HOME OFFICE

CIVIL DEFENCE

Manual of Basic Training

VOLUME II

BASIC METHODS OF PROTECTION AGAINST HIGH EXPLOSIVE MISSILES

PAMPHLET No 5

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GENERAL PREFACE

The series of Civil Defence handbooks and pamphlets is produced under the authority of the Home Secretary by the Civil Defence Department of the Home Office with the assistance of an in co-operation with the Secretary of State for Scotland and other Ministers concerned.

Measures for safeguarding the civil population against the effects of war which these publications describe, have become an essential part of the defensive organisation of this country. The need for them is not related to any belief that war is imminent. It is just as necessary that preparations for Civil Defence should be made in time of peace as it is that preparations should be made for the Armed Forces.

The publications cover, as far as is possible, measures which can be taken to mitigate the effects of all modern forms of attack. Any scheme of Civil Defence, if it is to be efficient, must be up-to-date and must take account of all the various weapons which might become available. The scale of bombing experienced in Great Britain during the 1939–45 war might be considerably exceeded in any future war, and types of weapons and tactics which were not experienced in this country might conceivably be used against it in the future. It does not follow that any one of the weapons, e.g., the atomic bomb, will necessarily be used, and it is most important that a proper balance is held between what is likely and what is possible.

The use of poison gas in war was forbidden by the Geneva Gas Protocol of 1925, to which this country and all the other countries of the Western Union were parties. At the outbreak of a war, His Majesty's Government would try to secure an undertaking from the enemy not to use poison gas. Nevertheless the risk of poison gas being used remains a possibility and cannot be disregarded any more than can certain further developments in other scientific fields.

The publications are designed to describe not only precautionary schemes which experience in the last war proved to be extremely effective in preventing avoidable injury and loss of life, or widespread dislocation of national industries, but also the training, both technical and tactical, which will he required of the personnel of the Civil Defence Corps if they are to be ready effectively to play their part if war should ever break out. The publications aim at giving the best available information on methods of defence against all the various weapons. Information is not complete in respect of some of these weapons and the best methods of countering them, but as results of experimental work and other investigations mature, they will be revised and added to from time to time so that the Civil Defence Corps may be kept up-to-date and their training may be on the most modern and experienced lines.

Binders for Manual of Basic Training are available from H.M. Stationery Office, price 1*s.* 0*d.* net.

CONTENTS

NOTE

The pagination of this pamphlet is not continuous as it may be necessary to introduce new pages at a later date.

Basic Methods of Protection Against High Explosive Missiles

INTRODUCTION

The purpose of this pamphlet is to describe as briefly as possible the effects
of the principles of protection against them which is essential to all persons connected with Civil Defence.

The atomic bomb, and also attacks by chemical and/or biological weapons, will provide their own problems which have been dealt with in separate pamphlets.

In the event of another war in which this country was engaged, the scale and weight of attack from the air might be heavier than any previously experienced in this country ; but—until atomic or biological weapons are used—the problems presented, including the protection that would be needed, would be of much the same order as were occasioned by World War II.

For the present it is probable that raids would be carried out by piloted aircraft carrying normal bomb loads of high explosive, incendiary bombs, or parachute mines ; rockets, or flying bombs. Flying bombs were carried by aircraft for a short period of the last war though their most effective use was from fixed launching sites on the ground. Rockets were, of course, an entirely independent weapon also fired from bases on the ground. Considerable experience was gained of all these types of attack during the last war and the lessons learnt can be applied to meet such attacks if they should arise in future.

Saturation Bombing

Saturation bombing is a form of tactics which can be used with any weapons, and may be defined as a concentrated attack upon a town, part of a town, or other strategic target, with the object of so saturating the target area that the defending forces are temporarily unable to function.

It was this form of bombing which was so highly developed by the United Kingdom and United States Army Air Forces against Germany during the latter part of the late war.

