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**AMC REGULATION**

**AMCR 385-224**

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**SAFETY:  
AMC SAFETY MANUAL**

AD 669253



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UNITED STATES ARMY MATERIEL COMMAND  
WASHINGTON, D.C. 20315

5 June 1964

AMCR 385-224, AMC Safety Manual, is published for the information and compliance of all concerned.

(AMCAD-S)

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SELWYN D. SMITH, JR.  
Major General, USA  
Chief of Staff

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**AMC REGULATION  
NUMBER 385-224  
CHANGE 11**

**30 October 1964**

**SAFETY  
AMC SAFETY MANUAL**

AMCR 385-224, 4 September 1951, is changed as follows:

Remove pages and insert new pages as indicated below.

*Remove pages*

15-1 through 15-39

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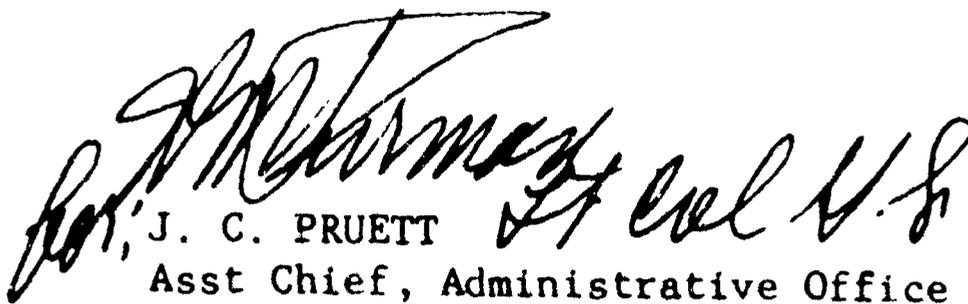
*Insert pages*

15-1 through 15-17

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AMC REGULATION 9 November 1964  
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**SAFETY**  
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AMCR 385-224, 4 September 1951, is changed as follows:

1. *All references to — are changed to—*
- |                     |                           |
|---------------------|---------------------------|
| Class 4 ammunition  | Class 5* ammunition       |
| Class 6 ammunition  | Class 7 ammunition        |
| Class 7 ammunition  | Class 6 ammunition        |
| Class 8 ammunition  | Class 7 ammunition        |
| Class 9 explosives  | Class 7 ammunition        |
| Class 10 ammunition | Class 7 ammunition        |
| tion                |                           |
| Class 11 ammunition | Class 8 ammunition        |
| tion                |                           |
| Class 12 explosives | Class 2 or 7 explosives** |

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\*Items previously in class 4 that are known to present a missile hazard to distances not greater than 800 feet have been included in the new class 4 (table 1733). Other items now being included in class 5 (table 1734) may be changed to class 4 by the Safety Division, Administrative Office, Headquarters, AMC, if further study or testing indicates that such action is appropriate.

\*\*See tables 1731 and 1739 for items included in classes 2 and 7, respectively.

**AMCR 385-224, C 12**

2. Remove pages and insert new pages as indicated below:

*Remove pages—*  
17-43 and 17-44  
17-49 through 17-66

*Insert pages—*  
17-43 and 17-44  
17-49 through 17-66.2

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CHANGE 10

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SAFETY

AMC SAFETY MANUAL

AMCR 385-224, 4 September 1951, is changed as follows:

1. All references to:                    are changed to:

"The Chief of Ordnance"	"Commanding General, AMC"
"Office of The Chief of Ordnance"	"Headquarters, AMC"
"Ordnance" or "Ordnance Corps"	"AMC"
"Ordnance establishment"	"AMC establishment"
  
2. Make the following pen-and-ink changes:
  - a. Page 1-1. Delete the footnote at the bottom of the page.
  
  - b. Pages 1-4 and 1-4.1, paragraph 105b. Delete the introductory portion of this paragraph and substitute:

"Upon local determination that a waiver is necessary, installations and activities will forward requests through command channels to the Commanding General, AMC, ATTN: AMCAD-8. Requests forwarded will contain, as a minimum, the following information:"
  
  - c. Page 1-9. Delete "Commanding Officer, Ordnance Field Safety Office, and the Office, Chief of Ordnance (ORDOU-SA)" and substitute "Director, AMC Field Safety Agency, and Commanding General, AMC, ATTN: AMCAD-8."
  
  - d. Page 21-22.
    - (1) Paragraph 2124c(1). Delete "Commanding Officer, Ordnance Ammunition Command, Joliet, Illinois, ATTN: ORDLY-Q" and substitute "Commanding Officer, Ammunition Procurement and Supply Agency, Joliet, Illinois, ATTN: BWJAP-Q."
  
    - (2) Paragraph 2124c(2). Delete "Commanding General, Army Rocket and Guided Missile Agency, Redstone Arsenal, Alabama, ATTN: FSD" and substitute "Commanding General, U.S. Army Missile Command, Huntsville, Alabama, ATTN: AMBNT-84."

AMCR 385-224, C10

e. Page 21-25, I, paragraph 2124e. Delete "OOO 19-51" and substitute "AMCR 385-3."

f. Page 29-5, paragraph 2904b. Delete "with an information copy to Chief of the Chemical Corps."

g. Page 29-6. Delete paragraph 2904c.

h. Page 29-9, paragraph 2907. Delete "Office of the Chief, Chemical Corps" and substitute "Headquarters, AMC, ATTN: AMCAD-SE."

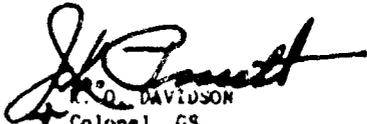
i. Page 29-51, paragraph 2937b. Delete "Chief, Chemical Corps" and substitute "Commanding General, AMC."

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## ABBREVIATIONS

<b>ASME</b>	<b>American Society of Mechanical Engineers</b>
<b>ASA</b>	<b>American Standards Association</b>
<b>AWG</b>	<b>American wire gauge</b>
<b>cal.</b>	<b>caliber</b>
<b>cfm</b>	<b>cubic feet per minute</b>
<b>CP</b>	<b>chemically pure</b>
<b>fpm</b>	<b>feet per minute</b>
<b>gpm</b>	<b>gallons per minute</b>
<b>HE</b>	<b>high explosives</b>
<b>hp</b>	<b>horsepower</b>
<b>ICC</b>	<b>Interstate Commerce Commission</b>
<b>LCL</b>	<b>less than carload lots</b>
<b>MAC</b>	<b>maximum allowable concentration</b>
<b>max</b>	<b>maximum</b>
<b>mm</b>	<b>millimeter</b>
<b>NBFU</b>	<b>National Board of Fire Underwriters</b>
<b>NFPA</b>	<b>National Fire Protection Association</b>
<b>psi</b>	<b>pounds per square inch</b>

**15 May 1958**

*This manual supersedes the Ordnance Safety Manual (OO Form 7-884), 3 May 1945, and all Ordnance Corps safety bulletins issued prior to the date of this manual.\**

## **SECTION 1**

### **INTRODUCTION**

---

#### **101. PURPOSE**

This manual, in its several sections, sets forth established Ordnance Corps safety rules and regulations. Information concerning the hazards of explosives and ammunition is also included.

#### **102. SCOPE**

The safety rules and regulations set forth in this manual prescribe safe methods and practices for insuring continuity of production, safeguarding personnel, and preventing property damage.

#### **103. APPLICATION**

a. The mandatory requirements and advisory provisions set forth in this Ordnance Safety Manual apply to each activity and facility where the Chief of Ordnance is charged with the responsibility for safety.

b. Mandatory requirements are those in which the terms "shall" or "must" are used, and no deviation is permitted without specific written authority in the form of a waiver, exemption or authorization from the Chief of Ordnance. The advisory provisions are those in which "may" or "should" are used,

---

\*No further safety bulletins will be published. Material of the type formerly issued as safety bulletins which cannot be inserted in this manual will be published in Ordnance Corps technical instructions of the 700-series.

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and no deviations are permitted unless exceptions are authorized in writing by the commanding officer or his designated agent. Local waivers covering correctible conditions should be granted for definite periods of time; preferably one year or less. Such waivers must be reviewed at least annually to determine whether changed conditions make continuation of the waiver justifiable. All exemptions, waivers and authorized deviations shall be maintained in a register which is readily available to authorized personnel.

c. Existing facilities not complying with safety regulations published after their construction or installation may be exempted from the new requirements when such action is authorized by the Chief of Ordnance. However, modifications, unless minor in nature and not decreasing safety, must comply with the latest safety requirements. Ordnance establishments with facilities exempted from compliance with regulations should take additional precautions to counterbalance the deficiencies.

#### 104. RESPONSIBILITY FOR ENFORCEMENT AND COMPLIANCE

a. The commanding officer of an Ordnance establishment is solely responsible for the safety of his establishment and it is important that he take the same active aggressive leadership in safety that he takes in other phases of command responsibility. It is the responsibility of the commanding officer to insure that all activities are conducted in accordance with the safety rules and regulations set forth herein. Where no existing safety rule or regulation applies

to circumstances of major importance or where a deviation from an established mandatory safety regulation is desired, it is the responsibility of the **commander** to submit, through command channels, full particulars and detailed plans to the Chief of Ordnance for authorization. In the interim, however, the **commander** shall take the action he deems necessary to control the hazard. The absence of a safety requirement in this manual or in the references cited does not necessarily indicate that no safeguards are needed.

b. It is also the responsibility of the **commander** to require personnel of other agencies, while on an Ordnance establishment, to conduct their activities in accordance with established Ordnance Corps safety rules and regulations. If such activities are not so conducted, the **commander** should require immediate corrective action.

c. The **commander** shall enforce the mandatory requirements of this manual and be guided by the advisory provisions. He shall institute those inspections necessary to effect compliance with the rules and regulations prescribed herein.

#### 105. PROCEDURE CONCERNING WAIVERS OF SAFETY REGULATIONS

a. A waiver may be granted after it has been ascertained that compliance with existing safety standards cannot be adhered to and the essential

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work of storage, production, or shipment of critical Ordnance material still be performed, or because of other extenuating circumstances. Waivers and exemptions (par. 103b) are granted for specific situations, are limited as indicated in the pertinent correspondence, and shall not be interpreted to cover similar operations, locations, or conditions. The waiver, when granted, will be issued only for such minimum time as is necessary to rectify the unsafe condition. In no case will a waiver be granted initially for a period in excess of 1 year. Installations and activities which have been granted exemptions or waivers should initiate action to effect cancellation when the necessity for the exemptions or waivers terminates prior to the established expiration dates.

b. Upon local determination that a waiver is necessary, installations and activities storing ammunition and explosives and assigned to the operating control of the Chief, Field Service Division, **Office of the Chief of Ordnance** (see app. 1, ORDM 1-1) will forward requests to the Ordnance Ammunition Command or *U.S. Army Ordnance Missile Command* (ATTN: ORDXM-N) whichever is assigned the national maintenance mission responsibility for the items of ammunition and explosives involved. The Ordnance Ammunition Command or *U.S. Army Ordnance Missile Command* will review and evaluate the requests and will forward those considered justified

to the Chief of Ordnance, ATTN: ORDGU-SA. All other installations and activities will forward requests through command channels to the Chief of Ordnance, ATTN: ORDGU-SA. Requests forwarded will contain, as a minimum, the following information:

- (1) Description of condition (maps showing distances to internal and external exposures, personnel involved, and facilities exposed).
- (2) Safety regulations violated.
- (3) Statement that compliance with mandatory safety requirements cannot be effected locally ((2) above).
- (4) Specific time required for waiver.
- (5) Precautions that will be taken to achieve safety in operations during period of waiver.

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In case of an extreme emergency, telephone, teletype, or telegram request may be made and confirmed in an official letter mailed to Office, Chief of Ordnance within 3 days of the initial request.

c. Renewals of a waiver will not be granted unless there is evidence that all practicable means for complying with approved standards have been exhausted. Waivers will be considered as rescinded on the stated expiration dates unless requests warranting renewal have been received in Office, Chief of Ordnance, in ample time to permit evaluation and reply.

#### **106. SAFETY ORGANIZATION**

Each Ordnance establishment shall institute and maintain a safety organization which functions essentially as shown in figure 106.

#### **107. SAFETY DIRECTOR**

(Added)

The commanding officer of each Ordnance establishment shall designate either a safety officer or a civilian safety engineer as safety director. This individual must be qualified to supervise the safety activities at the establishment and to perform the duties assigned him by the commanding officer. He shall be responsible directly to the commanding officer for the establishment, continuing interest in and the success of all phases of the safety program.

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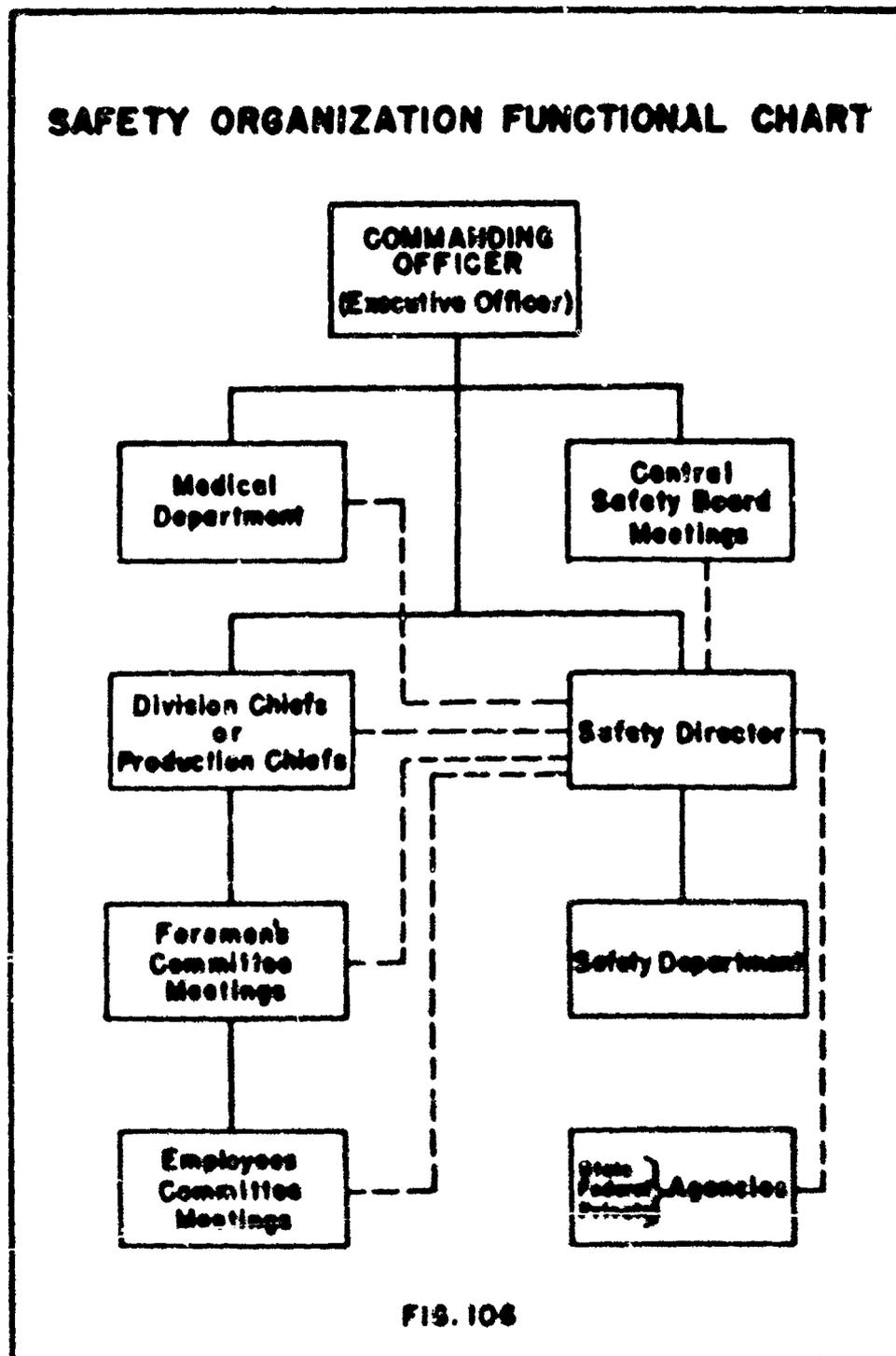


Figure 106. (Added) Safety Organization Functional Chart.

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**108. DIVISION CHIEFS OR PRODUCTION CHIEFS**

**(Added)**

Each division chief or production chief shall be responsible to the commanding officer for the safety of his division. Each shall take active aggressive leadership in the safety activities of his division, shall comply with the requirements of this manual and shall take an active part in the safety program of the establishment.

**109. FOREMEN**

**(Added)**

Each foreman shall consider the prevention of injuries to employees under his jurisdiction to be as important a phase of his job as quantity and quality production. To accomplish this, he shall train his men to work safely, supervise them closely, correct unsafe acts and mechanical or physical conditions, enforce safety regulations, investigate accidents and take other action necessary to insure the safety of the employees. The success of a safety program depends upon the ability of the foreman and his enthusiastic participation in the organized safety effort.

**110. EMPLOYEES**

**(Added)**

Each employee, as a condition of employment, shall adhere to all instructions and use the personal protective equipment and protective devices provided for machinery, equipment, tools, and processes. He

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should develop intelligent and safe working habits by following safe practice rules and regulations in order to protect himself and his fellow workers from injury and to prevent damage to material, equipment, and facilities. He should contribute any suggestions which may assist in the effort to prevent accidents and otherwise take an active part in the safety program.

### **111. CENTRAL SAFETY BOARD**

(Added)

a. A safety board shall be organized at each Ordnance establishment and shall hold meetings regularly. The board should include the following members:

Commanding officer, Chairman  
Safety director, Secretary  
Division and production chiefs  
Post engineer (chief engineer)  
Senior ammunition or explosives inspector  
Training officer  
Procurement chief  
Fire chief (fire marshal)  
Post surgeon (medical officer)  
Others, as determined by the commanding officer.

b. The board shall aid in establishing the safety program and determine its adequacy, effectiveness, and methods for improvement. To do this, the board shall become familiar with the personal injury experience of the establishment, and the po-

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tential hazards that might cause injury; and devise ways and means to eliminate unsafe acts and to correct unsafe mechanical and physical conditions.

c. (Added) Minutes of committee meeting should be prepared and copies furnished the Commanding Officer, Ordnance Field Safety Office, and the Office, Chief of Ordnance (ORDGU-SA).

### **112. FOREMAN'S SAFETY COMMITTEE**

a. One or more foremen's safety committees shall be formed at each Ordnance establishment and shall hold regular meetings at least once each month. Each committee should consist of not more than 15 foremen. Each foreman in the establishment should be a member of one of these committees, but if the committees consist of only a portion of the foremen, membership should be rotated so that each member serves for approximately six months and only a few members are replaced at any one time. Each foreman should take his turn serving on the committee. Each committee should have a chairman and a secretary. The safety director or a member of his office should attend each meeting in an advisory capacity.

b. Each foremen's safety committee shall take an active part in the safety program of the establishment and particularly shall strive to decrease personal injury possibilities of the employees under the jurisdiction of the foremen in the group.

### **113. EMPLOYEES' SAFETY COMMITTEES**

a. Employees' safety committees should be formed at each Ordnance establishment and should hold reg-

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ular meetings at least once each month in order that all personnel may participate in the safety program of the establishment. Each committee should consist of not more than 15 employees. Membership on these committees should be rotated so that each member serves for approximately three months and only a few members are replaced at any one time. Each committee should have a chairman and a secretary. The safety director or a member of his staff should attend each meeting in an advisory capacity.

b. Each employee safety committee shall take an active part in the safety program of the establishment and, particularly, shall strive to decrease personal injury possibilities within its own group.

#### **114. INTERDEPARTMENTAL COORDINATION**

The activities of all departments in an establishment shall be coordinated to insure the successful accomplishment of the safety program. Cooperation within departments and between other departments and the safety department should prevail.

#### **115. SAFETY PROGRAM**

a. A safety program, to be effective, must be planned in advance to accomplish certain predetermined objectives. The program shall have two phases, the general and the specific functions. The general function shall be continuous and repetitive and shall be planned to eliminate the conditions

14 May 1964

which cause the majority of accidents. The specific functions shall be specialized in character and shall be planned to determine and correct hazards associated with the flow of materials, the method of process, and/or the physical plan conditions. At each establishment, there shall be only one Safety Program, in accordance with the provisions of A.R. 885-10.

b. The object of the general function shall be the elimination of accidents occurring with a significant frequency and assignable to a particular agency, unsafe act, unsafe condition, etc., and of accidents which are concentrated in any particular area or section of the establishment. This phase of the program shall be broad in scope and shall include:

- (1) Safety committee activities.
- (2) Prevention, inspection and correction of day-to-day unsafe conditions and practices.
- (3) Employee training programs.
- (4) General use of educational bulletins, posters, hand-out cards, safety movie films, etc.
- (5) Accident cause investigation.
- (6) First-aid training.

c. The nature of the specific function requires the making of inspections and accident cause investigations pertaining to special studies and analyses of handling operations, process operations, physical conditions of a plant or area, the use of toxic materials, and of other specific operations. The safety director shall arrange for prior review of process plans, drawings of new construction and facility

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modifications as well as equipment specifications for compliance with established safety standards.

#### **116. HAZARDS**

(Added)

The safety organization shall review all regular operations and all seasonal or special operations such as tank cleaning, boiler cleaning, window cleaning, and infrequent materials handling jobs. Hazards may be determined through accident cause analyses and analyses of all operations, including seasonal or infrequent operations in the establishment.

#### **117. CONTROL MEASURES**

(Added)

Once the hazards of a particular operation have been determined, they shall be evaluated in order to facilitate correction. The specific preventive or control measures to be applied shall be determined by the characteristics peculiar to the hazard. The solution may be found in education of personnel through visual aids, demonstrations, training, preparation of special rules or of standard safe practices; in use of protective devices; or in engineering revisions including changes, additions or improvement of equipment, revision of method, change in materials used or development of standards for operations.

#### **118. HAZARD CONTROL ORDERS**

(Added)

Upon completion of the study of each hazard and

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the determination of corrective measures, all data should be assembled and a report prepared for the approval of the superintendent, production chief, safety board, or commanding officer, as may be required. Upon approval, the correction shall be effected and continuing protection assured through follow-up corrective measures by supervisory personnel and through inspections by the safety department.

#### **119. EDUCATIONAL PROGRAM**

(Added)

An educational program shall be instituted in each establishment to develop and maintain employees interest in the safety program, and to train employees in safe practices and safe procedures. The safety board shall determine the type of educational program most suitable for the particular establishment. Some of the mediums available for employee education are posters, bulletin boards, scoreboards, special exhibits, "no accident" campaigns, safety or clean up contests, articles in establishment publications, safety rules hand-out cards, pamphlets, warning signs for specific hazards, suggestion systems, essay contest, and sound slide films or motion pictures for groups of employees. Appropriate "off-the-job" accident prevention features should be included in the program, and the safety organization should stimulate the interest of and cooperate with outside agencies concerned with this phase of the accident prevention program.

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## **120. EMPLOYEE TRAINING** **(Added)**

a. The safety director shall collaborate with the personnel department or other departments charged with the responsibility for employee training to assure adequate treatment of accident prevention matters. Complete and proper training results in increased production through reduced susceptibility to mistakes and accident. It is the responsibility of the training department to assist all departments in determining training needs, and in establishing and conducting courses for employees to meet these needs.

b. Before any new employee is placed on the job, the establishment shall make sure that the employee knows the specific safety rules and regulations of the plant and department insofar as is practicable. This should be accomplished through an orientation course. Each employee shall be trained for the specific job to which he is assigned. Whether this training is accomplished by the foreman on the job, special instructors, experienced workers, an under-study system, or the apprenticeship method, the employee shall be thoroughly instructed in the efficient safe method of performing his assigned work before being permitted to work "on his own." The personal benefits accruing to the employee by conformity with these rules should be explained.

c. The instructors should be properly trained in the use of sound instructional methods and in deter-

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mining what knowledge must be passed along to the worker. The instructions concerning the performance of new duties should be well planned in advance so that the instructor can present them in an orderly and complete fashion. The use of a written job procedure (job breakdown) developed following a complete analysis of the job has been established as a valuable method for this purpose. Such analysis should include an outline of the necessary steps in the performance of the job, a listing of the essential techniques for the efficient performance of each step, a listing of the hazards present in each step, and definite, positive instructions regarding each hazard which will enable the worker to avoid accidents or injury.

d. To insure receiving the maximum benefits from any training, supervision shall maintain a continuous program of follow-up, reinstruction, and enforcement of regulations and procedures with each employee.

#### **121. FIRST AID TRAINING** (Added)

An approved course in first aid training shall be made available. Electricians, maintenance men, guards, firemen, foremen and supervisors, attendants and orderlies in the first aid room, and members of the safety staff, should be required to take the course. The items covered by this course and the number of hours of class attendance should be determined by the medical officer to fit local needs. The instructor

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shall be qualified and accredited. A certificate should be awarded to each person completing the course satisfactorily. A refresher course should be given at intervals, but it is more important to give first aid training to those who have not been trained.

## **122. INJURY REPORTS**

(Added)

A complete and accurate system of accident records constitutes the focal point of a safety program. Accident records must be used, and used effectively, to obtain the best results in any accident prevention program. Establishments shall submit reports of occupational disabling injuries and diseases to higher echelons as required by current directives from higher authority. In addition, such establishment-level reports as will promote an effective and well coordinated safety program shall be instituted. In order that effective accident cause analyses can be made, accident records shall be designed to enable collection of data which will:

- a. Indicate the accident trend,
- b. Identify departments with the poorer records,
- c. Reveal hazardous agencies, conditions, practices and processes requiring correction or protection,
- d. Point to predominant types of accidents,
- e. Indicate "accident prone" employees who require special attention,
- f. Reveal the lack of enforcement of established regulations, and

*g.* Indicate the need for additional safety standards.

### 123. ACCIDENT PREVENTION INSPECTIONS

Each part of the establishment should be inspected at least monthly for unsafe work practices and unsafe physical and mechanical conditions. Hazardous operations or accident experience will indicate the advisability of more frequent inspections. The safety director shall arrange for prompt inspections of any seasonal or unusual work of a hazardous nature. Foremen should assist the program by making daily inspections of work areas and operating conditions to assure themselves that all hazards have been minimized and that safe work practices are being employed. The foreman should also accompany the assigned safety inspector whenever possible, and all of the discrepancies noted, and recommendations to be made, should be brought to the foreman's attention during or immediately after the inspection so that unsafe acts and unsafe conditions may be corrected promptly. Accident prevention inspections shall be systematic and thorough so that no location will be overlooked. Inspections should include such items as:

*a.* Quarterly inspection of elevators.

*b.* Crane, derrick, and hoist inspections. The frequency of these inspections should be based on specific needs.

c. Boiler and unfired pressure vessel inspections. Boiler inspections shall be made in accordance with current applicable directives. Unfired pressure vessel inspections and tests should be made by certified insurance or state inspectors, or other qualified inspectors, at intervals as required by law but in no case at intervals greater than 1 year. **Hydrostatic testing of unfired pressure vessels should be performed upon installation or relocation of the vessel. Additional hydrostatic testing may be performed if during inspections, conditions found warrant such tests.**

d. Chains, cables, slings, hooks, ropes, and other special tools and equipment. The frequency of these inspections should be based upon specific needs.

## 124. ACCIDENT INVESTIGATION

Accidents should be investigated in accordance with current directives to determine all contributing causes and the preventive measures which will eliminate or reduce the number of accidents. Even accidents which do not cause severe property damage or injury to personnel must be investigated so that preventive measures can be taken before the same or a similar set of circumstance result in a serious accident. This is particularly true of accidents occurring in operations or buildings where explosives are present. The investigation of first aid cases must not be over-

looked however slight the injury may be, and an effective system for reporting first aid cases to the safety department must be instituted. The foreman shall be required to investigate, with the help of his supervisor or a safety department representative if necessary, all accidents involving operations, equipment, or personnel under his supervision, and his report shall be forwarded for appropriate action. The safety director shall be re-

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responsible for the arrangements necessary to receive immediate notices of all disabling injuries. When an accident occurs, immediate action shall be taken to:

- a. Interview the injured person before he is sent home or to the hospital when delay of treatment will not jeopardize the injured;
- b. Visit the scene of the accident to observe conditions as they were or might have been at the time of the accident;
- c. Obtain details of the injury from the medical department;
- d. Prepare or obtain photographs, diagrams, sketches, and maps as warranted by the circumstances;
- e. Confer with foremen, supervisors, and witnesses for information as to cause;
- f. Examine safety, medical, and personnel department records on the injured person's previous history, physical conditions and individual accident experience;
- g. Plan corrective measures with the foremen and other interested parties;
- h. Complete the necessary accident reports;
- i. Establish a follow-up on the application of recommended corrective measures;
- j. Follow through for exact information pertaining to the return of the injured to work.

## 125. ACCIDENT CAUSE ANALYSIS

(Added)

Accident reports shall be used to compile accident

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data, preferably on a monthly basis. The record shall show the accident factors (agencies, unsafe conditions, types of accidents, and unsafe acts) subdivided into major group classifications. Further analysis should be made of each factor to determine exactly what has happened. Analyses should be used in developing items such as:

- a. The educational program,
- b. Maintaining interest,
- c. Contests and "no accident" campaigns, and
- d. Safety meeting topics.

#### **126. OFF-THE-JOB SAFETY**

(Added)

a. Avoiding off-the-job accidents is fully as important to the employee, his family, and to the production of materials necessary to the welfare of the nation, as is being a safe worker at the establishment. Management should cooperate with civic organizations in efforts to make employees and their families aware of that fact. This can be accomplished through several media. Periodically, bulletin boards at the establishment should be used to promote off-the-job safety. At reasonable intervals, employees should be furnished with cards, payroll inserts, booklets, etc., devoted to such topics as pedestrian safety, safe driving, fire prevention, home safety, recreational safety and first aid. Management should consider other possibilities to stimulate interest in off-the-job safety such as analysis of after-work accidents based on absentee records and the development

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er defensive skill in driving—teaching employees to avoid accidents that may arise due to the unsafe driving of others.

b. Local conditions determine the role of the establishments in community safety. Management should consider taking an active part in installing suitable signs, signals, and street markings to control and expedite pedestrian and vehicular traffic on streets, sidewalks and roadways leading into the establishment. Policemen or guards officially designated by the establishment shall have full authority to regulate pedestrian and vehicular safety.

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## SECTION 2

### GENERAL DEFINITIONS

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#### 201. TERMS

The terms defined, with the meanings indicated, are used in this manual for this purpose only and should not be considered as being in conflict with other Department of the Army regulations or usage.

#### 202. ADMINISTRATION AREA

The area in which are located administrative offices which function for the establishment as a whole, in contrast to field offices. (See par. 218.)

#### 203. AMMUNITION

Type of munitions normally containing an explosive element and designed to inflict damage upon structures, personnel, matériel or military objectives. Ammunition includes shells, grenades, bombs, pyrotechnics and mines together with projectiles such as bullets, shot and their necessary primers, propellants, fuzes and detonators.

#### 204. APPROVED

Complying with the provisions of this manual and with instructions and details as issued by the Chief of Ordnance or with those or other approving agencies specifically referred to herein.

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### **205. AUXILIARY BUILDING**

Any building that supplements an operational building, line or area but which is not directly utilized for the productive activity. Examples of such auxiliary buildings are fan houses, valve houses and similar units.

### **206. BARRICADE**

An intervening approved barrier, natural or artificial, of such type, size and construction as to limit in a prescribed manner, the effect of an explosion on nearby buildings or exposures.

### **207. BARRICADED**

To be protected by a barricade.

### **208. CHANGE HOUSE**

A building provided with facilities for employees to change to and from work clothes. Such buildings may be provided with sanitary facilities, drinking fountains, lockers, and eating facilities.

### **209. CHEMICAL AMMUNITION**

Ammunition, the filler of which has the basic function of producing a toxic or irritant effect on the body, a screening or signaling smoke, or an incendiary action.

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## **210. CLASSIFICATION YARD**

A group of railroad tracks used for receiving, shipping, and switching cars containing explosives, ammunition, or inert materials. (See par. 1713.)

## **211. COMPONENT**

Any part of a complete item loaded with explosives (commonly called "live"), inert (not containing explosives), or empty.

## **212. DEMILITARIZE**

To mutilate, disarm, and to accomplish any other action required to render ammunition and explosives innocuous or ineffectual for military use.

## **213. EMPLOYEES AND PERSONNEL**

Any and all persons employed within the confines of the establishment and all authorized transients.

## **214. ESTABLISHMENT**

Any plant, works, arsenal, depot, proving ground, or any other activity under control of the Chief of Ordnance.

## **215. EXEMPTION**

A written authorization by the Chief of Ordnance which specifically permits deviation from a mandatory regulation of the manual.

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## **216. EXPLOSIVES**

The term explosive, or explosives, includes any chemical compound or mechanical mixture which, when subjected to heat, friction, detonation or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressures in the surrounding medium.

## **217. EXPLOSIVES AREA**

A restricted area specifically designated and set aside from other portions of an establishment for the manufacturing, processing, storing, and handling of explosives and ammunition.

## **218. FIELD OFFICE**

Any office, exclusive of the main administrative office, located within an establishment in which operational administrative functions only are performed.

## **219. FIRE HAZARD AREA**

A location in which the primary but not necessarily the only hazard is that of fire including "explosions" of gas or vapor and air mixtures.

## **220. FIRE-RESISTIVE**

A term used to indicate the design of a structure or materials and the like to resist a fire to which they might be subjected without themselves becoming weakened to the point of failure.

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**221. FIRE-RETARDANT**

A term used to designate generally combustible materials or structures which have been treated or have surface coverings designed to retard ignition or fire spread.

**222. FIRE WALL**

A wall of fire-resistive construction designed to prevent the spread of fire from one side to the other. A fire wall may also be termed a "fire division wall."

**223. FIXED AMMUNITION**

Ammunition, except small arms and rocket ammunition, consisting of a cartridge case loaded with propellant and a projectile which are loaded in one operation into the weapon, the cartridge case being firmly attached to the projectile.

**224. FLAMEPROOF**

A word applied to combustible materials, such as clothing, which have been treated or coated to decrease their burning characteristics.

**225. FLAMMABLE**

Combustible. A flammable material is one which is easily ignited and burns readily.

**226. FLAMMABLE LIQUID**

Any liquid, the vapor of which will burn. (See volatile flammable liquid par. 278.)

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**227. HAZARD**

Any condition which may result in the occurrence, or contribute to the severity of an accident.

**228. HAZARDOUS MATERIAL**

Any compound, mixture, element or assemblage of material which, because of its inherent characteristics, is dangerous to manufacture, process, store or handle.

**229. HOLDING YARD**

A group of railroad tracks used to store cars of explosives, ammunition or inert materials for indefinite periods. **Ammunition and explosives holding yards may include areas for parking trailers containing ammunition and explosives.**

**230. INERT (AS APPLICABLE TO AMMUNITION)**

Containing no explosives, active chemicals or pyrotechnics but not necessarily noncombustible.

**231. INERT AREA**

Any area other than an explosives or administration area within an establishment.

**232. INERT COMPONENTS**

The parts of ammunition which do not contain explosives, active chemicals or pyrotechnics.

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### **233. INHABITED BUILDING**

A building or structure other than operating buildings, magazines and auxiliary buildings occupied in whole or in part as a habitation for human beings, or where people are accustomed to assemble, both within and outside of government establishments. Land outside of the boundaries of Ordnance establishments shall be considered as possible sites for inhabited buildings.

### **234. INSPECTOR'S WORKSHOP**

A special building equipped to permit all normal surveillance inspections.

### **235. INTRALINE OPERATIONS**

Those processes accomplished within one operating line.

### **236. JATOS**

The basic term for jet thrust units including boosters, sustainers and aircraft assist take-off devices.

### **237. LOADING DOCKS**

Loading docks are facilities at ground level or elevated structures designed and installed for transferring explosives, ammunition, and component parts thereof between automotive vehicles and railway cars.

### **238. MAGAZINE**

A structure designed or specifically designated for the storage of explosives, ammunition, or loaded components.

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a. Many types of magazines are to be found at Ordnance establishments. A brief summary of types follows:

- (1) Igloo (earth-covered, arch) type.
- (2) Box (earth-covered reinforced concrete) type.
- (3) Stradley (Yurt) (earth-covered, reinforced concrete) type with vertical sidewalls and arched roof.
- (4) Corbatta (earth-covered, beehive or dome) type.
- (5) Aboveground type. Includes the following:
  - (a) Originally termed "Ammunition Magazine."
  - (b) Originally termed "Black Powder Magazine."
  - (c) Originally termed "Primer and Fuze Magazine."
  - (d) Originally termed "Smokeless Powder Magazine."

*Note.* The above 4 types of above ground magazines may or may not be barricaded.

- (e) Richmond type (two sides and rear are barricaded).
- (6) Hillside type.
- (7) Subsurface type (all portions underground).

### 239. MAGAZINE AREA

A restricted area, specifically designated and set aside from other portions of the establishment for the primary purpose of ammunition and explosives storage.

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#### **240. MAGAZINE DISTANCE**

The distance between magazines that is expected to prevent the propagation of explosion from one magazine to another.

#### **241. MAGAZINE PLACARDS**

Ordnance placards (O. O. Form 5991) that are required to be posted inside on or near each door of a magazine.

#### **242. MILITARY PYROTECHNICS**

Ammunition manufactured specifically for use as signals, illuminants and like items.

#### **243. MODIFY**

To make a major or a minor change in the design or assembly of an item of ammunition or component part thereof.

#### **244. MISSILE DISTANCE**

The limiting range of a considerable number of missiles from the quantity and types of ammunition involved in the quantity distance-tables (see sec. No. 17). The inhabited building distances in certain classes are sometimes used as the missile distance.

#### **245. NONCOMBUSTIBLE**

Not combustible, not burnable in the ordinary sense of the word.

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**246. NORMAL MAINTENANCE**

That work performed on ammunition to prevent deterioration and to correct minor defects not requiring renovation or major modification operations.

**247. OPERATING BUILDING**

Any structure, except a magazine, in which operations pertaining to manufacturing, processing or handling explosives or ammunition are performed.

**248. OPERATING LINE**

The group of buildings used to perform the consecutive steps in the loading, assembling, modification, normal maintenance, renovation, demilitarization or salvaging of an item of ammunition or in the manufacture of an explosive.

**249. OPERATING LINE SEPARATION**

The required distance separating each group of buildings forming one operating line and any other group of buildings forming another operating line.

**250. OPERATIONAL SHIELD**

A barrier constructed to protect personnel, matériel or equipment from the effects of a possible fire or explosion occurring at a particular operation.

**251. OUTDOOR STORAGE SITES**

Locations selected within the magazine area for the storage of ammunition and, in exceptional cases,

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inert items. These locations can be any of the following types:

- a. Earth revetted four sides (except entrance) located between earth-covered magazines.
- b. Earth revetted four sides (except entrance) not located between earth-covered magazines.
- c. Nonrevetted with roof cover only.
- d. Nonrevetted without cover.

#### **252. PUBLIC HIGHWAY**

Any street, alley, road, or navigable water open to the use of the general public. Navigable water is that part of a body of water capable of navigation by barges, tugboats, and larger vessels.

#### **253. PUBLIC RAILWAY**

Any steam, electric, or other railroad which carries passengers for hire.

#### **254. PROPELLANT, SOLID**

Those substances whose rate of combustion is such as to permit their use for propelling projectiles. The greater portion of this material was originally termed "smokeless powder." This now includes the solid propellants used in JATOS, etc.

#### **255. PYROTECHNIC MATERIAL**

The explosive or chemical ingredients, including powdered metals, used in the manufacture of military pyrotechnics.

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#### **256. QUANTITY-DISTANCE**

The quantity of explosives material and distance separation relationships which provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate quantity-distance tables in Section 17.

#### **257. RENOVATION**

That work performed on ammunition to restore it to a completely serviceable condition; usually involves the replacement of unserviceable or out-moded parts.

#### **258. RESTRICTED AREA**

Any area, usually fenced, at an establishment where the entrance and egress of personnel and vehicular traffic are controlled for reasons of safety or security.

#### **259. ROCKET**

A complete missile which derives its thrust from ejection of hot gases generated from propellants carried in the missile.

#### **260. ROCKET MOTOR**

That portion of the complete rocket loaded with propellant.

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#### **261. ROCKET HEAD**

That portion of the complete rocket loaded with high explosives, chemicals or inert material.

#### **262. SAFETY DIRECTOR**

The individual, military or civilian, designated pursuant to and assigned duties in the administration of an establishment's safety program in conformance with current Army directives.

#### **263. SAFETY SHOES**

Specially designed footwear of three general types identified as—

a. Industrial safety shoes with hard toes or other resistive physical characteristics.

b. Sparkproof safety shoes containing no exposed metal for use in locations where friction sparks are hazardous.

c. Conductive sole safety shoes used where static electricity or friction hazards are present.

#### **264. SEMIFIXED AMMUNITION**

Ammunition loaded into the cannon in one operation and whose propelling charge may be adjusted for zone firing.

#### **265. SEPARATE-LOADING AMMUNITION**

Ammunition whose propelling charge and projectile are loaded separately into the weapon.

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### **266. SERVICE MAGAZINE**

An auxiliary building used for the intermediate storage of explosives materials not exceeding the minimum amount necessary for safe efficient production.

### **267. SIMULTANEOUS DETONATION**

Detonation of separated quantities of explosives or ammunition occurring so nearly at the same time that the effect on the surroundings is the same as if the several quantities were not separated and were detonated en masse.

### **268. SMALL ARMS AMMUNITION**

Ammunition used in firearms of caliber up to and including caliber .60 and shotguns.

*Note.*—Quantity limitations and quantity-distance requirements given in this manual do not apply to finished small arms ammunition unless specifically so mentioned.

### **269. STACKS (APPLICABLE TO EXPLOSIVES AND AMMUNITION)**

Safe orderly groupings of explosives, ammunition and component parts thereof in storage.

### **270. STORAGE COMPATIBILITY**

Two or more ammunition or explosives items are said to be compatible when their characteristics are such that a quantity of two or more of the items stored together is no more hazardous than

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a comparable quantity of any one of the items stored alone.

**271. SUBSTANTIAL DIVIDING WALL**

An interior wall designed to prevent simultaneous detonation of quantities of explosives on opposite sides of the wall. (See par. 506.)

**272. SUSPECT CAR TRACK**

A railway spur track where a suspected car can be examined prior to unloading of the explosive contents.

**273. SURVEILLANCE**

The observation, inspection, investigation, test, study and classification of ammunition, ammunition components and explosives in movement, storage and use with respect to degree of serviceability and rate of deterioration. (See sec. 25 for renovation.)

**274. TEMPORARY STORAGE YARD**

Railroad tracks and designated suitable areas used to store rail cars, trucks or trailers of explosives, ammunition or inert materials for periods of from 24 hours to 2 weeks.

**275. TOXIC AREA**

An area in which the hazard is primarily a direct hazard to health.

**276. UNDERGROUND FACILITIES**

Piping, conduit, tunnels, tanks or other construction below ground level.

**277. UTILITIES**

Those services such as water, air, steam, sewage, and electricity necessary to the operation of an establishment.

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**278. VOLATILE FLAMMABLE LIQUID**

Any flammable liquid the vapor of which can be ignited at or below temperatures of 100° F. (closed cup flash point).

**279. WAIVER**

A written authorization by the Chief of Ordnance which specifically permits deviation from a mandatory regulation of this manual for a limited time pending correction of the condition, or a written authorization by an installation commander permitting deviation from an advisory provision of this manual. The latter type, local waivers, are also granted for specific periods of time.

**280. SEPARATED-LOADING AMMUNITION**

Ammunition which is loaded into a weapon in a single operation but is neither fixed nor semifixed.

