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There are three types of atomic explosions: in the air over the sea, at the surface, and underwater.

Depending on the target, the explosion in the air over the sea could take place at various altitudes. Thus, the most effective altitude for a 20 KT bomb is considered to be 600m. The effect the explosion may have depends on many variables, such as: the strength of the ship's construction, the height of the superstructure, the distance and position of the ship in respect to waves and the impact of the air wave. As a result of this, the requirements for the construction and design of ships, especially naval ships, are considerably changed at the present time..The residual effects, such as radioactive fall-out, are practically ignored, because the fall-out settles relatively quickly and the consequences of the contamination are not serious. The primary radiation, which is a flux of gamma rays and neutrons which have been freed at the moment of explosion, must overcome a number of obstaclės, such as the ship's plating, various partitions in the ship, etc. The contamination of the water surface from the radioactive fall-out, unlike the situation on land, disappears rather quickly.

The best time for this type of explosion is a clear, sunny day or a clear night, because the heat effect is strongest and the conditions for delivery are best. An atomic explosion in the air is considered most effective along the shore and over narrow seas, where there is close coordination between the various branches of the armed services in combat action and when it is desirable to make maximum use of the heat effect and the blast power. This type of explosion may very well be used against ships engaged in anti-landing operations.

Explosion of a nuclear bomb at the sea surface

In this type of explosion fission takes place either on the surface itself or under such conditions which permit the fire ball to touch the surface of the sea (For a standard bomb this height is around 140 meters.) In this type of explosion the heat radiation and the primary radiation are much less than those from explosions in the air over the sea because a large amount of the energy is absorbed in the sea water. Such an explosion produces a great amount of contamination in the area, and for a long or a short time (depending on the nuclear warhead) represents a considerable obstacle against which the ships must at all times be on guard for the safety of their personnel; they might press ahead or avoid the area, depending on the situation and their capabilities. The circulation of the air over the sea surface is even greater than in the case of a similar explosion over land, regardless of the fact that a large amount of energy is diverted for the formation of a water wave. That fact is explained by the existence of vegetation and the difference in topography, as well as by the quick heating of the land area by heat radiation, all this contributing to the reduction in the intensity of the heat wave over land. This is not the case when a similar explosion over the sea surface is involved. It may be concluded, therefore, that an air blast is the most destructive factor in this type of atomic explosion and it represents the greatest danger for the ships, of the attack is carried out in their proximity.

It is extremely important to keep in mind the characteristics and the position of the targets at sea when the zero point is selected for this type of explosion.

A nuclear explosion below the surface may be shallow or deep. In the case of a shallow explosion, the bubble of hot gases rises to the surface and has the appearance of the well known water dome, followed by the water column, condensed cloud, base surge, great radioactivity and prominent dynamication of the water.

The dynamication of the water following a shallow explosion is one of the most destructive factors: the surge of the water depends on the strength of the nuclear warhead, but it may reach a height of some 30 meters. The released energy is transformed into mechanical energy, which moves tremendous masses of water. The absolute magnitude, the heat action, and the primary radioactivity of this type of explosion are absorbed in the water, and as a result, no effect is felt from them. All the radioactive products of the explosion remain or are subsequently returned to the water. The primary radiation following a shallow explosion causes an artificial radioactivity which is induced in a number of elements which are found in the sea water and the sea bottom; as a result, there is a strong and relatively long lasting contamination, especially in the areas close to the center of the explosion. Such contamination is one of the main obstacles for the ships and their combat mission, and it must be overcome.

The size of the contaminated area, as a result of the additional contamination from the fall-out, depends on the power of the nuclear warhead as well as on the local geological and meteorological conditions. It should be noted that in the case of narrow seas, the meteorological conditions have great influence in the spreading of contamination.

The feature of this type of explosion make it suitable for use in tactical situations at sea for the achieve ment of the following goals:

1. As a strike against sea targets and naval units, especially in cases in which the area does not permit rapid maneuverability.

2. for the creation of heavily contaminated sea areas as a barrier against maneuvering of naval units; this is especially appropriate in narrow sea and closed areas (such as bays, ports, canals, etc.).

3. for clearing enemy mine barriers in cases which would require long term mine clearing with conventional methods. (The contamination of the sea some 3-4 hours after the explosion is 50 roentgens per hour. It has been calculated that the troops aboard landing ships will pass through such an area in 15 to 20 minutes, and so that they will receive a dose of not more than 20 roentgens, a significantly small amount of radiation in comparison with the permissible one under combat conditions. If the landing is carried out by fast amphibious ships which are armored or which could be hermetically sealed at a given moment, and thus protect the personnel from the contaminated water, the amount of radiation to which the personnel will be exposed will be considerably smaller. After three hours

in the water at the center of the explosion, the intensity decreases to 5 roentgens per hour. The contamination of the shore area poses a greater risk.)

