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SHIPBOARD PROBLEMS AND REQUIREMENTS FOR HANDLING AND STOWAGE OF CHEMICAL MUNITIONS (U)

14 NOVEMBER 1961

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UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 61-161

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SHIPBOARD PROBLEMS AND REQUIREMENTS FOR HANDLING AND STOWAGE OF CHEMICAL MUNITIONS (U)
(Preliminary Study)

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ABSTRACT: Recommendations are made for the shipboard stowage and handling of toxic Chemical Warfare (CW) munitions. Weapons expected to be in the Navy Stockpile until 1965 are considered. Recommendations include munition safety requirements and packaging, stowage and handling precautions, emergency and decontamination procedures, detection, and medical facilities. It is concluded that shipboard safety of CW munitions can be achieved if proper precautionary measures are adopted and personnel are thoroughly indoctrinated in emergency procedures. Munition packaging is recommended for stowage safety and for handling protection.

U. S. NAVAL ORDNANCE LABORATORY
White Oak, Maryland

NOLTR 61-161 14 November 1961

Shipboard Problems and Requirements for Handling and Stowage of Chemical Munitions (Preliminary Study)

This report covers a Naval Ordnance Laboratory study into the safety aspects of shipboard stowage and handling of chemical warfare (CW) munitions. The study was performed for the Bureau of Naval Weapons under WEPTASK No. RMMO 33010/212 1/F008 10 005. Information for the recommendations of this report was obtained from Army Chemical Corps documents and through frequent liaison with the Army Chemical Corps.

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By direction

CONTENTS

ILLUSTRATIONS

References

(a) Chemical Corps Safety Directive No. 385-8; Safety Criteria for Processing Filling, Handling and Decontamination of GB

(b) Department of the Army Technical Manual TM3-215, Military Chemistry and Chemical Agents

(c) (Sec) U. S. Army Chemical Corps Combat Development Project Report CMLCD 57-5, Final Report "Exploitation of Tactical Chemical Warfare (U)"

SHIPBOARD PROBLEMS AND REQUIREMENTS FOR HANDLING AND STOWAGE OF CHEMICAL MUNITIONS (U)
(Preliminary Study)

1.0. Introduction

1.1. Traditionally, the tactical employment of Chemical Warfare (CW) agents has fallen within the province of land-based forces. However, in its role of supplying close tactical support to Army and Marine Corps combat units, the Fleet must have the capability to deliver, on a target, whatever type of munitions the particular tactical situation requires. At present the Fleet's combat units do not carry CW munitions. However, the Navy has for some time had a limited stockpile of these munitions and is at present engaged in the development of more advanced CW disseminating systems armed with the more lethal nerve agents. Due to the insidious nature of the CW agents contained in these munitions, they can be very dangerous to the user if not handled properly. It is the purpose of this report to survey the shipboard-loading-to-target cycle of these munitions, with respect to the protection of the user. Suggestions will be made as to procedures that should be followed when dealing with CW munitions. These will include handling, storage, free agent detection, emergency procedures and mechanical safety measures as required. Many of the CW munitions to be discussed in this report were designed primarily for Army and Air Force use and, while they meet the requirements of these services, they do not necessarily meet some of the more rigid safety requirements of a shipboard environment. For these munitions, packaging methods will be suggested to correct these deficiencies.

1.2. Throughout the historical development of CW munitions, the trend has been toward higher-agent-to-total-weight ratios with less of the munition weight assigned to the structural case. These new thin-walled weapons will not meet minimum safety requirements with respect to structural integrity. Therefore methods of packaging to correct this condition will be recommended.

1.3. CW munitions which are now under development or have been developed to date fall primarily into two classes, gun-delivered and aircraft-delivered. Therefore this study will be mainly concerned with the DD, CA, and CV type ships; however, many of the recommendations made will be applicable to other types such as the AE. This study has been limited to toxic CW agents, with the greatest emphasis being placed on the newer nerve agents.

1.4. This study is a preliminary survey into the major problem areas arising from the shipboard use of CW munitions. General recommendations are made regarding these problems, however specific solutions for each munition per se must still be determined before these munitions can be safely carried aboard ship.

2.0. Navy CW Munitions as of 1965

2.1. This section will list and describe in some detail all CW weapons that will be available for Fleet use by 1965. The munitions listed will be separated into three broad categories:

Class 1. Munitions now in naval stockpile

Class 2. Munitions which have been developed and tested but not manufactured in quantity

Class 3. Munitions now under development

The agents contained in these three classes of munitions are listed and briefly described in Table 1.

2.2. Class 1. Munitions now in Naval Stockpile

2.2.1. 115# Chemical (gas) Bomb M70A1

Description: A chemical gas bomb constructed of stainless steel tubing with a central burster running the entire length of the body. The agent payload is mustard (H) or distilled mustard (HD). This bomb has a high drag configuration and is therefore limited to use on propeller type aircraft such as the AD5, AD7, and P2V. The bomb is protected during shipping and storage by lug protectors or shipping bands. All explosive components and the arming wire are packaged separately. Fuzing is of the impact type.

Status: Standard USA and USN. Final development and testing completed in 1946. At present there are 58,691 of these bombs, H filled, minus bursters, in the Navy stockpile.

Physical parameters:

Bomb length (assembled)	51.5"
Bomb diameter	8"
Fin span	11"
Bomb weight (empty)	55#
Filler weight (H)	60#
Weight of assembled bomb	128.1#
Agent-to-weight ratio	.4687

Comments: Due to its high drag configuration and low agent weight the M70A1 would be considered obsolete with respect to the "state of the art" in chemical munitions today. In a planned program of equipping the Fleet with CW munitions, it is very doubtful that this bomb would be used. However, it should be pointed out that if an immediate need arose for CW munitions this bomb might be used to fill the time gap until more up-to-date CW bombs become available. The M70A1 is the only CW bomb of which the Navy has a reasonably large quantity in storage.

2.2.2. <u>500# Chemical (gas) Bomb AN-M78</u>

Description: A 500# chemical gas bomb. The bomb's body is of one piece cast steel construction with a central burster running its entire length. The agent payload can be either Phosgene (CG) or Cyanogen Chloride (CK). The configuration is high drag and therefore limited to propeller type aircraft. The bomb is protected in transit by shipping bands with all explosive components and the arming wires being packaged separately. Fuzing can be either impact or aerial burst, depending on the agent used.

Status: The AN-M78 chemical bomb is standard USA and USN. At present the Navy has a stockpile of 1,751 of these bombs filled with Cyanogen Chloride (CK) in stockpile.

Physical parameters:

Body length	59.25"
Body diameter	14.18"
Fin span	18.94"
Bomb weight, empty	265 #
Filler weight (CG)	205 #
Filler weight (CK)	176 #
Weight of assembled bomb (CG)	495 #
Weight of assembled bomb (CK)	466 #
Agent-to-weight ratio (CG)	.4145
Agent-to-weight ratio (CK)	.3775

Comments: As in the case of the M70A1, this bomb, due to its high drag configuration and agent filler, is considered obsolete. The CW agents used in this munition have a much lower toxicity than nerve gases available now.

2.2.3. 1000# Chemical (gas) Bomb AN-M79

Description: A 1000# chemical gas bomb. The bomb has a one piece cast steel construction with a central burster running the entire length of the bomb. Its payload can be either Phosgene (CG), Cyanogen Chloride (CK) or Hydrogen Cyanide (AC). The bomb shape is high drag and therefore limited to use on propeller type aircraft. Shipping bands protect the bomb during transit and storage. All explosive components and arming wires are packaged separately. Fuzing can be either impact or VT.

Status: Standard USA and USN. The Navy has 2,756 of these bombs filled with CK, without bursters, and 5,268 empty bombs, in stockpile.

Physical parameters:

Bomb length	69.5"
Bomb diameter	18.8"
Fin span	25.4"
Bomb weight, empty	485#
Filler weight (CG)	415#
Filler weight (CK)	351#
Filler weight (AC)	195#
Weight of assembled bomb (CG)	937#
Weight of assembled bomb (CK)	873#
Weight of assembled bomb (AC)	717#
Agent-to-weight ratio (CG)	.444
Agent-to-weight ratio (CK)	.401
Agent-to-weight ratio (AC)	.272

Comments: For the same reasons as given for the AN-M78 this bomb is considered obsolete by today's standards. The Army is now in the process of destroying their stores of both the AN-M78 and AN-M79.

2.2.4. Aero 14B Airborne Spray Tank

Description: The Aero 14B is an airborne spray tank for dissemination of both BW and CW liquid agents. The major components of the tank are the nose section, center section, tail section, pressure control system, and tail pipe assembly. The agent to be employed is prepackaged in the center section. A high pressure air supply (1800 psi) is carried in the nose section, where it is reduced to 100 psi and used in discharging the agent. The agent is discharged from the spray tank as a liquid; its rate of discharge can be set according to the mission and the agent used. Upon completion of a mission the tank is disassembled into its major three sections and after decontamination is reassembled about a new center section. The agent filled center section is delivered to the user in its own container which adds both structural rigidity to the center section and also supplies a gas tight* outer shell. While the Aero 14B spray tank can dispense any liquid CW agent it is, due to its dispensing mode (liquid), best suited for dispensing agents such as GB and HD.