**281. MASS DETONATION**

(Added)

Detonation of separated quantities of explosives or ammunition occurring so nearly at the same time that the effect on the surroundings is the same as if the several quantities were not separated. "Simultaneous" detonation (par. 267).

**282. INTERCHANGE YARD**

(Added)

A location set aside for the exchange of rail cars or truck trailers between a common carrier and the Government.

**283. AUTHORIZATION**

(Added)

Approval of operation which this manual requires an installation to obtain from the Chief of Ordnance.

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## SECTION 3

# DECONTAMINATION OF EXPLOSIVE ESTABLISHMENTS

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### 301. GENERAL

The decontamination and dismantling procedures to be followed for explosive establishments upon cessation of activity or upon conversion to other uses are given in detail in SB 5-52, 11 July 1945. The requirements of SB 5-52 shall be followed at all Ordnance establishments, and they should be considered a guide for cleaning and dismantling equipment preparatory to repair or maintenance. Any equipment used in an explosive operation which may subsequently be used in operations with nonexplosive material or explosives other than that for which the equipment was used originally shall first be given whatever treatment is necessary to insure that no explosive material remains.

### 302. CHEMICAL DESTRUCTION OF EXPLOSIVES

The chemical destruction of loose explosives or ammunition except as provided below shall not be permitted unless approval is given by the Chief of Ordnance. Chemical methods must be supervised by qualified personnel having knowledge of chemistry. Chemical destruction methods rely upon chemical reaction which to be completed require time, full con-

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tact of the explosive with the chemical agent (may require agitation), solutions of adequate strength and quantity, etc. Chemical methods shall not be used in an attempt to destroy explosives which are enclosed or pressed into components such as detonators. The following procedures may be used under adequate supervision for small quantities of the explosive named. ("Small quantities" are 28 grams or less.)

*a. Mercury Fulminate.* Place a quantity of aqueous sodium thiosulfate (hypo) solution (20 percent by weight of sodium thiosulfate) equal to 10 times the weight of mercury fulminate to be destroyed in a wood or earthenware container. While agitating the hypo solution, add water-wet mercury fulminate. The mixture shall be agitated by air or mechanical means but not by hand. Agitation must be continued until all fulminate has been dissolved, usually within 2 hours. Operators shall keep to the windward of the container or wear gas masks to avoid inhaling any cyanogen gas evolved.

*b. Nitroglycerin.* Small quantities of nitroglycerin may be neutralized or destroyed with a mixture of the following solutions:

*Solution A.* Sodium sulfide (pulverized)—9 parts by weight and water—80 parts by weight.

*Solution B.* Denatured ethyl alcohol—70 parts by weight and acetone—20 parts by weight. Do not combine the two solutions until immediately before destroying the nitroglycerin as, after mixing

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the potency diminishes on storage. The use of this mixture should be limited to very small quantities such as the oily film that adheres to surfaces after the nitroglycerin has been removed with sponges or absorbed in wood pulp or sawdust. Operators using this solution should wear rubber gloves.

*c. Black powder.* Black powder may be completely destroyed by leaching or washing with large quantities of water and disposing of the washings separately from the residue.

*d. Lead azide.*

- (1) Lead azide accumulated on surfaces should be taken up with water wet-cloths. The cloths should then be washed out in one of the solutions named below after which the complete desensitizing treatment is carried out in the solution. The cloths should be thoroughly washed with water before reuse. Empty shipping bags while still water-wet should be turned inside out and treated. Three chemical methods are approved for destroying lead azide.
- (2) Probably the most satisfactory chemical method for destroying lead azide is the sodium nitrite-acetic acid method. For the destruction of a quantity of 1 ounce of lead azide, it should be placed in  $1\frac{1}{2}$  gallons of a 10 percent solution of ammonium acetate to which is added a solution of  $2\frac{1}{2}$  ounces of sodium nitrite in 1 pint of water. The mixture is stirred and while stirring, 7

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ounces of glacial acetic acid or its equivalent of weaker acid is added. The entire solution should be allowed to stand in a warm place for 1 hour or more before disposal.

- (3) Another method is to use sodium nitrite and nitric acid. The lead azide should be destroyed in small quantities at a time by successive treatment with a 25 percent solution of sodium nitrite and a 36 percent solution of nitric acid. Place water, then lead azide to be destroyed in a ceramic crock or other suitable container of ample size (at least 500 cc of pure water per gram of azide). Add sodium-nitrite solution and agitate carefully but thoroughly; then add the nitric acid solution slowly with continual agitation. Heat is generated during the decomposition so all additions must be made slowly. Decomposition is rapid and complete if sufficient quantities of the killing solution are employed. The resultant solution is clear. Ferric chloride solution is used to test for incomplete decomposition of the azide. A red color appears if azide is still present. Toxic fumes may be evolved during the killing reaction.
- (4) The third method is to dissolve lead azide in 10 percent ammonium acetate solution, from which the lead is precipitated with 10 percent aqueous potassium bichromate.

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This is followed by a thorough washing with water. However, this procedure may leave a sludge containing sensitive explosive material and appropriate precautions must be taken. All wash cloths or brushes used to apply ammonium acetate solution should be treated with a sodium bichromate solution.

- (5) (Added) A fourth method (preferred) is to use a 20-25 percent aqueous solution of ceric ammonium nitrate for the chemical destruction of lead azide. When small quantities of lead azide are destroyed in this manner, the reaction is not violent. Since one of the products of the reaction is a gas, the ending of the gas evolution indicates completion of destruction. This method offers the following advantages over preceding ones:
- (a) Safer to use because the chemical reaction is less violent than those involving acid,
  - (b) Residue formed is more readily disposed of than lead chromate, and
  - (c) Evolved gas acts as indicator to assure completion of the reaction.

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## SECTION 4

### LOCAL DISASTER PLAN

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#### 401. GENERAL

a. Each establishment shall prepare a local disaster plan to be followed in the event of a disaster.

b. Such a plan will establish written detailed instructions and assignments, and prescribe the duties of personnel and organizational units of the establishment in event of an incident of such serious nature as to be declared by the commanding officer to constitute a "disaster."

c. The local disaster plan should clearly define those incidents that are considered to be disasters.

d. The purpose of the plan is to reduce injury to personnel and damage to property, to maintain wholesome public relations, and to preserve all evidence pertinent to cause and effect. It should be practical, simple, easily understood, and prepared in anticipation of any predictable disaster originating either inside or outside the establishment. A local disaster plan should be coordinated with any other disaster, emergency, or defense plan of prepared action required by appropriate Department of the Army authority. It is essential that each establishment anticipate the need for coordinated action in the event of any unusual incident of purely local origin, such as fires, explosions, floods, and the like.

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#### **402. OBJECTIVES**

A local disaster plan should be formulated so that:

*a.* There is a clear allocation and designation of responsibility to each of the necessary participating units.

*b.* There is adequate and trained personnel available at all times to discharge the designated responsibilities promptly and competently.

*c.* The units activated by the local disaster plan will immediately and automatically begin to function the instant the alarm is given without waiting for orders or instructions.

#### **403. DUTIES AND RESPONSIBILITIES**

Each of the participating units shall be prepared by prior organization, training, and drill to assume specifically designated responsibilities and perform certain duties, as covered in detail in the local disaster plan and as outlined below.

#### **404. OPERATIONS CENTER**

*a.* The local disaster plan should designate an operations master control or command station where a responsible person should always be stationed as circumstances may require. He should have sufficient authority to:

- (1) Control all activities on the reservation including that portion outside of the affected area.
- (2) Make necessary major decisions.

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(3) Coordinate the activities of all units, departments, divisions, or agencies concerned in the relief of the disaster.

(4) Summon aid from outside agencies should the occasion develop.

b. An alternate operations center should be designated in case the first location is not available for use or is untenable at the time of the disaster.

#### **405. COMMAND FUNCTION AT SCENE**

Specific provision should be made for the designation of successive available personnel to discharge full command responsibility over all participating units at the scene of the disaster. Similarly, each participating unit should have clear indication of the command channels within the respective units. This designation of command responsibility at the scene is not to be confused with the over-all responsibility to be exercised by the commanding officer and when appropriate, the general manager for the operating contractor.

#### **406. COMMUNICATIONS DEPARTMENT**

The communications department should be prepared to:

a. Discontinue immediately upon receipt of initial report of disaster all telephonic communications between the installation and outside sources including telephone pay stations.

b. Notify in order: Fire department, guard department, medical department and such other participating units (and individuals in predetermined order)

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as the initial report may indicate advisable. One person should not be expected to make more than eight notifications.

*c.* Notify the commanding officer or his designated representative and, as appropriate, the general manager of the operating contractor or his designated representative.

*d.* Resume and maintain, in accordance with instructions to be issued in advance by the commanding officer, rigid control over all telephonic communications between the installation and outside sources until the necessity for such control has been terminated by declaration of competent authority.

*e.* Prepare for and provide adequate means of communication for the operations center at the scene during the disaster.

#### **407. FIRE DEPARTMENT**

The fire department should be prepared to—

*a.* Administer first aid.

*b.* Evacuate personnel from the area immediately affected.

*c.* Rescue or direct the rescue of injured or entrapped persons.

*d.* Combat any fire.

*e.* Request through command channels and utilize upon arrival the services of outside fire-fighting agencies.

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#### 408. GUARD DEPARTMENT

The guard department should be prepared to—

- a. Segregate the area immediately affected.
- b. Maintain effective control within the establishment over personnel and vehicular traffic beyond the affected area.
- c. Close all outside gates to traffic and permit access and egress only in compliance with instructions to be issued in advance by competent authority.
- d. Request, in accordance with previously completed arrangements, assistance from state and local enforcement agencies in establishing and maintaining road blocks and traffic control on highway approaches to the installation.
- e. Protect the scene from all unauthorized disturbance until all investigations are concluded.

#### 409. MEDICAL DEPARTMENT

The medical department should be prepared to—

- a. Administer appropriate treatment to injured persons.
- b. Obtain, and utilize effectively upon arrival, outside medical assistance.
- c. Check all employees from the affected area for possible injuries before they are permitted to leave the reservation. This should not unduly delay the removal to hospital of seriously injured persons.
- d. Arrange for any necessary evacuation of patients from the hospital or dispensary.

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#### **410. MAINTENANCE DEPARTMENT**

The maintenance department should be prepared to—

- a.* Start the fire pumps according to prearranged plans, and see that they function properly.
- b.* Eliminate hazards of electric, gas, and steam lines in the immediate vicinity of the incident.
- c.* Resume service at earliest moment of affected utilities.
- d.* Anticipate impairment of any utility service caused by spread of the incident and promptly advise the appropriate command authority at the scene.
- e.* Provide equipment for handling or removing heavy debris in the rescue of injured or entrapped personnel.

#### **411. TRANSPORTATION DEPARTMENT**

The transportation department should be prepared to—

- a.* Furnish immediately transportation for auxiliary firemen and guards.
- b.* Furnish, upon request, appropriate transportation to effect any necessary movement of personnel and material.

#### **412. PUBLIC RELATIONS UNIT**

The public relations unit should be prepared in accordance with existing Department of the Army directives to—

- a.* Issue immediately, and only after approval of

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the commanding officer, an appropriate preliminary statement couched in general terms containing only the then confirmed facts.

*b.* Issue at earliest practicable moment, and only after approval of the commanding officer, a complete statement of facts in accordance with current directives.

*c.* Receive, and furnish appropriate accommodations and escort for, authorized representatives of the press and radio.

*d.* Furnish appropriate information and notification to relatives and friends of positively identified casualties.

#### 413. INVESTIGATIVE UNIT

The investigative unit should be prepared to—

*a.* Have personnel available at the scene for the specific and exclusive purpose of recording all pertinent factual conditions at or immediately after the occurrence.

*b.* Contact and interview as promptly as possible all available eye witnesses in order to secure initial impressions before reflective imagination and shock have distorted the facts in mind.

*c.* Establish promptly and positively the identity of casualties.

*d.* Assist any duly appointed Board of Officers and representatives of any outside authorized investigative agencies.

*e.* Photograph pertinent exposures.

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*f.* Preserve evidence in its original condition and location as far as practicable and maintain an accurate record of continuity of handling all material which must be removed by consideration of public health and safety.

*g.* Following an explosion, locate pertinent factual conditions, casualties and results of the incident by distance and direction from the center of the explosion; and the cause of casualties as by blast, missiles, collapse of buildings, flying glass, etc.

#### **414. REQUIRED REPORTING OF LOCAL DISASTER**

The exact procedure for reporting local disasters in accordance with current Ordnance Corps directives, shall be incorporated in the local disaster plan of the establishment.

## SECTION 5

### CONSTRUCTION AND UTILITIES

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#### 501. INTRODUCTION

*c. New construction.* Each new operating and auxiliary building, and each new utility pertaining thereto, at any Ordnance establishment, shall comply with the mandatory and advisory provisions of this section and other Department of the Army regulations affecting safety. The advisory provisions may be waived in new construction only upon prior approval of the Office of the Chief of Ordnance. Each new magazine, barricade, splinterproof or bombproof shelter, or permanently-installed operational shield shall conform to plans and specifications approved by the Chief of Ordnance. Every other new building, structure, and utility, subject to approval by the Ordnance Corps or any echelon thereof, shall comply with applicable Department of the Army regulations affecting safety.

*b. Existing facilities.* Existing facilities of the classes covered above, which do not comply with safety regulations published after their construction or installation, may be exempted from the new requirements, when such action is authorized by the Chief of Ordnance.

*c. Modifications.* Modifications to existing facilities of the classes covered above, unless minor in nature and not introducing an additional hazard, must comply to the latest safety requirements.

## **502. BUILDING EXTERIORS**

Exterior wall and roof coverings of operating buildings in explosives establishments should be noncombustible. Roofs should also comply with paragraph 504b. The buildings should be without basements and not more than one story high, except where necessitated by process requirements.

## **503. FLOORS AND WORK SURFACES**

Floors and work surfaces in hazardous locations shall be constructed to facilitate cleaning and should have no cracks or crevices in which explosives may lodge. Subfloors, finished flooring, and work surfaces should not wrinkle or buckle under operating conditions. Where washing is required, surfaces must be capable of withstanding repeated applications of hot water. Nonsparking floors and work surfaces are required in all locations where exposed explosives and/or hazardous concentrations of flammable vapor or gas are present. Nonsparking floors and work surfaces must not spark when stroked vigorously with a hardened steel file. Locations requiring conductive flooring are specified in paragraph 705. When grounding is necessary, the provisions of para-

graph 702 apply to work surfaces. Cove bases at the junction of walls and floor are recommended. Exposed nails, screws, or bolts in work surfaces must be avoided.

#### 504. INTERIOR WALLS, ROOFS, AND CEILINGS

a. Interior surface finishes of explosives operating buildings should be of smooth, fire-retardant material, free from cracks and crevices, have joints taped or sealed and, if painted, be covered with a hard gloss paint to facilitate cleaning and to minimize the impregnation of finished wall and ceiling material

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**with explosives.** Horizontal ledges which might hold dust shall be avoided or be beveled.

b. Roofs and walls, except of **earth-covered magazines and containment type structures**, shall be as light in weight as practicable (weak) and so constructed and supported that they will vent an internal explosion with the formation of a minimum of large missiles. Exception is made in the case of fire walls (par. 505) and substantial dividing walls (par. 506).

### **505. FIRE WALLS**

Fire walls are designed to prevent the spread of fire from one side to the other. The design and construction of fire walls will vary with the type of construction of the building and the occupancy. For the types of construction commonly encountered, fire walls should extend through the roof and walls of the buildings as required by the manual cited below. In future construction, fire walls not winged beyond the walls of a building of frame construction should be returned on the faces of the building 10 feet from the centerline of the wall in both directions. Exterior sheathing and siding should butt against the masonry return and should not run continuous over its face. The minimum and detailed requirements for approved fire walls given in the Engineering Manual for Military Construction, Corps of Engineers, must be followed.

Openings in fire walls shall be held to a minimum and those necessary shall be protected in accordance with the requirements of National Board of Fire Underwriters' Pamphlet No. 80, "Protection of Openings in Walls and Partitions Against Fire."

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## 506. SUBSTANTIAL DIVIDING WALLS

Substantial dividing walls separating two independent concentrations of HE are considered an effective means for preventing the "simultaneous" detonation of the HE on both sides of the wall when the destructive force produced by the detonation of the concentration on either side of the wall does not exceed those forces which would be produced by 5,000 pounds (net) of HE. In this connection, if the total quantity of explosives located on one side of the dividing wall exceeds 5,000 pounds the criteria for maximum permissible concentration are considered to be satisfied if this larger quantity is subdivided into smaller quantities which, if initiated, will not involve independent explosions greater than 5,000 pounds of HE. If the explosives on both sides of a substantial dividing wall are prevented from exploding "simultaneously," the purpose for which the wall was provided will have been accomplished, even though the wall may be demolished in the process and structural damage in the plant may be severe. Under these conditions the quantities separated by a substantial dividing wall need not be added together for the purpose of quantity-distance computations (par. 1708). Stacks of explosives material should be kept at least 3 feet from these walls. A substantial dividing wall shall extend to the roof and should extend to the sidewalls of the space which is divided into separate rooms. It shall be constructed in one of the following forms:

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a. Reinforced concrete not less than 12 inches thick. Concrete and reinforcing steel shall be as shown on drawings approved by the Chief of Ordnance. Both faces shall be reinforced with rods at least one-half inch in diameter, spaced not more than 12 inches on centers horizontally and vertically, interlocked with the footing rods and secured to prevent overturning. Rods on one face shall be staggered with regard to rods on the opposite face, and should be approximately 2 inches from each face. Concrete should have a design compressive strength of 2,500 p. s. i. and should meet Corps of Engineers' specifications.

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b. Five-foot thickness of packed earth or sand, held between concrete, masonry or wooden retaining walls.

c. Six-foot thickness of sandbags (least desirable except for strictly temporary operations).

### 507. BUILDING EXITS

In small rooms or cubicles having substantially constructed walls on three sides and occupied by not more than two persons only one properly located exit is required. Otherwise at least two exits shall be provided for each operating room or building containing explosives and other materials which constitute a serious hazard to operating personnel. Exits should be at least 30 inches wide and located at opposite ends or sides of the area involved. They must be so located that each operator is between the explosives hazard and an exit. The path of travel from the work place should be unobstructed. Rooms in which more than eight persons are employed should be provided with one additional exit for each five additional employees or portion thereof. In determining the total number of exits required where exit widths exceed 30 inches each 30 inches of width may be considered one exit. It is desirable to have exits equally spaced about the perimeter of the building with no employee more than 25 feet from the nearest exit. Exit should be to the outside wall of the building rather than into a hallway or another room.

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### 508. DOORS

Exit doors in operating buildings shall open outward and during operating hours shall not be fastened with locks other than antipanic catches or other quick-releasing devices. Exit doors shall not be obstructed. Exit doors in buildings containing explosives, except storage magazines, should be casement type doors in pairs and glazed with non-shatterable plastic material such as "Lumapane" or "Cello-Glass." In no case should the opening be less than 2 feet 6 inches wide by 6 feet 6 inches high. All interior doors should open in the direction of flow of material through the building and should open upon unobstructed passageways. Exit doors or platforms upon which exit doors open which are 4 feet or higher above the ground shall be provided with safety chutes, ramps, or stairways with handrails. Doors opening on to ramps or passageways shall be designed for rapid exit.

### 509. SAFETY CHUTES

a. Safety chutes shall be provided as exits from hazardous locations where rapid egress is vital and cannot be otherwise obtained. Safety chutes normally are required for multistoried buildings and

shall be provided for work levels above the ground floor. Safety chutes should be located on opposite sides of the hazardous operation where practicable to reduce the likelihood of personnel being trapped by fire between them and a single chute. Exit to safety chutes must open on a platform not less than 3 feet square equipped with guardrails. The chutes shall begin at the outside edge of the platform and not at the edge of the buildings. Landings from safety chutes should be located at selected places which shall lead directly to escape routes free from tripping hazards, low guy lines, drains, ditches, or other obstructions. Manually or automatically controlled trips should be installed at or near the entrance to chutes to give an alarm in the operating building and in nearby structures; this device may also actuate deluge valves and water curtains in the building or room effected.

*b.* Recommended safety chute dimensions and construction are: Angle  $40^{\circ}$ - $50^{\circ}$  with the horizontal; depth of chute, 24 inches; radius at bottom of chute, 12 inches. The lower end of the chute must not be over 24 inches above the ground. If necessary, the end of the chute must have a horizontal run sufficient to prevent an injury to the employee because of speed of exit without the use of landing cushions which are unsatisfactory in cold weather. In general, chutes less than 15 feet long require no horizontal run, those 40 feet long require 6 feet of horizontal

run. The juncture of the two sections must be well rounded. The sheets of metal of which the chute is constructed must overlap in the direction of travel.

## **510. EMERGENCY EXITS AND FIRE ESCAPES**

a. The requirements of the latest edition of the ASA Building Exits Code should be used as a guide for the necessity, design, and construction of emergency exits and fire escapes. Provision of emergency exits, including safety chutes for explosives operating buildings, shall not be less than the requirements of paragraphs 507, 508, and 509.

b. Exterior fire escapes shall be of noncombustible material and should be located at a section of the wall not containing windows. Supporting members for safety chutes may be of wood. Windows or doors in proximity to the fire escape, and from which flames may reach escaping personnel, should be glazed with wire glass except in explosives operating buildings where the glazing should consist of relatively nonshatterable plastic materials such as "Plexiglas," "Lumapane," or "Cello-Glass." Fire escapes and stairways having four or more risers shall have handrails.

## **511. STAIRWAYS**

Stairways, four or more risers in height, must be provided with handrails. Open risers should

be avoided. Where stairways exist in an explosives building or in one where a dangerous fire hazard exists, handrails must be 42 inches high to preclude falls when vision might be impaired by injury or when panic might result. Risers should not exceed 7 inches and treads should be at least 10 inches wide exclusive of projections. In other cases, stair handrails shall be between 30 and 34 inches high. Long stairways should be provided with landings. Maximum height between such successive stair landings should not exceed 12 feet. The installation of winding or "spiral" stairways should be avoided. For a rise of less than 20°, an incline or ramp should be used. For a rise between 20° and 50°, stairways are required. Landings should be the same width as stairways and not less than 3 feet 6 inches in length.

## **512. FIXED LADDERS**

a. Fixed ladders should conform to the latest edition of ASA Safety Code for Construction, Care and Use of Ladders.

b. Fixed ladders erected in areas in which a stairway cannot be constructed may be of wood or steel. Where fixed ladders exceed 20 feet in height, a cage or basket guard (beginning not more than 8 feet above grade) or other acceptable device to prevent falling shall be provided. The ladder must have a minimum back clearance of

30 inches, minimum front clearance of 6½ inches, and a minimum side clearance of 15 inches measured from centerline. Side rails of permanent ladders should extend 3 feet 6 inches above landings. Landings or platform space should not be over 16 feet apart vertically. Where a ladder inclines more than 1 foot in 6 feet, it should be replaced with a stairway.

### 513. PLATFORMS, RUNWAYS AND RAILINGS

a. Platforms, runways, and railings should be in conformity with the latest edition of ASA Safety Code for Floor and Wall Openings, Railings and Toe Boards.

b. Platforms, runways, and railings must be of first-grade materials and constructed in a substantial manner. Platforms and runways less than 30 feet long require one stairway or fixed ladder; those over 30 feet long or more than 250 square feet in area require two stairways or ladders.

c. Platforms or runways around open tanks should be built at least 3 feet 6 inches below the top of tanks unless a railing 42 inches above the platform floor is provided around the top of the tank. Platforms, floor openings, runways, tanks, or open vats with tops which are less than 3 feet above the floor of the building, platform, and other places where the hazard can be minimized by a railing, must be guarded by suitable railings

consisting of handrails, midrails, and toeboards. Toeboards are not required on platforms or runways around tanks or vat tops which are 6 inches or more above the floor of the buildings, platform, or runways.

*d.* Permanent railings should be of metal except in those process buildings where metal railings would increase the hazard.

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#### **514. PASSAGEWAYS**

If weather-protected passageways (ramps) for communication between buildings or magazines are constructed, these passageways should be provided with suitable fire-stops between the buildings in order to interrupt a fire in its progress through the passage.

#### **515. ROADS AND WALKWAYS**

Good all-weather roads should be provided. Road systems serving groups of magazines or explosives buildings shall be arranged without dead ends in order that motor vehicles carrying explosives cannot be isolated. Interconnection roads for magazine service roads, to prevent dead-ending, need only be passable trails, adequate to accommodate the typical vehicles employed at the installation. Roads serving a single magazine or explosives processing building (including its service facilities) may dead-end at the magazine or building. The road system should be designed to eliminate the necessity for passing through an intermediate explosive area in traveling from one area to another. Walkways and roads at the entrances to or between adjacent buildings containing explosives shall be hard surfaced or boardwalks, installed to prevent employees from tracking stones, grit, and other foreign material into operating buildings. These walkways and roads should be kept free from foreign material. Foot brushes, door mats, and/or scrapers should be provided at all explosives building entrances except magazines. Special attention shall be given to passageways, walkways, stairs, etc.,

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which have been subjected to the effects of inclement weather (e. g., ice and snow).

#### 516. WINDOWS AND SKYLIGHTS

a. Since inhabited building distances do not protect against the hazards of flying glass, it is necessary in laying out and designing buildings of the administration area, shops, and other areas in relation to explosives area, that windows and large areas of conventional glass are located in directions other than those facing buildings in which explosives are manufactured, processed, handled, or stored even though the buildings may be separated by inhabited building distance requirements. "Lumapane," "Cello-Glass," "Plexiglas," or similar relatively nonshatterable plastic material may be used as glazing materials where there is danger of an explosion causing injury from falling or projected glass. Where glazing with conventional glass is in use, the danger of falling and projected glass is present and should be anticipated. The hazard may be reduced by covering such glass with wire mesh screening properly fixed in position on the inside.

b. Windows in buildings in which mild explosion hazards exist should be large in area to provide for release of pressure in the event of an explosion, and the frame or sash should be of a suitable venting type. Nonshatterable type glazing is recommended.

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c. Skylights shall not be used in buildings where explosives or ammunition are processed. Skylights should not be used in other buildings in an explosives establishment.

#### **517. DRAINS AND SUMPS**

a. All drain lines handling explosive wastes shall be provided with sumps or basins of adequate design and capacity for the removal of explosives by settling. The drains shall be of adequate capacity, free of pockets and shall have sufficient slope (at least one-quarter inch per foot) to prevent settling out of explosives in the drain line until it reaches the sump or settling basin where the explosives are to be collected. Sumps must be designed so that suspended and settleable solid explosive material cannot be carried in the wash waters beyond the sumps. The design shall allow sufficient settling time based upon the settling rate of the material and the usual rate of flow. The sump shall be constructed so that the overflow will not disturb any floating solids. The design must also permit easy removal of collected explosives, and for retention of those explosives which float on water until they can be skimmed off. Bolted sump tanks or other types of construction that permit the explosives to settle in obscure or hidden spaces are prohibited.

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b. Care must be taken to avoid the possibility of deposition of explosives from sump effluent due to drying, temperature changes or interaction with other industrial contaminations. When explosives which are appreciably soluble in water are handled, sweeping and other dry collecting measures shall be used to keep them out of the drainage system.

c. In all new construction subsequent to the date of this manual, drains between the source of explosive and the sump shall be troughs with rounded bottoms and with removable ventilated covers to facilitate inspection for accumulation of explosives. Waste liquids shall not be run into closed drains and sewers. Drains shall be inspected periodically and necessary steps taken to prevent the buildup of explosive deposits in them. Drains and sewers containing explosive waste materials must not be connected in a manner to empty such wastes into the normal sewage systems carrying inert or sanitary wastes.

### 518. HARDWARE

a. Hardware in buildings containing exposed explosives materials, explosive dusts or vapors should be nonsparking material.

b. Fasteners such as nuts and bolts, which are located so that accidental entry into explosives or explosive constituents is possible shall be securely held in place by being drilled and thonged or otherwise secured.

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### **519. TUNNELS**

Whenever tunnels are used, they shall be drained, adequately ventilated, well lighted, and preferably, provided with at least two exits. Water and steam service lines in tunnels shall be properly lagged with suitable insulation. Tunnels between buildings containing explosives shall be designed and constructed with special consideration given to the shock wave and blast to prevent possible communication of an explosion. All personnel except those required to do so shall be prohibited from entering the tunnels.

### **520. POWERHOUSE EQUIPMENT**

Powerhouse equipment, boilers, engines, and auxiliary equipment are installed in compliance with the A. S. M. E. Boiler Code, the A. S. M. E. Code for Unfired Pressure Vessels, the National Electrical Code

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and such other applicable codes, regulations, or standards as are recognized as standard good practice. Inspections are made in conformance with current directives.

#### **521. REFRIGERATION PLANTS**

Installation and equipment in refrigeration plants should be in accordance with the requirements of the American Standard B9-1939 Safety Code for Mechanical Refrigeration.

#### **522. LAUNDRIES**

Plants operating laundries should have facilities for washing and flameproofing uniforms where such clothing is in use. Where uniforms and rags which are contaminated with explosives are to be laundered, the facilities shall include a safe storage place for contaminated clothing prior to washing, and also sumps for the removal of explosives from waste water. Testing facilities should be provided to check the complete removal of the contaminant particularly when insoluble toxic substances are involved. Commercial concerns laundering such articles shall be informed of the nature of the explosives' contamination and dangerous chemical reactions therewith. These commercial concerns should have the facilities listed above.

#### **523. STEAM FOR PROCESSING AND HEATING**

Steam used for heating operating buildings containing explosives shall have a maximum pressure of

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5 psi (228° F.). Where necessary, process steam may exceed 5 psi but shall not exceed 15 psi. **Process steam is that which is in direct contact with explosives, used directly in the manufacture of explosives, or that which in case of equipment failure would exhaust directly into contact with explosives or explosive fumes.** The exterior of steam or hot water pipes in contact with wood, paper or other combustible materials shall not exceed 160° F. (71° C.). Where steam temperatures must exceed 228° F., in hazardous locations, steam lines shall be covered and painted with an impervious material or otherwise protected against contact with explosives. Where a reducing valve is used, a relief valve should be installed on the low pressure piping. The production of superheated steam which results from the throttling action of reducing valves must be prevented by positive means. The use of a "water leg" or water column for control of steam pressure of 5 pounds or less is recommended. Where close control of steam temperature is necessary, indicating and recording pressure or temperature gages should be installed. Such devices should be periodically tested and the test results recorded. Where resistance to ground is high, steam lines should be properly grounded where they enter buildings.

#### **524. SANITARY FACILITIES**

a. Distribution of sanitary fixtures depends upon local requirements. Shower baths, lavatories, and toilets should be provided as outlined in section 11.

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The establishments should have sufficient sewer and waste disposal systems to which all sanitary fixtures and appliances are connected.

b. Drinking fountains should be provided in selected locations as required. The fountains must comply with modern sanitary standards as outlined in section 11.

### 525. VENTILATION

a. Buildings where dust, fumes, or vapor are formed shall be adequately ventilated, preferably at the source of the hazard. Exhaust fans through which combustible dust or flammable vapor pass shall be equipped with nonferrous blades (or casting lined with nonferrous material) and approved motors. The entire ventilating system shall be bonded electrically and grounded properly. NBFU Pamphlet 91, "Standards for the Installation of Blower and Exhaust System for Dust, Stock and Vapor Removal or Conveying," may be used as a guide in the installation of such systems. When buildings are air conditioned (see below), or forced air inlet is provided for buildings in which there is explosives dust, air exhaust should be provided since the system should be balanced to give a slight negative pressure within the building. Assistance of Army Environmental Health Laboratory may be requested, when necessary, on these related problems.

b. Air conditioning equipment should be installed in accordance with the requirements of NBFU Pamphlet 90, "Air Conditioning, Warm Air Heating,

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Air Cooling and Ventilating System." Exhaust systems shall be cleaned thoroughly, serviced on a regular schedule and a log maintained.

## **526. FUELS FOR HEATING AND POWER BOILERS**

(Added)

a. Fuel oil, coal, natural or manufactured gases, and liquified petroleum gases may be used in both explosives and inert areas at Ordnance installations. Fuel oil is preferred.

b. All of the above fuels introduce certain hazards when used in explosive areas (and, to a lesser extent, in inert areas). Incandescent particles which are capable of starting fires in many combustibles may be exhausted from boilers fired with any of the fuels. Since particles from a coal fire are likely to retain their incandescence longer than those from oil or gas fires, this hazard is more severe when coal is used. In addition, abrasive particles are exhausted from coal fires and may remain airborne for considerable distances. If these abrasives become mixed with explosives, the sensitivity of the explosives may be increased. Liquified petroleum gases escaping from pipelines and storage tanks as a result of leaks or ruptures rapidly revert to their gaseous states. These gases spread rapidly and, being heavier than air, seek low levels such as depressions, drains, tunnels, etc. When initiated, these gases burn with explosive violence. Initiation at any point is likely to cause all the escaped gases to become involved. The hazards inherent to the use of natural and manufactured gases

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are of the same type as those from liquified petroleum gases, however, those from liquified petroleum gases are more severe.

c. Paragraphs 1705c and 1711 specify the siting requirements for boilerhouses in explosives areas. Fuel storage for these boilerhouses should be located at least 50 feet from the boilerhouses and should not be closer to the explosives facilities than are the boilerhouses.

## 527. SAFETY REVIEW OF CONSTRUCTION PLANS

(Added)

a. General plans for new construction or major modification (i.e., modification costing \$10,000 or more) of the following types of facilities shall be forwarded through command channels to the Chief of Ordnance for safety review and approval, at least 1 month prior to completion of detailed plans or initiation of any construction work or contractual obligation:

- (1) Facilities for ammunition and explosives activities.
- (2) Facilities for activities involving hazardous materials other than ammunition and explosives.
- (3) Facilities for activities not involving hazardous materials which would be exposed to such hazards if not properly located.

b. The term "major modification" does not include rehabilitation of an existing standby facility in preparation for the handling of materials or

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operations which the facility was originally designed to house.

c. Plans forwarded should contain, as a minimum, the following information:

- (1) Distances between the facility to be constructed or modified and other installation facilities, the installation boundary, public railways, and public highways.
- (2) Identification of all other facilities within inhabited building distance of the facility to be constructed or modified, with a brief description of the nature of occupancy of the former.
- (3) General type of ammunition, explosives, or other hazardous materials to be in the new or modified facility.
- (4) Explosives limits for the new or modified facility, including a breakdown by room or bay when appropriate.
- (5) Types and quantities of ammunition, explosives, or other hazardous materials in facilities located within inhabited building distance of the new or modified facility.
- (6) Personnel limits for the new or modified facility, including a breakdown by room or bay when appropriate.
- (7) Construction details regarding substantial dividing walls, vent walls, fire walls, roofs, operational shields, barricades, exits, and types of floor finish, as well as general materials of construction.

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- (8) Information relative to the type and arrangement of explosives operating equipment, fire protection system installations, electrical systems and equipment, heating systems and equipment, ventilation systems and equipment, hazardous wastes disposal systems, lightning protection systems, and static grounding systems.
- (9) Explanation of any deviations from published safety standards due to local conditions.

*d.* The above instructions provide solely for required safety review and approval. They do not affect other regulations or procedures for obtaining authority for construction or rehabilitation of facilities.

SECTION 6  
ELECTRICAL EQUIPMENT AND WIRING

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601. NATIONAL ELECTRICAL CODE REQUIREMENTS

*a.* The National Electrical Code, developed mainly by the National Fire Protection Association and published by them as National Fire Codes, volume V, has been adopted as regulations by the National Board of Fire Underwriters and issued as Pamphlet 70. It has also been approved and published by the American Standards Association.

*b.* The National Electrical Code is now widely accepted as giving the minimum requirements for electrical equipment itself and for the installation of electrical equipment to safeguard persons and property from electrical hazards.

*c.* Electrical equipment used in Ordnance establishments, and the installation of it, shall comply with the requirements of the latest edition of the National Electrical Code as a minimum. In certain cases, such as those occupancies involving explosives, it may be necessary to exceed the requirements of the code, in order that electrical installations will not create an undue

hazard. Electrical installations in explosives buildings at Ordnance establishments shall also comply with the requirements of this manual.

## 602. APPROVED EQUIPMENT

Electrical equipment listed by the Underwriters' Laboratories for use in ordinary locations and for use in hazardous locations or approved by other recognized testing agencies is acceptable to the Office of the Chief of Ordnance when used for the conditions of operation intended. Approval of the Office of the Chief of Ordnance shall be secured prior to placing in service any electrical equipment not specifically approved for the purpose or for the conditions of operation, intended by a recognized testing agency, or not specifically authorized by this manual.

## 603. DEFINITIONS

The following terms are used in this manual with the meaning indicated:

a. *Dustproof.* Dustproof means so constructed or protected that an accumulation of dust will not interfere with its successful operation.

b. *Dusttight.* Dusttight means so constructed that dust will not enter the enclosing case.

c. *Equipment.* A general term including apparatus, appliances, devices, wiring, fixtures,

fittings, material, and the like, used as a part of or in connection with an electrical installation.

*d. Explosionproof.* The term explosionproof as used in connection with electrical equipment means enclosed in a case which is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of the

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specified gas or vapor surrounding the enclosure by sparks, flashes, or explosions of the gas or vapor within.

*e. Hazardous locations.*

(1) Hazardous locations, as defined in the National Electrical Code, are divided into three classes as follows:

(a) Class I are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Rooms or buildings containing vapors from which explosives may condense shall be considered as class I hazardous locations as defined in the National Electrical Code.

(b) Class II are those which are hazardous because of the presence of combustible dust. **Rooms or buildings containing explosives dusts or explosives which are of such chemical composition or physical size that through movement, handling, or other means, particles of the explosives may become disassociated from the whole and become dispersed in the surrounding atmosphere, either through normal or unusual means shall be considered as class II hazardous locations as defined in the National Electrical Code**

(c) Class III are those which are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspen-

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sion in air in quantities sufficient to produce ignitable mixtures.

- (2) Each of the above three classes is divided into two divisions, depending on the degree of hazard within the class, viz., division 1 (the more hazardous) and division 2 (the less hazardous).
- (3) Equipment for use in hazardous locations, class I, as defined in the National Electrical Code, is tested by the Underwriters' Laboratories with respect to safety of operation in the presence of flammable mixtures of specific vapors or gases with air as follows:
  - (a) *Class I.*
    1. *Group A.* Atmospheres containing acetylene.
    2. *Group B.* Atmospheres containing hydrogen or gases or vapors of equivalent hazard, such as manufactured gas.
    3. *Group C.* Atmospheres containing ethyl ether vapors, ethylene or cyclopropane.
    4. *Group D.* Atmospheres containing gasoline, petroleum, naphtha, benzine, butane, propane, alcohols, acetone, benzol, lacquer, solvent vapors, or natural gas.
- (4) Equipment for use in hazardous locations, class II, as defined in the National Electrical Code, is tested by the Underwriters' Laboratories with respect to safety of operation in the presence of combustible dusts in air, as follows:

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(a) *Class II.*

1. *Group E.* Atmospheres containing metal dusts, including aluminum, magnesium, and their commercial alloys.
  2. *Group F.* Atmospheres containing carbon black, coal, or coke dust.
  3. *Group G.* Atmospheres containing flour, starch, or grain dusts.
- (5) In those locations which are both class I and class II hazardous locations, equipment shall bear the label of approval of the Underwriters' Laboratories for both class I and class II hazardous locations. The installation of it shall comply with the National Electrical Code requirements for class I, division I, hazardous locations.
- (6) In connection with hazardous locations, the following will be of interest:
- (a) Motors for class I, groups C and D locations, and classified as "explosion-proof motors for operation in flammable gas atmospheres" are built on the wide-flange principle. These motors are not gastight but the long, machined metal-to-metal joints between shaft and flange are relied upon to cool the flame of an internal explosion below the ignition temperature of the surrounding gases. Conduit box is independently explosion-proof, terminal leads are sealed with

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approved sealing compound, and fan (where required) is of nonsparking alloy.

(b) Motors for class II, group E, F, and G locations, classified as dust-tight motors for operation in a combustible dust atmosphere depend for safety not on the wide flange principle but on dust tightness accomplished by special shaft seals of extremely close fit. Conduit box is of dust-tight construction, terminal leads are sealed for dust-tightness with approved sealing compound and fan (where required) is of nonsparking metal. Examination of the differences in the essential construction features of these two classes of motors should make it evident that motors designed and listed for class I (flammable gas atmospheres) may not be suitable for class II (combustible dust atmospheres). Neither are motors manufactured for one group under either classification necessarily suitable for hazards specified under other groups in the same classification. As an exception to this general warning and remembering that the alphabetical listing of hazards is with the most extreme hazard first, a class I, group C, motor would be regarded by most inspection authorities safe for operation in class I, group D, atmospheres (but not vice versa) and a

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class II, group E motor would be likewise safe in higher lettered atmospheres in this classification.

- (c) It is furthermore important to note that all totally-enclosed and totally-enclosed fan cooled motors approved for class I and class II locations are suitable for outdoor operation except where flooding, heavy ice formation, or other extreme conditions may occur. The same regulations apply on the acceptability of motors, generators, converters, and any other rotating electrical equipment manufactured to operate on either direct or alternating current.

*f. Portable appliance.* An appliance capable of being moved readily where established practice or the conditions of use make it necessary or convenient for it to be detached from its source of current by means of flexible cord and attachment plug.

*g. Proof (used as a suffix).* Apparatus is designated as splashproof, dustproof, vaporproof, etc., when so constructed, protected, or treated that its successful operation is not interfered with when subjected to the specified material or condition.

*h. Tight (used as a suffix).* Apparatus is designated as watertight, dusttight, vaportight, etc., when so constructed that the enclosing case will exclude the specified material.

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*i. Vaporproof.* Vaporproof means so constructed or protected that the equipment will operate successfully in an atmosphere containing vapor.

*j. Vaportight.* Vaportight means so enclosed that vapor will not enter the enclosure.

#### **604. LOCATION**

In planning electrical equipment for special occupancies, or for hazardous locations as defined in the National Electrical Code, it is often possible to locate much of the equipment in less hazardous or in nonhazardous areas and thus reduce the quantity of special equipment required and decrease the hazard. This item shall be considered in the layout of electrical installations in Ordnance establishments.

#### **605. SPECIAL OCCUPANCIES**

*a.* On Ordnance establishments, electrical equipment and installations in hazardous locations class I, II, or III, as defined in the National Electrical Code, shall in all cases comply with the requirements of the code for division 1. Division 2 requirements are not considered to provide adequate protection against electrical hazards to personnel and property.

*b.* When electrical equipment is installed in those areas which fall within the category of both class I and class II hazardous locations as defined in the National Electrical Code, the equipment shall be approved for use in both locations and the installation shall be in accordance with the requirements for class I hazardous locations.

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c. Special requirements for electrical equipment and installation in certain specific processes such as "paint spraying," "dip tanks" and "infrared ray paint drying" will be found in other sections of this manual.

d. Many Ordnance establishments will have need of installing electrical equipment not only in ordinary locations and in hazardous locations as defined in the National Electrical Code, but also in special occupancies not specifically covered by the code. The kind of electrical equipment and the installation requirements in many such occupancies are specifically covered in this manual.

#### **606. MAINTENANCE**

a. The National Electrical Code requirements for the construction of equipment and for installation in hazardous locations are based on safe performance under conditions of proper use and maintenance. Ordnance establishments shall, therefore, exercise more than ordinary care with regard to maintenance of electrical installations in hazardous locations.

b. Electrical equipment and installations in hazardous locations shall be inspected and maintained periodically by qualified personnel. A written record of the inspections and of the maintenance work performed shall be kept.

