WASC-2396

① Leather Box
② Leather Brush
③ Ron Treadgold
lab Notebook
④ Armament Research
Safety Precautions

MUSEUM OBJECT ENTRY FORM

MUSEUM NAME:

Form No: 113

Received from: BUDDEN
Address:
1. CHAPEL CROFT
INGATESTONE CM4 0BU.
Tel No: 01277 3583663

Owner (if different):
Address: KATHLEEN BILEY
(deceased)
Tel No: rosiebudden@gmail.com

DESCRIPTION OF OBJECT/COLLECTION (note obvious damage, & any related information eg. when, where, or how was it found or used; names, dates & details of the people who made or previously owned it, etc. **Continue on a new sheet if necessary**)

Leather covered trunk + hand brush + Laboratory notebook. + safety Precautions book.

ADDED TO WASC 2396

Total no. of items: 4

REASON FOR ENTRY (tick as applicable, and sign)

☑ **Donation** - I offer to donate the object(s) listed above to the museum's governing body.
☐ **Sale** - I offer to sell the object(s) listed above to the museum's governing body (price sought £.................).
☐ **Loan** - I offer to loan the object(s) listed above for the use of the museum's governing body for a period of .... months.
☐ **Identification** - I leave the object(s) listed above for identification & undertake to collect these no later than 4 weeks from today.

I confirm that the information given on this form is correct to the best of my knowledge and belief, & that I accept the terms and conditions described overleaf.

Signed: RBudden **Date:** 9/2/2017

ADDITIONAL AGREEMENT (DONATIONS/SALES ONLY) (tick as applicable, and sign)

☑ I, the **owner**, confirm that I have undisputed title to the object(s) listed above, with full power to dispose of the items and transfer such title to the museum's governing body. OR
☐ I, the **depositor** acting on behalf of the owner(s), confirm that the owner(s) have undisputed title to the object(s) listed above, with full power to dispose of the items and transfer such title to the museum's governing body, & that I am authorised by the owner(s) to act on their behalf to that effect.

The title in the objects listed above, & subject to the conditions overleaf, is hereby transferred to the governing body of the museum.

Signed: RBudden **Date:** 9/2/2017

MUSEUM SIGNATORY

Receipt of the object(s) described above is hereby acknowledged.

Signed: on behalf of the museum's governing body **Date:** 09/02/2017

RETURN OF OBJECT TO OWNER (tick as applicable, and sign)

I, the depositor/owner, acknowledge the return of the object(s) described above in a satisfactory condition following:

☐ identification ☐ the end of the period of loan
☐ the museum's governing body declining to accept the donation, loan or purchase of the object(s)

Signed: **Countersigned** (for museum): Date:

WHITE - MUSEUM (FILE)
PINK - DEPOSITOR/OWNER (RECEIPT)

1 Chapel Croft
Ingatestone
Essex CM4 0BU

4th March 2017

For the attention of the Archivist
Royal Gunpowder Mills
Beaulieu Drive
Waltham Abbey
Essex EN9 1JY

Dear Sir or Madam

On 9th February I deposited a leather box, brush and laboratory notebook with you which had been found among my now deceased sister's belongings. I completed your form 113. I have now found another book, which I include. I hope it will be of some interest to you.

Yours faithfully

RBudden

Rosie Budden

POISONOUS
CHEMICALS

UNCLASSIFIED

MINISTRY OF SUPPLY

ARMAMENT RESEARCH ESTABLISHMENT

SAFETY PRECAUTIONS

THIRD EDITION 1954

Fort Halstead
Kent.

UNCLASSIFIED

A.R.E.
Publishing Section

HANDBOOK OF SAFETY PRECAUTIONS

Issued for the Guidance of the Staffs of

ARMAMENT RESEARCH ESTABLISHMENT

EXPLOSIVE RESEARCH AND DEVELOPMENT ESTABLISHMENT

ARMAMENT DESIGN ESTABLISHMENT

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

M.41/54

CONTENTS

CONTENTS (contd.)

CONTENTS (contd.)

ARMAMENT RESEARCH ESTABLISHMENT

HANDBOOK OF SAFETY PRECAUTIONS

Third Edition, 1954.

Foreword

The first edition of this handbook was issued in May, 1947 and a revised and enlarged edition was issued in 1949. The second edition was made available to members of the Armament Design Establishment, the Explosive Research and Development Establishment, and the Atomic Weapons Research Establishment, in addition to those of the Armament Research Establishment. In the present edition this wider distribution has been recognised by an alteration in the title page. Each Establishment has safety problems peculiar to itself which can only be dealt with by local regulations, but the basic safety problems arising in the handling of explosives, dangerous chemicals and in ordinary chemical and physical laboratory work are essentially the same everywhere. For each Establishment to draw up its own handbook to deal with them would result in unnecessary duplication.

In preparing this edition, the text of the second edition has been emended and considerably expanded and an endeavour has been made to provide a more comprehensive index. It is considered that the provision of an adequate index to a large extent removes the obvious objection to the production of a widely comprehensive handbook of safety, viz that such a book necessarily contains much that is of no immediate interest to a large proportion of its readers. It is hoped that each specialist can find the information which is of importance to him by consulting the index, and it is recommended that the book should always be kept to hand in the Laboratory or Office in order that such consultation may be made an essential preliminary to any operation which is in any way unfamiliar to those who are to carry it out.

This handbook is intended to supplement, but not to replace, rules dealing in detail with safety precautions special to certain areas or particular operations. It is the duty of all members of the Establishments to familiarize themselves with the special rules relating to their work, in addition to the rules given in this handbook, and scientists in charge of investigations should endeavour, by the issue and frequent revision of written codes of rules, to ensure that, as far as possible, all safety precautions particular to the work in hand are brought to the notice of their workers.

Attention is also drawn to the Safety Memoranda which are issued from time to time to supplement, when necessary, the information on general safety precautions contained in the handbook.

The thanks of the A.R.E. Safety Committee are due to the members of the E.R.D.E. Rules Committee who have assisted in the preparation of this edition, and to other members of the Establishments who have provided new material or corrected errors.

CHAPTER 1

INTRODUCTORY NOTES ON EXPLOSIVES

Properties of Explosives

1 - 1. It should always be remembered that the function of an explosive is to explode. Although explosives vary considerably in the ease with which they can be made to explode, experience has shown that all types of explosive, even the most insensitive, require to be handled with precautions. Above all, it is dangerous to hammer any explosive, or subject it to any process involving heavy grinding friction.

The method adopted for handling any given explosive is determined by the following of its properties:-

(a) Physical state, i.e. solid, liquid or gaseous, and in the case of a solid, the state of division.

(b) Sensitiveness to impact and/or friction.

(c) Temperature of ignition.

(d) Ease of ignition.

(e) Behaviour on inflammation.

(f) Inherent chemical stability.

(g) The effect on its stability or sensitiveness, of contact or admixture with other material.

(h) Volatility.

(i) Toxicity.

(j) Tendency to develop frictional or contact electrification.

Safety Certificates

1 - 2. For the guidance of the Ordnance Factories, the Armament Research Establishment issues documents known as "Safety Certificates", each relating to a specified Service explosive or composition. These contain information on the properties listed in the above paragraph, together with other information concerning safety in handling.

Provisional Safety Certificates are also prepared, for interdepartmental use, dealing with experimental materials not yet accepted into Service.

Safety Certificates can be consulted on application to the Safety Officers.

Sensitiveness Tests on Explosives

1 - 3. The information on the sensitiveness of an explosive, which is given in its Safety Certificate, is obtained by standard impact and friction tests.

1 - 4. The standard impact test is a modification of the well-known "falling weight" test, and is described in detail in the "Text Book of Explosives Used in the Service". The result given by the test is expressed in the form of a number, known as the "Figure of Insensitiveness", or "F.I.", which compares the impact-sensitiveness of the explosive with that of picric acid, to which is allotted an arbitrary Figure of Insensitiveness of 100, or (for very sensitive explosives) with that of mercury fulminate, to which is given a value of 10.

It should be noted that Figures of Insensitiveness are not directly comparable with published figures of "heights of fall" determined by ordinary types of falling-weight tests, even when these are expressed as percentages of the heights of fall required to explode picric acid.

1 - 5. The standard friction test is carried out by subjecting small samples of the explosive, placed on anvils of concrete, hardwood and softwood respectively, to glancing blows from a boxwood mallet. The result is expressed in the form of a group of three numbers indicating the percentages of explosions obtained in ten tests on each of the anvils. For instance, a Friction Test Result of 100, 50, 0, means that out of 10 tests on each anvil 10 explosions were obtained on concrete, 5 on hardwood and none on softwood.

1 - 6. For explosives which give figures of 100, 100, 100, in the standard friction test, a more refined test is sometimes used in which the explosive, under standard conditions, is subjected to gentle friction between rough surfaces by means of a pendulum device. The result is expressed as a figure indicating the maximum relative velocity of the two surfaces which, under the conditions of the test, gave no explosion in ten consecutive trials.

Interpretation of Sensitiveness Test Results

1 - 7. Explosives are occasionally encountered which are relatively insensitive to impact but highly sensitive to friction. It is essential to take into account the results of both tests in determining the degree of precaution required in working with a given explosive.

1 - 8. In Safety Certificates explosives are classified as regards sensitiveness, into three categories. Very Sensitive, Sensitive and Comparatively Insensitive.

1 - 9. Any explosive with a Figure of Insensitiveness less than 20, or with a Standard Friction Figure greater than zero on the softwood anvil, is classified as Very Sensitive. Explosives in this class must be handled with special precautions to eliminate risk of friction or blow, not only between metals but also between soft surfaces such as wood or cardboard. Examples:- Lead azide, mercury fulminate, cap compositions.

1 - 10. Any explosive with a Figure of Insensitiveness between 20 and 90, or with a Standard Friction Figure greater than zero on the concrete anvil, is classified as Sensitive. Explosives in this class should be handled with special precautions to avoid impact or friction between metallic or other comparably hard surfaces. Examples:- C.E., P.E.T.N.

1 - 11. Explosives with a Figure of Insensitiveness greater than 90 and with a zero Friction Figure on the concrete anvil are classified as Comparatively Insensitive. Examples:- T.N.T., Picric Acid.

Explosives classified as Comparatively Insensitive must be handled with precautions to eliminate blow or friction between hard metals and surfaces of comparable hardness, e.g., concrete, but can be subjected to light blow or friction between relatively soft metals, such as brass or approved types of bronze, without serious risk.

1 - 12. There are instances in which the Figures of Insensitiveness and Friction Test Figures, if interpreted without qualification, may give an exaggerated idea of the danger in handling the materials to which they refer. Since the pressure of a blow is largely determined by the resistance of the material to deformation, the standard tests for sensitiveness, which are carried out on thin layers of explosive, give results which do not necessarily represent the behaviour of the material when thick layers are struck. Thus, although colloidal propellants are definitely dangerous when struck in thin layers as used in the test, they are comparatively safe to handle when in the form of cord or thick sheet.

On the other hand, the Figures of Insensitiveness and Friction Test Figures for liquid explosives may give an exaggerated idea of the insensitiveness of these explosives to impact and friction under practical conditions where the liquid is liable to contain gaseous bubbles, or where air is liable to be entrapped between the liquid and solid surfaces during impact or friction. The heat generated by the compression of the entrapped gas may be sufficient to ignite the explosive even though the forces involved might be quite inadequate to ignite a solid explosive with comparable impact and friction figures.

1 - 13. Another class of materials for which the standard sensitiveness test figures need to be interpreted with qualification comprises oxidising agents such as bromates, chlorates, perchlorates, peroxides, permanganates, etc., and mixtures containing these substances. Mixtures of chlorates, perchlorates, permanganates, or peroxides, with carbonaceous matter or other oxidisable substances such as sulphur, phosphorus, aluminium, magnesium, calcium silicide, silicon, etc., are almost invariably very sensitive to impact and friction, but in some instances the very high friction sensitivity shown in the standard test is not confirmed when a friction test is carried out between steel surfaces. Also, the oxidising agents tested alone, even when they are in fact non-explosive, give high figures in the standard friction test. These abnormal results are due to reaction between the oxidising agent and the wooden mallet used in the test. High sensitiveness is also found when an aluminium mallet or anvil is used, owing to reaction with the metal. For this reason aluminium, in spite of its softness, is an unsafe metal to use with explosive compositions containing chlorates etc.

1 - 14. A further point to note is that relatively mild blows between some surfaces can produce sparks which can easily ignite some explosives, e.g., gunpowder and many pyrotechnic compositions, which are classified as comparatively insensitive.

Information on the inflammability of explosives is given in Clause 7 of the Safety Certificate and any explosive which ignites under the conditions of the test referred to in Clause 7 should be regarded as liable to ignition by spark.

Service Classification of Explosives

1 - 15. Service explosives, and stores containing them, are officially classified into numbered Groups. The Group Number is shown by a label or stencil on each package as a guide to the precautions necessary in handling or storing the contents.

Details of the Group Classification are given in the "Comprehensive Classified List of Government Explosives". The main characteristics which determine the Group are summarised below:-

Group 1

Explosives needing care in handling because they are liable to function by spark or friction, and liable in a fire, to burn rapidly to violent explosion or detonation, but which are not subject to deterioration with age. All explosives requiring "lead free" conditions are included in this Group.

Group 2

Explosives with risks similar to those of Group 1 but subject to deterioration with age. These explosives have usually an allotted "life" at the end of which they must be destroyed.

Group 3

Explosives of limited "life" but not liable to explode violently or detonate on catching fire. Cordite is the typical explosive of this group.

Group 4

Explosives, generally similar to those of Group 1 but less liable to function by a spark or friction.

Group 5

Unboxed shell.

Group 6

Boxed Service ammunition, containing high explosives, gunpowder and propellants only, except the types allotted to the following Groups.

Group 7

Mines, bombs, and underwater ammunition, filled H.E., plugged. With fuzes etc., in separate packages.

Group 7A

As for Group 7, but with fuzes, etc. fitted.

Group 8

Mortar ammunition, Grenades and Rockets containing H.E. and propellant only. Fuzes, etc., in separate packages.

Group 9

Pyrotechnics.

Group 10

Detonators, Initiating compositions.

Group 11

Incendiary and smoke compositions and ammunition. (Not containing white phosphorus, phosphides, inflammable liquids or gels.)

Group 12

Smoke and Incendiaries containing white phosphorus or phosphides.

Group 13

Chemical Warfare ammunition.

Group 14

This is a Naval Stowage Group.

Group 15

Incendiaries containing inflammable liquids or gels but not containing white phosphorus or phosphides.

Explosives in Groups 1 or 2, when stored in large quantities (total stock exceeding 200 lb.) must, according to Service Regulations, be stored under "magazine" conditions, i.e., with precautions, such as use of rubber overshoes or the equivalent, by persons entering the store, to reduce risk of ignition by friction. A full definition of magazine conditions is given in Magazine Regulations (Land Service) Part 1.