Status: The Aero 14B Spray Tank development was started in 1947 and completed in 1955. Over 200 of the spray tanks were built for the Navy, however due to exposure to the elements these tanks are at present in an unusable condition (seals cracked, etc.) and are being returned to the Edo Corporation, the manufacturer, for repair. Also a study contract has been awarded to the Edo Corporation for development of a more efficient disseminating system (new nozzles for the Aero 14B).

Physical Parameters:

Length, entire tank	190"
Maximum tank diameter	22"
Fin span	32.28"
Tank's assembled gross weight (empty)	664#
Center section's gross weight (empty)	346#
Agent capacity (HD)	897#
Agent capacity (GB)	772#
Container's weight (center section)	560#
Maximum shipping weight of filled center section in container	2270#
Dimensions of center section in container	
Length	8 ft to 8 1/4 ft
Height, casters retracted	3 ft
Width	3 ft to 3 3/16 ft

*Container has a gas mask canister so that any gas escaping container is filtered free of agents.

Note: The weights and measures given above are for tanks serial numbers 1 through 118, for serial numbers 119 through 251 the values varied slightly.

Comments: Aero 14B spray tank provides an excellent method of delivering CW agents to a target. It has a very high agent-carrying capability and delivers its agent to the target in a line source which is far more effective than a point source (bomb) delivery. However, due to its method of delivery, the aircraft must fly at very low altitudes (50 to 100 ft) and low speeds over the area to be sprayed to minimize the dissipation of the agent in the surrounding air. Therefore this method of delivery would be limited to those areas which have little if any antiaircraft defense capability.

2.3. Class 2. Munitions Developed and Tested but not Manufactured in Quantity

2.3.1. 500# Chemical (gas) Bomb Mk 94 Mod 0

Description: A 500# chemical gas bomb. The bomb has a steel body with a central burster running its entire length. In its chemical warfare application it carries a GB payload. However, it is also used as a fire bomb at which time it carries NAPALM (NP). The configuration is low drag and therefore can be externally carried on jet aircraft, but is limited to a speed of 475 knots IAS due to arming wires. Fuzing can be either impact or airburst.

Status: Standard USN. This bomb was released for production in 1958. However, aside from prototypes for initial testing none have been produced; consequently no stockpile exists. However, since all engineering, testing, and evaluation on this bomb have been completed it could be put into production almost immediately.

Physical Parameters:

Bomb length	88.79"
Maximum diameter	10.75"
Filler weight (GB)	108#
Weight of assembled bomb	441#
Agent-to-weight ratio	.2445

Comments: Being a low drag bomb the Mk 94 can be carried on present day Fleet aircraft. However its low agent-to-weight ratio leaves much to be desired. This munition is the only low drag bomb that has been qualified by the Navy as of this writing and will probably remain so until it is replaced by the "WETEYE" (sec 2.4.1.).

2.3.2. Warhead, Rocket, 5", Gas, Mk 40 Mod 0

Description: A 5" fin stabilized, surface-to-surface rocket warhead. This chemical warhead is GB filled and was developed to be used in off shore bombardments and is interchangeable with existing 5" naval rockets. The principal difference between this warhead and its HE counterpart is the larger burster required to convert the liquid agent into an aerosol.

Status: Nonstandard USN. No stock.

Physical parameters:

Rocket length	32.2"
Rocket weight (with fuze)	50.5#
Warhead length (with fuze)	20"
Warhead weight	28#
Filler weight (GB)	4.8#
Agent-to-weight ratio (rocket)	.095
Agent-to-weight ratio (warhead)	.160

Comments: The Medium Landing Ship, Rocket (LSMR) which is armed with the 5" bombardment rocket is no longer in the active Fleet.

2.3.3. Projectile, Gun, 5"/38, Gas, Mk 53 Mod 0

Description: A 5" GB filled round with a central burster extending the entire length of the projectile cavity. The projectile is a one piece forging and has a point detonation fuze which initiates a booster, which in turn sets off the burster, exploding the projectile.

Status: Planned standard USN. No stock at present.

Physical parameters:

Complete round weight	55.2#
Round length with fuze	20.75"
Maximum diameter	5"

Physical parameters (Cont.)

Filler weight (GB)	3.5#
Agent-to-weight ratio	.059
Range	18,000 yds,Max.

Comments: This CW projectile has been completely qualified, however no stockpile quantities have been manufactured. Through the use of this weapon, smaller (destroyer) class ships will have a limited CW capability.

2.3.4. Projectile, Gun, 5"/54, Gas, Mk 54 Mod 0

Description: A 5" GB filled round with a central burster running the entire length of the projectile cavity. The projectile is a one piece forging, and is accurately machined for press fit closures, thereby eliminating leakage and being able to withstand the high gun accelerations required.

Status: Planned standard USN. No stock at present.

Physical parameters:

Weight of complete round	61.7#
Length of round	26"
Maximum diameter	5"
Filler weight (GB)	4.75#
Agent-to-weight ratio	.077
Range	21,000 yds,Max.

Comments: As in the case of the 5"/38 projectile, this projectile has been qualified but not produced in stockpile quantities.

2.4. Class 3. Munitions now under Development

2.4.1. 500# gas bomb, WETEYE

Description: The WETEYE is a new 500# gas bomb development. It will be capable of carrying either GB or VX as its agent payload. However the GB version will be the first available. While the final bomb will be designated as the WETEYE, it will be a mating of two designs, the EX-38 bomb, originally designed by the Army Chemical Corps, and the WETEYE bomb designed by

NOTS. The bomb's body will be a one piece aluminum extrusion approximately 1/8" thick and will have a very high agent-to-weight ratio. Its shape will be "low drag" and will be suitable for carriage on the Navy's multiple bomb rack. The bomb's design has not yet been finalized, however it will have a central burster. With a very high agent payload the method of bursting becomes critical in that as much as possible of the agent must be aerosolized before it leaves the confines of the container (bomb). At this writing very little information is available as to the actual physical parameters of the design or of the fuzing. However the GB filled bomb will probably be fitted with an M990 electrical fuze set for impact detonation. This development could be available to the Fleet in the 1963-64 time period.

Physical parameters (approximate)

Diameter	14"
Length	90"
Weight	500#
Agent weight (GB)	340#
Agent-to-weight ratio	.7

Status: Under development

Comments: None

2.4.2. BIGEYE

Description: BIGEYE is the concept for a chemical gas bomb based on the principle of mixing two agents, harmless in themselves, to create VX. At present this process has only been carried out on a laboratory scale (one litre) at the Army Chemical Center. However, a feasibility study has been let to develop methods of carrying out this process on a larger scale. The process is called binary mixing and consists of adding sulphur, endothermically, to another agent which is VX, lacking only in sulphur to make complete VX. Both of these agents are harmless in themselves and will only form VX under forced mixing. One of the problems associated with this process is that of achieving a high percentage of mixing before the sulphurless VX agent is freed from the confines of the bomb. If this concept proves workable it will introduce a completely safe CW weapon in that its agents will be stored separately and only be mixed after the bomb is dropped from the delivery aircraft. It should be pointed out that of all the CW agents now in use only VX, due to its chemical makeup, can be formed by last stage binary mixing. The weaponization of this concept is now being studied by NOTS. Should the feasibility studies now in progress prove successful, a weapons program could then be initiated yielding a weapon in Fleet use around 1967.

Physical parameters: Not yet determined.

Comments: Weaponization of the binary mixing concept would usher in a new era in CW munitions. All the problems associated with shipboard leakage and/or spillage of CW agents would disappear and this bomb would be as safe, if not safer, than conventional HE munitions.

2.4.3. Warhead, BULLPUP missile

Description: The BULLPUP is an air-to-surface guided missile used to attack hard, "point" targets. The missile is radio-controlled and is relatively accurate (30-foot C.E.P.). The Army Chemical Corps is engaged in development and testing of a GB filled warhead for the BULLPUP. The warhead would carry 100# of agent and would be burst on or near the hard target (pillbox fortifications, etc.). The GB would not be aerosolized but would be allowed to splash over the target as a liquid which could then enter the target through ports or cracks in the target itself. This warhead would be interchangeable with the standard BULLPUP warhead and is extremely rugged in design.

Status: The Army Chemical Corps has completed its feasibility studies and fabrication of prototype warheads. A test program is now under negotiation with the Navy. A Navy project has not yet been established.

Physical parameters:

Warhead length	38.42"
Warhead diameter	10 7/8"
Warhead gross weight	250#
Agent weight	100#
Fuzing	Impact

Physical parameters (Cont.)

Minimum thickness of warhead casing	.188" steel
Agent-to-weight ratio (warhead)	.40
Agent-to-weight ratio (missile)	.1755

Comments: None

3.0. Recommended Safety Requirements for CW Munitions

3.1. Due to the highly toxic nature of CW agents, no leakage or spillage of the agent can be permitted in a shipboard environment. Therefore, these munitions must not only withstand the standard Navy munitions test but must be free from leakage for a reasonably long shelf life. Nowhere can justification be found for abandoning or lessening the Navy requirements for munition ruggedness and safety at sea. It is, therefore, deemed fundamental that CW munitions should in themselves meet the safety requirements under all of the probable and possible severe environments; or failing this, that they should be provided with gas-tight overpacking which will furnish adequate protection.