#### **607. WORKING LIVE OR "HOT" CIRCUITS**

(Superseded)

a. In some cases of commercial practice, energized

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electrical lines and equipment are worked due to inconvenience to the consumer as a result of shutdowns. In general, the inconveniences must not be considered causes for "hot" circuit work at Ordnance installations. In cases of critical processes and operations where alternate power sources are not available, it may become necessary to perform emergency work on energized circuits. Such work is authorized. When emergencies do not exist, electrical circuits must be disconnected, properly grounded and proven to be deenergized, except as outlined below, before work is performed. Where personnel are to work deenergized circuits which are in close proximity to energized circuits, rubber blankets or other suitable equipment shall be used for protection from the hot circuits.

b. Following is a list of "hot" circuit operations and conditions under which they may be performed:

(1) Whenever necessary, telephone circuits and other circuits of the same or less voltage may be worked while energized.

(2) Electrical equipment or devices may be tested or worked on while energized, provided the desired results cannot be accomplished with the circuits dead. The following precautions must be taken when such work is to be done:

(a) Two persons must be present at all times while work is being performed on energized circuits. The second person will

stand clear, ready to render assistance in case of accident.

- (b) The person working on or testing the live equipment must wear rubber gloves of approved type, or use insulated tools or high voltage probes, stand on rubber mats or dry wood boards, stay clear of all grounded surfaces, conductors, radiators, water pipes, etc.
- (c) Work on energized electrical service circuits may be accomplished when deenergizing the circuits would result in serious interruptions of work when specifically authorized by the commander or a duly appointed representative such as the Post Engineer and when proper tools, equipment, and techniques are used. **There must be an approved SOP (par. 1625).** Proper tools and equipment include: rubber gloves, rubber blankets, and hot sticks.

## 608. REPAIRS

Unauthorized employees shall not make changes in, or tamper with electrical equipment. Repairs and changes shall be made only by qualified persons authorized to do such work. Where the equipment may have been exposed to contamination from explosives, the explosives must

to be removed or neutralized before repairs are started.

#### 609. ALTERNATE POWER SOURCE

In any explosives operations where a continuous supply of power is required, the lack of which may cause a fire or explosion, provisions shall be made for an alternate source of power.

#### 610. TRANSMISSION LINES

Primary and secondary overhead transmission lines in explosives areas shall not be located closer to buildings containing explosives than the height of the pole carrying the lines, but in no case closer than 50 feet. Lightning arrestors should be installed to protect

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electric services entering buildings as required by the latest edition of the National Electrical Code.

#### **611. BUILDING SERVICES**

For future installations each light service and each power service to explosives buildings shall be run for the last 50 feet underground. Service to inert buildings may be overhead. The line side of the main disconnecting switch or circuit breaker shall be provided with suitable lightning arrestors.

#### **612. MOTORS**

Electrical motors preferably should not be installed in rooms or buildings which are either class I or class II hazardous locations. They should be located outside of the room or building with no connection to the process building except through mechanical glands or apertures adequately sealed against entrance of hazardous materials into both the location where motors are positioned and the motor inclosure itself. Where it is essential to mount electric motors within rooms containing explosives, they shall meet the requirements for class II hazardous locations. See paragraph 603e.

#### **613. MOTOR CONTROLS, CIRCUIT BREAKERS AND SAFETY SWITCHES**

a. Motor starters, circuit breakers, safety switches, service entrance switches, and speed controllers should preferably be installed on steel racks as follows:

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- (1) At a distance from the exterior building wall as specified in later sections of this manual for the particular risk of hazard involved.
- (2) In separate buildings with no connection, except electric conduits, between the small building housing the control equipment and the buildings containing the electrical equipment for hazardous locations. Such conduits shall be provided with sealing fittings to prevent possible communication of flame or arcs from the starters to the hazardous area.
- (3) On the outside wall of the building considered a hazardous location.

b. The above rules shall be complied with in accordance with the instructions for specific risks where construction of new facilities is authorized. It is not considered necessary to change electrical control equipment located in existing manufacturing and loading buildings when such equipment bears the label of approval of the Underwriters' Laboratories, or other approved testing agency, for the risk involved and when conduit installation and grounding comply with article 500 of the latest edition of the National Electrical Code.

c. (Revised) Limit switches, pressure switches, float switches, and any other control device which for practical operating reasons cannot be located outdoors shall be approved by Underwriters' Laboratories, or other approved testing agency. Elec-

trical conduit connections to such equipment shall comply with the requirements of the latest edition of the National Electrical Code for the specific hazard.

*d.* The primary electric supply to an entire explosive area shall be so arranged that it can be cut off by switches located at one or more central points away from the area.

#### 614. LIGHTING

*a.* It is preferred that lighting installations (including panelboards, wiring and fixtures) not be located in rooms or buildings containing dusts from explosives or flammable vapors or combustible dusts which may form explosive or flammable mixtures with air. When for practical reasons such installations are necessary, the equipment or device must be approved for use in classes I or II hazardous locations, and shall be dual rated if both hazards exist. Where the interior of a building or room is to be illuminated from the outside, the light should shine through approved transparent panels, set in the wall and designed to prevent explosives from coming in contact with the lighting fixtures.

*b.* Lighting fixtures in atmospheres containing explosive dust must not exceed a maximum surface temperature of 228° F. (109° C.) when operating at an ambient temperature of 80.6° F. (27° C.). The clamping ring which secures the

lens to the fixture body shall be designed without external bolts. No parts of the fixture shall contain horizontal flat surfaces or projections which may collect dust.

#### **615. MAGAZINE LIGHTING SYSTEM A**

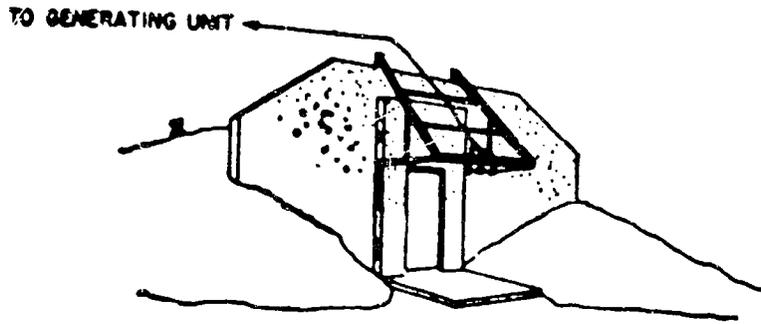
This system of interior lighting is shown in figure 615. The support consists of a hook frame hanging from the top of an igloo type or above-ground type magazine. The frame is sturdy enough to support a ladder placed against it to enable adjustment or replacement of lights. A weatherproof and dust-tight unit with a diffusing lens, approved class II unit, shall be used. Two-hundred-watt lamp bulbs, one in each of the three floodlight fixtures, provide ample and efficient illumination within the structure. A 12- by 12-foot tarpaulin spread over the top of the frame provides suitable protection not only to the floodlight units but to personnel, permitting loading or unloading operations during inclement weather.

#### **616. MAGAZINE LIGHTING SYSTEM B**

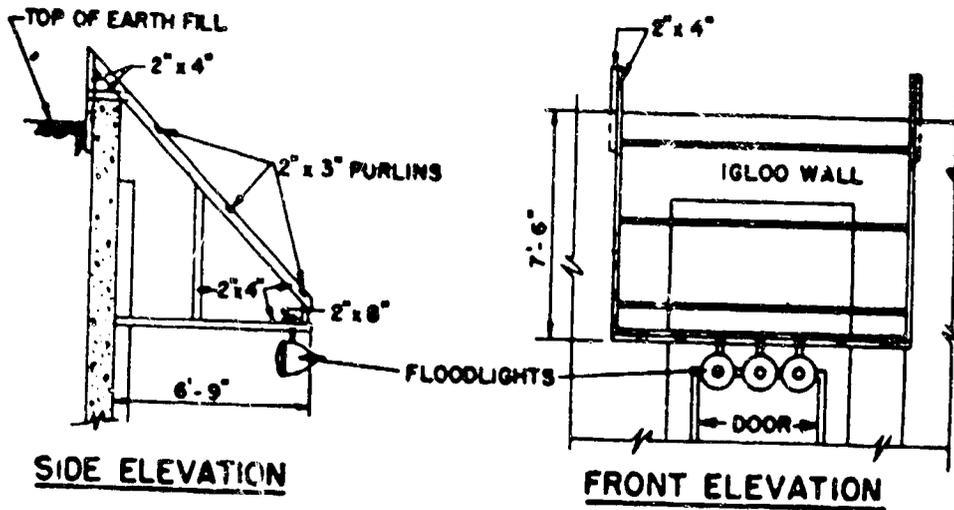
*a.* This system is shown in figure 616. It accommodates three floodlights as in system A above. The floodlights, when attached to the bracket in the igloo type or aboveground type magazine, can be focused to make the light direction or refocusing unnecessary as loading or unloading progresses. In this system a permanent

conduit connection is made through the front wall of the structure with the approved fitting shown on the drawing on both ends of the conduit. When required, each floodlight unit is plugged in on the inside of the building and the power supply plugged in on the outside. The attachment plug on the power supply cable on the out-

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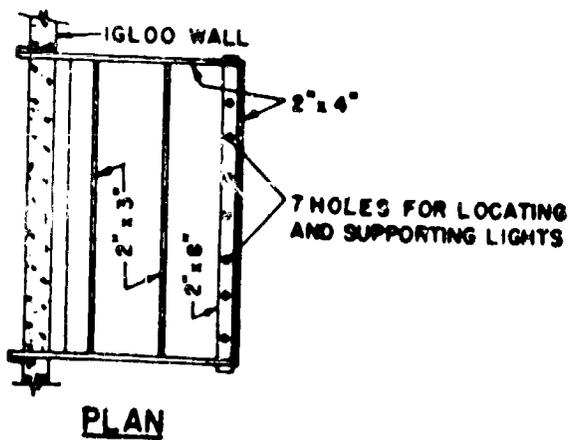


PERSPECTIVE VIEW



SIDE ELEVATION

FRONT ELEVATION



PLAN

Figure 615. Interior Lighting of Igloos—System A.

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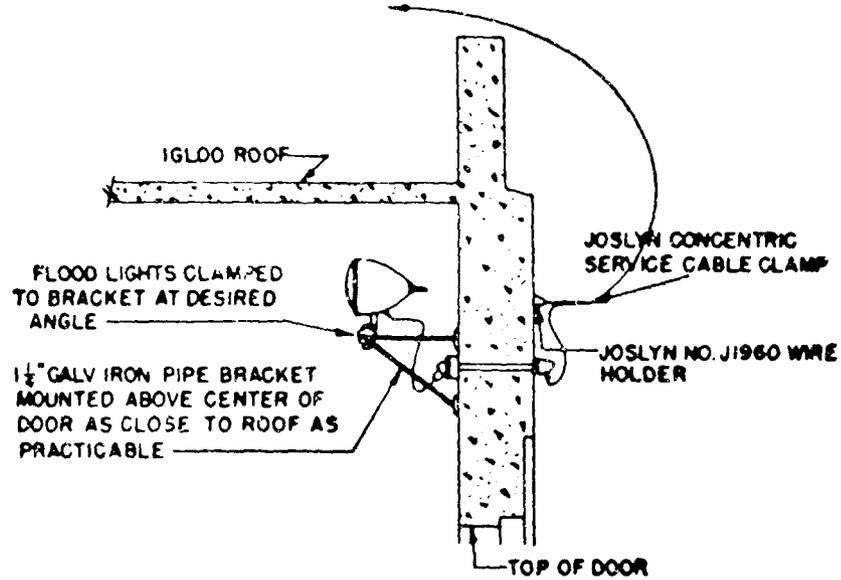
side of the building shall contain a six ampere fuse. Upon completion of the loading or unloading operations in igloo type or aboveground type magazines, the supply cable plug is pulled from its receptacle and the self-closing lid on the fixture automatically closes, practically sealing the outdoor end of the conduit. The floodlight plugs are then removed from the individual fixtures and the self-closing lids automatically close on the inside of the structure. The floodlight units are then removed from the bracket and are ready to be installed on the existing bracket in the next igloo type or aboveground type magazine.

b. In lieu of the arrangement just described, an approved type of heavy duty extension cord (type S) may be run from the generator to the portable lights set on brackets in the igloo type or aboveground type magazine provided the cord is protected in the door opening by a conduit so installed as to prevent accidental breaking of the wire by the door. The conduit used should be of standard weight (thin-wall conduit is not acceptable) and should be located at the top of the door jamb just below the door head. System B may also be modified by mounting the lights permanently on a portable board and setting the board on the brackets when needed. This eliminates clamping individual lights to the supports.

c. In Richmond type magazines, the portable cord may be run through the louvers at the back of the magazines provided the cord is protected where it extends through the louvers by standard weight conduit.

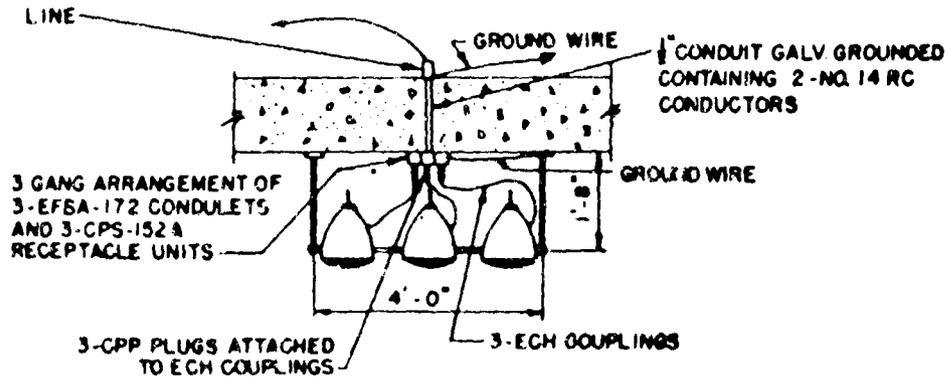
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CABLE SLUNG OVER ROOF TO GENERATING UNIT



SECTION

ARJG 13 CONDUIT EQUIPPED WITH AR 332 RECEPTACLE AND APF PLUG WITH FUSE (6 amp) CONNECTED TO POWER LEAD LINE



PLAN

3 FLOOD LIGHTS G.E. TYPE L-29 OR EQUAL  
CONDULETS, RECEPTACLES, PLUGS, ETC.  
CROUSE-HINDS OR EQUAL  
SERVICE CLAMPS JOSLYN OR EQUAL

Figure 616. Interior Lighting of Igloos--System B.

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*d.* The position of the lights shall not be changed unless the current is off.

#### **617. MAGAZINE LIGHTING SYSTEM C**

This system shown in figure 617 consists of a standard open chock casting attached to the magazine wall. The floodlight with a bracket made of two steel rods welded together, with a filler at the top to provide taper to the bottom of the bracket. The bracket is set in the open chock casting and permits the floodlights to be set at the desired angle. The rest of the installation should conform to the requirements for system B.

#### **618. MAGAZINE LIGHTING SYSTEM D**

*a.* An approved portable system of magazine lighting consists of floodlights with clear lens mounted on heavy portable stands and placed outside of the magazine door. Current for the lights is obtained from a 1½-kw. electric generator powered by gasoline engine located on the rear of a pickup truck. Two 50-foot extension cords leading from the lights can be plugged into polarized outlets. When work is being performed at night, the truck is parked not closer than 50 feet from the magazine and out of the flow of traffic. The floodlights are placed outside the magazine door in a position so that the beams cross. The following additional requirements apply:

- (1) The truck must be parked at least 50 feet from the magazine door in a place where

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gasoline will not flow toward the magazine in the event of a break in the gasoline system. The truck must be equipped with a spark arrestor and should carry first-aid fire-fighting equipment.

- (2) Extension lights must not be placed inside the magazine or igloo. Electric cords and outlets must be properly maintained and cords so placed that they will not be trucked over or walked on during loading or unloading operations.

b. The interior lighting of a Corbetta type magazine introduces problems not covered by sketches in this manual. The correct positioning of the floodlights as described in the above paragraph in a Corbetta type magazine would prove satisfactory.

#### **619. BOXCAR INTERIOR LIGHTING**

Suitable hangars securely mounted on the roof above the doorway of the cars to support the same type floodlights as used in system A (see par. 615) will provide adequate illumination within the car provided the floodlights are correctly focused and directed.

#### **620. PERMANENT SERVICE FOR ABOVE-GROUND TYPE MAGAZINES**

In general, permanent magazine lighting service is not considered favorably. If, however, permanent service is essential to provide current for lighting of

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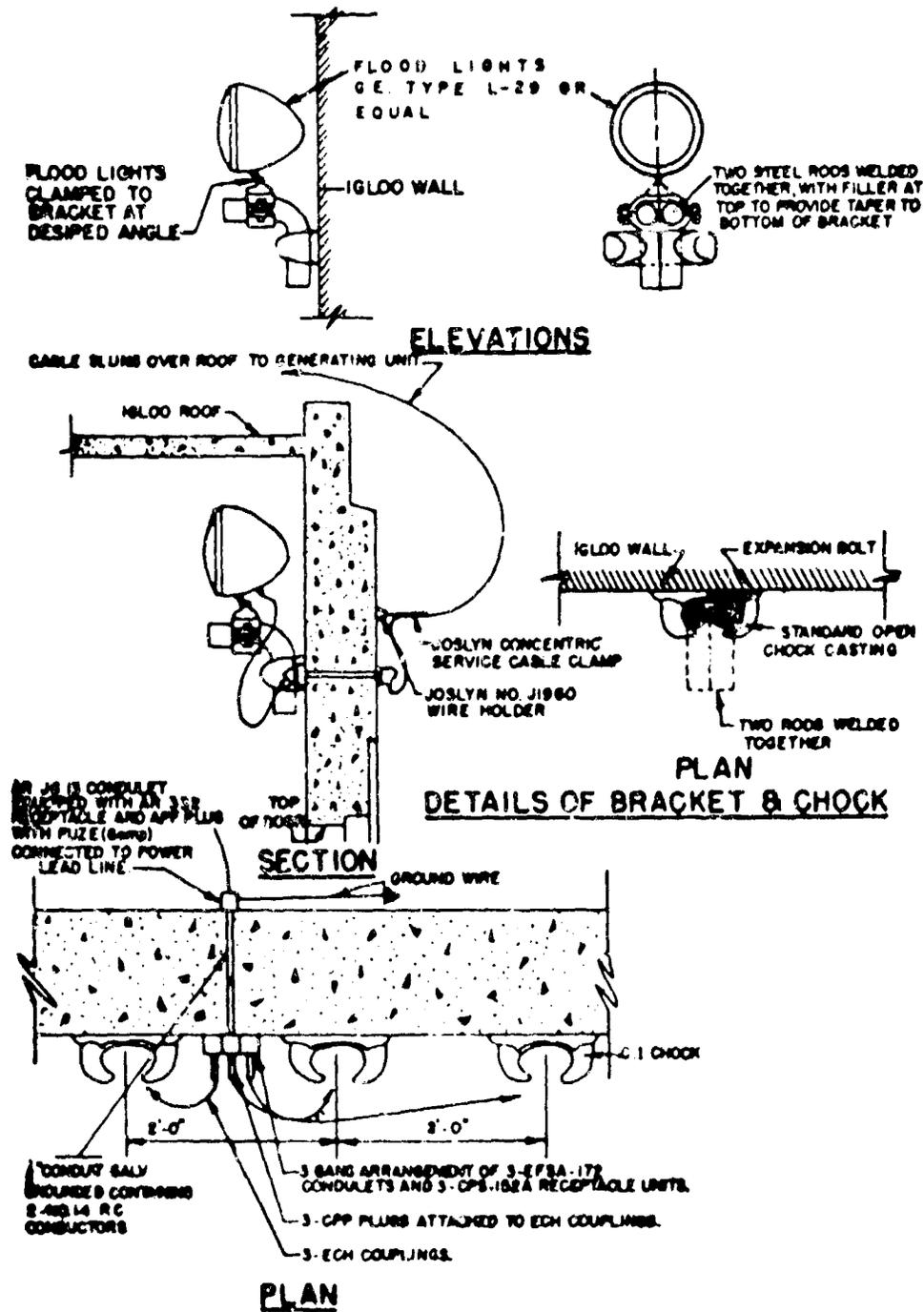


Figure 617. Interior Lighting of Igloos—System O.

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this type magazine, an approved type of disconnect switch is to be located on the pole nearest to each magazine and so arranged that the switch is locked in the open position. The wires in these magazines are to be energized only at those times when men are working in magazines or when men are near the magazines. When a magazine of this type has several doors and operations require several outlets within the magazine to be run from the same circuit, a second switch with fuze may conveniently be located approximately 6 feet above the end of the platform. This will permit shutting off the current while moving magazine lights from one receptacle to the other without cutting off the power at the pole.

#### **621. SINGLE PHASE PORTABLE EQUIPMENT**

*a.* **Single phase electric handtools and other single phase portable electric equipment, used in either hazardous or nonhazardous locations, shall be approved by the Underwriters' Laboratories, Inc. or other recognized testing agency and shall have all exposed noncurrent carrying metal parts grounded. Noncurrent-carrying metal parts of single phase electrical equipment such as fans, typewriters, calculators, etc., which are portable in the sense that they can be moved with a minimum of effort whenever necessary, require grounding only when existing circumstances are such that lack of grounding will endanger exposed personnel. Where the equipment is to be used in a class I or class II hazardous location, the device shall be approved for the specific hazard. Flexible cords supplying them shall be type S hard service cord approved for extra hard usage in damp places, or rubber covered heater cord**

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type HSJ approved for portable heaters in damp places. Cords for equipment in classes I and II locations shall be three wire with the third wire, identified by green or other acceptable colored braid, acting as the ground wire for the exposed noncurrent carrying metal parts of the appliance. In no case shall the white identified neutral power conductor be used as the ground wire. Splices in flexible cords are not permitted. Plugs shall be approved and shall be equipped with three prongs with the third prong acting as the ground. Exposed noncurrent carrying metallic parts of the plug shall be grounded.

b. Because of the necessity of safeguarding persons against the hazards of defective portable appliances, cords, and plugs, more than ordinary care shall be exercised with regard to their maintenance. Each portable appliance shall be assigned a number and shall be inspected and tested by a qualified individual on a regular schedule. The frequency of tests shall be determined by the degree of service, and shall be in sufficient detail to uncover any defects. A written record of the tests, defects found, and repairs made shall be kept. It is recommended that the maintenance inspections and tests be made by the Electrical Department and that spot checks of the equipment against the records be made by the safety director.

c. Employees about to use portable appliances should examine them for obvious deficiencies in the appliances, the cords, and the plugs. If any deficiency is noted, the appliances shall not be used but shall be returned to the Electrical Department for repairs.

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*d.* If the establishment is not equipped with three-wire receptacles and plugs, two-wire devices may remain in service until the change-over is accomplished provided that three-wire flexible cords are

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used *and* the third wire grounded by means of a substantial battery clamp attached to the third wire and fastened to the grounded conduit system or other satisfactory ground.

e. No single phase portable appliances having a name plate rating of more than 230 volts shall be permitted.

f. Portable extension lights and appliances shall not be used in manufacturing, in processing or in storage buildings which contain explosives. Portable battery lamps or flashlights for use in such buildings are approved under certain conditions. *See* paragraph 625.

#### **622. THREE PHASE PORTABLE EQUIPMENT**

Three phase portable equipment such as motor driven portable conveyors, shall follow all of the requirements of paragraph 621, "Single phase portable appliances" except that the voltage may exceed 230 volts and the flexible cords shall be four wire instead of three, with the fourth wire (green or other acceptable color identified) acting as the ground wire for the exposed noncurrent carrying metal frame or parts.

#### **623. PORTABLE ENGINE-DRIVEN GENERATORS**

a. Portable engine-driven generators such as the Schram portable Navy type gasoline electric unit have proved satisfactory as a source of electric power. When in use, the exposed noncurrent carrying metallic frame and parts shall be grounded.

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b. Portable appliances, cords and plugs shall meet the requirements of all parts of paragraph 621, "Single phase portable appliances."

c. When generators are used for generating current to light magazines, the following precautions shall be taken:

- (1) The generating unit shall be placed at least 50 feet from the magazine.
- (2) The ground area between the generating unit and the magazine shall be clear of debris or other combustible materials.
- (3) The flexible cord should be temporarily supported from the exterior of the magazine to the power supply in such a position as to prevent trucks or personnel from running over or otherwise damaging the cables.
- (4) When refueling the gasoline tank, the standard fire protection requirements therewith shall be observed.
- (5) The generating unit and the gasoline supply containers shall be so located that spillage of gasoline would flow, by gravity, away from the magazine. If necessary, a trench shall be built to prevent spilled gasoline from reaching the magazine.

#### **624. ELECTRIC WELDING UNITS**

a. AC welding machines supplied from a primary service shall meet the requirements of paragraphs 621 and 622, "Single phase portable appliances," or

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"Three-phase portable electric equipment," depending on whether single or three-phase current is supplied from the primary sources.

b. The frames and exposed noncurrent carrying metal parts of engine driven welding units shall be grounded.

### 625. FLASHLIGHTS AND LANTERNS

Flashlights and hand lanterns powered by low voltage dry cell batteries and "Miners' Cap Lamps," each approved as "Permissible" by the United States Bureau of Mines and/or for class I hazardous locations by Underwriters' Laboratories Inc., are considered satisfactory for both class I and class II hazardous locations.

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## SECTION 7

### STATIC ELECTRICITY

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#### 701. GENERAL

a. The generation of static electricity is not of itself a hazard. The hazard arises when static is allowed to accumulate, for subsequently it may discharge as a spark across an air gap in the presence of highly flammable material, and thus provide a source of ignition.

b. Detailed discussions of the hazard of static and ways of reducing it are contained in the following pamphlets:

- (1) "Static Electricity" published by the NFPA.
- (2) "Static Electricity" Bulletin No. C438, United States Department of Commerce.
- (3) "Static Electricity in Nature and Industry" Bulletin No. 368, United States Department of Commerce.
- (4) "Standards for Grounding and Bonding Equipment" published by the Underwriters' Laboratories Incorporated.

#### 702. GROUNDING OF EQUIPMENT

The general method employed for eliminating or reducing the hazard from static is to provide elec-

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trically continuous paths to ground to allow the charges to dissipate as fast as they are generated. When all the objects concerned are conductive, grounding can be readily accomplished by electrically connecting all parts to a common ground conductor. Grounding exterior parts of containers alone does not necessarily eliminate all of the danger from static electricity for in order to be completely effective, grounding must include the contents, which is not always practicable, e. g., ungraphited solid propellants in metal containers. Partial grounding or using conductors of insufficient strength or too high resistance may increase the static hazard by providing other opportunities for discharge through an uncontrolled path to ground. Electrical continuity may be broken by oil on bearings, paint or rust at any contact point and, in order to obtain a continuous circuit, grounding straps should be used to bridge such locations. Permanent equipment in contact with conductive floors or table tops is not considered to be adequately grounded. Static grounds should not be made to electrical conduit systems; gas, steam or air lines; dry pipe sprinkler systems or air terminals of lightning protection systems. Static grounds can be made to water pipes, ground cones, buried copper plates or driven ground rods, which may or may not be part of the lightning protection system or to down conductors of lightning protection systems. The size of wires used as static ground conductors should be large enough to withstand mechanical damage.

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### 703. BELTS

Nonstatic producing conductive belting shall be used in locations where static is a hazard. Such belting shall have a resistance to ground not exceeding 600,000 ohms.

### 704. TESTING EQUIPMENT GROUNDS

Grounding systems shall be tested for electrical resistance and continuity when completed and in the case of active equipment, prior to operation and at periodic intervals thereafter. All explosive materials shall be removed prior to making tests. Complete record of all tests shall be kept. In testing for resistance to ground, equipment should be considered as a unit **except** in the case of a belt-driven machine. **In measuring the total resistance to ground for belt-driven machinery to assure compliance with paragraph a below, resistance of the belting is to be excluded.** The maximum resistance to ground permitted for different types of equipment is as follows:

*a. Hazardous locations (operations where a static spark discharge may be dangerous).* All conductive parts of equipment should be grounded to a maximum resistance of 25 ohms, unless 10 ohms is required for lightning protection as specified in section 8. For existing equipment, the rate of static generation should be considered before changes in grounding systems are made.

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*b. Nonhazardous locations.* Nonelectrical equipment in nonhazardous locations need not be grounded unless grounded for static dissipation, but should be grounded as a part of the lightning protection system when such system is installed.

### 705. CONDUCTIVE FLOORS

Conductive floors and conductive shoes shall be used for grounding personnel at operations where explosives such as primer, initiator, detonator, igniter, tracer, and incendiary mixtures are exposed. Some materials sensitive to static sparks (easily ignited or detonated) are lead styphnate, lead azide, mercury fulminate, tetrazene, diazodinitrophenol, potassium chlorate-lead styphnate mixtures, igniter composition, grade B magnesium powder, and black powder dust when exposed in layers. Dust of solid propellants can also be ignited from the spark energy that can be accumulated on a person and conductive floors and shoes must be employed when the dust is present. In addition, dust-air mixtures of ammonium picrate, tetryl, tetrytol, and dust of solid propellants are sensitive to static electricity discharge. Many flammable liquids and air mixtures tested (ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) can be ignited by static discharge from a person. When personnel come into the proximity of (possible contact with) explosives or mixtures enumerated above, conductive floors shall be installed except where the hazards of dust-air or flammable vapor-air mixtures are eliminated by adequate house-

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keeping, dust collection, ventilation, or solvent recovery methods. Conductive floors and footwear are not required throughout an entire building or room if the hazard remains localized, in which case conductive mats or runners may be used where required. Personnel, except electricians, in locations where conductive floors are required and installed shall wear conductive footwear (See par. 1011).

#### **706. CONDUCTIVE FLOOR SPECIFICATIONS**

(Superseded)

Conductive floors must be of nonsparking material such as lead, conductive rubber, or conductive flooring composition and shall meet the following requirements in addition to those given in paragraph 503:

a. The electrical resistance measured between ground and a 5-pound electrode in direct contact with 5 square inches of floor area must not exceed 250,000 ohms.

b. The surface of the installed floor must be free from cracks and reasonably smooth, and the material must not slough off, wrinkle, or buckle under operating conditions.

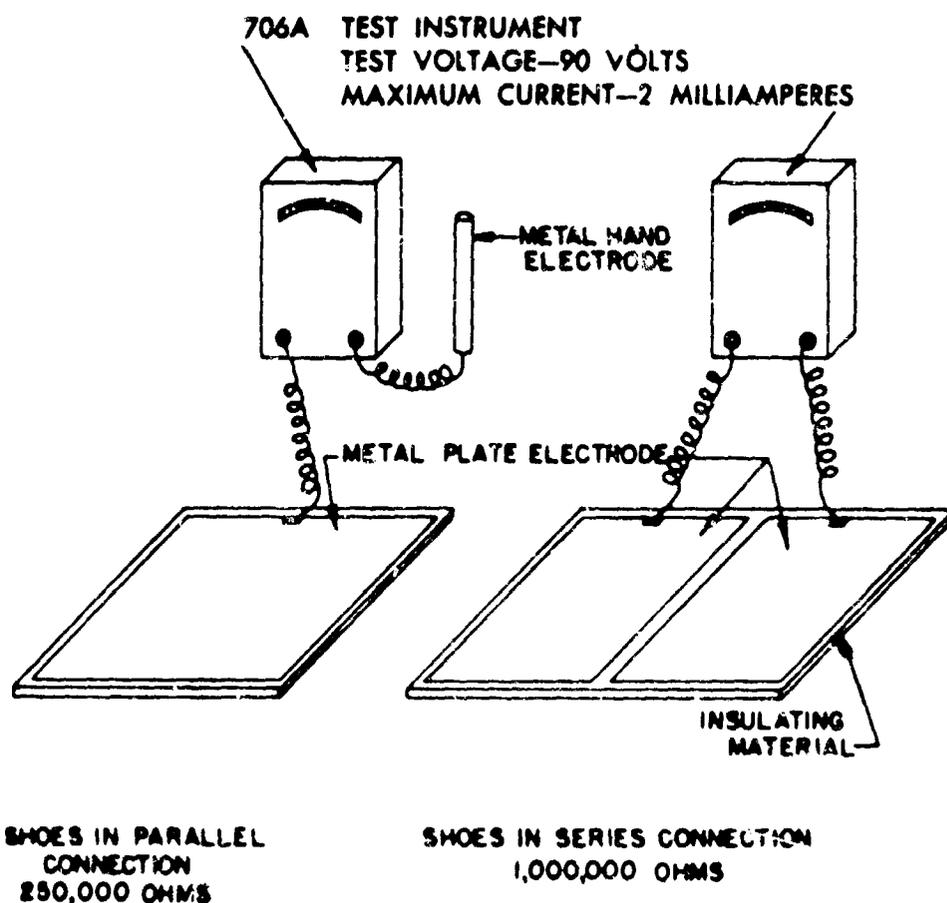
c. Where conductive floors and shoes are required, the resistance between the ground and the wearer shall not exceed 1,000,000 ohms; i. e., total resistance of conductive shoes on a person, plus the resistance of floor to ground. Where conductive floors and shoes are required, table tops upon which exposed explosives or dusts are encountered should be covered with a properly grounded conductive material meeting the

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same requirements as those for flooring. See figures 706A and 706B.

### 707. CONDUCTIVE FLOOR TESTS

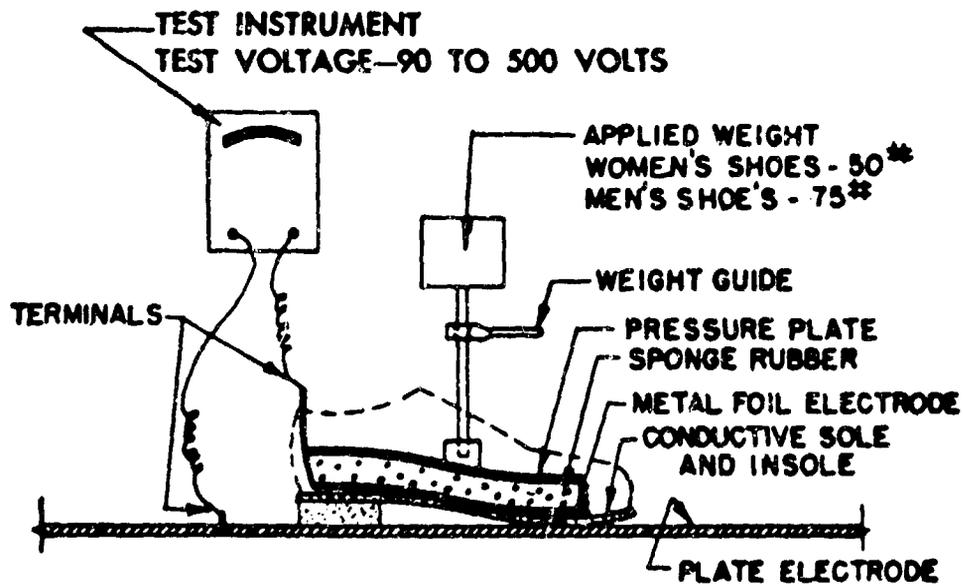
a. Initial tests shall be made of all conductive floors and subsequent tests shall be made semian-



Note: See paragraph 1013

Figure 706A. Testing shoes on wearer.

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Note: See paragraph 1013

Figure 706B. Testing Shoes off Wearer.

nually. The test results shall be permanently recorded with a copy filed in the safety office. Instruments used in making tests shall be used only when the room is free from exposed explosives. The instrument used should be a portable, self-powered, enclosed unit and should consist of two dry electrodes. One electrode shall consist of a special metal block (5 pounds in weight) which makes contact with 5 square inches of floor area. The block should be equipped with a nonmetallic strap to enable pulling it along the surface of the floor under test. If the flooring is uneven, making it difficult to obtain 5 square inches of contact, a thin coating of "electrode jelly" (brushless shaving soaps) may be applied to the underside of the block. The other electrode should consist of a suitable spring test clip for attachment to a permanent ground. The electrodes

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shall be insulated from each other and should be connected with instruments by test leads of such length that all parts of the floor can be reached, and connected in such a manner that the resistance between electrodes may be measured as shown on figure 707. The operation and maintenance of test instruments shall be entrusted to competent personnel.

b. The voltage applied to the instrument should be between 90 and 500 volts. Low voltage instruments may be used, but if the floor shows more than the maximum permitted resistance with instruments of less than 500 volts, a test with a 500-volt instrument should be made before any action is taken to gain greater conductance. If the resistance is then greater than 250,000 ohms, and the floor and electrodes are free from insulating materials, the effectiveness of the floor grounds shall be tested.

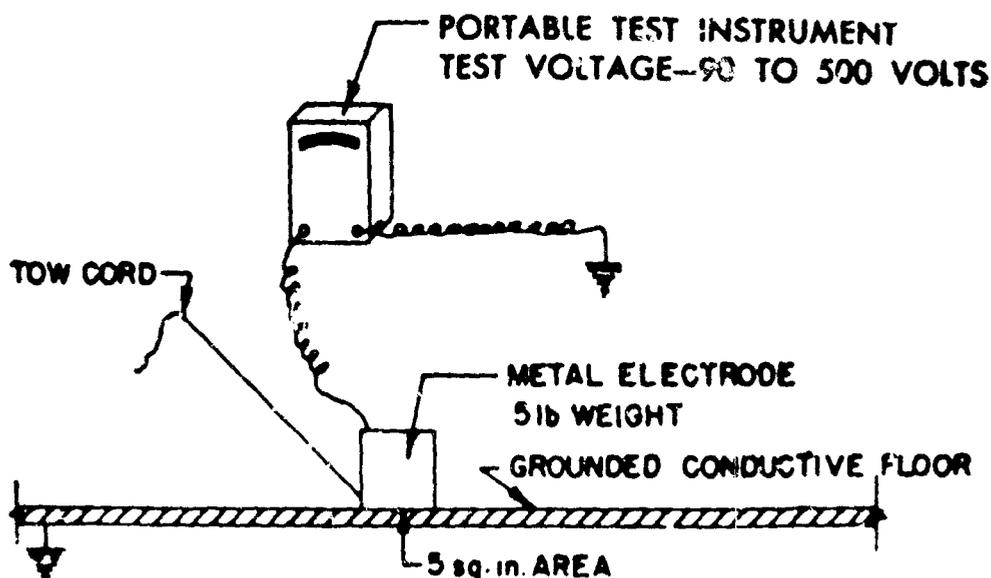


Figure 707. Testing Grounded Conductive Floors.

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#### 708. HUMIDIFICATION

Humidification for preventing static electrical accumulations and subsequent discharges is usually effective if the relative humidity is above 60 percent. However, certain materials such as metallic powders and some of the pyrotechnic mixtures cannot be exposed to air with 60 percent relative humidity because of the possibility of spontaneous ignition.

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## SECTION 8

### LIGHTNING PROTECTION

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#### 801. POLICY

a. It is the policy of the Ordnance Corps to install lightning protection on buildings and structures used for manufacturing, processing, handling or storing explosives, ammunition or explosive ingredients, particularly where operations cannot be shut down during electrical storms and personnel evacuated, where damage from lightning would cause large economic loss or would handicap activities essential to the Department of Defense. Each such building and structure shall be equipped with an effective lightning protection system. Temporary storage facilities and structures housing operations not regularly conducted at a fixed location need not be protected. In locations where lightning storms occur with an average frequency of less than five per year, lightning protection systems may be omitted from all or certain specific structures when specifically exempted by the Chief of Ordnance. In the case of existing igloo type magazines without lightning protection, where damage from lightning would not handicap activities essential to Department of Defense, protective systems need not be erected when specifically exempted by the Chief of Ordnance, if metallic ven-

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tilators, doors, and reinforcing steel are electrically bonded together and grounded. However, all igloo type or Corbetta type magazines to be constructed after publication of this manual shall be externally protected, since the additional cost of the air terminal system would be minor during the construction period. Groups of above-ground type magazines shall be provided with lightning protection systems.

b. All details and pertinent data of proposed installations of lightning protection systems shall be submitted through appropriate channels to the Office of the Chief of Ordnance for review and approval before any construction is started.

## **802. APPROVED SYSTEMS**

Approved lightning protection systems are the integrally mounted system, the separately mounted shielding system (mast type), and the separately mounted shielding system (overhead ground wire), which are described in this section. In planning the system, the following should be considered: adaptability to the type of facility to be protected; comparative degree of protection under the prevailing circumstances and economics. The details of construction and installation of lightning protection systems shall, in general, if not specifically called for in this section, conform with the regulations of the National Bureau of Standards Handbook H-40, "Code for Protection Against Lightning." All future installations shall be under the supervision of the Underwriters' Laboratories, Inc., or other ap-

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proved testing agency familiar with lightning protection installations and the materials shall be so labeled. A laboratory report of final acceptance issued to the establishment by the testing agency may be accepted by the commanding officer as evidence that the equipment used and the installation are in compliance with this section.

### **803. INTEGRALLY MOUNTED SYSTEM ON WOOD FRAME CONSTRUCTION WITH NONMETALLIC ROOF**

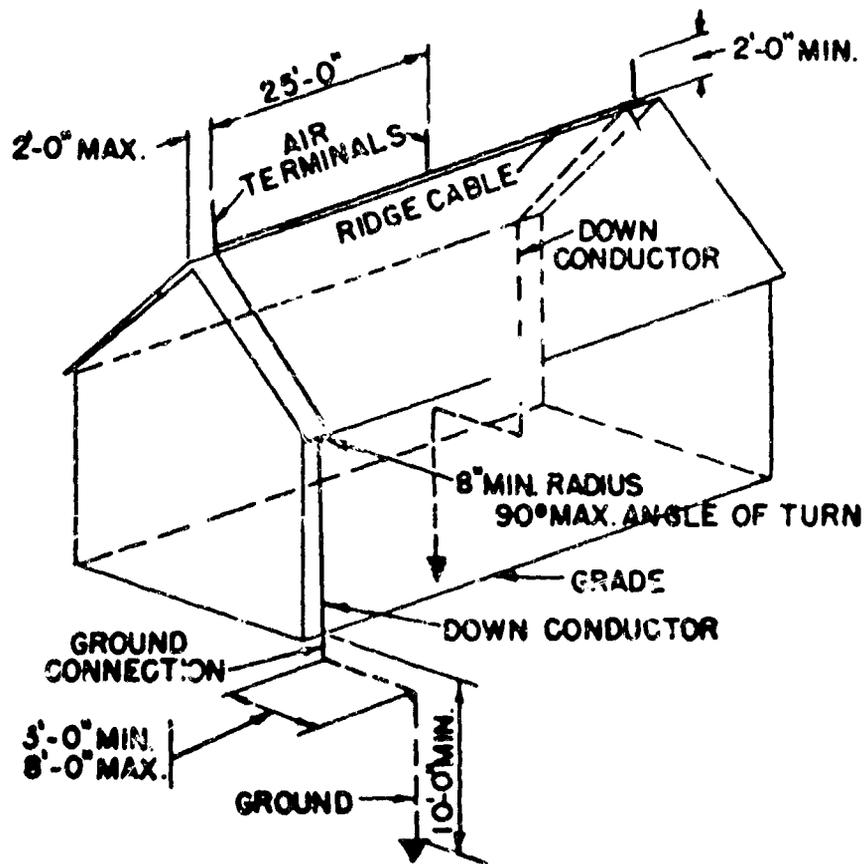
a. The lightning protection system shall consist of air terminals, ridge cables, down conductors, ground connections and grounds, securely and electrically interconnected to form the shortest distance practicable to ground without passing through any nonconducting parts of the structure. The cone of protection theory does not apply to the integrally mounted system, however, on small structures (not over 10 feet on the maximum diagonal) on which a 6-foot air terminal is mounted in the center of the roof, the cone of protection theory may be said to apply. See figure 803A.

b. The purpose of the air terminals is to intercept the electrical discharge at a safe distance above vulnerable and flammable parts of structures. The receiving points of the air terminals should be placed high enough above the structure to obviate danger of fire from the arc; the more flammable or explosive the conditions, the higher the point should be placed. Air terminals shall be securely connected to and

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made electrically continuous with the ridge cable. They are best attached to the cables by means of crimped joints of malleable metal in T form and connected to the air terminal by a dowel or screw coupling. Air terminals should be at least 2 feet high except on open or hooded vents emitting explosive dusts or vapors under natural or forced draft. Air terminals on such vents should extend not less than 5 feet above the opening. When explosive dusts, gases, or vapor are emitted under forced draft from open stacks, the air terminals should extend not less than 15 feet above the vent opening. On existing installations, approval of requests may be given by the Chief of Ordnance for the continued use of existing air terminals less than 2 feet high in locations where explosive vapors, gases, or dusts do not contribute to the hazard. Air terminals shall be amply secured against overturning either by attachment to the object to be protected or by means of a substantial tripod, or other braces which shall be permanently and rigidly attached to the building. Where air terminals are over 2 feet high, braces shall be provided to prevent damage to the structure due to whipping. Metal projections and metal parts of inert buildings, smokestacks, and other metal objects (which do not emit explosives dusts, vapors or gases) which may be struck but not be appreciably damaged by lightning, need not be provided with air terminals, but these metal objects shall be securely bonded to the lightning conductor through a metal conductor of the same unit weight per length as the main con-

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DOWN CONDUCTORS TO BE PROTECTED, IF NECESSARY, AGAINST MECHANICAL INJURY

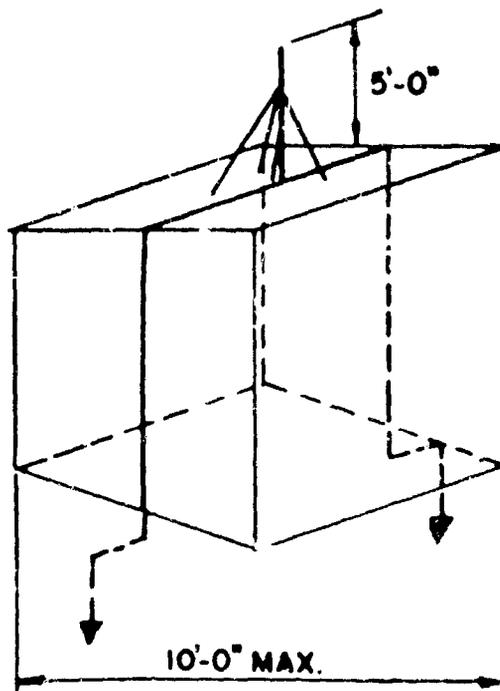


Figure 803A. Typical Lightning Protection.

