SALEM POLICE DEPARTMENT

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FIRE, EXPLOSIVES, AND WAR GASES CAUSED BY ENEMY ATTACK
(compiled by Portland Fire Department)

THEIR EFFECT AND HOW TO FIGHT THEM

INCENDIARIES

Incendiary Bombs: Incendiary bombs may be of any weight from 2 pounds to 50 pounds, or even more. Several types and sizes have been tried out in recent years by different countries, but the design that has proved most successful to date is a bomb commonly called in Europe an electron bomb, weighing 2 pounds and consisting of a thick-walled magnesium tube, filled with a mixture of powdered aluminum and iron oxide called "thermite".

One large bomber can carry between 1,000 to 2,000 of these very light incendiary bombs, the number usually varying with the weight of gasoline carried. They are generally dropped from high altitudes, since they do not attain their maximum velocity and penetrative power until they have fallen about 5,000 ft. The bombs are usually dropped from containers, each holding 10 to 20 bombs, and the contents of several containers may be released simultaneously. The bombs spread out as they fall, and a group dropped simultaneously from 5,000 ft. covers an area of about 100 yds. square. As these small bombs have very poor ballistics, they cannot be aimed accurately, but precision is not essential in this case. All that is necessary is that the bombs cover the target area generally.

Effect of Incendiary Bombs: The 2 pound electron bomb, falling from 5,000 ft. will penetrate normal roof construction and a plaster ceiling below the roof but is unlikely to penetrate the first floor below. If not immediately extinguished or removed, the bomb may burn through a wooden floor and possibly through further surfaces, causing a succession of fires in the building.

The number of fires that may be started simultaneously cannot be precisely estimated, but the following calculations will give some indication of what might be expected: In large towns in this country the average proportion of open spaces to built-up areas may be taken as about 4 to 1, or about 20 per cent of the ground space occupied by buildings. Accordingly, for every 5 bombs dropped, 1 may be expected to hit a building, and the remaining 4 to fall in streets, gardens, yards, rivers, lakes, etc., where they would burn themselves out without doing any serious damage. Supposing, therefore, that a single bomber carrying 1,000 bombs has reached such a town, 1 hit in 5 would mean about 200 hits. But, of these, about half either might glance off sloping roofs and not penetrate or, penetrating might fail to function the remaining 100, or approximately 10 per cent of the bombs dropped, would probably cause fires. The size of the area in which these fires may occur would depend upon the speed at which the bomber was flying, how quickly the bombs were released, and the height from which they were dropped. For instance, flying in a straight line, at 200 mph at a height of 5,000 ft. or over, and releasing 20 bombs per second, the bomber would drop its 1,000 bombs in a little under 3 miles and would start an average of 1 fire every 50 yds. In practice, there is little doubt that attacks would be made by squadron formations, which means, of course, that the number of fires would be multiplied by the number of planes in the squadron.

Larger Sized Electron Bombs: Since the main object of an attack with incendiary bombs is simultaneously to start more fires than can be dealt with by the fire-fighting services normally available in a community, this result can best be achieved by dropping the greatest number of the smallest sized bomb that can be relied upon to initiate a fire. The 2 pound electron bomb fulfills this requirement for ordinary houses and the more flammable of industrial buildings. For the more fire-resistant type of structure, larger bombs of similar type are likely to be used, and 5 pound, 25 pound, and 50 pound sizes of electron bombs have been developed for this purpose. Although the 5 pound bomb might be used for general incendiary bombing, it is probable that the larger sizes would be reserved for special targets of unusual military importance. Except that the larger electron bombs will penetrate through several floors of a wooden building, they differ from the 2 pound sized bomb not in effect but only in degree.

Multiple-unit Electron Bombs: In addition to the single-unit types of electron bomb already mentioned, there has also been developed a special multiple-unit type of electron bomb for use against certain kinds of target, such as storehouses, large factory buildings, and ammunition storage yards. These bombs usually have a minimum weight of 25 pounds and consist of a casing containing a number of separate incendiary units. The casing is provided with a steel nose to enable it to penetrate a strongly constructed roof. After penetration the bomb bursts and expels the incendiary units over a relatively wide area. Each unit functions as a separate small incendiary bomb and may initiate a fire wherever it falls. Since each unit is substantially the same as a small incendiary bomb, it has about the same igniting effect, although it does not possess the same penetrating power as the single-unit bomb.