CHAPTER 2

EXPLOSIVES WORKROOMS

Approved Workrooms

2 - 1. Work on explosives must only be carried out in rooms approved by the scientist in charge of the area concerned. Wherever possible, the work should be done in rooms designed specially for explosives work, and containing (apart from permanent fixtures) only the apparatus and tools necessary for the intended operations. Where this is not practicable, and explosives have to be handled in a laboratory used for other work, an adequate area of bench should be cleared of all apparatus and tools not required for work on the explosives.

2 - 2. Work on the different classes of explosives, e.g. High Explosives, Propellants, Initiators, and Pyrotechnic Compositions, should not be carried out in the same room.

Electrical Equipment in Explosives Workrooms

2 - 3. The rules given in paras. 2-4 to 2-10 apply particularly to explosives work, further rules of more general application are given in Chapter 11.

2 - 4. All electric lighting, heating and power installations in rooms specially designed for explosives work must be maintained in accordance with current Explosives Storage and Transport Committee specifications. If work on explosives is carried out in a room not so equipped, the electrical installation should be tested by the Establishment Engineer and made sound before the work is started.

2 - 5. No alteration to electrical installations may be made except by approval of the scientist in charge of the area, and by requisition through the Establishment Engineer.

2 - 6. Failures in lighting or power circuits must be reported to the Establishment Engineer immediately they occur. On no account may fuze wires be replaced except by the Establishment Electricians, who will ensure that the correct size of fuze is inserted. Whenever practicable, the cartridge type non-rewirable fuze boxes should be installed.

2 - 7. Lamps on wandering leads may only be used in explosives workrooms when illumination by fixed installation is impracticable for the work in hand. The lamps and the leads must be approved by the Safety Officer.

2 - 8. For use in emergencies due to failure of electric light supplies, a sufficient number of approved Safety Handlamps should be provided.

Details of these handlamps are given in Appendix 2.

2 - 9. Temporary connections to the supply mains may be made by means of flexible leads attached to the permanent pin sockets, but only approved safety cable must be used, and care must be taken by frequent inspection, to ensure that all connections are sound. These temporary leads must not be laid on the floor where they might present a hazard. Where three pin sockets are available the earth lead should always be used.

2 - 10. If controlling electrical resistances or switches (other than those in the permanent installation) are required for work on explosives or inflammable liquids, they should, whenever possible, be placed outside the room.

Controlling electrical resistances are liable to spark and to become hot, and care should be taken not to place them in positions where explosives can accidentally fall on to them, or where they can heat adjacent woodwork or other inflammable material.

Doorways of Explosives Workrooms

2 - 11. Nothing should be allowed to obstruct the doorway of an explosives workroom, or to bar the free opening of the door. If the room has an emergency door, it must be kept unbolted while work is being done.

Repairs and Cleaning of Explosives Workrooms

2 - 12. Before allowing repairs to be started in rooms which have contained explosives, the responsible scientist must ensure that the room is free from explosive or at any rate in a condition safe for repairs to be carried out. With some types of room, e.g., climatic huts, it may be necessary to wash down the walls, etc., to remove explosive deposit.

Aluminium Paint

2 - 13. Steam pipes and radiators in explosives workrooms must not be painted with aluminium paint. Radiators so painted easily give sparks on being struck with a metal tool.

Floors of Explosives Buildings

2 - 14. Floor coverings of workrooms and corridors should be of non-slippery type, particularly where sensitive explosives have to be carried about. Excessive polishing of floors should be discouraged.

Explosive Limits

2 - 15. The maximum weight of explosive permitted in a magazine is known as the "explosive limit" for that magazine, and is fixed by the Safety Officer in accordance with Service Regulations.

Explosive limits must also be fixed for each laboratory or workroom by the scientist in charge in consultation with the Safety Officer.

The scientist in charge is responsible for determining the amount of explosive to be used in individual operations carried out under his orders, and for the amounts which may be placed in ovens or behind protective screens, etc., but the Safety Officer should be consulted in any doubtful case.

Records of Quantities of Explosives in Workrooms

2 - 16. The quantity of explosive in a workroom should not exceed the requirement of the operation in hand, and should in no case exceed the limit laid down for the room. Explosives necessarily left in workrooms overnight should be reduced to the minimum practicable, and the scientist concerned must ensure that the nature and approximate amount of such residual explosive is recorded. This record, is for the information of Firemen and employees on duty during closed periods.

CHAPTER 3

EXPERIMENTAL WORK WITH EXPLOSIVES

General Precautions

3 - 1. Before work on any explosive composition is begun, or any method of filling applied, the intended operations should be critically considered in detail to ensure that no unsafe step is included. A useful aid in doing this is to try out the process on an inert substance having physical properties approximating to those of the explosive composition.

3 - 2. Information on the sensitiveness of the composition should be obtained from the Safety Certificate, if one has been prepared, or by inquiry to the Safety Officer who will have tests carried out, if necessary.

3 - 3. Care should be taken before starting an operation on a sample of explosive or an object containing explosive, to reduce the amount of other explosive in the room to the minimum possible, and to place any explosive necessarily retained in the room as far as possible from the material to be worked on, and if possible, behind protective screens. All explosives not in actual use should always be covered.

3 - 4. Attention is drawn to the risks involved through explosives or components containing them being accidentally mislaid. Explosives should never be put away in drawers or cupboards in laboratories.

3 - 5. A thorough check should always be made at the end of a series of operations to make sure that all explosive brought into the workroom, or area of operations, has been accounted for. This is particularly important when using detonators.

3 - 6. When working with explosives containing more than one ingredient, it should be remembered that segregation may occur and cause, possibly, an increase in sensitiveness. This is of particular importance in connection with the cleaning out of explosives from apparatus.

3 - 7. Cleanliness, method and care are essential in all explosives work. Any form of accidental contamination introduces an unknown factor, and may make risky an operation permissible with the pure material.

For this reason, it is essential that benches and receptacles used for explosives work should be kept scrupulously clean. In particular, it should be remembered that almost all explosives are made more sensitive by the presence of grit, and relatively safe explosives so contaminated may become dangerous to handle.

Tools

3 - 8. Although iron and steel are frequently employed for machinery in explosives factories, it is, in general, advisable to avoid using tools made of these metals, or of glass, in operations on explosives. The material to be used will depend upon the sensitiveness, and chemical properties of the explosive. For highly sensitive explosives, paper should if possible be used. For other explosives, tools of an appropriate soft metal may be used, but care must be taken that the metal selected is chemically compatible with the explosive. Bronze or copper must not be used for explosives containing nitrates; aluminium must not be used for explosives or pyrotechnic compositions containing peroxides, perchlorates, chlorates etc. (See para.1-13).

Cement and Packing Materials

3 - 9. Cements and packing materials, wads, containers etc., employed in explosives work must be selected so as to be compatible with any explosive with which they may come in contact.

In the absence of previous experience, trials should always be made, under precautions, before adopting an untried material. A number of "R.D." cements of known compatibility are available, and standard methods of testing compatibility have been developed by the Armament Research Establishment.

Containers for Explosives (See also Transport of Explosives, Chapter 5)

3 - 10. The use of glass bottles as containers for explosives should be avoided whenever practicable, and certainly restricted to comparatively insensitive explosives or explosives for which containers of other materials are chemically unsuitable.

Glass stoppers must never be used for bottles containing explosives. Cork or rubber stoppers should be used for high explosives or fine grain propellants. Plastic screw-on caps may be used for propellants, other than fine grain, but not for other types of explosive. Metal screw-on caps must not be used.

For explosives in the Very Sensitive class (see para. 1-8) containers designed to eliminate friction must be used, e.g., papier-mache boxes with lids lined with felt or chamois leather, or special rubber or soft metal containers with loose fitting rubber lids, should be used. For other explosives, papier-mache boxes with ordinary lids are suitable.

For transport of Very Sensitive explosives by vehicle specially designed boxes are available (see para. 5-4).

Dangerous Operations

3 - 11. When a possibly dangerous operation has to be performed, adequate measures must be taken against injury to the personnel engaged or others in the vicinity. Protective screens, or where these are not suitable, protective goggles, of approved type, should be used. Where the risk is of fire or splashing by corrosive substance, protective spectacles and clothing should be used. Attention is drawn to the risk involved in the use of sulphuric acid baths for heating explosives, e.g. in determination of melting point.

In all hazardous operations, the number of persons involved should be reduced to the minimum. No one should, however, undertake a hazardous operation unless a second person is present in the room, or in the nearest safe location. This applies especially to work outside normal hours.

Grinding of Explosives

3 - 12. If an explosive has to be ground in the laboratory by hand, an agate mortar and pestle should be used. The use of agate in preference to a softer material is recommended because its highly polished surface reduces friction, and is easily cleaned. The hardness of the surface, of course, increases the danger of impact between pestle and mortar but this can be avoided by careful manipulation.

The surfaces of both mortar and pestle must be thoroughly cleaned before use, and examined closely to ensure that they have not been roughened by wear.

The operation should be carried out well away from the bulk of the explosive, and the grinding effected with a slow, smooth motion avoiding all jerks. Care must be taken not to drop the pestle or, to use it as a tool for emptying the mortar, in case a small portion of the explosive is trapped between the pestle and the edge of the mortar.

The operator should wear protective goggles or use a protective screen. The hands should be protected by wearing washleather gloves.

The quantity of explosive which can be ground at one time by the above method, without risk of serious injury to the hand in the event of ignition, depends on the explosive. If the explosive detonates or violently explodes on ignition by friction, the maximum amount which should be ground at one time is about 0.05 gramme. With explosives which merely burn more or less violently the amount can be increased to about 2 grammes.

Before risking grinding operations on an explosive of unknown properties, preliminary trials should be made, starting with quantities not greater than 10 mg. in which the material is ignited by heat, and also, if possible, by impact and friction. For the latter tests a hammer and anvil and a rough stoneware mortar and pestle may be used.

Handling of Explosives Packages

3 - 13. Packages containing explosives should be moved by lifting, never by dragging or rolling.

Effect of Sunlight on Explosives

3 - 14. Sunlight may cause chemical decomposition in explosives. They should, therefore, never be left in positions where exposure to direct sunlight may occur. Positions where the sun's rays can be focussed by glass apparatus to give a "burning glass" effect should especially be avoided.

Spillage of Explosives

3 - 15. Care should be taken to avoid spilling explosives on benches or floors. If explosive is accidentally spilt, it should, as a general rule, be gathered up before proceeding further with the work. But this should not be undertaken without careful forethought. If the explosive is at all sensitive the operation of gathering it up may be risky, and some process of desensitisation, e.g., wetting may be advisable. It will usually be desirable to remove all other explosive from a room before gathering up spilt material, but this may not always be the case. The correct procedure will depend upon the nature of the explosive and the circumstances.

Toxicity of Explosives

3 - 16. Many explosives are poisonous, and some e.g., C.E. and hexanitrodi-phenylamine, may cause dermatitis.

Strict cleanliness in handling explosives is, therefore, essential, and food or drink should not be admitted into explosives workrooms.

3 - 17. Workers exposed to irritant or dusty explosives, whether toxic or not, should wear protective clothing and take a bath at the end of each day. It has been found that dust tends to collect on moist surfaces of the body and, under the chafing effect of clothing such as occurs round the neck and elbows, may cause dermatitis. Workers should be warned that it is unadvisable to inhale dust, even when it is not known to be poisonous, and should be encouraged to use respirators when handling dusty materials.

Further information on Toxicity is given in Chapter 8 and Appendix 7.

Initiators and Detonators

3 - 18. Explosives of the initiator type, and detonators, should not as a rule be introduced into rooms containing other explosives. Where this is inevitable, special precautions must be taken to ensure the best possible segregation, and padded receptacles of an approved type should be used.

Care should be taken to segregate percussion detonators and to keep them away from other explosives.

Stringent precuations must always be taken to protect electric detonators from accidental contact with batteries, dry cells or other sources of electricity.

Operations on Live Ammunition and Firing of Experimental Charges

3 - 19. Assembly or breaking down operations on live rounds, fuzing, defuzing, cartridging, decartridging, etc., and firing of experimental charges, must only be carried out by or under instruction of a technical officer or a scientist who will be responsible for ensuring that due precautions are taken.

Operations on ammunition of unknown or incompletely known design, damaged rounds, rounds suspected to have been incorrectly assembled, and rounds which have been fired and have failed to function correctly must be regarded as dangerous and appropriate precautions taken (vide para. 3-11).

Static Electrification

3 - 20. Static electric charges can be produced by operations such as sieving, pouring, and mixing. Driving belts are also liable to cause accumulation of charges on the apparatus driven. The charges so produced may have sufficient energy to ignite explosives such as dry guncotton and initiating compositions. Ignition through electric discharge may also occur when materials giving rise to fine combustible powders dispersed in air, or inflammable vapours, are being handled. Serious accidents have been caused, for instance, through electric ignition of the inflammable vapour arising from the residual solvent in the propellant neonite. Similar risks are present with ballistite and other fine-grain solvent-type propellants.

3 - 21. In order to reduce risks of the above type, all fixed plant used in handling explosives should be permanently "earthed" and, when necessary, movable apparatus should be fitted with temporary earthing connections.

3 - 22. It should be remembered that, even when apparatus is earthed, operatives wearing insulating footwear such as "danger building" goloshes, or walking on insulating floors, may develop on themselves a dangerous electro-static charge. Where such conditions may lead to risk, the approved "personnel earthing technique" should be employed. Details of this procedure may be obtained from the Safety Officer.

Machinery, Provision of Guards and Safety Devices

3 - 23. Machines, whether hand operated, or power driven, used in explosives workrooms, must, as far as practicable, be fitted with such guards and safety devices as would be requisite if the machines were installed in a workshop to which the provisions of the Factories Acts apply. No newly installed machine must be put into use until it has been approved by the Safety Officer. (See also Chapter 9).

Machinery, Protection of Personnel

3 - 24. In addition to the provision of the devices referred to in para. 3 - 23, all precautions practicable should be taken to protect personnel against risks due to machinery. In particular, female workers should be provided with protective headgear when working near revolving spindles, drills and cutters. It should be noted, however, that the provision of such headgear does not, according to the Factories Acts, relieve the employer from the responsibility of providing guards.

Heating of Explosives

3 - 25. The heating of an explosive is liable to cause chemical deterioration and should, therefore, be restricted to the lowest temperature and shortest time necessary for carrying out the required operation. Prolonged heating may give rise to ignition at temperatures appreciably below the "Temperature of Ignition" recorded in the Safety Certificate, e.g., mercury fulminate is liable to explode when heated at 100°C. although the temperature of ignition as determined by the Safety Certificate test is 147°C.