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ductor. If it is the desire to prevent damage to these parts, air terminals should be provided. The air terminals at the ends of the structure shall be set not more than 2 feet from the ends of the ridge. The spacing of air terminals 2 feet in height on ridges, parapets, and around the perimeter of buildings with flat roofs shall not exceed 25 feet. In specific instances where it is necessary to exceed this spacing, the specified height of air terminals shall be increased not less than 2 inches for each foot of increase over 25 feet. On large, flat or gently sloping roofs, air terminals should be placed at the points of the intersection of imaginary lines dividing the surface into rectangles having sides not exceeding 50 feet in length. Where practicable, all air terminals should be provided with at least two paths to ground. Where metal ventilators are installed, air terminals are to be mounted on same, where practicable. If it is necessary to erect the air terminals to one side of the metal ventilator, they should be bonded together near the top and bottom of the ventilator. Where nonmetallic ventilators are used, air terminals may be mounted on them or to the side, and a direct connection is to be made between the air terminal and the ridge cable. See figure 803B.

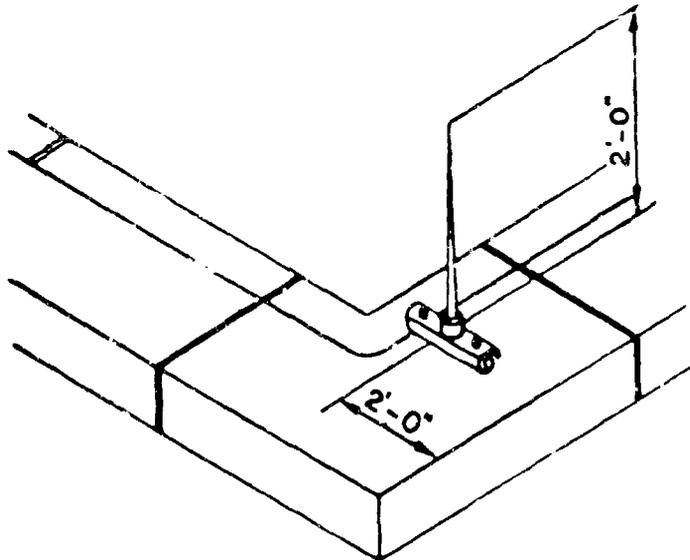
c. Ridge cables or roof conductors may be connected directly to the ridge roll or roof. Sharp bends or turns in ridge conductors and other conductors shall be avoided, but where necessary, they shall have a radius of not less than 8 inches. The angle of any turn shall not exceed 90°. Conductors shall, in all

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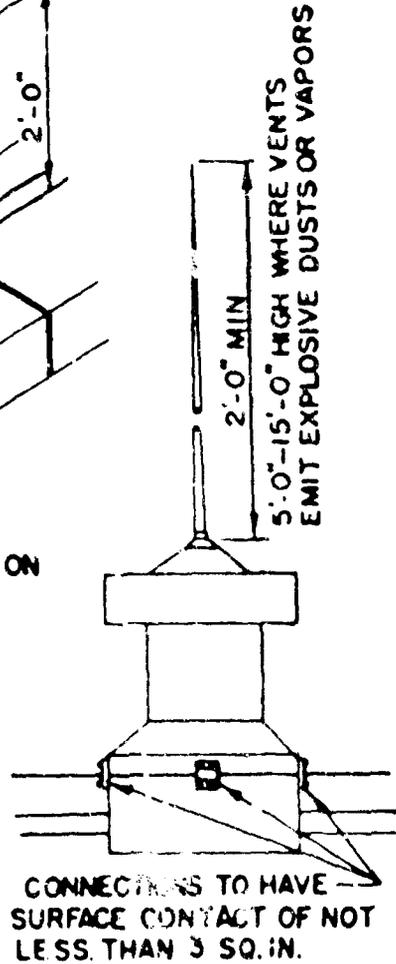
cases, preserve a downward or horizontal course. Cables shall be securely fastened every 4 feet along the ridge and down the building to ground. Metal ventilators shall be securely connected to the ridge cable at three places. All connections must be electrically continuous. Roof conductors shall be coursed along the contours of flat roofs, ridges, parapets, and edges; and where necessary, over flat surfaces, in such a way as to join each air terminal to all the rest. Roof conductors surrounding decks, flat surfaces and flat roofs shall be connected to form a closed loop.

d. Down conductors shall be electrically continuous from air terminals or roof cables to ground connections. Down conductors should preferably be coursed over the extreme outer portions of the building, such as corners, due consideration being given to the best places for making ground connections and the location of air terminals. There shall be not less than two down conductors on any type of building or structure and these shall be as widely separated as practicable (preferably at diagonally opposite corners). On rectangular structures having gable, hip or gambrel roofs, more than 110 feet long, there shall be at least one additional down conductor for each additional 50 feet of length or fraction thereof. On rectangular structures having French, flat or sawtooth roofs exceeding 300 feet in perimeter, there shall be at least one additional down conductor for each additional 100 feet of perimeter or fraction thereof. On an L or T shaped structure, there

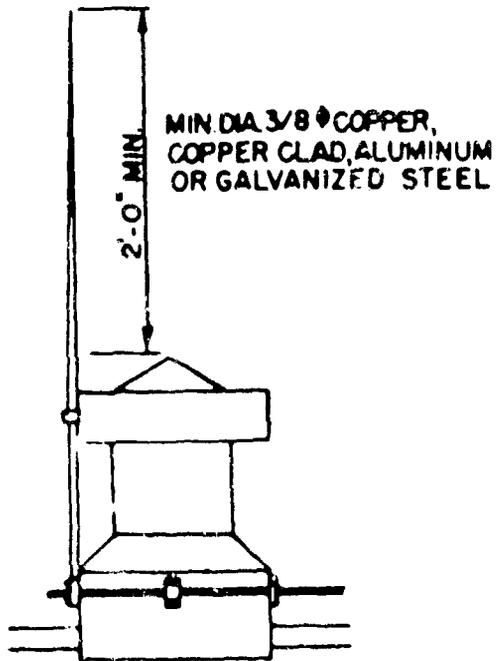
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AIR TERMINAL & ROOF CABLE ON TOP SURFACE OF COPING



AIR TERMINAL MOUNTING ON VENTILATOR WHICH IS ELECTRICALLY CONTINUOUS



AIR TERMINAL MOUNTING ON VENTILATOR NOT ELECTRICALLY CONTINUOUS

Figure 803B. Typical Lightning Protection.

15 May 1958

shall be at least one additional down conductor, on an H-shaped structure at least two additional down conductors, and on a wing-built structure at least one additional down conductor for each wing. On irregular shaped structures, the total number of down conductors shall be sufficient to make the average distance between them along the perimeter not greater than 100 feet. On structures exceeding 50 feet in height there shall be at least one additional down conductor for each additional 60 feet of height or fraction thereof, except that this application shall not cause down conductors to be placed about the perimeter of the structure at intervals of less than 50 feet. Additional down conductors shall be installed where necessary to avoid "dead ends" or branch conductors, ending at air terminals, which exceed 16 feet in length. Down conductors should be equally and symmetrically spaced about the perimeter of the structure. Down conductors shall be protected where necessary to prevent mechanical injury to the conductor. See figures 803C, 803D, 803E, 803F, and 803G.

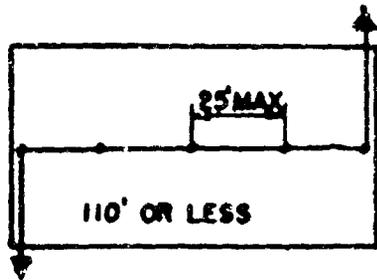
e. All metal doors, windows, gutters, etc., shall be connected by not smaller than No. 6 copper cable or equivalent, directly to the grounds or down conductors in an approved manner. Special consideration should be given to those placed where there is unusual wear, possibility of mechanical injury, or corrosion, in which case a larger conductor will be required if the cable does not have other means of protection. The ground connection to metal doors and windows shall be by means of mechanical ties under pressure.

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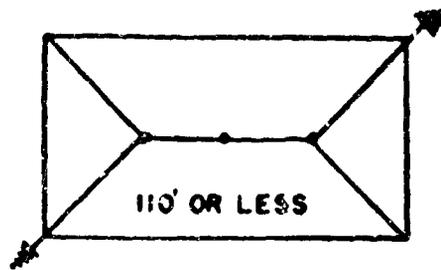
*f.* Ground connections are continuations of down conductors from the structure to the grounding electrode and are to be securely connected to the down conductor and grounded in an approved manner so as to insure electrical continuity between the two. Connections may be of the clamp type or the thermit weld type if thermit welding can be safely accomplished. There shall be a ground connection for each down conductor, preference being given to metal water pipes and other large underground metallic objects. Ground connections shall be protected from mechanical injury. In order to aid testing and inspection, a box with removable lid may be built around the junction of the ground connection and ground rod. In making ground connections, advantage should be taken of all permanently moist places where practicable, although such places should be avoided if the area is wet with waste water which contains chemical substances, especially those corrosive to metal. Where buried metal pipes enter a building at least one down conductor shall be connected to them, preferably at a point immediately outside the foundation wall, by means of a substantial clamp to which the conductor can be attached by bolts or solder.

*g.* Grounding electrodes shall be placed at as uniform intervals about the building as practicable, grouping of grounds on one side of a building is to be avoided. A driven ground should extend into the earth for a distance of not less than 10 feet. Grounds shall be set not less than 3 feet, nor more than 8 feet from the structure. The type and size of the ground

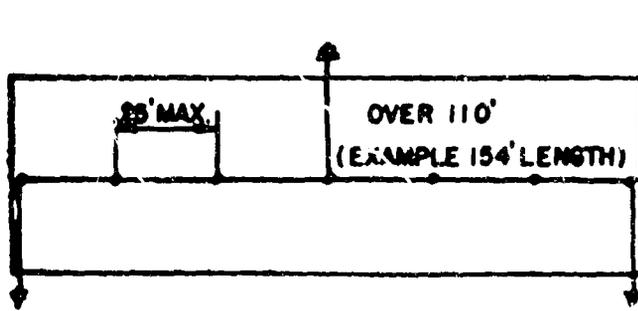
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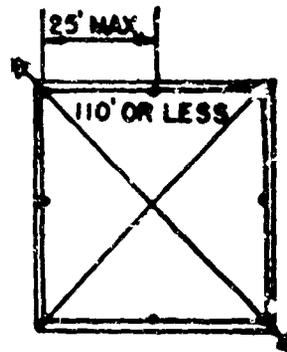
GABLE ROOF



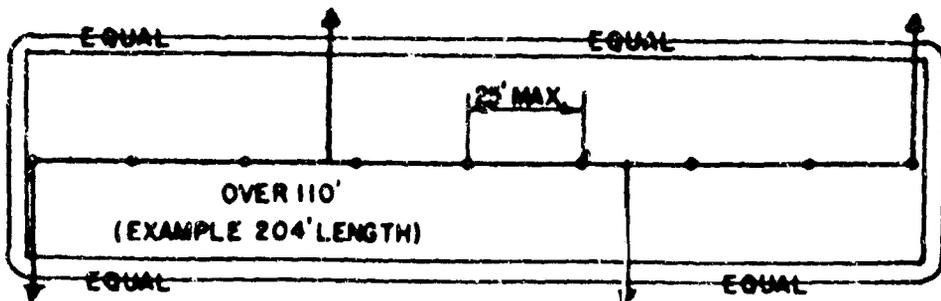
HIP ROOF



GABLE ROOF



HIP ROOF



GABLE ROOF

Figure 803C. Typical Lightning Protection.

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will depend on local soil condition. Test borings taken in the areas where buildings or structures are to be erected may be used for deciding upon an adequate grounding system. Underground water pipes, walls, ground plates, cones and railroad tracks (where rails are grounded and signalling system is insulated) may be used in addition to the above. A salt ground is not recommended as this type requires

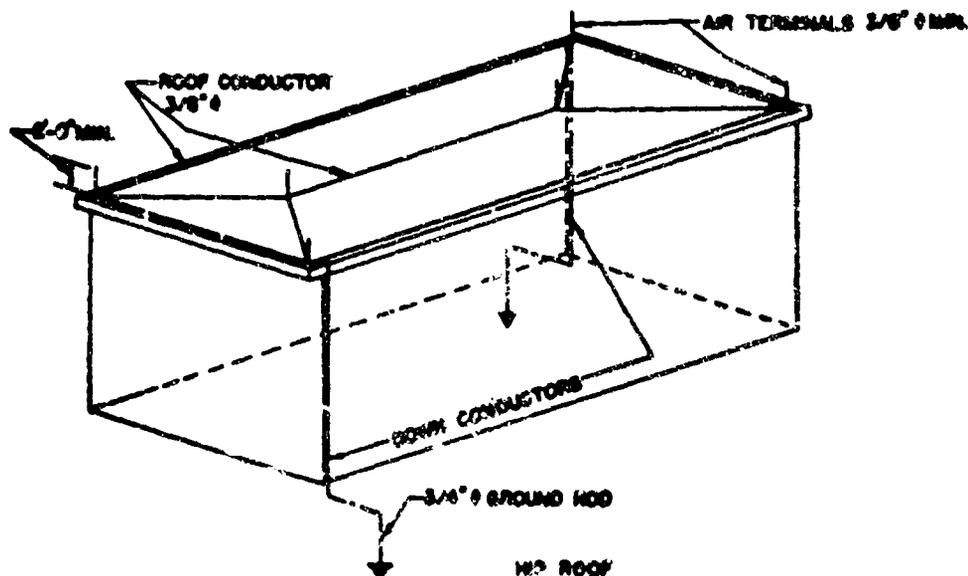


Figure 803D. Typical Lightning Protection.

constant inspection and maintenance. All portions of the ground connections shall be tested to make sure that the complete installation does not have a total resistance to ground of more than 10 ohms. If two of any three ground rods, driven not less than 10 feet into the ground and equally spaced around the perimeter, gives a value exceeding 50 ohms immediately after driving, then a counterpoise shall be used. If two or more driven grounds are used at any one point

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the rods shall be spaced at least 10 feet apart. Where counterpoises must be used the entire system resistance requirement of 10 ohms or less need not be met. When a counterpoise is required it shall be of No. 1/0 copper cable or equivalent material having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 2 feet deep at a distance not less than 3 feet nor more than 8 feet from the nearest point of the structure.

All connections between ground connectors and grounds or counterpoise, and between counterpoise and grounds shall be made in an approved manner and shall be electrically continuous. An alternate method for grounding electrodes in shallow soil is to dig trenches radially from the building, burying in them the lower ends of the down conductor or their equivalent in the form of metal strips or wires. See figure 803H.

#### **804. INTEGRALLY MOUNTED SYSTEM ON WOOD FRAME STRUCTURES WITH METALLIC ROOF AND NONMETALLIC EXTERIOR WALLS**

Metal roofs which are in the form of sections insulated from each other shall be made electrically continuous by bonding. The specifications of paragraph 803 shall be modified only in that air terminals be securely bonded directly to the metal roof by soldered or bolted joints. All connections must have electrical continuity and have a surface contact of not less than 3 square inches. Ridge cables and roof

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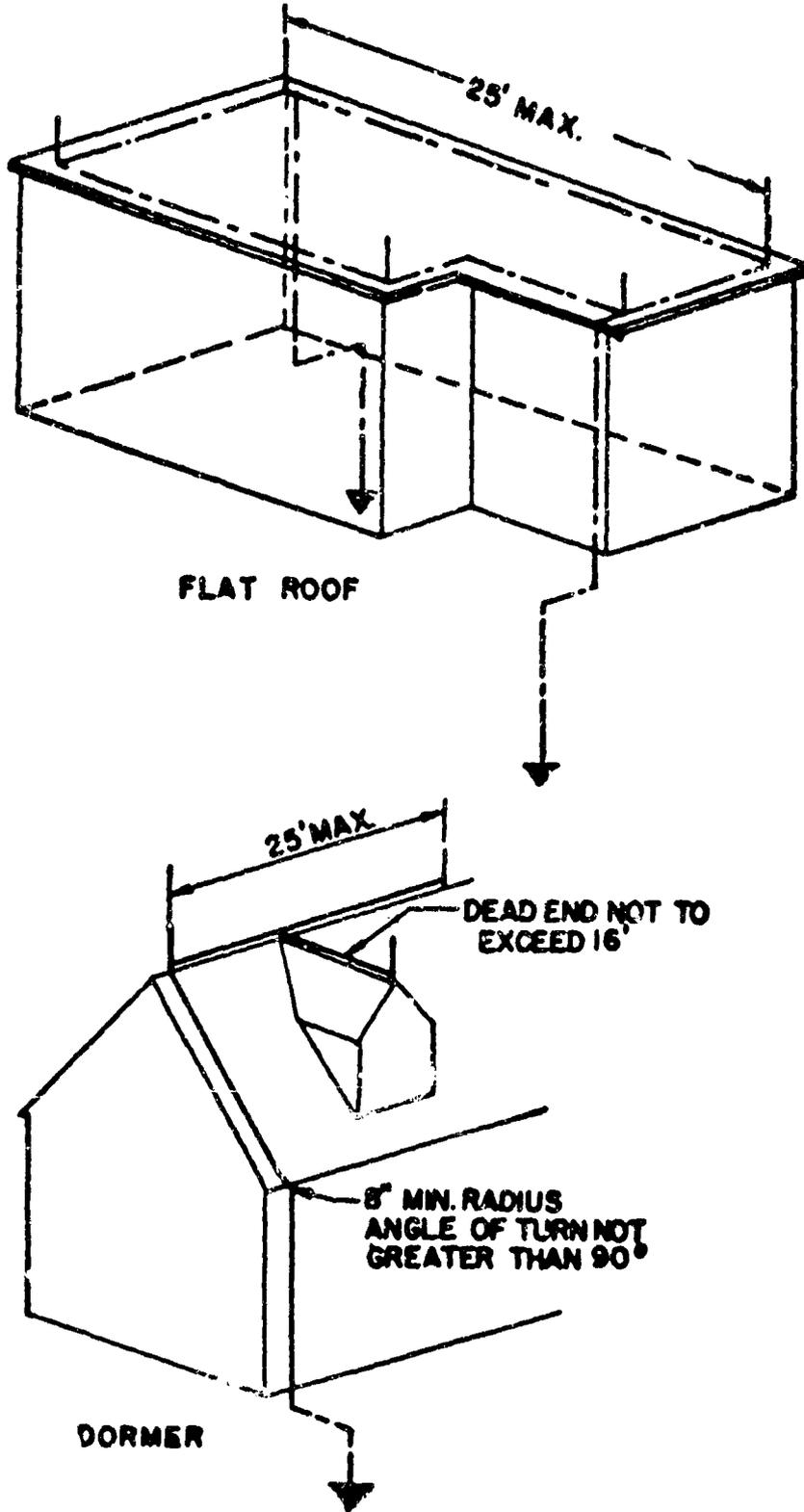
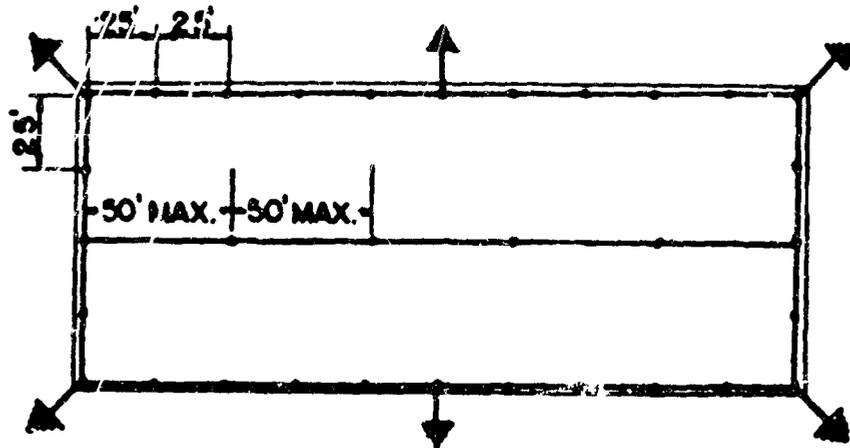
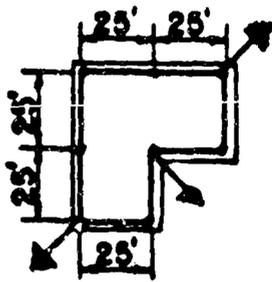


Figure 803E. Typical Lightning Protection.

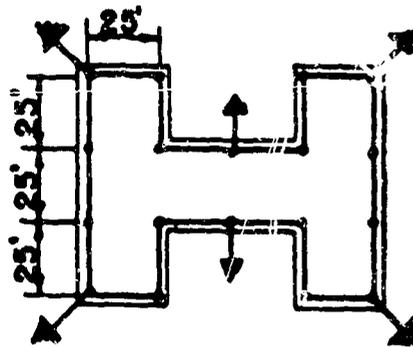
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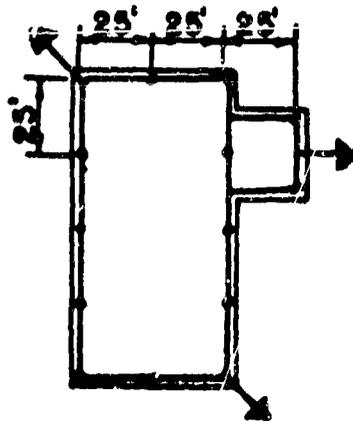
FLAT, FRENCH, OR SAW TOOTH ROOFS  
OVER 300' IN PERIMETER



L OR T SHAPED  
STRUCTURES



H SHAPED STRUCTURES



WING STRUCTURES

Figure 803F. Typical Lightning Protection.

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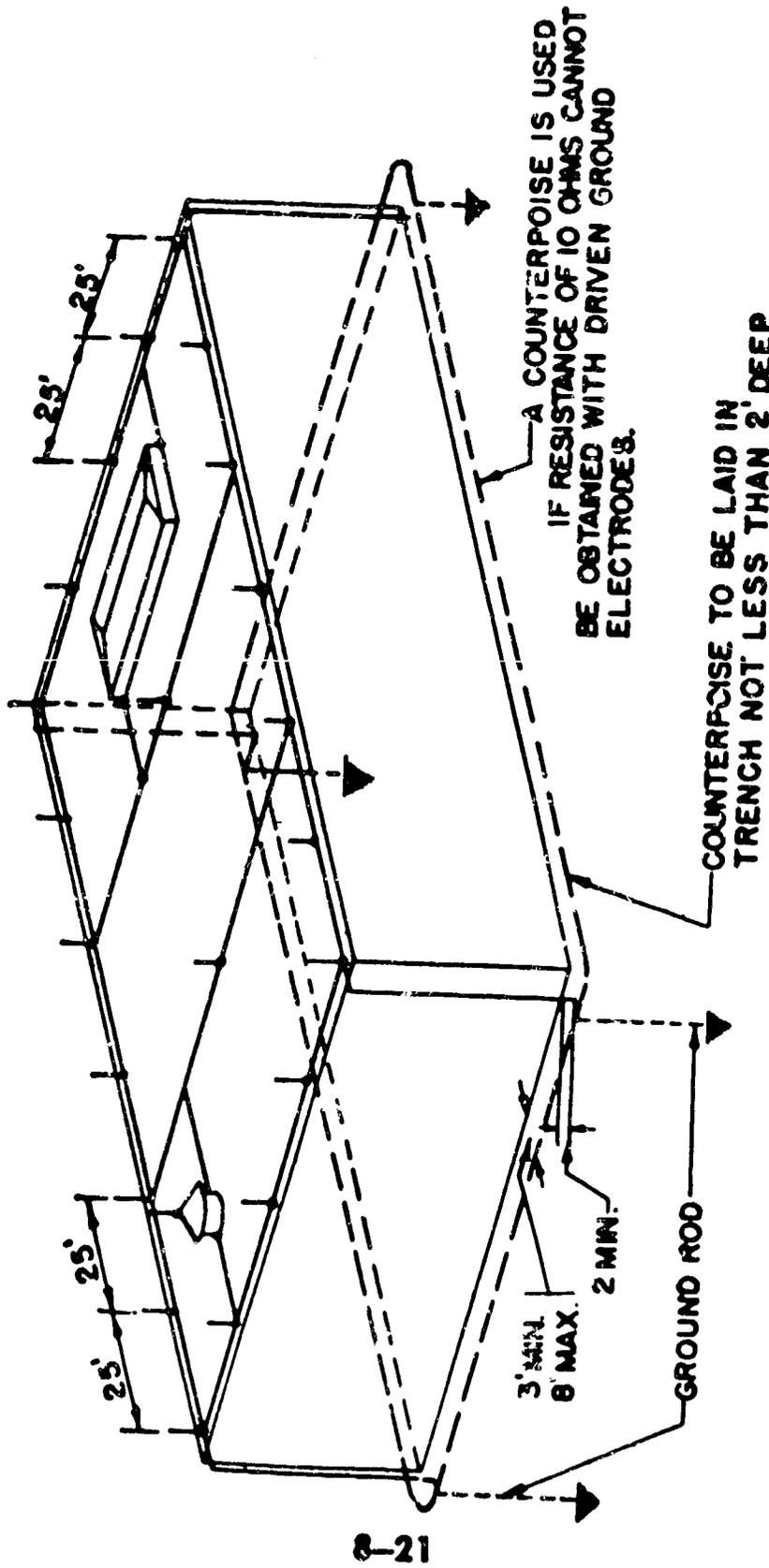
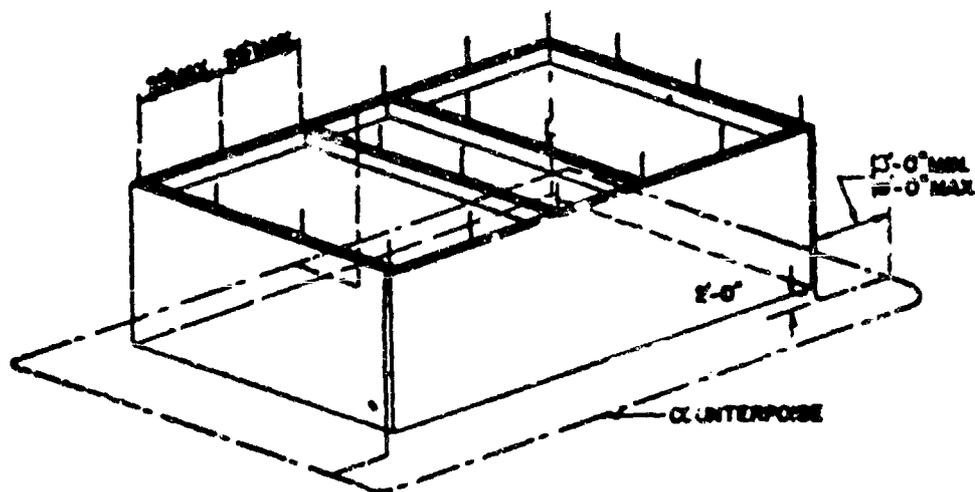


Figure 803G. Typical Lightning Protection.

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conductors are not needed if the roof is electrically continuous. The down conductors shall start at, and be securely bonded to the edges of the metal roof. If the metal of the roof is in small sections, the air terminals and down conductors shall have connections made to at least four of the sections. The down conductors shall be grounded as described in paragraphs 803f and g.



FLAT ROOF WITH PARAPET WALLS

Figure 803H. Typical Lightning Protection.

#### 805. INTEGRALLY MOUNTED SYSTEM ON WOOD FRAME BUILDING WITH METAL ROOF AND METAL EXTERIOR WALLS

The metal roof and the metal walls shall be bonded and made electrically continuous and shall be considered as one unit provided the walls are properly bonded to the roof. All conductors between air terminals and ground connections may then be omitted. The sidewalls and roofs shall be so bonded and interconnected to provide as many paths and in the same

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locations as required in paragraph 803*d*. The air terminals shall be securely bonded to the metal roof and the ground connectors shall be bonded directly to the lower edges of the metal walls. In all other respects the requirements of paragraph 803 shall be observed.

#### **806. INTEGRALLY MOUNTED SYSTEM ON STEEL FRAME BUILDING**

*a.* The steel framework shall be made electrically continuous. The air terminals shall be securely connected to the structural steel framework at the ridge. Where metal ventilators are installed, the air terminals are to be securely connected and bonded to the top of them, and the ventilators are to be securely connected to the metal building framework. For spacing of air terminals see paragraph 803*b*. Short runs of conductors may be necessary to join the air terminals to the metal framework so that proper spacing of air terminals is maintained. Separate down conductors from air terminals to ground connections are not required.

*b.* Where a water system enters the building, the structural steel framework and the water system shall be securely connected at the point of entrance by a ground connector. Connections to pipes shall be made by means of substantial ground clamps with lugs. Connections to the structural framework shall be made by nut and bolt. In addition, ground connections to the grounds or counterpoise shall be run from not less than one half of all the columns, dis-

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tributed equally around the perimeter of the structure. Connections between columns and ground connectors shall be made at the bottom of the steel columns. All connections and the entire system shall be tested for electrical continuity. When no water system enters the structure, ground connections shall be run from the bottom of all steel columns, distributed equally around the perimeter and connected to the grounds or counterpoise. All connections shall be tested for electrical continuity. Resistance to ground shall not exceed 10 Ohms. Metal doors, windows, gutters, etc., should be grounded as outlined in paragraph 803e.

#### **807. INTEGRALLY MOUNTED SYSTEM ON MASONRY BUILDING**

Protection for masonry buildings with nonmetallic or nonreinforced concrete roofs shall conform to the requirements of paragraph 803. For masonry buildings with steel roofs, the specifications given in paragraph 804 shall be used. The specification requirements of paragraph 804 shall be used also for masonry buildings with steel roof trusses and metal roofs except that the air terminals and down conductors are to be securely connected to steel trusses in addition to the metal roof.

#### **808. INTEGRALLY MOUNTED SYSTEM ON REINFORCED CONCRETE BUILDING**

The lightning protection system for reinforced concrete buildings in which the reinforcing rods are

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not electrically continuous shall meet the requirements for wood frame buildings. (See par 803.) If the reinforcing rods are properly bonded and are electrically continuous, the buildings shall meet the requirements of paragraph 806, except that spacing of air terminals shall be as required by paragraph 803b.

#### **809. INTEGRALLY MOUNTED SYSTEM ON RAMPS**

Lightning protection for covered ramps (connecting passageways), where necessary, shall conform to the requirements for lightning protection systems for buildings of similar construction, as hereinbefore specified. A down conductor and a driven ground shall be placed at one of the corners where the ramp connects to each building, or structure, having a counterpoise. This down conductor and driven ground shall be connected to the counterpoise of the building or structure. Where buildings or structures and connecting ramps are clad with metal, the metal of the buildings or structures and the metal of the ramp shall be connected in a manner to insure electrical continuity, in order to avoid the possibility of a flash over or spark due to a difference in potential.

#### **810. INTEGRALLY MOUNTED SYSTEM ON IGLOO TYPE MAGAZINES**

In earth covered reinforced concrete igloo type magazines, where the reinforcing steel has been made

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electrically continuous, the air terminals and ground connectors shall be securely connected to and made electrically continuous with the reinforcing steel. One air terminal shall be located on the top of the front wall and one on or at the ventilator in the rear. The air terminals shall extend vertically at least 2 feet above the top of the front wall and the highest point on the ventilator. Ground connections shall be securely connected to the horizontal reinforcing rods below the floor line of the wall system. The installation shall show a resistance to ground of not more than 10 ohms. The type of grounding required to obtain this resistance will depend upon soil conditions and shall be in accordance with paragraph 803g. If the steel door frame is made electrically continuous with the reinforcing steel and the steel hinges make the door and frame electrically continuous, the steel door does not have to be bonded to the steel frame.

#### **811. SEPARATELY MOUNTED SHIELDING SYSTEM (MAST TYPE)**

a. The mast type protection consists of a pole, which, if of a nonconducting material, shall be provided with an approved air terminal securely mounted to the top, extending not less than 2 feet nor more than 5 feet above the top of the pole and a down conductor shall be run down the side of the pole and be connected to ground electrodes. If a metal pole is used, the pole will act as both a down conductor and a ground. For such systems air terminals

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need not be provided and if resistance of the pole to ground is 10 ohms or less, additional grounding is unnecessary. When the resistance exceeds 10 ohms, additional grounding shall be provided and the ground connection shall be securely fastened to the metal pole and the ground.

b. When a ground rod is necessary, it shall be driven approximately 6 feet from the base of the pole. If the resistance to ground of this rod is more than 10 ohms, an additional ground rod shall be driven not closer than 10 feet from the first rod. If the resistance of the system to ground is greater than 10 ohms when the two ground rods are connected together, a counterpoise shall be provided for the pole which may be a part of a counterpoise system used in connection with a grounding system for a protected structure. In general, the grounding system at the base of the pole shall be interconnected with any grounding system provided for the protected structure.

c. A grounded mast establishes a so-called "cone of protection," the height of which is the height of the mast. The circular base of the "cone" has a radius equal to twice the height of the mast. The mast shall be of such height that no part of the structure to be protected extends outside of the "cone." Two buildings may be protected by the same pole provided all parts of these buildings fall within the cone of protection. The mast must be set at a distance from the structure equal to one-third the height of the building, but in no case shall

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be less than 6 feet. If the slope of the roof is small, then the height of the building is taken as the distance from the ground to the eave of the roof, and if the pitch of the roof is high ( $72^\circ$  or over) then the height of the building should be taken as the distance from the ground to the ridge of the roof. Where the end wall continues straight to the ridge and, therefore, no pitch of roof is involved, the height of the building should be considered from the ground to the ridge, and when the mast faces that end wall it should be located at one-third of this height, but in no case less than 6 feet. Where two buildings are to be protected by the same mast it shall be placed at least one-third the height of the tallest building away from the tallest building and at least one-third the height of the shortest building from the shortest building but not less than 6 feet from either building.

**812. SEPARATELY MOUNTED SHIELDING SYSTEM  
(OVERHEAD GROUND WIRE TYPE).**

(See fig. 812.)

*a.* This type of protection consists of two or more poles connected to each other by overhead conductors. If the poles are made of a nonconducting material, an approved type of air terminal shall be securely mounted to the top of each pole and shall extend not less than 2 nor more than 5 feet above the top of the pole. Down conductors may be run down the side of the pole or a guy wire may be used as a conductor. If the guy wire is used, it and the

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overhead ground wire should be "dead-ended" at the pole. The overhead ground wire and the guy wire should then be connected to each other by a separate cable using standard cable clamps in such a manner that the discharge will not be reversed at any point. Guy wires used as down conductors shall be grounded to comply with the requirements of paragraph 803f and the material of the guy wire shall comply with the requirements of paragraph 820. Where metal poles are used, air terminals are not needed and if resistance of the poles to ground is 10 ohms or less, additional grounding is unnecessary. When the resistance exceeds 10 ohms, additional grounding shall be provided and the ground connections shall be securely fastened to the metal poles and the ground.

b. The height of the poles shall be sufficient to provide a clearance of not less than 6 feet between the overhead ground wire and the highest projection on the building. When the ground cable runs across and is used to protect stacks or vents which emit explosive dusts, vapors, or gases under forced draft, the cable should have at least 15 feet clearance above the stack or vent. The zone of protection is considered as a triangular prism having a rectangular base four times as wide as the height of the poles. Each pole shall be set at a distance from the structure equal to at least one-third the height of the building but in no case at less than 6 feet.

c. A ground rod shall be driven approximately 6 feet from the base of each pole. If the resistance



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to ground of the rod for each pole is more than 10 ohms, the conditions stated in paragraph 803g apply.

### **813. FENCES**

a. Fences should be grounded on each side of every gate, and where crossed by high tension lines, at points 150 feet on each side of high tension line crossings. Fences should be grounded every 1,000-1,500 feet of length when the fences are located in isolated places and at lesser distances depending upon proximity of fence to public roads, highways and buildings.

b. If the fence consists of wooden posts and horizontal metal strands only, down conductors shall be run the full height of the fence and securely fastened to each wire so as to be electrically continuous. Where the fence is a chain link fence and the wires are electrically continuous, the connection to ground may be made from the bottom strand or from the post, if it is of metal and is electrically continuous with the fencing.

### **814. EXTERIOR OVERHEAD PIPE LINES**

Overhead pipes which enter a building containing explosives shall be properly grounded preferably to the building grounds at points where pipes enter the buildings. If a separate ground is used, the pipes should also be bonded to the building ground at points where they come closest to it. In addition, they should be bonded to any metallic masses that are within 6 feet of these pipes.

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## 815. TANKS AND TOWERS

*a.* Wooden towers and tanks, or tanks made of light metal or having light metal roofs shall have air terminals. Tanks with a metal roof or sides which will not be damaged by a lightning discharge, need not have air terminals. If metal tanks and towers are electrically continuous, down conductors are not needed. All structures shall have at least two ground connections and be properly grounded. On tanks, towers, and stacks exceeding 100 feet in height, it is advisable to use more massive conductors and fastenings than are ordinarily called for in this section. The number and location of air terminals shall, in general, comply with the requirements of paragraph 803*b*; however, if the roof of the structure ends in a peak, a single air terminal may be regarded as sufficient. Care must be taken to assure rigid connections and electrical continuity without air gaps. All metallic guys should be grounded. All requirements specified in paragraphs 811*a* and *b* shall be observed.

*b.* Where more than one air terminal is used they shall be connected together by a conductor which forms a closed loop about the structure near the top or passes over it, as the contour of the roof may require. From these conductors, or from the single air terminal if but one is used, at least two down conductors shall be extended directly to the ground connections and diagonally opposite sides if the structure is isolated. If the tank or tower is an adjunct

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of a building, near or touching the perimeter, one of the down conductors shall be extended directly to a ground connection while the other may be connected to the lightning protection system on the building. If the tank or tower is set well within the perimeter, both down conductors may be connected to the lightning protection system of the building. If the height of the structure exceeds 100 feet, the down conductors should be cross connected midway between the top and bottom.

c. Metal guy wires on tanks and towers shall be grounded. Metal guy wires or cables attached to steel anchor rods set in earth may be considered as properly grounded. Those set in concrete or attached to buildings or nonconducting supports require grounding.

#### **816. STACKS**

a. In general, stacks should meet the requirements of paragraph 815 for tanks and towers. Metal smokestacks need no protection against lightning other than that afforded by their construction except that they shall be electrically continuous and be properly grounded. If the construction of the foundation is not such as to provide ample electrical connection with the earth, ground connections shall be provided. Metal guy wires for stacks shall be grounded. Metal guy wires or cables attached to steel anchor rods set in earth may be considered as sufficiently well grounded. However, those set in

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concrete or attached to buildings or nonconducting supports shall be grounded.

b. On nonmetallic smokestacks constructed of brick, hollowed tile or concrete, the air terminals shall be strongly constructed of the same grade of material as the conductor, or may be made of stainless steel, monel metal or other equally corrosion-resistant metal. They shall be uniformly distributed about the rim of the stack at intervals not exceeding 8 feet and shall extend at least 30 inches above the rim of the stack. The air terminals shall be electrically connected together by means of a metal band or ring which forms a closed loop about 2 feet below the top of the stack. If there is a metal crown, the air terminals should be connected thereto. Where stacks have a metal lining extending part way up, the lining shall be connected to the air terminal at its upper end and grounded at the bottom.

- (1) At least two down conductors shall be provided on opposite sides of the stack leading from the ring or crown at the top to the ground. If the stack is an adjunct of a building near or touching the perimeter, one of the down conductors shall be extended directly to a ground connection while the other may be connected to the lightning protection system on the building. On stacks exceeding 160 feet in height, the down conductors shall be cross connected approximately midway between the top and the bottom. Where a metal ladder is electri-

cally continuous from the rim to the ground and the vertical members have a cross section of not less than twice that specified for galvanized steel conductor, such members may be utilized as down conductors. Joints in conductors shall be as few as practicable and of such construction as to show by laboratory tests a strength in tension of at least 50 percent of that of the conductor. Fasteners shall be spaced not over 4 feet apart and of a material similar to that of conductors and shall be resistant to corrosion.

- (2) To prevent corrosion by gases, copper air terminals, conductors, and fasteners within 25 feet of the top of the stack shall have a continuous covering of lead at least one-sixteenth inch thick.
- (3) Stacks partly or wholly reinforced concrete shall comply with the requirements of nonmetallic stacks and, in addition, the reinforcing metal shall be electrically continuous and shall be electrically connected to down conductors at the top and bottom of the concrete.

## 817. RAILROADS

Rails which are not electrically continuous together with rail switches shall be bonded for a

distance of at least 100 feet on each side of the structures, including loading docks where explosives and/or ammunition are stored, handled, or processed. These rails shall also be effectively grounded. At points where the tracks come within 25 feet of structures already provided with a grounding system, such groundings shall be interconnected to the nearest rail. The cable used for bonding shall be of at least  $\frac{3}{8}$ -inch diameter or the same size as the conductors used on the structure, unless bonding points are on the sides of the rail heads and  $3\frac{1}{2}$  inches from the ends of the rails. In the latter case,  $\frac{3}{16}$ -inch cable is satisfactory.

#### 818. PIERS AND WHARFS

Lightning protection systems for piers and wharfs shall comply with the requirements of this section for the type of construction involved.

