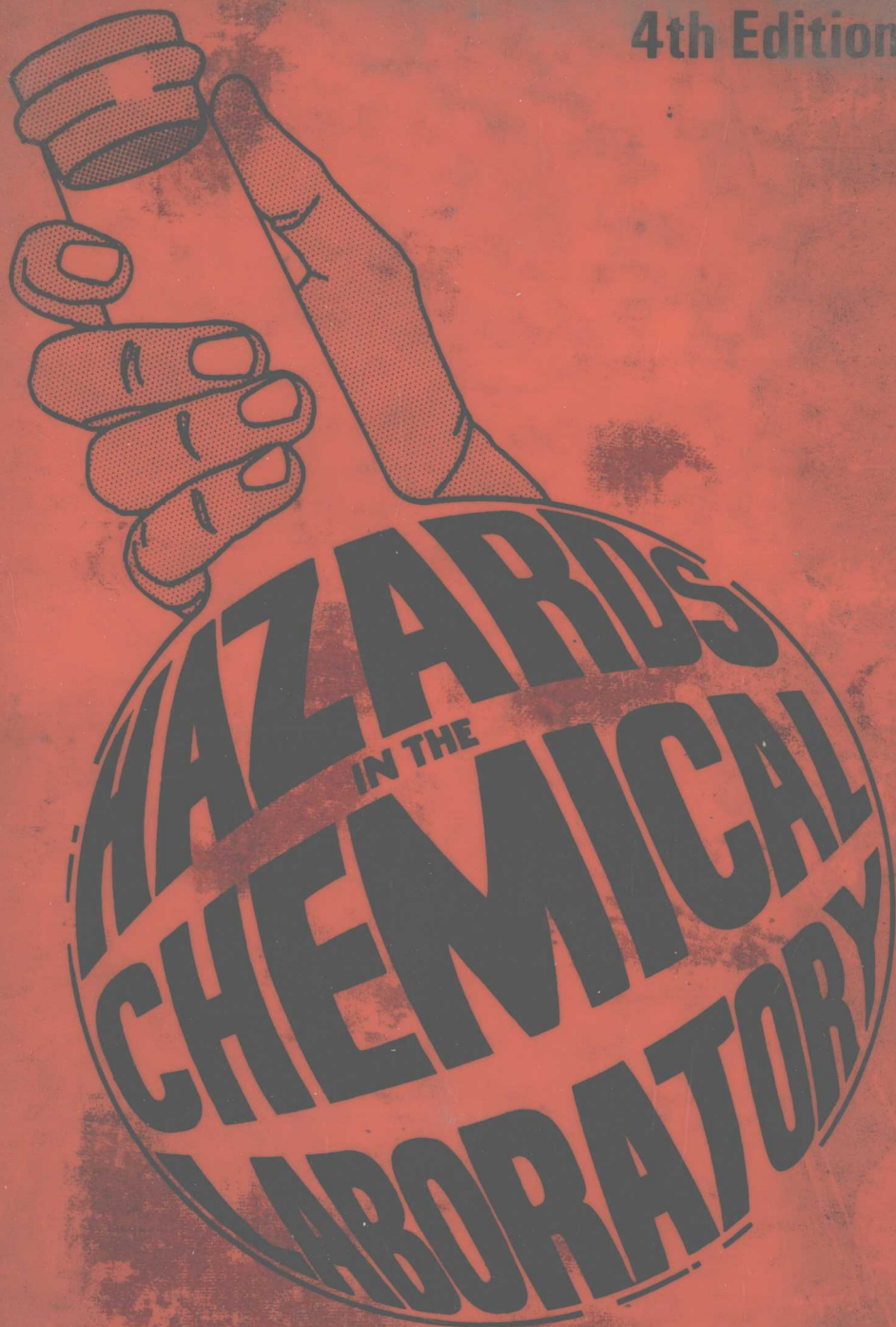


4th Edition



Edited by L. Bretherick

HAZARDS IN THE CHEMICAL LABORATORY

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**HAZARDS
IN THE
CHEMICAL LABORATORY**