Other Types of Incendiary Agents: White phosphorous has the property of igniting spontaneously and burning vigorously when exposed to the air. Experience has shown that against readily combustible materials and substances which can be ignited by a brief exposure to a small flame, phosphorous is undoubtedly effective. It is therefore well suited for use against hydrogen-filled balloons and aircraft, and for setting fire to woods, brush, and grain fields. However, against wooden structures and materials relatively difficult to ignite, phosphorous is of little value.

Sodium and potassium, both in pure and alloy forms, were used to some extent as incendiary agents in the World War, chiefly in artillery shells. Although they react vigorously with water and generate enormous quantities of heat, they do not function very effectively as incendiaries against dry materials. Their chief use would probably be in conjunction with one or more of the other incendiary agents already mentioned, to prevent quenching with water, since violent explosions are apt to result when attempts are made to extinguish such mixtures with water.

All in all, thermite proved to be the best incendiary agent used in the World War because of its high temperature of combustion and intense localized heat production. The greatest improvement in the development of incendiary agents since the World War has been the addition of magnesium to the thermite filling. This combination greatly exceeds either material alone in its incendiary effect and appears to be by far the most efficient fire producer of any material yet discovered. In view of the immense amount of development work that has been performed in the field of incendiaries during and since the World War and well-known limitations of other materials as incendiary agents, it is not likely that anything other than thermite and magnesium, in combination, will be used until some new compound is developed and found to be more effective.

PROTECTION AGAINST INCENDIARY BOMBS

Nature of Incendiary Bombs: While incendiary bombs may range in size from 2 pounds to 50 pounds in weight, the most dangerous from the viewpoint of attack on cities is the 2 pound size because of its widespread multiple effects. Thus, a 50 pound incendiary bomb can start only a single fire whereas the same weight of 2 pound bombs may start simultaneously as many as 25 separate fires over an area of several acres, the actual number of fires depending upon the number of bombs that strike inflammable targets.

It cannot be too strongly emphasized that the chief danger from air attack with incendiary bomb is the probability of a large number of fires occuring at the same time over considerable areas. Unless these fires are extinguished promptly, they will almost certainly give rise to widespread conflagrations which may produce enormous property damage and seriously dislocate the normal life of the community.

The prevailing type of small incendiary bomb used in Europe during the past few years is, as already mentioned, the 2 pound electron bomb. When dropped from a height of 5,000 ft., this bomb penetrates any ordinary roof, including tiles, slate, and corrugated iron, and an underlying plaster ceiling, but probably not a wooden floor below. It is, therefore, apt to remain in an upper story and start a fire, either in the attic or on the first floor below the roof. Moreover, if the burning bomb is not promptly extinguished or removed, it may burn through a wooden floor and possibly through one or more floors below, thus causing a succession of fires.

When the electron bomb strikes an object, the thermite filling is ignited and burns fiercely at a temperature of about 3,000° C. for approximately 1 min., melting and setting fire to the magnesium casing, which, in turn, burns less fiercely than the thermite for about 15 min. While the thermite is burning the combustion reaction is very violent, jets of flame are emitted from the vent holes of the bomb, and pieces of molten magnesium are often thrown as far as 50 ft. Since the thermite contains its own oxygen, it cannot be extinguished by smothering, but the magnesium must receive oxygen from the air or surrounding materials in order to burn. Except for a few ounces in the sheet iron tail and the igniter, the whole of the electron bomb is consumed in the reaction of combustion which makes this type of bomb very efficient.

Methods of Controlling Incendiary Bombs: When an incendiary bomb has penetrated a building, it becomes immediately necessary: (1) to control the bomb and prevent it from burning through the floor or igniting flammable materials in its vicinity; (2) to subdue and localize the fire resulting from the bomb, before it gets beyond local control. It cannot be too strongly emphasized that time is of the utmost importance in dealing with incendiary bombs. The situation should, therefore, be tackled as soon as possible after the bomb commences to function, in order to prevent an incipient fire from becoming a conflagration that can be extinguished only by a fire battalion.

There are two general methods of dealing with an electron incendiary bomb: (1) the sand method; and (2) the water method. In the first method the bomb is smothered with sand and removed to a safe place; in the second method, a fine spray of water is played on the bomb, causing it to react more violently and burn itself out in a shorter time. The sand method is preferable where the bomb can be reached before the surrounding materials have caught fire, and particularly where the surrounding property may be damaged by the sputtering caused by the water method. On the other hand, the water method is more effective where the fire has already spread and there is no danger to surrounding materials from sputtering.