#### 819. INTERCONNECTION OF METAL BODIES

a. Metallic masses about a building which are a permanent portion of the structure or are permanently installed within or about it, shall, with the exception of those of comparatively small size, be made part of the lightning conductor system by interconnection with it, or be independently grounded, or both, depending upon their location with respect to the lightning conductors and their surroundings.

b. Metal bodies situated wholly on the exterior of buildings (ridges, valleys, gutters, etc.) shall be electrically connected to the conductor at its upper

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(nearest) end and, if the body is of considerable length, it shall be grounded or electrically connected to the conductor at its lower (or farthest end).

c. A metal body situated wholly in the interior of a building (tanks, radiators, piping systems, stationary machinery, etc.) which at any point comes within 6 feet of a lightning conductor, or metal connected thereto, shall be electrically interconnected with it, and if of considerable size or length, shall be grounded at its lower or farther extremity within the building. A metallic body having any dimension exceeding 5 feet and situated wholly within a building, and which does not at any point come within 6 feet of a lightning conductor or metal connected thereto shall be independently grounded. All metal parts which are within a metal roofed and metal clad building (metal of building electrically continuous) shall be independently grounded and if within 6 feet of the sides or roof shall be connected thereto.

d. Metal such as soil pipes, metallic flues and overflow pipes of hot water heating systems which project through roofs or through the sides of buildings above the second floor, shall be bonded to the nearest conductor at the point where it emerges from the building and be grounded at its lower or extreme end within the building. Metal which projects through the sides of buildings below the second floor shall be treated as though it were wholly within the building.

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*e.* Extended metal parts of the building shall not be substituted for regular conductors, except where they are permanently electrically continuous and have a conducting cross-sectional area at least double that of the lightning conductor that would otherwise be used.

*f.* For bonding, interconnecting and independent grounding of metallic masses, the conductor used shall be at least the equivalent in strength and conducting cross-sectional area of a No. 6 AWG copper wire, except where a full size conductor (same weight per unit of length as the main conductor) is required for ventilators, stacks, etc.

## **820. MATERIALS**

*a.* No combination of materials shall be used that form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause deterioration or corrosion of conductors, conductors with suitable protective coatings or of large size wire than that specified below should be used. If a mechanical hazard is involved, the conductor size shall be increased to compensate therefor, or suitable protection shall be provided. The conductors may be protected by covering them with molding or tubing preferably made of wood or nonmagnetic material. If metal tubing is used, the conductor shall be electrically connected to it

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at its upper end. Conductors shall consist of any of the following materials:

b. Where copper is used, it shall be of the grade ordinarily required for commercial electrical work, generally designated as being 98 percent conductivity when annealed. If the conductor is of copper cable the weight shall not be less than 187.5 pounds per 1,000 feet and the size of any wire of this cable shall not be less than No. 17 AWG (0.045 inch). Copper tube or solid section conductors of copper or copper clad steel shall weigh not less than 187.5 pounds per 1,000 feet and any tube wall shall not be less than No. 20 AWG (0.032 inch). The thickness of any copper ribbon or strip shall be not less than No. 16 AWG (0.051 inch). Copper conductors used on non-metallic stacks shall weigh not less than 375 pounds per 1,000 feet and the size of any wire in the cable (or wall thickness if tube is used) shall not be less than No. 15 AWG (0.057 inch). The thickness of any web or ribbon used on stacks shall be not less than No. 12 AWG (0.081 inch).

c. Where copper clad steel is used, the copper covering shall be permanently and effectively welded to the steel core and the portion of copper shall be such that the conductance is not less than 30 percent of the conductance of an equivalent cross-section of solid copper. The diameter of such solid wire or stranded cable shall be not less than three-eighths of an inch and the weight per 1,000 feet shall not be less than 187.5 pounds. The strands of the cable shall be not less than No. 14 AWG (0.064 inch).

d. Galvanized steel should not be used in areas in which the atmospheric conditions are destructive to galvanized steel. Galvanized steel solid wire or

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stranded cable shall have a diameter of not less than three-eighths of an inch and shall have a net weight of steel of not less than 320 pounds per 1,000 feet and the size of any wire of the galvanized steel cable shall be not less than No. 14 steel wire gauge (preferably No. 10, for overhead ground wire protection). The thickness of any tube wall, web or ribbon before galvanizing shall not be less than U. S. Standard sheet gage No. 17 (0.056 inch), and the diameter of any wire of a cable before galvanizing shall be not less than No. 14 steel wire gage (0.080 inch). Where galvanized steel conductors are used the individual wires of the cable shall be provided with a protective coating of zinc (hot dipped process) capable of withstanding, after cabling, four 1-minute immersions in a standard copper sulphate solution without showing a fixed deposit of copper.

e. Air terminals shall be tapered to a point and the minimum diameter of the rod (below the point) shall be  $\frac{3}{8}$ -inch solid copper, copper clad steel, or hot dipped galvanized steel. **Solid aluminum points shall be not less than  $\frac{1}{2}$  inch in diameter and of same length as required for copper. Aluminum tubular points shall be not less than  $\frac{5}{8}$  inch in O. D. No. 16 AWG (0.050-inch) wall thickness and of the same lengths required for copper points.** Separate points are not required on top of air terminals, but if used they shall be substantial and be securely attached by screw or slip joints.

f. (Added) Where aluminum is used, care should be taken not to use it in contact with the ground or elsewhere where it will deteriorate rapidly, special attention shall be given to connections with dissimilar metals. Cable conductors shall be of elec-

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trical conductor grade aluminum. Aluminum cable conductors shall weigh not less than 95 pounds per thousand feet and the size of any wire of the cable shall not be less than No. 14 AWG (0.064 inch). Aluminum conductors for bonding and interconnecting metallic bodies to the main cable shall be at least equivalent in strength and cross-sectional area to the No. 4 AWG (0.204-inch) aluminum wire. Aluminum strip conductors for interconnecting metallic bodies to the main conductor cable, if void of perforations, shall not be less than No. 14 AWG (0.064 inch) thickness and at least  $\frac{1}{2}$  inch wide. If perforated, the strip shall be as much wider as the diameter of the perforations. Aluminum strips for connecting exposed water pipes shall not be less than No. 12 AWG (0.80 inch) in thickness and  $1\frac{1}{2}$  inches wide. Aluminum connectors shall not be less than No. 12 AWG in thickness and of the same design and dimensions required for stamped copper connections. Aluminum, galvanized iron or aluminum alloy fixtures and fittings are the only types permitted, except that copper or copper-covered ground rods and leads may be employed, provided clamps for connecting aluminum down conductors to the copper or copper-covered grounding equipment are types specially designed for making the connection between two dissimilar metals. The connection shall be made at a point not less than 1 foot above ground line. Suitable guards shall be used to protect the connection from mechanical damage and displacement.

## **821. TESTING AND INSPECTION**

*a. General.* Lightning protection systems shall be visually inspected semiannually and shall be tested

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once each year for electrical continuity and adequacy of grounding. A record of results obtained from the continuity and grounding tests, including action taken to correct deficiencies noted, must be maintained at the installation. Any system shall be considered deficient if electrical continuity does not exist. Except where counterpoises are installed, systems shall be considered deficient if resistance to ground exceeds 10 ohms. Whenever tests result in readings of 10 ohms or less resistance to ground, the record may consist of a single statement to that effect. When resistance to ground exceeds 10 ohms, the record should include the following:

- (1) Building number, contents and/or use.
- (2) Date of inspection.
- (3) Identification of part of system.
- (4) Resistance (in ohms).
- (5) Remarks (mechanical condition, nature of soil, etc.).
- (6) Corrective action taken.

*b. Test instruments.* Electrical tests consist of measuring the ohms resistance of the systems to ground and the ohms resistance of any grounding system or individual ground connection. The following description and cited drawings are based on the use of a testing instrument which employs one instrument test ground. If an instrument such as the "Megger" is used, two instrument test grounds are needed. The manufacturer's instruction manual

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should be followed to assure proper use of the instrument.

*c. Integrally mounted systems.* Reference is made to figure 821A. The testing consists of firmly attaching one lead, either positive or negative, of the resistance meter to the test ground which has been driven to a depth of at least 3 feet at a distance of at least 50 feet from the system and attaching the other lead of the resistance meter to each of the air terminals consecutively, reading the resistance on the meter for each of the air terminals. If the continuity of the lightning protection system is good, there should be practically no difference in the resistance value at any one of the testing points. However, if a marked increase in resistance is noted, it is an indication that a loose, corroded, or broken connection exists in the system. If the resistance of all air terminals to ground is high, then a test can be made at the earth line by connecting the test lead to the down conductor of the system, thus measuring the resistance of the system ground only.

If the resistance is again found to be high, then the system ground is the cause of the indicated high resistance value. If the resistance, when the testing lead is connected to the down conductor, is low, it is then an indication that the trouble is between the

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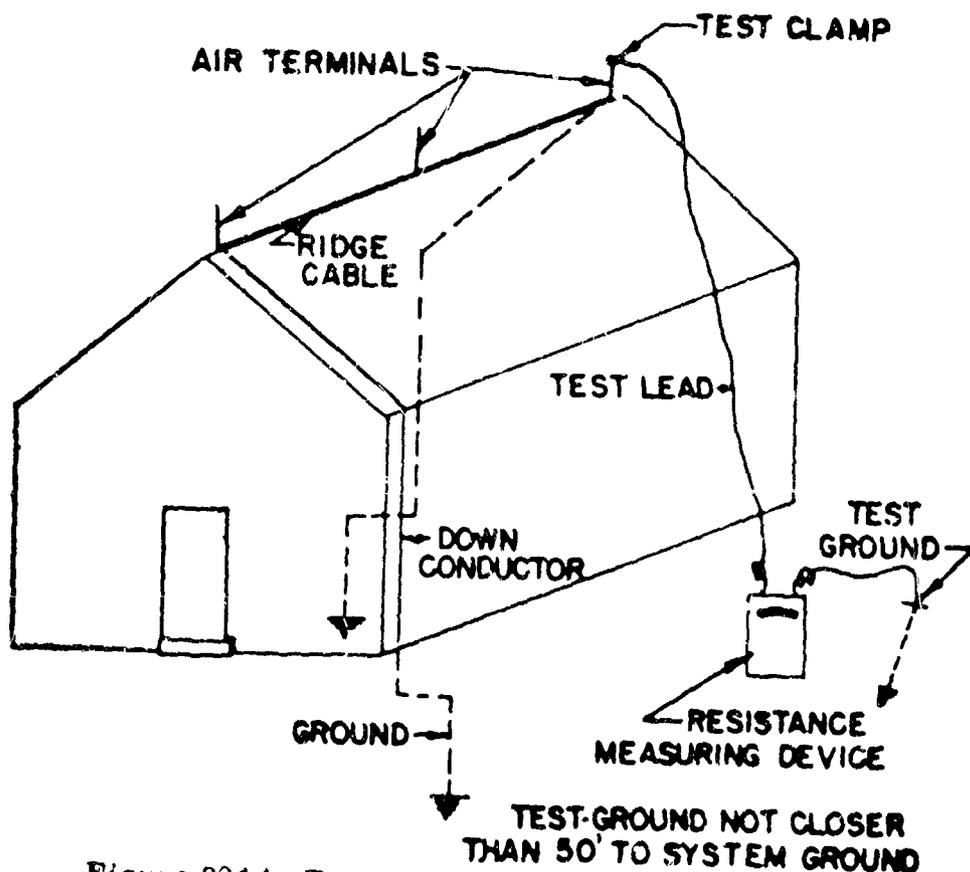
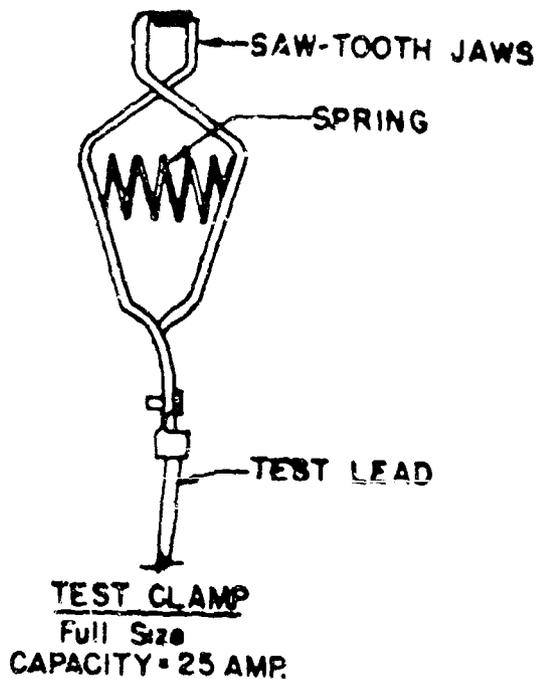


Figure 821A. Testing Lightning Protection System.

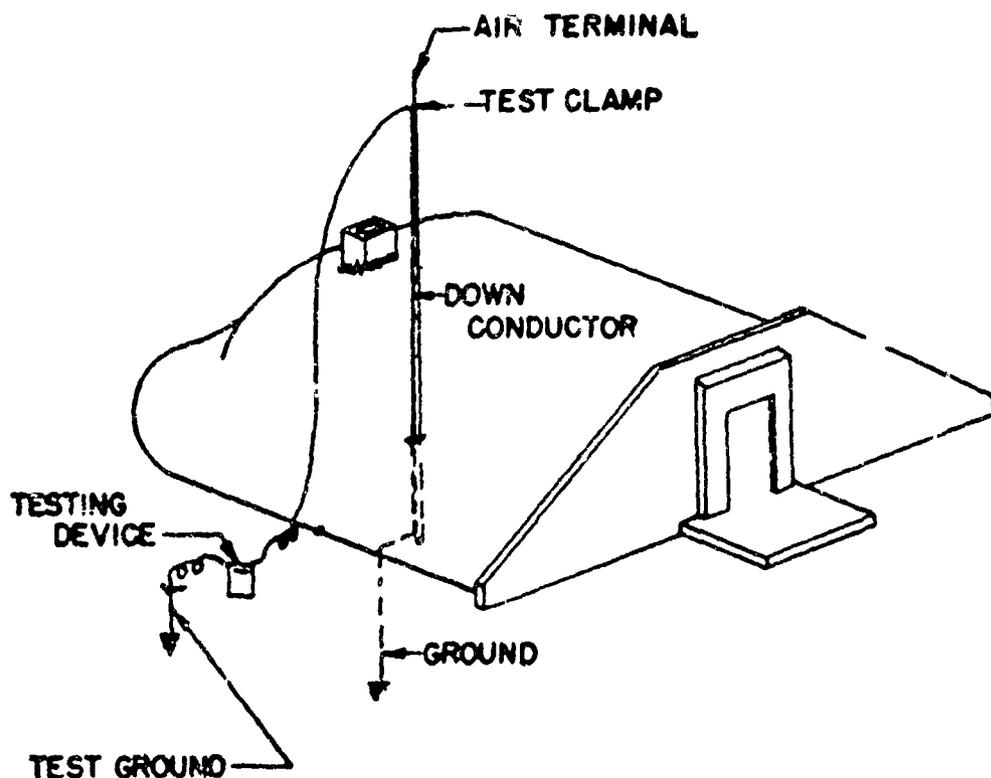
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original point of contact on the air terminal and the point of contact on the down conductor. Steps should be taken to reduce all resistances that are above 10 ohms, this might mean checking all connections, cables, installing a new ground or a counterpoise, changing parts or by other means called for in previous paragraphs.

*d. Separately mounted shielding systems (mast type).* Reference is made to figure 821B. There is a possibility that the down conductor may have been severed at some time, therefore, the test lead should be connected to the air terminal, the other lead to the test ground and the resistance to ground read. The test ground shall be driven at the same distance and to the same depth as for testing the integrally mounted system. When testing a system using a metal mast, one of the test connections is made directly to the mast at a point approximately 24 inches above the ground and the other to the test ground. The resistance is then read on the instrument.

*e. Separately mounted shielding system (overhead ground wire).* Reference is made to figure 821C. One lead of the testing instrument should be connected to one air terminal and the other to the test ground and the resistance read. This operation should then be repeated on the other air terminal. This will determine the resistance between air terminals and ground. A continuity test can then be made by disconnecting one ground connection and attaching one lead of the testing instrument to one guy down conductor approximately 24 inches above

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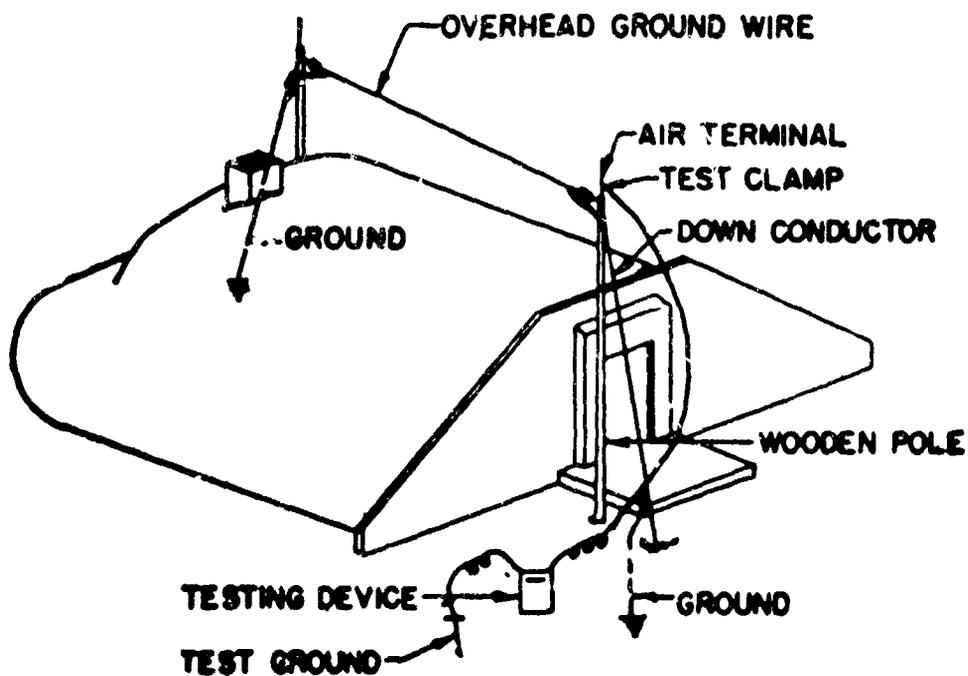
IF METAL POLE IS USED AIR TERMINAL IS OMITTED AND  
POLE ACTS AS DOWN CONDUCTOR

*Figure 821B. Testing Grounds Separately Mounted Shielding System (Mast Type).*

ground and the other lead to a similar place on the other guy down conductor. The test instrument is then read and the reading should be approximately zero if all connections are good. In an overhead ground wire system using metal masts, one test lead should be connected to the metal mast and the other to the test ground and the instrument read. This same operation is repeated using the other metal mast. It is more difficult to check the electrical con-

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tinuity in a system using metal masts than in a system using nonconducting masts as the system using metal masts has no guy down conductors that can be disconnected. It is not a reliable check to connect the leads to the metal masts and take a reading, as the bottoms of the masts may be in water and the path through water show less resistance than the path through the poles and overhead ground wire. To accurately check continuity in a system using the metal mast it will be necessary to disconnect the



**IF METAL POLES ARE USED, AIR TERMINALS ARE OMITTED AND THE POLES ACT AS DOWN CONDUCTORS**  
*Figure 821C. Testing Grounds Separately Mounted Shielding System (Overhead Ground Wires).*

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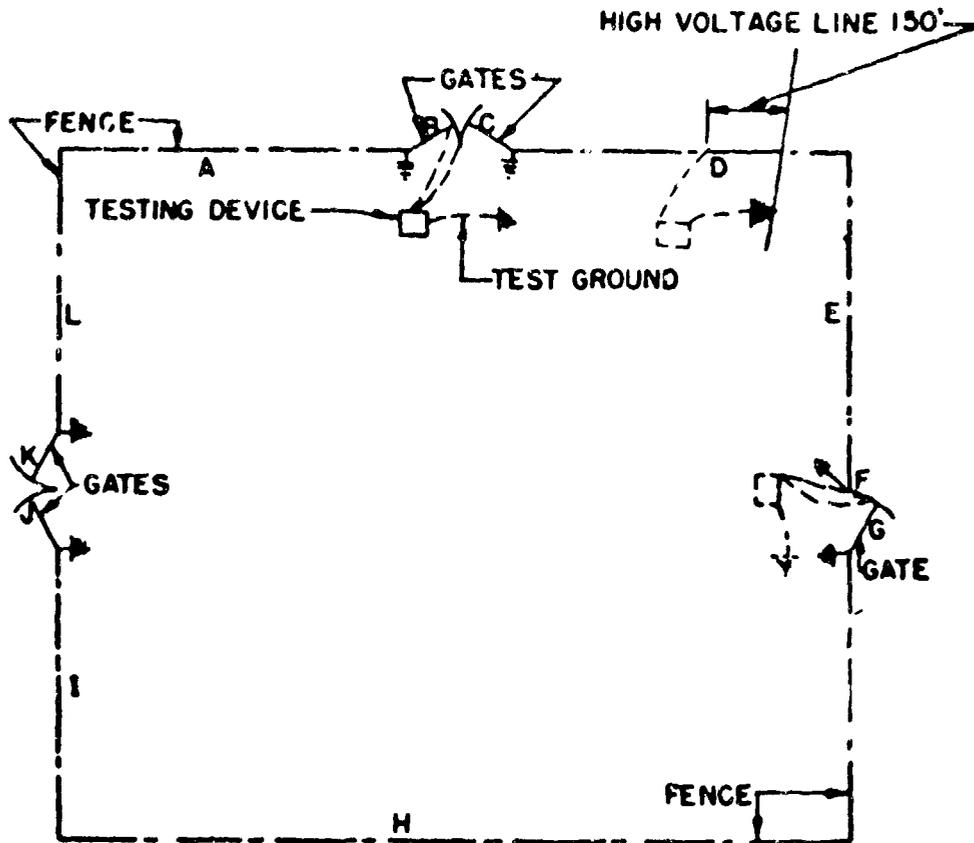


Figure 821D. Testing Grounds of Fences.

overhead ground wire at one mast and then connect one lead of the testing instrument to the free end of the overhead ground wire and the other lead near the base of the opposite mast. The operation should be repeated checking the continuity through the overhead ground wire and its connection at the opposite mast.

*f. Fences.* Reference is made to figure 821D. In view of the fact that a continuity test of a complete fence or appreciable section thereof, is, in most cases impracticable, the only resistance tests that will be considered at this time are those illustrated on the

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above-mentioned drawing. A resistance test should be made at each gate, with the gate or gates open, by connecting one lead of the testing instrument to the free end of the gate at point "B," then with the other lead of the instrument connected to a test ground, a reading is taken. This shows the resistance from the swinging end of the gate to ground. The same test should be made at point "C" and at each other gate. A test between points "B" and "C" will give the actual resistance in ohms between the two swinging gates. If the resistance found at "B" and "C" is not the same in each case, a difference of potential can exist at times between the two gates. If a difference in resistance to ground does exist from points "B" and "C," the fencing on opposite sides of the gates should be bonded together by means of an underground conductor. A resistance test made at point "D" will show the resistance to ground at a point 150 feet from the point where the fence is crossed by a high voltage line. By conducting similar tests at other sections of the fence, a suitable check on the fence grounding system will be obtained.

*g. Stacks.*

- (1) Reference is made to figure 821E. To determine the resistance to ground of air terminals on nonmetallic stacks, it is necessary to connect one lead of the testing instrument to an air terminal, the other lead to the test ground and the instrument read. This operation must be repeated for each air terminal. To check the resistance of the

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ground and ground connection the disconnect clamp "A" should be removed and one lead of the testing instrument connected to the remaining part of the down conductor at point "W" the other lead to the test ground and the instrument read. Repeat operations on ground "B." Continuity can be checked to the cross-connecting band at the base of the air terminals or the midway cross-connecting band if the stack is over 160 feet in height without leaving the ground by the following method. Remove disconnecting clamps "A" and "B" and connect the leads of testing instruments to points "X" and "Z." If the reading is practically zero, it is a fair indication that the continuity to the first cross-connecting band is good; however, it cannot be taken for granted that the continuity above the mid cross-connecting band, if there is one, or to the air terminals is good.

- (2) Metal stacks should have one lead of the testing instrument attached to the stack, the other lead to the test ground and the instrument read. If the grounds alone are to be tested, the ground connections should be disconnected from the stack, one lead attached to the loose end of the ground connection and the other lead attached to the test ground.

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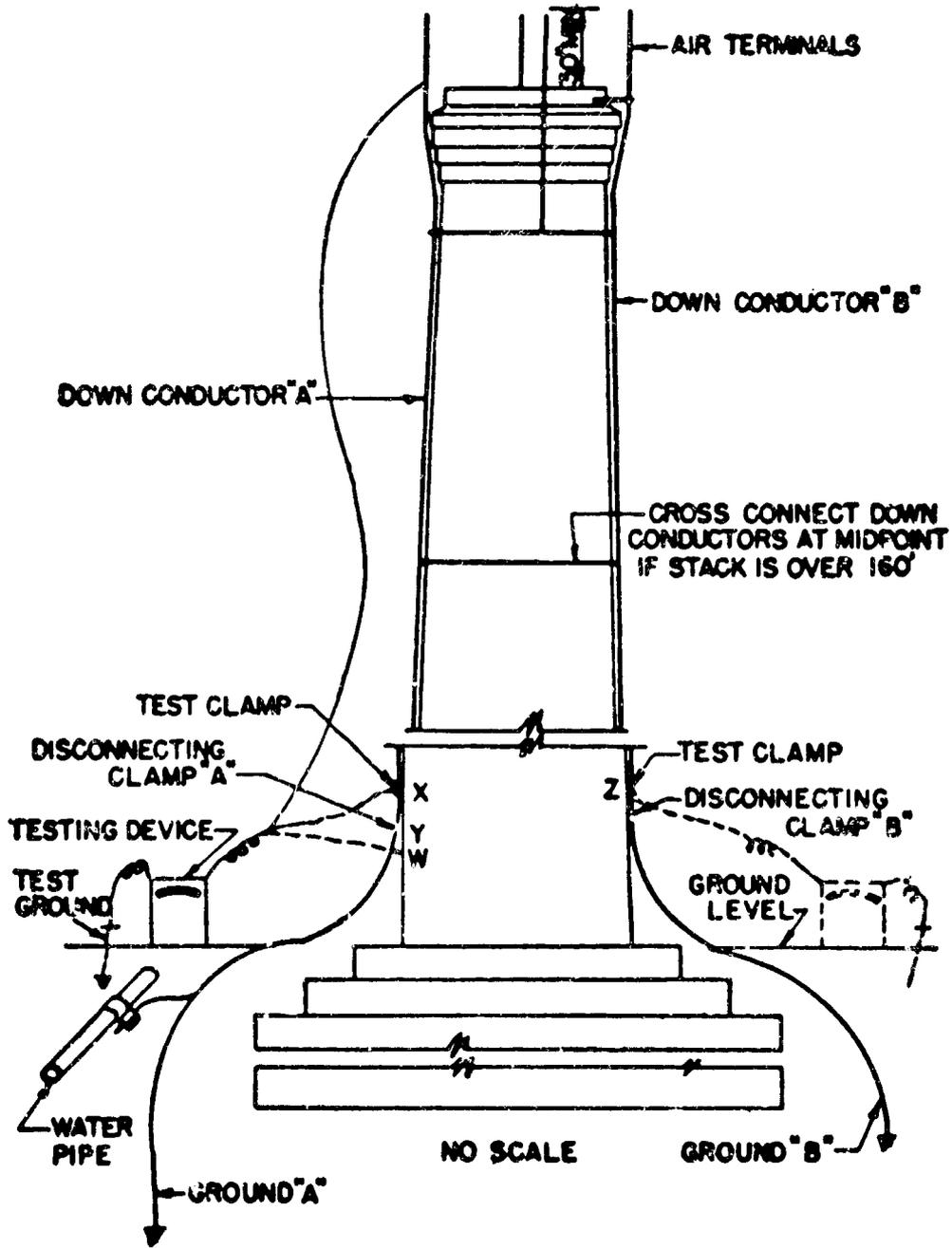
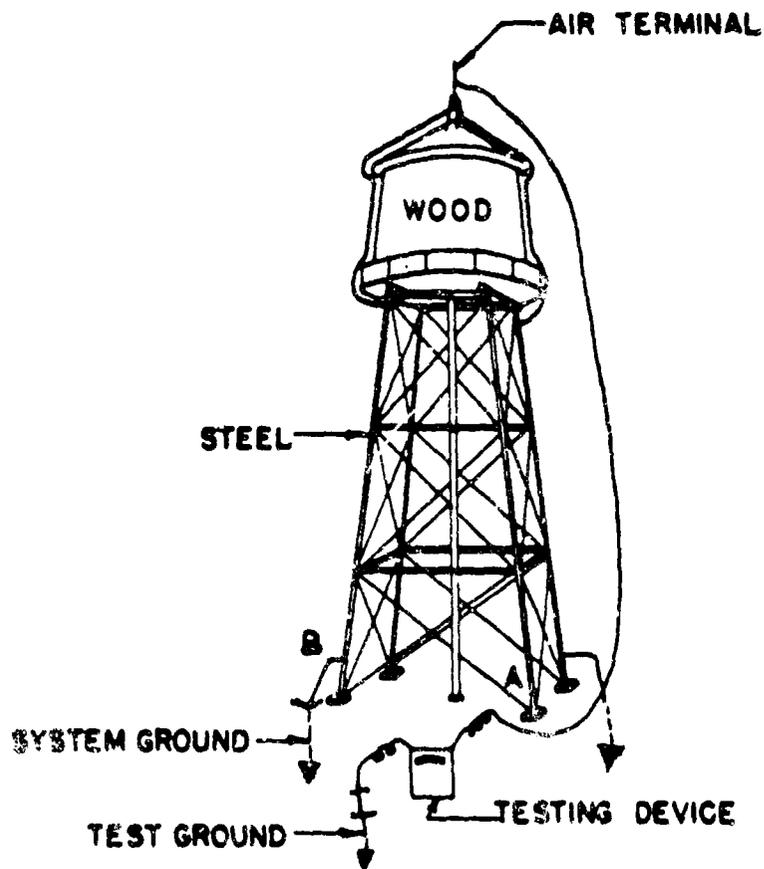


Figure 821E. Testing Grounds of Stacks.

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*h. Wooden tanks.* Reference is made to figure 821F. To check the resistance of the air terminal and cable to ground, one lead of the testing instrument is connected to the air terminal, the other to



FOR INSTALLATIONS HAVING WOOD FRAMES, DOWN CONDUCTORS FROM THE AIR TERMINAL ARE REQUIRED.

FOR INSTALLATIONS HAVING STEEL TANK, HEAVY STEEL ROOF AND TOWER, NO AIR TERMINAL OR DOWN CONDUCTORS ARE REQUIRED AS STEEL TANK ACTS AS CONDUCTOR.

*Figure 821F. Testing Grounds of Tanks.*

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the test ground and the instrument read. To check the resistance of the ground, one lead is connected to point "B" and the other to the test ground. If the tank has a cross-connecting band, continuity should be checked as described for nonmetallic stacks.

*i. Metallic tanks.* On metallic tanks that have air terminals, the same procedure as for wooden tanks shall be used. When testing metallic tanks (and metallic framework) without air terminals, one lead of the testing instrument should be attached to the roof, the other to the test ground and the instrument read. To test the grounding electrodes, the leads of the testing instrument should be connected one to the ground connection and the other to the test ground, and this procedure shall be repeated for all the other ground connections.

*j. Miscellaneous.* The resistance and electrical continuity of all grounded doors, windows, gutters, metal masses, etc., in buildings equipped with lightning protection systems, should be tested by clamping one lead of the test instrument to the door, etc., and the other lead to the system ground. The resistance reading should be practically zero.

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## SECTION 9

### ORDNANCE TECHNICAL INDUSTRIAL SAFETY

(Superseded)

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#### 901. SAFETY STANDARDS

a. Appropriate local standards for safe practices and procedures, personal protective equipment, machine guards, etc., shall be developed, approved, and adopted. Upon adoption, the standards should be circulated to all division chiefs, production chiefs, and foremen to whose departments they apply. The engineering and purchasing departments should receive copies of all new standards. The standards developed locally shall not be in conflict with the requirements of this manual without written authority from the Chief of Ordnance.

b. The latest editions of American Standards as published by the American Standards Association and the National Bureau of Standards Codes are acceptable as reference codes for Ordnance establishments. However, where these codes conflict with the requirements of this manual, this manual shall apply.

c. Publications of the National Safety Council are acceptable as guides in the formulation of safety standards except where such publications may conflict with the requirements of this manual in which case this manual shall apply.

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## 902. MATERIALS HANDLING

*a. General.* Materials handling and production methods affecting materials handling should be studied as a specific phase of the safety program for determining unsafe methods and for promoting greater safety. Movement of materials should be continuous to produce greatest efficiency and to avoid congestion by accumulation at machines and in other working spaces. Procedures should be in conformity with the following basic rules:

- (1) Keep material moving uniformly through the process steps.
- (2) Minimize unnecessary rehandling.
- (3) Eliminate heavy manual lifting.
- (4) Reduce transport distances wherever possible.
- (5) Provide special handling equipment, such as conveyors, fork lift trucks, etc., where practicable.

These basic approaches simplify handling of materials and aid in the control of accidents. Where these processes are organized, standard safe practices can be developed, and increased accident control can be accomplished.

*b. Movement of materials.* Materials should be delivered to each succeeding operation in units of proper size. Generally, materials should be supplied and finished parts removed at frequent intervals to eliminate congestion, blocking of aisles, and attendant hazards. The materials should be brought

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to each operation by conveyors, platform skids, etc., at the same height they will be used so that unnecessary manual or mechanical lifting or handling will be avoided. Equipment for handling materials should be especially designed to accommodate the size and type of materials being moved. Where material is handled manually, every effort should be made to eliminate the necessity for lifting and to substitute methods for pulling, pushing or rolling loads.

*c. Stacking.*

- (1) At all points, materials shall be piled in a manner that assures stability and facilitates removal. Some materials should be stacked in sequence so that the oldest will be used first; occasionally selective piling is required, both of which require careful planning in all storage operations. Careful consideration should also be given to the methods of loading materials for transporting so that hazards will be minimized in the unloading of the item.
- (2) Storage stacks and loads on shop trucks, conveyors, etc., must be stable to minimize slips, slides or tip-overs, which create hazards and slow operations. Stacks should be chocked where necessary.

**903. LOADING DOCKS**

*a.* Ample space at loading and unloading docks should be provided off the traveled roadways to per-

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mit efficient operation without hampering the flow of traffic. Adequate bumper rails should be installed parallel to loading docks, at distances which permit trucks and trailers to back in without striking the dock.

b. Gangplanks of proper design should be provided to compensate for horizontal and vertical differences between truck bodies and the edge of the loading dock. Loading docks should be high enough to permit the placing of gangplanks as nearly as possible in a horizontal plane. Gangplanks shall be fastened securely to prevent displacement while in use. Well-constructed skids kept in good repair should be carried in trucks or provided at points where they will be needed. Consideration should be given to the design, construction, and use of special aids in connection with loading and unloading operations to lessen inherent handling hazards.

c. The location of loading docks upon which explosive materials are handled shall conform to the requirements of paragraph 1717.

#### **904. CRANES**

a. *Operation.* Cranes shall be operated only by authorized crane operators whose physical fitness for the job has been certified by the medical officer. The operator should be governed in his movement of material by a uniform code of signals such as American Standards Association, Code for Cranes, Derricks, and Hoists. He should inspect his crane at the beginning of each shift to determine that it is in safe oper-

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ating condition. All loads should be lifted vertically and side pulls avoided. When necessary to guide the load, guy lines should be used. Operators should avoid carrying loads over persons. Gantry cranes must not be operated while workmen are present on tracks unless bumpers have been placed between the crane and the men. If the electric power fails during crane operations, the crane operator should turn the controller to the "off" position immediately. Before leaving the crane, the operator should see that all hooks are clear of all moving objects below. Before lifting any unusual loads, the safety director should be notified and approval secured.

*b. Specifications.* A plate showing the maximum lifting capacity in pounds shall be posted in a protected yet conspicuous place where it is clearly visible from the floor. The plate should show the lift capacity at the usual angles of lift. **Boom angle indicators are desirable.** The control board and all exposed wiring and switches should be guarded. Access ladders for electrically driven overhead cranes should be located so that the operator does not pass within reach of electrical conductors while approaching the controls of the crane. Installation of crane facilities should include a proper "catwalk" for the entire length of the crane runway. Where needed, an adequate rope ladder or other suitable device should be provided for the escape of the operator in an emergency. Cranes shall be equipped with brakes and traveling cranes shall be equipped with a signal warning device to be sounded intermittently while

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the crane is in motion. Locomotive cranes and derricks should be equipped with effective outriggers and rail clamps.

*c. Special hazards.* Electrical cranes shall not be used where flammable dust or vapor is present.

*d. Inspection.* Inspection schedules should include the inspection of each crane monthly. Inspections should conform to the procedures outlined in the latest revision of American Standard Code for Cranes, Derricks, and Hoists, B30.2-1943, published by the American Standards Association. Inspection records files should be maintained at station level.

## 905. HOISTS

*a.* This paragraph includes manually operated and power-operated hoists commonly called chain hoists, air hoists, and portable floor cranes. All such equipment shall be inspected for determination of hazards incident to its use and appropriate safety control measures shall be instituted. Periodic inspection shall be made as outlined in the latest revision of American Standard Code for Cranes, Derricks, and Hoists, B30.2-1943, published by the American Standards Association. Detailed inspection of chains used in chain hoists is discussed in paragraph 907.

*b.* On electric and air hoists, a limit stop should be provided to prevent the hoist block from over-travel in case the operating handle is not released in time. A spreader should be used to separate control ropes, each of which should be marked; sound practice indicates that handles of different contour should be provided on each rope to avoid mistakes in operating

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direction. Hoists mounted on monorail or tramrail systems should not be used to lift or move a heavy object by a side pull since it may spread or break the trolley frame or loosen supports. Stops should be provided at all switches and turnouts on monorail systems to prevent the trolley from running off if the switch is left in the open position. Load capacity shall be plainly marked on each piece of equipment.

c. Electric hoists shall not be used where flammable dust or vapor is present.

### **906. ELEVATORS**

The carrying capacity of the elevator shall be posted at all entrances to the elevator and in the elevator. Elevators must be equipped with safety catches, automatic limit stops, and emergency exits. The access openings must be guarded securely by approved gates or doors. Gates or doors must be arranged so that the elevator cannot be started until the gate or door to the elevator has been closed. Elevator shafts and all elevator equipment should be inspected **quarterly** and an inspection report filed. They shall be inspected annually by a qualified agency. Unless specifically designed for passenger service, personnel should not be permitted to ride in elevators.

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## 907. CHAINS

*a. Usage.* Wrought iron or "crane chain" is the acceptable type of chain used for slings, hoists, cranes, steam shovels, and marine purposes. The iron must be free from iron scrap, steel scrap, and should be lap welded for strength. Chains shall be used only for loads within their rated strength. Normalizing or annealing should be done as recommended by the manufacturer of the chain. He should be informed as to the use of the chain and if normalizing or annealing is recommended, the intervals and procedures should be obtained from him. End fastenings on chains should sustain loads up to the breaking strength of the chain. Shackles and pins should be of forged steel, preferably drop forgings and weldless throughout. Pin shackles should be fitted and maintained with cotter pins or safety pins of a positive locking type.

*b. Inspection and repair.* A thorough inspection should be made of all chains at least once a month and a signed report of same kept on file. The inspection should cover interlink wear, stretch, defective links, peening or hammering action of the links on each other, work hardened surfaces, corrosion, or any other defects. Chains should be removed from service when the increase in length of the measured section exceeds 5 percent; when a link is bent, twisted, or otherwise damaged; or when raised scarfs or defective welds appear. All repairs to chains should be made only by an experienced chain

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man; it is preferred that chains be returned to the manufacturer for repairs. Defective links or portions of chain should be replaced by links having proper dimensions and of material equal to that of the original chain. All repaired chains should be proofed to twice the corrected safe working capacity (corrected for wear) before reinstallation.

#### 908. WIRE ROPE

*a. Use.* Braided cable wire rope is preferable. Wire rope shall be used for loads only within its rated capacity. It should be handled in such a way that it is neither twisted nor untwisted; kinks should be avoided. Wire rope should be kept well lubricated with the lubricant approved by the manufacturer of the rope. Eye splices should be made in an approved manner by an experienced splicer and thimbles should be used in them except in slings, where the use of thimbles is optional. When wire rope clips attached with U-bolts are used, the bend in the U-bolts should be on the dead or short end of the rope. After the equipment has been in operation for an hour after the initial installation, all nuts on the clip bolts should be tightened, and they should be checked for tightness at frequent intervals thereafter. Socketing should be done with zinc (spelter) in the manner specified by the manufacturer. Wire rope should be stored off the ground, in a dry, protected place, free from any exposure to acids, alkalis and their vapors. The storage place should not be permitted to become so hot as to injure the hemp core.

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*b. Inspection.* A thorough inspection of wire ropes should be made at least once a month by a qualified individual and a full written and signed report of rope condition be kept on file. Special attention should be given to the end fastenings. Rope should be examined frequently at socket fittings and upon the development of one broken wire adjacent to this point, the rope should be resocketed. Portions of rope subject to reverse bends and use over small sheaves or drums should also receive close attention. Any marked reduction in diameter of the rope indicates the need for more frequent examination to detect critical reduction of wire area. All wire rope in regular and active use should be inspected carefully for broken wires, abrasions, and any localized spots showing excessive wear. Wire ropes should be replaced when the wear, the number of broken wires in a lay, or corrosion has reached a point which indicates an unsafe condition. When corrosion is present, the remaining strength of the wire rope cannot be calculated with safety. Corrosion can be controlled by proper and suitable lubrication.

#### **909. FIBER ROPE**

*a.* Sisal rope of good quality is only about 67 percent as strong as manila rope. The best hemp is not quite equal in strength to manila fiber but is slightly more resistant to atmospheric deterioration. Ropes should be thoroughly cleaned and stored in a dry, well-ventilated place free from any exposure

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to acids, acid vapors, or strong alkalis, and they should not be used where they are exposed to these materials. Ropes should be kept away from radiators, steam pipes, or other sources of heat. Small ropes should be hung in loose coils and large ropes coiled on gratings raised from the floor. While in use, rope should be kept free from grit and should not be dragged on the ground. Fiber rope should be handled in such a manner that it is neither twisted nor untwisted. Kinks should be avoided. When splicing two rope ends for permanent use, for ring fastening or for fastening around a block or thimble, splices should be made only by an experienced rope splicer. Fiber ropes shall be used only for loads within their rated capacity.

b. Fiber rope should be inspected before being put into use and monthly thereafter, and a full written and signed report of rope condition should be kept on file. Inspections should cover external wear, broken or cut fibers, displacement of yarns or strands, variation in size or roundness of strands, discoloration or rotting. When any of these conditions which affect the safe use of the rope are found, it should be replaced with a new rope.

#### 910. SLINGS

Braided cable wire rope slings are generally more satisfactory than slings of chain or fiber rope. A greater load can be lifted safely when all legs of the sling are in a vertical position. Slings should always be used at as small an angle as possible since

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increasing the angle between the leg of the sling and the vertical greatly increases the stress in each leg. This angle should never be greater than 45°. When a multiple leg sling is used, the sling should be so arranged that the strain can equalize itself among the legs. Hooks on slings should be of the safety type and designed to lift the load without overstraining any part of the hook. When plates are hoisted, they should be held by properly designed clamps that hold firmly under load. When hoisting loads which require sharp bends of the sling over unyielding surfaces or over sharp corners, suitable corner pads should be used. Rope slings should not be used where the rope is subjected to high temperature, strong alkalis, corrosive vapor or exposed to rough edges which will have the tendency to sever the strands. A thorough inspection should be made of all slings at least once a month and a signed report of same kept on file.