4. for the destruction of important targets of the coastal defense, port facilities, dockyards, etc., located on shore where the heavy contamination prevents quick repairs and rescue at sea.

In the case of deep underwater explosion, it is characteristic that the gas bubble does not come to the surface, there is no water column and dynamication of the wave such as occurs after the shallow explosion. This type of explosion is suitable for use against modern nuclear powered missile submarines which sail at great depths. It is believed that such a blast at great depths, which covers a wide area, will shock the submarine and its sensitive instruments and thus render it inoperative.

The Effect of environmental Factors (Geology, Hydrology, Meteorology) on the use of Nuclear Devices at Sea)

The achivement of the tactical goals depends on geographical factors as well as on such hydrological factors as the depth of the sea, the nature of the sea bottom, salinity of water, sea currents, and the local meteorological conditions. Each of these factors must be analyzed from the point of view of the contamination effect for maximum utilization of the atomic explosion. A lack of knowledge of the air currents, especially those in the upper atmosphere, may cause an opposite effect from that which is desired in respect to contamination (planning of an atomic attack in the Adriatic, for example, must take into account that the air current in the south is in the opposite direction at altitudes over 1500m; therefore, an atomic explosion in the air over the Adriatic, whose radioactivity reaches this altitude, will have effects in areas in the south-southwest.) The influence of this local factor leads to a careful selection of the zero point and the type and strength of the atomic explosion. Consideration should also be given to such factors as the average annual temperature, relative humidity, air insolation, cloud cover, amount and time of precipitation, number and time of clear days and nights, etc.

The importance of the geological, hydrological and meteorological factors should not be under-estimated, not only for atomic, but also for chemical and biological, warfare. This is very important, especially in the case of narrow seas which touch on the territory of several states.

Chemical agents

In order to understand the main features of the chemical agents (especially the modern combat agents which act on the nervous system immediately and effectively in small concentrated doses), it is necessary to make a comparison between the action of these agents and the action of an explosion.

The differences consist in the following:

1. the conventional explosion acts immediately while the action of the combat agent continues for some time after it has been used. The time during which the effectiveness of the chemical agent continues depends on' the type of agent used.

2. the destruction of the explosion is limited in space, while the area covered by a chemical agent depends on the quality and quantity of the agent used and on the meteorological conditions. The effect on the enemy's manpower depends on the protective equipment which they employ and the training of the people in its use.

3. a good defense against an explosion may not be sufficient against a chemical agent if the structure is not air tight.

4. an explosion is employed against living things as well as against man-made objects, while combat agents are intended only against living things.

They can be divided into three basic groups according to the effect of the combat agents on the crews of ships.

1. Those which exhaust or temporarily disable the crew. They could be delivered in a cloud generated by special gear on small fast boats, by hand grenades, or by special airborne means. Those are shortlived chemical agents which act in small concentration of 0.001 mg per cubic meter. Their specific weight is greater than that of the air, and they are not likely to undergo quick hydrolysis or be absorbed quickly by the water. The action of these agents is effective as long as the ship is enveloped in the cloud, which may last for several minutes in actual practice.

2. The features of the second group of chemical agents are that they are persistent and, when they fall on the surface, they move relatively quickly through porous materials and such places as the weld seams of ship plating. Such chemical agents do not dissolve readily in water; as a result they float, and represent a danger for the ships' surface. It is difficult to recognize these agents, because they are similar to engine oil which is often found on the surface of the sea. This type of chemical agent could be delivered by aircraft or artillery shells or missiles with chemical warheads. The weak points of these agents is that their effect is felt after a delay of 1-2 hours, which is a long period of time for naval actions.

3. The third group is comprised of modern combat agents, the so-called TRILONS, which have a cumulative effect because they cause instant death even in very small doses. The means for delivery are the same as in the other two groups.

An attack with chemical agents against ships which are in the vicinity of their bases is usually carried out within the scope of a general attack. Only in exceptional cases is aviation or other means of delivery used as an isolated attack against naval units. In order to be successful, such an attack must have an element of surprise, so that any quick and effective defense can be prevented. Used in such an attack, combat agents have an extra effect, as it is difficult to determine their presence, because they are odorless, noiseless, and react very quickly even in small concentrations, with death occuring within two or three minutes.