The Sand Method of Control: As the burning bomb generates considerable heat and glare and throws off sputtering fragments, it may be safely approached within 2 or 3 yd., only in a crouching or prone position, with the operator protected by a fire-fighting mask or anti-gas eye goggles and heavy gloves.

A wet blanket thrown over the operator's back also offers protection from sputtering fragments. About three-fourths of a bucket of sand is dumped on the floor, approximately 2 yd. from the bomb, and with a long-handled shovel the operator places the sand around and on top of the bomb. The operator then shovels the bomb into the bucket on top of the sand remaining therein and covers the bomb with sand from the floor. He then places the end of the shovel under the handle of the bucket and carries it out of the building to a safe place. Instead of using a sand bucket and shovel, a special long-handled scoop and hoe may be employed in removing the bomb. The sand method cannot be used when the bomb has caused a fire so extensive as to prevent close approach, unless special protection can be provided.

The Water Method Of Control: In the usual case, where the bomb falls among inflammable material, a fire will always have started before the scene is reached and therefore close approach to the bomb will be difficult if not impossible. A spray (not jet) of water directed at the seat of the fire is the most effective means of dealing with this situation and will generally be sufficient if applied within the first few minutes after the bomb begins to function. The spray of water increases the rate of combustion of the magnesium by supplying it with extra oxygen, and so the bomb burns itself out in 2 or 3 min., instead of the normal 10 to 15 min. If water is thrown from a bucket or projected in a solid stream upon a burning bomb, it causes violent sputtering and scattering of the molten metal; hence, this procedure is not advisable.

When a bomb has been burning in a room, the heat, glare, sparks, and smoke generated make it unwise to attempt to approach the bomb within about 10 yd. and then only in a prone or crouching position. For this reason a pump capable of projecting a stream of water about 30 ft. (or spray of 15 ft) is required; it should be equipped with at least 30 feet of hose, so that the person operating the pump may be not less than 60 ft. away from the fire. The pump should be capable of delivering about 2 gal. per min. through a 1/8 inch nozzle. Two operators are required to handle this equipment; the first directs the spray, and the second operates the pump. A third person is also very useful to replenish water in the pump bucket and relieve the pump operator.

It is important that the stirrup hand pump be of simple design and rugged construction, so that it is easy to maintain and always reliable in an emergency. The pump should be of the double-action type, with all-metal pistons and valves, capable of delivering about 2 gal. a min. when working at 75 strokes per minute. The pressure should be not less than 12 lb./sq. in. on a 1/8 in. nozzle at the end of 30 feet. The nozzle should be of the dual-jet type, so that the stream may be changed from a solid jet to a fine spray by simply turning the nozzle.

The first operator, wearing heavy gloves and a mask of goggles, approaches the bomb to a distance within range of the jet, about 30 ft. and first extinguishes any fire in the area surrounding the bomb by playing the jet of water upon it. After the surrounding fire is put out the operator approaches closer and plays the spray upon the bomb until it is burned out.

About 6 gal. of water are generally required to subdue the bomb and extinguish the fire in an average room. Therefore, two 3-gal. buckets should be kept constantly filled and placed on the top floor, at a convenient point to the entrance of the attic. If more than two buckets of water is required, the first bucket emptied can be used to carry more water from the nearest tap.

Another and even simpler means of applying water to an incendiary bomb is an ordinary garden hose attached to the nearest faucet in the house. If the hose is sufficient in length to reach any part of the house, particularly the attic, and the municipal water supply is maintained at a sufficient pressure at all times, even when large quantities are being used at the same time to fight fires, then the garden hose will serve the purpose and no hand pump is necessary. The only difficulty about relying upon a garden hose is that, when water is being drawn in large quantities by fire engines from the city mains, it is probable that the household pressure will drop so that a sufficient stream could not be obtained in the attic of the house. Also, there is always the chance that a water main may be broken by a high explosive bomb during an air raid and that the city water supply to the house may fail at the critical time. For these reasons, a hand pump, with buckets of water always available, is much to be preferred to reliance on a garden hose, although obviously a garden hose is better than nothing and should be kept in readiness where hand pumps are not available.

It has been stated above that playing a jet of water directly on a burning bomb causes it to sputter violently and is not recommended as a normal practice. However, if the jet of water is large and strong enough, as from a fire hose, it may safely by played directly on the bomb, for although the bomb may react violently and throw pieces of molten magnesium to a considerable distance, the bomb will be consumed in about 15 sec., and the fire hose delivers a sufficient volume of water to deal with any sputtering effects of the bomb.