## 911. CONVEYORS

*a. General.* The use of conveyors is a desirable method of moving materials under most conditions provided certain basic precautions are observed. Cross-over walks for employees should be constructed at reasonable intervals. Cross-over walks, however, should not be considered an acceptable method for providing access to an exit from a building which constitutes a severe fire or explosion exposure. Conveyors should not be placed between an operator and his nearest exit from such exposures. Conveyors in-

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stalled flush with the floor should be guarded except at the loading and unloading points to prevent workmen from stepping on the moving conveyor. Working conditions should be arranged so that employees will not be required to stand on the supports of supporting frames to unload or load materials. Guards should be installed at corners or turns where material is most likely to fall; when handling explosive materials, this requirement is mandatory.

*b. Gravity conveyors.* In addition to the above requirements, all sections of gravity roller conveyors should be equipped with some type of positive locking device to prevent them from working apart during operations. Supports should be sufficiently substantial to give solid support under operating conditions. Supports of the horse type with an adjustable horizontal member allowing variation of the elevation of the conveyors, or the three dimensional block type supports have proved successful. Boxes should not be used as supports unless they are safe from overturning and are securely tied together when more than one is to be used. Containers of hazardous materials shall not be used as conveyor supports. Conveyor sections and supports should be frequently inspected for unsafe conditions.

*c. Mechanical conveyors.* Mechanical conveyors are usually safer than other methods for moving materials. However, certain precautions in addition to those outlined in paragraphs 911*a* and *b* are necessary. Devices for stopping the conveyor should be located at loading and unloading stations, at drives

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and take-up ends and at other reasonable intervals along the conveyor. Emergency switches should be installed within easy reach of employees at points where their activities cannot be readily seen by supervisors or other employees. Mechanical guards should be installed around the driving mechanism and where belts travel around tail drums to prevent personnel from being caught in the equipment. Workmen should not be permitted to remove material that sticks to the tail drums or pulleys while they are in motion. Fixed scrapers and revolving brushes may be used to make it unnecessary to perform this operation by hand. Practical guards should be installed where necessary when chain belts are used particularly when equipped with prongs, lugs, hooks, buckets or scrapers. Conveyors running in pits or tunnels should have ample clearance and should be guarded to prevent employees from being caught. Where conveyors pass from one floor to another, the openings should be inclosed by railings and toeboards. Screw conveyor troughs should be covered with removable covers and no attempt should be made to dislodge jammed material without first shutting off the power. Charging openings to screw conveyors should be covered with a grating, or the opening boxed or railed in to prevent workmen from stepping into them. All power conveyors shall be electrically grounded. Conveyors running into chutes that are enclosed should have a simple mechanically or electrically operated warning device to

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caution that material is about to be delivered from the chute.

### **912. INTERMEDIATE STORAGE**

The term intermediate storage refers to the temporary storage of materials at machines, work benches and other process locations throughout the establishment. Such temporary storage, if not carefully planned and supervised, may create hazards due to congestion and other factors. Proper planning is required to assure that materials arrive at the intermediate storage point in proper quantities and in the type of totebox, skid or other containers best suited for the job. Modification or redesign of the container and a more frequent delivery schedule of reduced quantities very often improve the efficiency and safety of operations. The intermediate storage areas should be clearly defined. Material stored should be piled to prevent collapse or tilting and piles should be orderly with the materials to be used first on top. Wherever possible, materials should be brought to the operation and left in storage at the working level. Stocks at operations should be placed to provide adequate work space, a minimum of turning away from the point of operation, and to lessen any interference which directly or indirectly could cause an accident.

### **913. MANUAL HANDLING**

Regardless of available mechanical handling equipment, a certain amount of manual handling will

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be necessary. Observance of the following basic principles will assist in reducing accidents:

a. Lifting should be with the knees bent and the back straight in order that the thigh muscles may assume the greater portion of the load. If the object to be lifted is too awkward or too heavy to be handled in this position, additional help should be obtained to move the load. Lifts should be made vertically and close to the body. Side lifts or off-balance lifts frequently result in muscle strains.

b. Loads which obstruct vision should not be carried.

c. Steel-toe shoes should be worn by all employees engaged in material handling operations. Gloves, aprons, and other items of personal protective equipment should be worn when handling materials which are sharp, abrasive, corrosive or which might splinter.

#### **914. MACHINE GUARDING**

a. *Guarding.* While every effort should be made to select new equipment with adequate guards incorporated in the design and construction, it should, nevertheless, be the responsibility of the safety office to assist in the procurement and proper installation of adequate transmission or point of operation guards for all machinery as follows:

- (1) Transmission includes all moving parts of equipment used in the mechanical transmission of power, including prime movers, in-

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intermediate equipment and driven machines, excluding point-of-operation.

- (2) Point-of-operation indicates that point at which cutting, shaping or forming is accomplished upon the stock and includes other points that offer a hazard to the operation in inserting or manipulating the stock in the operation of the machine. Well-designed guards will protect the operator from contact at the danger zone. The guards should be fixed so that the machine operator cannot remove or displace them.

*b. State laws.* All protective appliances required by laws of the State in which the plant is located should be installed whether or not specifically included in these standards.

*c. References.* Since it is impractical to incorporate into this work description of every machine used in Ordnance establishments, reference is made to the American Standard Codes, published by American Standards Association, which set forth specifications for the guarding of most standard machines. The standard machines should be guarded as called for by the codes. Wherever Ordnance establishments use machines known by different names, or similar machines not particularly mentioned, the requirements outlined in the American Standard Codes should be adapted to the specific operation.

#### **915. LADDERS**

Ordnance establishments should be guided by the

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American Standard "Safety Code for the Construction, Care and Use of Ladders," published by the American Standards Association.

#### **916. LADDER INSPECTION**

a. New ladders should be inspected promptly to assure conformity with the purchase order requirements and to discover defects. Wooden ladders should not be painted and all painted wooden ladders should have the paint removed since it conceals defects. Varnish, linseed oil or shellac may be applied if preservatives are needed. When not in use, ladders should be stored in readily accessible areas away from sources of heat and dampness. Each ladder should be inspected at least every four months. To insure regular inspection, all ladders should be numbered.

b. Ladders should be inspected for such items as:

- (1) Loose or broken steps or rungs.
- (2) Broken, split or cracked rails.
- (3) Loose nails, screws or bolts.
- (4) Missing, broken or damaged safety shoes.
- (5) Condition of hinges and spreaders.
- (6) Defective locks (on extension ladders).
- (7) Condition of rope and sheaves.
- (8) General serviceability.

#### **917. SAFE USE OF LADDERS**

Portable and extension ladders should be placed at a "safe" angle, i. e., the distance between the foot of the ladder and the wall or object against which

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it is leaning should be approximately one-fourth the length of the ladder. Portable and extension ladders should be carefully placed to insure secure footing for both side rails. Ladders should never be placed against window sash; a board should be fastened securely across the top of the ladder to give bearing at each side of the window. When it is necessary to place ladders in front of doors which open toward the ladder, adequate means to divert traffic should be taken. Where operations on the floor level are such that the security of the ladder may be endangered, an employee should be stationed at the base of the ladder to steady it or the ladder should be securely tied in position.

#### 918. SCAFFOLDS

a. Specific regulations governing construction of scaffolds are contained in U. S. Army Engineers regulations, "Safety requirements for Excavation, Building and Construction" (see also American Standard Code for Floor and Wall Openings, Railings and Toe Boards). Sap pine, long leaf yellow pine or wood of equivalent strength should be used in the construction of scaffolds. The lumber should be free from large knots, cross grain, dip grain, shakes, large checks, brashness, rot or wormholes. Lumber should be thoroughly inspected before use and should be capable of supporting at least four times the maximum load to be imposed upon it. Planks used for flooring should be of uniform thickness to avoid unevenness. Securely fastened guard-

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rails and toeboards should be provided on the outer edges and ends of the platforms of all scaffolds six feet or more above the ground, except for riveters' outrigger scaffolds and window jack scaffolds. The guardrails shall be 42 inches in height and should be equal in strength, at least, to 2- by 4-inch wood of the type specified above. Nails of ample size and length (minimum 8d) should be used and fully driven, especially in braces. Principal members of scaffolds should be rigidly and securely sway-braced to prevent displacement. When a scaffold has been damaged or weakened, it should be repaired immediately. Moving parts of mobile scaffolds should be inspected twice each month.

b. When trestle ladders are used for temporary scaffolding, the strength of the ladders should be checked against the number of men the scaffolding will be required to hold; the total load to be carried; the height of the scaffold; and the span and size of planking between supporting trestles.

c. Where it is necessary for employees on scaffolds to crawl out on thrust-outs or projecting beams, life lines and safety harness belts of an approved design shall be worn and anchored properly.

## 919. MACHINE OPERATIONS

a. *General.* Safe practices at machine operations should be developed through job safety analysis. This manual makes no attempt to cover all safe practices in detail, but deals only with those applicable to general processes and to certain specific machines

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that are commonly used or that require concentration of effort on safe practices because of unusual exposure. Complete safe practice procedures which cover fully all accident possibilities arising from operations should be developed at each establishment.

*b. Training.* Safe machine operation demands that the operator be properly trained and instructed in safe practices before starting work on the assigned machine. Observation of the new operator's work should be continued until the supervisor is fully satisfied that safe practices are being followed. A regular checkup should be made thereafter to assure that safe methods of operation are permanently established. Only authorized employees shall operate machines.

*c. Housekeeping.* Good housekeeping is essential to safe machine operation. Floors of work areas should be kept dry, clean, and free from obstructions to insure safe and secure footing. Spilled oil, material, and the like that have been dropped on the floor should be removed promptly. No accumulations of scrap metal, scrap wood, shavings, dust, or dirt should be tolerated. A nonslip surface covering should be provided for employees to stand on while operating machines. It may be a floor surface composition, embossed metal, or other material which provides adequate protection against slipping. Whatever the footing provided may be, it is important that its nonskid characteristics are not permitted to be lessened by accumulations of dust, dirt, oil, sweeping compounds, or sawdust. Good housekeep-

ing at operations requires also the proper location of supplied stocks which is discussed in paragraph 902.

*d. Repairs and adjustments.* Before oiling, cleaning, or adjusting machines, the machines shall be stopped and switches or other controls should be "locked out" and the machine tagged. A careful check should be made before starting the machine to determine that everyone is standing free. The machine guards shall be replaced upon completion of repairs, adjustments, etc., and before switches or other controls are made operative. **The design limitations of machines must be recognized and no repair, adjustment or modification which might cause these limits to be exceeded shall be made. (E. g., Grinding machines must be equipped with abrasive wheels which have been rated as suitable for use at speeds equal to or greater than that of the machine.)**

## **920. GRINDING WHEELS**

*a. General.* The majority of grinding wheel accidents are caused by using the wrong wheel for the job, careless handling, improper mounting, too high speed, or too much pressure on the wheel. Failure to wear goggles has resulted in many eye injuries. Wheels should be carefully inspected upon receipt and immediately before use; all cracked wheels shall be rejected. Only competent mechanics should be assigned to the mounting, care, and inspection of wheels. New wheels, newly mounted, should be run

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at full operating speed for at least one minute before being used. During this test, the operator and other employees should stand **clear, in a protected area,** to avoid injury should the wheel disintegrate **as the result of hidden defects.** Wheels should never be run at speeds greater than that for which the wheel has been designed since the excessive speed often causes a wheel to disintegrate while in operation. Work should not be forced

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against a cold wheel, but should be applied gradually to give the wheel time to warm up. If it is necessary to use the side of the wheel for grinding, wheels should be watched for wear and be changed promptly when appreciably worn. No sudden or heavy pressure should be applied to the sides of wheels. Wheels should be tried regularly and tested for balance. Wheels used in wet grinding should not be allowed to stand partly immersed in water, as the water-soaked portion may throw the wheel out of balance.

*b. Guarding and work rests.* All wheels should be provided with hoods to confine the small flying particles produced during grinding. No hood, however, will confine all the particles and some will be thrown into the open. Therefore, goggles shall be worn by all employees on every grinding operation, and in addition, protective eye shields should be mounted on each machine. Portable or stationary screens should be located to prevent injury to persons working in or passing through the vicinity. The work rest should be kept adjusted close to the wheel with a maximum clearance between rest and wheel of one-eighth inch to prevent work from being caught between the two. The adjustment should never be made while the wheel is in motion.

## 921. METAL WORKING PRESSES

The press requires extensive consideration, both in guarding and in the development of safe practices. The layout of the press room or the location

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of any employee in the department should be carefully considered from a safety viewpoint. Press operators should not be exposed at any time to the possibility of being struck by passing trucks, tractors or other mobile equipment, and they should be free from interference from supplied stocks and finished products. Before a press operator starts work, he should first test the clutch mechanism to be certain the brake band is working properly. A press operator should not place his hand under the ram unless the machine control has been locked out and the ram blocked. Feeding attachments, special tools or controls which require both of the operator's hands away from the point of operation to move the ram should be provided. Material which sticks in the die should be removed by a special tool only, unless the type of controls mentioned above are provided. Continued sticking of the work in a die should be reported to the supervisor or foreman.

## **922. CIRCULAR SAWS**

The sharpening and conditioning of saws should be done by an experienced mechanic who should check regularly all saws assigned to his care. Rip saws should have guides parallel to and extending beyond the saw to keep work straight. Adjustment of the guide while the saw is running shall be prohibited. Jigs and fixtures should be used on small pieces, especially on mitre saws so that work can be held at a safe distance from the saw. During operations of a saw, the operator should watch for and

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report promptly wavering or overheating of the saw which indicates that the speed of the saw is too great, the saw too thin or that the stock is being fed too rapidly. Operators should apply a steady pressure on work being ripped to decrease the possibility of kick-backs. Hand-push sticks should be used to push stocks. An operator should stand to one side of the work and saw so that he will not be in the path of a kick-back. There should be no reaching over the saw to pick up finished material. The operator's hands should be kept out of line of travel of the saw and placed to the side and rear of the material being sawed. Operators should be instructed concerning the necessity of keeping alert at all times because fingers can be pushed into the saw while feeding even though a hood guard is provided. Brushes should be used for cleaning off the saw table and the floor should be kept free from accumulation of sawdust and cuttings to insure a sound footing for employees.

### **923. BAND SAWS**

No band saw should be run at a speed greater than that which will allow a safety factor of 10 in all parts of the wheel. Qualified mechanics should check band saws regularly to insure they run true without excessive vibration. Band saw wheels should be tested at least once a week to detect and replace wheels with cracks or loose spokes. Band saws should be kept sharp and properly set. Each saw should be suitable for the work to be done on it. Using a small

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saw for large work or forcing a wide saw on a small radius should be prohibited. If the operator finds that work binds or pinches on the blade, he should never try to back the work away from the blade while the saw is in motion. Band saws shall not be stopped quickly by thrusting a piece of wood against the cutting edge or side immediately after the power is shut down. Operators should always adjust the guide to the thickness of stock being cut. If a saw blade should break during operations, the operator should shut off the power promptly and shall not try to remove any part of the blade until the machine has completely stopped.

#### **924. WOOD JOINTERS**

Only sharp and evenly balanced knives should be used in the jointer cutting head. Machine bearings should be checked regularly to prevent vibration. When pieces shorter than 18 inches are machined, a pusher block should always be used. The operator should try the jointer before using it to be certain that the knives are not set to take too heavy a cut. Trying to take too heavy a cut may cause a kick-back. Chips or dust shall not be removed by hand; a brush should be used for that purpose. Jointers should be guarded.

#### **925. COMPRESSED AIR**

Where necessary, compressed air for removing foreign particles from machines and other surfaces should be used only under carefully controlled con-

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ditions. Air so used should preferably not be in excess of 10 p. s. i. pressure. All users of this air shall wear protective goggles and should ascertain that adjacent operators and casuals are properly protected. The use of air for cleaning and drying purposes should be permitted only when all other means have failed. The use of appropriate brushes for this work is preferred. The use of air in removing foreign particles from personal attire is prohibited. Inclosures of adequate size to house movable items to be cleaned by air should be used. This inclosure should have only one side open and should have adequate mechanical exhaust ventilation.

## 926. HAND TOOLS

*a. General.* Prevention of accidents involving hand tools is largely a matter of proper instruction and training of employees and maintaining the tools in safe working condition. Hand tools, as herein considered, are sufficiently light in weight to be carried by hand, and include movable tools of hand motive power and mechanical and electrical tools which when in use are carried and held by a person. Hand tools should be made of good quality material and should be appropriate for the job at hand. Hand tools should be kept in good repair or state of maintenance and they should be tempered, dressed or repaired by qualified persons only. Racks, shelves or tool boxes should be provided for tools not in use to assure immediate availability and eliminate the hazards created by misplaced and forgotten tools.

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When tools are used on ladders, scaffolds, platforms or other elevations, special precautions should be taken to prevent their being dropped or having them fall from these levels. Tools should be inspected frequently by officially appointed, competent employees. Defective tools should be removed from service immediately to be repaired or discarded. When being carried by a person, tools with sharp cutting edges or sharp points should be carried in sheaths for the protection of the workman. Pipes or other improvised extension handles should not be used on hand tools. Portable power tools should be equipped with guards which fully inclose moving parts. All electrical contacts on power tools should be inclosed and all exposed wiring should be well insulated. Exposed noncurrent-carrying metal parts of portable electric tools shall be grounded. (See par. 621.) When the use of hand tools generates injurious dusts, portable exhaust systems should be provided.

b. Hammers with high-tempered steel heads should not be used on hard surfaces. Hammers with soft material heads securely fastened to smooth handles should be used instead.

c. Heads of chisels, punches, nail sets, and other tools of the same type should be ground down frequently to keep them in safe working condition. Without such attention, continued pounding causes mushrooming of the head to a dangerous degree. In this condition the material is highly crystallized and

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with each blow of the hammer, fragments are likely to fly from the tool head with great velocity.

*d.* Handles of tools such as hammers, axes, picks, or sledge hammers should be replaced when broken, cracked, split, or badly splintered. Heads should be securely fastened by wedges and if the heads can be drilled a steel pin through the head and handle will provide greater safety.

*e.* All files should be equipped with suitable handles and all recut files should be tested for fractures.

*f.* Small parts being repaired should be placed in a vise. Many serious injuries have occurred as a result of holding an object in one hand and a hand tool in the other while attempting repairs, particularly when screw drivers or other sharp pointed tools were being used.

*g.* Knives and similar tools should be equipped with disc-type guards at the hilt to prevent the hand from slipping onto the blade.

*h.* Electricians should use nonmetallic tools wherever possible. Fiber fuse pullers, foot rules without metal rims, cloth tapes without wire reinforcements, and insulated handles on those metal tools that are necessary are essential to safety.

## 927. WELDING AND CUTTING

*a.* Probably the most difficult hazard to control in cutting and welding operations is that of sparks setting fire to combustible materials in the vicinity of the operations. Wherever possible, cutting and

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welding should be done in a noncombustible location. When such operations are conducted away from the shop, all combustible materials, where practicable, should be removed from the site of the operation or, if practicable, the area should be wetted down thoroughly. Under any circumstances where combustibles are present, personnel equipped with suitable fire extinguishing equipment, filter goggles, and protective equipment should be stationed near the welder to extinguish sparks that may ignite the operator's clothing or other combustibles in the vicinity. Because welding and cutting operations generate harmful gases, fumes, and dusts, adequate ventilation is essential. Local exhaust systems should be provided to reduce the hazard and where severe conditions exist, special respiratory equipment should be used by those exposed. On all oxy-acetylene welding and cutting operations, employees shall be provided with safety goggles to protect the eyes from heat, glare, and flying fragments of hot metal. Fire resistant gauntlets and aprons should also be worn. On electric welding operations, employees shall be provided with safety goggles and a hand shield or helmet equipped with a suitable filter glass of the shade required (depending upon the size of the welding rods or the magnitude of the welding or cutting current), to protect against the intense ultraviolet and infrared rays. Protective sleeves, gloves and aprons shall also be worn. When other employees are in the vicinity of electric welding operations, the operations shall be screened so that the employees cannot

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see the arc. Welder's helpers shall be provided with and required to wear filter goggles and other protective equipment applicable to the work. After welding operations are completed, the operator should mark the hot metal to warn other employees of the hazard.

b. Cylinders of compressed gas shall be stored and handled as described in paragraph 1320. Hose lines from oxygen and fuel cylinders should be different in color to avoid confusion. Hose should be tested regularly and replaced when it becomes damaged.

c. When welding or cutting is to be done in locations where explosives and highly flammable materials may be present, permits for the work must be obtained in advance and in accordance with all requirements of paragraph 1605.

d. Valves should be shut off at the cylinders and at the torch when the torch is not in use.

## **928. MAINTENANCE AND REPAIRS**

a. Past experience shows that a relatively high percentage of the accidents reported occur in maintenance, repairs and temporary construction projects. This is due largely to failure to observe well established safe practices and indicates inadequate training or supervision of employees engaged in such work. To reduce the number of these accidents, the responsible personnel should make certain that employees are properly trained and that supervision is competent. The safety regulations and safe practices specified here and elsewhere in this manual

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shall apply to maintenance employees as well as those engaged in production activities. This includes the requirements concerning personnel protective clothing, use of hand tools, storage of material and rules governing good housekeeping.

b. When maintenance work entails operations that might endanger employees at work in the vicinity, the area should be roped or fenced off. When overhead work is being done and employees must continue working immediately below such operations, they shall be provided with hard hats or otherwise protected. Unfinished repairs or installations should be protected after working hours by roping or fencing the area to prevent access by unauthorized personnel. Excavations should be further marked by red lanterns at night.

c. Before repairing, adjusting, or cleaning any power driven machinery, the control switch should be "locked out" and the machine conspicuously tagged to indicate the presence of maintenance men. Where some type of switch other than a knife switch is used, fuses should be removed from the circuit before repairing, adjusting, or cleaning to avoid confusion as to whether or not the circuit has been opened. After repairs or adjustments have been made, it should be the responsibility of the maintenance men to replace all guards, to remove any grease, oil, or other materials spilled on equipment or floors, and to remove all tools, equipment, and spare parts from the machine area. Machines and

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floors should be cleaned of any dirt resulting from repairs.

d. When the use of portable grinders or other equipment results in dusts, fragments, or flying objects, the operation should be inclosed by portable screen guards for the protection of passers-by and employees at work in the vicinity.

e. For general cleaning purposes, a safety solvent, having a flash point of 100° F. (37.8° C.) or above, should be used. However, when the parts to be cleaned, the solvent, or the objects in the vicinity approach a temperature of 100° F., the use of such a solvent is as hazardous as that of any other solvent at or near its flash point. The use of carbon tetrachloride is prohibited for such use unless strictly controlled in its application.

## 929. ENTERING STORAGE TANKS

Tank work need not be hazardous if proper precautions are taken. When tanks are not adequately purged, toxic, flammable, or otherwise harmful gases, vapor, dusts, fumes, etc., may be present. Even after purging, the danger of the tank's atmosphere containing an insufficient amount of oxygen is a reality. Precautions such as, but not restricted to, those listed below are intended to offset the hazards encountered in entering tanks:

a. The tank should be thoroughly cleaned and purged of toxic, flammable, or otherwise harmful gases, vapors, dusts, fumes, etc., prior to entry.

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b. The tank should be provided with special ventilation by means of forced air from an uncontaminated source.

c. One man, on the outside of the tank, shall keep the person in the tank under observation and at least one additional man shall be available for rescue work should the person in the tank be overcome. Men performing such duties shall be properly trained to perform tank rescue work. Additional trained personnel should be available.

d. Personnel entering tanks shall be equipped with suitable respiratory protective equipment, lifebelts or harnesses and lifelines.

### **930. STORING REFRIGERATORS AND DEEP-FREEZE CABINETS**

(Added)

Excess refrigerators and deep-freeze cabinets shall be stored as follows to prevent asphyxiation of children who may obtain entry:

a. Units stored in buildings where unauthorized entry is possible shall have their doors disengaged from the hinges and strapped to the units. Doors being strapped to the unit shall be wedged open at least 1-inch to provide for free circulation of air to the refrigeration compartment, to prevent development of objectionable odors.

b. Units stored in locked buildings shall have their doors secured by metal strapping or heavy rubber-covered wire. Doors of such units need not be disengaged from their hinges.

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**931. EXPLOSIVE CARTRIDGE ACTUATED HAND-  
TOOLS**

(Added)

a. In many respects, hazards encountered in the use of cartridge actuated handtools are similar to those from small arms weapons. Drive pins and studs fired from cartridge actuated handtools can be as lethal as bullets.

b. Precautions to be taken when handtools of this type are used include—

- (1) The manufacturer's instructions should be scrupulously followed.
- (2) All working parts of the tool should be thoroughly inspected at periodic intervals.
- (3) Guards or shields provided for the prevention of ricochet should always be in place when the tool is being used.
- (4) Explosive cartridge actuated handtools shall not be used in explosive atmospheres or other locations where nonsparking tools are required.
- (5) Potential applications must be screened to assure that these tools are not used if the drive pins or studs will completely penetrate the materials involved, endangering personnel or equipment that may be on the other side. In questionable cases, necessary shielding must be provided to capture, without ricochet, the penetrating drive pins or studs.

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- (6) Suitable goggles or face shields must be worn for protection of the eyes and face from dirt, scale, splinters, etc., resulting from the high velocity impact of drive pins and studs.
- (7) Operators should be carefully selected and adequately trained.
- (8) Because of the tendency of the materials to shatter or split, drive pins and studs should not be fired into such hard and brittle materials as: Cast iron; high carbon or heat treated steel; thin slabs of marble; glass; glazed brick or tile; or narrow strips of hardwoods such as oak and maple.
- (9) The tool should never be pointed at any person. Fingers and hands must be kept away from the front of the barrel.
- (10) In the event of misfire, the tool should be held in the operating position for at least 1 minute and then immediately be placed in a vertical position, muzzle down, and the explosive cartridge removed.
- (11) Studs and drive pins must not be driven into explosives contaminated materials.
- (12) Cartridges must not be carried loosely in the pockets of operators. Wood, metal, or heavy cardboard containers with means for separation of individual cartridges should be provided for storage of the working supply of cartridges. Cartridges should be accounted for at the end of each workday or shift.

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## SECTION 10

### PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

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#### 1001. GENERAL

a. Personal protective clothing and equipment consists of garments or devices to protect individuals against definite hazards inherent in the performance of a specific job. Wherever possible these hazards should be corrected by engineering revision such as process changes and control, construction and ventilation. If it is impracticable to remove or control the hazards by these methods, adequate protective equipment shall be worn as prescribed by the commanding officer and the use of required items shall be enforced. Proper protective clothing and equipment shall be furnished or made available to all employees whose duties require its use.

b. The following are examples of personal protective clothing and equipment:

Airline respirators	Electricians' rubber line covers
Arm guards	Electricians' rubber gloves
Blankets	Eye protective devices
Chemical cartridge respirators	Face shields
Coats	Flameproof coveralls
Conductive shoes	Foot guards
Electricians' fuse pullers	Gloves

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Hard hats	Safety shoes
Hose masks	Self-contained breathing apparatus
Industrial gas masks	Soap
Leather palms	Sweat bands
Linemen's climbers	Tool belts
Life belts	Towels
Nonsparking tools	Welders' coats
Protective cream	Welders' helmets
Rubber suits	

c. Equipment described above should not be confused with safe work clothing which comprises the items furnished by the employee to protect himself against the normal hazard of his job. These items are designed to conform to safe practices on individual jobs; short sleeves for machine workers, cuffless trousers, close-fitting trousers, pocketless shirts, bandannas, caps, etc. and may be altered for each individual case.

## 1002. DETERMINING REQUIREMENTS

The most logical method of determining the need for, and the specific kind of, personal protective clothing and equipment is a thorough survey of all operations in the establishment. All hazards inherent in operations and unsafe acts disclosed by safety inspections should be noted. Accident experience should be analyzed and the part of the body injured should be correlated with the agency involved. Individual injuries where the use of protective clothing or equipment has been recommended to prevent a recurrence should be studied and suggestions from employees should receive consideration. With these

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data in hand, all hazards should be corrected immediately by operational changes or mechanical guards. If neither is feasible, the appropriate personal protective clothing or equipment should then be selected to protect the employee against the hazard.

### **1003. SELECTING EQUIPMENT**

Establishments should develop standards of use and procurement standards for personal protective clothing and equipment. The standards should be understood by the purchasing department to insure efficient service in ordering, by the foremen to insure proper requisitioning and to aid in enforcing rules, and by employees to insure cooperation in complying with rules. Federal Specifications, Navy Specifications, United States Bureau of Mines publications, American Standards of the American Standards Association and National Safety Council Safe Practices Pamphlets may be used as guides in the development of standards.

### **1004. EDUCATION AND ENFORCEMENT**

Definite rules governing the utilization of protective clothing and equipment should be formulated and enforced. During the pre-employment safety lecture, all employees should be informed of the personal protective equipment they will be expected to wear and use. All employees should be provided with locally supplied rule books governing safe practices. At safety meetings attended by foremen and

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workers. the use and care of personal protective clothing and equipment should be discussed in detail. Special emphasis should accompany the introduction of new items in the plant since complete information covering safety devices increases their acceptance and use. Posters can be a worth-while means of encouraging the use of safety appliances. Photographs of accidents which have occurred as a result of failure to wear protective clothing or equipment have proven effective. Foremen and supervisors should be especially careful about wearing protective clothing and using special equipment in order to set an example for employees and to gain experience in solving problems created by the use of these devices. Complaints from employees regarding the wearing of protective clothing and equipment should be investigated promptly and thoroughly. Garments and devices should be adjusted to suit the individual and repairs should be made without delay, since one dissatisfied employee can jeopardize the entire program.

#### **1005. MAINTENANCE**

a. Protective clothing and equipment should be inspected by the foreman at least weekly to be certain it is in serviceable condition. Spot checks should be made periodically by the safety department.

b. Adequate laundering and sterilizing facilities for garments should be provided where necessary. Uniforms and special clothing shall be laundered ac-

ording to schedules based on the toxicity of material with which they are in contact.

## 1006. SPECIAL CLOTHING

a. When manufacturing or handling certain hazardous materials, special clothing and head coverings are required. Safety uniforms, head covers, or other special clothing shall be worn as prescribed by the commander. Employees required to wear safety uniforms or special clothing shall leave their street clothes at designated locations only. The clothes that are worn at work should not be taken from the plant unless they are in a safe condition. Employees shall be inspected before reporting to their work to insure that proper clothing and safety shoes are worn. Outer clothing of wool or fabrics that resist corrosive chemicals shall be worn by employees who handle or are otherwise exposed to acids. Cotton outer- and undergarments should be worn in any operation where the generation of static electricity (sec. 7) would create a hazard.

b. Explosives plant clothing, generally referred to as powder uniforms, for men and women, must be fastened with nonmetallic fasteners and be easily removable. Pockets should be of the lattice type. Trouser legs, slacks, and sleeves should be tapered and the trouser legs and slacks shall be without cuffs, and should

extend over the top of shoes or boots. The garment should fit snugly around the wrist and neck but caution must be exercised to avoid a fit around the waistband, belt, or neck sufficiently tight to cause skin irritation or dermatitis. These garments as well as head coverings should be made from tightly woven, smooth fabric and should be flameproofed.

#### 1007. FLAMEPROOFING

a. Clothing is flameproofed to make it less combustible, thereby reducing the hazard of burns to the wearer. Personnel exposed to possible flash fires and those at operations or in buildings where their clothing may become contaminated with materials that may increase the burning rate of their clothing to flash fire proportions shall be provided with and must wear flameproofed uniforms. All operations shall be carefully examined to determine the need for flameproofed clothing for the personnel exposed. To enable ready assurance during inspections that employees are properly clothed, flameproofed clothing should be of a color which is distinctive from similar clothing that is not flameproofed.

b. Clothing should be washed thoroughly, and dried prior to being immersed in the flameproofing solutions. Effective flameproofing solutions are: a 15 percent aqueous solution of diammonium phosphate; a 15 percent aqueous solution of ammonium.

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sulfamate or a solution of 2 pounds of ammonium sulfate, 4 pounds of ammonium chloride and 3 gallons of water. These are the minimum prescribed strengths of flameproofing solutions considered efficient; stronger solutions may be used without effect on the wearing life of the clothes. The third-mentioned solution causes stiffening of the cloth. Regardless of the strength of solution used, the important criterion of effective flameproofing is the percentage increase in weight of the dry treated garment over its original weight. The weight increase should range between 7 and 15 percent. Drying after immersion in the solution should be at temperatures not exceeding 200° to 230° F., since the fabric is likely to be weakened at higher temperatures. Most flameproofing chemicals contain ammonium salts which have a corrosive action on copper, brass, bronze and galvanized iron. Ordinary black iron, wood, enamel and certain alloys such as stainless steel, may be used in handling these chemicals.

#### **1008. EYE PROTECTION**

Suitable eye protection devices must be worn by personnel exposed to eye injuries. The equipment shall be cleaned and maintained in good serviceable condition in accordance with the manufacturer's instructions. Goggles and eye shields must not be made of nitrocellulose or other highly flammable materials. Goggles and eye shields should comply with Federal Specifications and/or ASA Standards.

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#### **1009. RESPIRATORY PROTECTIVE DEVICES**

Persons employed in dusty or toxic atmospheres shall be provided with and should wear respiratory protective devices of the type approved by The United States Bureau of Mines or The Army Environmental Health Laboratory. These respirators are listed in TB Med 223. The concentration of the toxic atmospheric contaminant shall determine the necessity for such equipment. The type of equipment provided will depend on the kind of hazard. Positive pressure hose masks, airline respirators, self-contained breathing apparatus, industrial gas masks and the like should be approved for the purpose for which they are utilized by a recognized testing agency. Such equipment should be maintained in good serviceable condition.

#### **1010. SWEATBANDS**

Operators should wear sweatbands and take other precautions when necessary to avoid perspiration falling on material such as finely divided magnesium or aluminum which may be ignited by moisture.

#### **1011. CONDUCTIVE SHOES**

Personnel who walk upon conductive flooring where explosives are present must wear conductive shoes. Personnel from other departments or visitors who enter an area equipped with conductive floors shall wear conductive shoes, conductive rubbers with angle straps properly adjusted on the wearer or other approved devices before entering.

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## 1012. CONDUCTIVE SHOE SPECIFICATIONS

a. The specifications for conductive shoes with conductive composition soles and heels are given in American War Standards Z41.3—1944, 4th Edition Men's Conductive Shoes, and Z41.9—1944, 3d Edition Women's Conductive Shoes.

b. The maximum electrical resistance permitted for each shoe is 450,000 ohms. Conductive rubbers which are to be used by visitors must meet the same resistance requirements. Conductive shoes and floors require care to insure retention of their conductive properties; when the shoes are not in use, they should be stored in lockers close to the room in which they are to be worn, and the change from nonconductive to conductive shoes should be made at the location. A thin layer of dust or wax on the conductive floor may insulate conductive shoes from the floor.

c. Only conductive materials shall be used for the repair of conductive soled shoes. Conductive shoes shall be thoroughly cleaned before being repaired.

## 1013. TESTING CONDUCTIVE SHOES

Tests of conductive shoes on individuals (see figs. 706A and 706B) for use in recommended locations shall be made initially and frequently enough thereafter to assure that the resistance from person to ground (through conductive flooring) is less than one million ohms. The testing instrument may be similar to the one described in paragraph 707 except

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that the two electrodes should consist of conductive plates arranged in such manner that the employees stand with only one foot on each plate to complete the circuit. When tests are so made the maximum allowable resistance is one million ohms. The test voltage shall be approximately 90 volts and the circuit must be so arranged that the test current shall not exceed one milliamperere. In addition, no more than two milliamperes shall flow across the plates when a direct short is made across the plates. Positive safeguards must be incorporated into the design of the instruments to eliminate the chance of electric shock to the subject undergoing test. Tests must not be performed in rooms where exposed explosives are present. Shoes shall be tested first without cleaning the soles and heels and if the resistance does not exceed required limits, the shoes may be put in service. If resistance exceeds 450,000 ohms per shoe, they shall be cleaned and retested. If readings are then sufficiently low, the shoes may be returned to service, those with excessive readings shall not be used as conductive shoes. Sandpaper, solvents or other agents effecting the structure or conductivity of the sole materials shall be avoided. Separation of or removal of the conductive sock liner from the conductive plug or depression of the conductive plugs below the surface of the insole of the shoe may cause high resistance. Nonconductive stockings such as silk or wool or the drying action of foot powders should be avoided.

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**1014. SPARKPROOF SAFETY SHOES**  
(Revised)

The friction and shock of shoes on explosive materials and sparks from metal parts in shoes are potential hazards with all explosive materials. For wear in the vicinity of exposed explosives not susceptible to static spark of the energy that can be discharged from a person, sparkproof (nonspark-producing) shoes are required. The construction of nonspark-producing or explosives operation shoes is to be in accordance with American War Standard Specification or revision thereof. Shoes with soles and heels of leather, rubber, or synthetic compositions (neolite, Neoprene, and similar compositions) may be used provided the soles and heels contain no exposed nails or holes. The shoes should have a fully enclosed safety toe cap. Shoes purchased prior to the issue of the specifications may be used if they have no exposed metal. Periodic inspection shall be made to detect and eliminate any shoes with exposed metal. The soles and heels of shoes must be cleaned free from sand and dirt before entering a building containing explosives. Conductive shoes meeting the requirements for explosives operations (nonspark-producing shoes) may be substituted for them if desired.

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**SECTION 11**  
**HEALTH SERVICE (INDUSTRIAL MEDICAL)**  
**PROGRAM**

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**1101. RESPONSIBILITY**

a. The important relationship between the safety program and the health service program (industrial medical program) should be thoroughly understood if both are to be effectively administered. Therefore, the purpose of this section is to explain the nature and scope of the Army Civilian Employee Health Service program authorized at Ordnance establishments. It is not the purpose of this section to prescribe standards to be followed by the health unit of the establishment.

b. As outlined in AR 40-220 and SR 40-220-5, responsibility for Army Federal Civilian Employees' Health Service programs at Government-owned, Government-operated Ordnance establishments is vested in The Surgeon General, in the commanding generals of armies (ZI) having administrative control over Army Medical Service activities, and in the commanding officer of the establishment. Surveys and special investigations relative to the control of occupational health hazards and subsequent improvement of working conditions are made by the Army Environmental Health Laboratory upon request through Medical Service channels.

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c. In carrying out this responsibility certain publications have been issued to provide reference and directive material necessary in the program. Some of the available publications are Department of the Army Technical Bulletins, TB MED 35, "Health Hazards from Industrial Solvents;" TB MED 62, "Medical X-Ray Protection;" TB MED 223, "Respiratory Protective Devices;" TB MED 232, "Radioactive Luminous Compounds—Protective Measures;" and Army Environmental Health Laboratory memoranda.

d. Medical benefits available to military personnel are not discussed in this manual except that where military personnel are exposed to industrial health hazards, protective criteria are the same as for civilian personnel.

e. (Rescinded)

## 1102. HEALTH SERVICES

The prescribed health services include, but are not necessarily limited to the following:

a. Treatment of occupational injuries and diseases. Prompt and efficient medical and surgical treatment of all occupational injuries and occupational diseases is given to reduce disability to a minimum. Subsequent treatment of injured Civil Service employees is covered by the regulations governing the administration of the Federal Employees' Compensation Act.

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*b. Treatment of nonoccupational injuries and diseases.* Treatment of minor nonoccupational injuries and nonoccupational diseases is given to enable the employee to complete his shift, thereby reducing lost-time. Workers with more serious illnesses are advised as to their immediate medical needs and referred to their private physicians. Extensive diagnostic procedures or prolonged treatment are not contemplated, except in isolated areas where private medical services are not readily available.

*c. Complete individual health records are kept by the health unit for each employee. These include the records of preplacement and periodic physical examinations, medical and occupational histories, laboratory tests, X-rays and illnesses or injuries reported to the health unit. Necessary data regarding occupational injuries are furnished to the officials or departments authorized to have such data. The clinical information contained in the health records is treated as a privileged communication between the individual concerned and the health unit. General statements concerning the physical fitness and classification of the worker are furnished officials or departments are require to facilitate fitting the worker to his job. Reports showing the scope of the several activities of the health unit and the incidence and nature of various injuries and illnesses are submitted as required by higher Medical Service authority.*

*d. Clearance of employees through the health unit. To keep adequate health records and to advise the*

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employee regarding his medical needs, it is the policy, wherever practicable, to have each employee becoming ill at work clear through the health unit before leaving the plant. Similarly, employees returning to work after an absence lasting 3 or more days due to illness or injury are cleared through the health unit to insure their fitness to work safely and efficiently. This practice minimizes the possibility of introducing communicable diseases into the plant and frequently results in finding diseases in their early stages. Any worker found to be ill with an occupational disease should, of course, report promptly to the health unit.

*e. Preplacement physical examinations.* Preplacement physical examinations are performed to insure the physical and mental fitness of the employee for the job to which he will be assigned. Workers are placed at tasks according to their capabilities where they will not be a hazard to themselves or others. Physically handicapped workers are placed at jobs they can perform safely and efficiently, so far as possible. The personnel, production and safety departments should cooperate closely with the health unit in fitting the worker to the job.

*f. Periodic physical examinations.* Periodic physical examinations are aimed at detecting diseases or physical defects in their earliest stages. In this manner the physical efficiency of the working group is maintained. The need for these examinations varies considerably. Individuals whose work involves toxic

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exposures, or those whose jobs place special demands on the worker are examined at more frequent intervals than others.

*g. Vaccination and immunization.* It is the policy of the health service program to vaccinate new employees against smallpox as a part of the preplacement physical examination unless there is evidence of a successful vaccination within a 5-year period prior to the examination. Revaccination is advisable at 5-year intervals. In areas where typhoid fever is endemic, the health service recommends that employees be immunized against this disease. In the event of an epidemic of smallpox or typhoid fever in or about the plant, it is advisable to vaccinate or immunize plant personnel against these diseases.

*h. Other examinations.* Wherever possible, new employees are given an X-ray examination of the chest for evidence of pulmonary disease, a serodiagnostic test for syphilis, urinalysis, and such other tests as may be indicated.

*i. Inspection of operations.* Periodic inspection of operations and shops is a function of the health unit. Through such inspection it is possible for health unit personnel to detect working conditions or practices inimical to health and efficiency, to detect unsanitary conditions and to become thoroughly familiar with the nature of the various tasks and the potential hazards associated with them. Symptoms of employees indicative of occupational disease may be detected and measures necessary for the control or

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elimination of the hazardous exposure may be recommended.

*j. Nutrition.* The health unit should act in a supervisory capacity in the plant nutrition program. The serving of well-balanced meals at low cost to the workers should be encouraged and the use of protective foods and milk over nonprotective beverages and food is recommended. Bread and pastries should be made from either whole grain flour or enriched white flour.

*k. Health education.* Health education can be promoted in an establishment by personal contacts, newspaper articles, posters, pamphlets, lectures to groups, and motion pictures to instruct employees in personal hygiene, nutrition, sanitation, and disease prevention. These activities closely parallel the educational activities on safety. A Health Activities Committee is recommended to aid in promoting health education.

### 1103. CONTROL OF PERSONNEL TO TOXIC EXPOSURES

The principles upon which the control standards are developed by the health unit of the establishment are discussed as follows:

*a.* The preplacement examination, including the appropriate laboratory tests, should be performed on each employee prior to his assignment to a job. On the basis of this examination, each employee should be classified as to what type of work he may or may

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not do. Workers with constitutional disorders likely to be aggravated by toxic exposures should not be recommended for work in such exposures. Foremen should be made familiar with the early symptoms of occupational diseases and should observe each worker daily and promptly send anyone showing symptoms to the health unit for examination. No worker in a toxic exposure should be permitted to leave the establishment because of illness, or return to work after an illness, without clearing through the health unit (see par. 1102d). The health unit should be notified immediately if such workers become ill off the job. Generally, no worker should be employed in, or transferred to, an operation involving a toxic exposure without approval of the health unit.

b. A worker in a toxic exposure such as TNT should be examined physically at regular and frequent intervals to detect early symptoms of chemical intoxication. The frequency of examinations is best based on individual plant experience. So far as practicable these examinations should be performed at the line first-aid stations or in mobile clinics in the interest of efficiency and to minimize lost-time. Workers found to have systemic poisoning should be removed from the hazardous exposure and placed under close medical supervision. Attention should be directed immediately toward controlling the hazardous exposure so that other employees will not be affected. Similar examinations should be made at the termination of employment.