3 - 26. Unless it is certain that the temperature of heating and the stability of the explosive are such that there is no risk of inflammation or explosion, explosives must only be heated under conditions as to place, type of apparatus, and explosive limits approved by the Safety Officer. Electric ovens if used must contain no exposed heating elements, and must be installed and operated under conditions approved by the Safety Officer.

3 - 27. Attention is drawn to the relatively low temperatures of ignition of most propellants, mercury fulminate, and coloured-smoke compositions.

Drying of Explosives. Desiccators (See also Chapter 8)

3 - 28. The common drying agent used in desiccators, viz. concentrated sulphuric acid, is unsuitable for use with explosives, some of which, e.g. mercury fulminate and lead azide, explode on coming into contact with it. "Drierite" (anhydrous calcium sulphate) is a safe drying agent which meets most ordinary needs. If a more powerful desiccant is essential, phosphorus pentoxide can be used. This substance, however, although less dangerous than sulphuric acid, must be prevented from coming into contact with the explosive.

3 - 29. Glass vacuum desiccators must not be used for initiators or other very sensitive explosives. (See para. 6-7).

CHAPTER 4

STORAGE OF EXPLOSIVES

General Rules

4 - 1. It is the duty of all engaged on explosives work to keep stocks of explosives as small as possible by avoiding over-requisitioning, and by getting rid of explosives as soon as they are no longer required.

4 - 2. As far as is practicable, explosives should be kept in the main magazines. The locker magazines and ready-use magazines under the control of Heads of Sections, should be used only for experimental explosives and for those required for day to day use.

The explosive limits for locker magazines (per locker) are as follows:-

High Explosives	8 lb.
Propellants	8 lb.
Initiators	1/2 lb.
Gunpowder and Pyrotechnic Compositions	2 lb.

Each locker must be used for one of the above types only.

Explosive limits for individual ready-use magazines are fixed by the Establishment Safety Officer.

4 - 3. Before any explosive is stored in a magazine it must be entirely enclosed in an approved container or package. Each container or package must be labelled with a description of its contents, the name of the scientist responsible for it, and the dates of periodic stability tests as detailed in Appendix 1.

Containers or packages must not be opened in the magazine, but must first be transferred to a place well away from other explosives and from gas flames or other possible sources of ignition.

While the doors of magazines, or of the magazine enclosure, are being opened or closed, the explosive package must not be placed on the ground but on the shelves provided.

The person using a magazine is responsible for locking it securely immediately on leaving it and for returning the keys to the appointed place.

4 - 4. If the magazine is heated, no package may be placed within two feet of the heating apparatus.

Storage of Unstable Explosives

4 - 5. Explosives of doubtful stability must not be stored in ready-use or locker magazines, but arrangements must be made to have them kept in isolation magazines under periodic observation.

Records of Explosives Stocks

4 - 6. It is the responsibility of Heads of Sections to ensure that written records are kept of all explosives in the charge of the Section. These will normally consist of the following:-

(a) Lists of explosives stored in the Section's ready-use and locker magazine.

(b) List of explosives held specially for the Section in the main magazines.

(c) Lists of explosives held in workrooms or laboratories (see para. 2-16).

(d) Results of periodic stability tests (vide Appendix 1).

These records should include the name of a scientist responsible for each item. It is essential that, before a scientist goes on leave, or ceases to work in the Section, he should make arrangements to transfer to a successor or deputy his responsibility for all explosives stored under his name.

4 - 7. The records should be checked with the actual stocks at least once every four months, and certified as correct by a scientist of grade not lower than S.O. or S.E.O.

Records relating to the storing of dry nitrocellulose must comply with the requirements detailed in para. 4-8.

Storage of Dry Nitrocellulose

4 - 8. Nitrocellulose should not be accepted for drying without full information as to its Heat Test and alkalinity. In the case of Service nitrocellulose drawn from the original package, the data on the Inspection Certificate of the Lot concerned may be accepted. All non-Service nitrocellulose should be sampled for departmental analysis and test, before drying is proceeded with. Records should include these stability data and others arising under (c) below.

The following procedure must be strictly followed whenever it is necessary to store nitrocellulose in the dry condition.

(a) Nitrocellulose must not be stored in the dry condition for more than twelve weeks

If kept dry for four weeks it should be heat tested at 170°F. and subsequently be heat tested every two weeks. The results of these tests should be entered on the storage label of the sample.

At the end of twelve weeks storage the nitrocellulose, if still required, must be re-wetted and tested for heat test and alkalinity before it is re-dried. After re-drying, the sample will enter a fresh cycle of twelve weeks permitted storage in the dry condition under the same conditions as above.

Samples of dry nitrocellulose must be taken with precautions appropriate to the sensitivity of the material, the bag being removed to a safe distance from other explosive.

(b) Storage bags of approved type of rubberised fabric should be numbered consecutively in bold characters, and these numbers recorded on the tag labels and records along with all other details necessary for identification of the contents. The records should include the name of the scientist who has authorised the storage of the sample.

(c) The approved form of storage label is shown in Appendix 3.

(d) Stocks of dry nitrocellulose should be scrutinised weekly, and a record kept of these inspections and of any re-wetting actions taken.

Storage of Wet Nitrocellulose, Collodion, etc.

4 - 9. Explosives which are normally stored with the addition of a certain proportion of water or other liquid and any other samples of explosives which it is considered desirable to store wet, must be placed in well closed containers to prevent evaporation of the liquid and must be inspected at regular intervals (See Appendix 1).

CHAPTER 5

TRANSPORT OF EXPLOSIVES

Transport within the Establishment

5 - 1. Explosives may only be transported by persons authorized to do so by the responsible scientist, and must be entirely enclosed in a package before being transported from one building to another, unless the transit is merely between neighbouring buildings in the same "clean" area.

5 - 2. For transport of explosives in quantities too great to be carried by hand, trucks of design approved by the Establishment Safety Officer must be used.

5 - 3. Should circumstances arise requiring transport, other than by hand, of explosives with a Figure of Insensitiveness less than 35, or a Friction Sensitiveness Figure greater than zero on the softwood anvil, a truck of approved design must be used.

It is the responsibility of the scientist ordering explosives to be transported, to ensure that the correct type of package and/or truck is used, and that any truck used is correctly loaded.

5 - 4. Detonators, initiating explosives, or any explosive or pyrotechnic composition with a Figure of Insensitiveness less than twenty or a Friction Sensitiveness Figure greater than zero on the softwood anvil, should normally only be carried by hand, and in an approved detonator carrying case or "Transport Box for Very Sensitive Explosives".

Transport outside the Establishment

5 - 5. All arrangements for the transport of explosives by rail, sea and public roads must be made through the Magazine Chargeman who will consult with the Safety Officer to ensure that Service Regulations are complied with. Carriage of explosives in departmental passenger cars or in private cars used on official journeys is controlled by Establishment Instructions. Permits to carry small samples of certain explosives by passenger train can be obtained from the Safety Officer. These permits cannot be used on the railways of the London Passenger Transport Board and are subject to compliance with a code of rules a copy of which will be supplied with the permit. Such samples may not be carried in any public vehicle e.g. omnibus, but may be carried in a taxi-cab.

Explosives for transport by road or rail must be packed and labelled by the Magazine Chargeman who will ensure that they are packed in accordance with Service Regulations, or, if appropriate Service Regulations do not exist, in a type of package approved by the Establishment Safety Officer.

5 - 6. No explosive, corrosive or otherwise dangerous material may be sent by the public post. Explosive must not be included in correspondence carried by official messengers, or otherwise, within the Establishment or outside.

5 - 7. It is stressed that the reference to explosives in this chapter refers to both loose compositions and any explosive filled store and component.

CHAPTER 6

SPECIFIC EXPLOSIVE RISKS. EFFECT OF CONTAMINANTS

6 - 1. In this Chapter, attention is called to some important properties of a number of explosives and the extent to which their safe handling may be endangered by contaminants.

Effect of Water on Explosives

6 - 2. The addition of water to an explosive usually makes it more safe, but there are important exceptions to this rule, and with some explosives, moisture is a dangerous contaminant. Thus, although the sensitiveness of mercury fulminate or lead styphnate is appreciably diminished when these explosives are immersed in water, that of lead azide is not diminished, and detonators containing lead azide, if exposed to moist conditions, will evolve hydrazoic acid (gaseous) which may form highly sensitive azides on metal surfaces, e.g., on the outside of the detonator sheath.

Compositions containing metallic powders are liable to develop dangerous reactions if they become moist. Pyrotechnic compositions containing magnesium powder and a nitrate, and smoke compositions containing zinc dust, if moistened, may heat up to the ignition temperature. Interaction and resultant gassing of aluminized high explosive compositions is increased by moisture. Residues of such compositions, if they cannot be kept free from moisture until destruction, should not be left in a slightly moistened or damp condition, but should be completely immersed in water (with thorough stirring in the case of smoke or pyrotechnic compositions), and the containing vessel kept in the open.

Sensitive Compounds of Heavy Metals

6 - 3. Contact of explosives with heavy metals or their salts, even in solution, particularly lead and its salts, may produce substances whose sensitiveness is very much greater than that of the parent substance. This risk is particularly marked with nitrophenolic compounds, e.g. picric acid, picrates and dinitrophenol.

Effect of Alkalies and Acids

6 - 4. The presence of alkali (including ammonia) with T.N.T. may increase its ease of inflammation. T.N.T. on exposure to gaseous ammonia forms compounds with ignition temperatures considerably below 100°C.

The stability of nitric esters, e.g., nitroglycerine and nitrocotton, is seriously impaired by acidic conditions, and the presence of acid in any form may lead to inflammation. Strong caustic alkalies have a similar effect.

Coloured-smoke compositions, which usually consist of a mixture of a sugar and potassium chlorate heavily diluted with a dye, are liable to develop dangerous instability if contaminated with a trace of acid (e.g. in the dye).

Sensitive Corrosion Products of Copper and Tin

6 - 5. Copper or brass, especially if tinned, will react with ammonium nitrate producing sensitive salts.

Basic stannous nitrate is especially sensitive.

Reaction of Aluminium with Mercury Fulminate

6 - 6. Aluminium is rapidly attacked by mercury salts and, therefore, must not be used as a container for any composition containing mercury fulminate.

Effect of Chlorides on Smoke Compositions

6 - 7. Smoke compositions are seriously affected by contamination with soluble chlorides, e.g., sea water or zinc chloride soldering flux; spontaneous fires have been attributed to both of these contaminants.

Liquid Explosives. Methyl nitrate, Nitroglycerine, etc.

6 - 8. Liquid explosives present special risks on account of their mobility and generally high sensitiveness. In handling them, the use of glass, earthenware or metal stoppers and stopcocks should be avoided and only suitable plastic types used. Special care must be taken to guard against dropping containers filled with them.

For further information regarding the sensitiveness of liquid explosives see para. 1-12.

Nitroglycerine should always be handled with the greatest care, and it should be remembered that when this explosive is in the frozen or semi-frozen condition the risk may be increased. Other liquid explosives such as methyl nitrate may have a high vapour pressure, and a flash may be transmitted from the vapour phase to the liquid phase. The sensitiveness of methyl nitrate to friction between glass surfaces is abnormally high.

Sensitiveness of Fine-grain Propellants

6 - 9. Cordites and other propellants, although not dangerous to handle when in stick or tubular form are dangerously sensitive to impact or friction when in the form of fine flake or thin sheet and have an enormously increased rate of burning. For these reasons, ballistite and neonite, for instance, require care in handling.

Sensitiveness of Mixtures Containing Chlorates, Bromates, Perchlorates

6 - 10. Any mixture containing a chlorate must be handled with the greatest care; such mixtures are in general extremely sensitive, both between metal and metal and between wood and wood.

Mixtures containing bromates are usually more sensitive, and those containing perchlorates somewhat less sensitive than the corresponding chlorate mixtures.

Chlorates should not be allowed to come into contact with ammonium salts or strong acids.

Sensitiveness of Compositions Containing Powdered Metals or Calcium Silicide

6 - 11. All pyrotechnic compositions containing powdered metals or calcium silicide are very sensitive between steel and steel. They sometimes ignite during compression in steel or metal moulds when there is no material such as paper between the composition and the mould. Scratching of compressed composition with a sharp brass tool has on occasions caused ignition.

Plastics, synthetic resin adhesives and cements with polymerisation catalysts

6 - 12. Before any of these materials are used under conditions in which they may come into contact with explosives, it is essential to ensure that they are compatible. A number of commercial types have been tested and information concerning their suitability for any application can be obtained from the Safety Officer (See also para.3-9).

CHAPTER 7

DISPOSAL OF WASTE EXPLOSIVES

General Rules

7 - 1. For the purpose of disposal, waste explosives are separated into two classes as follows:-

A. Explosives which must be destroyed under the personal supervision of Scientists in the Sections concerned

These include all initiating compositions, gunpowder, pyrotechnic compositions, and liquid explosives. Experimental explosives, and foreign explosives are also included in this class, except those for which other methods of disposal have been approved by the Establishment Safety Officer.

7 - 2. Gunpowder should be destroyed by washing out the nitrate with water, similar wet methods can be used for some pyrotechnic compositions. Chemical methods should be used when practicable for destroying initiator and cap compositions. If these compositions have to be burnt, they should first be immersed in oil. These operations must only be performed by persons familiar with the properties of the explosive.

7 - 3. Filled caps, and detonators should be destroyed by detonation in a shell. Arrangements can be made for detonators, in quantity, to be destroyed by R.O.F. Woolwich provided they are safe for transport. Requests for this facility should be made to the Safety Officer.

B. Explosives which may be destroyed by the Magazine Chargeman

7 - 4. Material placed in the official waste explosives bins, or (by special arrangement) collected from the Sections by Magazine Staff, which complies with the following requirements:-

(a) The material must be segregated into the following categories:-

  (i) Service H.E. (not containing R.D.X.)
  (ii) Service H.E. (containing R.D.X.)
  (iii) Minol and other aluminised Service explosives.
  (iv) Cordite
  (v) Nitrocotton and guncotton.
  (vi) Neonite, ballistite, N.C.Y. and other fine-grained propellants.
  (vii) Industrial explosives and explosives (other than cordite) containing N.G.

(b) The material must contain no unopened packages or large lumps.

(c) The material must be free from non-explosive waste other than paper or rags contaminated with explosive.

7 - 5. Material, not complying with the above requirements, the receipt of which has been authorised and for which a safe method of destruction has been approved by the Establishment Safety Officer. This class includes residues from the extraction of nitroglycerine from dynamite.

Laboratory receptacles for waste explosive

7 - 6. For the immediate receipt in the laboratories and workrooms of waste explosives intended for destruction by the Magazine Chargeman, lightly covered receptacles are provided. These should be sufficient in number to accommodate all the categories of waste explosive likely to be produced, and should be plainly labelled. The receptacles should contain some water, and should be kept close to a door. They should be emptied daily into the appropriate bulk waste explosives bin.

