A Guide to Laboratory Design

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Butterworths

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Butterworths

London Boston Sydney Durban Wellington Toronto

First published 1975
Reprinted with additions 1979
Reprinted with further additions 1981

ISBN 0 408 70935 9

Printed and bound in England by Butler and Tanner Ltd, Frome, Somerset.

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Preface

The authors wonder what reviewers will make of this book; it is not on architecture, or on engineering or on science. Its purpose is to draw together information which was in the main sought of the authors by many people involved in various aspects of laboratory design. It is presented in the hope that it will be of help to others who are engaged in the designing and the building of laboratories.

K.E.
D.H.

To the reader

This book attempts to set out many of the problems encountered in the design of laboratories for work with hazardous materials and to describe some of the solutions possible, often from the direct experience of the authors. However, the authors are not omniscient; the advice is given in good faith, but other solutions may be preferable in some instances. *In all cases, a designer must satisfy himself that any arrangement that he proposes to adopt is suitable and safe for his specific application.*

Acknowledgements

Laboratory design is an exercise which involves many people from several disciplines. The authors record their appreciation of the many helpful discussions which they have had with various colleagues during the past few years. They are particularly indebted in this respect to the staffs of the Planning Office and of the Office of the Surveyor of the Fabric in the University of Leeds.

The authors wish to thank the following persons, organisations and journals for their permission to reproduce drawings and photographs for which they hold the copyright:

Chemistry in Britain
Dunford Fire Protection Services Ltd
Engineering Developments (Farnborough) Ltd
Professor S. C. Frazer, University of Aberdeen
Mr Denys Horner, Senior Assistant Bursar (Planning), the University of Leeds
Koch-Light Laboratories Ltd
Laboratory Animals Ltd
Laboratory Practice
Microflow Ltd
The Fire Protection Association

Finally, the authors wish to acknowledge their appreciation of Mrs J. M. Carr and Miss D. Lewis, who translated the manuscript into a legible typescript for transmission to the Publishers.

Contents

One
Introduction

The dangers associated with the use of hazardous substances in research and in routine laboratory work are greatly reduced when the operations are carried out in laboratories properly designed or adequately adapted for such work. Hazardous substances may be grouped under a number of headings, not necessarily mutually exclusive. They may be: allergenic, asphyxiant, carcinogenic, corrosive, dermatitic, explosive, flammable, lachrymatory, pathogenic, poisonous, powerfully oxidant, powerfully reducing, radioactive, teratogenic. In most cases laboratory design must take account of the same basic features: containment, cleanliness, ventilation, waste disposal, storage, security, control of personnel, fire precautions and provisions for an emergency. In certain cases additional special features are needed: for example, shielding for radioactive substances or sterilisation for microbiological materials.

In this book, in order to avoid a great deal of repetition, the basic features of laboratory design are considered first (Chapters 2, 3, 4 and 5). The various aspects of the control of airborne contaminants by ventilation are dealt with next (Chapters 6, 7 and 8). Stores and other ancillary areas are considered in Chapter 9. Finally, the additional special features required for some of the different groups of hazardous materials are summarised in the Appendices.

No attempt is made to provide an architecturally integrated design for a whole laboratory and office complex, and the reader is referred to other works for this aspect of the problem.[1–9, 226] In most chapters the authors have tended to concentrate on points of detail rather than present over-all schemes. The extent to which these points need to be incorporated in the design of a particular laboratory and office complex depends on the nature of the work to be done in the various sections of the complex. Much chemical work, for example, is relatively innocuous and, although some of the design features described are appropriate in a laboratory for such work, it is not necessary to provide others, such as rigid segregation of personnel and glove-box facilities. On the other hand, there are circumstances when, for example, the work involves virulent pathogenic micro-organisms or alpha-particle-emitting radionuclides, where a segregated suite of rooms with elaborate mechanical services is essential for the safety of people and for the successful control of the experimental procedures. With these circumstances in mind, Chapter 2 has been devoted to the design of a *laboratory suite* where hazardous experiments can be contained; such a suite might be provided as one special area within a large building with many other laboratories for less hazardous work, or the suite might be expanded to become a whole laboratory block if the scale of the work required this.

It must be emphasised that detailed consideration by the architect, the engineer and the client of many of the matters raised in this book is imperative right from the conception of the building project to the final commissioning. Laboratories for work with hazardous materials are usually complicated entities with extensive engineering services; if the laboratories are to function efficiently and safely, the services must be considered from the outset of the project and the appropriate provisions must be made in the over-all architecturally inspired design to accommodate them so that their efficiency is not impaired. The classic example here is that of the fume-cupboard and its extract system; if the decisions relating to the location of a fume-cupboard and to the routing of its extract ductwork are left to a late stage in a project, the most hideous and undesirable convolutions can occur in the ductwork, as installed, with consequent difficulties if the extract fan has been sized on the basis of a lower duct-resistance.