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c. The health unit should determine which workers have significant exposures to toxic chemicals such as TNT, DNT, tetryl and nitroglycerine. These workers should not be permitted to leave the establishment after work until they have taken a thorough shower bath and made a complete change to uncontaminated clothing. They should be provided with powder uniforms (see par. 1006b), underwear, socks and head covering. These should be laundered daily unless the health unit recommends less frequent laundering. TNT uniforms should be checked periodically with Webster reagent after laundering to determine cleanliness. Each worker having a toxic exposure should be provided two lockers, one for street clothes and one for work clothes. Suitable soap should be provided for removing toxic or oily materials from the skin. TNT, DNT and tetryl workers should be supplied with indicator soap and their skin tested at intervals with Webster reagent to determine cleanliness.

d. Another means of detecting early signs of chemical intoxication in workers is through regular tours of the lines by the physicians during which he can inspect the workers, and note any unhygienic or unhealthful conditions or practices. Recommendations may then be made to the proper official for correction of undesirable conditions. Qualified line nurses may assist in these inspections.

e. Adequate nutrition is essential since it promotes health and the healthy worker presents maximum

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resistance to chemical intoxication. A well balanced mid-shift meal at a reasonable cost should be available to workers in toxic exposures. These employees should be especially instructed as to the importance of eating three well-balanced meals daily.

f. The health unit maintains a complete medical record on each worker in toxic exposures. This record shows the results of all examinations and tests, and contains a complete occupational history of the worker.

#### **1104. SPECIAL PROBLEMS OF WOMEN**

a. Women may be employed at any "toxic" operations that are safe for men as there is no satisfactory evidence that women are more susceptible than men to chemical intoxication. Wherever women are employed, however, jobs should be engineered to prevent undue postural strains or excessive weight lifting since the average strength of women is about half that of men. Women should not be permitted to work more than 8 hours per day or 6 days per week. Appropriate rest periods should be allowed during each shift; at intensive tasks requiring constant vigilance, short, frequent rest periods may be advisable. Rest rooms should be provided where women suffering from menstrual or other difficulties may lie down when necessary.

b. When it is found that a woman employee has become pregnant, the provisions of AR 620-90 apply. The following is from these regulations:

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- (1) A pregnant employee should not be continued at work after the 32d week of pregnancy.
- (2) The employee should not return to work until 6 weeks after delivery, and then only upon approval of her physician.
- (3) It is inadvisable to employ pregnant women between the hours of 12 midnight and 6 a. m., and for more than 48 hours a week. Overtime work of pregnant employees should be avoided.
- (4) Pregnant women will not be assigned to work requiring heavy lifting or strain or to work which in the opinion of the physician in charge of the health program or the employee's family physician would constitute a hazard to that employee.

c. Current state laws and regulations regarding the employment of women should be observed.

#### **1105. SUPERVISION OF SANITATION**

It is the function of the health unit to exercise close supervision over sanitation in the cafeterias, canteens, change houses, toilets and rest rooms; to institute the necessary procedures to assure the potability of drinking water at all times and the serving of only properly pasteurized and chilled milk; and to determine that sewage is being disposed of in a sanitary and satisfactory manner.

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## **1106. DISASTER PLANNING**

(See Sec. 4)

The health unit of the establishment is responsible for the development of fully perfected plans for the efficient and prompt handling of large numbers of seriously injured workers in event of a disaster. The plans include provisions for first-aid, transportation of the injured, adequate surgical supplies, blood plasma, blood donors in the plant and nearby hospitals, and coordination of procedures with the safety and fire departments, guards, police, road patrols, and local physicians and hospitals. Physicians, nurses, and supporting personnel generally should be readily available to handle such emergencies.

## **1107. COOPERATION WITH LOCAL AUTHORITIES**

It is important that friendly and cooperative relationships be maintained with local health authorities and private physicians in the interest of maintaining the health and efficiency of plant employees. The plant sanitary program should be closely integrated with that of nearby communities. All local and state health laws, regulations, and codes are to be observed.

## **1108. HEALTH AND HYGIENE STANDARDS**

It is the responsibility of the health unit to promulgate the standards necessary for maintaining the health of plant employees.

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## 1109. ENVIRONMENTAL HYGIENE SERVICES

(Revised)

The environmental hygiene services, commonly referred to as the industrial hygiene services, consist of the valuation of health hazards and recommendations for their control by qualified industrial hygiene personnel who are chemists or sanitary, chemical, or mechanical engineers with specialized training in industrial hygiene. Although such personnel should function for or as a part of the health unit, a close relationship between their activities and the engineering, planning, and safety departments is necessary if the program for the control of health hazards is to be successful. For all Government-owned, Government-operated plants, industrial hygiene services are available through the Army Environmental Health Laboratory.

## 1110. ATMOSPHERIC HEALTH HAZARDS

*a. General.* All operations and processes in which toxic materials are handled present potential health hazards by atmospheric contamination. Except for processes conducted in airtight systems or in inclosed systems under negative pressure, atmospheric contamination is produced at all operations, the amount depending upon the nature of the material being processed, the nature of the operation, the tempera-

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ture, the humidity and the air movement. Whether or not the health of a worker is being affected by his environment is determined by medical examination. Many occupational illnesses of a chronic nature, however, are demonstrable by medical methods only after prolonged exposures which, as with silicosis, may be as long as 20 years. Experience has shown also that the incidence of illnesses may be reduced to a very low figure if the worker's exposures to atmospheric contaminants are kept below predetermined values. Consequently, it is necessary that the atmospheric health hazards be evaluated by the industrial hygienist on the basis of the known or estimated toxicity of the contaminant or contaminants.

*b. Evaluation.* The evaluation of a specific health hazard consists of the determination of the chemical composition of the atmospheric contaminant to which the worker is exposed and the concentration of the contaminant in the atmosphere breathed by the worker. From these data the degree of hazard is determined. The concentration is determined only by a standard method and technique and only by a qualified person; that is, a person technically trained in a suitable field who has had specific training or experience in industrial hygiene. Conclusions as to the concentration of atmospheric contamination are not based on the result of a single determination unless previous determinations have indicated the same concentration range. At least three individual determinations of the concentration of atmospheric contamination at a specific operation are usually consid-

ered necessary to arrive at an acceptable value. This value is applicable only to the conditions existing at the time the determinations are made but they may be used in conjunction with the composition of the atmospheric contaminant to decide whether a health hazard exists.

*c. Over-all exposure.* In addition to the evaluation of the health hazard and the adequacy of, or need for control measures, a worker's average over-all exposure may be determined from time to time to explain the medical findings or to develop data on the toxicity of certain contaminants. To determine a worker's weighted average exposure the following equation is used:

Weighted average exposure =

$$\frac{E_1T_1 + E_2T_2 + E_3T_3 + \dots + E_nT_n}{T_1 + T_2 + T_3 + \dots + T_n}$$

in which  $E_1, E_2,$  etc., represent the average exposures to a given contaminant at different operations in a convenient unit of concentration such as parts per million;  $T_1, T_2,$  etc., represent the durations of the different exposures in a convenient unit of time such as days, weeks, months, or years; and  $n$  represents the number of different locations of employment.

#### 1111. ENGINEERING CONTROL OF ATMOSPHERIC HEALTH HAZARDS

*a.* Control measures are designed to keep the atmospheric contaminant below its maximum allow-

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able concentration for an 8-hour exposure. Contaminants of low toxicity are to be kept below a reasonable or "nuisance" concentration. Control methods by which the desired ends are accomplished include those outlined below:

- (1) Control the contaminants at point of generation or dissemination.
  - (a) Inclose sources of contamination.
  - (b) Provide local exhaust ventilation at major sources of contamination.
  - (c) Utilize wet processing methods.
  - (d) Maintain good housekeeping.
- (2) Install general ventilation of work spaces.
- (3) Isolate or segregate those operations which produce considerable contamination so that large areas or large numbers of workers are not affected.
- (4) Substitute less toxic materials for the more toxic ones.
- (5) Utilize appropriate respiratory protection for workers having intermittent exposures of short duration. See paragraph 1009 and TB MED 223.

b. Of the foregoing control measures, the use of properly designed local exhaust ventilating systems is by far the most important one for the control of atmospheric health hazards. It is, however, the most difficult to apply since the proper design of the system can be accomplished only by experienced industrial hygiene engineering personnel or experienced ventilating engineers. Paragraph 2707 outlines the

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design requirements for exhaust systems where explosive materials are involved.

c. Table 1111 outlines some of the more important health hazards and the control measures recommended in establishments handling explosives.

Table 1111. Control data on important health hazards TNT handling

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
Screening	TNT dust. Intermittent to continuous.	Severe	Inclose operations. Provide local exhaust ventilation at minimum rate of $Q = 300A$ . ( $Q$ represents rate of air removal in cubic feet per minute. $A$ represents effective area of hood opening in square feet.) Respirators for infrequent exposures.
Melting	TNT dust, fume and vapor. Intermittent. Few workers.	Slight	Provide exhaust ventilation at minimum rate of $Q = 150A$ . ( $A$ represents area of one lid or door.)
Draw off	TNT fume and vapor. Few workers direct, many indirect. Usually intermittent.	Moderate	For infrequent operations, use respirators. For frequent operations, room ventilation and respirators or local exhaust ventilation, maintain about 200 cfm.

Table 1111. Control data on important health hazards TNT handling—Continued

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
TNT cooling	TNT fume and vapor. Few to many workers. Intermittent to continuous.	Slight to severe.	Mechanical agitation. Respirators for infrequent exposures. Adequate room ventilation, preferably local exhaust ventilation at kettles ( $Q = 120A$ ) for continuous exposures. ( $A$ represents area of top of kettle.)
Pouring	TNT dust, fume and vapor. Many workers. More or less continuous.	Slight to moderate.	Careful filling and puddling. Elimination of all unnecessary sources of atmospheric contamination. Good general ventilation. Rotation of workers. Respirators for infrequent exposures. Local exhaust ventilation as an alternate to above measures.

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<p>Bomb filling (draw off.)</p>	<p>TNT fume and vapor. Few workers. Intermittent.</p>	<p>Slight to severe.</p>	<p>Have valve operator stand to side of bomb and remove fumes from room. Provide local exhaust ventilation Q of about 200 cfm per draw off site; or general ventilation. Same as pouring.</p>
<p>Bomb puddling. Nose and tail pouring.</p>	<p>TNT dust, fume and vapor. Many workers. Intermittent to continuous. Same as above.</p>	<p>Slight to moderate. Moderate to severe.</p>	<p>Careful handling of scrap. Local exhaust or good ventilation. Clean gloves. Rotation of workers. Respirators for infrequent exposures.</p>
<p>Adding TNT.</p>	<p>TNT dust. Few to many workers. Intermittent to continuous.</p>	<p>Slight to severe.</p>	<p>Eliminate deep drilling. Apply suction during entire cycle; use local exhaust ventilation.</p>

Table 1111. Control data on important health hazards TNT handling—Cont. ued

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
Riser knock off	TNT dust. Few to many workers. Intermittent to continuous.	Slight to moderate.	Employ risers of good design. Use care in knocking risers off. Isolate and exhaust ventilate if possible.
Riser break out	TNT dust. Few direct, many indirect. Usually intermittent.	Moderate to severe.	Exhaust hood or booth similar to spray paint booth. Ventilation rate $Q=300A$ .
TNT scrap	TNT dust. Few direct, many indirect. Essentially continuous.	do	Different method of scrap production or exhaust hood or booth similar to spray painting booth. Ventilation rate $Q=300A$ .
Tubs and buckets break up.	TNT dust. Few direct, many indirect. Intermittent.	do	Exhaust hood or booth similar to spray paint booth. Ventilation rate $Q=300A$ or isolate operation and have workers wear respirators.

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<p>Screening, blending, canning. Pelleting (charging koppers). Pellet alignment</p>	<p>TNT or tetryl dust. Few workers. Intermittent. TNT or tetryl dust. Few to many workers. Intermittent to continuous. TNT or tetryl dust. Few workers. Continuous.</p>	<p>do do do</p>	<p>Inclosure and respirators. See screening TNT above. Respirators. Local exhaust ventilation if continuous.</p>
<p>Cup loading</p>	<p>TNT or tetryl dust. Few to many workers. Continuous.</p>	<p>do</p>	<p>Downdraft exhaust ventilation through grille top work benches or slotted alignment trays. Q=200A. Partial inclosure also.</p>
<p>Tube loading</p>	<p>TNT or tetryl dust. Few to many workers. Continuous.</p>	<p>Moderate to severe</p>	<p>Downdraft exhaust ventilation through grille top work benches or screen or perforated bottom trays. Q=200A. Partial inclosure also. Downdraft exhaust ventilation through grille top work benches or slotted or screen bottom trays. Q=200A. Partial inclosure also.</p>

Table 1111--Continued  
Manufacturing plants--TNT

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
Flaking or graining--	TNT fume and dust--	Insignificant to moderate.	Inclose process as much as possible and exhaust ventilate at minimum rate of $Q=150A$ . Provide local exhaust ventilation at sources of dust dispersion through a box filling hood around the end of chute provided with flexible flange. $Q=200A$ for space between box and hood. Same as box filling using tapered hood.
Box filling--	TNT dust. Few workers.	Slight to severe--	
Box shakin'--	TNT dust. Few workers.	do--	

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*Small arms ammunition (manufacturing)*

<p>Proof testing (target area).</p>	<p>Lead dusts and fumes. Intermittent.</p>	<p>Moderate to very severe.</p>	<p>Exhaust ventilation of target end of range and "dog houses." <math>Q=200A</math>. (<math>A</math> represents cross sectional area of range.) Local exhaust ventilation through adjustable hood near gun breach and over ejected shell container at rate of 300-400 cfm. Clean ranges and prepare sand butts after or between work shifts. Provide cleaners with Bureau of Mines approved mechanical filter respirators. Inclose and exhaust ventilate testing stations at rate of 250 cfm or <math>Q=150A</math> whichever is greater. (<math>A</math> represents area of opening into partial inclosure around testing station.)</p>
<p>Proof testing (firing area).</p>	<p>Lead fumes. Intermittent to almost continuous.</p>	<p>Moderate to severe.</p>	<p>-----do-----</p>
<p>Proof testing (cleaning ranges and preparing butts).</p>	<p>Lead and sand dust. Infrequent.</p>	<p>-----do-----</p>	<p>-----do-----</p>
<p>Primer testing</p>	<p>Lead fumes and dust. Intermittent to continuous.</p>	<p>-----do-----</p>	<p>-----do-----</p>

Table 1111—Continued  
Small arms ammunition (manufacturing)—Continued

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
Mercury crack testing.	Mercury vapor. Intermittent to continuous.	Slight to severe.	Provide exhaust ventilated hood over coating and inspecting locations, and over entire sink area. $Q=150A$ . ( $A$ represents area of opening between hood edge and sink or table top. Keep $A$ as small as consistent with good operation.) Keep tested cases in closed container and empty at least daily.

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*Maintenance and miscellaneous*

Spray painting-----	Paint pigment and thinner. Few workers. Intermittent to continuous.	Slight to severe-----	Exhaust ventilated booths for routine work. $Q=200A$ where $A$ is under 10. $Q=150A$ where $A$ is over 10. Supplied-air respirators for intermittent or repair work, also when operator working between spray source and booth exhaust. Local exhaust ventilation at each routine welding site. $Q$ should be 350 to 1,000 cfm. Good general ventilation for occasional work. Respirators for toxic material.
Welding-----	Metal oxide fumes and nitrogen oxide gases. Few to many workers. Intermittent to continuous exposure.	do-----	

Table 1111—Continued  
Maintenance and miscellaneous—Continued

Operation	Nature	Severity of exposure usually encountered	Recommended control measures
Degreasing.....	Toxic vapors from organic solvents. Few workers direct, usually. Sometimes many indirect. Intermittent to continuous exposure.	Slight to severe.....	Proper tanks, vats or container. Proper operation of tanks and control measures. Slow rate of withdrawal of parts. Control of solvent from cleaned parts. Inclosures. Local exhaust ventilation. $Q=50LW$ . Good general ventilation. ( $L$ and $W$ represent tank length and width respectively, in feet.)
Electroplating.....	Acid gases and mists. Few workers usually. Exposure intermittent as a rule.	.....do.....	Inclosure and exhaust ventilation. Local exhaust ventilation. $Q=120LW$ . General ventilation for infrequent, short operation.

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Metallizing.-----  Luminous dial painting.	Metal oxides and carbon monoxide. Few workers. Exposure usually intermittent.  Harmful radiation, dust and gas. Usually few workers. Often continuous.	-----do-----  Moderate to severe.	Exhaust ventilated booths for routine work. Q=200A. Supplied-air respirators for intermittent or repair work.  Small quantities of radioactive substance only permitted near workers. Personal hygiene. Local exhaust ventilation. Q=100A.
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### **1112. DRINKING WATER**

The drinking water supply should be from a source approved by the health unit or the local health authorities having jurisdiction and should be checked periodically for potability by plant personnel or by the local health department personnel. Cool water should be made available at convenient locations through, or by means of, approved sanitary dispensers. Salt tablets should be made available at or near drinking dispensers for employees during hot periods or in locations where ambient temperatures are high. Cross connections between the approved drinking water supply and a nonpotable supply for fire and industrial processes are not permitted. Nonpotable water is unsafe for drinking.

### **1113. WASHING FACILITIES**

Washing and bathing facilities should be made available for each sex in quantities indicated below. Such facilities should be designed and constructed to meet all the requirements of the local plumbing codes. Soap, preferably liquid or powdered in suitable dispensers (explosives indicator soap where needed) and "single use" towels should be made available near all washing facilities. Water for washing should be from a source approved for drink-

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ing. Hot and cold water should be available. Change houses for workers in toxic exposures normally should be designed in a manner to afford effective control of compulsory bathing.

Table 1113. Recommended minimum number of washing facilities

Number of employees (maximum on any one shift)	Workers not having exposure to toxic chemicals	Workers having exposure to toxic chemicals	
	Wash basins	Wash basins	Showers
1 to 100	1 per 10	1 per 5	1 per 7.
Over 100	1 for each additional 15	1 per 5	1 per 7.

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#### 1114. TOILET FACILITIES

Toilet facilities should be provided for each sex in quantities indicated below. Where urinals are provided, the number of closets for males may be reduced accordingly, but never less than two-thirds the total number indicated in the table. Water closets should be used for all establishments employing more than 25 workers and for smaller establishments if practicable. Where only a few workers are employed, chemical closets or privies of a type approved by the local health authorities having jurisdiction may be used. The design and construction of toilets and toilet facilities should fulfill all requirements of local plumbing codes and local health departments. Toilet paper, waste receptacles, and washing facilities should be available at or near the facilities. Toilet rooms should be ventilated to the outside.

*Table 1114. Recommended Minimum of Toilet Facilities*

Number of employees	Minimum number of facilities
1 to 9.....	1
10 to 24.....	2
25 to 49.....	3
50 to 100.....	5
Over 100.....	(1)

<sup>1</sup> 1 for each additional 30 employees.

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### 1115. SEWAGE

The sanitary and industrial sewage may be disposed of into sewers, treatment tanks, or rivers, provided it is in accordance with local, state and Federal regulations. (See SR 75-70-10.) Precautions should be taken to prevent explosives from entering sewer lines. Plant sweepings and trash should be collected in conveniently located trash cans which should be kept covered and in a sanitary condition. These sweepings should be separated to prevent explosives, oily rags, or chemicals from being placed in the same cans as ordinary refuse.

### 1116. REST ROOMS AND DRESSING ROOMS

Locker and dressing rooms, and rest rooms should generally be provided. The type and number of locker and dressing rooms will depend upon the nature of the operation as well as the number of employees. For workers having substantial exposure to toxic materials such as TNT, tetryl, and nitroglycerin, two lockers should be provided for each exposed worker, one for the street clothes and one for the work clothes. Where females are employed, rest rooms with beds or cots where practicable should be provided. **The size of the rest rooms should be approximately 60 square feet for 10 females and an additional 2 square feet for each additional female.** The number of cots or beds should be 1 for 10 to 100 females, 2 for 101 to 250 females, and 1 additional for each 250 females. Where practicable, rest rooms

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should be in or adjacent to first-aid stations and under the supervision of the health unit.

Table 1117. Gases and Vapors (Maximum Allowable Concentration)

Substance	MAC value (parts per million in air for an 8-hour workday)
Acetaldehyde.....	200
Acetic acid.....	10
Acetic anhydride.....	5
Acetone.....	1,000
Acrolein.....	.5
Acrylonitrile.....	20
Ammonia.....	100
Amylacetate.....	200
Iso-amyl alcohol.....	100
Aniline.....	5
Arsine.....	.05
Benzene (benzol).....	35
Bromine.....	1
1,3-butadiene.....	1,000
n-Butanol.....	100
2-butanone.....	250
n-butyl acetate.....	200
Butyl cellosolve.....	200
Carbon dioxide.....	5,000
Carbon disulfide.....	20
Carbon monoxide.....	100
Carbon tetrachloride.....	25
Cellosolve.....	200
Cellosolve acetate.....	100
Chlorine.....	1
2-chlorobutadiene.....	25
Chloroform.....	100
1-chloro-1-nitropropane.....	20

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Table 1117. Gases and Vapors (Maximum Allowable Concentration)—Continued

Substance	MAC value (parts per million in air for an 8-hour workday)
Cyclohexane	400
Cyclohexanol	100
Cyclohexanone	100
Cyclohexene	400
Cyclopropane (propene)	400
o-Dichlorobenzene	50
Dichlorodifluoromethane	1,000
1,1-dichloroethane	100
1,2-dichloroethane (ethylene dichloride)	100
1,2-dichloroethylene	200
Dichloroethyl ether	15
Dichloromethane	500
Dichloromonofluoromethane	1,000
1,1-dichloro-1-nitroethane	10
1,2-dichloropropane (propylene dichloride)	75
Dichlorotetrafluoroethane	1,000
Dimethylaniline	5
Dimethylsulfate	1
Dioxane	100
Ethyl acetate	400
Ethyl alcohol	1,000
Ethyl benzene	200
Ethyl bromide	200
Ethyl chloride	1,000
Ethylene chlorohydrin	5
Ethylene oxide	100
Ethyl ether	400
Ethyl formate	100
Ethyl silicate	100
Formaldehyde	5
Gasoline	500

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Table 1117. *Gases and Vapors (Maximum Allowable Concentration)—Continued*

Substance	MAC value (parts per million in air for an 8-hour workday)
Heptane.....	500
Hexane.....	500
Hydrogen chloride.....	5
Hydrogen cyanide.....	10
Hydrogen fluoride.....	3
Hydrogen selenide.....	05
Hydrogen sulfide.....	20
Iodine.....	1
Isophorone.....	25
Mesityl oxide.....	50
Methanol.....	200
Methyl acetate.....	200
Methyl bromide.....	20
Methyl butanone.....	100
Methyl cellosolve.....	25
Methyl cellosolve acetate.....	25
Methyl chloride.....	100
Methylcyclohexane.....	500
Methylcyclohexanol.....	100
Methylcyclohexanone.....	100
Methyl formate.....	100
Methyl iso-butyl ketone.....	100
Monochlorobenzene.....	75
Monofluorotrichloromethane.....	1,000
Mononitrotoluene.....	5
Naphtha (coal tar).....	200
Naphtha (petroleum).....	500
Nickel carbonyl.....	<u>.001</u>
Nitrobenzene.....	1
Nitroethane.....	100
Nitrogen oxides (other than nitrous oxide).....	<u>5</u>

Table 1117. Gases and Vapors (Maximum Allowable Concentration)—Continued

Substance	MAC value (parts per million in air for an 8-hour workday)
Nitroglycerin.....	. 5
Nitromethane.....	100
2-nitropropane.....	50
Octane.....	500
Ozone.....	0. 1
Pentane.....	1, 000
Pentanone (methyl propanone).....	200
Phosgene.....	1
Phosphine.....	. 05
Phosphorus trichloride.....	. 5
iso-propanol.....	400
Propyl acetate.....	200
iso-propyl ether.....	500
Stibine.....	. 1
Stoddard solvent.....	500
Styrene monomer.....	200
Sulfur chloride.....	1
Sulfur dioxide.....	10
1,1,2,2-tetrachloroethane.....	5
Tetrachloroethylene.....	200
Toluene.....	200
Toluidine.....	5
Trichloroethylene.....	200
Turpentine.....	100
Vinyl chloride (chloroethane).....	500
Xylene.....	200

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Table 1118. *Dusts, Fumes and Mists (Maximum Allowable Concentration)*

Substance	MAC value (milligrams per cubic meter of air for an 8-hour workday)
Antimony.....	0.5
Arsenic.....	.5
Barium.....	.5
Cadmium.....	.1
Chlorodiphenyl.....	1
Chromic acid and chromates (as CrO <sub>3</sub> ).....	.1
Cyanide as CN.....	5
Dinitrotoluene.....	1.5
Fluoride.....	2.5
Iodine.....	.1
Iron oxide fume.....	15
Lead.....	.15
Magnesium oxide fume.....	15
Manganese.....	6
Mercury.....	.1
Pentachloronaphthalene.....	.5
Pentachlorophenol.....	.5
Phosphorus (yellow).....	.1
Phosphorus pentachloride.....	1
Phosphorus pentasulfide.....	1
Selenium (compounds as selenium).....	.1
Sulfuric acid.....	1
Tellurium.....	.1
Tetryl.....	1.5
Trichloronaphthalene.....	5
Trinitrotoluene.....	1.5
Zinc oxide fume.....	15

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*Table 1119. Mineral Dusts (Maximum Allowable Concentration)*

Substance	MAC value (million particles per cubic foot of air for an 8-hour workday)
Alundum.....	50
Asbestos.....	5
Carborundum.....	50
Dust (nuisance, no free silica).....	50
Mica (below 5 percent free silica).....	20
Portland cement.....	50
Silica—high (above 50 percent free SiO <sub>2</sub> ).....	5
Silica—medium (5 to 50 percent free SiO <sub>2</sub> ).....	20
Silica—low (below 5 percent free SiO <sub>2</sub> ).....	50
Slate—low (below 5 percent free SiO <sub>2</sub> ).....	50
Soapstone (below 5 percent free SiO <sub>2</sub> ).....	20
Talc.....	20
Total dust (below 5 percent free SiO <sub>2</sub> ).....	50

*Table 1120. Radiant Energy (Maximum Allowable Concentration)*

Material or radiation	Radiant energy
Gamma (roentgen per week).....	0.3
Radon (curies per cubic meter).....	10 <sup>-6</sup>
Thoron (curies per cubic meter).....	10 <sup>-6</sup>
X-ray (roentgen per week).....	0.3

**1121. CANTEENS, LUNCHROOMS**

a. Canteens or lunchrooms should be made available to all workers who are exposed to toxic ma-

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terials. They should usually be available to all employees. If food is served to employees, pasteurized milk should be the only type of milk served. The milks, custards, meats and other perishables should be refrigerated properly prior to serving. All food should be served in a sanitary condition and in a sanitary manner. (See Ordinance and Code Regulating Eating and Drinking Establishments, Public Health Bulletin No. 280, U. S. Government Printing Office, Washington, D. C., 1943.) Utensils, dispensers, and display cases should be kept in a sanitary condition through periodic cleaning and disinfecting by an approved method. Lunchrooms should be constructed of, and provided with, materials and equipment suitable for the purposes for which they are intended. The interior surfaces of lunchrooms and surfaces of tables, chairs and other equipment should be of a light, hard finish so that sanitation thereof is fostered. Lunchroom areas generally should comply with the following table:

*Table 1121. Lunchrooms (personnel limitation)*

Number of persons (greatest number of employees on any one shift)	Square feet per person
Less than 25	8
25 to 74	7
75 to 149	6
150 to 499	5
500 or more	4

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b. Toilet (see par. 1114) and washing facilities should be provided for cafeteria employees.

## 1122. TEMPERATURE AND HUMIDITY

a. Except where equipment or processes require abnormal atmospheric conditions, the temperature in buildings during the heating season should be kept within the limits prescribed by the State Ventilation Codes, or by the American Society of Heating and Ventilating Engineers, New York, N. Y., in the latest edition of "Heating, Ventilating and Air Conditioning Guide." It is desirable to keep the relative humidity above 20 to 30 percent during the heating season, except that where metal powders are involved the relative humidity should be maintained between 50 and 55 percent and in other locations where accumulations of static electricity are to be minimized, the relative humidity should be maintained at 60 percent or more (see sec. 7). Spot heating or cooling is permissible for large buildings occupied by only a small number of workers. In this way the workers are kept comfortable with a resulting economy in heating or cooling equipment and in fuel consumption.

b. Where it is necessary for workers to go from change house to work place or from building to building in a specified work uniform, inclosed passageways (heated if necessary) should be provided between the various buildings or the workers should be provided with warm over-garments during cold weather.

## 1123. NOISE

The intensity of a sound alone is not the only consideration in determining whether a noise exists—contrast is also important. For example, a moderate sound would be noise in the reading room of a library but not in a steel mill. Objectionable noise produces fatigue, impairs hearing, fosters neuroses, causes emotional disturbances, and decreases efficiency. It is eliminated if feasible by one of several of the following engineering methods:

- a. Elimination of noise at its source.
- b. Isolation of noisy operations.
- c. Reduction of noise by insulation.
- d. Personal protection devices (ear defenders, etc.).

## 1124. RADIANT ENERGY

The most important sources of harmful radiant energy are welding, inspection of materials by means of x-rays or radium, and luminous dial painting. Adequate protection measures should be provided at all such operations to prevent a health hazard to workers. X-ray equipment and operations, and the use of radium should conform to the requirements of the latest edition of ASA Safety Code for the Industrial Use of x-rays. Operations involving the use of radioactive luminous paint should conform to the provisions

of TB MED 232. Handling and disposal of radioactive tubes and materials shall be in accordance with TB ORD 648 and AR 755-380.

## SECTION 12

### FIRE PROTECTION

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#### 1201. SCOPE

The term "fire protection" is used in this manual in its broad meaning to include:

a. Measures necessary to detect and eliminate the causes of fires and thus prevent their occurrence (often called fire prevention).

b. The methods utilized to confine fire to the place of origin.

c. The means of extinguishing fires promptly when they do occur.

#### 1202. INERT AREA

a. Fire protection (par. 1201) for inert areas (par. 231) and for administrative areas (par. 202), shall be provided and maintained in accordance with the requirements of all applicable current directives such as TM 5-687, TM 5-695, TM 5-696, AR 420-10, and AR 420-90. Recommendations in such directives shall be complied with unless exceptions are authorized in writing by the commander or his designated agent.

b. In the absence of requirements or recommendations in applicable current directives on

any phases of fire protection, establishments shall follow the mandatory provisions of NBFU Standards and shall be guided by the advisory provisions. Establishments shall also be guided by the publications of the NFPA—particularly the latest edition of the Crosby-Fiske-Forster Handbook of Fire Protection.

### 1203. EXPLOSIVES AREA

a. Fire protection (par. 1201) for explosives areas (par. 217) shall be provided and maintained in accordance with the requirements of all applicable current directives, including paragraphs 1203 through 1230 and other applicable parts of this manual. Recommendations in applicable current directives, including paragraphs 1203 through 1230 and other applicable parts of this manual, shall be complied with unless exceptions are authorized in writing by the commander or his designated agent.

b. In the absence of requirements on any phases of fire protection in applicable current directives, including paragraphs 1203 through 1230 and other parts of this manual, establishments shall follow the mandatory provisions of the NBFU Standards where they apply, and be guided by the advisory suggestions where they apply. Establishments shall also be guided by the publications of the NFPA—particularly the latest edition of the Crosby-Fiske-Forster Handbook of Fire Protection.

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#### **1204. PROGRAM**

Each Ordnance establishment having an explosives area (see par. 217) shall institute an effective program designed to carry out the steps necessary to prevent fire in such areas and to fight fires that do occur.

#### **1205. FIRE MARSHAL**

The commanding officer should appoint a qualified fire marshal who shall be responsible for the efficient administration of the program. He shall also be responsible for reviewing plans for installing equipment, construction of new buildings, modification of existing buildings or installations, changes of work processes, and fire main systems; and for detecting and correcting fire hazards before work proceeds.

#### **1206. FIRE PLAN**

A written fire plan shall be prepared. Although details of the plan may vary to suit the individual establishment, the over-all plan shall include a description of the emergency function of each department or outside agency indicating responsible individuals and alternates, as well as:

a. The organization and training of personnel whose responsibility includes:

- (1) Reporting the fire.
- (2) Directing orderly evacuation of personnel.

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- (3) Notifying personnel in nearby departments or buildings of impending dangers.
- (4) Activating deluge systems or other means of extinguishing or controlling the fire.
- (5) Meeting and advising the fire fighters as to details of the fire up to the time of their arrival.
- (6) Checking the effective operation of elevator shaft inclosures, fire doors or other means of confining the fire.

b. The list of intraplant and outside telephone calls or alarm signals which must be made is as follows:

- (1) Notify the fire department, the guard department, post authorities, engineering department, maintenance department, auxiliary fire fighters and others.
- (2) Notify the transportation department to transport auxiliary fire fighters or necessary equipment to the scene.
- (3) Call for outside fire department assistance as required.

#### **1207. EDUCATION OF PERSONNEL**

Instructions to supervisors and workers shall include such steps relative to their operations which will add to fire safety. All "job instruction breakdowns" should be reviewed by the fire marshal and supervisor for inclusion of necessary precautions. Each person acting in a supervisory capacity shall

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be thoroughly conversant with the fire hazards of the operations for which he is responsible.

#### **1208. HOUSEKEEPING**

a. Covered, fire-resistant rubbish cans should be provided. Metal waste cans with self-closing covers shall be conveniently located for the disposal of oily rags and waste. Accumulations of odds and ends or waste material in out-of-way places should be avoided. Cupboards, closets, and spaces under benches, conveyors, stairs, and platforms shall be inspected periodically to assure cleanliness. Painting with light colored paint is recommended for such spaces as well as building interiors. Volatile flammable liquids shall not be permitted to remain in open containers nor shall they be used except where specifically authorized as process requirements. Where use of such liquids is authorized, working quantities shall be confined to approved safety containers.

b. Sand pails should be provided where smoking is permitted. No cigarette, tobacco, or match disposal will be permitted in rubbish cans, or in such manner as to involve risk of igniting combustible material.

c. Dripping and spillage of oil and oil soaking of floors should be avoided. Noncombustible absorbent materials should be used to reduce or eliminate this hazard.

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d. Baled supplies of packing materials should be stored in the open, suitably protected from weather, or in a separate shed or building set aside for the purpose. The location should be isolated and free of combustible vegetation. "No Smoking" signs should be posted in the vicinity and suitable fire extinguishers or water barrels and pails provided.

#### 1209. INFRARED RAY DRYING

a. Infrared ray drying processes should not be used in the same room in which exposed explosives are present. Special precautions shall be taken to insure that all items from which explosives have been removed by processes such as "steam out" are free of explosives contamination before subjecting them to this process.

b. If sealed items containing explosives are to be subjected to infrared ray drying processes, prior tests to determine maximum internal temperatures to which explosives will be raised by such rays shall be conducted on duplicate sealed containers with inert filler having a thermal conductivity and specific heat similar to that of the explosives. Conveyor speed, time of exposure, and intensity of exposure to infrared rays will be adjusted so that the maximum internal temperatures to which explosives are subjected do not exceed 170° F. (76.7° C.) during entire period of exposure.

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c. Before freshly dipped or painted articles are processed in infrared ray drying equipment, they shall pass through a predryer. This predryer shall be exhaust ventilated, constructed of noncombustible materials, and shall be provided with automatic sprinkler protection. The air exhausted from the predryer shall be discharged to the outside at a point where possibility of re-entry into the building is at a minimum. The predryer need not be heated. The time the article must remain therein will be determined by actual test when using the normal paint mixture. Freshly dipped or painted articles shall be predried until at least 85 percent of the volatile flammable vapors are removed. (In most instances, less than 2 minutes are required when air velocity past the article in the predryer is 300 fpm and the circulated air temperature is 70° F.)

d. Within 20 feet of the predryer, paint spray booth, or dip tank, the electrical equipment shall be installed in conformity with NBFU Pamphlet No. 33, Spray Finishing.

e. Conveyor motor controls shall be interlocked with the magnetic switch in the main supply circuit to the infrared drying equipment so that the lamp circuit will be opened when such conveyor stops.

f. Infrared ray drying equipment shall be installed in a large open room at least six times as large in unobstructed area as the area of the infrared ray drying equipment.

g. Adequate ventilation, preferably exhaust venti-

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lation of the predryer, shall be provided for the room to keep vapor air mixtures at least 50 percent below the lower explosive limit, and also below the maximum allowable concentration as a health hazard (sec. 11). Periodic tests in the vicinity of the infrared ray drying equipment shall be made with a flammable vapor indicator to insure low vapor concentrations.

h. The construction of infrared ray drying equipment shall be such that paint dripping from articles will not strike the lamps, reflectors or wiring.

i. The construction and position of the infrared ray drying equipment and conveyor equipment shall be such that contact between articles and bulbs is not possible.

j. Provisions will be made so that items being processed cannot drop off the hooks and lodge in the dryer unnoticed. If the drying equipment is constructed so that falling articles will not pass completely through it, arrangements shall be made to automatically stop the conveyor and extinguish the lights concurrently by the use of suitable protective devices.

k. The infrared ray drying equipment should be screened, or the source of infrared radiation shielded in such a manner as to protect workers from prolonged or close exposure to radiation. If screening or shielding is not adequate to protect employees' eyes while working in the vicinity of the drying equipment, safety goggles with Nos. 1½ to 3 shade lens shall be worn by those so exposed.

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**1210. ELECTROSTATIC PAINT SPRAYING OR DIPPING  
OF INERT ITEMS IN NONHAZARDOUS LOCA-  
TIONS**

*a.* When spray painting equipment utilizes high potential electrical current to assist in distributing paint uniformly over the surface of the article to be coated, or when such electrical current is installed, the following safety precautions will apply in addition to the requirements of NBFU Pamphlets No. 33 "Spray Finishing," and No. 34 "Dip Tanks," so far as they apply.

*b.* Transformers and power packs shall be located outside of the immediate painting area, in no event closer than 20 feet to spray booths, dip tanks, and pressure vessels containing paint mixture.

*c.* The electrical installation shall be in accordance with the National Electrical Code so far as it applies.

*d.* Electrodes shall be rigidly supported in a fixed position and well insulated.

*e.* The minimum spacing between electrodes and objects being painted or de-teared shall be twice the length of the possible spark gap, under the operating conditions.

*f.* All items subject to the processes shall be handled on conveyors and so fixed to the conveyor that at least the minimum spaces outlined in paragraph *e* above from items to electrodes will be maintained under all circumstances. Guards shall be provided where necessary to produce this result.

*g.* An automatic switch should be provided so that

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article entering the electrostatic field on the conveyor closer to an electrode than the minimum distance outlined in paragraph *e* above shall automatically stop the conveyor and disconnect the high potential circuit.

*h.* Mechanical means only shall be used in the painting operations and in the carrying of the article to be processed into and through the electrostatic field.

*i.* Whenever possible a noncombustible insulating panel or screen should be mounted between the electrodes and the articles being processed. (Specific data should be obtained concerning this precaution from the manufacturer before the equipment is installed.)

*j.* Automatic control should be provided to shut off the entire electrostatic equipment whenever the vent fans and/or conveyors are not operating.

*k.* Adequate ventilation should be maintained for the areas containing electrostatic apparatus; the fan motors for the ventilating system shall be interlocked with the voltage pack primary.

*l.* Painting or de-tearing processes involving electrostatic apparatus shall be protected by automatic sprinklers or other approved automatic extinguishing systems.

*m.* Adequate fencing, railings or guards shall be provided to maintain safe isolation of the process from other work in the vicinity and to protect personnel.

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n. Signs designating the work zone as dangerous as regards fire and accident shall be posted at the process.

o. Electrode insulators should be maintained clean and dry.

p. Drip plates, grids, and noncombustible insulating panels or screens shall be removable so that they may be taken to a designated, safely located place for cleaning.

q. Excellent housekeeping and cleanliness shall be maintained in the area. Stock or items must not be stored within 5 feet of the process.

#### 1211. SPRAY PAINTING

a. All spray painting operations involving flammable liquids should be segregated from other operations, except where portable spraying apparatus is not used repeatedly in the same location. Mandatory provisions of NBFU Pamphlet No. 33, "Spray Finishing Using Flammable Materials" shall be followed.

(1) In addition to the standards of NUFB Pamphlet No. 33, the following requirements shall apply in buildings where spray painting of loaded ammunition is conducted:

(a) Water wash or dry filter type spray booths shall be used exclusively. Filters for dry type booths must not support combustion when clean and must be capable of effectively arresting paint overspray. They must be replaced when collected

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overspray reduces the flow of exhaust air below 150 linear feet per minute and whenever the type of paint being sprayed is changed. Paint-encrusted filters shall be disposed of promptly.

- (b) If electrical equipment is necessary within a distance of 20 feet from the spray booth, such equipment will conform with the requirements of class I, group D installation for hazardous locations, National Electrical Code. Whenever possible, every effort should be made to eliminate the use of electrical equipment within the aforementioned distance.
- (c) Spray booths shall be equipped with a sprinkler extinguishing system with extra hazard pipe sizes installed in accordance with recognized practices. If automatic operation is provided by electrical means, the heat actuated devices will comply with the requirements for class I, group D installations for hazardous locations. If other electrical controls for automatic operation are located within a distance of 20 feet of the spray booth, such controls will also comply with the aforementioned requirements. Dry type booths shall be constructed with deluge extinguishing systems installed in a manner which will assure blanketing of the filter wall

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with water in the event a fire occurs. The plenum of the booth shall be equipped with an automatic fire extinguishing system.

- (d) Automatic sprinklers shall be installed within a radius of 20 feet of the paint spray booth, if the building in which the spray booth is located is not provided with sprinkler protection.
- (e) Controls for paint spray booth ventilating fan motors shall be interlocked with the

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controls for conveyor motors where the conveyor delivers material to the booth. With this arrangement, failure of the ventilating system will shut off power to the conveyor motor. Interlock arrangement should permit fan to operate in the event conveyor stops.

b. Where it is necessary to set up field operations and the requirements of paragraph 1211a above cannot be met, spray painting of sizable quantities of loaded ammunition or inert items is permissible if:

- (1) Paint booths are constructed of noncombustible material.
- (2) An exhaust system with exhaust fan is installed to remove paint fumes from the booth (the fan may be powered by an air motor).
- (3) At least two CO<sub>2</sub> or foam type extinguishers are installed within the booth with rate of rise actuated nozzle attachments. Two manual type CO<sub>2</sub> or foam type first-aid fire extinguishers must also be provided at the paint spray booth or operation.
- (4) Special precautions are taken to keep the booth clean and prevent the accumulation of paint on the surface of the booth or fire extinguisher nozzles.
- (5) The number of items in the booth at any one time are restricted to the minimum

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number required for efficient and continuous operation.

- (6) The area within 50 feet of the paint booth is kept free of combustible material, such as dry vegetation, wooden pallets, combustible crating or packing materials.
- (7) Paint and chemical mixing operations, supplies and air compressors are located at least 50 feet from the booth.
- (8) Personnel limits are maintained at the minimum consistent with safe and efficient operation.

c. If the quantity of loaded ammunition or inert items to be spray painted in an outside location does not warrant the provision of a paint booth, such operations are permissible provided:

- (1) The area within 50 feet of the spray paint operation is kept clean and free from extraneous combustible material, air compressors and paint mixing operations.
- (2) At least two CO<sub>2</sub> or foam type first-aid fire extinguishers are provided at the spray painting operation.
- (3) Personnel are protected from toxic materials by means of respirators, approved for the amount and type of exposure involved.
- (4) Personnel limits are maintained at the minimum required for safe and efficient operation.