Preface to the Fourth Edition

The continuing developments in many technical and legislative matters which have taken place in the past 5 years since publication of the third edition, and which impinge upon safety aspects of chemical laboratory practice, call for further revision of many of the significant points of detail herein. The good reception accorded to the previous edition, coupled with the nature of these developments, led the existing team of authors and myself, after consideration with appropriate RSC Management, to the view that its format and general content are still sound and capable of adequate updating together with some extension and this has now been done.

Mr Luxon has revised both his 'Introduction' in Chapter 1 and his Chapter 2 on the 'Health and Safety at Work Act 1974' to reflect the steady developments in the effects of this key legislation upon laboratory life. Chapter 3 now draws attention to the likely effects of the forthcoming regulations on the Control of Substances Hazardous to Health, and to the need to make effective provision for laboratory waste disposal. Several of the detailed references and regulations related to 'Fire prevention' have been revised, and these have all been included by Messrs Warwicker and Sheldon in their revision of Chapter 4. Chapter 5 has been extended to include a brief account of instrumental and computational methods of assessing and predicting chemical reaction hazards, and the examples given are now keyed

to the page numbers of the 3rd edition of *Handbook of Reactive Chemical Hazards* published at the end of 1985.

Dr Magos has recast and partially rewritten his Chapter 6 to emphasize the key role of exposure factors and their consequences in the whole area of 'Chemical hazards and toxicology'. Chapter 7 has been considerably revised by Dr Gilks to take account of some changes of detail and emphasis in several areas of his speciality topic of 'Health care and first aid'. The many changes, largely of minor detail necessary to update fully the major Chapter 8 on 'Hazardous chemicals', ('Yellow pages'), have arisen from three separate sources. Translation of the EEC Directive on Classification and Labelling into UK legislation as the *The Classification, Packaging and Labelling of Dangerous Substances Regulations 1984* now permits the officially accepted risk classification phrases to be included in most of the nearly 500 monographs forming the heart of the Chapter. The significant change in the occupational exposure limit values in Guidance Note EH 40/85 away from the TLV to the dual concepts of *Control limits* and *Recommended limits* has led to many changes in the monographs, though not necessarily of the numerical values quoted. A selection of new reactive hazards drawn from the third edition of the *Handbook* mentioned above has been added, and all the page numbers referring to that new text have been changed. CAS Registry numbers have now been added to the title lines for each chemical entry, and where possible each monograph ends with a reference to the appropriate Laboratory Hazard Data Sheet originating from the RSC Information Services at Nottingham.

Dr Osborn has completely recast his Chapter 9, 'Precautions against radiations' and associated bibliography to match the requirements of the long awaited and complicated *Ionising Radiations Regulations 1985* and its *Approved Code of Practice 1985*. Finally we welcome to the team a new author and old friend from the USA, Howard H. Fawcett, who outlines authoritatively for us in Chapter 10 (An American view) some of the principal distinctions between US and UK legislation and practice in chemical laboratories.

It is again a pleasure to record the great encouragement and assistance extended by the Editorial and Information Services staff of the Royal Society of Chemistry, in particular by Dr. Ivor A. Williams, Dr Philip G. Gardam and Mr Peter W. Shallis who were jointly responsible for converting promptly our combined offerings into this new volume.

L. BRETHERICK
January 1986

Preface to the First Edition

The present volume is a successor to the Royal Institute of Chemistry's *Laboratory Handbook of toxic agents*, first published in 1960, and issued in a revised edition in 1966. Before the second edition went out of print, the future of the publication was considered by both the Institute's Publications Committee, and by the previous editor, Professor C. H. Gray, and myself. It was generally felt that, rather than merely revise the existing material, it would be preferable to alter the underlying philosophy of the book by changing its scope from toxic hazards to a consideration of all hazards likely to be encountered in the chemical laboratory.