3.2. The munitions should be subjected to the following tests in the unpackaged condition except as noted:

a. Shock and acceleration - The criterion is that the weapon be safe and operable after undergoing shock and acceleration which simulate the environment of gunfiring, catapult launching, or arrested landing shocks.

b. Transportation vibration (Mil-Std 303) - The criterion is that no hazardous condition be created and that the munition be safe and operable after undergoing this test.

c. Temperature and humidity (Mil-Std 304) - To undergo this test for sustained periods of time such as during long-term storage.

d. Salt spray (Mil-Std 306) - This represents the corrosive effects of shipboard environment.

e. Forty foot drop (Mil-Std 302) - The criterion for this test is that the munition does not function, rupture, or leak and is safe for disposal after the drop.

While many of the older CW munitions such as the M70A1 bomb, AN-M78 bomb, etc., might meet this requirement, the new designs incorporating a high agent-to-weight ratio, such as the "WETEYE", will certainly not. To design these munitions to meet this requirement would defeat the whole concept of high agent-to-weight munitions. Therefore it is recommended that these munitions be packaged in a vapor barrier and structural container and subjected to the aforementioned drop test in the container. Deformation of the packaging, including loss of vapor barrier features, would be anticipated but the munition itself should be undamaged.

f. Ten foot drop - Munitions requiring structural overpacking to survive the 40 foot drop test should be able to survive a 10 foot drop test without overpacking and be safe for disposal.

3.3. The more rugged CW projectiles and bomb types may be capable of fulfilling the structural safety requirements of 3.2 now. It is doubtful, however, that sufficient tests and field data are available over the broad spectra of environment, duration and corrosiveness to establish safety with reasonable assurance. Therefore it is recommended that even the rugged CW munitions, when introduced into the Fleet, be provided with vapor barrier overpacking until sufficient stockpile-to-target experience has indicated it may not be required for stowage safety.

3.4. The less rugged CW weapons such as WETEYE and the Aero 14B spray tank will require extensive shock mitigation and vapor barrier packaging to satisfy the basic safety requirements. It should be anticipated that the nature of the WETEYE and Aero 14B (high agent-to-total-weight ratio) will require such overpacking for the life of the respective weapon systems. It may well be that this complication of the handling and stowage operations and the resulting logistics cost may reduce the system effectiveness of these weapons.

4.0 <u>Packaging Recommendations</u>

4.1. <u>General</u>

4.1.1. The packaging requirements of CW munitions are threefold:

a. Packaging should increase the ability of the munitions to meet the 40 foot drop test. Design of the packaging from a strength point will then be a function of the individual munitions involved.

b. Packaging must be so designed as to contain any gaseous or liquid agents that may escape the munitions during storage and/or routine handling.

c. Packaging should incorporate a simple monitoring system for the detection of free CW agents within the package. This detection device must be accessible when the munitions are stacked in the magazine, for ease of periodic inspection, and should remain operable over the shelf life of the munition in question.

4.1.2. While the physical parameters and structural strength of the packaging will be a function of the munition per se, the concepts and methods of packaging developed hereafter will be applicable to all CW munitions studied in this report.

4.2. Container Design

4.2.1. Probably the most rigorous, from a structural standpoint, of the tests outlined in Section 3 is the 40 foot drop test. In discussing the structural packaging requirements of each munition, it is best to separate the munitions into two classes, thick-cased and thin-cased. The munitions falling into the "thick" case class are the M70A1, AN-M78, AN-M79, and the Mk 94 bombs, the M53 and M54 projectiles, and the BULLPUP CW warhead. All of the aforelisted munitions are of steel case construction and extremely rugged in design. The Mk 94 bomb has successfully undergone a 30 foot drop test and it is likely, due to the similarity in their design, that the other bombs* could also achieve this. The projectiles are designed to withstand high gun accelerations and are therefore very rugged in design. No structural test data are available for the BULLPUP warhead, however the minimum thickness of the warhead case is .188" steel and therefore it probably is quite rugged. It is recommended that these munitions be drop tested to determine the maximum height drop they will withstand and still be safe for disposal. Should this height fall short of 40 ft, a structural container should be fabricated to correct this, but should the munitions in question be able to survive this test only a

*Drop test data not available on M70A1, AN-M78 and AN-M79 bombs.

light, agent containing, package would be provided. In either case the structure could be of light aluminum with shock mountings as required (Figures 1 and 2).

4.2.2. The "thin" case munitions include the WETEYE bomb and the Aero 14B spray tank. Due to their high agent-to-overall-weight ratio, these munitions have extremely light cases and could not sustain the required drop test. The WETEYE 500# gas bomb has a 1/8" (approximately) aluminum extruded skin. The bomb is being designed to survive a 10 foot drop test and still be safe for disposal. The packaging for WETEYE will have to be designed to shield the bomb from high impact loads. The case could be of aluminum or magnesium with the bomb encased in a honeycomb structure which could be reinforced with foamed plastic (see Figure 3). The Aero 14B center section is delivered to the user in the Edo Model 223 center section shipping container. The center section in its container has successfully undergone 3 foot drop tests. These tests were for operability after drop and therefore the munitions could survive a higher drop test height using safety of disposal as a criteria. Also, the present Model 223 container (Figure 4) could be "beefed up" for more structural rigidity. Therefore it is recommended that the center section be tested for a 10 foot drop and the center section in its container be subjected to a 40 foot drop test. If it is found through design analysis that it is not feasible to redesign the container to withstand a 40 foot drop, then the spray tank should be deleted from shipboard use.

4.2.3. All CW munitions packaging should be so designed as to contain within the package all gaseous and/or liquid CW agents that could become free of the munitions itself, either through leakage or rupturing of the munitions. For most CW munitions packages this could be achieved by a gas tight seal between the mating parts of the container. However the Aero 14B center section container is fitted with a gas mask canister. This canister is designed to remove any agent, due to leaks in the center section, from the air that is passed through the canister and its surroundings. This device was designed to protect against small leaks in the center section. However, if the center section ruptures within the container, freeing approximately 84 gallons of agent, the gas mask canister would soon become saturated. Also if the container, after drop, came to rest bottom-side-up with a ruptured center section, the agent in the form of a liquid would contact the canister and in this case the canister would provide no protection at all. Therefore it is recommended that the filtering system of the Aero 14B center section container be redesigned to be capable of protecting against a ruptured tank or be eliminated entirely.

4.3. <u>Monitoring System</u>

4.3.1. Periodic inspections should be carried out on the CW munitions in their containers to check on possible leakage; also an inspection should be made just prior to removing the munitions from their containers for use. One method of doing this would be to "sniff" each container and test for contamination using the M15-A1 or M18 gas detector kits. However a much simpler method would be to have a go no-go device built into the container that could be visually inspected. The Army Chemical Center has under development an optical indicating plug for agent detection. This plug (Figure 5) is made of lucite and its tip is coated with a chemical that changes color when in contact with the CW agent to be detected. One or more plugs are then installed in the container. The plug also acts as a magnifying glass so that by looking through the hexagonal (viewing) end of the plug which is outside the container, the color at the other end of the plug is easily visible. The color will remain unchanged until in contact with the CW agent it is designed to detect. Water will remove the chemical coloring agent from the end of the plug. Therefore no water vapor or moisture, which might condense on temperature change, can be permitted within the container. Use of an inert gas or dry air within the container would suffice. As an added precaution, packets of silica-gel could also be included. Due to the motionless condition of the inert gas or air within the container, it will take time for any leaking agent to spread through the entire case. Therefore, for more rapid response, it is desirable to have three or four of these plugs located at different positions in the case. VX is likely to leak from the munition in liquid form and due to its very low volatility (2 mg/meter^3), the resulting amount of vapor in the case will be too small to detect. The liquid VX will naturally flow to the lowest part of the container so the detection plugs should be placed at low points to contact the liquid VX. If necessary, a small trough or the like could be built into these cases, expediting the accumulation of the liquids in a detectable quantity.

5.0. Handling & Stowage Precautions

5.1. General

5.1.1. It is believed that chemical munitions can be adapted to shipboard use without compromising safety provided basic safety principles of weapon and container design and evaluation are followed (see section 3 and 4). The importance of training cannot be overemphasized; poorly trained personnel will panic with a resulting high casualty rate if an accident occurs. All personnel should learn to respect rather than fear chemical agent. Should an accident occur, properly trained personnel can protect themselves and decontaminate the areas affected. All personnel should be thoroughly trained and indoctrinated in emergency procedures and in the use of the mask and other protective clothing. Frequent masking and decontamination drills should be held so all personnel can react rapidly and efficiently in an emergency. This section deals with precautions to be observed during handling and stowage and section 6 covers emergency accident procedures.

5.1.2. Most of the problems associated with shipboard use of CW weapons will come during loading and handling operations when accidents are more apt to occur. During stowage, the problem is essentially to monitor the magazine area and to make certain that leakage does not contaminate the rest of the ship. Leakage during stowage will probably be of a minor nature and the task of clean-up and decontamination will be relatively easy. On the other hand, handling accidents may produce complete rupture of the munitions, making clean-up and decontamination quite difficult.