The scientist is responsible for ensuring that the appropriate bulk waste receptacle is used, and that no unopened packets or large lumps are placed therein. Non-explosive waste, apart from paper or rag contaminated with explosive, must not be placed in these waste pots. Oily rags must be rigidly excluded and placed in steel containers placed outside laboratories for this purpose. If there is an abnormal amount of waste for disposal, special arrangements must be made with the Magazine Chargeman for its removal and destruction. Metal contaminated with explosive must not be placed in the waste pots. If it cannot easily be freed from explosive, special arrangements must be made with the Magazine Chargeman for it to be dealt with, consulting the Safety Officer, if necessary. Wood (except small pieces) or oily rags contaminated with explosives should be sent separately to the Magazine Chargeman.

Burning of Waste Explosive

7 - 7. When experimental explosives have to be destroyed by burning, the operation must be carried out, on the approved burning ground by arrangement with the Magazine Chargeman.

The minimum number of men should be present on the burning ground.

The following procedure must be strictly followed:-

(i) Explosives must be burnt only on the steel trays provided for the purpose. Before use, the trays and the ground surrounding them must be inspected to ensure that they are free from objectionable material.

Before destruction of waste explosive, the grass surrounding the burning ground is to be well watered, especially to leeward. A small fire hose must always be laid out in readiness before commencing operations. A supply of birch brooms must also be kept nearby in order that any grass fire may be extinguished.

Before explosive is brought up to the trays, it must be ascertained that the trays and ground are cold. If not, they must be cooled by watering with the hose.

(ii) The maximum quantity of explosive to be burnt in one tray for each explosive must be limited to the quantity stated in the instructions issued by the Safety Officer.

(iii) Only one waste container must be taken at a time to the trays. After emptying, the container must be removed to the edge of the burning ground before another is brought up.

(iv) Only one kind of explosive must be burnt in one tray.

(v) Propellant should be spread evenly over the tray in a layer not greater than three inches deep.

(vi) H.E. should be spread over the tray to a maximum depth of two inches, and mixed with clean wood shavings or chopped wood. It should then be damped with mineral burning oil.

(vii) Pyrotechnic Compositions and Incendiary Compositions must be spread over the tray in a layer not greater than 1/4 inch deep. It is emphasized that loose pyrotechnic composition, unless spread out in a thin layer, may explode when ignited, and if laid in a heap will almost certainly do so.

(viii) Ignition The explosive must be ignited by means of a thin cordite train, at least 10 ft. in length, laid at right angles to the wind direction, and arranged so as to ignite the explosive at the leeward edge of the tray. The train must be set alight by means of a fusee, before the train is lighted, all personnel must retire to the approved safety distance, except the operative who lights the train.

(ix) Misfire In case of misfire, the explosive must not be approached for at least five minutes, and then only by one man, who will renew the train or take such steps as are necessary to proceed with the burning in safety.

(x) Use of more than one tray If more than one tray is required the trays should be at least 5 feet apart, and connected by a cordite train laid in the same manner as that used for igniting the first tray. Not more than 4 trays are to be used at one time.

(xi) Residues When the bulk of the explosive has been burnt away, and only a smouldering mass of residue remains, the contents of the tray may be raked over with the long-handled rake provided. Only one man should approach the tray during this operation. When all burning is obviously finished, the residues should be quenched with water. If any unconsumed explosive remains, it must be collected for subsequent burning.

(xii) After the completion of any burning operation, the site should be hosed down.

CHAPTER 8

SAFETY PRECAUTIONS IN GENERAL LABORATORY WORK

Inspection and Cleaning of Workrooms and Laboratories

8 - 1. The scientist will arrange, by the appointment of a suitable member of his personnel, for the routine inspection at the end of each working day of the workrooms under his control. The results of the inspection will be entered in the local certificate book in accordance with the Fire Regulations.

The inspector will ensure that all dangerous materials such as oily waste, explosives, etc. have been removed, that no inflammable material is in contact with steam pipes or where it increases fire risks, and that no objects are left in places where they might cause hindrance to fire fighting. He will also ensure that all windows are closed and properly fastened, and that all services are turned off at terminal points, unless special provision has been made and the necessary notification given to staff on duty during closed periods.

It is important that the above inspection should include any rooms temporarily out of use.

A routine cleaning schedule should be drawn up to ensure regular cleaning of every part of each room. This should include a weekly cleaning of radiators, steam and other service pipes.

Gas Burners

8 - 2. When lighted gas burners are left unattended, the scientist must ensure that the rubber tubing, if used, is in good condition and protected from radiant heat. Special attention should be given to the parts of the tube at the ends of the metal connections where it is liable to break. Joints should be secured by wire, the tube being wrapped with tape to prevent cutting of the rubber. "Jubilee" clips can be used instead of wire, and are better.

Care should be taken that the burner is in a stable position protected from draughts, and that no inflammable material is in the vicinity. Where burners have to be left on overnight, in addition to these precautions, a notification in writing must be made to the appropriate authorities, who will arrange for periodic inspection. As far as possible all experiments necessitating heating by gas overnight should be carried out in rooms approved for the purpose. Whenever practicable, and particularly for the more permanent installations, the burners should be connected to the gas main by brass or steel tube.

Toxic Substances and Fumes

8 - 3. It is the responsibility of the scientist to ascertain as far as possible by consulting the literature or by reference to the Medical Department or Safety Officer, the toxic properties, if any, of materials used in work carried out. Particular care is required in regard to volatile substances. It should be noted that many materials commonly handled with little precaution e.g., benzene, petrol and many other volatile solvents, are dangerous if breathed in concentrations which may be met with during some ordinary operations carried out with them. (See Appendix 7).

Precautions should be taken to ensure strict cleanliness in handling toxic substances. In particular, persons should not be allowed to eat food in rooms where toxic contamination is possible, and smoking should be prohibited. When work is in hand requiring frequent use of toxic substances, notification should be made to the Safety Officer who will arrange with the Medical Department for advice as to the provision of suitable antidotes or treatments.

8 - 4. Work involving the production of harmful fumes or airborne dust should be carried out in fume cupboards or with other adequate draught arrangements. If this is not practicable, respirators should be used. Respirators with suitable canisters covering the range of toxic substances likely to be dealt with are available in the Establishment Store. Before a respirator is used, care should be taken to check that it is in working order and fitted with the correct canister for the risk involved. Respirators should not be worn for periods longer than those for which they are known to give protection.

8 - 5. Attention is drawn to the insidious action of certain toxic gases. Continuous breathing, for instance, of carbon monoxide, or nitrous fumes, may result in serious illness, even though the atmosphere concerned may seem quite tolerable.

Mercury vapour is highly poisonous; spilled mercury should not be left lying about on floors or benches.

8 - 6. For dealing with heavy concentrations of toxic gases, e.g., in emergencies, Gasmasks and Self-contained Breathing Apparatus are available, and every laboratory worker should familiarise himself with the use of these equipments.

Vacuum Desiccators (See also para. 3-29).

8 - 7. Large vacuum desiccators, especially those which are not spherical, are liable to collapse under vacuum, and precautions should be taken, during and after evacuation, to prevent damage to the surroundings should a collapse occur. This can be done by fitting the desiccator with a protecting wire cage, but the risk of accident can generally be sufficiently reduced by using the smallest desiccator possible and making sure that it is free from flaws, and is of good design. The best type has both lid and body of approximately hemispherical shape. Besides being strong enough to stand a complete vacuum, a satisfactory desiccator should be easy to open after it has been under vacuum for a long time, and should have a suction tube so designed as to prevent the contents being disturbed by the inflow of air when the vacuum is broken at the maximum rate.

Centrifuges

8 - 8. Laboratory centrifuges which are hand operated should be fitted with protecting screens wherever practicable. Power driven centrifuges may only be operated after the installation has been approved by the Safety Officer.

Vacation of Laboratories. Clearance Certificate

8 - 9. Whenever a laboratory is vacated, a clearance certificate is to be passed by the responsible scientist to the incoming tenant.

This certificate should certify freedom from explosive or other dangerous material for all parts of the laboratory, including the catch pots in the drainage from sinks if any are present.

Copies of the certificate should be sent to the Safety Officer, the Establishment Administrative Officer and the Superintendents concerned.

Drain Contamination

8 - 10. Every care must be taken to prevent explosive material, waste solvent, or mercury getting into the drains. Exits from all laboratory sinks should be provided with catchpots to arrest such material, and steps must be taken to ensure that these are periodically cleared.

Inflammable Solvents

8 - 11. The quantity of inflammable solvents retained in any laboratory should be kept to a minimum. Special solvent cupboards, outside the laboratories, are provided for storage purposes. In addition, main solvent stores are available for bulk storage.

8 - 12. On no account should inflammable liquids be heated by, flame, electrically heated hot plate or sand or oil bath. When steam heating is impracticable an approved form of electric heating mantle may be used.

8 - 13. The distillation, boiling or refluxing of inflammable liquids in glass apparatus always present grave fire risks. Every precaution should be taken to prevent spread of fire in the event of breakage of the solvent container or receiver. Where relatively large quantities of liquid are involved, the provision of a suitable collector, under the boiling vessel is a useful precaution.

8 - 14. The most important precaution, of course, in work with inflammable liquids, is to do it well away from lighted gas burners, electrical hot plates, resistances, etc. The ideal method is to isolate the work in a room from which all sources of ignition are excluded. A less satisfactory but useful, method is to mark off a similarly restricted area in the laboratory. Inflammable vapours are generally much denser than air, and can flow considerable distances along a bench top before becoming sufficiently diluted to be non-inflammable. Carbon disulphide is particularly dangerous on account of its dense vapour and its very low ignition temperature. Fires have occurred through the vapour of carbon disulphide being ignited by steam radiators. It should be noted that electrical heaters can be accidentally left "on" without necessarily giving visible indication of it. Instances have occurred of solvent fires started by bunsen burners apparently "out" but, in fact, alight. In one case the flame was made invisible by sunlight, and in the other a burner fitted with a bye-pass feeding a tiny pilot flame had been left with this flame alight. Bunsens fitted with pilot lights should not be admitted into ordinary laboratories.

8 - 15. If inflammable solvents, particularly ether or benzene, have to be poured from metal containers, care should be taken to ensure that the container is earthed by a suitable connecting wire. Otherwise ignition is liable to occur by spark due to static electrification.

8 - 16. Inflammable solvents containing sodium as drying agent are a serious fire risk, and are not permitted in the main bulk solvent stores. They should be kept outside the laboratory in the local solvent store.

Cleaning of Glass-ware

8 - 17. The scientist conducting an experiment is responsible for making sure that apparatus handed to junior staff for dismantling or cleaning, is safe. If residues e.g. sodium, hydrogen peroxide, organic matter, requiring special treatment are likely to be present the necessary warning and instruction must be given before the apparatus is handed over.

Care should be taken to instruct junior staff in the correct methods of cleaning apparatus where cleaning agents such as nitric acid, mixtures of sulphuric acid with potassium bichromate etc., are used. These acids are capable of inflicting severe burns if they are spilt or splashed on the exposed skin. The work should be carried out, whenever possible, in a large sink with an adequate water supply, and protective gloves and goggles should be worn. These reagents may develop violent reactions with residues in the apparatus, and with alcohol, ether etc., which are sometimes used to follow them. An explosion has occurred through the use of the sulphuric acid-chromate mixture to clean a flask containing traces of concentrated hydrogen peroxide.

8 - 18. For reasons which have already been mentioned, carbon disulphide should not be used by laboratory attendants as a cleaning agent, except under supervision.

Concussion from Gun Fire or Bomb Chamber explosion

8 - 19. In laboratories situated near gun ranges or bomb chambers, precautions are necessary to prevent breaking of glass apparatus by concussion. Fractionating columns, for instance, must be carefully secured.

Shelves carrying bottles of solvents, acids, etc., should be fitted with a light rail to prevent the bottles being shaken off.

Glass Cutting and Apparatus Assembly

8 - 20. Broken glassware is a frequent cause of injury, in Chemical Laboratories.

It is essential that no-one should be allowed to cut glass tubing and assemble or dismantle glass apparatus who has not been trained to observe the following rules:-

(a) Use a duster or other suitable protection of the hands in all possible operations with glass e.g., when snapping glass tube after notching it or when forcing a tube into or out of a stopper.

(b) Fuse the cut edges of all tubes which are to be inserted into stoppers or rubber tubing.

(c) When pushing a tube into a stopper always use a lubricant and employ a twist motion. Hold the stopper against a firm surface until the end of the tube is through the perforation. Grasp the tube close to the stopper, never more than one inch away.

(d) Examine glassware carefully before use and reject any showing signs of flaws. Fused joints should be carefully annealed to dissipate strain. For critical joints it is advisable to test by means of a strain detector employing polarized light.

(e) Scrap broken glassware immediately or make it safe. Never put it into a drawer or cupboard. Never put broken-ended tubing back into stock, cut the ends clean and fuse them.

(f) Never accumulate bent glass tubing in a drawer.

Glass Apparatus. "Burning Glass" Effect

8 - 21. Instances have occurred of fires started in laboratories through the focussing of sunlight by globular pieces of glass apparatus, e.g., washbottles. The risk is, of course, particularly great when explosives are present, but should be guarded against generally.

Gas Cylinders

8 - 22. Compressed gases supplied commercially in cylinders are of three types:-

(a) "Permanent" gases (e.g., oxygen, nitrogen, carbon monoxide, coal gas, methane) at a pressure of up to 1,980 lb. per square inch in round ended cylinders which can be stored or used in either the vertical or horizontal position. The cylinders for inflammable or toxic gases are usually provided with a screwed collar to take a valve cap, but caps are usually absent.

(b) "Liquefiable" gases e.g., ammonia, carbon dioxide, sulphur dioxide, chlorine, hydrocyanic acid, phosgene, ethylene, nitrous oxide, methyl chloride, in round or flat-based cylinders which must be stored upright and used upright (unless it is intended that they should deliver liquid). The cylinders usually are issued with valve caps.

(c) Dissolved gases, of which the only present example is acetylene dissolved in acetone under a presure of 225 lb. per square inch. The cylinders are flat based and must be stored and used upright. A valve cap ring is provided, but under present conditions valve caps are usually not available.

Precautions applicable to all types of Compressed Gases

8 - 23. (i) As an aid in identification, a colour code for gas cylinders (see Appendix 4) has been introduced by the British Standards Institution. This code is, however, not yet in full use and it is necessary to refer to stamped markings or attached labels to be sure of the identification of a cylinder.

(ii) To prevent the interchange of fittings between cylinders of combustible and non-combustible gases, the valve outlets are screwed left and right hand respectively. This difference in threads is maintained on all accessories such as pressure regulators, adaptors, hose connectors etc., sold by appliance makers for use with cylinders, but does not apply to the valve spindle on the cylinder valve which is always closed by turning to the right.