Chemical fire extinguishers may also be used to extinguish incendiary bombs, provided that they are of sufficient capacity and do not give rise to toxic gases as products of reaction with the burning bomb. However, at least two such extinguishers will be required for the average incendiary bomb.

It is important that fire extinguishers used against incendiary bombs be of the soda acid type, or at least one employing chemicals that do not break down in the presence of heat and liberate toxic gases. Thus, it would be dangerous to use a fire extinguisher employing carbon tetrachloride (pyrene) or methyl bromide, since the first compound generates phosgene, on contact with burning magnesium, and the latter similarly decomposes into toxic bromide gases.

In general the fire started by an incendiary bomb is more important than the bomb itself, but no hard and fast rule can be laid down as to which should be dealt with first. A great deal depends upon the seriousness of the fire, and it is essential that it should not be permitted to get out of control. At the same time, water should be sprayed on the bomb itself as soon as possible to prevent it from burning through the floor. Frequently it will be necessary first to spray and cool the atmosphere of the room before the seat of the fire can be approached sufficiently close to deal with the bomb and the surrounding fire.

Whenever it is apparent that the fire is getting beyond control, a call for assistance to the fire department should be made without delay. However, the fire department should not be called before such a crisis is reached, as it must always be borne in mind that many serious fires will occur simultaneously during an air raid with incendiary bombs, and the efforts of the fire department should be directed to the serious fires that have got beyond control of fire-fighting means locally available.

Other Types of Incendiary Bomb: What has been said concerning methods of controlling incendiary bombs applies primarily to the small single-unit electron bomb. There are, however, other types of incendiary bomb that may be encountered and that should therefore be considered in formulating any scheme of defense against incendiary attack.

It has been pointed out that electron bombs larger than 2 pounds would probably be used only against special targets but that it was possible that the 5 pound size might be used in indiscriminate bombing. The principal difference between the 2 pound and the larger sized electron bomb is in their penetrative powers. Whereas the 2 pound size will penetrate an average roof and underlying ceiling, it will seldom go through the floor below. On the other hand, the 5 pound bomb will probably penetrate at least one or two floors below the roof, and the larger incendiary bombs will penetrate additional floors, in proportion to their weight. Except for this additional penetrative power, the 5 pound electron bomb can be dealt with by the same methods of control as the 2 pound size. The larger sizes, however, will generate such great heat and cover so much larger areas with burning fragments that it is necessary that special collective-fire-fighting means be provided to combat them.

Owing to its steel nose, the multiple-unit incendiary bomb will undoubtedly penetrate several floors of a wooden building before it bursts and scatters its incendiary units about in the building. The single units, however, have small penetrative power after ejection from the main bomb and will probably not go through more than one ordinary partition wall. The problem of dealing with the multiple-unit bomb is, therefore, essentially one of handling several small bombs concurrently. With regard to each incendiary unit, the same methods of control can be applied as in the case of the 2 pound bomb.

If petroleum-filled bombs are encountered, the resulting fire can be smothered with sand or similar material or subdued with water, if care is taken not to spread the oil. As burning gasoline or fuel oil floats on water, care should be exercised not to direct a stream of water on a pool of oil and thus spread the fire. It is better to spray the surrounding material with water until the oil burns out or can be smothered. Chemical extinguishers, particularly those of the fire foam type, are especially effective against burning petroleum.

Fires caused by phosphorous-filled bombs are easily extinguished with sand or water but reignite again on drying. It is therefore necessary after extinguishing a phosphorus fire with water to keep all contaminated material wet until it can be removed. When a phosphorus fire is smothered with sand, the phosphorus should be promptly removed to a safe place and there allowed to burn out. In removing phosphorus in sand or when wet with water, great care should be used because phosphorus causes dangerous burns on coming in contact with the skin. In spraying burning phosphorus with water, caution is necessary to ensure that no sputtering particles strike the operator. Gloves and a mask or goggles should always be worn.

It is improbable that sodium or sodium potassium alloys will be used alone as incendiary bomb fillings, but it is not unlikely that these materials may be encountered in conjunction with other incendiary agents, such as phosphorus dissolved in carbon disulfide, and petroleum. The best method of dealing with a sodium or sodium-potassium alloy bomb is to prevent the fire from spreading by the cautious use of water spray, special care being taken to keep the water away from the bomb itself, and allow the bomb to burn itself out. Smothering with sand is the only practicable method of dealing with such fires.

