containing Medical air and the Teflon tubing to the sample line. Air pressure was adjusted to 15 psi at the air cylinder which was reduced to a pressure of 5-7 psi in the drums. This pressure forced the sample out of the bags at the correct flow rate into the olfactometer. Using software developed in this laboratory, the test sample of collected air and Medical air (control) was delivered under computer control via solenoid valves to the three Teflon sniff'ng ports.

D. Collection Siies

The two suburbs where air samples for the study were collected were:
1) Glenfield.
The specific locations at Glenfield were dictated by wind direction. Initially, the plan was to sample from a street location within Glenfieid where many of the complaints about sewage odours originated. However, due to the low frequency that the wind was in the correct direction, i.e., blowing from the plant to the particular street, the strategy adopted was to collect air downwind from the Plant at street locations in Glenfield which were similar distances from the Plant (-500 metres) to the original target street and had similarterrain between each location and the plant. Street locations, date and time of collection as well as wind direction are given in Table 4. Wind direction was obtained before each collection from the wind gauge at the sewage plant. From this information and a map of the immediate environs, a collection site was chosen. Samples were collected late in the afternoon (1600-1700 hrs) close to the time period when members of the local Resident's Committee and the Sydney Water Board indicated most corn-

Table 4 Co ection Data

Glenfie c

Collection No.	Date	Wind Direction	Wind Strength	Location*	Comments#
1	4 3	SE	weak	A	no smell
2	13 3	E	weak	B	strong smell
3	18 3	SE	moderate	C	no smel
4	25 3	SE -E	strong	A	slight smell
5	4 4	E -NE	weak	D	smell
6	11 4	E -NE	weak	C	pockets of smel
7	17 4	N	very weak	D	no smel
8	22 4	E -SE	moderate	A	strong smell
9	6 5	N	very weak	F	bad pollution day in Sydney
10	8 5	E -SE	weak	A	no smel

* A. Owen Stanley Street. B. Orb Place. C. Melia Place. D. Hickory Place. E. Laure Place. F. Beech Place
# Comments refer to odours at the Glenfelc Sewage Treatment Plant prior to each collection. In no instance was there an obvious sewage smell in the street locations sampled

Wahroonga

Collection No	Date	Wind Direction	Wind Strength	Comments
1	13 2	N	moderate	
2	20 3	SE	moderate	
3	28 3	S	weak	
4	2 4	S	weak	
5	10 4	W	moderate	
6	15 4	SE	weak	
7	24 4	SE	moderate	
8	30 4	W	moderate	strong smoky smell

plaints involving sewage odours occurred.

2) Wahroonga.

Following a review of locations in the Sydney Metropolitan area, a location in Wahroonga in the North Western part of Sydney was chosen as an example of a relatively pollution free envronment. The collection site was at the centre of a grassy oval which was surrounded by bush and there were relatively few cars and houses in the immediate vicinity. In addition, there are no local industries or a sewage plant within several kilometres of the site, and all residences in the area are sewered. The site, therefore, provided an excellent example of a relatively pollution free location to compare with the background odours experienced by residents of Glenfield downwind from the sewage plant.

E. Odour Threshold Test

It is widely recognised that a very sensitive and reliable method for the determination of odour tnresholds is the three-alternative forced choice procedure. This method involves the selection of the odd sample from a set of three, where two of the samples are controls, in this Instance Medical air. Furthermore, to ensure minimal interference from olfactory adaptation the test samples should be presented in an ascending order of concentration which maximises panellist sensitivity and reliability.

The method followed in the present study, therefore, was an ascending three-alternative forced choice procedure. A computer controlled both the delivery of a sample and monitored the responses of each panellist. A panellist assessed a sample following an instruction given on She computer monitor which displayed three rectangles representing me three sniff outlets before the panellist. Once all three outlets nad been sniffed the panellist used a 'mouse' to indicate on the monitor which outlet contained the different sample of the three presented, two of which were controls. The first sample was at a very low concentration (high dilution), normally corresponding to about 32 dilutions (volume volume) (Table 3). A response was required on each trial even if no difference between the samples could be discerned. An incorrect response by a panellist resulted in a sample twice the concentration being presented on the next trial, whilst with a correct response the same concentration was repeated. Following a second correct response a third replicate at the same concentration was given. If all three replicates at a particular concentration elicited a correct response, that concentration was taken as detection threshold 1 for the panellist. The same procedure for establishing the threshold was then repeated a further two times during the session and the median value of the three thresholds was defined as the detection threshold for that particular individual for that day. Using this stringent but conservative threshold criterion there was only a 1/27 probability that the three correct choices made during each replicate had occurred by chance. From experience with each panellist prior to commencing the study, a starting d lution was chosen for each panellist wnich was approximately three concentration steps below their detection threshold, i.e.. about 1/8 x threshold. This tactic saved time and sample, and proved to be satisfactory for establishing the threshold three times during each session.

The timing for sample presentation to each panellist and flusfiing of the olfactometer lines between test trials was:

Pre-sniffing delivery of sample 5 sec
Sniffing time allowed 15 sec
Flushing of sampling ports and delivery lines 10 sec
Flushing of olfactometer mixing manifold to exhaust 10 sec
Total time for delivery, sampling and flushing during one test trial, therefore, was 40 sec.

Table 5 Variation of Odour Threshold Levels Across Collections

Location	Collection	No of Panellists	Dilution Step
Glenfield	1	10	6.5
	2	10	5.6
	3	10	5.6
	4	10	5.6
	5	9	5.6
	6	10	5.4
	7	10	5.3
	8	10	6.0
	9	10	6.6
	10	10	6.8
Wahroonga	1	10	7.1
	2	10	4.7
	3	8	5.8
	4	10	5.2
	5	10	5.4
	6	10	5.8
	7	10	6.9
	8	10	5.4

RESULTS

The data from 10 collections at Glenfield and 8 collections at Wahroonga are shown in Table 5. The Table shows tne number of panellists and mean panel thresholds (dilution step) for samples from the two locations. The calculation of the threshold for an individual panellist for a single air collection was defined as the median of three thresholds using the three forced-choice procedure. From these data the mean thresholds (dilution step) and standard errors (in parenthesis) over all collections were calculated to be 5.9 (0.14) and 5.8 (0.18) for Glenfield and Wahroonga respectively, which correspond to 4.4 and 4.8 odour dilution units (Table 6). The mean value and standard error for the control (Medical air) sample was 6.6 (0.33) or 2.8 odour dilution units.

A chi-square test (Mood et al.1974) indicated that the distributions of thresholds for samples from the two collection sites (Fig. 2) were not significantly different (X2 = 2.25. p = 0.95i. A one way analysis of variance using the median threshold values for individuals as the data, also indicated that there was no significant difference between the odour levels at Wahroonga and Glenfield :F = 0.52. P = 0.473). but that there was a significant difference between the odour levels from these two locations (combined because of their similar values) and the control (Medical air) (F = 4.25. P = 0.04).

Further analyses (t tests) were employed to investigate whether the absence of a significant difference between the distributions for the two locations was being masked by much larger differences between individual panellists. Accordingly the analyses assessed whether tne thresholds of individual panellists were differert for the two sites. In this instance only the data from panellists who had participated in a significant proportion of the tests from both sites were considered. The analyses clearly snowed (Table 7) that in no instance was there a significant difference between the mean thresholds (dilution step) of a panellist for the two sites. An analysis was aiso conducted to determine if there was a significant variation in odour levels across collections from the same site. e.g.. Wahroonga. A one-way analysis of variance indicated that there were significant differences between odour levels of air collected at Wahroonga (F = 3.70. P = 0.002) but not across collections from Glenfield (Table 5).

Since there was no significant difference between the odour levels at the two collection locations but the levels were significantly higher than the control, a preliminary assessment of the type of odours perceived at the two locations and their pleasantness was conducted. This was achieved by establishing the threshold of each panellist using the same procedures as outlined earlier, then giving each panellist a single presentation of the sample at increasing suprathreshold concentrations. At each dilution step above threshold, panellists were required to provide a description of the odour and to rate its pleasantness on a 150 mm line scale which had the words 'Extremely Pleasant' and 'Extremely Unpleasant' on opposite ends. A similar procedure was used with a control sample.