(iii) When mains gas is used in conjunction with compressed oxygen or air (whether from a cylinder or from the mains), or when a compressed inflammable gas is used in conjunction with air from the mains, a non-return valve must be fitted to the mains supply. Valves for this purpose are supplied by the appliance manufacturers.

(iv) When in use, cylinders should be held in the approved type of stand or firmly clamped to a bench, and must be placed well away from sources of heat.

(v) Cylinders should be transported only on the special trucks supplied for the purpose by the Stores Officer, and must always be handled with care. Instances have occurred in which the dropping of a cylinder has caused it to explode, and careless handling of a cylinder may result in the valve head being broken off. With a permanent gas this accident can cause serious injury through the violent projection of the cylinder caused by the escaping gas. If the cylinder has a valve cap it should always be put on during handling and transport. To prevent accident due to building up of pressure in the valve cap in the event of the cylinder valve leaking, valve caps are provided with a vent. Before fitting a valve cap it should be confirmed that the vent is not blocked.

(vi) When gas is not being taken from the cylinder the cylinder valve must be closed. It is unsafe to leave the cylinder valve open with a valve elsewhere on the system closed.

(vii) No undue force should be used in opening or closing cylinder valves. If the valve does not turn with moderate force the gland nut should be slackened slightly, if this does not ease the spindle, the gland should be re-tightened and the cylinder returned to store for special treatment. No attempt should be made to correct a leaky valve by forcing the valve spindle on to the seating. The valve should be opened slightly to allow it to clear and then closed firmly but using no more force than can be applied by one hand on the key. If repetition of this treatment fails to remedy the leak, the cylinder should be taken into the open and discharged under suitable precautions.

A leak at the valve packing will only be evident when the valve is open and can usually be remedied by tightening the gland nut.

(viii) Run down cylinders should always be left with the valve closed to prevent air diffusing into them.

(ix) No oil or grease should be used inside or outside any valve fitting, or pressure regulator.

(x) Gas cylinders of all types are liable to explode when heated and are, therefore, a serious addition to the fire risk of a building. This should be taken into account when deciding where to use them in a laboratory. Whenever it is practicable they should be removed to a fire proof store or isolated building overnight. Always use the smallest size cylinder adequate for the work.

(xi) Gas cylinders whether full or empty should not be used as mandrels for bending sheet metal etc. or as rollers to move heavy equipment.

(xii) Gas cylinders should be returned to store immediately they become empty. They should be clearly labelled "Empty".

Special Precautions

8 - 24. Permanent Gases

(i) Cylinders of permanent gases should only be used with a pressure regulator attached. Before the regulator is fitted, the cylinder head and the regulator connections must be cleaned free from dirt. The cylinder valve should always be opened gently; sudden release of the gas into the regulator may cause local heating by adiabatic compression and particles of grit propelled by the gas may become heated by friction. With an inflammable gas there is a risk of its being ignited, and with oxygen, combustible material in the regulator and even metallic parts of the regulator may be ignited. For this reason, cylinder fittings should never be oiled and jointing materials such as red lead or white lead containing organic matter, and components containing aluminium or magnesium should be excluded from apparatus in which compressed oxygen is used. Oxygen cylinders should not be handled with greasy hands, gloves or rags. Oxygen should never be used in place of compressed air or nitrogen for pressure testing, cleaning etc. Several serious explosions have occurred through neglect of this rule.

Inflammable Gases

(ii) In the B.S. Colour code, cylinders of inflammable gas are coloured red, except acetylene cylinders which are maroon.

Cylinders of inflammable gases should only be used in positions remote from flames, electric heaters etc. and in well ventilated positions. Inflammable gases should never be released into the air or allowed to escape into a laboratory fume extraction system.

It should be noted that the sudden discharge of a compressed inflammable gas into the air from a cylinder has on more than one occasion resulted in its catching fire.

Acetylene

(iii) Acetylene cylinders are liable to develop internal heating if improperly used. If a cylinder is found to have become hot the valve should be closed and the regulator detached. The cylinder should then be taken into the open air and cooled by immersion in water or by means of a fire hose. When cool the cylinder should be taken to a suitable place distant from buildings and flames and the gas allowed to escape by opening the valve.

Cooling should be continued if practicable.

If gas is drawn from an acetylene cylinder too rapidly, there is a risk of its being diluted with acetone vapour. The hourly rate of withdrawal should not be greater than 20% of the content of the cylinder.

Copper reacts with acetylene to form an acetylide which is a very sensitive explosive. No pipe or fitting of copper or any alloy containing more than 70% of copper should be allowed to come in contact with acetylene.

Toxic Gases

(iv) In the B.S. Colour code, cylinders of toxic gases have a yellow band.

Cylinders containing toxic gases must not be brought into a laboratory without permission from the Head of the Section.

When using a toxic gas, it is a good plan to fix the cylinder in the open air and lead the gas into the laboratory through a tube. Adequate protection of the cylinder from rain and, in hot weather, from the direct rays of the sun, should, however, be provided.

Before work with a toxic gas is started, it should be confirmed that appropriate protection in the form of respirators etc., is ready to hand. It should be noted, however, that respirators are only adequate to deal with moderate concentrations of gas, and that an emergency such as a cylinder which is freely discharging into the air can only be safely dealt with by means of a self-contained breathing apparatus.

Liquid Air, Oxygen and Nitrogen

8 - 25. Containers for these liquefied gases depend for their efficiency on the maintenance of a high vacuum in the insulating chamber. If this chamber is damaged by rough handling the vessel will be ruined. Containers must, therefore, not be dropped or knocked.

It should be remembered that liquid air, oxygen and nitrogen are continually evaporating and a vent must always be provided in any vessel in which they are stored or used. If the vent is closed, bursting of the vessel will result. The use of any type of plug, e.g. cotton or glass wool, is dangerous because it may become coated with ice owing to freezing of moisture from the atmosphere. For the same reason it is dangerous to leave a glass or metal funnel in the neck of the vessel.

Should the outlet of a liquid gas container become obstructed by ice the blockage should be cleared as follows:-

(a) Remove vessel to an uncongested area.

(b) Puncture the ice with a clean piece of stiff wire. Do not attempt to use heat.

(c) Be on the alert for the possibility of a burst. The face and hands should be protected by a mask and gloves.

When pouring liquid gases it is advisable to have the hands bare. Splashes on the skin are harmless but frost bite may result if contact is prolonged e.g., through the liquid entering the glove.

Liquid oxygen should only be used or stored under conditions which ensure adequate dilution of the escaping gas; otherwise the increased oxygen concentration near the apparatus or container causes an increased fire and explosion risk, particularly since liquid oxygen can itself cause spontaneous ignition if it comes into contact with oil, grease or other combustible material. Liquid oxygen should, therefore, not be used in place of liquid nitrogen for cooling traps or metals and especially not for cooling combustible matter.

Gas Syphons

8 - 26. The precautions detailed in the above paragraph are in part applicable to the use of sulphur dioxide, phosgene, etc., in glass syphons, particular care should, however, be taken not to place them where they can be accidentally heated, or broken by objects falling on them.

Sealed Glass Tubes

8 - 27. Sealed glass tubes containing reagents or specimens may develop pressure on standing. They should always be opened with care, the operator using cloth protection for the hands, and wearing goggles.

Pipettes

8 - 28. Corrosive or dangerously toxic liquids should never be pipetted by mouth suction.

Pipetting of hot or volatile liquids is also dangerous and should be avoided.

Vacuum Distillation

8 - 29. Glass apparatus under vacuum is liable to disrupt violently if the vacuum is broken suddenly. Suitable means of gently admitting air should, therefore, be provided and care taken not to subject the apparatus to strain or blows which may crack the glass. Rubber stoppers are liable to be sucked into apparatus under vacuum, particularly if they become softened by heat, they should, therefore, be large enough to give a tight fit with an ample margin protruding from the closure.

Testing of Vacuum Apparatus

8 - 30. The testing of vacuum apparatus for leaks by subjecting it to internal pressure requires to be carried out with great care if the apparatus is wholly or partly of glass. Precautions should be taken that no injury can result from an accidental burst.

Gas-fired Furnaces - Crucible furnaces

8 - 31. In order to avoid risk of explosion the following technique is recommended for lighting and closing down gas fired crucible furnaces in which gas and air under pressure are fed through concentric nozzles.

(a) Open the lid of the furnace.

(b) Place a lighted piece of paper inside, or a lighted taper across the top edge, then turn on the gas.

(c) When the gas is alight, slowly turn on the air.

(d) Close the furnace.

(e) Adjust flame by opening or closing the air and gas valves in small stages.

To close down:-

(a) Open the lid.

(b) Turn off the gas.

(c) Turn off the air.

If it is not desired to open the lid it is even more important to turn the gas off before the air.

Muffle Furnaces

8 - 32. To light:-

(a) Close all the jets by means of their individual taps except the one adjacent to the lighting hole.

(b) Apply a lighted taper to the lighting hole and turn on the main gas tap.

(c) Turn on the remaining jets one at a time starting from the jet next to that already lighted.

To close down:-

Turn off main tap.

Melting of Metals

8 - 33. If a new crucible is to be used it should be dried slowly in the furnace, with the lid open, before use.

A new crucible may explode with considerable violence if heated rapidly.

If additions have to be made to a molten bath each piece must be well dried or a serious explosion may result.

In adding certain metals, e.g., zinc or cadmium (which have low boiling points) to a molten bath of high melting point metal such as copper, e.g., in making up a brass, there is usually a slight "blow out" of molten metal. It is, therefore, essential to keep well out of range of this ejected material.

Skimmers or stirrers should always be well heated before use.

Care should be taken to provide adequate ventilation to remove any toxic fumes produced in furnace operations.

Casting of Metals

8 - 34. Metal moulds should be dried thoroughly by heating to above 100°C. before use. Mould dressing containing water may cause a blow-out if the mould is not well dried after watering.

Electric Arcs and Gas Welding Flames

8 - 35. Protection of operators against radiation from welding arcs or flames is normal procedure but it is often forgotten that persons up to a distance of thirty feet, even outside the lines of direct radiation, may suffer. Rooms in which there are open arcs should be painted dull black to absorb visible and invisible (infra-red and ultra-violet) radiation.

CHAPTER 9

Safety considerations in Plant Design

9 - 1. The following notes have been compiled to draw attention to matters which require consideration both in the design of plant and the carrying out of experimental plant work generally.

Choice of materials of construction

(a) Chemical compatibility.

(b) Friction or impact effects of surfaces with the explosives or other materials involved.

(c) Spark producing materials.

(d) Corrosion

These factors must be considered not only with the metals of construction but with all the materials which might be involved e.g., gland packings, gaskets, tools etc., under the conditions of temperature, pressure and concentrations arising in the working conditions of the proposed plant.

Toxicity

9 - 2. It is a statutory requirement that persons employed are to be protected against the inhalation of dust, fumes or other impurities which are given off, although these may not be definitely dangerous but merely offensive.

The primary requirement is to instal local exhaust ventilation, as near the point of origin as possible, and only where this is impracticable is the principle of dilution by general ventilation recognised.

It is also necessary to prevent any accumulation of dust or fumes in the workshop.

Explosion risk of gas, vapour or dust

9 - 3. In plants or processes which produce inflammable dust, gas or fume, attention must be given to the possible risk of explosion. If this risk cannot be eliminated explosion reliefs should be provided in the most suitable positions in the plant.

It should be remembered that "flash-back" can occur over distances of many feet and suitable arrestors or purging devices should be provided wherever possible.

Interlock and control systems

9 - 4. Use should be made, if practicable, of remote control and interlocking controls on any hazardous process.

Provision of Safety guards

9 - 5. It is a statutory requirement that all transmission and dangerous machinery must be securely fenced. Advice on this subject can be obtained from the Safety Officer.

Pressure vessels

9 - 6. With a few exceptions, regulations exist, under the Factories Acts, of pressure vessels relating to the strength of construction and the provision of suitable safety relief devices and gauges. Reference should be made to B.S.1500/1949 and other related British Standards.

Pressure vessels should be constructed to the satisfaction of and subject to inspection by the insurance company employed by the Establishment. It is normal for an examination to be made by the insurance company's inspector of each vessel every year, the annual certificates should be filed with the original.

It is usual for the test pressure to be set at twice the working pressure up to pressures of 2000 lb. per square inch, over 2000 lb. the test pressure is twice the working pressure plus an additional 1000 lb.

Methods of pressure release must be so positioned as to be unlikely to cause injury to personnel in the event of their operation, and remote methods of cut off of energy supply should be incorporated in the design. Draining and flushing devices should be included where necessary and these should be so positioned as to give the maximum accessibility.

Electrical installations

9 - 7. Flameproof electrical equipment is necessary for use in places where certain fumes or vapours are produced, but it may prove that the precise equipment required for the particular service is not manufactured. In these circumstances recourse must be made to other forms of energy supply such as air, water or oil.

Alternatively the motors, lighting and switchgear may be sited outside the workroom where the fumes or vapours arise. In passing driving shafts through walls or partitions the entry gland must be sealed to prevent the egress of dangerous fumes or vapours.

Emergency stopping arrangements must be provided within immediate access of all machine operators.

Wherever the failure of the mains supply would introduce special danger in any process, an alternative emergency supply must be provided.

Attention is drawn to the E.S.T.C. regulations which govern the electrical installations in explosives buildings.

Valves and Stop Cocks

9 - 8. The choice of valves and stop cocks to be used on explosives plant is a complex matter and advice should always be sought. In general, valves operating on the diaphragm or pinch clip system are more acceptable provided they are not quick acting. Other points to be considered are:-

(1) The nipping of material between unsuitable surfaces.

(2) The trapping of air or gas in the valve which could give rise to the cavity effect. (See para. 1-12).

(3) The method of securing valve stems.

(4) The method of lubrication.

Drowning and drenching devices

9 - 9. Consideration should always be given to the possibility of providing drowning tanks or drenching devices for charges which may become overheated or for reactions which get out of hand.

Such arrangements can also often be used for the washing out and drainage of the plant in normal working.

Run-offs to drowning tanks should be in the form of open troughs as the confinement caused by closed pipes may increase the risk of explosion.

Temperature and pressure control devices

9 - 10 . Wherever the safety of a process demands the close control of temperature or pressure and thermostats and the like are provided, these instruments should be duplicated, and if they have to be energised each equipment should obtain its power from a separate source.

Fencing

9 - 11. It is a statutory requirement that large vessels which contain dangerous materials should be fitted with lids or be securely fenced unless the edge of the vessel is more than three feet above the adjoining ground or platform. Gangways crossing open tanks must also be fenced to a height of three feet.

Where a person has to work at a place where there is a risk of injury by a fall, means for ensuring his safety must be provided.

Cranes, lifting tackle, mechanical hoists

9 - 12. Manual or mechanically operated equipment of the above types must conform to the safety requirements of the process on which they are used, in addition to complying with the statutory regulations regarding strength and design.