Individual Fire Fighting: If an incendiary bomb is not dealt with at an early stage and a serious fire is started, the situation will usually call for the resources of the organized fire department, and it is accordingly important that every person should know the fire organization of his locality and the quickest way of obtaining its assistance. However, since the vast majority of incendiary fires can be extinguished by one or two individuals, properly equipped and acting promptly, it is even more important that everyone understand that a fire resulting from a small 2 pound incendiary bomb is an ordinary fire and can be dealt with successfully by individual fire-fighting methods in the vast majority of cases.

The following rules apply to fire fighting in general and to individual fire fighting in particular:

1. Equipment for combating an ordinary fire should be kept on hand at one or more readily accessible locations.
2. Anyone discovering a fire should first try to put it out himself, if he can reach it. If he is unable to get at or put out the fire personally, he should at once summon help from the nearest quarters--neighbors, police, Air Raid Wardens, and finally the fire department--if it is apparent that the fire cannot be extinguished by local means.
3. Since the fire resulting from an incendiary bomb is the same as any other fire (except as to the bomb itself), it can be extinguished by water like ordinary fires. It is only the bomb itself that requires special treatment.
4. Doors and windows should be kept closed. If the door of a room on fire is left open, the intensity of the fire will be increased, the stairways and passages will act as flues, and the fire will soon spread all over the building. If it is necessary to open a door, it should be opened only a minimum distance and the person opening it should stand behind the door while doing so, if the door opens toward him. Care should be taken to prevent the door flying open.
5. In searching a burning building, the start should be made at the top of the building and progress to the comparative safety of the lower floors.
6. By keeping close to the wall, it is often possible to move safely across a floor or staircase that have been weakened by fire.
7. Upon entering a room on fire, a crouching or crawling posture should be adopted, for the smoke and fumes are less dense near the floor. Hence, the air will be purer, one can see better, and there is less danger of tumbling or falling.
8. Occupants of a building on fire, who are not required to assist in fire fighting, should be promptly evacuated to a safe place.
9. The possibility of a fire traveling under a floor, in a wall, or up a shaft should not be overlooked, and all such possibilities should be carefully examined before leaving the scene of a fire.

Fire Precautions: The following simple fire precautions can be taken in the home at very small expense and will add greatly to the protection of the household during incendiary attacks:

1. Make sure that each member of the family knows the emergency fire-fighting arrangements for the neighborhood where the nearest fire station or fire patrol is established, and how to call the local Warden and to summon the regular city fire department if all other measures fail.
2. Clear the loft, attic, or top floor of the house of all inflammable material, such as "junk", paper, litter, and lumber, in order to reduce the danger of fire and to prevent its spread.
3. Arrange a sure and quick means of entry into the attic or roof space. If the only entrance is through a trap door, see that a ladder is kept on hand at all times.
4. For controlling an incendiary bomb, it is desirable to have on hand at a convenient place in the top story of the house at least four large buckets, a long-handled scoop or shovel, and several bucketfulls of dry earth or sand in a box.
5. As water is the best means of putting out a fire started by an incendiary bomb, at least two buckets should be kept filled with water near the attic entrance. These should be supplemented wherever possible with a stirrup hand pump or a garden hose long enough to reach from the nearest water tap to the attic.
6. The inside of the loft, attic, or top story of the house should be rendered more fire resistant by coating all woodwork with two coats of whitewash consisting of 2 pounds of slaked lime, 1 oz. of common salt, and 1 pt. of cold water.
7. The floor of the loft, attic, or top story of the house should be protected by covering it with sheets of corrugated or plain iron (22 gauge or thicker) or asbestos wallboard or with 2 in. of dry sand. As the sand will considerably increase the weight on the floor, it should not be used until advice is obtained from the local authorities as to whether the floor is strong enough to bear the extra load and, if not, how it should be propped up for the purpose.

The purpose of this study bulletin is simply to present an introduction to the problem of war gases in relation to defense; to give a preliminary picture of the problem involved by briefly discussing the characteristic properties, protection required, and first-aid for four different type gases. The fundamental problems in civil defense, individual protection, group protection, and decontamination, will not be entered into at this time.