The very preliminary results indicated that odours from all three sources were generally unpleasant (Table 8). As regards the type of odour no specific type emerged with different panellists using different descriptions for a particular location and there was little variation in the odour descriptions by an Individual for odours from the two sources. Thus there was no odour which was characteristic of Glenfield or Wahroonga. It is stressed, however, that this was a preliminary study and the data are based on a single collection from each location. It is possible that different odours might be perceived

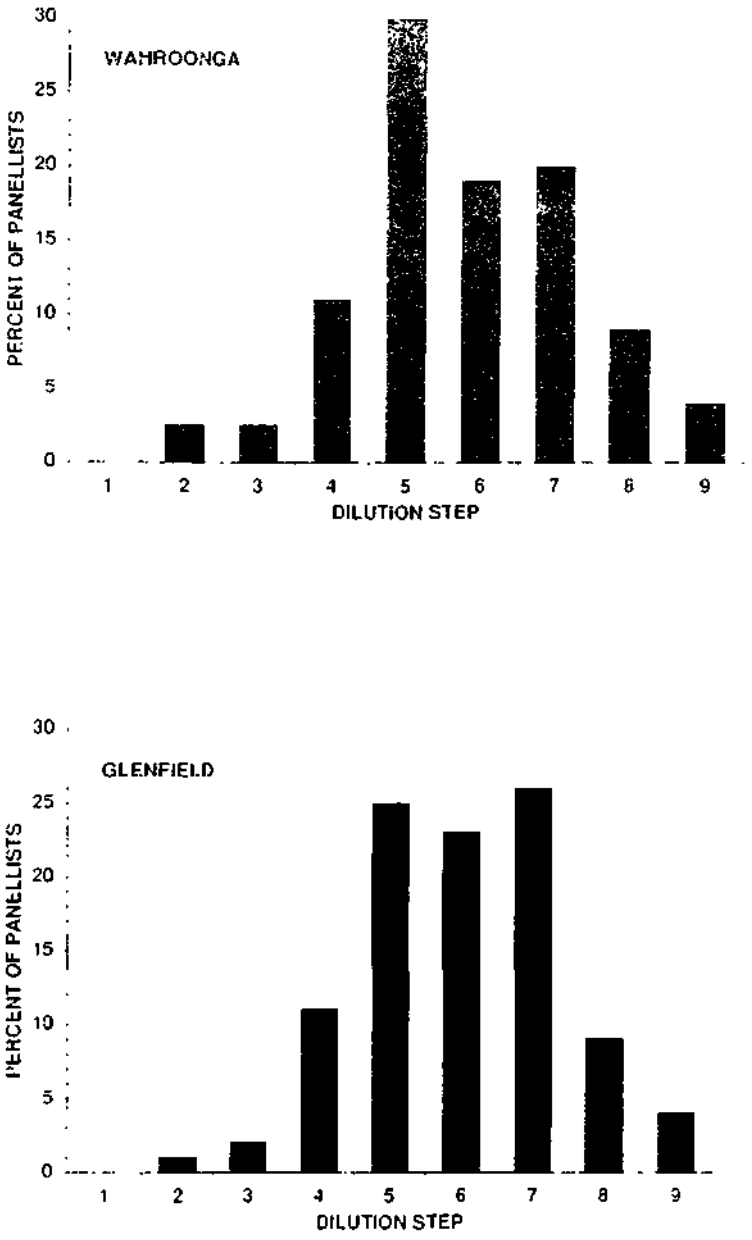


Fig 2 Distributions of odour thresholds to air collected at Glenfield and Wahroonga

in samples collected on other days. However, it should be noted (Table 3) that during every collection at Glenfield, although there was an obvious odour at the plant, none could be perceived downwind at any of the collection sites.

DISCUSSIONS AND CONCLUSIONS

The most important finding of the present study was that the levels of odours at the sampling sites at Glenfield and Wahroonga were low and not significantly different. Indeed the results indicate that this finding held for each of the panellists who participated in most of the assessments (Table 7j. demonstrating both the consistency and validity of the data. Importantly, although statistical analysis showed that the level of odours at the two iocations was higher than that found for the control sample (Medical air), the difference in practical terms was small i.e.. 2.8 v. 4.4- 4.8 odour dilution units. This conclusion is supported oy the fact that no clear descrptions of tne odours at both locations emerged from a preliminary assessment of the characteristics of the odours. To put the levels in another context, hydrogen sulphide, for example, at a level of about 4 odour dilution units is described as 'faint'.

An interesting and perhaps controversial outcome of the present study was the finding that the odour back-

Table 6 Panel Thresholds

Location	Dilution Step	SE	Odour Dilution Units
Glenfield	6.9	0.14	4.4
Wahroonga	5.8	0.18	4.8
Control	6.6*	0.33	2.8*

* significantly different ($p < 0.04$) from other values

Table 7 Thresholds of Individuals

Panelist	Location	N	MEAN DILUTION STEP	SE
1	Wahroonga	8	5.50	0.53
	Glenfield	10	5.40	0.37
T	0.15 P	0.88 DF	13	
2	Wahroonga	8	5.63	0.46
	Glenfield	9	5.00	0.24
T	1.21 P	0.25 DF	10	
3	Wahroonga	7	5.43	0.37
	Glenfield	10	5.60	0.37
T	-0.33 P	0.75 DF	14	
4	Wahroonga	7	5.00	0.53
	Glenfield	8	5.25	0.45
T	-0.36 P	0.73 DF	12	
5	Wahroonga	6	6.50	0.34
	Glenfield	6	6.83	0.40
T	-0.63 P	0.54 DF	9	
6	Wahroonga	8	4.25	0.62
	Glenfield	10	4.50	0.48
T	-0.32 P	0.75 DF	13	
7	Wahroonga	7	6.29	0.42
	Glenfield	9	6.11	0.26
T	0.35 P	0.73 DF	10	
8	Wahroonga	6	5.67	0.42
	Glenfield	6	6.33	0.21
T	-1.41 P	0.20 DF		

Table 8 Pleasantness of Collected Air

Sample	Dilution Step							
	1	2	3	4	5	6	7	8
Wahroonga	0	0	39.5	71.8	73.2	82.4	83.4	95.4
Glenfield	0	0	0	12.3	69.5	85.7	93.6	107.83

A rating -75 indicates the sample was pleasant; +75 unpleasant

ground air.sing from new Tedlar bags was found to be 2.8 odour dilution urits One implication of this result s that tne current thrust in Australia to legislate tor a level of one odour dilut:on unit at the boundary of a sewage plant or factory will be difficult to establish since it appears impossible to measure that level with the best quality collection bags despite repeated flusning with Medical air.

In concluson it seems clear that the community at Glenfield is not exposed to higher levels of odorous chemicals than other communities in the Sydney Metropolitan region, except on nfrequent occasions when high odour emission rates from the sewage plant and appropriate weather conditions prevail.

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ACKNOWLEDGMENTS

The authors wish to thank Mr D J Best and Ms M Sullivan for statistical analyses, and the sixteen panellists for participating in the study. Thanks also go to the CSIRO Division of Food Processing for providing the test lac iities. and the Water Board, Sydney for a grant to finance the study.

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ION BEAM ANALYSIS TECHNIQUES IN AEROSOL ANALYSIS

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ABSTRACT

The three accelerator based ion beam analysis tecnniques of particle nduced X-ray emission (PIXE). particle induced gamma ray emission (PIGME) and particle elastic scattering (PESA) are described. Their application and suitability to aerosol particulate analyss is discussed and it is shown that these ion beam analysis techniques are fast, relatively cheap, non destructive, very sensitive to a broad range of elements across the periodic table from hydrogen to uranium and ideally suited to the elemental analysis of filter papers obtained in these studies. The tecnniques require access to a megavolt particle accelerator, however, there are hundreds of these available, mainly in nuclear physics laboratories, around the world which have adapted their nuclear structure studies to include ion beam analysis techniques.

INTRODUCTION

Over the past decade there has been a steady growth both in the number and the sophistication of elemental analysis techniques being applied to the particulates on aerosol samples. These elemental techniques include neutron activation analysis (NAA), X-ray fluorescence (XRF), atomic absorption spectrometry (AAS). inductively coupled plasma mass spectrometry (ICPMS) and ion beam analysis (IBA). The principles, instrumentation and methodological aspects of several of these as applied to aerosol studies have been reviewed by Johansson and Campbell 1988 and Maenhaut 1990. It is the purpose of this article to describe the application of some accelerator based IBA techniques to elemental analysis of particulate matter on filter papers obtained during atmospheric aerosol studies. These techniques have been used extensively overseas for pollution studies but have not been used quantitatively for large number of samples in Australia until now.

In modern day environmental studies there is an increasing need for atmospheric aerosol studies. Particulate matter in the size range up to 100 µm in diameter effects human lungs and health, deposits on vegetation and buildings and impairs visibility. Concentrations of these particulates may vary from around 10 ng m^3 in the stratosphere to 1 kg m^3 in stacks and industrial environments.

We will show that accelerator based IBA techniques are ideal for elemental analysis of aerosols. They are fast, non- destructive, require no sample preparation and can analyse submicrogram samples on a filter paper in just a few minutes of machine time for more than 35 different elements simultaneously. The range of possible elements covers most of the periodic table including hydrogen with more than sufficient sensitivity. Furthermore, because the techniques are so fast hundreds of samples a day can be analysed.