No mention is made of cost/effectiveness analysis for any of the provisions suggested. What is very clear, however, is that it is cheaper to build the laboratory correctly at the first attempt than to have to rectify deficiencies after the laboratory has been brought into use. Equally clear is the fact that architects and engineers usually have to work within prescribed cost limits which may restrict the extent of the facilities that can be provided. On the latter point, if the funds available are inadequate to provide the facilities that are necessary for the work to be carried out, then the project should be reconsidered.

Certain aspects of laboratory design are subject to statute in the UK and to similar legal constraints in other countries; for example, there are regulations relating to fire precautions and to radioactive substances. Further control over design is exercised by national codes of practice and by the recommendations of international bodies; these do not have the force of statute law, but usually they can be invoked in civil actions at law. Where appropriate, statutory requirements and recommendations applicable in the UK are usually referred to in later chapters. It is possible that the present interest in health and safety in the workplace shown by the UK government and by other bodies will result in further control of the standards required in the design of laboratories; of particular interest will be the consequences of the Health and Safety at Work etc. Act.[10]

Two
Laboratory Suites

It is sometimes appropriate, because of the level of hazard involved, to confine work with hazardous materials to a segregated suite of rooms in a building or to provide a separate laboratory block if the scale of the work requires it. Such arrangements have been made for many years for work with radionuclides[11–14, 216, 249, 252] and they are applicable to other types of work also.[6, 15, 225]

When such a laboratory suite is planned, special consideration must be given to the following points, which are illustrated schematically in *Figure 2.1:*

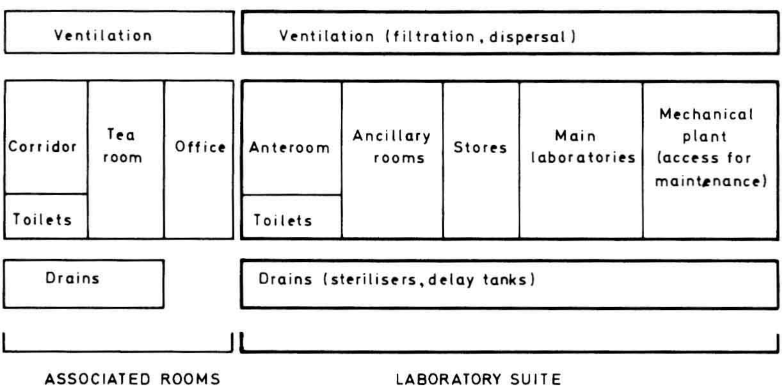

Figure 2.1 Schematic diagram of the general arrangement for a laboratory suite

1. The segregation of the laboratory suite from other (non-laboratory) areas.
2. The control and the suitability of the access to the suite.

3. The separation of the various levels of potential hazard within the suite.
4. The provision of individual laboratories and ancillary rooms as appropriate for the operations to be carried out.
5. The provision of alternative exits for use in an emergency.
6. The design of the ventilation and drainage systems and the space necessary to accommodate them.
7. The need to install services so that much of the maintenance can be carried out without high-hazard areas having to be entered.
8. The provision of associated rooms outside the suite, such as tea rooms and offices.

An isolated single-storey building devoted entirely to the one type of work is an attractive proposition, provided that it will not be surrounded by taller buildings at a future date. Among the advantages are:[16]

1. The less serious consequences that are likely to arise if a temporary failure to contain the hazardous material occurs.
2. The easier control of persons entering the area.
3. The absence of other occupants who might be affected by the discharge of fumes.
4. The shorter runs of internal drains to a relatively large sewer with the consequent advantage of early dilution.
5. The higher permissible floor-loading available to support heavy items such as the shielding against radiation required in some radioactive laboratories.
6. The reduction of the problems caused by vibration.
7. The greater freedom possible in the arrangements for the delivery of materials and the removal of hazardous waste.

However, in many places it is inevitable that the work will have to be done in part of a tall multistorey block shared with other occupants. If the laboratory suite is placed near ground level, long, expensive extract ducts will be needed for the ventilation system. These will have to discharge through a high stack, possibly appearing as an incongruous feature disturbing a graceful skyline, in order to escape from the downdraughts surrounding the building (see Chapter 7). If the laboratory suite is sited on the top floor, the long extract ducts are exchanged for long drain runs with the attendant risk of contaminating uncontrolled areas lower down in the building; deliveries of materials, perhaps heavily shielded in the radioactive case, and the removal of contaminated waste are less conveniently arranged.