Chapter I

Types of High Explosive Bombs and their Effects

1. Elementary Principles of Explosion

A high explosive substance is one which is capable of very rapid burning ; when this takes place a relatively small amount of high explosive is almost instantaneously converted into a large volume of gas at a very high temperature. This produces a very high pressure. Some high explosives are more effective than others. For example the aluminised explosives developed during the last war were considerably more powerful than T.N.T.

When an explosion occurs above the ground the rapidly expanding gases transmit a considerable shock to the surrounding air and produce what may be termed a " pressure pulse " this is followed by a " suction wave ". The word " blast " is commonly used to describe both these phenomena.

When an explosion occurs underground, at a moderate depth, the force of the explosion will blow out the earth above it and form a crater.

Debris will be scattered, there will be earth shock and some blast though the latter will be less than from a burst above ground.

When an explosion takes place at a greater depth below ground the force of the explosion is used up in making an underground cavity, known as a "camouflet". The explosive force will be transmitted through the ground as earth shock ; there will be no blast above ground. The dangers of a camouflet are two-fold : first, the roof may cave in when traffic passes over it and people may be injured by falling into the cavity; secondly, the cavity will be full of poisonous gases—largely Carbon Monoxide—so that a person falling into the cavity, though not injured, may well die as a result of inhaling Carbon Monoxide.

2. High Explosive Bombs and Fuses

A high explosive bomb consists of a charge of high explosive contained in a case fitted with an exploder, fuse and detonator.

The thickness of the case may vary from a very thin one made of steel or some light alloy to a heavy steel case fitted with an armour-piercing nose for use against objectives protected by armour or thick concrete.

The fuse may be designed to detonate the charge :—

(i) Before reaching the target (proximity fuse),

(ii) On impact,

(iii) After a period of delay, which may vary from a fraction of a second, up to days.

The fuse may be functioned mechanically, electrically or on the radio or barometric principle.

N.B.—An H.E. bomb which functions correctly, is said to detonate. Detonation may be complete, partial or incomplete, in some cases explosion only occurs. Apart from failures in the components, viz. fuse, detonator, exploder and main filling, the degree of detonation may be affected by the dying out of the explosion before it has passed through the main charge, the unexploded portion of which is merely scattered.

3. Types of High Explosive Bombs

Broadly speaking, high explosive bombs can be divided into three main types.

(i) *Light Case Bombs*

In this type the ratio of the weight of the charge to the total weight of the bomb (known as the charge/weight ratio) is highest. Detonation of the L.C. bomb produces maximum blast effect whilst the material effect of fragmentation is negligible.

This type of bomb is normally fitted with an impact fuse since, if fused for delay action it would be liable to break up on hitting a hard target owing to its thin walled construction.

(ii) *Medium Case Bombs*

The charge/weight ratio of the M.C. bomb is less than that of the L.C. bomb thus the blast effect
than in the case of the latter.

Any type of fuse may be fitted to this bomb. If a delay action fuse is fitted and the bomb penetrates the ground the effects of blast and fragmentation decrease with the depth of penetration, but there is a corresponding increase in the effects of earth shock.

(iii) *Heavy Case Bombs*

These bombs have a low charge/weight ratio and are usually referred to as armour piercing or semi-armour piercing and are used principally against heavily protected targets such as capital ships, important installations protected by massive reinforced concrete, large shelters, submarine pens and the like.

Being of the piercing type they are fitted with a fuse with sufficient delay to allow the bomb to penetrate the target before detonating. The damage is caused by heavy fragments and blast.

4. Effects of High Explosive Bombs

(i) *Impact*

Any bomb which strikes a target, even though it fails to explode, will cause damage by its mass and momentum. The heavier the bomb and the more robust its construction the greater will be the damage done.

If a large bomb just misses a target and is of such a type that it will penetrate the ground, even though it does not detonate, enough earth shock though slight may possibly cause damage to the target.

(ii) *Blast*

Blast from high explosive bombs will break windows and may remove roof coverings over a wide area. Within a more limited area it may cause the collapse of the ordinary brick built house.

(iii) *Fragmentation*

Fragments from bombs besides inflicting casualties can cause structural damage. The same applies to debris which may be flung violently from craters or damaged buildings.