Definition of War Gases: A war gas is defined as any chemical substance, either solid, liquid, or gas, that can be used to produce, physiologically, a disabling effect upon a human body. War gases are released to mix with the air and to produce their harmful effect upon all unprotected persons exposed to them. While chemicals may be disseminated by numerous means, their use against civil populations would probably be limited to airplane dispersal by means of drop bombs and chemical spray. Chemical bombs will range in size from twenty pounds to six hundred pounds, depending upon the type of gas, and when used will result in a large area being covered, more or less thickly, depending upon the number of planes used, with heavily contaminated spots. When a chemical spray is desired, attack-type planes, flying relatively low, will release streams of liquid gas which will settle to earth as a fine spray or mist, contaminating every exposed surface in the area with a light concentration of a persistent agent. Against these two methods of chemical attack a trained civilian population need have little fear, whereas a gas attack upon an uninformed and untrained civil population could easily produce widespread panic.

Toxicity of War Gases: While the toxic or lethal effect, that is, the amount of gas required to produce a casualty, varies with the different gases, one thing is true in all cases; the effects of any war gas will always be in proportion to the amount of gas present and the length of time a person is unprotected. The stronger the gas, the greater will be the injury produced in a given time. However, it is important to remember that even quantities of gas too weak to detect by odor will cause injury if the time of exposure is sufficient. A certain quantity of each gas must be breathed or come in contact with the body to produce a disabling effect, but this required exposure could be for two minutes in a high concentration or for two hours in a low concentration with the same ultimate result. Similarly a person undergoing hard physical exercise breathes a much greater volume of air per minute than a person at rest, so that if both were exposed to the same concentration of gas for the same length of time, the former would suffer the greater injury.

Classification of War Gases:

Persistency: One basis for classification of chemical agents is the length of time they remain in effective strength at the point of release. In this manner gases are classified as being either persistent or nonpersistent.

The non-persistent gases are the very volatile ones which quickly evaporate when released from their containers, forming visible or invisible clouds which drift along with the wind, thus effectively covering a large area, but at the same time gradually mixing with larger quantities of air and becoming progressively more diluted and less dangerous with distance from the point of release. Thus these agents do not remain in effective concentration in the open for more than about ten minutes and so are said to be nonpersistent. However, it should be borne in mind that on windless days and in enclosed spaces these same gases may remain effective for several hours.

The persistent agents are less volatile and are usually liquids that evaporate slowly giving off dangerous vapors which form toxic concentrations and move along with the surrounding air. Being non-volatile liquids, persistent gases, unless removed or neutralized, remain in effective concentration in the open for many hours or days and in cold weather may persist for weeks. As most persistent agents are also blister producing agents, the combination is extremely efficient. All personal clothing, equipment, material, and buildings contaminated with persistent gases must be decontaminated or destroyed before again being used. And successful decontamination of these agents requires skilled and trained operators or else casualties will surely result.

Physiological Effect: Another method of classifying war gases is by their physiological effect, as follows:

Tear Gases: Tear gases or lacrimators, are those which affect only the tear glands of the eyes. They cause intense eye irritation and temporary blindness for a short period with no harmful after effect. They will probably not be used in future warfare except against untrained and unprotected civilian populations to produce panic and widespread disorder and confusion.

Example: A typical tear gas is Chloracetophenone, or, as it is commonly called, CN. CN is a crystalline solid which is readily vaporized, yielding a colorless, nonpersistent gas with an odor in low concentrations like apple blossoms. It is readily identified by its odor and also by its immediate action upon the eyes. It is effective in concentrations as low as one one-hundredth ounce per thousand cubic feet of air.

Protection Required: Complete protection is obtained with any approved gas mask or with a good pair of tightly-fitting goggles.

First Aid: Normally, the effects of a tear gas leave as soon as one gets out of the contaminated atmosphere. One can also stand and face the wind with the eyes open and allow the wind to blow the gas from the eyes. In aggravated cases, the eyes can be washed with boric acid solution.

Lung Injurant Gases: These are gases which when breathed attack the pulmonary system, causing a burning sensation in the nose and throat and a feeling of suffocation. Breathing these gases results in destruction of the lung tissue, and concentrations may be readily established which will prove fatal to unprotected persons after a ten-minute exposure, or result in serious disability upon shorter exposure. More casualties from this type of gas result in death than from any other type. Lung injurant gases have no effect on any part of the body except the lungs.

Example: A good example of a lung injurant gas is Phosgene, a colorless nonpersistent gas, three and one-half times heavier than air with a stifling, though not unpleasant, odor resembling new-mown hay. In high concentrations phosgene causes coughing, difficulty in breathing, pains in the chest, nausea and vomiting. In extremely high concentrations, collapse may be immediate. In concentrations most frequently encountered, the action of phosgene will be delayed, especially when the concentration is real low and the exposure prolonged. Under such conditions, the almost total lack of irritation may result in a person's being seriously, if not fatally, gassed and not realizing it until serious symptoms set in. Such a person may feel well able to carry on his duties, only to be stricken suddenly and die within a few hours as a result of insufficient oxygen supply.