The general format remains the same, with the major part of the book (printed on tinted paper) being an alphabetical guide to hazardous chemicals and measures to be taken in the event of accidents in their use. However, whereas previous editions have included details of measures to be taken against the toxic hazards of such chemicals, the present edition also includes methods for spillage disposal and extinguishing of fires where appropriate. Once more, an alphabetical listing is adopted to enable the use of the book as a speedy reference in the case of emergency.

Much assistance was required in preparing this chapter, now extended to over 430 hazardous chemicals, and the preceding one on first aid. I must record my special thanks to my colleague Mr W. G. Moss for his collaboration

when we prepared these chapters for the first edition of the earlier book, and BDH Chemicals Ltd for permission to use their extensive records on the hazards, handling and disposal of chemicals; also my colleague Dr P. Mostyn Williams who has added considerably to the earlier medical advice of Dr W. B. Rhodes.

Dr D. P. Duffield and Dr K. P. Whitehead of Imperial Chemical Industries Ltd have also provided important medical advice on up-to-date first aid practice, particularly on the treatment of cyanide and phenol poisoning. The chemical world must always be grateful for the pioneer efforts of ICI in encouraging chemical factory and laboratory safety and we would record again our thanks to Dr A. J. Amor and Dr A. Lloyd Potter for their interest in the first book and to pay special tribute to the work of Dr L. J. Burrage who has contributed so much to promote laboratory safety in this country.

Many other firms have given us the benefit of special knowledge of certain of their products and we are also grateful to James North & Sons Ltd for permission to reproduce their chart advising on the types of glove to be used when handling different classes of chemicals.

Despite extensive practical experience of chemical hazards, the writers of a book such as this lean heavily on the authors of major works on industrial toxicology. Not many may have had the privilege of knowing the charm and intelligence of that great lady, Dr Ethel Browning, who guided the Institute and some of the authors when the first book was conceived and drafted, and wrote two renowned works upon which we draft extensively. *Toxicity and metabolism of industrial solvents* and *Toxicity of industrial metals*, as well as editing the important series of monographs on toxic agents in which they appeared. Her death last year ended a long life of devoted service to industrial safety.

The valuable publications of the Chemical Industries Association—*Marking containers of hazardous chemicals* and *Exposure to gases and vapours*—have been referred to frequently and we would like to thank the Association for the privilege of perusing the text of the latter at the proofing stage. The *Laboratory waste disposal manual* published by the Association's counterpart in the US, the Manufacturing Chemists' Association, was also consulted extensively in preparing chapter 6, as were the following works.

Dangerous properties of industrial materials by N. Irving Sax

Extra pharmacopoeia (Martindale) edited by R. G. Todd

Industrial hygiene and toxicology edited by Frank A. Patty

Industrial toxicology by L. S. Fairhall

Poisoning by drugs and chemicals by P. Cooper

Poisons by Brookes and Jacobs

Toxicology of drugs and chemicals by W. B. Deichmann and H. W. Gerarde.

Other acknowledgements appear in chapter 5.

Of the remainder of the book, new chapters have been provided by Mr

Ackroyd, Dr Taylor and Mr Sheldon on fire protection and by Mr Neill and Dr Russell Doggart on the particular hazards facing chemical workers in hospital biochemistry laboratories. In addition, Mr Luxon, of the Department of Employment, has contributed an entirely new introduction to replace the one by the late Sir Roy Cameron which appeared in the earlier editions. Mr Beard and Dr Osborn have thoroughly revised chapters 2 and 7 respectively. To all these authors, I am extremely grateful for the time they have spent on and interest shown in this project.

Dr Farago and his staff in the Editorial Office of the Institute have my sincerest thanks for their painstaking help and I am particularly indebted to Dr Martin Sherwood for his close collaboration in co-ordinating our efforts, sharing in our proof reading, and carrying out all the necessary negotiations with the printers. With my co-authors he has made the task of editing not only light, but both stimulating and enjoyable.