(iv) *Earth Shock*

As stated above the impact and penetration of unexploded bombs may cause slight earth shock, this effect will clearly be much greater from bombs detonating correctly underground.

5. Special Types of High Explosive Bombs used in the Last War

(i) *Incendiary Bombs*

The majority of incendiary bombs dropped functioned in a straightforward manner on impact, penetration taking place whilst the priming ignites the main filling. A small proportion were, however, fitted with an explosive attachment to discourage fire fighters. This device operated after the bomb had been burning for a short period.

(ii) *Anti-personnel Bombs*

Anti-personnel bombs are normally of thick-walled construction with a low charge/weight ratio to produce maximum fragmentation effect. They are impact fused.

Certain types of small anti-personnel bombs were fitted with a device to slow up their descent and to prevent penetration of the ground when used with delay fuses. In order to present the maximum hazard to Bomb-Disposal Squads and personnel in the area affected some were fused to explode on impact, some after a period of delay and others if subject to vibration or movement.

Special types of small anti-personnel bombs were fitted with delay and anti-disturbance devices in addition to impact fuses.

(iii) *Other Aerial Weapons*

Parachute Mines, Flying Bombs and Rockets were extensively used against civilian targets. From the nature of the damage produced these weapons may be classified as light case bombs. The rocket, although fitted with an impact fuse, hit the ground so fast—about 3,000 miles per hour—that a considerable crater was formed. Casualties and damage were caused by blast and earth shock and also by the outflung debris and parts of its own machinery which were blown in all directions and acted as additional missiles.

Whether the fall of a single high explosive bomb, a saturation raid with high explosive bombs or even a raid with atomic bombs is being considered, the fundamental principles underlying their action remain the same, save that the atomic bomb introduces additional hazards peculiar to itself.

6. Atomic Bombs

Civil Defence Pamphlet No. 6, " Atomic Warfare " deals not only with the effects
protection and remedial measures against its various effects can be taken. Attention is drawn to the report of the British Mission to Japan published by H.M. Stationery Office in 1946, which gives valuable information in regard to the effects
Nagasaki.

Although the atomic bomb possesses special properties, i.e., heat flash and gamma rays, it is in many ways essentially a blast weapon of very much greater destructive capability than any ordinary type of bomb. In the form used against Japan the heavy damage is found within half a mile from ground zero (the point directly underneath the point of burst), but damage of varying degrees from blast, fire and radiation extend up to a radius of 2½ miles.

Investigations made so far indicate that protection designed to resist the effects of normal high explosive attack (other than direct hits) will give some measure of protection against the atomic bomb and that the addition of supplementary strengthening will obviously help to increase such protection.

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CHAPTER II

PRINCIPLES OF PROTECTION

12. SOME RECOMMENDATIONS

Part of the object of a bombing offensive production and to disrupt the life of the community.

If the enemy is to be prevented from achieving this aim, work must go on until danger is imminent and the ordinary day to day life of the community must be interrupted as little as may be.

Due to the ever increasing speed of aircraft and the rocket-type of missile the interval between the warning and the fall of the bomb will become shorter.

Even in saturation attacks the number of direct hits on buildings is small compared with the number of near misses.

Taking all these considerations into account together with the fact that to get protection one must be *inside* the shelter *before* the bomb bursts, the following recommendations are made.

13. TAKING COVER

(i) In the Open

A bomb or other missile which is going to strike very near to you if audible at all cannot usually be heard for more than a couple of seconds.

If you are exposed in the open during an attack you have not more than a second or two to do what you can to protect yourself.

The worst and most dangerous thing you can do is to run for cover unless, indeed, you are within one jump of it.

Throw yourself flat, wherever you are. Lie face downwards, resting on the elbows, and clasp your hands behind your head. The chest should be very slightly raised off the ground so as to prevent internal injury from earth shock.

Blast, splinters and debris tend to fly outwards and *UPWARDS*. Therefore, if you can manage to roll into the gutter, do so, as the camber of the road and the kerb both tend to protect you.