When this danger is taken into consideration, one has to keep in mind that ships are frequently anchored in bays which are surrounded by hills. As a result of this the circulation of the air is slow and the poisonous gases remain in the vicinity longer. On the other hand, such places provide better protection against enemy aircraft and, therefore, one must decide which is the greater danger at any given moment. The presence of water vapor in the atmosphere over the anchored ships also causes a heavier absorbtion of the agents by the sea water, and, for that reason, isolated attacks on ships with chemical agents are not very effective.

In open sea, a ship is a relatively small target. If we take into account its ability to maneuver and change course in relation to the air currents the ship becomes a very unsuitable target indeed for a limited attack with chemical agents. Because of the environment in which the ship sails, it is relatively easy to eliminate the effect of a chemical agent attack. The air movement at sea is intensive, and the ship tends even to increase it by its own movement. This diffuses the concentration of combat agents. If the enemy uses a poisonous cloud to disable the crew, the effect is usually a short-lived neutralization of the crews of landing ships and their escorts. The combat capability of the crew is usually restored very quickly after such an attack. The methods of delivery of such an attack (poisonous smoke) are very complex and require good preparation on the part of the unit which employs them. It is a well known fact that the air currents at sea very often change their course, and for that reason the chemical agent might be blown right back into your own ships, if the agent is delivered by ship. If it is delivered by aircraft, the plane must fly low; however, then it becomes an excellent target for the ship's AA guns.

The protection of the crew while the ships are at sea is increased also by the fact that the ships are on one of the ABC alert conditions when most of the crew is inside the ship and the protective equipment is held ready.

The combat agents which act on the nervous system are an exception from the rule concerning employment of chemical agents in the open sea and may be employed while the ships are in motion because they act quickly and effectively on the human body, even in small concentrations. For that reason the danger from chemical agents cannot be discounted especially in narrow seas, where maneuverability may be limited. In addition to that the effectiveness of these agents is increased when the ships are not ready to cope with an ABC attack and especially when their unpreparedness is known to the enemy.

Biological Agents

It is a well known fact that biological warfare employs live agents or their toxins for the purposes of destroying the human, animal and plant life of the enemy. The technology and tactics for the use of these agents in war are still in a very primitive stage of development.

The basic conditions which must be met for choosing biological agents for military purposes are their capability to infect and their virulence.

These are important considerations in causing enemy losses and providing suitably for their delivery. In order to be suitable, a biological agent must be easy to cultivate and mass produce at a given moment; it must be capable of being produced and safely stored in peace time. These, of course, are problems which have not gone beyond individual laboratory solutions. It should be noted that the production of such stockpiles during peace time is a very difficult proposition on account of the short life span of the otherwise suitable biological agents, with the exception of toxins. Difficulties also arise with respect to the safety of the personnel who handle these agents.

The defense against this type of attack is difficult, because of the problem of identifying the biological agents. At the present time this identification process is very complicated, resulting in a delay in the employment of countermeasures. This delay, as we know, might have fatal consequences. The detection of these agents is somewhat easier if it is based on a well organized warning system, on the fast delivery of samples of suspected agents and on the appearance and observation of unexpected maladies.

From the point of view of carrying out a biological attack at sea, the methods which could be employed for atomic and chemical agents are by and large valid in this case also. Ships could also carry out an attack with biological agents, which could be dispersed as aerosols along the enemy shores, provided that they are equipped with the necessary generators and that they are operating under favorable meteorological conditions. Under such circumstances the Navy could also be directly endangered by the military actions of the enemy, a very likely possibility in an unlimited war. The danger for the Navy as a whole from an attack with biological agents may result from such an attack against a large portion of the home territory or directly from an attack from the sea. On board a ship, as a unit, the effects will be felt through the water, food, and the other necessities as well as through the people who come on board ship from areas which were subjected to such an attack.

By way of summary, we may note that the techniques of employing ABC agents at sea, especially those concerning some details, have already passed into a stage of improvement in which only a few technological deficiencies need to be corrected. These deficiencies are mainly connected with the guidance system; there is also a prevailing tendency towards developing tactical atomic weapons and towards adapting existing ship armament for the use of nuclear charges. The latter development is still in the experimental stage. It is apparent that the development of techniques and uses of ABC agents is moving along the line of finding means, and improving those already existing, for delivering them over great distances. It is also evident, although not much has been said about it, that measures are being taken for developing a state of readiness for protection against the effects of ABC agents. It should be kept in mind also that the use of such agents calls for safety measures which are very important and which must be taken by those who deal with ABC agents.