The ion beam analysis techniques to be discussed here are:
(a) PIXE - Particle induced x-ray emission, useful for the analysis of elements from silicon to uranium in concentrations from a few µgg $^{-1}$ to 100%.
(b) PIGME - Particle induced gamma ray emission, useful for the analysis of light elements such as Li. B, F, Na, Mg. Al and Si in concent'ations from a few µgg $^{-1}$ to 100%.
(c) PESA - Particle elastic scattering analysis, useful for the analysis of light elements such as H. C and N in concentrations from tens of µgg $^{-1}$ to 100%.

In general, analytical techniques with capabilities of detecting elemental concentrations of parts per million by weight on milligram samples will have the ability to quantify nanograms of material in the sample. Aerosol filter papers are such samples, typically weighing around 0.3 mg cm" with elemental concentrations several orders of magnitude below this. The ion beam techniques discussed here are ideally suited to perform such elemental analyses on filter papers. Cahill 1990 shows that IBA techniques have been used to detect elemental quantities as small as 50 p g m^3 of air obtained from only 50 µg of sample on a filter paper.

A complete ion beam analysis system consists of three basic components:
(a) Low voltage :few tens of kV) on source which produces slow low energy keV ions usually of protons of helium ions.
(b) An accelerator consisting of a high voltage terminal (1 to 10MVi whicn accelerates the low erergy ons to MeV energies for interaction with the target.
(c) A target chamber generally under vacuum, into which the accelerated ion beams are passed and made to interact with the target or sample. The chamber can contain three or more detectors to detect interaction products such as X-rays, gamma rays and scattered particles. Data from all of these detectors may be collected simultaneously and target manipulation and data acquisition are typically fully automated so hundreds of samples a day can be handled.

MeV ion accelerators are not small devices. Accelerator tanks can vary

in size from 1m in diameter and 2m long for a 1 MV machine to 4m in diameter and 14m long for a 10 MV Tandem accelerator. The picture of Fig. 1 shows the 8 MV FN Tandem at the ANSTO which is capable of accelerating protons to energies of 16 MeV and Cl^{n+} ions to nearly 100 MeV. Accelerators are not portable devices, so the samples for analysis must come to the machine and these are placed in the target chamber at the high energy end of the beamline. Fig. 1b shows the ion beam analysis chamber at ANSTO. It consists of a central target chamber surrounded by detector systems and a target manipulator for inserting the samples automatically into the ion beam.

Typically for aerosol filter paper analysis ion beam current densities of around 1 nA mm^2 or less are used so volatile elements such as hydrogen, selenium and mercury, which are not lost in the vacuum, are not driven off the sample by heating effects of the ion beam. Currents as small as this correspond to power densities for MeV ions of only a few mW mm^2. This leaves the sample fully intact for further analyses by other techniques and is the main reason for the non destructive nature of ion beam analysis techniques.

ION BEAM ANALYSIS TECHNIQUES

When a light ion such as a proton or helium ion from an accelerator interacts with an atom in the target material several reaction processes are possible. Some of these are shown in Fig. 2. Ion interactions with a target atom electron cloud produce ionisation (electron ejection) and subsequent photon emission, usually an X-ray photon. This is called particle induced X-ray emission (PIXE). Nuclear interactions may scatter the incoming ion, produce gamma rays, called particle induced gamma ray emission (PIGME), or interact with the nucleus producing other light particles, this is called nuclear reaction analysis (NRA). Furthermore, ion interactions with several target atoms may break chemical bonds, produce light or UV, sputter atoms from the surface itself or, if the target has its own crystalline structure, even channel the incoming ion along the ordered rows of atoms in the target. The result of all these processes is the ion loses energy in the target material and products are produced which when detected can provide valuable information about the target's elemental composition with very high sensitivities.

Fig. 1 (a) Picture of the 8 MV Tandem accelerator at ANSTO (b) The PIXE, PIGME and PESA system at ANSTO. The central target chamber is surrounded by detectors and a winged beamline at 90 degrees to the incoming ion beam which contains a 1m long target stick holding up to 30 aerosol samples at a time

PARTICLE INDUCED X-RAY EMISSION (PIXE)

Particle induced X-ray emission or PIXE became popular in the mid 1970's following an excellent review on the analytical applications of PIXE by Johansson and Johansson 1976. PIXE now has a world wide following with many small accelerator laboratories operating their own analytical facilities. There are currently over 100 laboratories in more than 30 different countries throughout the world operating PIXE systems. The technique of using light ion beams from accelerators to induce X-rays characteristic of the surface being bombarded has been adequately reviewed over the years (Johansson and Campbell 1988 and Cohen and Clayton 1989) and will not be treated again in depth here.

The earliest publications on PIXE

included analyses of aerosol filter papers and this work still continues today at a great pace, (see Vis 1990). The reasons for these types of studies are obvious. They encompass occupational health, atmospheric visibility, acid rain, soil erosion and ecological effects. PIXE can contribute to these studies inspite of the very small masses of material collected on filter papers.

PIXE laboratories all over the world are engaged in studies of the environment, particularly atmospheric aerosol analysis studies. They are producing data of use to legislators in establishing air quality standards as well as a wealth of information for scientific evaluation. Table 1 shows a partial list of some of these laboratories and shows the true international nature and versatility of PIXE analysis for aerosol studies. Cahill 1990 reports on large scale aerosol monitoring programs which extend across the whole of North America, containing more than 50 sampling stations, and generating tens of thousands of aerosol samples for PIXE analysis each year. He comments that since 1975 in north America 90% of all size segregated ambient aerosol samples that have been chemically analysed have been analysed using the ion beam technique of PIXE.

Table 1 A list of some of the international organisations using accelerator based ion beam analysis studies for aerosol research.

Laboratory	Comments
ANSTO, Lucas Heights, Sydney, Australia	Ambient air and occupational monitoring for several years on 1000's of samples.
Florida University, USA	International aerosol studies for over a decade, on thousands of samples.
University of California, Davis, USA	Run major aerosol studies over the whole of north America for decades, using 30000 samples year
Brooklyn College, CUNY, USA	Occupational studies
Lund Institute Lund, Sweden	Leading PIXE laboratory studying aerosols, utilising thousands of samples
University of Helsinki, Finland	Indoor air pollution and aeroso studies
RISO Denmark	Marine aerosol studies
CISE, Milan Italy	Urban environmental studies, particle size and trace metal monitoring
ETH, Zurich Switzerland	Sulphur and fine particle studies
University of Frankfurt Germany	Global source and transport studies from airborne and seaborne samplers
Geel,Gent Universities Belgium	Extensive aerosol studies of urban and remote sites.
University of Sao Paulo Brazil	National air quality monitoring program
IAP, Budapest Hungary	Urban and rural aerosols and long range transport modelling.
Queens University Kingston,Canada	Time resolved streak filter studies of S and Ca concentrations

In Australia, at ANSTO at Lucas Heights, together with the New South Wales Environmental Protection Agency (EPA), the Pacific Power Company and the universities of New South Wales and Macquarie have established a 24 station fine aerosol network system across New South Wales. This network will produce 3000 filter paper samples a year which will be analysed by ion beam techniques on the 3 MV accelerator at ANSTO. This is the first large scale network system in Australia to use quantitative accelerator based ion beam analysis techniques.

PIXE SPECTRA

The X-ray signals produced by ion bombardment of a target atom generate a unique fingerprint for that atom. Figs. 3a and b show the K and L shell fingerprints of pure Cu and Pb targets respectively. These spectra were taken usinga standard energy dispersive Si(Li) detector system and they demonstrate the basic principle of the PIXE technique. That is the X-ray energy or position of the peak determines the element present in the target and the number of X-rays in this peak specifies the amount of that element in the target. For targets containing several elements a detection system with sufficient resolution to detect each elemental signature is required.