5.1.3. The potential accident hazard aboard carriers is much greater than aboard cruisers and destroyers. Projectiles are inherently more rugged and carry smaller agent payloads than bombs. The handling sequence aboard carriers is much more extensive, thereby increasing the accident probability. Therefore, the majority of this phase of the study was slanted toward carrier operations but the basic conclusions regarding decontamination and safety procedures apply to all ship types.

5.2. Handling

5.2.1. All ammunition should be inherently rugged or be so packaged to satisfy standard naval ordnance safety criteria (see section 3). In instances where packaging is required to provide ruggedness, the munition should not be removed from the package until the last practical stage prior to gun firing or aircraft loading. No deviations from standard handling procedures are recommended for CW munitions, but the extreme toxicity of CW agents dictates that additional safety precautions be observed when CW munitions are being handled. These precautions include protective clothing, monitoring, and availability of decontamination personnel and equipment.

5.2.2. During all handling and loading operations, all crew members should have masks and other protective clothing plus atropine syrettes available for immediate use. Personnel who must come in direct contact with CW munitions should wear impregnated uniforms and treated gloves. Since pilots would have difficulty donning masks with the other flight gear required, the aircraft oxygen system could be utilized as a source of uncontaminated oxygen during emergencies. The area should be continuously monitored and trained decontamination teams should be ready to immediately don fully-impermeable clothing and decontaminate the affected area. Because of the extended handling sequence aboard CV-type vessels, decontamination teams may be required at several levels. A single decontamination team would probably suffice aboard DD and CA types. Sufficient decontaminate should be immediately available to the decontamination team to insure proper clean-up of a single munition CW payload. A sealable container should be available into which damaged and leaking weapons can be placed for disposal. Emergency procedures to be followed if an accident occurs are given in section 6.

5.2.3. Provision should be made for CW munitions to be taken on board expeditiously during the shortest possible portion of the total loading operation, thus minimizing the time during which special precautionary measures must be implemented.

5.3. Stowing

5.3.1. The objectives of the stowing and handling container (section 4) are to protect the weapon from hazardous damage during handling and to contain any agent that may leak from the weapon during stowage. All ammunition, including rugged bombs and projectiles, should be packaged for safety during stowage since Chemical Corps experience has shown that chemical munitions, due to the corrosive effect of chemical agents on metals, are prone to develop leaks during long-term stowage (reference (a)). However, the container will be required to furnish handling protection only for those weapons not possessing inherent ruggedness.

5.3.2. Standard procedure should be to retain the weapon in the container until the very last practical stage of the handling cycle, especially when the container is also required to provide ruggedness. Fuzes and bursters should be stowed separately from the munition and not installed until immediately prior to use.

It is understood that under certain conditions, one-half of the air group must be strike-armed within 30 minutes. The container could be equipped with quick-release fittings so that removal from the container during the loading cycle should not compromise the loading time.

5.3.3. CW munitions should be stowed in specially equipped magazines. It is desirable but not mandatory that CW munitions be separated entirely from other munition types whenever possible. Separate stowage aboard DD and CA types may not be feasible, since magazines and guns on these ships form intimate operational units; but aboard CV types separate stowage probably could be implemented.

5.3.4. Magazines in which CW munitions are stowed should be equipped with detectors to monitor munition leakage. For vapor detection, the Army LOPAIR E33 (infrared) Detector, described more fully in section 7, appears most promising for this purpose for sensitivity, selectivity, and adaptability to shipboard conditions. Remote alarms, both visual and aural, should be incorporated into the detection system. The container proposed in section 4 will feature a visual indicator to monitor for individual leakers. Therefore, the magazine stowage arrangement should allow access to each weapon to permit specific determination of leakers.

5.3.5. Since ventilation systems generally exhaust topside, CW filters should be installed in CW-magazine exhausts. Such filters would constitute a first line of defense for the ship's complement against CW leakers in the magazines. Fixed-installation CW filters have been developed with flow capacities up to 5,000 CFM and Chemical Corps filter personnel foresee no difficulty in fitting large capacity filters to the dimensions associated with combatant ship-ventilation systems. A negative pressure differential should be established with CW magazines relative to surrounding areaways, a procedure which would insure leakage into the magazine from its surroundings and preclude leakage of toxic agents into the body of the ship. The pressure differential need be equivalent to only an inch or two of water, and backfitting existing ships with higher power exhaust blowers probably would not be necessary. Bureau of Ships' representatives have disclosed that procedures have been established for maintaining small pressure differentials aboard ship to control air circulation and that application of the principle to CW stowage areas poses no unmanageable difficulties. Release valves may be required, however, to facilitate easy opening of magazine doors against even these small pressure differentials.

5.3.6. Magazines containing CW munitions should be closed off tightly from the remainder of the ship and should be maintained always in condition x-ray; that is, entered only when necessary with permission of the damage control officer. Periodic inspections within the magazine should be conducted to monitor the leak indicators on individual weapon containers. CW munitions in stowage must be accessible for individual inspection and disposal in case of leakage. The difficulty of providing for such accessibility is recognized, but the possible consequences of permitting a leaker to remain within the confines of the ship leaves no alternative.

5.3.7. To lessen the potential problem of leaking during stowage, all gun projectiles should be stowed in magazines with no normal stowage in ready-service racks. CW projectiles, when used, would be cycled directly from the magazines to firing with minimum intermediate stowage at the upper handling level. Projectiles would be removed from the container and fuzes and bursters installed in the upper handling room. It is expected that delivery of CW gunfire support will be on a planned (not emergency) basis and the fire plan will often call for a "time on target" (TOT) delivery. The necessary CW projectiles can, therefore, be shifted topside and fully assembled immediately in advance of the fire mission.

5.3.8. Magazines will have to be arranged to accommodate the increased bulk of the stowage and handling container. The capacity of the magazine will be reduced and any special brackets, battens, etc., will require redesign or modification to fit the external container contour. Future service experience may prove that leakers in stowage do not pose an unacceptable crew hazard. Elimination of the stowage container for the rugged type munitions may then be warranted, permitting conventional magazine arrangements for these weapons. The stowage and handling container, and consequently the special magazine arrangements, for the less-rugged weapons (e.g., WETEYE and the Aero-14B Spray Tank) will probably be required for the life of the weapon system.

6.0. Emergency Procedures

6.1. Potential hazards from accidents or other emergencies will be minimized if proper precautions are observed and personnel are indoctrinated in emergency procedures. All personnel should be thoroughly oriented regarding hazards of and protection from chemical agents. There are several Chemical Corps training films available but the majority of these are oriented along Army lines. Training films dealing with specific shipboard situations should be prepared. Frequent masking and decontamination drills should be held and all personnel should know explicitly what to do and where to go in an emergency. This section deals with emergency procedures to be followed in the event of CW leakage. Detailed decontamination procedures are given in Appendix A.

6.2. Decontamination supplies and equipment should be stored in a ready-to-use condition near various critical areas. Premixed decontaminating solution (5 to 15% lye in water) of sufficient quantity to insure clean-up of a single munition CW payload should be available since the large amount of heat liberated during mixing precludes rapid mixing. Approximately 2 gallons of decontaminate (10% solution) is required per pound of GB. Therefore, at least 1500 gallons of solution will be required to decontaminate a ruptured Aero-14B spray tank. The solution is extremely caustic and must be kept in glass or similar containers with rubber stoppers. In addition, mops, brooms and other disposable clean-up equipment should be available. Impermeable clothing should be hanging in a ready-to-use condition for the decontamination team. The area where this clothing is kept should be well ventilated with an exhaust hood and be equipped for decontamination of the clothing following use. Gas masks should be issued to all personnel with each crew member responsible for availability of his own mask when required. However, individual crew members may be caught with masks not available or defective. It is therefore recommended that spare masks for general use be provided in various locations.

6.3. A sealable disposable container should be available into which leaking CW munitions can be placed for disposal. Since accidents may occur in locales where immediate disposal is not practical or safe, the container should be sufficiently sealed to enable safe retention until disposal is permitted. For disposal at sea, the specific gravity of the weapon in the container should be greater than one.

6.4. In addition to decontamination and clean-up supplies, emergency equipment should include equipment for moving and lifting munitions and for monitoring contaminated areas during clean-up operations. Emergency handling devices should be capable of lifting 1,000-pound bombs, Aero-14 spray tanks, or projectiles, as appropriate. Inasmuch as access to damaged munitions may be difficult, portable block and tackle rigs with an option of power or hand operation appear desirable for lifting. The portable E41 CW detector seems ideal for monitoring clean-up operations by decontamination crews.

6.5. Wood, gaskets, and other porous material cannot be completely decontaminated and will continue to exude toxic vapor, especially when subjected to heat. Therefore, any items of this type which become contaminated will require disposal and spare parts should be stocked. Sealable containers having a specific gravity greater than one should be available for disposal of miscellaneous items of contaminated material.