In open country it is sometimes possible to roll into a fold of the ground, or into a ditch.

(ii) When very near to buildings or other cover

A wall, archway, doorway or narrow alley may give protection. It must be remembered, however, whether indoors or out, that shock is transmitted through walls, etc., so that it is dangerous to lean directly against any part of a building. Your head is the most vulnerable part from this point of view.

(iii) When inside a building

It is better to be near an inside wall than an outside one.

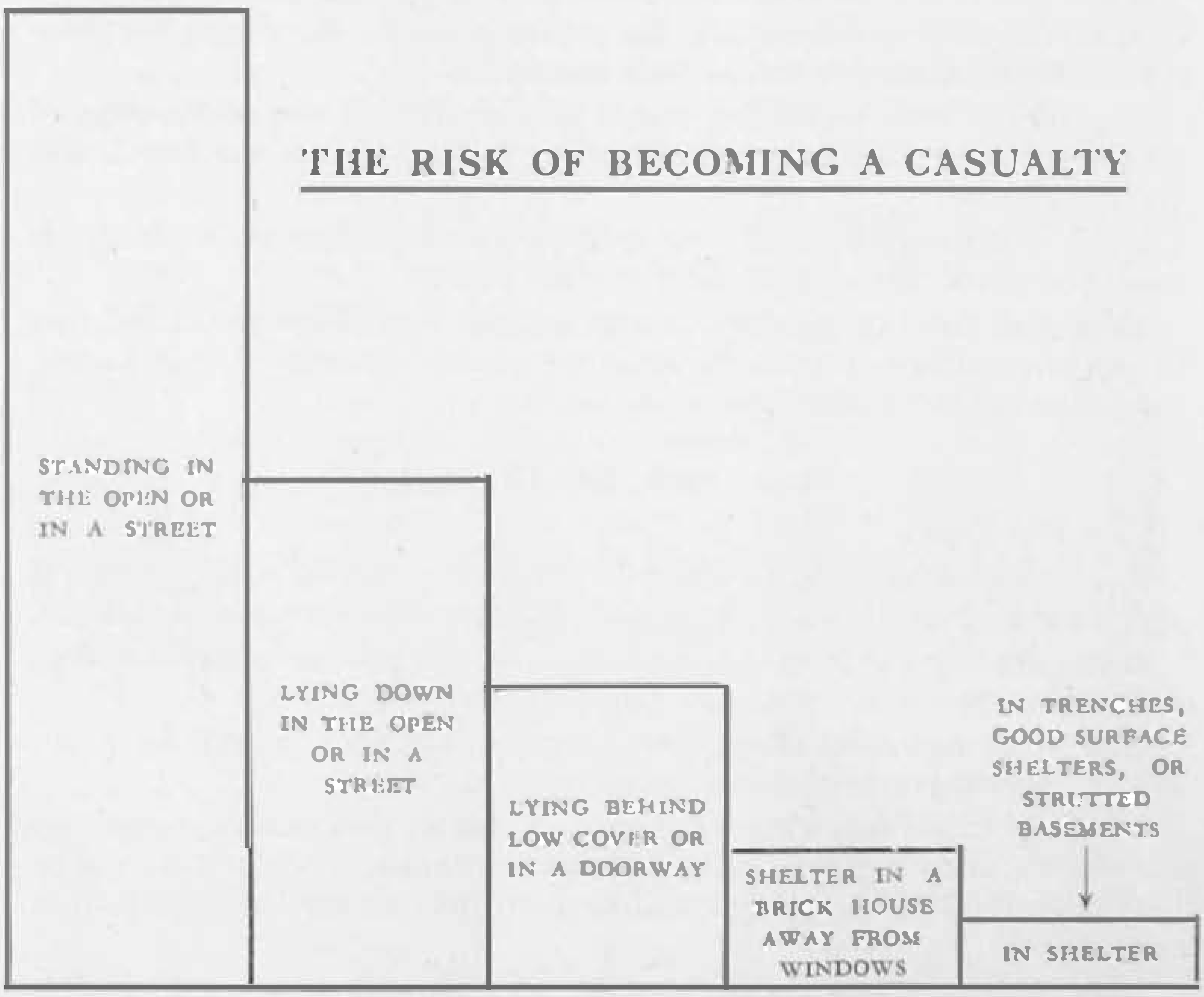
Avoid being in a direct line with an outside door or a window.