There are over 20 elements present at the 0.1wt.% level or less in an average urban air sample. Fig. 4 shows a typical PIXE spectrum obtained for an urban aerosol filter paper after just a few minutes of bombarding with 2.6 MeV protons. The 2.27 cm^2 Teflon filter paper was loaded with fine particles (< 2.5 μm) by exposure to urban air for 24 hours at a flow rate of 21 litres min (total volume 31 m^3). The spectrum consists of characteristic peaks sitting on a background which rises initially but then falls quickly to zero. This background falls by 2 orders of magnitude between 2 and 5 keV, being essentially zero above 6 keV as shown in Fig.4. The lack of background in the

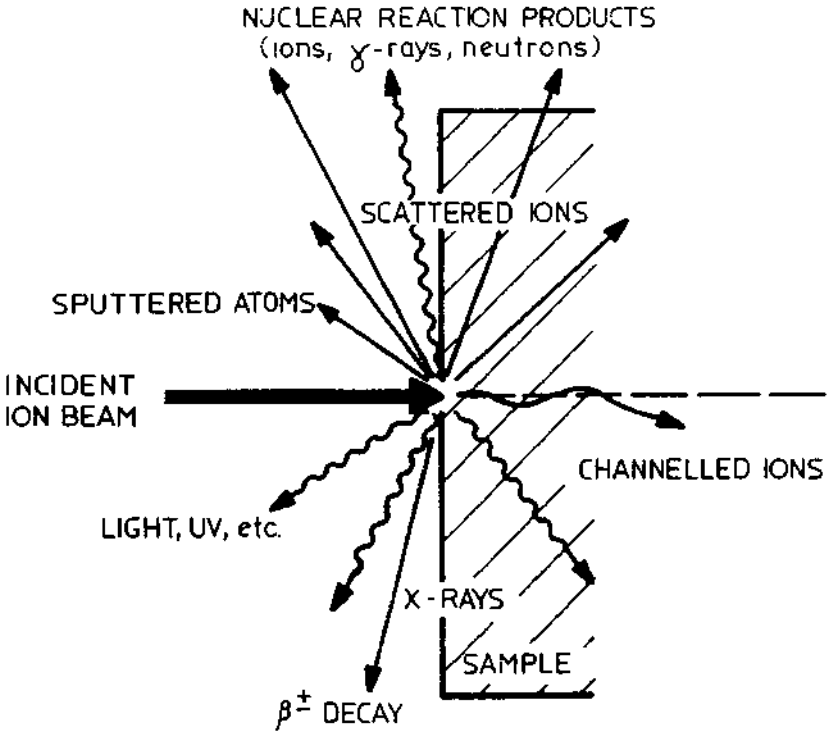

Fig. 2. Ion beam interactions with solid targets The ion beam penetrates the target surface interacting with the target atoms as it loses energy.

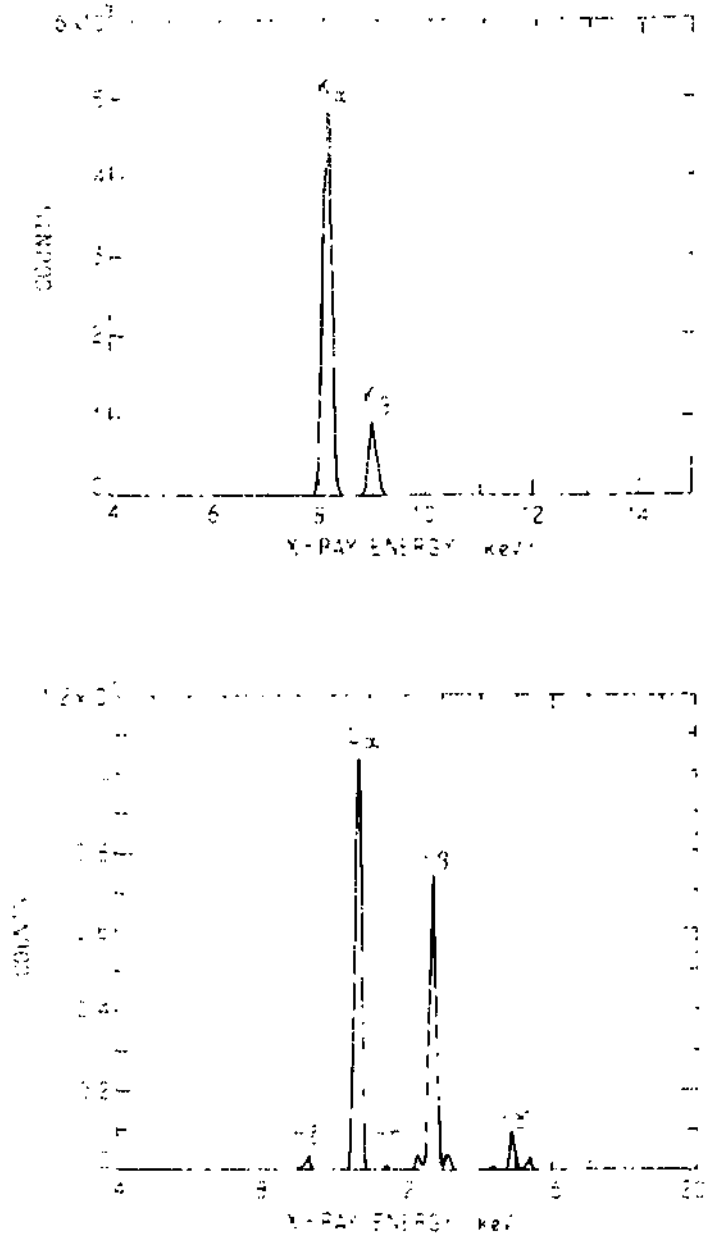

Fig. 3 (a) The K shell X-ray spectrum of pure copper (b) The L shell X-ray spectrum of pure lead

X-ray region above several keV is the reason for the high sensitivity of PIXE compared to other X-ray analytical techniques such as X-ray fluorescence (XRF), see Maenhaut 1989.

The characteristic peaks sitting on this background vary in height over several orders of magnitude. They represent elemental concentrations down to a few parts per million by weight and clearly demonstrate the power of the PIXE technique for elemental analysis. The dashed curve corresponds to the experimental data and the solid curve is a theoretical fit produced by the computer codes generated at ANSTO. These codes enable us to find the peak areas and hence the elemental concentrations in the aerosol sample. Peaks corresponding to X-rays for elements from Al to Pb are clearly seen, including commonly occuring elements such as Cl, S, K, Ca, Fe and Br. The S, Fe and Pb concentrations were found to be 604, 219 and 856 ng m^3 respectively. The minimum detectable limits (MDL's) for these three elements under these run conditions for this spectrum were found to be 3, 1 and 13 ng m^3 respectively which corresponds to only 41, 14 and 178 ng cm^2 of these elements present on the Teflon filter paper.

Applications of the PIXE technique to aerosol monitoring have been adequately summarised by Rinsvelt et al 1987 and Vis 1990 in the proceedings of the two most recent international Conferences on PIXE and its Analytical Applications held in Tallahassee, Florida and Amsterdam, Holland respectively.

PIXE SENSITIVITY

In practice the number of X-rays detected in a PIXE system is not only a function of the probability of the ion beam to produce X-rays but also of their detection efficiency. Most modern X-ray detection systems are designed to operate efficiently for element detection in the range silicon to uranium which is extremely broad and covers a large fraction of the periodic table. Furthermore, the X-ray yields for pure elements over this range are typically much larger than 10^8 counts for common ion beam analysis systems. This shows the power of the PIXE analytical system and demonstrates its μg g capabilities across a large fraction of the periodic table.

For such high yields and low backgrounds the minimum detectable limits (MDL) for many elements are very low. Fig. 5 is a plot of the MDL's for trace elements in a Teflon filter paper for 2.6 MeV proton bombardment. MDL's of a few ng m^3 of air are readily obtainable for elements with atomic numbers from 15 (phosphorous) to 35 (bromine) while MDL's below 20 ng m^3 are readily obtainable for all elements heavier than aluminium. These MDL's can be converted to their equivalent MDL's in ng cm^2 of Teflon filter paper by multiplying by 13.7. It should be stressed that these low MDL's are obtained on up to 35 elements simultaneously during the same 300 seconds of machine running time and corresponds to an analysis rate of 12 samples hour.

Table 2 is a similar calculation of MDL's for trace elements in a quartz matrix together with an estimate of the error on these values. Again we see that MDL's less than 10 μgg^{-1} of quartz are readily obtained for a wide range of trace elements on quartz. If we consider that a quartz filter for aerosol studies might weigh 500 μg cm^2 and have an area of 2 cm^2, similar to the Teflon filters discussed above, then we can see that an MDL of 1 μg g of quartz corresponds to 1 ng cm^2 on a quartz filter and the μg.g values of Table 2

for quartz are d rectiy ccmparaDle to those values for the Te*lo". filter oivon n F-3. ft.