Protection Required: Since all lung injurant gases must be breathed to be effective, complete protection against these agents is obtained with a good gas mask, if properly adjusted in time.

First Aid: The essential physiological action of the lung injurants is to cut down the supply of oxygen to the body tissues. Consequently, in order to reduce oxygen requirements to the minimum, a lung injurant casualty should be put at absolute rest. He should be made to lie down and not allowed to walk to an aid station even though he insists that he is able to do so. He should, as soon as possible, be removed from the contaminated atmosphere; his equipment should be removed, and his clothing loosened, and he should be kept warm, since cold increases the consumption of oxygen by the body. In addition to wrapping in blankets, non-alcoholic stimulants, such as hot coffee or tea, should be given; and he should be evacuated as soon as possible, as an absolute litter case. If available, oxygen should be administered.

Vesicant Gases: Vesicant agents are those which produce vesicles or blisters wherever they come in contact with a body surface, either interior or exterior. Exposure to these gases produces no immediate sensation or pain, so often there is delay before the symptoms are noticed. This absence of immediate effect and the fact that a concentration of gas too weak to be detected can cause disabling burns on long exposure constitute two of the greatest dangers from these gases. Frequently the need for protection may not be realized until it is too late. The vesicants are also encountered in the liquid form in which state they are much quicker acting. One outstanding feature of liquid vesicants is their remarkable power of penetration.

A single drop no larger than a match head will penetrate clothing or even leather shoes and produce a blister the size of a quarter. Wood, paint, concrete and leather are readily penetrated and the human body itself has no resistance to vesicants. It is this remarkable power of penetrating all ordinary substance that makes protection against vesicant agents so difficult.

Example: The best example of a vesicant agent is, of course, mustard gas. Mustard gas is normally a dark-brown, oily-like liquid which vaporizes to a colorless gas five and one-half times heavier than air. It is easily recognized by its distinctive odor, which is similar to onions or garlic. Areas or objects which have been splattered with liquid mustard appear just as if they had been splattered with old crankcase oil.

The first effect noted from mustard gas is irritation and inflammation of the eyes and eyelids. Then follows irritation of the respiratory tract, with nasal discharge, nausea and pain in upper front abdomen, cough, and finally reddening and blistering of the skin. Broncho-pneumonia is a frequent late result where mustard gas has been breathed and is the cause of most mustard gas deaths.

Ordinary clothing is readily penetrated by mustard vapor, and severe skin burns result, especially on areas of the body which perspire freely. The area affected and the severity of the burn will depend upon the concentration of the gas and the length of exposure. Skin effects usually do not appear until from two to six hours after exposure. A reddening of the skin, similar in appearance to that of a severe sunburn, is usually the first effect noticed. This is followed by itching and a drawing sensation and later by the development of blisters.

The effects resulting from contact with liquid mustard are similar to but more severe than those caused by the vapor. They develop more rapidly, often within the hour. Severe burns readily become secondarily infected and often result in deep sloughing ulcers which are slow to heal and require long hospitalization. It is interesting to note that there is no pain from a mustard burn, except when the liquid gets in the eye.

Protection Required: As mustard, either as a liquid or a gas, readily penetrates ordinary clothing and burns any part of the body with which it comes in contact, the problem of individual protection is a real one. Not only is a gas mask required to protect the face and lungs, but also the entire body must be clothed in special material which will keep out the mustard. This type of clothing is necessarily air-tight, which makes it exhausting to wear over prolonged periods. While trained men can work in this type of clothing for periods up to three hours, inexperienced crews become exhausted within thirty minutes.

First Aid: The casualty should be immediately taken out of the contaminated atmosphere or area and his contaminated clothing removed. Should only portions of the clothing be splashed with liquid mustard, these can be cut away. If the face has been exposed, wash the eyes and rinse the nose and throat with a saturated boric acid, weak sodium bicarbonate, or common salt solution. If the vapor has been breathed, treat and handle as a lung injurant casualty. First aid must be prompt for little can be done later than twenty to thirty minutes after exposure.

Vapor burns on the skin may be lessened or even prevented by thorough cleansing with soap and water (preferably hot) immediately after exposure. Cleansing the exposed parts with gasoline (not containing lead tetraethyl) or kerosene prior to the use of soap and water will facilitate the removal of all traces of the gas.