6.6. When alarms indicate the presence of CW agents in a particular magazine, the following procedures are recommended, as practicable:

a. All ship's personnel should mask, and personnel not essential to the operation of the ship should proceed topside. Personnel who must remain below, e.g., the engine crew, should mask and reduce their activities to a minimum. Recognizing that wearing masks in the engine room of older-construction ships will be uncomfortable, it is believed that essential shipboard activities could be maintained for relatively long periods under such circumstances, in shifts if necessary. Some newer ships have been provided with air-conditioned main-propulsion-control cubicles; the possibility of filtering chemically the air intake of these cubicles should be explored.

b. Exhaust blowers should continue to operate to aid in clearing the contaminated magazine of toxic vapor; otherwise the concentration in the magazine may make it impossible for a decontamination and clean-up team to enter the magazine. The exhaust ventilators serving the contaminated magazine should be designated as danger areas and the crew should remain upwind. Where possible, the ships heading should be altered to utilize prevailing winds to blow toxic exhaust away from the ship's company.

c. Disaster teams in impermeable protective outfits should enter the contaminated magazine to identify and dispose of the leaker. The magazine doors should be opened for the briefest possible time necessary to facilitate this operation. Munitions must be monitored individually to establish which among them is leaking; the monitoring scheme suggested in section 4 appears most promising. When the leaker is identified it should be disposed of as suggested in item d below. This tedious and dangerous operation is essential: the presence of leaking CW munitions cannot be tolerated in confined environments such as ships at sea. Details of the recommended decontamination procedure are given in Appendix (A).

d. Leaking munitions should be secured in gas-tight containers and jettisoned as soon as possible. It is noted that existing doctrine forbids jettisoning CW munitions within the limits of the continental shelf. The mechanics of disposing of CW leakers should be left to the discretion of the damage control officer.

e. Following the disposal of leaking munitions, the disaster team clothing should be decontaminated, and the ship monitored thoroughly for residual contamination and decontaminated as appropriate. Special attention should be directed to the magazine and implements used in the disposal operation. Biological detectors as recommended in section 7 would be especially useful as indicators of those areas which had not been contaminated.

6.7. If a CW munition suffers any visible damage during handling and loading operations, or if any suspicion arises that a munition is unsafe, the decontamination procedure proposed in Appendix (A) should be followed. These procedures apply during all handling operations such as on-and-off loading of ships, strike arming of aircraft, gun firing operations, or transfer of munition from one location to another. Highlights of this procedure are given below.

a. Ship's personnel should mask and loading and handling operations should cease at once. Disaster teams should don their impermeable protective outfits. Personnel not essential to ship operation or disposal and clean-up operations should secure their immediate area and retire upwind of the damaged or suspicious munition, as practicable.

b. The damaged munition should be recovered and placed in a container having provision for gas-tight sealing. This container provides a means of retaining damaged munitions safely until such time as they can be jettisoned.

c. The ship should be monitored for contamination and decontaminated according to established procedures. Biological detectors would be useful as toxic agent indicators during handling and loading operations.

6.8. In the event of fire, explosion, or similar accident involving quantities of GB, the danger area may extend for several miles. Until decontamination is complete, all other ships within this area should exercise proper precautions. Isolated anchorages should be employed whenever practicable for loading CW munitions aboard ship. Unexpended CW munitions should be jettisoned before recovery of strike aircraft. It is necessary that the aircraft armament system and fuze combination be capable of jettisoning CW munitions in the unarmed condition. If recovery of aircraft carrying CW munitions should prove necessary in particular situations, all precautionary measures should be adopted.

7.0. Detection Equipment

7.1. Magazines in which CW munitions are to be stowed must be monitored continuously for toxic munition leakage. Army developments in automatic CW detection and warning techniques could be adapted to this need without substantial change; in fact, certain natural advantages accrue to shipboard installations. The LOPAIR (E33) detector appears most promising among Army detectors for use in general-purpose magazine areas, for these detectors apparently can be arranged to discriminate against harmless vapors while detecting various toxic gases. Moreover, the system could provide handily for remote alarms, a highly desirable feature aboard ships at sea.

7.2. LOPAIR (long path infrared) consists essentially of an IR transmitter-receiver and a reflecting device. Its operation involves transmitting an IR beam through the suspect atmosphere, reflecting this beam back to the receiver, and examining the IR absorption spectrum for evidence of toxic agents. Its sensitivity is reported to be 0.01 to 0.1 microgram of G agent per liter of air over a total path length of 400 yards where the agent concentration is assumed to prevail throughout the total path. For shorter transmission paths, higher concentrations are required to exceed the detection threshold. While LOPAIR was developed originally to detect G agents, it also can be adjusted to detect mustard and other toxic vapors but not VX leakers. The system provides both visual and aural alarms.

7.3. Magazine dimensions aboard combatant ships range up to about 40 feet and it is clear that the maximum detection potentialities of LOPAIR cannot be realized with IR beam lengths of this order. Army representatives have suggested that multiple reflection arrays could be devised in magazine areas to increase the effective beam length. Limited magazine dimensions therefore do not constitute a major obstacle to the use of LOPAIR.

7.4. LOPAIR is under active development by the Army but has not yet been standardized. The system exhibits major shortcomings for Army field use; in particular, its total weight of about 135 pounds and its long path and exacting alignment requirements lead to transportation and installation difficulties. Moreover, atmospheric shimmer limits the reliability of LOPAIR in the field. Such problems are far less serious when considered in terms of permanently enclosed detection systems mounted in ship's magazines. Based on this consideration, Army detection specialists have stated that IR monitoring of CW magazine areas is well within the state of the detection art. This opinion is supported by the fact that IR detection systems have been mounted and operated successfully in CW production and handling facilities.

7.5. Despite the natural advantages of a permanent and enclosed installation, some modification of existing IR detectors clearly will be required for shipboard use. Problem areas have been foreseen as follows:

a. Multiple IR beam reflection dictates very precise alignment of the reflecting surfaces. The degree to which ship's vibration will disturb such alignment cannot be estimated and special linkages may prove necessary between various detector elements to reduce this source of trouble.

b. Magazine areas generally contain numerous physical obstacles to IR beam transmission. Custom design of detection arrays to avoid such obstacles probably will be required. In this connection, IR transmitters and receivers could be separated in shipboard installations to provide for more flexibility in establishing beam transmission paths.

c. Care must be taken that IR sources in any magazine installation do not constitute a magazine safety hazard. This consideration may prove to be unimportant, since it is recommended that fuzes and bursters be stowed separately from CW munitions. In view of these and other installation problems which doubtless will arise, Army experience should be exploited initially in devising Fleet CW detection.

7.6. It is to be noted that the Army is developing automatic detectors other than the E33 described above. SHOPAIR (short path infrared), a transistorized and self-contained version of LOPAIR, is under development to meet Army requirements for a portable field instrument. The sensitivity of this instrument is reported to be about an order of magnitude less than that of the E33. The E21 detector employs chemical and photometric techniques to detect the presence of G agents in air samples. Some 200 of these detectors which weigh about 100 pounds each have been procured by the Bureau of Yards and Docks for installation at shore establishments. The portable E41 CW detector under development by the Army appears to be ideal for monitoring cleanup of GB by decontamination teams. This miniaturized and improved version of the E21 may weigh as little as 25 pounds complete with batteries and is capable of detecting nerve agents by means of a chemical/photometric analysis sequence.

7.7. LOPAIR, or any other vapor-detection system is not satisfactory for magazine monitoring of V agents. The spectrum of VX is within the GB spectrum but due to the low vapor pressure and volatility any spilled VX will remain in the liquid state without producing a detectable vapor concentration. Therefore, agent leakage will not produce a vapor hazard but spilled VX will impose a percutaneous contact hazard and any suspicious liquid accumulation must be regarded with caution. The Chemical Corps has developed various reactive agents in the form of paints, powders, and papers which can be used to detect the presence of liquid VX. Personnel entering magazines or handling VX munitions should be alert for and monitor all liquid deposits to prevent contact with the toxic agent.

7.8. Biological detectors, e.g. pigeons or rabbits, could be maintained at strategic locations aboard ship to serve as sensitive indicators of CW agents. It is noted that they are extremely cheap, both in initial cost and maintenance, and have the property of expiring with 100% reliability in the presence of sub-lethal concentrations (to humans) of CW agents. Their continued good health doubtless would be reassuring to the ship's company. While an autopsy generally is required to establish specifically the cause of death, the possibility of false CW alarms could be reduced drastically through the use of animals in small groups. The Chemical Corps makes extensive use of pigeons in their storage areas and the personnel in these areas enthusiastically endorse the reliability of pigeons as CW detectors.

7.9. It is recommended that the Navy actively support Chemical Corps efforts toward development of detection devices having shipboard application. Of specific interest is the selection of the optimum chemical reagents for use with the visual indicators proposed in section 4 for monitoring of stowage containers. The Chemical Corps has indicated that such devices are within the state-of-the-art but that additional research is required for determination of reliable detector materials.

8.0. Medical Safety Measures

8.1. Medical facilities for treating CW casualties should be expanded generally aboard ships carrying CW munitions. When CW weapons are to be carried aboard ship, the Bureau of Medicine should be alerted in advance in order that the necessary increase in shipboard medical facilities can be implemented. Discussions with the Special Weapons Defense Division of the Bureau of Medicine have indicated that adequate shipboard medical facilities are presently available if currently standardized equipment is utilized. Anti-CW medical supplies required aboard ship will include the following types of equipment:

Gas Masks (individual and collective), gas hoods, respirators, etc.
Resuscitators, intubation sets*, etc.
Medical oxygen cylinders
Blood analysis kits
Atropine and other antidotes

*A tube for insertion into the larnyx for introduction of air

8.2. All crew members should be familiar with the symptoms of CW intoxication and be prepared to treat both themselves and their fellow shipmates. Non-medical crew members may in case of emergency be required to administer atropine injections and to provide artificial respiration or other therapy. Respirators should be available close to critical areas so emergency treatment can be rendered without delay. Mask-to-mask resuscitation according to the new Army technique should be evaluated for shipboard application.