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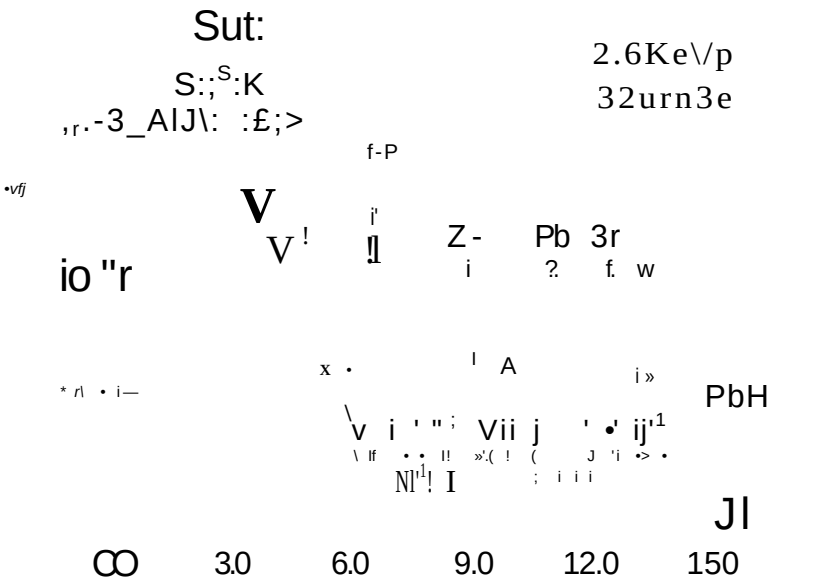
tie-		MDL	Expt Error
Ci	17	44 - 5	10-25
K	19	15 • i	10-25
Ca	20	11 • i	15-25
Ti	22	5.8 • 0.6	15-30
Cr	24	3.5 • 0.4	24-40
Fe	26	2.5 - 0.4	15-25
M	28	22 • 0.4	25-40
Zn	30	2.0 • 0.4	25-40
Ge	32	1.9 • 0.4	25-40
Ro	37	4.8 0.5	25-40

COMPARISON WITH KNOWN REFERENCE STANDARDS

The PIXE icch-uque is not only capabie of producing data on face element concentrations at the parts per million level but also at the same-time can produce estimates of the bulk mafix composition. F:g. 6 ta<en from. Cohen and Clayton 1989 shows the measured PIXE concentrations versus the reference concentrations of hundreds of standard reference materials measurec at ANSTO ove[r] the years. The concentrations cove[r] six decades from 1/ugg[-1] to l00°oand tne solid line of least squares f.t is given by :T.0O - 0.20;. The standard reference materials cover an exfemely rjroad range of trace elements and matrices from biolog-ical to geolog'cal and cemonstrate the real breadth of tne PIXE analys s technique.

Thin and thick target PiXE calcu-lations, and the daia bases asso-ciated with these have reached such a deg[r]ee of sophistication that X-ray yields for trace elements can now be predicted at the 5°= level for an extremely diverse range of known target matrices. Further evidence for this is given by Maenhaut and Raem-donck 1984 who measured a set of accurate thin fum standards and compared this with absolute theoret-ical calculations. They found an individual element could be analysed with an accuracy of better than 4°c for elements from Na to Sn using the PIXE technique.



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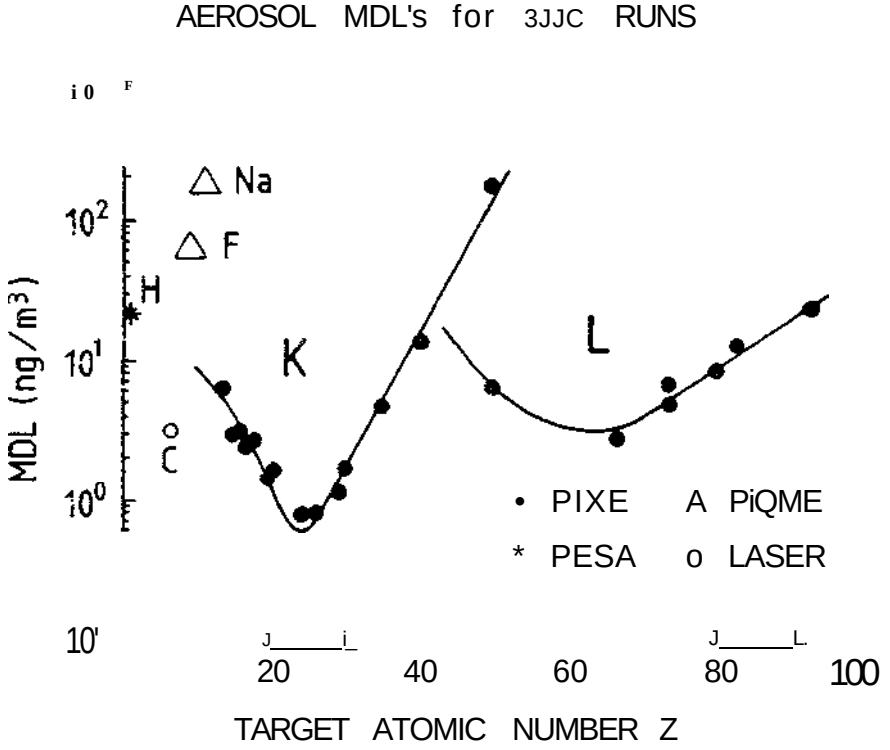

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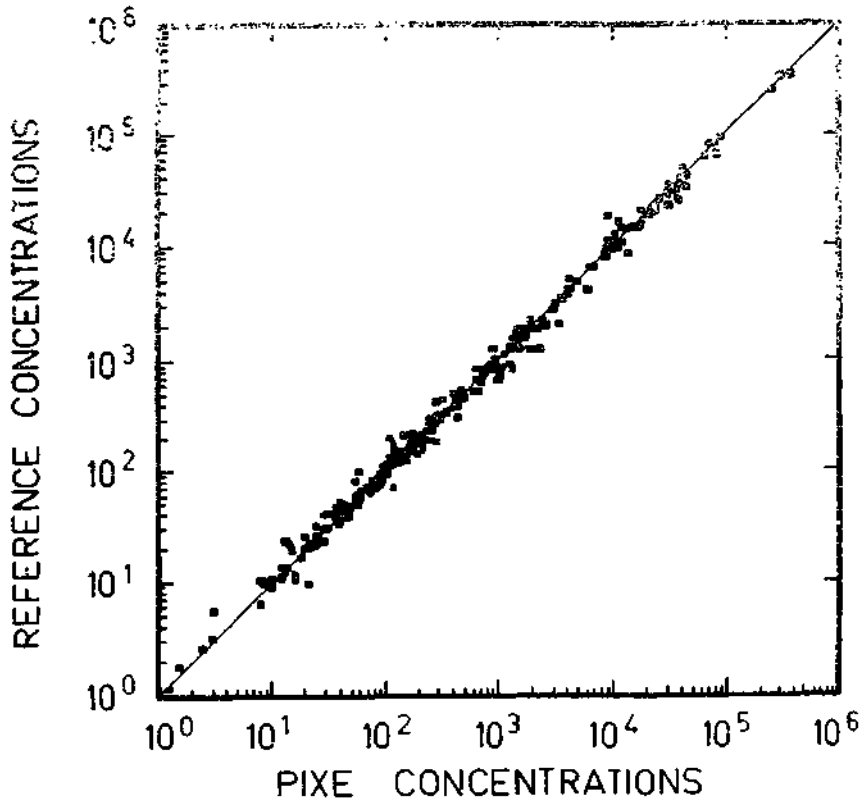

Fig. 2 Comparison of reference concentrations versus measured PIXE concentrations for over 200 reference standards measured at the ANSTO over the past decade or so.

PIXE APPLICATIONS AND LIMITATIONS

A summary of general uses, applications and limitations of PIXE has been given by Cahill 1985 in an excellent review of the topic. It emphasises the power of the PIXE analytical technique which may also include the spatial resolution of better than 1 μm for microprobe systems and mass detection limits well below 1 nanogram. Its application is in the non destructive multielemental analysis of thin and thick samples for elements from aluminium to uranium. This covers such areas as analysis of atmospheric aerosols by particle size for source transport, removal and effect studies. Air filters analysed in this way require no sample preparation they are presented directly to the ion beam for analysis.

The limitations of the PIXE technique include:-

(a) Access to an ion beam accelerator of few megavolts is required. This machine is a large device which is not portable.

(b) Elements below aluminium are generally not readily analysed, although sodium is routinely done by the University of California, Davis Group (Cahill 1985) using a thin windowed Si(Li) detection system and some windowless detectors have detected elements down to carbon.

(c) Minimum detectable limits are generally around 1 μg g so elements present below this value are not detected in reasonable analysis times.

(d) No chemical information is generated, for example, the technique does not distinguish between sulphur as sulphate or sulphur as sulphide.

(e) Analysis of filter papers, although fast and non destructive, is usually done several days or even weeks after their collection.

Analysis times for PIXE are usually between 30s and 5 min and with fully computerised automation available on many systems thousands of samples a week can be analysed for up to 35 different elements each. The capability to analysis large numbers of samples means the cost per sample can be quite small and charges between $40 and $80 per sample, depending on the number of elements required, are typical.

PIXE AND OTHER TECHNIQUES

The principles, instrumentation and methodological aspects of other techniques competing with PIXE have been very thoroughly reviewed in the excellent recent article by Maenhaut 1990. The techniques he discusses include neutron activation analysis (NAA), X-ray fluorescence (XRF) including total reflection XRF and synchrotron radiation XRF, atomic emission (AES), atomic absorption (AAS) and atomic fluorescence spectrometry (AFS) and atomic mass spectrometry, in particular inductively coupled plasma mass spectrometry (ICPMS). Particular emphasis is placed on instrument cost, speed of analysis, sample type and mass required for analysis, accuracy and detection limits. Table 3 has been taken from this review and summarises its findings.