Mustard burns or skin areas wet with liquid mustard should be immediately and repeatedly swabbed with a solvent such as kerosene, straight gasoline, any oil, alcohol, or carbon tetrachloride. Fresh cloths should be used and the spreading of the contamination should be avoided. After cleasing with the solvent, the effected parts should be thoroughly washed with soap and hot water. Cloths used in removing the liquid vesicant will be contaminated and should be burned or buried after use.

A weak, freshly prepared solution of chloride of lime in water may be used in place of the oily solvent, but this solution is itself very irritating to the skin and must, therefore, be removed by subsequent washing with soap and water.

Fresh, uncontaminated clothing must be supplied and all casualties removed from aid-stations to hospitals as soon as possible. Always wear your gas mask and protective gauntlets when handling vesicant casualties.

Respiratory Irritant Gases: These substances, also called sternutators or sneeze gases, are usually disseminated as extremely minute solid particles or smokes. They produce intense pain in the nose, throat, and chest, followed by headache, nausea, vomiting and a general weakness. The effects, however, are not permanent, lasting only from several minutes to a few hours after the victim has been removed to the fresh air. These gases are doubly annoying because they readily penetrate all but the finest gas mask canisters and are effective in extremely low concentrations, one-quarter ounce of the agent per one ounce of the agent per one thousand cubic foot of air being intolerable to an unmasked person after a two-minute exposure.

When a person is nauseated by an irritant gas, he will vomit and can not wear a gas mask continuously, and if he removes his mask he exposes himself to any other gases present. For this reason, irritant smokes will undoubtedly be used in conjunction with other more lethal types of gas, in order to increase casualties. When used in this way, irritant smokes become a serious danger in air attacks, owing to their great mask-penetrative powers and effectiveness in extremely low concentrations.

Example: A good example of this type of agent is diphenylaminechlorarsine, commonly known as Adamsite. It is a bright yellow, crystalline solid, which when vaporized condenses to form a dense canary-yellow smoke, with a characteristic smoky odor. The odor is not so pronounced, however, as the burning sensation in the nose and throat which is usually the first symptom produced.

Protection Required: Since irritant smokes are chemically inactive solid particles, they are not removed by the chemical contents of a gas mask canister, but must be removed by means of a very efficient mechanical filter. Probably the only canister available which will remove irritant smokes from the air is the Army canister. It is doubtful whether any commercial or fire fighting canister would be adequate.

First Aid: Remove patient from contaminated atmosphere, keep away from heat, and remove outer clothing. Flush the nose and throat with a weak solution of sodium bicarbonate or of salt. The exposed surface of the body should be washed with soap and water.

Type War Gases and Their Properties

Type Gas	Tear Gas	Lung Injurant	Vesicant	Respiratory Irri-tant
Common Name	CN	Phosgene	Mustard Gas	Adamsite
Persistency	3-10 min	3-10 min	3-36 hrs	3-10 min
Lowest Irri-tant Conc.	0.0003 oz per 1000 cu ft	0.0005 oz per 1000 cu ft	0.001 oz per 1000 cu ft	0.00038 oz per 1000 cu ft
Lethal Concen. 10 min expos.	0.85 oz per 1000 cu ft	o.50 oz per 1000 cu ft	0.15 oz per 1000 cu ft	3.00 oz per 1000 cu ft
Vapor Density	5.2	3.5	5.5	
Solvents For	Chloroform		Oils, Alcohol Carbon tet	
Odor in Air	Apple Blossoms	New Mown Hay Ensilage	Garlic Horseradish	Smoky
Odor Detect-able at	0.0002 oz per 1000 cu ft	0.0044 oz per 100 cu ft	0.0013 oz per 1000 cu ft	0.0025 oz per 1000 cu ft
Physiological	Eye and Skin Irritation	Burns Lower Lung Tissue	Reddening and Blistering of Tissue	Headache, Nausea Sneezing
Protection Re-quired	Gas Mask Goggles	Gas Mask	Gas Mask and Protective Clothing	Best Type of Filter in Gas Mask Canister
Method of Neutralizing	Strong Hot Sodium Carb. Solution	Steam and Alkalies	Bleaching Powder	Bleach Sol. Chlorine Gas
First Aid	Face Wind Boric Acid Solution	Warmth, Rest Oxygen	Wash with Kerosene or Solvent and then with Hot Soap and Water	Breathe low conc. of Chlorine Gas