Remember the extreme danger from flying glass. Even interior glass can become a deadly missile.

One of the safest parts of a normal room is in the angle of the chimney breast and the wall. Chimney breasts are less liable to collapse than any other part of a building.

(iv) General

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.



CHAPTER III

STANDARDS OF PROTECTION AGAINST HIGH EXPLOSIVE AND OTHER BOMBS

19. GENERAL INFORMATION

The following information in regard to protection afforded materials and conditions is given to afford a general background knowledge of the effects interest to everyone concerned with Civil Defence.

20. SURFACE SHELTERS

Properly constructed surface shelters having walls of 12 in. of reinforced concrete or 13½ in. of reinforced brickwork (Quetta Bond) and a 6 in. reinforced concrete roof tied to the walls will provide full protection against the effect from a shelter wall, and will be capable of resisting light incendiary bombs and any normal debris load.

21. PROTECTION AGAINST BLAST AND SPLINTERS

Protection against blast and splinters from a 500 lb. medium case bomb exploding 50 ft. away will be afforded by the following materials of the thickness indicated:—

Lateral protection

(i)	Mild steel plate ...	... 1½ inches
(ii)	Reinforced concrete	... 12 ,,
(iii)	Brickwork or masonry	... 13½ ,,
(iv)	Unreinforced concrete	... 15 ,,
(v)	Ballast or broken stone	... 24 ,,
(vi)	Earth or sand ...	... 30 ,,
(vii)	Solidly stacked timber	... 36 ,,

Overhead protection

(i)	Mild steel plate ...	... 5/16 inch
(ii)	Reinforced concrete	... 6 inches
(iii)	Efficient brick arching	... 9 ,,
(iv)	Earth, sand or ballast	... 18 ,,
(v)	The inside of an existing substantial building having a roof and not less than two storey floors overhead, provided that the floor above the protected space is supported to enable it to resist the debris load.	

22. DEBRIS LOAD

The strength of the roof of a shelter should also be sufficient to withstand any debris load which might fall on it on the collapse of adjacent buildings.

23. EARTH SHOCK

A shelter should be designed as a complete box to enable it to resist earth shock.

24. MINES AND ROCKETS

Shelters constructed to the above requirements will also provide whole or partial protection against the effects [illegible] their situation in relation to the point of burst. As a rough guide it may be stated that complete protection can be obtained at a distance of 70–120 ft. from the centre of the explosion, though this distance will vary with the weight of the explosive charge.

25. BOMB RESISTING STRUCTURES

To resist a direct hit from a 500 lb. medium case bomb, a shelter will require a reinforced concrete roof 4 ft. 6 in. thick. The walls above ground should be of the same thickness and below ground they should be 7 ft. thick.

Tunnels or caves 60 ft. below ground or 40 ft. in solid rock would provide equal protection. The standards quoted above would also provide protection against a direct hit by a 1,000 lb. medium case bomb, though some damage might be caused in the compartment below the point of impact.

Shelters providing protection against medium case type bombs also provide a measure of protection against the atomic bomb. They can generally be so constructed as to be capable of being strengthened at a later step, if necessary, to provide a higher degree of protection.

CHAPTER IV

TYPES OF SHELTERS

31. BROAD CLASSIFICATION

In this chapter a brief description is given of the various types of shelters used successfully in the last war. This information is again intended as a general background of interest in helping to understand the basic principles of protection against High Explosive missiles.

Shelters were given a broad classification by types as follows:—

(i) Domestic Shelters (for household use)

(*a*) ANDERSON SHELTER. This shelter was designed for erection outside the house. It consisted of 14 gauge corrugated steel sheets, steel angles, ties and channel irons. It was normally sunk about 3 ft. into the ground and covered over with earth to a minimum depth of 15 in., which, with the 14 gauge corrugated sheet gives the equivalent of 18 in. of earth.