8.3. Since anticholinesterase agents are cumulative, periodic blood tests for traces of these agents should be performed on representative crew members. Such a test can readily be performed by corpsmen. A test of this type will serve to protect the crew against slow toxic accumulation. However, such a test is not accurate enough to serve as an indirect detector of CW leakage aboard ship.

8.4. Chemical Corps films are available showing various aspects of field medical treatment. However, these films do not portray shipboard conditions and it is recommended that some training films be prepared dealing specifically with shipboard emergencies.

9.0. Summary

9.1. CW munitions can enhance the combat effectiveness of the Navy without posing an unreasonable safety hazard to the ships of the Fleet. CW agents are highly toxic but proper precautions and emergency procedures will minimize the potential disaster resulting from shipboard handling and stowage accidents. Thorough training of personnel is mandatory and all crew members must be completely indoctrinated in the use of the mask and other protective equipment, and in the procedures to be followed in an emergency situation.

9.2. The more rugged CW projectile and bomb-type munitions may be capable of fulfilling the safety and ruggedness requirements of standard Navy ordnance items; however, sufficient data are not now available to establish safety with high assurance. Therefore, a vapor barrier overpacking for all munitions is recommended to reduce the risk to the ships's crew. Experience may later prove that this overpacking can be deleted, but until then, the magazine arrangements will have to provide for the increased bulk of munitions in sealed containers.

9.3. The less-rugged weapons such as WETEYE and the Aero-14B spray tank will require extensive shock mitigation, in addition to the vapor barrier overpacking in order to meet minimum safety requirements. It is probable that the overpacking for these munitions will be required for the life of the weapon system.

9.4. Reliable detection equipment will be required to prevent casualties from agent leakage and spillage. The Chemical Corps has extensive background in the detection field and active Navy support of Chemical Corps research and development toward specific Navy applications is recommended. It is felt that biological detectors such as pigeons comprise excellent and reliable detection facilities.

9.5. Medical facilities must be augmented aboard vessels carrying and handling CW munitions. The Bureau of Medicine is aware of the problems involved and equipment required and is prepared to implement the program if given sufficient lead time.

9.6. Information required for this study was obtained through frequent liaison with the Army Chemical Corps and by perusal of Chemical Corps documents. Effort and time was expended in obtaining applicable documentary references, which are compiled in Appendix B for the benefit of any future investigations.

TABLE I

CW TOXIC AGENTS IN NAVY MUNITIONS AS OF 1965[1]

Agent Symbol	Designation	Brief Description	Median Lethal Dosage[2]
H	Mustard	World War I blister gas. Lethal in sufficient dosage but now considered primarily incapacitating in comparison to more lethal nerve agents (percent fatalities among casualties = 3%.	1,500 mg-min/m^3 (inhalation) 10,000 mg-min/m^3 (skin absorption)
HD	Distilled Mustard	H purified by washing and vacuum distillation. Less odor, more stable than H.	Same as H
CG	Phosgene	Chocking gas. Obsolescent, some munitions now in stockpile but most new munitions will contain the more lethal nerve agents	3,200 mg-min/m^3 (inhalation)
CK	Cyanogen Chloride	Blood gas. Same comments as CG.	11,000 mg-min/m^3 (inhalation)
AC	Hydrogen Cyanide	Blood gas. Same comments as CG. Lethal dosage varies with concentration due to high detoxication rate.	2,000-4,500 mg-min/m^3 (inhalation)
GB	Sarin	Nerve gas. Primarily an inhalation hazard (vapor or aerosol) but also a percutaneous hazard (aerosol and liquid). Percent fatalities among casualties = 25%	70 mg-min/m^3 [3] 15,000 mg-min/m^3 [4] 2,400 mg [5]
VX		Nerve gas. Due to low volatility, practically no vapor hazard. However, aerosol poses an inhalation and percutaneous hazard and liquid is a percutaneous hazard. Percent fatalities among casualties = 25%.	35 mg-min/m^3 [3] 200 mg-min/m^3 [4] 3.0 mg [5]

[1] Data for this table obtained from references (b) and (c).
[2] Dosage to kill 50% of exposed personnel, e.g., exposure to concentration of 150 mg/m^3 for 10 minutes = 1500 mg-min/m^3
[3] Inhalation, vapor or aerosol
[4] Skin absorption, vapor or aerosol
[5] Skin absorption, liquid