Finally, I should like to pay tribute to the immense amount of work which Professor Gray put into the planning and production of both editions of the *Laboratory handbook of toxic agents*. Although pressure of work prevented Professor Gray from taking a full part in the editing of this volume, I have had the benefit of his wise advice throughout its preparation. Without this and the substantial contribution he made to the earlier book, it is unlikely that this volume would have been possible.

G. D. MUIR
April 1971

CONTENTS

PREFACE

ix

1. INTRODUCTION

1

Identification, 3—management's task, 3—fire and explosion hazards, 4—reactive chemical hazards, 5—toxic hazards, 5—general environment, 8—radiation hazards, 9—conclusions, 10

S. G. LUXON, CChem, FRSC, FIOH, Dip Occ Hyg, *Health and Safety Consultant*

2. HEALTH AND SAFETY AT WORK ACT 1974

11

General, 11—scope, 12—general obligations, 12—duties of employers to their employees, 13—employers' general duties, 14—articles and substances for use at work, 14—training, 14—employers' safety policies, 15—safety representatives and safety committees, 16—duties to people who are not employees, 16—regulations and approved codes of practice, 17

S. G. LUXON, CChem, FRSC, FIOH, Dip Occ Hyg, *Health and Safety Consultant*

3. SAFETY PLANNING AND MANAGEMENT

19

Safety policy and implementation, 20—responsibilities, 20—consultation, 20—safety audits, 21—information, 21—laboratory safety officer, 21—other matters, 22—laboratory premises, services and equipment, 22—space requirements, 22—surface finishes, 23—ventilation and fume cupboards, 24—safety equipment, 25—laboratory furniture and equipment, 27—bench services and lighting, 30—vacuum and pressure equipment, 31—laboratory instrumentation, 32—glass and plastic ware, 33—laboratory materials: handling, storage and disposal, 33—specially hazardous chemicals, 34—gas cylinders, 35—storage, 35—waste disposal, 36—laboratory techniques and procedures, 37—measuring liquids, 38—heating, 38—stirring, 38—cooling, 39—vacuum distillation, 39

L. BRETHERICK, BSc, CChem, FRSC, *Safety Consultant*

4. FIRE PROTECTION

42

The nature and source of the fire risk (solids, liquids, compressed and liquefied gases), 43—structural protection and segregation, 45—controlling ignition sources, 47—emergency action (raising the alarm, summoning the fire brigade, first aid fire fighting, evacuation of personnel), 48—classes of

fire and suitable extinguishing agents (selection of and distribution, fixed extinguishing systems), 50—working practice, 54—legislation, 56—insurers' approach to fire protection, 60

M. SHELDON, BSc, *Technical Officer, Fire Protection Association*, and
L. A. WARWICKER, AIFST, CChem, FRSC, *Deputy Chief Technical Officer, Fire Offices' Committee*.

5. REACTIVE CHEMICAL HAZARDS

63

Physico-chemical factors, 64—concentration of reagents, 64—reaction temperature, 64—operational considerations, 65—pressure systems, 66—adiabatic systems, 66—types of decomposition, 66—chemical composition in relation to reactivity, 67—overall composition and oxygen balance, 68—molecular structure, 70—redox compounds, 71—pyrophoric compounds, 71—peroxidisable compounds, 72—water-reactive compounds, 73—endothermic compounds, 74—hazardous reaction mixtures, 74—potential storage hazards, 75—incompatible chemicals with reactive or toxic hazards, 76—appeal for further information, 79—special warning on aluminium lithium hydride (LAH), 79