The standard shelter was 6 ft. 6 in. by 4 ft. 6 in. by 6 ft. high. It was designed to shelter six persons, but was capable of being lengthened to accommodate eight, ten or twelve persons; or of being shortened to accommodate four persons.

Unless the entrance was screened (within 15 ft.) by a building or existing wall, a screen wall had to be provided. Trouble was sometimes experienced due to flooding by subsoil water in which case the below ground portion was tanked by a lining of cement concrete.

The shelter was, on occasions, erected on the surface, which involved casing it in cement concrete. The result was efficient but expensive.

(*b*) MORRISON SHELTER. This shelter was designed for use in a house and its chief function was to protect the occupants from being crushed by the collapse of the building. Protection against blast and fragments was provided by the walls of the house, which were sometimes specially thickened for this purpose.

It consisted of a steel table measuring 6 ft. 4 in. long by 3 ft. 10½ in. wide. It provided sleeping accommodation for two adults and a child, or a considerable number of small children in a sitting position, when used as a school classroom shelter.

(*c*) STRUTTED REFUGE ROOM—STRUTTED BASEMENT. The object of this form of shelter was the same as the Morrison shelter, i.e. to provide strutting to prevent the collapse of the room and to use the walls as protection against blast and fragments. Strutting was either steel or wood and the design and strength suited to the weight to be supported.

(*d*) SMALL TRENCH OR SMALL SURFACE SHELTER IN GARDEN. This type of shelter needs no special comment.

(ii) Communal or Communal Domestic Shelter

This type of shelter was designed for the joint use of the occupants of two or more houses or flats in cases where it was impracticable to provide shelter for individual households.

Various kinds of shelter were used to suit local conditions, of which the principal were:—

(*a*) TRENCHES. Trench shelters were trenches dug in the ground with a suitable lining to the sides, floor and roof and provided with entrances and emergency exits. They were constructed either wholly or partly below ground. Any part above ground was protected by earth cover (18 in. of earth) or 6 in. of reinforced concrete.

Trench linings found best by experience consisted of reinforced concrete cast in situ; but timber, steel sheeting or precast concrete units were also used.

An important consideration was found to be the effect
the sides of the trench which would cause the roof to collapse unless the design was such as to prevent this contingency.

Normally trenches were 4 ft. 9 in. or 7 ft. clear width with a height of not less than 6 ft. They were constructed in separate 50-person units, or divided into sections by changes in direction at right angles or by baffle walls so that each section would accommodate not more than 50 persons.

Seating or bunking was provided in accordance with the needs of the situation.

(*b*) SURFACE SHELTERS. This type of shelter, as its name implies, was constructed entirely above ground. Walls were of structural concrete not less than 12 in. thick, or reinforced brickwork not less than 13½ in. thick. The roof was of reinforced concrete not less than 6 in. thick. The structure was also designed to resist earth shock.

If the shelter was designed to hold more than 50 persons it was divided into compartments each holding a maximum of 50 persons.

All such shelters were provided with one or more entrances screened against blast and fragments, and a suitable number of emergency exits spaced as far apart as possible.

Any shelter sited nearer to a building than half the height of that building, had the roof designed to take the debris load from the building if it should collapse.

(*c*) STRUTTED BASEMENTS—VAULTS OR COAL CELLARS. No special comment is needed on these two types of shelter, both of which were extensively used. In the case of vaults and coal cellars, means of intercommunication were made where possible so as to provide emergency exits, especially in rows of houses in typical London streets.

The strutting was designed to carry any normal weight that might collapse on the roof of the shelter.

(iii) Public Shelters

Public shelters were constructed or adapted as circumstances required. The principal types were:—

(*a*) TRENCHES—SURFACE SHELTERS—BASEMENT SHELTERS. Descriptions of these types of shelter have already been given in the immediately preceding sections.