All cranes, lifting gear etc., must be tested annually by an independent body to ensure that the safe lifting load of the equipment is established and that it is maintained in safe working order.

The period between inspections of equipment necessarily exposed to a corrosive atmosphere should be shorter than that for equipment in normal use.

In the same way any rope slings used in these surroundings should be frequently inspected and tested. For use in strongly corrosive atmospheres nylon rope slings are recommended.

Glands and bearings

9 - 13. As a general rule bearings on explosives plant should be designed to avoid contact with explosive, either by position or by the use of sealing glands, collars or reversed threads to prevent material creeping into the bearings or gears. In some cases where the friction of packing materials may be undesirable, open glands should be considered.

Vessels liable to sudden abnormal high pressures

9 - 14. Vessels which may be subjected to sudden high pressures due to "fume off" etc., should be designed, either to withstand the pressure, or be provided with means of relief so positioned to avoid injury to operators.

Static risks

9 - 15. These are dealt with in paras. 3-20 to 3-22).

Anchoring of movable parts

9 - 16. Movable parts such as nuts, etc. which might be liable to work loose and fall into contact with explosive should be secured by wire, welding or other suitable means.

Cleaning of plant

9 - 17. Provision should be made for the easy cleaning and washing out of all plant, by providing easy means of access and drainage.

Fume ducting should be of such size that it can easily be cleaned internally.

CHAPTER 10

DANGEROUS CHEMICALS

Transport and Handling of Dangerous Chemicals

10 - 1. Bottles containing acids, inflammable liquids, or other dangerous substances must only be transported in the special carriers provided. It is the duty of the scientist to warn his subordinate staff of the risks involved in careless handling of these materials. On no account should these special carriers be transported by bicycle.

10 - 2. Carboys, whether their contents are dangerous or not, must only be transported on a truck approved for the purpose by the Safety Officer.

Carboys containing strong acids or alkalies must be handled with precaution. The operators should wear rubber gloves, and when pouring acids or alkalies, should also wear protective goggles. Particular care is required in removing the stopper from a carboy if the carboy is very full.

10 - 3. In all operations involving the pouring (except from small and easily handled containers) of corrosive liquids, e.g., acids, alkalies, bromine, nitrogen peroxide, concentrated hydrogen peroxide, etc. (see list para.10-10) protective goggles and gloves should be worn, and a supply of water should be at hand. It should be noted that rubber gloves are slippery when wet, but that types with roughened surfaces are available with which this trouble is much reduced.

Some of the chemicals referred to above, e.g. bromine, nitrogen peroxide, concentrated nitric acid, etc. produce extremely irritating fumes, and should only be handled in a fume cupboard or in the open from the windward side.

It should be noted that concentrated hydrofluoric acid can cause very dangerous burns.

10 - 4. In all laboratories, workshops and stores where corrosive liquids have to be handled, an eye wash bottle containing a buffer solution of the composition given below must be kept ready for use. The bottle should be of the special first aid type which can be used by the injured person himself. Either the type which operates by gravity flow on being inverted, or the polythene spray type which is worked by squeezing the bottle.

Composition of solution:-

Potassium dihydrogen phosphate KH_2PO_4	70 grammes
Disodium hydrogen phosphate $Na_2HPO_4 12H_2O$	180 grammes
Distilled water	850 grammes

In laboratories where large amounts of corrosive liquids are handled, or where nitrations and similar operations are carried out, there should also be available a lightly covered vessel, about one foot in diameter and four to six inches deep, containing a large amount of the above solution.

These appliances must be plainly labelled and kept in an easily accessible position.

Storage of Dangerous Chemicals

10 - 5. The storage in laboratories and workrooms of dangerous chemicals in excessive quantities or under unsuitable conditions may involve hazards comparable with those arising from incorrect storage of explosives. The following rules give the approved laboratory storage conditions for a number of dangerous chemicals, and may be used as a guide in choosing suitable conditions for other dangerous substances not mentioned.

Oxidising Materials

Chlorates, bromates, iodates, perchlorates, permanganates, persulphates, chromium trioxide

10 - 6. These may be kept in chemical laboratories in glass bottles containing not more than 500 gm. In pyrotechnic workrooms the stock bottles may have twice this capacity. All larger stocks must be kept in approved storerooms and records of quantities kept as for explosives.

Perchloric Acid, concentrated hydrogen peroxide, metallic peroxides

Quantities not greater than 100 gm. may be kept in chemical laboratories. Larger quantities must be kept in a dangerous chemical store outside the laboratory.

Organic nitrates, nitrites, peroxides

10 - 7. To be stored as sensitive explosives in a locker magazine.

Spontaneously Inflammable or Easily Oxidisable Substances

Phosphorus (White)

10 - 8. Must be stored under water in glass (not metal) containers in a dangerous chemical store; care should be taken that the store is warmed during cold weather to prevent freezing.

Phosphorus (Red), sodium sulphide (anhyd.) Metallic alkyls, pyrophoric metals

10 - 9. Must be stored in a dangerous chemical store.

Corrosive Substances and Toxic Materials

Bromine

10 - 10. May be stored, in the original bottle as supplied, standing on a porcelain tray in a fume cupboard or in a dangerous chemical store.

Sulphur dioxide

Must be kept in a fume cupboard.

Fuming nitric acid

May be kept in quantities not greater than 200 c.c. in a bottle standing on a porcelain tray in a fume cupboard, or in a dangerous chemical store.

Concentrated nitric, sulphuric, hydrochloric, acetic acids, mixed acids, oleum

May be kept as bench reagents in bottles of not greater than 500 c.c. capacity standing at bench level on porcelain trays. All other stocks to be kept in an acids store outside laboratory, or (if only small stocks are required) in a reserved area in the laboratory where the bottles can be kept on a tiled surface or in an acid resisting tray.

Dimethyl sulphate, sulphur trioxide, chlorsulphonic acid, titanium tetrachloride, stannic chloride, hydrofluoric acid

May only be kept in a dangerous chemicals store outside laboratory.

Acetyl chloride, acetic anhydride, benzoyl chloride

May be kept, in quantities not exceeding 100 gm., in a fume cupboard, the bottle standing on a porcelain tray. All other stocks to be in an acids or dangerous chemical store outside laboratory.

Inflammable Liquids

10 - 11. May be kept on laboratory benches and reagent shelves, but not in cupboards, in bottles containing not more than 500 c.c. or in flasks containing not more than 250 c.c. except in the case of carbon disulphide where reagent bottles containing not more than 250 c.c. must be used.

All other stocks of inflammable solvents must be kept in a solvents store outside the laboratory.

Materials which React Dangerously with Water

Potassium, sodium, etc.

10 - 12. May be kept in quantities not greater than 50 gm., under naphtha in bottles standing on a porcelain tray. Larger stocks to be kept in a dangerous chemicals store outside the laboratory.

Magnesium powder, aluminium powder

Amounts not exceeding 500 gm., in glass bottles with rubber stoppers may be kept in laboratories. Sections requiring to use larger amounts must store them under restrictions similar to those applying to explosives.

Metallic phosphides

Must be kept in a dangerous chemicals store.

Ether

10 - 13. (See para. 11-2)

10 - 14. The storage of corrosive and toxic chemicals even in an approved dangerous chemical store presents another hazard which is not always appreciated. It is that such storage produces an atmosphere in which ordinary labels quickly disintegrate and doubts as to the contents of various bottles will arise.

The most satisfactory method of labelling is to seal a paper label, on which the name of the substance has been written in Indian ink, inside a glass tube which is then dropped into a bottle. If exterior labels are used they should be varnished with a silicon resin varnish similar to type LR/3610. The area of the varnish should be extended beyond the edges of the labels on to the glass for at least half an inch.

CHAPTER 11

SPECIFIC CHEMICAL RISKS

11 - 1. In this Chapter, attention is called to a number of chemicals the explosive nature of which is commonly overlooked or which, whilst not in themselves explosive, may produce explosion or violent reactions under certain conditions. It should not be regarded as a complete guide; experience is constantly adding to the list of chemicals which, either by themselves or in mixtures, may present unexpected risks. (See para. 11-14).

11 - 2. Ethyl ether tends to form explosive peroxides which may produce unexpected explosions when it is distilled, evaporated or, in extreme cases, when merely heated. The formation of the peroxides is accelerated by sunlight, stocks of ether should, therefore, be kept in obscured-glass bottles or otherwise protected from sunlight, and should be regarded with suspicion if they have been in stock a long time. A test for peroxide in ether is given in Appendix 5. Similar peroxides are also formed by some other ethers, e.g., dioxane and di-isopropyl ether.

Inorganic Peroxides and Per-salts

11 - 3. Peroxides should be handled with care. Hydrogen peroxide of high concentration will ignite fabric, oil, wood and certain resins with which it comes in contact, and is liable to decompose violently if contaminated even with minute traces of certain catalysts. It should be stored only in glassware, earthenware, aluminium, or approved stainless steel containers, and carefully protected against accidental contamination. Sodium peroxide reacts violently with water, and if mixed with wood, cotton, sulphur, aluminium, etc. in the damp condition it is liable to inflame. It should not be put into paper or cardboard containers. Barium peroxide is less dangerous than sodium peroxide, but should be protected from damp, and kept away from organic matter, sulphur, powdered metals etc.

Per-salts have similar risks to those of peroxides, the perborates being probably the least dangerous. Persulphates when moist are particularly reactive with metals, and may produce ignition when mixed with them.

Ammonium perchlorate, perbromate and periodate are explosive, the periodate is very sensitive to friction.

Organic Peroxide

11 - 4. Organic Peroxides are explosive and should be handled with precautions. They should only be stored in the wet condition. Benzoyl Peroxide has been known to explode spontaneously. Acetyl Peroxide when dry is a very sensitive and violent explosive.

11 - 5. Perchloric acid, used as an analytical reagent, is liable to cause explosion. Before any method involving its use is undertaken, the literature should be consulted to ensure that a safe technique is obtained.

All the above-mentioned oxidising agents form explosives when mixed with carbonaceous material, sulphur, aluminium, magnesium or other easily oxidisable substances. Many of the mixtures are extremely sensitive.

11 - 6. Silver salts when mixed with ammonia, as for example in the well known process for silvering mirrors, may produce an explosive compound. This process must be carried out with great care, using an approved "formula". Solutions after use must not be kept.

11 - 7. Devarda's alloy when used as a reducing agent is liable to give an explosive mixture of hydrogen and air in the apparatus. It is advisable to prevent this by passing an inert gas through the apparatus.

11 - 8. Nitrogen chloride, which is an extremely sensitive explosive, may be formed by the action of chlorine on ammonia or ammonium salts in solution.

11 - 9. Acetylene forms highly dangerous explosive compounds with copper and silver, and should not be brought into contact with these metals or their salts.

11 - 10. Inorganic nitrates give inflammable mixtures with carbonaceous matter and other easily oxidisable substances, but the mixtures are normally much less sensitive than those formed by chlorates, peroxides, etc. Wooden casks which have been used for ammonium nitrate, and sacks used for sodium nitrate, are highly inflammable.

11 - 11. Sodium hypophosphite (NaH_2PO_2), gives explosive mixtures with nitrates, the one formed with lead nitrate is very sensitive and violent.

11 - 12. Carbon monoxide forms highly toxic carbonyls with metals. Nickel carbonyl vapour may explode when heated to 60°C.

11 - 13. Sodium azide although non-explosive, is a serious hazard in case of fire, on account of the formation of free sodium on heating.

Mixing of Reagents

11 - 14. The mixing of reagents may sometimes lead to reactions of unexpected violence, even giving fire or explosion. Heating of apparently harmless mixtures may also give similar surprises.

The following examples have been collected from various reports:-

Glycerine and nitric acid
Glycerine and solid permanganate
Concentrated hydrogen peroxide and permanganates
Concentrated hydrogen peroxide and hydrazine hydrate
Concentrated nitric acid and organic substances generally,
  particularly amines, aldehydes, alcohols, esters, and ketones.
Hydrazine nitrate and solid permanganate
Hydrazine nitrate and metallic nickel (on heating)
Bromine and red phosphorus
Lead nitrate and potassium acetate (on heating)
Phthalic anhydride and cupric oxide (on heating)
Sodium hypophosphite and sodium chlorate (on heating)
Sodium nitrite and sodium thiosulphate (on heating)
Sodium nitrite and potassium ferrocyanide (on heating)
Chromium trioxide and acetic anhydride (See Chem.& Ind. Nov.27,
  1948)
Hydrogen peroxide and stannous chloride
Aluminium powder and copper oxide (explodes on heating)
Potassium permanganate and concentrated sulphuric acid
Metallic sodium and mercury

Styrene and maleic anhydride (may develop violent reaction even without catalyst)
1,3-Dichloro-5,5-dimethylhydrantoin and xylene
N-Chlorosuccinimide and benzylamine
N-Chlorosuccinimide and aliphatic alcohols
N-Bromosuccinimide and hydrazine hydrate
N-Bromosuccinimide and diallyl sulphide
N-Bromosuccinimide and aniline
Tri-N-bromomelamine
3-Nitro-N-bromophthalimide and tetrahydrofurfuryl alcohol
2-Chloro-methylthiophene (may explode spontaneously - see Chem. Eng. News 1952. 30.(24) 2546, 30.(32) 3352.
Mixtures of oxidising substances such as ammonium nitrate or potassium chlorate and organic matter (or clothing)
Active carbon with ammonium nitrate
Rags soiled with paint or with a drying oil
Rags and concentrated sulphuric acid
Wood fabrics with concentrated nitric acid
Aluminium with chlorinated organic compounds
Perchloric acid with alcohol
Sodium or potassium with water
Aluminium powder with ammonium persulphate and water
Chromium trioxide with sulphur, glycerol or organic matter.
Organic matter with aluminium (alloys) in nitrate-nitrite salt bath
Ammonium nitrate with zinc powder and water
Barium rhodanide with sodium nitrate
Nitric acid with thiophene or with hydrogen iodide
Nitrates with certain esters
Nitrite with potassium cyanide
Peroxides with magnesium, zinc or aluminium
Chlorates and perchlorates with sulphuric acid
Nitric acid with zinc, magnesium or other metals
Halogens with ammonia or ammonium salts or their solution
Phosphorus with nitric acid, nitrate, chlorate
Mercuric oxide with sulphur
Magnesium and aluminium with chlorate or nitrate
Nitrate with stannous chloride
Magnesium with phosphate, sulphate, carbonate and many oxides
Oxalates of heavy metals
Liquid air or oxygen with organic matter
Concentrated per formic acid which is unstable and may explode.
Carbides, particularly those of copper and silver which are very explosive
Liquid ammonia and mercury may form an explosive compound

CHAPTER 12

SAFETY OF ELECTRICAL EQUIPMENT IN LABORATORIES

Permanent or Semi-permanent Connections to the Supply Mains

12 - 1. Connections to the electric supply mains to meet a permanent or semi-permanent experimental requirement should not normally be made by scientific or laboratory staff, but by a qualified electrician (requisitioned through the Establishment Engineer) or by some other properly qualified person. This procedure should, for example, be adopted for the installation of electric motors (other than fractional H.P. sizes) or for any other requirement, either permanent or temporary, involving the use of direct or alternating mains voltage in excess of 250.