Figure 2.2 illustrates an arrangement of rooms which could be incorporated in a building where a small number of people wish to use a particular type of hazardous material – for example, radioactive substances. The various stages of the work are identified and appropriate provisions made for them: the stocks are kept in the stores; the initial dispensing at relatively high concentrations and the more hazardous manipulations are performed in the glove-box, safety cabinet or fume-cupboard; the less hazardous work is accommodated on the open benches; the samples of very low activity level are manipulated or assayed in a separate ancillary room; the staff washing facilities and the personal lockers for use by staff who wear protective clothing in the laboratories are accommodated in the changing room which is divided into 'clean' and 'dirty' sides by a change barrier; and alternative exits are provided from each room and from the whole suite.

There are incidental advantages in the type of arrangement shown in *Figure 2.2.* The changing room acts as a buffer between the main laboratories and the corridor and it discourages the casual caller (complete with tea mug, pipe or cigarette). The ancillary room can provide some protection for expensive electronic (or other) equipment which could be easily damaged by exposure to any corrosive fumes generated if a relatively small fire occurred in one of the main laboratories. The ancillary room can also be used for purposes of calculation and writing-up with the workers in the main laboratories kept under surveillance (in case of accident) through the observation window.

The laboratory suite illustrated in *Figure 2.2* represents the basic unit which is borne in mind throughout this book. Its size obviously varies with the circumstances, but ample space should always be provided to permit of safe working. A minimum area of 4.5 m^2 (50 ft^2) per person has been recom-

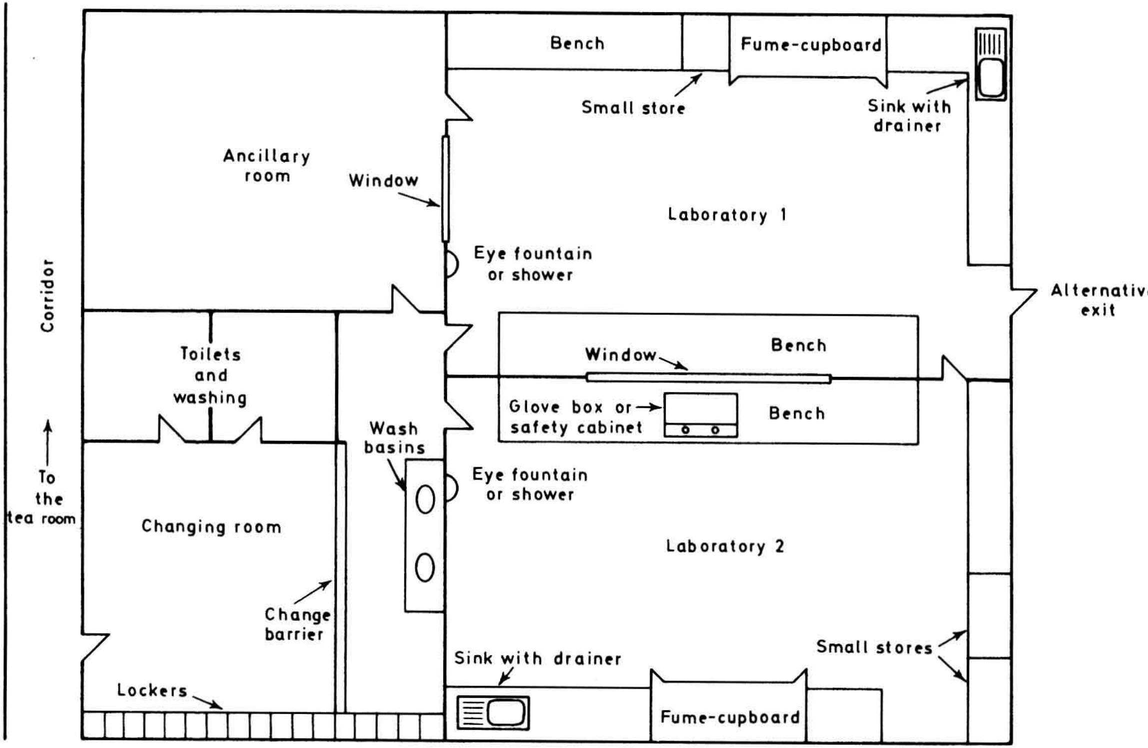

Figure 2.2 Illustrative arrangement of a laboratory suite