(*b*) RAILWAY ARCHES. Good shelter was provided by railway arches by closing the ends by reinforced brick or concrete screen walls to a height of not less than 8 ft. Because railway communications are especially liable to attack however, care had always to be taken not to concentrate too many people in any one archway.

(*c*) TUNNELS AND CAVES. Tunnels with 40 ft. or more overhead cover were used as shelters, as also were caves where they existed, e.g. London Transport Tube Stations and the Chislehurst Caves. Some tunnel shelters were specially constructed. As with all types of shelters, entrances had to be adequately protected by screen walls. In cases where the top cover fell below the general standard, baffle walls were provided to limit the number of persons in any one compartment.

(*d*) OTHER SHELTER REQUIREMENTS. Shelters of suitable type were also provided for schools, factories and commercial buildings. Normally they conformed to those already described, and many of them were made available to the public outside working hours.

(*e*) ADDITIONAL POINTS OF INTEREST. A few tools such as picks, shovels and crowbars were always kept in shelters to help the occupants to force a way out if they were trapped by debris.

Originally all shelters were provided with gas-proofing equipment, though this practice was later abandoned.

CHAPTER V

METHODS OF PROTECTING DOOR AND WINDOW OPENINGS

37. SIMPLE METHODS

Large numbers of casualties were caused by glass during the last war, and particular attention was directed towards reducing this risk and also to the dangers of open doorways through which blast and splinters might travel.

The methods employed were simple. Door openings or windows were screened by baffle or screen walls of any suitable materials of a thickness equivalent to 13½ in. of brickwork built up to a height 6 ft. above the floor level of the room to be protected. Sandbags were also used for this purpose.

The danger from flying glass was further reduced by fixing wire netting of not more than ⅛ in. mesh on the inside of the window frame or over the whole of the window opening; or by pasting a fabric, such as cheese cloth or curtain net, on the inside so as to cover completely the glass and frame. The most satisfactory adhesive was found to be flour paste with a small quantity of borax (¼ oz. to 1 pint of paste) added to prevent mildew.

CHAPTER VI

NOTES ON SOME SPECIAL FACTORY PROBLEMS

Bombing experience showed that factories presented certain problems which had to be given special consideration and treatment. The position varied naturally with different types of industry, but the notes in this Chapter cover points of interest which were, in the main, common factors in industry.

43. LOCATION OF PROTECTION

It was found essential, in the interests of production to try and provide shelter or emergency protection as close to the actual place of work as possible. Since factories were instructed normally to ignore the public warning siren and work to an emergency alarm provided by roof spotters or other means, the siting of the protection had to be carefully chosen and many methods improvised, sometimes using stacks of solid raw materials in shops, adapting trenches used for running heating pipes and so on.

44. CAUSES OF CASUALTIES

Casualties in factories were caused by glass splinters, bomb fragments and blast as is normal with High Explosive bombing. In addition, however, it was found that casualties were also caused by the blast hurling tools, raw materials and other things found loose in most factories and special precautions had to be taken to reduce this risk. Most factories have also a considerable roof space and even if the roof itself survived, parts of it were liable to be dislodged and cause injury to personnel.

In other words it was found that, apart from the usual hazards caused by the explosion of a High Explosive missile, most factories provided a number of additional potential missiles which blast might hurl about and thus increase generally the risk of casualties, unless practical steps were taken to reduce this possibility to a minimum.

45. PROTECTION OF PLANT

The importance of giving special protection to important plant and vital points in factories, against blast and splinters, was very fully demonstrated during the war. Comparatively trivial damage might easily suspend production for days or even weeks. The most important services, where such special protection was required were water, electricity and gas; and essential machinery required special care in some cases.

The most usual form of protection was the provision of blast or traverse walls and substantial overhead cover, and, in addition, where practicable, of the duplication of supplies and services.

It is of interest to note that machine tools were found, on the whole, the most difficult to destroy by bombing; and even though the factory buildings were collapsed or badly damaged, production could be started up again provided the necessary services could be restored, in a surprisingly short time.

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