L. BRETHERICK, BSc, CChem, FRSC, *Safety Consultant*

6. CHEMICAL HAZARDS AND TOXICOLOGY

80

The basic rules of toxicology, 80—a) how toxic is 'toxic', 80—b) molecular structure and physico-chemical properties, 82—c) biological variation in response to chemicals, 83—kinetics and metabolism, 84—a) absorption, 84—b) distribution, 85—c) metabolism, 85—d) body burden and biological half time, 86—e) excretion, 87—dose and damage, 88—a) critical organ, 88—b) dose-effect relationship, 89,—c) dose-response relationship, 89—toxicity testing, 90—a) acute (single dose) toxicity tests, 90—b) sub-acute toxicity test, 91—c) chronic toxicity test for carcinogenicity, 92—d) *in vitro* tests for carcinogenicity, 93—e) special tests, 93—the predictive value of toxicity testing, 94—a) extrapolation from animal experiments to man, 94—b) threshold and risk, 95—exposure as a measure of relative hazard, 98—a) toxicity and exposure, 98—b) the problem of complex exposure, 99—c) physical conditions and other factors in relation to exposure, 99—d) working processes as the source of exposure, 100—e) exposure and the route of uptake, 100—f) the permissible limits of exposure, 101—g) biological monitoring, 102—the consequences of toxic exposure, 103—a) the respiratory tract and the lungs, 103—b) skin and eyes, 103—c) gastrointestinal tract and liver, 104—d) blood, 105—e) nervous system, 106—f) kidneys, 107—g) cardiovascular system, 108—h) bone and muscles, 108

L. MAGOS, MD (Szeged), DCP (Budapest), FRCPATH, *Medical Research Council, Toxicology Unit, Carshalton, Surrey*

7. HEALTH CARE AND FIRST AID 110

Medical services and poison information centres, 110—exposure standards, 112—carcinogenic and mutagenic chemicals, 113—safe handling precautions, 114—biological monitoring, 117—dermatitis, 119—local preventive measures, 122—first aid, 123—training, 125—equipment, 126—treatments, 128—standard treatments, 129—special treatments, 131—summary of standard treatments, 136—addresses of principal European labour inspectorates and occupational health authorities, 138—addresses of principal European poison information centres, 139

J. M. L. GILKS, MA, BM, FFOM, DIH, *Chief Medical Adviser, Kuwait Petroleum Company; formerly Chief Adviser, Occupational Health and Hygiene Division, Shell International Petroleum Company; Regional Employment Medical Adviser, NE Region, UK Health and Safety Executive*

8. HAZARDOUS CHEMICALS 141

Properties, 142—warnings, 144—toxic effects, 145—carcinogens, 147—hazardous reactions, 149—first aid, 149—fire hazards, 150—spillage disposal, 150—alphabetically arranged section consisting of monographs on common laboratory chemicals (incorporating notes on properties, HSE warning phrases, injunctions, toxic effects, hazardous reactions, first aid treatments, fire hazards and spillage disposal procedures), short notes on the hazardous properties, reactions and exposure limit values of several hundred other less common chemicals, and cross references for synonyms; this section is not covered by the Subject Index at the end of the book.

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G. D. MUIR, BSc, PhD, CChem, FRSC, *Consultant; formerly Technical Development Manager, BDH Chemicals Ltd, Poole, Dorset*

9. PRECAUTIONS AGAINST RADIATIONS 557

Ionising radiations (x-rays, α -rays, β -rays, γ -rays, bremsstrahlung, neutrons, positrons), 558—quantities and units, 559—effects of radiation, 560—ICRP standards, 561—general principles of radiation protection, 561—legislation, 563—general precautions, 568—precautions with x-rays, 568—precautions in work with sealed sources, 569—precautions in work with open radioactive sources, 571—measuring instruments (personal monitors, survey monitors), 573—precautions against non-ionising radiations, 575—ultraviolet radiation, 576—infrared radiation, 578—lasers, 579—ultrasound, 580—radiofrequency and microwave radiation, 580

S. B. OSBORN, BSc, PhD, FInstP, *Radiological Protection Consultant, SE Thames Regional Health Authority; formerly Director, Department of Medical Physics, King's College Hospital and Medical School, London and Consultant to the World Health Organisation.*