Temporary Connections to the Supply Mains

12 - 2. In experimental laboratories or workshops temporary connections to the supply mains are usually made through an approved type of two or three pin socket, preferably fitted in conjunction with a self-contained double pole switch.

The safety and efficiency of these temporary mains connections can be increased if attention is paid to the following points:-

(a) One of the conductors of the mains supply usually has an appreciable difference of potential from earth. This conductor is called the LIVE side of the mains and it is ESSENTIAL that if any additional single pole switch is to be included in the circuit it should be wired in this lead. If this precaution is neglected a severe shock can be experienced (even when the single pole switch is in the OFF position) from exposed portions of the circuit by contact with surrounding earthed objects.

The live side of the mains can be recognised by the fact that nearly full mains voltage is obtained by connecting it through a voltmeter or suitable lamp to a temporary earth connection such as a water pipe.

(b) The other conductor of the mains supply (called the NEUTRAL side of the mains) is usually at or near earth potential. This main is suitably connected to earth at the generating station and no connection with an additional local earth either through the apparatus or by contact with water pipes, gas pipes, lightning conductors, etc., should be permitted.

(c) In a "three pin" plug connection a lead connected to an EARTH pin (usually of larger diameter than the two plugs connected to the mains) is used to connect the frame of a motor, the body of a kettle, etc., to a local earthed point, so as to give protection from shock in the event of an insulation breakdown.

(d) It will be noted that a properly installed supply from the electric mains already includes provision for an earth connection at appropriate points and no other additional DIRECT earth connection should be permitted UNDER ANY CIRCUMSTANCES.

When necessary an INDIRECT connection to a local earth through a transformer or a suitable condenser should be arranged.

(e) If an earth connection to a piece of experimental apparatus is required, a short low-resistance lead taken to a carefully made joint on a convenient water pipe or earthing rod should be used, either by soldering or by the use of a properly designed earthing clip. Care should be taken to see that the apparatus is not earthed at more than one point, as a system of multiple earth connections frequently gives rise to corrosion and other difficulties and should be avoided.

Temporary earth connections to gas mains should NEVER be made.

(f) It is obvious that the number of exposed conductors should be reduced as far as possible and any worn or frayed cables should either be repaired with insulating tape or preferably replaced without delay by serviceable material.

Ordinary types of electric cable should not be permitted to remain in contact with chemicals, steam or hot bodies (e.g., soldering irons).

Temporary leads between sections of equipment or connections to the mains should, wherever possible, be suspended at high level. The trailing of temporary leads along the floor, particularly across gangways is objectionable and should be avoided.

(g) Care should be taken to see that the current carrying capacity of the mains wiring and of the wiring of the circuit is appropriate to the conditions of the experiment.

Lamp sockets should not normally be used to supply current for experimental apparatus and in any case the load from each socket should not exceed 250 watts (corresponding to a current of about 1 ampere).

The conventional '5 amp. tumbler' switch might be expected to operate satisfactorily on a pure resistance load up to (say) 5 amperes, but a switch of this type should not be used for currents in excess of (say) 2 amperes for circuits containing considerable inductance or capacity, e.g., motors or transformers.

(h) In each supply circuit a fusible wire or 'fuse' is introduced to keep the current below a suitable maximum value. If for any reason this value has been exceeded, due to an electrical fault arising from an abnormally low value of the resistance of the circuit, an attempt should be made to locate the electrical fault before inserting fresh fuses. The practice of inserting successive fuse wires of increasing current capacity without proper examination of the circuit is useless and dangerous. (See para. 2-6).

(i) Leads to portable equipment such as inspection lamps, soldering irons, hand drilling machines, ovens etc., should be inspected by a competent person at regular intervals to ensure that insulation is satisfactory, that there are no breaks in the leads, or loose connections, and that there is continuity in the earthing connection from the apparatus to the approved electrical earth.

(j) Special care is needed for circuits intended to be operated for continuous periods with the minimum of attention.

All the components in such circuits should be used well within their rated values and with adequate ventilation. For example, it is pointed out that tubular laboratory rheostats operate at a lower and, therefore, safer temperature in the vertical position with free air cooling, than when operated horizontally. It should also be noted that the values of permissible current quoted by the makers are sometimes unduly large, and should not in any case be exceeded for continuous running.

In some instances rheostats are made by winding a layer of resistance wire over an enamelled iron tube. These rheostats are not suitable for use on an alternating supply in view of the heating effect of the eddy currents induced in the iron tube.

When rheostats or furnaces are required to run for long periods without attention, e.g. overnight, they should not rest in contact with the wooden top of a laboratory bench, but should be supported on a metal sheet raised on bricks so that free air circulation can occur. A metal sheet is considered to be preferable to one of heat resisting material, as the formation of local hot spots is prevented by conduction through the sheet.

High Voltages

12 - 3. No attempt should be made to operate any electrical circuit involving voltages in excess of 400 without advice from a competent person, who will ensure that the circuit is correctly designed and assembled, and fitted where necessary with appropriate safeguards. These safeguards should, wherever practicable, include the provision of an easily accessible and plainly marked switch or other means of bringing all parts to a safe potential in emergency.

High Frequency Apparatus

12 - 4. Exposed H.F. conductors should, whenever possible, be guarded by a suitable earthed barrier of H.F. conducting material to prevent accidental contact, or some suitable warning device provided. If neon lamps are used for the latter purpose, they should be fitted in duplicate to reduce chance of error due to lamp failure.

Contact with an H.F. conductor may result in deep-seated burns although no shock is felt and the effect on the skin may be very slight.

Variable Auto Transformers

12 - 5. In the use of high voltage equipment where a variable auto transformer is used to control the output on the primary side, attention is drawn to the following possible risk. In the variable auto transformer it is usual for a sliding brush to come into contact with successive turns of the auto transformer. It is important to note that even for a Zero Setting of the control, an output can be obtained equivalent to that of a single turn. Although this represents only a small fraction of the full voltage, the condensers, etc., on the high voltage side might very well have sufficient charge to give a severe shock. Before any adjustments are made the mains connection should be broken (preferably by a double pole switch) to ensure complete safety.

CHAPTER 13

MISCELLANEOUS

Disposal of Non-explosive Waste

13 - 1. Bins are provided for waste paper, glass, oily rags, and miscellaneous scrap. It is essential that all material placed in these bins should be free from explosive, and it is the responsibility of the scientist in charge of each workroom or laboratory to ensure that his subordinate staff are clearly instructed as to the serious consequences which can occur if this rule is broken.

Large pieces of scrap metal should not be placed in the bins, but should be sent to the Foreman of the Engineering Shop with a certificate that they are free from explosive.

Care must be taken that glass apparatus which has contained phosphorus is not placed in a waste bin until all trace of phosphorus has been removed. Oily rags must be placed in the special metal bins provided for the purpose, and not placed amongst other waste.

Engineering Shops

13 - 2. No explosive, or dangerous material may be taken into or sent to engineering shops except by arrangement with the Engineer in Charge and with the approval of the Safety Officer.

Special care should be taken that explosive is not entrapped in apparatus sent to the shops. Where necessary a certificate of freedom from explosive should be supplied.

Lighting of Fires in Explosives Area

13 - 3. Should it be necessary to light a fire, or operate with a blow-lamp within the explosives area, prior approval of the Safety Officer must be obtained.

Grass Fires

13 - 4. Broken glass, if left in the grass, may cause fires through focussing sunlight in hot weather. If glass apparatus is used out-of-doors, precautions should be taken to ensure that it cannot cause a fire in a similar way.

Action in Case of Fire

13 - 5. Separate regulations are issued prescribing the action to be taken in case of fire or explosion in the Establishment. Every member of the staff should be conversant with these regulations, and know how to operate the first aid fire-fighting appliances provided in his building. He should also know how to cut off electricity, gas and other services.

The inspection and maintenance of fire appliances is the responsibility of the Fire Brigade Officer and any deficiencies should immediately be reported to him.

It should be noted, however, that the users of buildings are responsible for ensuring that fire buckets are kept full of water and that they are protected against frost.

It is important to note that fires in electrical gear should be extinguished with C.T.C. (Carbon tetrachloride) extinguishers, but that these extinguishers may produce a toxic atmosphere if used in small enclosures and are dangerous if used to extinguish burning metals, e.g., sodium or magnesium. As an alternative to C.T.C. extinguishers, Carbon-dioxide or Antifyre Pistole extinguishers can be used on electrical fires and are free from toxic risk.

Accidents and Injuries

13 - 6. Separate detailed instructions will have been issued by Establishments covering the action to be taken in dealing with the above. It is only necessary here to remind every member of the Establishment that any injury sustained during his work, however trivial it may seem, must be reported to his superior, who will ensure that a record of it is made in accordance with the provisions of the National Insurance (Industrial Accidents) Act 1946. It is important that anyone who becomes ill at work or contracts an ailment, e.g., dermatitis, should report the matter and obtain attention at the Surgery.

Requisitions to Temperature Recorders (Woolwich)

13 - 7. Requests for the services of the Temperature Recorders during "closed periods" (at Woolwich) must be made on the appropriate form (Form T.R.1.) and must reach the Supervising Officer of the Temperature Recorders not later than 4.30 p.m. on the day on which the service is to start.

The services of temperature recorders are not available for inspection of apparatus left working during the lunch period. The necessary supervision during this interval must be provided by the laboratory staff or it must be made certain that the apparatus can safely be left unattended.

To prevent interference with apparatus, laboratory doors may be locked during the lunch period at the discretion of the responsible scientist, but the full locking up procedure laid down for the end of the working day need not be carried out. Rooms containing explosives or other dangerous stores should always be locked or supervision arranged to prevent unauthorised entry.

Other establishments will doubtless have their own system for this service and the arrangements will be found in local regulations.

Access to Establishment (Woolwich)during Closed Periods

13 - 8. Should it be necessary for any member of the Staff to make an unexpected visit to the Establishment (Woolwich) outside official hours, he must on arrival, record in the book provided for the purpose in the Temperature Recorders' Office, the time of entry, proposed length of stay, and the numbers of the buildings to be visited. On leaving he must record his time of departure.

Empty Containers

13 - 9. Bottles or vessels which have contained chemicals should be returned to the Store when empty. It should be stressed that the store can only receive these back if it is clear that nothing other than the material as stated on the label has been contained in them.

If trade packages have been used for any other material than that shown on the label, they must be well washed out before they can be accepted by the store. Care should be taken not to wash off the manufacturer's label.

APPENDIX I

PERIODIC TESTING OF EXPLOSIVES STORED IN MAIN, "READY USE" AND "LOCKER" MAGAZINE

Explosive	Nature of Test	Action	Frequency of Test
Nitrocellulose Dry	Heat Test 170°F.	Destroy if result is less than 10 minutes.	See Para. 4 - 8.
Nitrocellulose Wet Collodion Nitrocellulose for lacquers	" " "	" " "	Every 3 months
Guncotton slabs in Service Packages	" " "	" " " rewet if storage continued.	Every 12 months
Dry guncotton primers in Service Packages Dry Guncotton Yarn	" " "	Destroy if result is less than 10 minutes.	" " "
Nitro-glycerine Dinitroglycol Diethylene glycol dinitrate and other liquid nitric esters	Heat Test 180°F.	" " "	Every 4 months
Dynamite	Heat Test 180°F. on extracted nitro-glycerine.	" " "	" " "
Propellants	Heat Test 160°F.	" " "	" " "
Cordite Paste	" " 170°F.	" " "	Every 3 months
P.E.T.N.	" " 180°F.	" " "	" 12 "
C.E.	" " 210°F.	" " 20 minutes	" " "
C.E.	Vacuum Stability 120°C.	Destroy if result is more than 5 mls. in 40 hours.	" " "
R.D.X.	" " 150°C.	Destroy if result is more than 4 ml. in 24 hours.	" " "
T.N.T.	(" " 120°C.) (5g TNT + 5g AMNO$_3$)	Destroy if result is more than 3 ml. in 16 hours.	" " "
Other Explosives	Refer to the Safety Officer before storage is started		

APPENDIX 2

SPECIFICATION FOR SAFETY HANDLAMPS

Chapter 2, para.2-8

The handlamp approved for emergency use in explosives workrooms or in any place where inflammable vapour or dust presents a fire risk is the

"Nife" Safety Handlamp, Type NH.10A

Size 2.13/16" x 4.1/4" x 5.1/2" (not including the height of the handle)

Weight 4 lbs. approximately

Bulb fitted is the M.E.S. 2.5 volt, 0.75 amp.

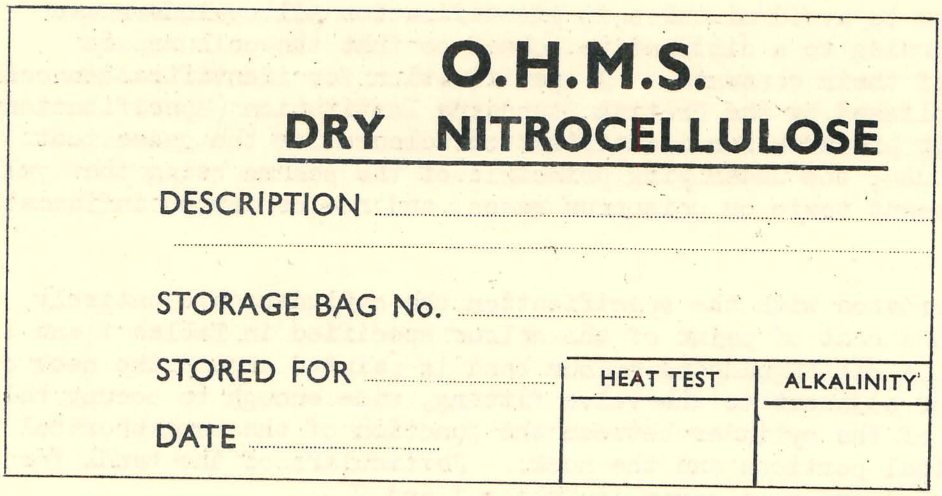
Marketed by Nife Batteries, Redditch.

This handlamp is certified by the Ministry of Fuel and Power for use in gaseous mines, Certificate No. B/85.

It is recommended that when these handlamps are used in explosives workrooms the sealing device which prevents them from being easily opened should be used.

APPENDIX 3

Approved form of label for the storage of Dry Nitrocellulose



O.H.M.S.