In this article Maenhaut also points out that:-

TABLE 3 Detection limits, in μg g solid sample for 27 elements and six analytical techniques

Element	NAA	ED-XRF[a]	PIXE[a] MDLs	ICP-AES[b] μg g	ETA-AAS[b]	ICP-MS[b]
V	0.03	20	1.3	3.5	0.2	0.03
Cr	0.03	16	0.6	4	0.01	0.06
Mn	0.001	12	0.6	0.95	0.01	0.10
Fe	6	12	0.5	3	0.02	
Ni	3	5	0.4	6.5	0.2	0.10
Cu	0.03	6	0.3	3.5	0.02	0.32
Zn	0.3	5	0.3	1.2	0.001	0.21
As	0.03	4	0.4	35	0.2	0.04
Se	0.03	2	0.4	50	0.5	0.79
Mo	0.3	5	1.9	5.5	0.02	0.04
Cd	0.6	6	1.0	1.7	0.003	0.06
In	0.0006		1.4	40		0.07
Sn	1	8	1.6	17	0.1	0.06
Sb	0.01	8	1.4	20	0.1	0.05
Hg	0.003	7	1.0	17	2	0.02
Tl			1.1	25	0.1	
Pb		8	1.1	30	0.05	0.05

[a] ED- energy dispersive for 1 mg cm^2 sample layers of a light element matrix on a thin substrate film

[b] ETA- electrothermal atomisation for solutions containing 0.1% dissolved solid sample

(a) PIXE offers significant advantages for fast, multielemental analysis of small samples and exhibits its best detection limits for samples consisting of a light element matrix. However for some samples such as liquids, the optical spectrometric techniques and particularly ICPMS are much more suitable. The PIXE technique is still at least an order of magnitude more sensitive than transmission X-ray fluorescence (XRF) technique.
(b) When only mg amounts or less of solid samples are available or when one is interested in measuring the composition of mm sized areas in a large sample or of thin superficial layers in a bulk sample. PIXE is virtually the only non destructive technique available. The analysis of small aerosol deposits on filter papers remains an area where PIXE has virtually no competition.

PARTICLE INDUCED GAMMA RAY EMISSION (PIGME)

For sufficiently high ion beam energies the interaction of the ions with the nuclei of the target atoms may produce gamma rays and other light product particles such as alpha particles. These gamma rays have energies from a few hundred keV to several MeV and in a manner totally analagous to X-ray production discussed above maybe detected in either a lithium drifted germanium detector (Ge(Li)) which has high resolution (3keV) or a sodium iodide detector with lower resolution (100keV) but higher detector efficiency. The energy of the gamma ray determines the element nuclei hit by the incoming ion beam and the number of gamma rays detected is a function of the concentration of this element in the target.

In fact the PIGME technique is ideally suited to compliment the PIXE results for elements below silicon where the X-ray detection efficiency for PIXE falls very rapidly making measurements of light elements up to aluminium extremely difficult. This is one of the main reasons that PIGME and PIXE spectra are often acquired simultaneously on the same target sample as PIGME then compliments the PIXE measurements.

Table 4 gives the gamma ray energies for the common high yield PIGME gamma ray lines for various elements. Approximate absolute yields (x10^6 μC·sr) for 3.1 MeV ion energies are also given together with some typical minimum detectable limits for 10 μC runs (30 nA of protons for 330 seconds).

Table 4 PIGME gamma ray energies and typical MDL's for common light elements on typical filter papers for 10 μC runs using 3.1 MeV protons and a Ge(Li) detection system.

Element	Energy keV	Yield (10^6 μC sr)	MDL (μg cm^2)
Li	477	56	0.1
Be	3562	2.5	
B	429	72	
F	110	72	
	197	2.9	0.2
	1236	3	
	1349	1.3	
	1357	1.4	
	6129	67	
Na	440	9.6	0.7
	1634	9.9	
Mg	417	-	
	1368	0.9	
Al	843	2.3	10
	1013	4.6	
Si	1778	1.2	

Table 4 shows that for the majority of the elements listed these conditions would yield a gamma peak of around 10^3-10^4 counts for 1% elemental concentrations in the sample for typical detection systems.

Fig. 7 shows a typical PIGME Ge(Li) spectrum for 3μC of 2.6MeV protons on a Teflon filter. It was acquired simultaneously with the PIXE spectrum of Fig. 4. The fluorine gamma rays from the Teflon are clearly visible at the gamma ray energies 197, 1236, 1352, 6129 keV and its two escape peaks at 5107 and 5618 keV. The fluorine content of the filter was around 226 μg cm^2.

PIGME DETECTION LIMITS

Experiments on aerosol filter papers have shown that the minimum detec-

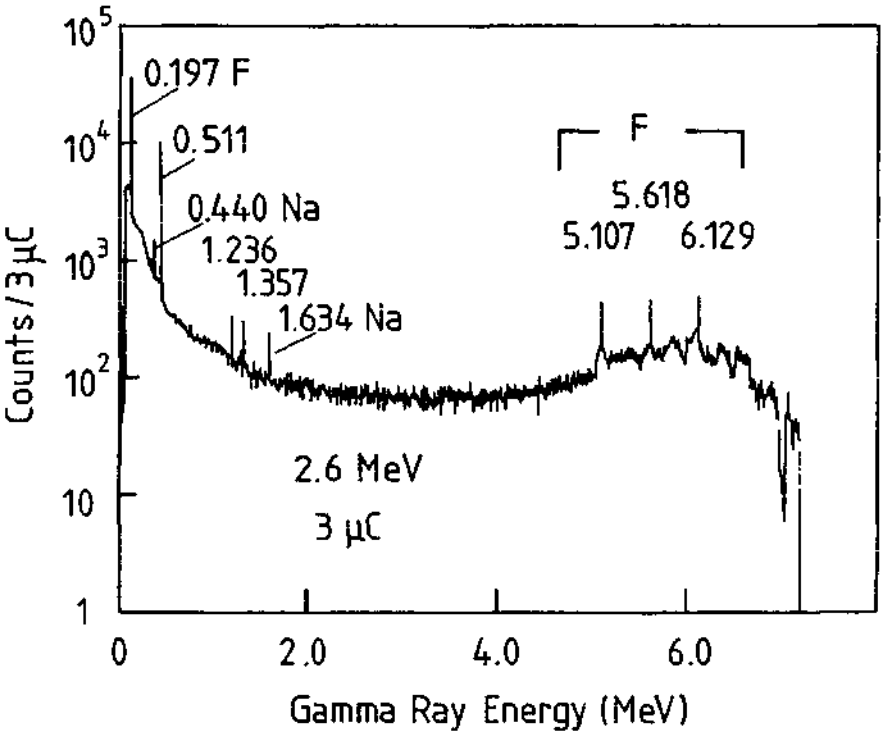

Fig. 7 Typical gamma ray spectrum for 2.6 MeV protons on a Teflon filter paper. The detector was a Ge(Li) detector placed at 135 degrees to the incoming ion beam. The 3 μC total charge collected corresponds to 10 nA beam current for 300 seconds. The major gamma ray lines correspond to the ion beam interacting with elements F, Na and K.

table limits for these elements are around 100 ng cm^2 of filter paper but depend strongly on ion energy and backgrounds in the detector system. Asking et al 1987 measured PIGME MDL's for sodium for proton energies between 2.20 and 3.56 MeV using the 440 and 1634 keV lines of Table 4. They found detection limits ranging from 120 to 250 ng cm^2 of filter paper for NaI detectors and from 110 to 190 ng cm^2 of filter paper for GeLi detectors on 250 μg cm^2 filter papers. Analysis of Fig. 7 gives the MDL for fluorine for 2.6 MeV protons and a 3μC charge as 0.8 μg cm^2 of filter paper. Similar analyses under the same run conditions for sodium, magnesium and fluorine gave MDL's of 2, 100, and 34 μg cm^2 of filter paper respectively. Raisanen and Lapatto 1988 have measured sulphur concentrations on aerosol filter papers using an external proton beam (not in vacuum) with ion beam energies between 4 and 6 MeV. They detected the 2230 keV gamma rays from the proton reaction on sulphur and obtained maximum MDL's of 300 to 400 ng cm^2 of filter paper for proton energies around a 4.77 MeV resonance in the proton reaction with sulphur. Higher energies and longer run times will obviously increase these sensitivities considerably.

The PIGME technique is therefore very useful for light element analysis and compliments the PIXE technique. However, because it originates from a nuclear process rather than an atomic reaction it is somewhat less sensitive for aerosol filter paper analysis than PIXE.