Contents

10. AN AMERICAN VIEW	585
Chemical knowledge of science, 585—hazard assessment and communication, 587—physical facilities and services, 587—chemicals, 588—the human element and training, 590—regulations, 591—other considerations, 592—medical surveillance, 594	
H. H. FAWCETT, BS, PE, <i>Consultant, Wheaton, Maryland, USA</i>	
INDEX	599

Chapter 1

Introduction

Since the publication of the third edition a number of major chemical disasters have occurred which have involved not only those workers immediately concerned with the processes but also the general population in the immediate vicinity of the plant. This has brought renewed public pressure to bear on the relevant regulatory authorities for a more formal assessment of the hazards associated with the storage and use of chemicals of all kinds. Fortunately, the general requirements of the Health & Safety at Work Act of 1974 provide the necessary framework by which some additional more comprehensive controls can be effected. The recent spate of proposals for new regulations to be made under the enabling powers contained in this Act may be considered as but one response to that increased public awareness of the dangers that chemicals pose to the environment.

The Act has now been on the Statute Book for some ten years and as indicated in Chapter 2, its general purpose is to provide for one comprehensive and integrated system of law dealing with the health and safety of all persons engaged in work activities and the health and safety of others who may be affected by such activities. Reference has been made to one of the principal features of recent legislation, *i.e.*, the provisions relating to the making of detailed Regulations and Codes of Practice. Such requirements have now been laid down in respect of a number of hazardous substances, for example, Lead

Compounds and Asbestos and others are under active consideration. It is expected that over the next decade this will continue, many of the earlier regulatory requirements being updated, simplified and replaced. In the meantime the advice given in the previous edition is still valid, *i.e.*, guidance as to what may be required in laboratories may be drawn from existing parallel legislation in other areas such as factories, and from codes of practice such as that on the use of ionising radiation. More general guidance and the reasoning underlying such guidance is contained in this manual.

Particular attention should be paid to systems of work and to the clear delegation of specific responsibilities to those organising units of laboratory activity. A further important aspect of the legislation lies in the requirements in respect of consultation and this places a particular responsibility on chemists who are best able to advise the layman on the hazardous nature and properties of chemical substances, and the precautions necessary to ensure their safe use. It is, therefore, important that everyone concerned makes an evaluation of all aspects of health and safety and puts in train any necessary steps to ensure that his house is in order.

Regrettably, perhaps, in the past chemists, who habitually handle dangerous substances, have been inclined to disregard the hazards associated with their use particularly if such hazards are of a long-term nature. Every human being, and a chemist is no exception, tends towards the view that although an accident may happen to another, it will never happen to him personally because he is too wise and knowledgeable. Experience shows that nothing can be further from the truth. During work in the laboratory, many persons have suffered injury to their health which because of the insidious symptoms, may never have been associated with their work activity. It is only when permanent injury has occurred that many persons come to realise that the observance of even elementary precautions could have prevented such injury or, in extreme cases, premature death.

It is against this background that one should look at this edition of the handbook. The contributors have attempted to indicate and discuss the dangers likely to arise in the laboratory and have offered practical advice on their avoidance. The work will, I believe, also prove most useful in devising precautionary techniques in respect of the many reagents and substances which, for reasons of space, have not been included in this work.

At the same time the manual has become a much more useful and complete work not only for chemists in the laboratory but also for all those who handle hazardous substances on a small scale, *e.g.*, in industry. Additionally, the work will be useful in schools and higher education establishments where training in the correct use and handling of the substances should be considered an integral part of the curriculum of students in science subjects, and where the Health and Safety at Work *etc* Act has extended specific obligations in respect of safety and health matters.