DRY NITROCELLULOSE

DESCRIPTION ....

....

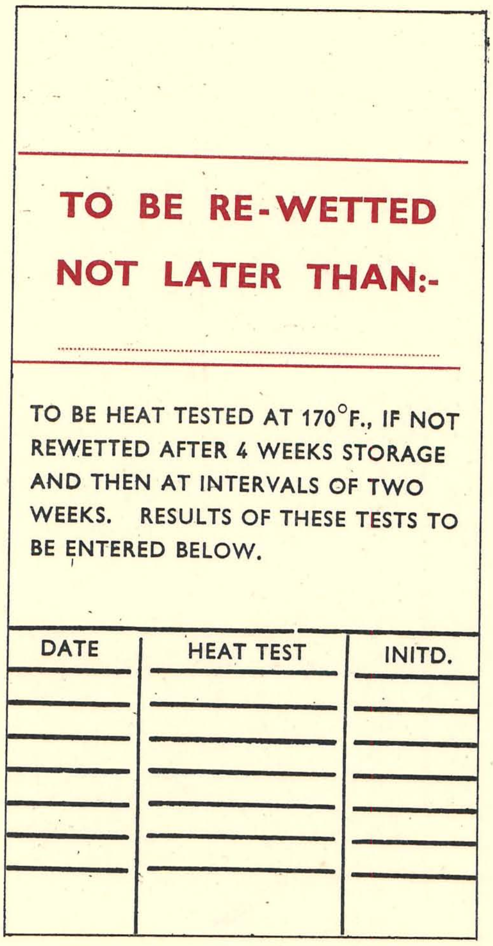
STORAGE BAG No. ....

STORED FOR ....

DATE ....

HEAT TEST	ALKALINITY

FRONT



TO BE RE-WETTED NOT LATER THAN:-

....

TO BE HEAT TESTED AT 170°F., IF NOT REWETTED AFTER 4 WEEKS STORAGE AND THEN AT INTERVALS OF TWO WEEKS. RESULTS OF THESE TESTS TO BE ENTERED BELOW.

DATE	HEAT TEST	INITD.

BACK

APPENDIX 4

IDENTIFICATION COLOURS OF GAS CYLINDERS

In order to avoid mistakes in identification all cylinders are painted according to a distinctive scheme so that the colours are indicative of their contents. A specification for identification colours has been published by the British Standards Institution (Specification No.349 - 1932). It provides for identification colours for the gases most commonly in use, the underlying principle of the scheme being that yellow should represent toxic or poisonous gases, and red or maroon inflammable gases.

In accordance with the specification the cylinders are entirely covered with a coat of paint of the colour specified in Tables 1 and 2. In addition, a distinguishing colour band is painted around the neck of each cylinder adjacent to the valve fitting, wide enough to occupy half the portion of the cylinder between the junction of the hemispherical and cylindrical portions and the neck. Particulars of the bands for different gases are also given in Tables 1 and 2.

For cylinders for medical purposes, the name or chemical symbol of the gas is stencilled or painted on or near the shoulder of the cylinder. For gases other than those provided for in these tables, the cylinders are specially labelled indicating the nature of the contents.

APPENDIX 4

Table 1

British Standard Identification Colours for Gas Cylinders, excluding Cylinders for Medical Purposes

Gas		Ground colour of cylinder		Colour of bands	
Name	Symbol	Nominal	British Standard Colour No.	Nominal	British Standard Colour No.
Acetylene	C_2H_2	Maroon	41	None	
Air		Grey	30	None	
Ammonia	NH_3	Black		Red and Yellow +	37 and 56
Arcton 6. (Dichlorodifluormethane)	CCl_2F_2	Parti-coloured Grey and Mauve			
Argon	A	Blue	3	None	
Carbon dioxide for temperate use	CO_2	Black		None	
Carbon dioxide, for tropical and marine use	CO_2	Black		White or aluminium paint	
Carbon monoxide	CO	Red	37	Yellow	56
Chlorine	Cl	Yellow	56	None	
Chlorine, cylinders fitted with internal dip-pipes	Cl	Yellow	56	Black	
Coal Gas		Red	537	None Stencilled with name	
Ethyl chloride, inflammable	C_2H_5Cl	Grey	30	Red	37
Ethyl chloride, non-inflammable	C_2H_5Cl	Grey	30	None	
Ethylene	C_2H_4	Mauve		Red	37
Ethylene oxide	C_2H_4	Mauve		Red and Yellow +	
Freon (Dichlorodifluormethane)	CCl_2F_2	Parti-coloured: bottom end grey, neck end mauve	30 (grey)		
Helium	He	Medium Brown	11	None	
Hydrocyanic acid		Blue	3	Yellow	56
Hydrogen	H	Red	37	None	
Methane	CH_4	Red	37	None	
Methyl bromide	CH_3B	Blue	3	Black	
Methyl chloride, inflammable	CH_3Cl	Green	25	Red	37
Methyl chloride, non inflammable	CH_3Cl	Green	25	None	
Neon	Ne	Medium Brown	11	Black	
Nitrogen	N	Dark grey	32	Black	
Oxygen	O	Black		None	
Phosgene	$COCl_2$	Black		Blue and Yellow +	3 and 56
Sulphur dioxide	SO_2	Green	25	Yellow	56

\+ The red or blue band should be placed adjacent to the valve fitting and the yellow band between that and the ground colour of the cylinder.

APPENDIX 4

Table 2

British Standard Identification Colours for Gas Cylinders, for Medical Purposes

Gas		Ground colour of Cylinder		Colour of bands	
Name	Symbol	Nominal	British Standard Colour No.	Nominal	British Standard Colour No.
Carbon dioxide (for inhalation)	CO_2	Green with black bottom	25		
Carbon dioxide with internal tube (for snow making)	CO_2	Green	25		
Ethyl chloride	C_2H_5Cl	As Table 1			
Ethylene	C_2H_4	As Table 1			
Nitrous oxide	N_2O	Black			
Oxygen	O	Black		White	
Oxygen and CO_2 mixture		Black		Green and white neck	25

The British Standard Colours referred to are contained in the British Schedule of Colours for Ready-Mixed Paints (No. 381).

APPENDIX 5

TEST FOR PEROXIDE IN ETHER

Place 8 ml. of freshly prepared potassium iodide solution (10 gm. per 100 ml.) in a stoppered tube of about 12 ml. capacity and 1.5 cm. diameter. Fill to the brim with the ether to be tested and place the stopper in position so that no air bubble is enclosed. Shake vigorously and set aside in the dark for 30 minutes.

The resulting yellow colour must not be deeper than that of 0.5 ml. of N/1000 iodine solution diluted with 8 ml. of freshly prepared potassium iodide solution as used in the test.

APPENDIX 6

LIST OF PUBLICATIONS OF SAFETY INTEREST

Magazine Regulations (Land Service) Part I (1941)

Guide to Explosives Acts., 1875 and 1923

Redgrave's Factories,Trucks and Shops Acts

Comprehensive Classified List of Government Explosives (1952)

Notes on the Transport of Explosives by Land in Great Britain (1943)

Text Book of Explosives Used in the Service(1938)

Safety Rules for Use in Chemical Works (A.B.C.M.)

Fire Regulations (Establishment Publications)

Quarterly Safety Summary (A.B.C.M.)

Industrial Accident Prevention Bulletin (R.O.S.P.A., monthly)

The British Journal of Industrial Safety (R.O.S.P.A., quarterly)

Accidents, how they happen and how to prevent them (H.M.S.O., quarterly)

Electrical Accidents and their causes. (H.M.S.O., annually)

APPENDIX 7

TABLES OF TOXIC LIMITS

Maximum allowable concentrations

These figures have been extracted from tables prepared by the American Government Hygienists and I.C.I. (Industrial Products and Health Research Committee). Where these authorities disagree the most stringent figure has been adopted in the following tables.

Gases and vapours

Substance	Permissible Concentration Parts per million	Substance	Permissible Concentration Parts per million
Acetaldehyde	200	Cyclohexane	400
Acetic acid	10	Cyclohexanol	100
Acetic anhydride	5	Cyclohexanone	75
Acetone	400	Cyclohexene	400
Acetone cyanohydrin	10	Cyclohexylamine	20
Acetonyl acetone	75	Cyclopropane (propene)	400
Acetophenone	20	o-Dichlorobenzene	25
Acetyl chloride	1	ββ Dichlorodiethyl ether	15
Acrolein	0.5	(cis & trans) Dichloroethylene	250
Acrylonitrile	20	1.1 Dichloroethane	100
Allyl alcohol	5	1.2 Dichloroethane (ethylene dichloride)	50
Allyl chloride	50	Dichloroethylether	15
Ammonia	100	Dichlorodifluoromethane	1000
Amyl acetate	100	Dichloromethane	500
iso Amyl alcohol	100	Dichloromonofluoromethane	1000
Aniline	5	1.1 Dichloro-1-nitroethane	10
Arcton 6 (Freon 12)	10000	1.2 Dichloropropane(propylene dichloride)	75
Arsine	0.05	Dichlorotetrafluoroethane	1000
Benzene (Benzol)	35	Dicyclohexylamine	20
Benzine (as Hexane)	250	Diethyl carbonate	200
Benzyl acetate	15	Di-isobutylene	1000
Benzyl chloride	5	Di-isobutyl ketone	100
Bromine	0.5	Dimethylaniline	5
1:3 Butadiene	1000	Dimethyl dioxane	200
n-Butanol (Butyl alcohol)	50	Dimethyl sulphate	1
2-Butanone (Methyl ethyl ketone)	200	Dioxane	100
n-Butyl acetate	200	Ethyl acetate	400
Butyl cellosolve	200	Ethyl alcohol (Ethanol)	1000
n-Butyl methacrylate	200	Ethyl acetoacetate	50
Carbon dioxide	5000	Ethyl benzene	200
Carbon disulphide	10	Ethyl benzoate	50
Carbon monoxide	50	Ethyl bromide	50
Carbon tetrachloride	50	Ethyl chloride	1000
Cellosolve	200	Ethyl ether	400
Cellosolve acetate	100	Ethyl formate	100
p-Chloraniline	2	Ethyl silicate	100
Chlorobenzene (mono)	75	Ethylene chlorhydrin	2
2-Chlorobutadiene	25	Ethylene dichloride	50
Chlorine	1	Ethylene glycol dinitrate	0.5
p-Chloronitrobenzene	1	Ethylene oxide	10
Chloroform	50	Ethylidene dichloride	50
1-Chloro-1-nitropropane	20	Formaldehyde	5
Chlorotoluene (o & p. mono)	75		
Cyanogen chloride	0.5		

Substance	Permissible Concentration Parts per million
Freon 12 (Arcton 6)	10000
Hydrazoic acid	1
Hydrogen chloride	5
Hydrogen cyanide	10
Hydrogen fluoride	2
Hydrogen selenide	0.05
Hydrogen sulphide	20
Iodine	0.1
Isophorone	10
Ketene	0.5
Lauryl mercaptan	5
Mesityl oxide	50
Methacrolein	2
Methacrylic acid	200
Methallyl alcohol	50
Methanol (methyl alcohol)	200
Methyl acetate	100
Methyl acrylate	25
Methyl bromide	20
Methyl butanone	100
Methyl iso-butyl ketone	100
Methyl cellosolve	25
Methyl cellosolve acetate	25
Methyl α-chloracrylate	1
Methyl chloride	100
Methyl cyclohexanone	75
Methyl cyclohexane	500
Methyl cyclohexanol	100
Methyl ethyl ketone	200
Methyl formate	100
Methyl iodide	10
Methyl methacrylate	1000
Monochlorobenzene	75
Monofluorotrichloromethane	1000
Mononitrotoluene	5
Naphtha (coal tar)	200
Naphtha (petroleum)	500
Naphtha (distillate as cumene)	50
Nickel carbonyl	1
Nitrobenzene	1
Nitroethane	100
Nitrous fumes (as NO_2)	10
Nitroglycerine	0.5
Nitromethane	100
1-Nitropropane	100
2-Nitropropane	50
o-Nitrotoluene	1
Octane	500
Ozone	1
Pentane	1000
Pentanone (methyl propanone)	200
Perchloroethylene	100
Phosgene	0.5
Phosphine	0.05
Phosphorus trichloride	0.5
iso-Propyl alcohol	400
Propyl acetate	200
iso-Propyl ether	500
β-Propiolactone	10
Stibine	0.1
Styrene	100
Sulphur chloride	1
Sulphur dioxide	10
Sulphuryl chloride	1
Tetrachlorethane	5
Tetrachloroethylene	100
Thionyl chloride	5
Thiophosphoryl trichloride	1
Toluene	100
Toluidines	5
Trichloroethylene	100
Turpentine	100
Vinyl chloride	500
Xylene	100
Xylidines	5

Maximum allowable concentrations of toxic fumes, dusts and metals

Substance	Concentration Mg./Cubic Metre	Substance	Concentration Mg./Cubic Metre
Antimony	0.5	Manganese	6
Arsenic	0.5	Mercury	0.1
Barium salts (as Ba)	0.5	α-Naphthylamine	0.01
Benzidine	0.015	Pentachloronaphthalene	0.5
Cadmium	0.1	Pentachlorophenol	0.5
Chlorodiphenyl	1	p-Phenylene diamine	0.1
Chlorinated Naphthalenes	1	Phosphorus pentachloride	1
Chromates (as CrO_3)	0.1	Phosphorus pentasulphide	1
Cyanide (as CN)	5	Potassium permanganate	5
Dinitrocresol (and salts)	0.5	Selenium (as Se)	0.1
Dinitrophenol (and salts)	1	Sulphuric acid	1
Dinitroresorcinol	1	Sodium cyanide	5
Dinitrotoluene	1.5	Tellurium	0.1
Fluoride	2.5	Tetryl	1.5
Iron oxide fume	15	Trichloronaphthalene	5
Lead (and salts)	0.15	Trinitrotoluene	1.5
Magnesium Oxide fume	15	Zinc Oxide fume	15

Maximum allowable concentration of Mineral Dusts

Substance	Million particles per cub. ft. of air standard light field count
Alundum	50
Asbestos	5
Carborundum	50
Dust (nuisance, no free silica)	50
Mica (below 5 per cent. free silica)	50
Portland cement	50
Talc	20
Silica	
High (above 50% free SiO_2)	5
Medium (5 - 50% free SiO_2)	20
Low (below 5% free SiO_2)	50
Slate (below 5% free SiO_2)	20
Total dust (below 5% free SiO_2)	50

Maximum allowable concentration of Radiations

Material or radiation	Radiant Energy
Gamma (roentgens per day)	0.1
Radon (curies per cubic meter)	10^{-8}
Thoron (curies per cubic meter)	10^{-8}
X-Ray (roentgens per day)	0.1

INDEX

Index (contd.)

Index (contd.)

Index (contd.)

Index (contd.)

Index (contd.)