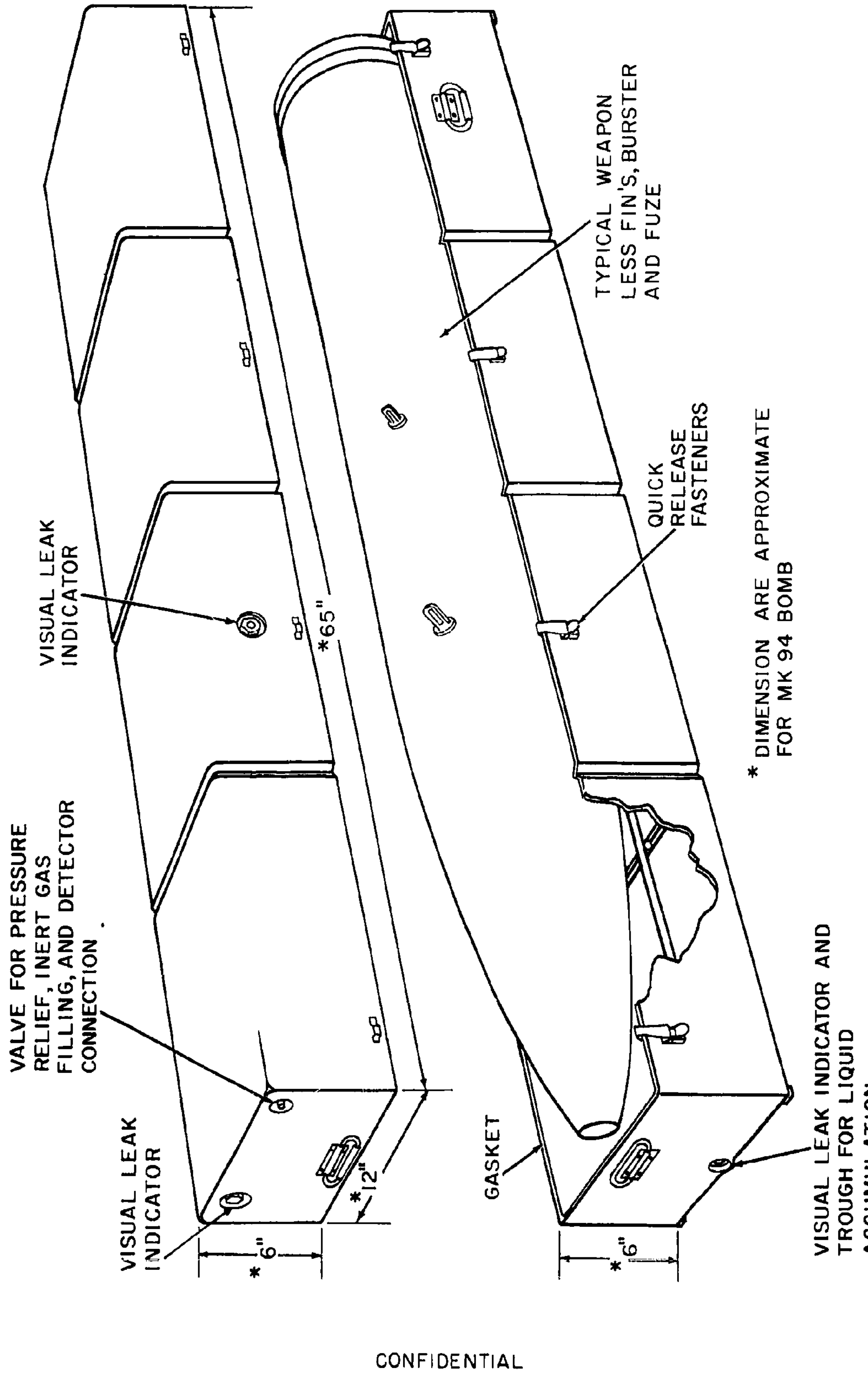

FIG.1 CW WEAPON STOWAGE CONTAINER FOR RUGGED BOMBS

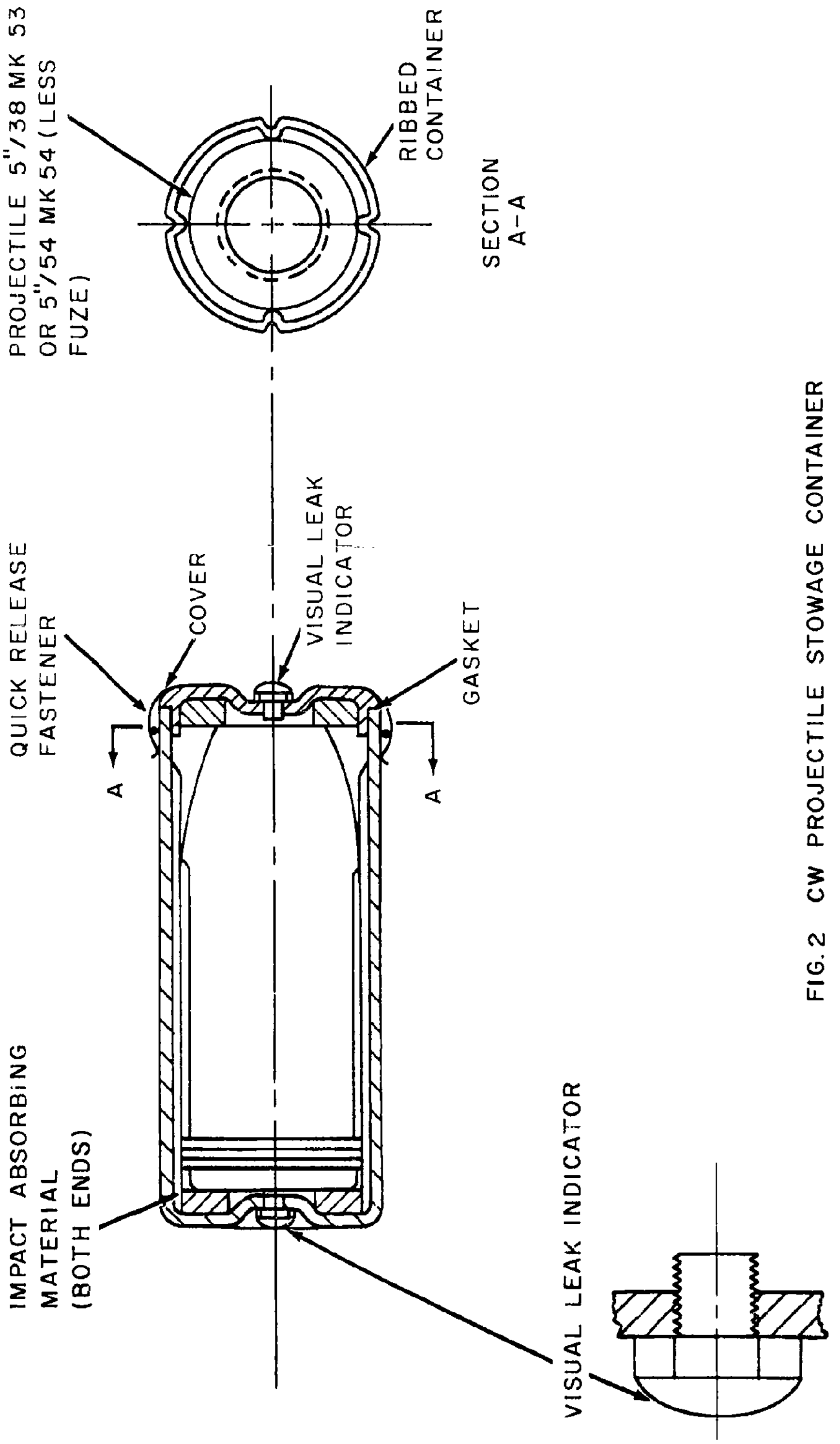

FIG. 2 CW PROJECTILE STOWAGE CONTAINER

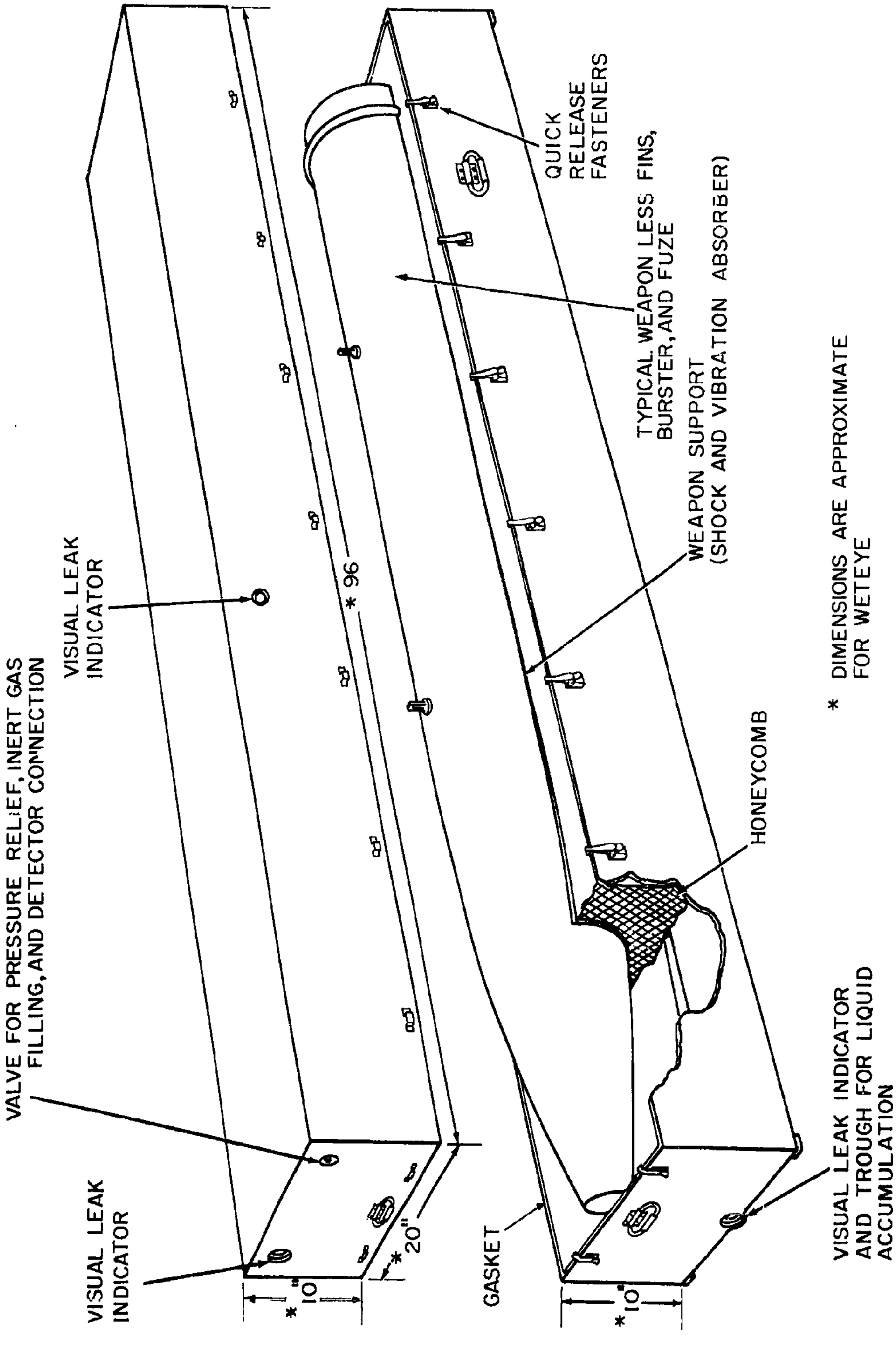

FIG. 3 CW WEAPON STOWAGE AND HANDLING CONTAINER FOR NON-RUGGED BOMBS

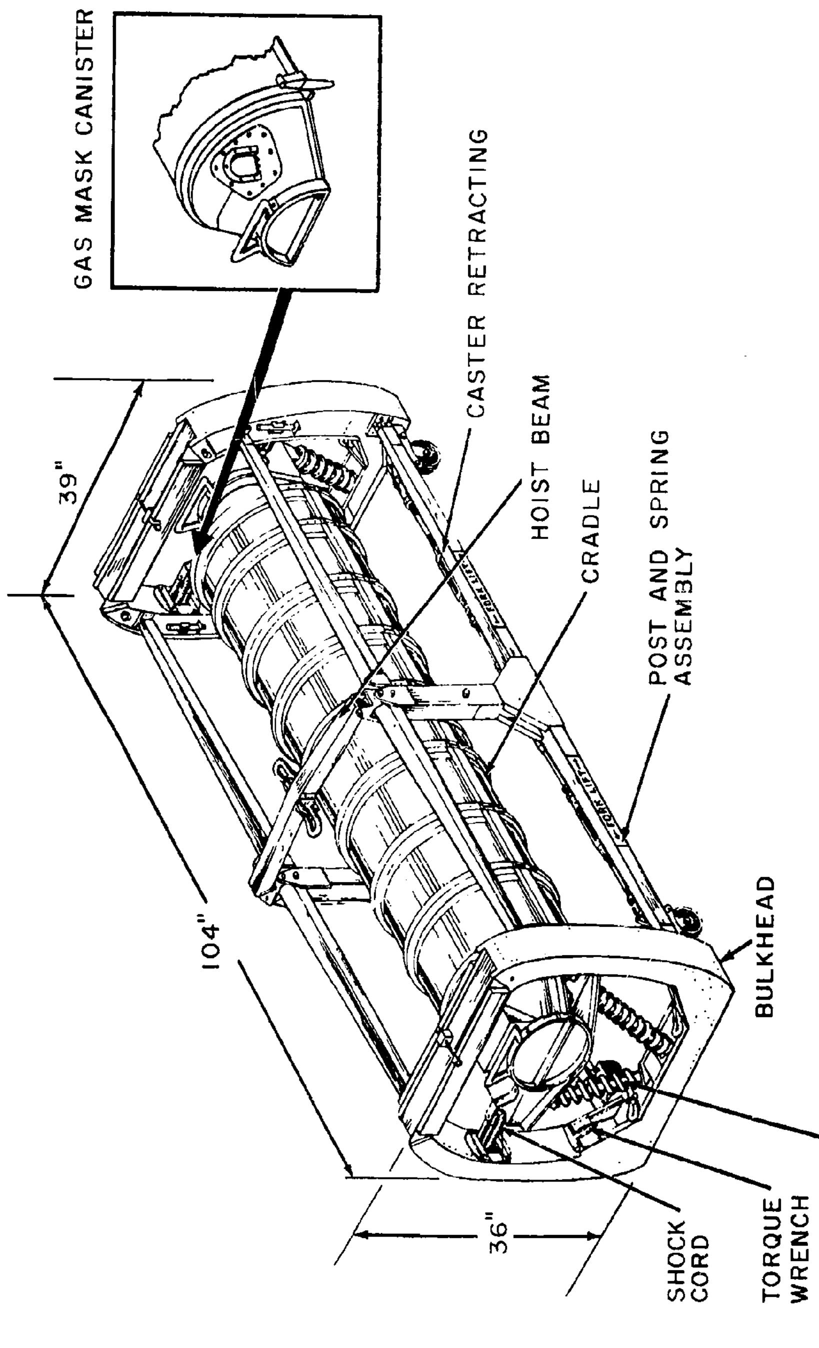

FIG. 4 AERO 14B SPRAY TANK CONTAINER

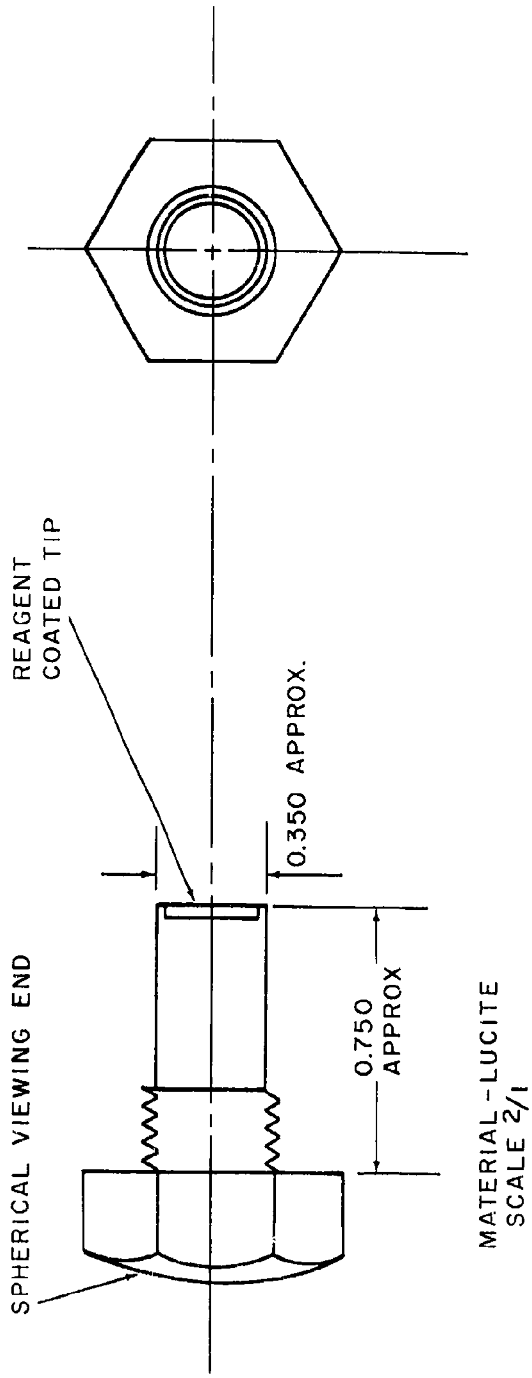

FIG.5 CONTAINER VISUAL LEAK INDICATOR

Appendix A

Decontamination Procedures

A-1. Decontamination procedures for Chemical Munitions are promulgated in the Army Chemical Corps Safety Manual and in the Chemical Corps 385 Series of Safety Directives. Excerpts from these documents are presented with primary emphasis on the decontamination of GB. Basic procedures for all agents are the same but specific details, such as the decontaminate used, vary from agent to agent.

A-2. Personnel aboard ship at the time contamination is known or suspected should follow explicitly established evacuation and decontamination procedures. All hands should be thoroughly indoctrinated in these procedures through training and frequent drills. Personnel having no official duty in connection with decontamination operations will don masks and evacuate to a safe area. Those having specific duties to make an operation secure will don protective clothing as required and after having performed the prescribed duty, will also evacuate. The decontamination team will immediately don impermeable clothing and masks and begin decontamination operations, continuing until decontamination is complete.

A-3. Decontamination team personnel should wear a gas mask and the complete impermeable suit consisting of coveralls, hood, gloves, and boots. The suit is impermeable to air or vapor but can be penetrated by liquid agent. To minimize the possibility of entry through the cloth, care should be taken to prevent unnecessary creasing. The gas mask with military type canister is designed for concentrations not greater than 1% by volume. For greater concentrations, the self-contained oxygen-generating mask, the air-supplied mask, or a mask equipped with the all-purpose canister or Scott-pack can also be used. At temperatures above 60°F, wearing time of the impermeable suit is greatly increased if the cooling suit and hood are worn and kept wet with water. After use, the impermeable suit should be decontaminated prior to removal. The clothing should be removed in front of a well-ventilated hood and the clothing placed therein. The mask should be removed last.

Appendix A

A-4. Caustic soda (lye) in 5% to 15% water solution is the standard chemical for neutralizing GB. A 5% solution is obtained by adding 0.4 pound of caustic to one gallon of water. Because of the large amount of heat of solution generated, the caustic must be added to the water slowly and the water should be cool. Personnel preparing the solution should wear a mask and rubber gloves, boots, and apron. Solid caustic soda is sealed in steel drums to prevent contact with water. Solutions of caustic soda must be kept in glass or similar containers with rubber stoppers.