The control of hazards of the laboratory is well known: the enforcement of safe work systems; the need for mechanical safety involving the guarding of dangerous parts of machines, even if driven by only fractional horse power motors, so that injury from contact with moving or trapping parts is prevented; the need to provide safe means of access to every place where anyone is at work even if the work is only undertaken on rare occasions; the need for good housekeeping to minimise the possibility of accidents occurring through persons striking or being struck by objects, the need for care in handling glassware; the need to protect electrical conductors and to provide or use low voltage supplies or adequate earthing; and, of course, the matters with which this handbook is intimately concerned—the prevention of injury from fire, explosion or from exposure to hazardous substances.

Identification

Perhaps the most important single step we can take in securing the safe handling of chemicals is to ensure that a proper system of labelling is used that will identify the substance, indicate the hazards involved, and set out the simple precautionary measures to be followed. There has, of recent years, been considerable international discussion concerning labelling systems and the original work carried out by the Council of Europe has now been taken up and extended by the European Economic Commission. Directives have now been published dealing with the commoner pure substances and with some formulations such as solvents, paints, varnishes and printing inks. The Treaty of Rome setting up the EEC requires that such instruments be given legal force in the UK. Chapter 8 details these labelling requirements where they are directly applicable and in respect of other chemicals applies similar parameters. Failure to give some such simple warning of hazards is inexcusable, particularly in the laboratory where many chemicals may at some time be handled by inexperienced and unskilled persons who are not members of the lab staff, *e.g.*, cleaners and maintenance workers. Accordingly all chemicals should be labelled following the general guidelines used in these systems as set out elsewhere in this work.

Management's task

Safety and health is the responsibility of management and must be set out in a policy statement. Not only must the manager and all members of the staff know the hazards involved, but they must all be clearly seen to be directly interested and involved in the promotion of a safe and healthy environment. Strict procedures should be written into analytical and other methods. Where such methods do not exist, the work should be immediately supervised by a responsible person who is aware of the dangers and precautions to be followed

both during normal working and in any emergency that may arise. In larger laboratories a safety officer and hygienist should be appointed to provide advice and general supervision and, not least, to look critically at the procedures involved from outside the group undertaking the project. Experience shows that such a view dissociated from the actual scientific work is invaluable in bringing to light relatively simple hazards which may have been overlooked.

General management and supervision must be tight to ensure that work is conducted in a predetermined and orderly manner, that unauthorised actions are checked and that proper care and attention is given to the minute-by-minute operation of processes or experiments. In particular, at each meal or tea break and at the end of the day a thorough check must be made to see that everything can be left safely. If there is any doubt, arrangements should be made for the continued supervision of the operations still in progress.

The overall aim should be to design out hazards so that the whole system can operate in such a way that any possible human error is eliminated as far as is practicable. Chapter 3 deals with this general aspect of the problem.

Fire and explosion hazards

The dangers of fire are well known, but again we must remember the maxim 'familiarity breeds contempt'. The very large number of fires in laboratories proves the seriousness of this problem. Chapter 4 gives detailed advice on such risks and the text under each substance in Chapter 8 indicates properties on which an assessment of the fire hazard can be based and makes suggestions as to the selection of fire fighting equipment.

It should be clearly understood that when a liquid is used having a flash point below the highest normal ambient temperature it can, in suitable circumstances, liberate a sufficient quantity of vapour to give rise to a flammable mixture with air. This can accumulate in the workroom to such an extent as to give rise to the possibility of a serious explosion by ignition of the vapour/air mixture from an ignition source already present some distance away, causing a flash-back to the original source. There is then the consequent possibility of disastrous fire.

A flammable gas or vapour must be present in a concentration of the order of 1 per cent or more by volume if its mixture with air is to be flammable, so it is a relatively simple matter to check whether or not a dangerous concentration is likely to be present in closed plants such as ovens *etc.* During normal working it is desirable to ensure that one-quarter of the lower flammable limit is never exceeded. The amount of flammable vapour or gas in the workroom air should, of course, never approach this concentration during normal working procedures. Account must, however, be taken of possible leakages and spillages so that although it is, perhaps, unnecessary to provide special