PARTICLE ELASTIC SCATTERING ANALYSIS (PESA)

Particle elastic scattering (PESA) involves an incoming ion beam elastically scattering off target nuclei and their energies being detected as a means of identifying the target nuclei struck. For a proton beam traversing a thin target, such as an aerosol filter paper, this technique becomes particularly suited for hydrogen analysis. The principles of the technique are schematically shown in Fig. 8 where 2.6 MeV protons are incident normally onto a 25 μm thick Teflon filter paper. If the detector is placed at small forward scattering angles (~30°) it will receive a range of scattered proton energies. The kinematics of the scattering process are such that for elements heavier than hydrogen, such as the carbon and fluorine in the Teflon filter, protons of higher scattered energy are produced and the cleaned spectrum of Fig. 8 results. Hydrogen, being the lightest element has a unique signature, shown as [a]-[b], at the lowest scattered proton energies. Other heavier elements produce the peak [c]-[d], at higher scattered proton energies, shown in Fig. 8 and are generally not resolved.

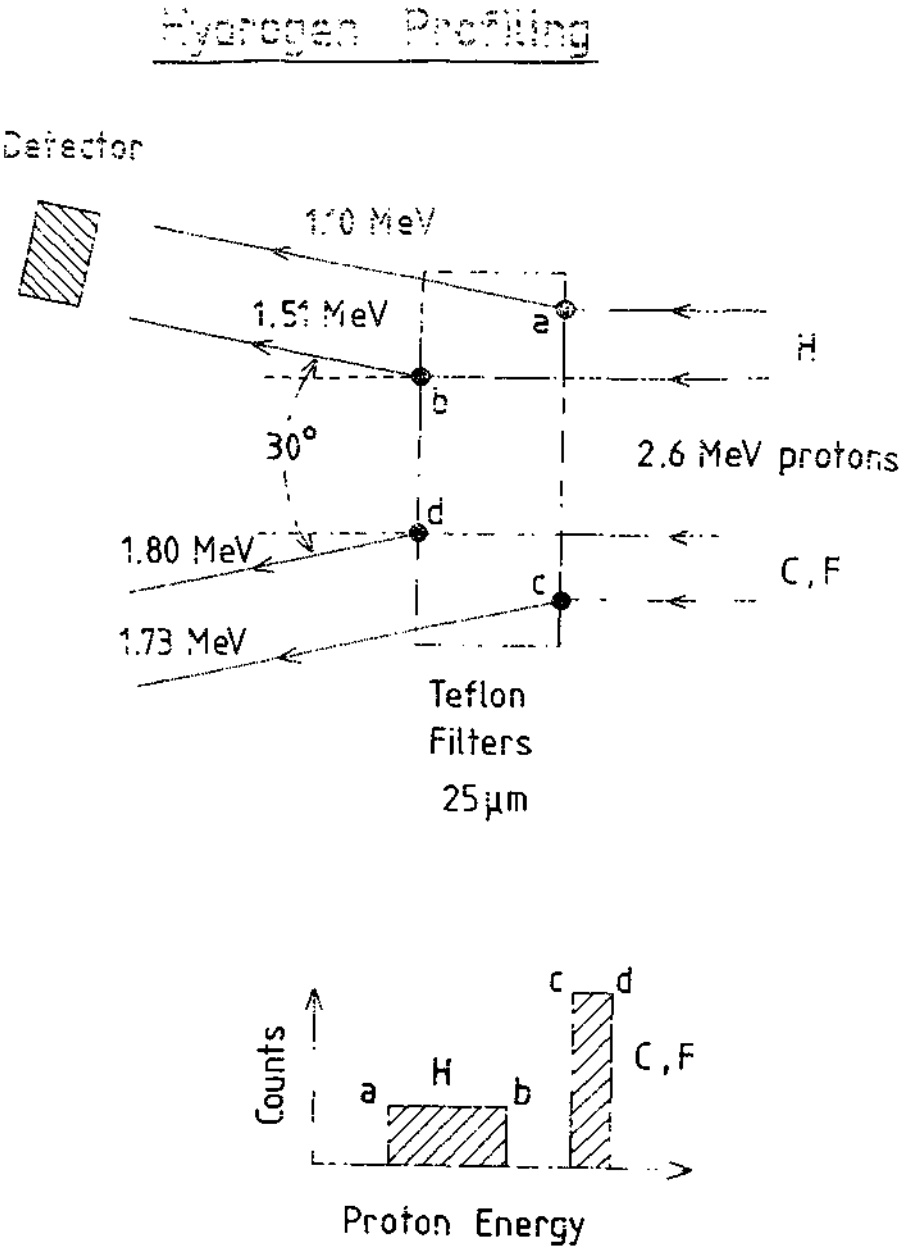

Fig. 8. Schematic of a typical particle elastic scattering experiment for 2.6 MeV protons on a Teflon filter paper. The inset spectrum at the bottom shows the expected spectrum for proton scattering off hydrogen in the sample [a]-[b] and off carbon and fluorine in the sample [c]-[d]. The energy loss for 2.6 MeV protons traversing through the 25 μm thick Teflon filter paper is just a few keV. The detection system is typically placed at 30 degrees to the incoming ion beam.

Fig. 9 shows the PESA spectrum for the Teflon filter paper whose PIXE spectrum is shown in Fig. 4. The three spectra of Figs. 4, 7 and 9 were acquired simultaneously. Despite the presence of many elements heavier than fluorine (S, Pb, Br, etc.) the hydrogen peak of Fig. 9 is still well resolved and corresponds to a mass of about 7 μg cm^2 on the filter paper.

PESA DETECTION LIMITS

For the spectrum shown in Fig. 9 the filter area was 2.27 cm^2 and had 31 m^3 of air through it in a 24 hour period. This corresponds to about 500 ng m^3 of hydrogen in air. MDL's 70 times lower than this are readily attainable. This would correspond to around 8 ng m^3 of hydrogen in air under these conditions. The PESA technique is therefore a fast and sensitive method

for hydrogen analysis on filter papers.

The measurements are performed in vacuum so all free water vapour and volatile hydrocarbons would evaporate off the filter paper. However experiments by Kusko et al (1989) show the filter paper's organic matter content can be estimated successfully by subtracting from the total hydrogen measurement the hydrogen associated with sulphur as $(NH_4)_2SO_4$ or H_2SO_4, two very important species in aerosol analysis. They also show that the PESA technique at 62° using 30 MeV helium beams from a cyclotron is capable of resolving carbon, nitrogen and oxygen peaks with MDL's of 800, 230 and 460 ng cm^2 of filter paper respectively for 10 μC total beam charge on nominal 250 μg cm^2 Teflon filters. This corresponds to elemental concentrations of 350, 100 and 200 ng m^3 of air respectively over a 24 hour period.

The PESA technique, like the other ion beam techniques described above, is fast and non destructive but it is also one of the very few techniques capable of analysing for hydrogen.

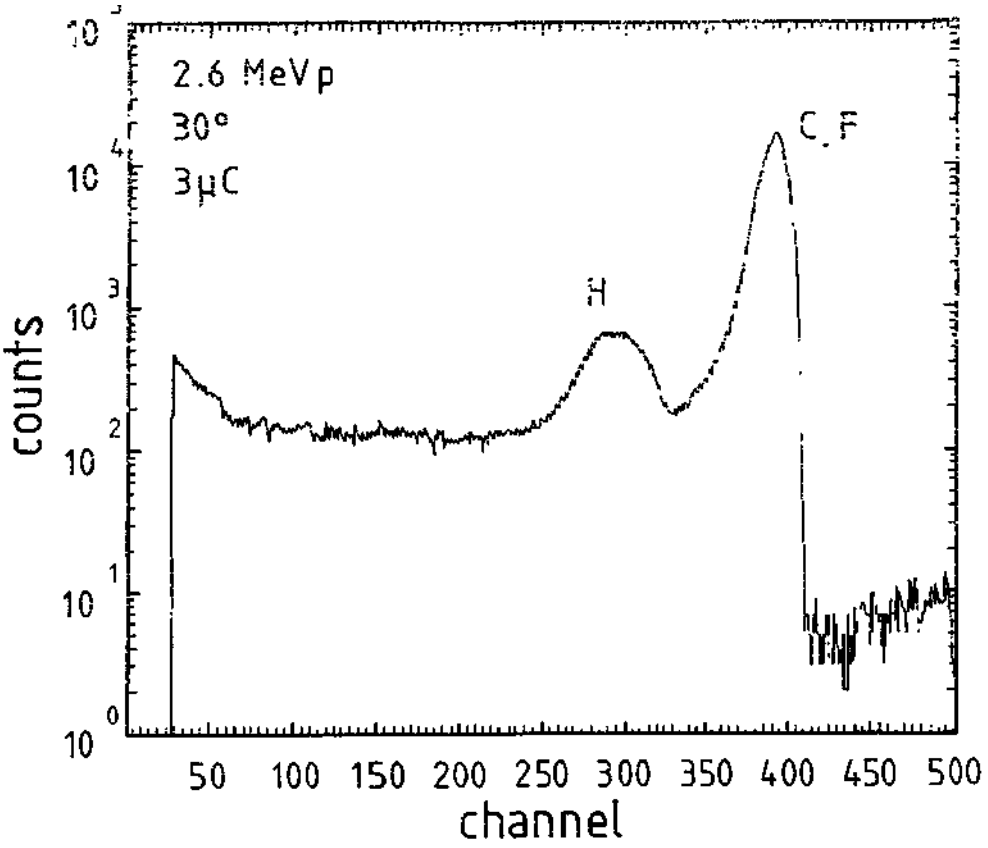

Fig 9 A typical PESA spectrum from the same Teflon filter paper used to to acquire the PIXE spectrum of Fig 5. This spectrum was taken simultaneously and under the same run conditions as the PIXE spectrum of Fig 4. The broad peak marked H, due to scattering from hydrogen in the filter paper, is well separated from the larger narrower peak due to scattering from all elements heavier than hydrogen. The area of this peak, after background subtraction, is proportional to the hydrogen concentration on the filter paper.