A-5. Leaking munitions equipped with fuzes and bursters will be placed in a steel container in such a position that the munition will leak vapor only. The void between the munition and the container will be filled with sand or some other non-reactive material and water will be added to a height of 6 inches above the top of the munition. If the munition is not equipped with fuze and burster, a 10% caustic solution may be used in place of the water. The caustic solution should not be used with fuzed munitions since the heat of reaction between the caustic and the agent may create a safety hazard. The container should be sealed and disposed of as soon as practical. For disposal at sea, the specific gravity of the sealed container should exceed one.

A-6. All areas where spillage has occurred should be decontaminated with a caustic solution. An excess of decontaminant should always be used to insure that the GB is rendered non-toxic. Approximately two gallons of 10% solution are required to neutralize one pound of GB. Care must be taken that all contaminated areas are completely cleaned as any small residue of GB will remain hazardous, especially if subsequently exposed to heat. It is difficult, if not impossible, to decontaminate porous surfaces; therefore, wood, gaskets, and other porous material should be destroyed if exposed to GB. Decontamination should not be stopped until available detection equipment indicates the absence of chemical agent. Since the caustic solution is extremely corrosive, the area should be completely washed down following decontamination.

A-7. Where spillage of large quantities of agent has occurred, the decontamination problem can be eased if some of the agent can be washed overboard. Care must be taken that such a procedure does not spread contamination. Soap and detergents can be added to the water to aid in the removal of spilled agent. However, the water will not completely decontaminate and the area must still be scrubbed with a caustic solution to assure complete decontamination.

Appendix A

A-8. To prevent excessive accumulation of toxic vapor, adequate ventilation is recommended. Care should be taken that the exhausted vapor does not produce additional casualties. However, since transient vapor does not leave a lingering contamination when passing through an area, the probability of casualties is small if the entire crew is properly masked.

A-9. In the event of fire, explosion, or similar accident involving GB in quantity, the danger area may extend for several miles. Until decontamination is complete, all other ships within this area should exercise proper precautions.

Appendix B

Bibliography of BW/CW Studies
(Underlined report Nos. are NOL Library File Nos.)

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2. (SECRET) Chief of the Bureau, NAVAER 11-45-601, Handbook on AERO 14 B Airborne Spray Tank Discharge Nozzle Assembly, 15 March 1955, S-127869

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26. Headquarters Army Chemical Center, Chemical Corps Materiel Command Safety Manual, Volumes I & II

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(NOL technical report 61-161)
SHIPBOARD PROBLEMS AND REQUIREMENTS FOR HANDLING AND STOWAGE OF CHEMICAL MUNITIONS (U) (PRELIMINARY STUDY), by M. Riess and others. 14 Nov. 1961. v.p. SECRET

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2. Chemical warfare agents - Storage
3. Chemical warfare agents - safety measures
4. Chemical warfare agents - Detection
5. Chemical warfare agents - Handling

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