CONCLUSION

The three accelerator based ion beam analysis techniques of PIXE, PIGME and PESA are ideally suited for elemental analysis of aerosol particulates on filter papers. They can be performed simultaneously on the one aerosol sample providing elemental concentrations on more than 35 different elements at a time on elements from hydrogen to uranium. The techniques are non destructive, fast, relatively cheap and have high sensitivities especially for trace elements of common interest such as hydrogen, fluorine, sodium, aluminium to bromine and lead. Minimum detectable limits for these elements around a few ng m^3 of air are obtainable in just a few minutes of accelerator running time. Sample throughputs of around 12 hour or greater are possible. The techniques are very powerful elemental analysis techniques which have been used world wide for some years now and are just starting to become popular in Australia.

The megavolt accelerators required to perform these techniques are commonplace with most developed countries possessing several of them. The last decade or more has seen a significant upsurge in the public's perception of the importance of pollution studies and so there has been a corresponding increase in the use of these accelerators for aerosol analysis studies. Many ion beam analysis systems, like the ones at ANSTO and the University of Davis, California, are fully automated and can analyse hundreds of samples a day and have handled thousands of samples a year. The usefulness of these fast multielemental analysis techniques is well established internationaliy and it is clear that they will have a significant role to play in future aerosol particulate studies both nationally and globally, although in Australia today their potential has not been fully utilised yet.

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NEW PRODUCTS

ENVIRONMENTAL DATA ACQUISITION AND CONTROL SYSTEM

Ecotech Pty Ltd introduce their new model 9200ERM data acquisition and control system, which has been designed specifically for the monitoring and control of ambient air analysers and meteorological sensors. The logger will automatically separate out real-time data for a calibration report. This method eliminates the filtering out of these calibration readings from the data base.

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SOURCE TEST CASCADE IMPACTORS

The Mark 20 & 10 Pilat (UW) Source Test Cascade Impactors are new impactors developed for stack sampling. The Mark 20 model samples at 2 actual cubic per minute (acfm) gas flowrate and sizes particles into 15 size fractions ranging from 0.05 to 20 microns aerodynamic diameter. The Mark 20 has a right angle inlet nozzle jet stage, eliminating the need to use a button-nook nozzle which can distort size data, 13 multi-jet stages, and a 90 mm diameter outlet filter. It is designed for use at the outlet of control equipment where the particle mass concentration is lower.

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The Mark 10 and 20 models are also designed for simultaneous inlet-outlet sampling to provide data on the particle collection efficiency as a function of particle size.

For more information, please contact: Keri Olsen, Operations Manager, Pollution Control Systems Corporation, P O Box 15570, Seattle, WA 98115: Telephone (206) 523-7220: Fax (206) 523-7221.

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EnvironRent announce that they have available for rental the latest version of the Ecotech High Volume Air Sampler Model 2000. This unit is designed to meet the Australian Standard and all proposed amendments to that Standard.

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For further details please contact: EnviroRent Pty Ltd, P O Box 388, Blackburn, Vic 3130.

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Drager has just released in Australia their acclaimed 'mini Pac Series' of Personal Toxic Gas Monitors. Individual mini Pac units are available for the continuous monitoring of Hyudrogen Sulfide, Carbon Monoxide, Sulfur Dioxide and Nitrogen Dioxide gases.

The mini Pac personal monitors will be of interest to the mining, photochemical, brewing and plastics industries. Other application areas include underground work areas such as waterways, sewers, tunnels or any confined space that may contain hazardous gases.

Weighing only 185g, the mini Pac units are exceptionally lightweight and being pocket sized (the size of a small calculator) permit the user total freedom of movement, enabling the wearer to perform normal work duties without any hindrance. For those people working undergournd and who often are operating machinery, the mini Pac monitors offer security in personal air monitoring without work practice interference.

The sophisticated sensing technology is world patented by Drager and provides high performance and utter reliability. Fast and accurate readings

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A critical factor for those people in a constantly changing environment is the ability of a personal measuring unit to quickly and accurately monitor the changing air composition. The Drager mini Pac serics are quick to register readings of gas concentrations and have fast recovery times. Multiple readings are provided with the continuous operation providing reliable. accurate frequent readings to ensure work place safety. even when operators are constantly moving around.

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The alarm on the mini Pac Nitrogen Dioxide (NO2) monitor can be set to trigger between 0 to 12 ppm. the Carbon Dioxide (CO) monitor between 0 to 300 ppm. the Sulfur Dioxide (SO2) monitor between 0 to 10 ppm and Hydrogen Sulfide (H2S) monitor between 0 to 50 ppm.

Designed for tough on the job use. the sensor and electronics are protected in a strong casing and shielded from RFI signals to avoid false alarms.

The mini Pac Nitrogen Dioxide (NO2) has a measuring range of between 0 to 50 ppm, the mini Pac Carbon Monoxide (CO) a measuring range between 0 to 2000 ppm. the min Pac Sulfur Dioxide (SO2) a measuring range between 0 to 50 ppm and the mini Pac Hydrogen Sulfide (H2S) a range bwtween 0 to 200 ppm.

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The mini Pac series of personal toxic gas monitors are supported by the excellent Australia wide Drager Technical Service Division.

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The rugged but light die-cast housing will fit comfortably into a shirt or overall pocket with the sensors positioned above the pocket line. A

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The MiniGas offers a choice of one. two or three gas sensors for continuous monitoring on all channels. Sensors are available for Flammable Gas. Oxygen. Carbon Monoxide and Hydrogen Sulfide.

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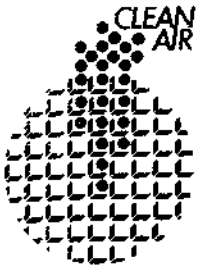

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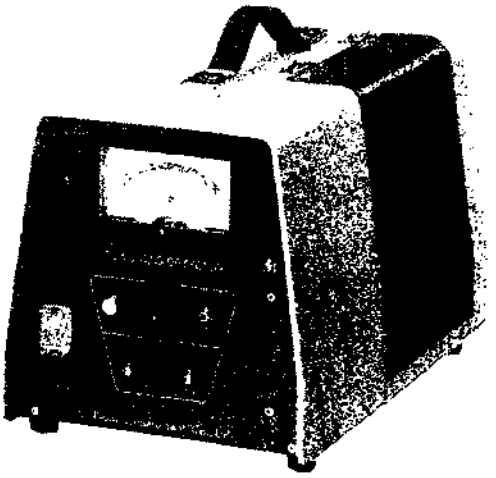

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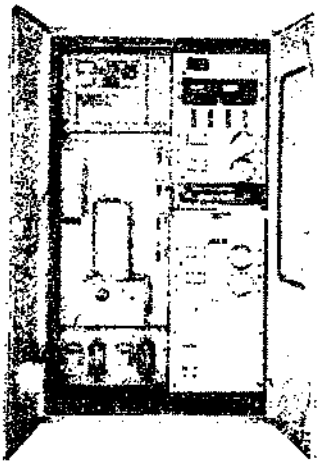

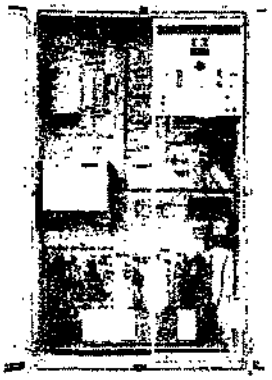

SERVICES AVAILABLE AUSTRALIA WIDE INCLUDE:

* DESIGN, MANUFACTURE, INSTALLATION, COMMISSIONING, ONSITE GENERAL SERVICE AND MAINTENANCE REPAIR.
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