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## 1212. DRYING FRESHLY PAINTED LOADED AMMUNITION

a. Ovens in which loaded ammunition is dried shall comply with the requirements of NBFU Pamphlet No. 86, "Class A Ovens and Furnaces," so far as they apply. The recommendations in the pamphlet should be followed where practicable.

b. In addition, the following requirements apply:

- (1) Automatic thermostatic controls should be arranged to stop the application of heat upon reaching a predetermined maximum temperature which should not exceed 170° F. (76.7° C.)
- (2) The oven shall be equipped with an automatic sprinkler system installed in conformity with the requirements of NBFU Pamphlet No. 13, "Sprinkler Equipment." Automatic operation of the system may be accomplished by electrical heat actuated devices provided they are approved for, and are installed in accordance with the requirements of, class I, group D hazardous locations as defined in the National Electrical Code. See paragraph 603e.
- (3) Heating may be by hot air or other means as long as ammunition or explosives do not come in contact with coils, radiators or heating elements.
- (4) If a conveyor system is employed, provision will be made to shut off the heat supply

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automatically in the event of power failure to the conveyor.

c. When an electrical drying unit is not approved for use in class I locations as defined in the National Electrical Code (par. 603e), the system should be designed so that the atmosphere in the oven is kept below 50 percent of the lower explosive limit of the mixture of solvent vapors and air.

### **1213. LIMITATION OF FIRE AREAS**

When the stock of an important or critical item in storage warrants it, distribution should be secured by dividing the stock and storing each part in a separate building or fire division. The need for limitation of areas subject to one fire, or separation of values may be considered lessened with the installation of approved automatic extinguishing equipment. Fire walls (par. 222) should conform to the standard prescribed in the Engineering Manual for Military Construction, Corps of Engineers. Communicating openings in fire walls should be protected by approved automatic fire doors as prescribed in the Engineering Manual for Military Construction, Corps of Engineers, and installed and maintained in a manner conforming with the requirements of NBFU Pamphlet No. 80, "Protection of Openings in Walls and Partitions Against Fire." Such doors shall be clear of obstructions to insure their proper closing. Extra hazardous occupancies such as spray

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painting or dipping, storage of highly combustible materials or flammable liquids, and handling of combustible salvage or waste material shall be effectively separated or their hazards so controlled as to not constitute a severe exposure to other property.

#### 1214. SEPARATION OF BUILDINGS

a. Buildings housing nonexplosives materials only shall be separated by clear space in compliance with part XI, Engineering Manual for Military Construction, Corps of Engineers. **Combustibles shall not be stored in this clear space.** Rubbish shall not be permitted to accumulate, and vegetation shall be controlled so that it will not serve to communicate fire from building to building. Lumber or other combustible materials stored in the open shall be similarly protected. Vehicles or materials of any kind shall not be permitted to obstruct access to fire hydrants or be placed so as to impede the work of the firemen.

b. **Buildings in explosives operating lines must be separated in accordance with paragraph 1705.**

#### 1215. CONTROL OF VEGETATION

Local, State, or Federal forest service officials should be consulted with respect to periods of greatest danger of forest and grass fires in the locality and with respect to extinguishing equipment which has proven *most* effective in extinguishing such fires. **The information received shall be utilized in developing a Land Management and Vegetation Control Plan which will minimize the danger of forest and grass fires on land under Government control and the**

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**spread of fire from adjacent land to land within the installation boundary.** Vegetation in the form of grass, undergrowth, weeds, etc., the density or nature of which constitutes a fire hazard or which is likely to become a fire hazard to structures, facilities and other Government property, shall be controlled or removed by cutting, plowing, grazing under supervised conditions, covering with noncombustible materials or by killing with a nonflammable vegetation eradicator. Seeding with species which do not become fire hazards is permissible. Where complete removal of vegetation is necessary to provide an effective firebreak but would tend to create an erosion problem, the firebreak should be covered with noncombustible materials. During calm weather and when adequate precautions are taken to prevent the spread of fire, burning may be accomplished. Burning, however, shall not be permitted within 200 feet of any above-ground type magazine or outdoor storage pad containing explosives or ammunition, or within 50 feet of any **earth-covered** magazine containing explosives or ammunition. During burning operations, all windows, doors, and ventilators of magazines shall be closed. All dead wood, down or standing, should be cleared out of woodland areas. Cutting or clearing of live brush and small trees should be avoided unless essential to provide access to the area.

#### **1216. FIREBREAKS IN MAGAZINE AREAS**

a. Firebreaks around magazine areas and at other places within such areas should be maintained wherever deemed necessary. A firebreak at least 50

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feet wide and free from combustible material shall be maintained around each aboveground type magazine and around each outdoor storage pad containing ammunition or explosives. Temporary magazines with exterior covering which may be readily ighited; magazines with fire-resistant construction where the fire-resistant materials do not completely cover the combustible framing, plates, sills, and supports; and outdoor ammunition storage pads containing combustible packing materials, damage, or other framework must be protected by a 50-foot firebreak in all directions on which no materials or vegetation capable of supporting combustion are permitted to exist. Magazines with fire-resistant exterior covering completely protecting the combustible framing, sills, and plates, and outdoor ammunition storage inherently somewhat resistant to fire because of the fire resistance of the explosives casing (e. g., heavy case HE bombs), must be protected by a firebreak beginning at the magazine or pad and extending 50 feet in all directions. This firebreak need not be devoid of vegetation but the growth must be controlled in a manner to prevent rapid transmission of fire to the pad or magazine.

b. The maintenance of firebreaks around **earth-covered** magazines and the cutting of grass covering these structures are not normally required. If the commanding officer believes that conditions at his establishment are exceptional, he should so advise the Chief of Ordnance. In emergencies, however, the commanding officer may take whatever action is deemed necessary to eliminate the hazard. Excess

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vegetation and dry debris on **earth-covered magazines**, and large trees, the root system or weight of which may damage these **magazines**, shall be cut and removed. Growth of vegetation around ventilators on **earth-covered magazines** must be controlled in a manner which will prevent rapid transmission of fire and provide visibility of the ventilator flag from ground level.

### **1217. FIRE-RETARDANT COATINGS**

a. Certain proprietary fire-retardant coatings for surface treating wood and fiber products have been classified by recognized testing agencies on the basis of their effectiveness to retard the ease of ignition and the flame spread characteristics, when combustible materials are exposed to incipient fires.

b. The value of such surface coatings is limited. They may decrease the ease of ignition, flame spread characteristics, and quality of fuel, but their limitations should be recognized. They are not effective when exposed to prolonged high temperatures and should not be used as a substitute for fire-resistive materials (par. 220) nor for non-combustible materials (par. 245).

### **1218. FIRST-AID FIRE EXTINGUISHERS**

(See par. 1326.)

a. The appropriate use and proper distribution of the various types of fire extinguishers are described in detail in NBFU Pamphlet No. 10, "First-aid Fire Appliances." First-aid fire extinguishers shall be maintained at all times in proper operative condition and shall be readily available for instant use.

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b. The placement of hand extinguishers in or in the vicinity of a building containing explosives shall be carefully scrutinized. In some cases the availability of hand extinguishers within a building will enable the extinguishment of incipient fires which might otherwise endanger life and property. On the other hand, first-aid fire extinguishers placed inside particularly hazardous buildings may serve as a temptation to fight the fire when the building should be abandoned. First-aid equipment may prove valuable in extinguishing incipient fires external to or on the exterior of, explosives buildings such as aboveground magazines. After activation of deluge systems, where available, employees should be made to understand clearly that their first duty is to report any fire to the fire department immediately after detection and that no employee shall reenter an explosives building to fight a fire except as directed by proper authority.

#### **1219. WATER BARRELS IN EXPLOSIVE STORAGE AREAS**

Water barrels and pails provide a recognized means of combating incipient fires in explosives and ammunition storage areas where the combustible material consists principally of grass, wood dunnage, ammunition boxes, etc. Where used, at least one water barrel and two pails or two water-type extinguishers, winterized when necessary, should be available for immediate use by workmen in and around magazines. Water barrels should be treated periodically to keep mosquito breeding to a minimum.

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Under normal conditions, however, water barrels and pails are not recommended in extensive explosives and ammunition storage areas if:

a. The provisions of paragraph 1215, pertaining to vegetation control, are strictly complied with;

b. (Revised) Working crews and all vehicles operating regularly in the magazine area, including locomotives, are equipped with two water type hand extinguishers, preferably of the back pack or 4-gallon hand pump type; and

c. The installation has an organized fire-fighting force equipped with pumpers or brush trucks, tank trucks and other necessary equipment to combat grass and brush fires.

#### **1220. FIRE-FIGHTING FORCES**

The duties of guards, watchmen, firemen, military personnel and others shall be so arranged that a fire-fighting force is available at all times. Fire-fighting forces shall be instructed thoroughly in the hazards due to fire and explosion, the safety precautions to be taken, and the means and methods to be used in preventing and fighting fires. Fire drills and inspections shall be conducted carefully to insure that fire-fighting forces understand their duties and that fire alarm systems and fire-fighting and other protective equipment function dependably under actual working conditions. Unannounced fire drills involving the response of motorized emergency vehicles are prohibited.

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## 1221. FIRE DEPARTMENT ASSISTANCE AGREEMENTS

a. At establishments where fire departments from nearby municipalities or industrial centers are partially or wholly depended upon for major fire-fighting effort, assistance agreements may be involved.

b. Adapters shall be provided if there is any difference in the thread size of equipment connections in use by the cooperating departments.

c. Fire chiefs and officers of cooperating departments shall become familiar with the special fire-fighting problems in the territory served by both departments to better integrate their forces in an emergency.

d. Outside fire fighters should not be permitted to fight fires involving explosives and ammunition. If the practical necessity of permitting them to do so can be anticipated, they shall be given prior instruction in fire-fighting procedures to insure that they shall not attack fires involving ammunition and explosives having fire symbol 4 characteristics (par. 1222).

## 1222. HAZARDS IN FIGHTING FIRES IN EXPLOSIVES

a. *General.* To provide a guide for fire-fighting forces, explosives are divided into four groups in accordance with the general burning or explosive characteristics of the materials and the relative danger encountered in fighting fires in which they are present. The four groups are identified by

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symbols (1 to 4), the hazards of which are described below. The appropriate symbol shall be plainly marked on buildings and storage sites containing explosives or ammunition. **Warehouses and other facilities in which are stored returned containers (i. e., explosives and propellant boxes, cans, etc.) should be placarded with appropriate fire symbols.** Symbols applying to the most hazardous material in the building shall be used. Fire symbols are not required on **earth-covered magazines** nor on outdoor revetted sites when the outdoor sites are restricted to storage of symbol 4 material. The symbols may be placed directly on the exterior of the building but removable plaques bearing the symbol are preferred because of the continuous changes in the explosives content of certain buildings. The symbol number should be at least 24 inches high and 20 inches wide and visible from each road of approach which may be used by fire fighters. A sign made with reflectorized or luminous materials is preferred. For buildings of long dimensions, more than one symbol

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to a side may be needed. Visibility at long range is improved by adopting a distinctive shape for the background of each symbol number, for example: a rectangular background for symbol 1; a square background for symbol 2; a diamond shaped background for symbol 3; and an octagonal background for symbol 4. All railroad cars and motor vehicles containing ammunition or explosives while on Ordnance installations must be provided with a means for quick identification of fire hazard. Installation railroad cars and motor vehicles which are not destined for offpost movement shall display at least two Ordnance fire symbols. Installation vehicles destined for offpost shipment and commercial railroad cars and motor vehicles will have ICC placards displayed when containing ammunition or explosives. Fire symbols or ICC placards shall be placed on vehicles immediately prior to loading and shall be removed or covered immediately upon completion of unloading. The recommended size of Ordnance fire symbol plaques for use on rail cars and motor vehicles should not be less than 16 inches square with symbol number not less than 12 inches high. To aid in distant identification the same shapes for symbols as previously described for buildings should be adopted. Where dependence for identification of fire hazards is placed on ICC placards only, "Explosive" cars shall be treated as symbol 4 fire hazards and "Dangerous" cars as symbol 3 fire hazards. It should be the responsibility of those who have charge of storage

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within the building or storage site which contains explosives to post the correct symbol or to change it as required by changes in the content of the building. The fire department shall be notified immediately of posted symbols and changes, if any. Chemical ammunition, in addition to possessing an explosive hazard when involved in a fire, also presents a toxic danger. Four-inch wide diagonal stripes may be superimposed upon fire symbols to denote such hazards. A single diagonal stripe should be used to indicate less serious toxic hazards (HC-smoke, etc.) and double stripes for more serious hazards (CG, H, etc.).

*b. Symbol 1.* Ammunition and explosives present a fire hazard and fires in which they are involved should be fought with first aid and mobile fire extinguishing equipment until the fire has been brought under control. Some hazard may be expected to fire-fighting personnel from fires in these materials and precautions should be taken against them. Symbol 1 materials include classes 1, 11, 12, and solid propellants (smokeless powder) up to and including the graining operation; solvents, oil, paint, gasoline, compressed gases, and metallic powders when packed in closed shipping containers approved by the Interstate Commerce Commission, chlorates, perchlorates, peroxides, and other oxidizing agents when uncontaminated with organic substances and stored in undamaged containers. For description of the various classes of explosives, see section 17.

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*c. Symbol 2.* Ammunition presents limited explosion hazards. Personnel discovering a fire in such material shall first give the alarm, and should attempt to put out the fire with equipment at hand provided the fire is in the incipient stage. When the firefighting organization arrives, the fire should be fought if it appears that it will be possible to put it out. If it does not appear possible, the building should be abandoned and firefighting efforts concentrated on preventing the spread of fire. Personnel should exercise precautions to prevent injury to themselves and equipment. **Symbol 2 materials include class 3 ammunition.** See section 17.

*d. Symbol 3.* Ammunition and explosives include class 2 and class 2A explosives. (See sec. 17) Personnel in the immediate vicinity should do everything possible to activate deluge system and give the alarm without incurring undue personal hazard. Unless the fire is of a minor nature and does not involve the explosive itself, and there appears to be a chance to control it, the firefighting organization shall confine its operation to preventing the spread of fire to other buildings. Fire in these materials produces intense radiant heat over a wide area, which is dangerous to personnel and equipment in the vicinity. Extreme caution should be taken by the firefighting organization.

*e. Symbol 4.* Ammunition and explosives include explosives in classes 4, 5, 6, 7, 8, 9 and 10.

- (1) These materials can be expected to detonate when involved in a fire, and except for

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classes 4 and 5, are subject to mass detonation. **Therefore, no attempt to fight fires involving symbol 4 material shall be made except for manual activation of installed fire extinguishing equipment.** Personnel shall leave the building immediately, using as much protective cover as possible and activating deluge systems and fire alarm equipment while escaping. Personnel evacuating the building are not free from danger until they reach bombproof shelters, although a reasonable degree of safety is afforded in the open at public highway distances from the building in question. When exit drills are held, employees should be instructed as to the safest line of travel to shelter or to a destination the required distance away. If the fire in a symbol 4 building is in non-explosive material and is small or in a separate container, an attempt may be made to extinguish the fire with an extinguisher or other means readily at hand. However, the placement of fire-extinguishing

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equipment designed for hand use adjacent to symbol 4 material must be carefully scrutinized.

- (2) After **Notifying** the fire department, the superintendent and other responsible persons shall travel as far as possible in the direction from which the fire-fighting forces may be expected in order to advise them as to the nature of the fire and the kind of material involved or likely to be involved. When symbol 4 materials are directly involved, fire-fighting forces shall not approach closer than 1,000 feet to the scene of a fire in which not over 50,000 pounds of explosives may be involved or to a proportionately greater distance up to 2,000 feet where 100,000 pounds are involved, and the mobile equipment shall be kept at a protected location. If it is known that a considerable distance or effective screening separates burning non-explosive materials from symbol 4 materials, or if an explosion has already occurred with assurance that only the heat of burning wreckage exposes other buildings whether containing explosives or not, and the fire chief and person-in-charge are in agreement on the procedure, fire-fighting forces may approach to extinguish the fire or protect adjacent buildings. However, no person shall reenter a symbol 4 building in which there is a fire to determine the

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conditions surrounding the fire. The safety of personnel in fighting a symbol 4 fire depends on the accuracy of the information made available to the fire-fighting forces. When the question of safety is in doubt, no effort shall be made to fight the fire and men and equipment shall take suitable cover and remain at safe distances from the building.

**1223. FIRE FIGHTING IN CLASSIFICATION, HOLDING, AND STORAGE YARDS**

(See sec. 21.)

a. The general provisions of paragraph 1222 apply to fighting fires in yards. However, because of the nature of railway cars, fires will most likely occur in the understructure. Often they can be extinguished readily if discovered in the incipient stages, but every effort should be made to obtain prompt movement of undamaged cars from yards where fire has broken out. All employees, including trainmen and guards should be trained in the use of first-aid fire equipment, with instructions concerning the dangers where explosives are involved.

b. Fire-tool boxes painted red and plainly marked

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"For Fire Only" should be installed at intervals of not more than 500 feet adjacent to yard tracks. These boxes should contain as a minimum, one fire ax, one shovel, one pinch bar, three fire pails and one 5-gallon, pump-type water fire extinguisher (nonfreeze when necessary). A properly maintained water barrel and a 16-foot straight ladder should be placed alongside the tool box. If water hydrants are available, hose carts equipped with hose with adapters and spanner wrenches should be supplied.

#### **1224. WATER FOR FIRE FIGHTING**

With the exceptions noted below water is used as the fire-fighting medium. Some exceptions to the general use of water as a fire-extinguishing medium are magnesium, aluminum and other finely divided metal powders, peroxides, calcium carbide, thermitite and metallic sodium. Water mains, hydrants, etc., are normally installed in built-up areas where ammunition or explosives are manufactured, renovated or demilitarized. Standards for their installation set forth in paragraph 1-08b, c, and e of part VII of the Engineering Manual for Military Construction, shall be followed.

#### **1225. STORAGE OF WATER FOR FIRE FIGHTING**

a. At least 1,000,000 gallons of water shall be stored or available for fire fighting in load line and

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in explosives manufacturing areas. Water supply for fire fighting shall be from two sources.

*b.* Such storage may be partly or totally in elevated gravity tanks, or in tanks or reservoirs at or below ground level. These tanks and reservoirs should be located at a minimum of inhabited building distance from explosives locations.

*c.* If stored at or below ground level, pumping facilities shall be adequate, reliable and maintained properly.

*d.* Means shall be provided for replenishing within 48 hours the total quantity of stored water without using portable pumpers or emergency hose lines.

*e.* Storage facilities for process water should be located at not less than intraline distance from operating buildings.

#### **1226. FIRE FLOW**

*a.* An outside, underground, looped system of mains, preferably cast iron, shall be installed properly and maintained as prescribed in load line, and in explosives manufacturing areas. The mains shall be large enough to supply a flow of water for fire fighting of at least 2,000 gpm at adequate pressure.

*b.* Where mains are provided, an adequate number of hydrants shall be set properly and supplied from the mains.

*c.* The mains shall be valved properly.

*d.* Where automatic sprinkler systems or deluge

systems are provided, studies shall determine that water supplies are adequate and reliable.

e. If domestic or process consumption of water in surveillance inspection buildings or in ammunition workshops is large enough to require underground mains, such areas shall be provided with the protection outlined in *a*, *b*, *c*, and *d* above.

f. Mains shall not extend under ammunition sites.

#### 1227. HOSE

Standard 2½- or 1½-inch single jacketed hose, as required, should be permanently connected to hydrants in those locations where it is permissible and necessary for operating personnel to attack a fire or act to prevent its spread. Such hose and accessories shall be protected from deterioration by approved hose houses, and such additional protection as necessary in areas subject to corrosive fumes. Procedures prescribed in TM 5-687 for the care and testing of hose shall be followed.

#### 1228. AUTOMATIC SPRINKLER SYSTEMS

The installation of automatic sprinkler systems may be justified in certain buildings in load line explosives manufacturing, surveillance and inspection building, or ammunition workshop areas. A specific example would be the receiving building in a load line. In such cases, the proper

automatic sprinkler systems should be determined by engineering studies of special hazards involved (par. 1624).

### 1229. DELUGE SYSTEMS

Melting kettles, cotton pickers, powder cutters, and other machinery or processes in which there is a process fire hazard should be equipped with hand-operated, quick-acting control deluge equipment in addition to an automatic device. The deluge system should be charged with steam, water, or chemicals depending upon the character of the fire to be controlled, as described in NBFU Pamphlet No. 13, Sprinkler Equipment, or as deemed proper after engineering studies of hazards involved. The use of control devices actuated by rate or rise of temperature is recommended (par. 1624).

### 1230. FIRE EXIT DRILLS

a. Frequent and regular fire exit drills should be held when the size of building and number of occupants so warrant. If emergency exits other than the usual doors or stairways are provided, it is important for employees to be drilled in their use so that they will go to them automatically in case of fire or other emergency. Organization among the employees for fire drills is essential. The latest edition of ASA Building Exits Code should be used as a guide.

b. To facilitate the prompt evacuation of all personnel from buildings, an alarm system which is audible or visible, or a combination of both, should be installed in each explosives operating building. The alarm system for operating buildings containing explosives in melt loadlines shall be so arranged that in case of fire or explosion in any one of them, personnel in all buildings in the line shall be warned; in case of fire in inert buildings in melt loadlines, the personnel in the building in which the fire occurs shall be warned, and the personnel of the entire line may be warned by manual methods.

### 1231. HAZARDS IN FIGHTING FIRES INVOLVING LIQUID PROPELLANTS

a. *General.* To effectively and safely combat fires involving liquid propellants, firefighters must have knowledge of their burning characteristics and the specific hazards which may be encountered. Since the smoke and fumes from such fires are generally toxic, fires should be approached and fought from the upwind side. Firefighters should wear full protective clothing and self-contained breathing apparatus of approved type.

b. *Aniline-furfuryl alcohol mixtures.* These mixtures are toxic by absorption through skin, inhalation, and ingestion. They are highly flammable and react violently with most oxidizing agents. They are considered generally non-

corrosive but will slowly attack rubber, cork, and most plastics and will promote combustion of organic materials. Fire extinguishing agents which provide a smothering action (e.g., foam, carbon dioxide, and dry chemicals) are recommended. Water fog or mist is effective but solid streams of water should not be used for fire-fighting.

*c. Unsymmetrical dimethylhydrazine (UDMH).* UDMH is toxic by inhalation, ingestion, and skin contact. It is a volatile flammable liquid which is completely miscible in water, ethanol, and most petroleum fuels. When diluted with 2-3 times its volume of water, UDMH will not burn. Large quantities of water (solid hose streams directed at the base of the fire) provide the most effective means for extinguishing fires in UDMH.

*d. Fuming nitric acid.* Fuming nitric acid is extremely corrosive. Contact with the skin will produce severe caustic burns. It is toxic by inhalation. It does not burn, but through violent oxidizing action greatly increases the flammability of combustible material with which it comes in contact. Fires involving fuming nitric acid should be fought promptly with large volumes of water. In applying the water, care must be taken to prevent splashing or spattering. The area surrounding the fire should be thoroughly wet down to prevent organic material such as brush and grass from igniting.

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## SECTION 13

### SPECIFIC CHEMICALS

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#### 1301. BUILDING CONSTRUCTION FOR ACIDS

Buildings where acid is stored, handled, or used should be built of materials resistant to the action of the vapors produced or of the liquids themselves. Examples of such materials are acid-resisting brick, tile, asphalt-painted concrete acid-resisting cement, steel covered with acid-resistant coatings and the like. Wood and other carbonaceous materials affected by contact with acids and their vapors should be kept to a minimum. Floors should be of acid-resistant material sloped to a drain connected to sumps. Drains from the sumps should not be connected to the industrial and sanitary sewers. In lieu of drains, floors could be constructed with acid proof retaining walls to prevent escape of acid should leaks occur. Earth floors should have dykes, and should be covered with crushed limestone sized from 1 inch down with not more than 10 percent limedust.

#### 1302. ACID STORAGE

*a. General.* Acids are often stored in the steel drums or the glass carboys in which they are received at the establishment. These containers should be stored in a cool dry place away from the direct rays

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of the sun and from heat sources. Because of the possible hazard of igniting hydrogen gas which is generated by the action of certain acids when stored in metal tanks or drums, the use of heat producing equipment should be controlled as outlined in paragraph 1606. For storage of concentrated sulfuric or fuming sulfuric acid, precautions should be taken that the temperature is maintained above its freezing point. Certain strong oxidizing acids should be kept completely isolated as mixing with other acids may create an extremely hazardous condition, e. g., perchloric acid solution with acetic, citric, nitric or sulfuric acids.

*b. Tanks.* Storage tanks should be located to permit complete inspection of the tank, piping, valves, etc. They should not be located in areas containing underground tanks, highly flammable materials or chemicals which can react with the acid to form a dangerous product. Overflow lines from the top of storage tanks should be installed and equipped with a flow detector and alarm to give warning when overflowing occurs. Tanks should also be equipped with an external gauge to show the quantity of acid in the tank. Tanks with bottom outlets should be equipped with standard safety plugs and the tank area should be suitably dyked.

*c. Carboys.* Carboy stores should be elevated from floors to keep the bottoms of the crates dry and prevent rotting. Carboys may be stored in tiers not over two high with care taken to insure that the bottoms of the upper row do not touch the glass necks

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or the wooden hoods of the lower carboys. At least one side of each carboy must be exposed to permit detection of leakers. Generally, when carboy shipments are received, the stoppers should be loosened carefully and then retightened.

### 1303. HANDLING ACIDS

(See TM 3-250.)

#### *a. General*

- (1) Acids should be handled in bulk and conveyed from one point to another by means of pumps or gravity. Handling by pumps is preferred to a gravity system. With either method, the piping should be arranged so that the liquid will drain out of the piping when the supply pump is shut down, or when the discharge valves are closed.
- (2) Transfer by compressed air systems or blow cases is not considered as safe as other methods. When their use is unavoidable, it is important that the equipment be continually watched, inspected, and tested. Blow cases should be designed to conform to ASME "Code for Unfired Pressure Vessels." The vessel should be studied from a corrosion and erosion viewpoint so that additional metal can be added at vulnerable points. Unless the vessel is constructed to withstand main line pressure, a pressure reducing valve shall be installed on the air

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line between the main air line and the pressure vessel. A check valve should also be installed on the air line to prevent acid from being drawn into the air line after the pressure is relieved. In addition, a safety valve and a pressure gauge shall be installed between the reducing valve and the vessel. Because of the corrosive effect of the acid on the valve, safety discs may be used in place of safety valves. Blow cases should be located in pits which shall be kept dry. Blow cases shall be inspected internally and externally periodically by qualified personnel and shall be tested frequently for leaks. During actual blowing operations, all employees should retire from the immediate vicinity and the apparatus operated from a protected position. A signal light or horn shall be used to warn employees that the equipment is in operation.

- (3) Acid pump glands, flanged fittings and valve stems should be provided with splash shields or collars where personnel are exposed to acid leaks or sprays from equipment. Danger signs should be posted to indicate active leaks until repairs can be made. When mixed or nitrating acids are handled, packing for pumps, glands, etc., must be of a material that cannot become nitrated.

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b. *Tank cars.* When loading or unloading tank cars, warning signs **must** be placed on the railroad track at both ends of the car. All valves in the line from the tank car to the storage tank should be checked to make certain they are in the proper position for the flow. A rigid pipe with several joints should be used to connect the tank car to the permanent line. At the completion of the transfer, the pipe used to connect the car and the permanent line should be washed thoroughly.

c. *Carboy handling.* Carboy trucks, inclinators, or special bottle carriers should be used in the manual handling of small quantities of acids. Inclinators or safety siphon devices shall be used to empty carboys. Emptied carboys should be inverted, and thoroughly drained.

d. *Protective equipment.* All employees handling acids shall be provided with rubber gloves and boots, goggles, aprons, and hats. Employees should examine the equipment daily for defects before using. Acid workers should wear woolen outer clothing. Where acid "fumes" have a toxic, corrosive or asphyxiating action, suitable approved respirators must be used to protect workers. Safety shower heads (designed to deliver large quantities of water without subjecting personnel to excessive pressure from water spray) equipped with quick operating valves shall be readily available for removing acid spilled on employees. Woolen blankets should be provided at the job site.

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*e. Repairs to equipment.*

- (1) Before a pipeline, pump, or other equipment exposed to acid is dismantled for repairs, it should be completely drained and washed down with water. A careful check shall be made to see that all pressure is relieved and all necessary valves, switches, etc., are properly tagged or locked to prevent accidental application of pressure or the introduction of acid in the line. Particular attention should be paid to branch lines where pockets may exist. All pumping on the system connected with parts under repair should be stopped with starters tagged or locked unless blank flanges are installed in the lines to cut off the affected parts from the pump. In breaking a flange, the bottom bolts should be loosened first and the line allowed to sag slightly, permitting the liquid to run out by gravity. When repairs are completed, all spilled liquid should be carefully washed away with water. All chemical pipelines should be considered as containing liquid unless proved otherwise.
- (2) Two types of hazards exist in repairing used steel acid tanks. If all traces of weak acid and weak acid sludge are not removed, the weak acid reacts violently on the metal causing the generation of gases which may result in an explosion if welding is carried

out on the tank, or if men work inside the tank, serious poisoning from the gases might take place. The tank should be washed out and then filled with water and drained before repairs start. If all acid is not removed, it may be necessary to resort to soda ash solution and steam followed by filling with water, etc. If a man is carrying out repairs inside the tank, another man shall keep him under observation and at least one additional man shall be available for rescue work should the man in the tank be overcome. Men performing such duties shall be properly trained to perform tank rescue work. Additional trained personnel should be available. Personnel entering tanks shall be equipped with suitable respiratory protective equipment, life belts, or harnesses and life lines.

*f. Neutralizing spills.* Slaked (hydrated) lime shall be made available for neutralizing large quantities of acid in event of a spill. For cleaning acid from floors or equipment, a 10 to 20 percent sodium carbonate solution should be used. For washing floors a 10 percent solution of sodium bicarbonate is satisfactory. Neutralization gives off heat and must be used with great care when large quantities of acid are involved. All places made slippery by acid shall be adequately neutralized with soda or other alkaline

solution and washed with water to completely remove the acid contamination.

*g. First aid treatment.* Immediate first aid treatment for all acid burns consists of flushing the affected parts with copious quantities of clean water, followed by treatment with a 10 percent solution of bicarbonate of soda unless other solutions are prescribed for specific acids. First aid treatment should be administered by fully qualified, well-trained personnel. Pails of clean water, neutralizing solutions, or quick-acting safety showers for counteracting acid burns, should be in an accessible location.

*h. Mixing acid with water.* When diluting a significant quantity of acid with water, the acid shall be added to the water and never vice versa. Acid should be added slowly with agitation. Similar precautions should be taken when using a weak acid instead of water as a diluting agent. Thorough mixing should be given, particularly in a steel tank.

*i. Empty containers.* Carboys that have contained acids must be thoroughly drained before being offered for transportation. Small quantities of residual acid may remain in other containers being shipped as "empty" provided all openings are tightly closed.

#### 1304. HYDROCHLORIC ACID

In itself hydrochloric acid offers no fire or explosive hazard. It reacts violently with zinc,

iron, aluminum, and other common metals, generating heat and liberating hydrogen which may become a hazard. It is stored in carboys or bottles. It should not be stored with nitric acid or strong oxidizing chemicals.

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### **1305. HYDROFLUORIC ACID**

Hydrofluoric acid is very volatile. The liquid and its vapor are very corrosive to many substances, especially glass. It is shipped and stored in lead carboys, rubber drums or wax bottles. Special care must be taken to protect the containers from injury as leaks may develop quickly. The action of hydrofluoric acid on human flesh is exceedingly bad and the acid should be handled with extra precaution. It should also be isolated because when in contact with chemicals, such as metals, ammonia, etc., toxic fumes or compounds are formed.

### **1306. MIXED ACIDS**

Mixed acids refer to mixtures of sulphuric (see par. 1309) and nitric (see pars. 1308 and 1523) acids used in the nitration of various explosives constituents. Carboys of mixed acids sometimes rupture violently due to the pressure of liberated gases. Mixed acids can start fires and cause explosions by generated gases, and give off poisonous oxides of nitrogen. Mixed acid containing not less than 10 percent of nitric acid will not freeze at ordinary temperatures and will not actively attack steel storage tanks.

### **1307. WASTE ACIDS (SPENT ACIDS)**

Waste acids usually contain small amounts of nitrocompounds and thus present the hazard of explosive

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material. Spent acid from the manufacture of nitroglycerin is particularly hazardous.

**1308. NITRIC ACID**

(See par. 1523.)

Nitric acid forms explosive compounds with most organic materials. With nearly all oxidizable material, it forms flammable compounds some of which are subject to spontaneous ignition. The oxides of nitrogen, commonly called "nitrous fumes" evolved in a nitric acid fire are exceedingly toxic. (See table 1117.) Nitrous fumes vary in color from colorless to dark yellow and brown. Approved respirators must be used to protect against the toxic gases when ventilation is inadequate. Effective and thorough ventilation is required in buildings involving the use of nitric acid. Space between buildings should be sufficient to give room for fire-fighting forces and to prevent the accumulation of acid "fumes." The first symptoms of nitrous poisoning are usually followed by a latent period during which the affected person may feel very comfortable even though the poisoning action does not cease. For this reason, any person showing even mild symptoms of nitrous poisoning must be placed in a position of complete rest immediately and placed under a physician's care as soon as possible. Workers in nitric acid areas should wear suitable personal protective equipment such as shoes, gloves, gauntlets, woolen uniforms and aprons of impervious material.

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### **1309. SULFURIC ACID (OIL OF VITRIOL)**

Concentrated sulfuric acid chars wood, cotton and vegetable fibers, usually without causing fire. Fuming sulfuric acid (oleum) usually causes fires when in contact with these materials. The addition of water develops heat which may be sufficient to cause a fire or explosion. The addition of water to the concentrated acid or to oleum greatly increases its corrosive properties. This does not preclude the use of large quantities of water to dilute or dissipate relatively smaller quantities of acid. Sulfuric acid should not be stored with nitric acid, volatile or flammable liquids or with oxidizing agents such as peroxides. It may be stored in carboys, drums, tanks or glass bottles. Storage in large outdoor tanks is accepted. All the precautions listed above for sulfuric acid are applicable to oleum. Sand, earth or similar noncombustible absorbents may be used to absorb any spilled oleum or oleum which has leaked from storage containers, as an emergency measure. After the primary emergency has been effectively controlled the oleum soaked mass can be neutralized with solid carbonates (such as calcium carbonate).

### **1310. OXIDIZING AGENTS**

These chemicals which will decompose readily under certain conditions to yield oxygen belong to a class of chemicals called oxidizing agents. The conditions may be elevated temperatures or contact with other chemicals with which they readily react. Ex-

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amples of inorganic oxidizing agents are the chlorates, perchlorates, peroxides and nitrates of barium, sodium, potassium, strontium, ammonium, etc. Organic oxidizing agents are often violent explosives and special instructions for their storage and handling should be obtained from the Chief of Ordnance. The following discussion is, therefore, limited to the inorganic oxidizing agents. Oxidizing agents in the pure state present only a fire hazard but because of their ability to furnish oxygen, the hazard is greatly increased and violent explosions may occur when they are mixed or contaminated with even small quantities of certain carbonaceous and combustible materials such as wood, paper, metal powders, sulfur, etc. The violence of reaction depends upon subdivision, intimacy of mixtures, degree of contamination, degree of confinement and the type initiation afforded. Impregnation of combustible materials including leather shoes, clothing, etc., with dust or solutions of oxidizing agents is equally dangerous as an intimate mixture of finely divided oxidizers and fuels. The mixtures described are very sensitive to heat, friction and impact.

### **1311. HANDLING OXIDIZING AGENTS**

a. Oxidizing agents shall be stored and processed only in rooms or buildings of fire-resistive construction. They shall be separated from supplies of fuels, flammable materials, metal powders and acids until the process requires incorporation. Rooms

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used for processing oxidizing agents shall not be used for the processing of fuels or combustible materials including metal powders.

*b.* Equipment for the processing of oxidizing agents shall not be used for the processing of fuels, flammable substances, metal powders, etc. Processing equipment for oxidizers should be constructed of noncombustible materials only.

*c.* Solutions of oxidizing agents shall be placed only in nonabsorbent and noncombustible containers.

*d.* Damaged combustible containers shall not be repaired in the storage building because they may be impregnated with oxidizing agent and ignited during repairs. Discarded containers should be burned in the open and should not be sold for other uses. Combustible containers impregnated with oxidizing agents burn fiercely if ignited and may explode.

*e.* Employees handling oxidizing agents should wear "flameproof" clothing (see par. 224) as a minimum protection. The clothing should be stored in metal cabinets when contaminated. Clothing shall be laundered frequently to minimize the hazard.

*f.* Spills of small quantities of oxidizing agents during processing must be cleaned up immediately. Such spills shall not be salvaged. If large quantities are spilled, the uppermost layers may be salvaged if there has been no opportunity for it to have become contaminated.

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### 1312. CHLORATES

(See pars. 1310 and 1311.)

*a.* Chlorates mixed with sulfur, sulfides or other readily oxidizable material may result in spontaneous ignition. Sulfur presents a greater hazard than sulfides. The addition of phosphorus to a sulfur-chlorate mixture produces an even more dangerous composition. Shellac, potassium or sodium nitrate with petroleum derivatives, and powdered metals render chlorates sensitive; and mixtures of trinitrocresol or picric acid and chlorates should be avoided since they are particularly sensitive. Chlorates should never be mixed with ammonium salts since the ammonium chlorate which may be formed may explode spontaneously. Moisture to the extent of 0.5 percent or more in mixtures containing chlorates is regarded as a contributing element of danger due to the possible formation of chloric acid.

*b.* In any of the above described mixtures, the substitution of sodium chlorate for potassium chlorate increases the hazard.

*c.* Ammonium chlorate decomposes spontaneously and when mixed with perchlorates constitutes a major hazard.

*d.* Barium chlorate is very toxic in contact with the skin, when inhaled as a dust and when ingested. It is the consensus that barium chlorate is more dangerous than potassium chlorate for storage.

*e.* Zinc chlorate when in contact with certain organic materials will explode under the influence of

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slight friction, percussion or shock. It is a serious hazard to life when involved in a fire.

f. Containers for shipping and packing chlorates are described in paragraph 1311c.

g. Storage of chlorates should be arranged to preclude contact with other combustible organic or inorganic material. Broken or damaged containers should be removed and spilled material swept up promptly and destroyed.

A. Fires involving chlorates should be fought with solid streams of water or with water fog, depending upon circumstances. The use of solid streams enables fighting the fire from a greater distance but introduces the possibility of steam explosion against which precautions must be taken. Water fog offers the advantage of quicker cooling. Its normal smothering action, however, is obviated by the ability of chlorates to furnish oxygen to the fire.

### **1313. PERCHLORATES**

(See para. 1310 and 1311.)

Perchlorates form slightly less sensitive mixtures than do chlorates and should be substituted wherever possible. Advantages of using perchlorates include a lesser sensitivity to impact and friction, the non-formation of a free acid when moisture is present, and greater safety in the event of accidental contact with weak acids which form the principal part of many of the gums such as rosin used in binding pyrotechnic mixtures.

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a. Ammonium perchlorate alone is an explosive but is exploded with difficulty. It is stable at ordinary temperatures but decomposes at a maintained temperature of 302° F. (150° C.). It has the same degree of sensitivity to impact as picric acid. It becomes a high explosive when mixed with flammable materials and metal powders.

b. Containers for perchlorates and chlorates in storage include wooden boxes, kegs, barrels and sometimes iron drums. All damaged and broken containers should be removed from the storehouse and spilled material swept up promptly and destroyed.

c. Fires involving perchlorates alone may be fought with water.

#### 1314. PEROXIDES

(See pars. 1310 and 1311.)

a. *General.* Solid peroxides decompose easily in the presence of moisture to liberate oxygen and should, therefore, be stored in a cool dry place. They present a dangerous fire hazard, particularly when incorporated with combustible materials. Sodium peroxide should be protected from contact with water inasmuch as it then becomes explosive. Hydrogen peroxide of approximately 30 percent strength is unstable, liberates oxygen and exhibits much the same characteristics as the solid peroxides.

b. *High strength hydrogen peroxide* (see par. 1518).

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- (1) High strength hydrogen peroxide (90 percent or greater) is shipped in specially designed containers which are vented. It should be stored only in containers which are vented to the atmosphere and the vent constructed so that foreign material will not enter the containers. It must be stored in a cool, shaded location devoted exclusively to the purpose. Containers of hydrogen peroxide must never be permitted to exceed 15° or 20° above ambient temperatures. Larger increases in temperature may indicate a decomposition of the hydrogen peroxide. Operators shall be instructed to report any undue heating of hydrogen peroxide drums to the person in charge, and the area shall be evacuated immediately. A water spray system for cooling should be installed in hydrogen peroxide storage locations. The spray system must be turned on immediately upon observation of any undue heating of the storage drums. If hydrogen peroxide is to be stored for long periods, high purity aluminum containers should be used.
- (2) Cleanliness and good housekeeping are of prime importance in handling this material. All tanks, tubes and fittings must be thoroughly cleaned. The recommended cleaning procedure is: place parts in a pickling solu-

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tion of 0.5 percent sodium hydroxide for one hour at room temperature, then wash with clean water, dry and place in 35 percent solution of CP sulfuric acid for one hour at room temperature. Wash, dry, and place in 25 to 30 percent solution of hydrogen peroxide for at least 24 hours, then drain off the solution. The part is then ready for use. The 25 to 30 percent peroxide solution is discarded.

- (3) Hydrogen peroxide when in contact with the skin causes a burn and discoloration. Running water should be available in the storage area and any part of the skin that has contacted hydrogen peroxide should be washed immediately with water. A 3 percent boric acid solution should be available for irrigation of the eye in case of accidental splashing. Spillages of hydrogen peroxide must immediately be washed away with water. All persons handling this material must wear face shields, rubber gloves and rubber trousers worn on the outside of rubber boots.
- (4) Only the following materials should be used in equipment contacting high strength hydrogen peroxide: "Pyrex" glass, high purity aluminum, pure tin, "Keroseal" or equal. Stainless steel types 304, 309, 310, 316, 321, and 347, are suitable for periods of two months or less.

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*c. Fires.* Fires involving peroxides, except sodium peroxide, may be fought with water. Sodium peroxide fires should be smothered with sand, ashes, dirt, or rock dust.

### 1315. NITRATES

*a. General.* Many nitrates are not flammable in themselves. They are usually stored in wooden boxes, kegs, or barrels. Ammonium nitrate, however, is normally shipped in special waterproofed bags or metal containers. Barium nitrate is sometimes stored in iron drums. Regardless of the type of container it should be moistureproof and nitrates should be stored in a dry place since they cake in the presence of moisture.

*b. Ammonium nitrate.*

- (1) Ammonium nitrate in confinement sometimes detonates with the violence of a high explosive but a relatively heavy initiator is ordinarily required. Under the effect of heating alone, ammonium nitrate will decompose. Contamination with chlorides, sulfur, nitrocompounds, charcoal, metallic nitrates, metal powders, petroleum derivatives and oxidizable carbonaceous materials sensitizes ammonium nitrate, accelerates its decomposition, and increases the violence of the reaction. Zinc or lead contamination lowers the decomposition temperature to 200° F. (93.3° C.). Galvanized

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metals and lead solder must not, therefore, be used in the vicinity of ammonium nitrate operations. The burning of ammonium nitrate and combustible material, as for example wood or paper containers, has been said to produce a mixture of gases which under proper conditions of pressure may detonate with sufficient force to initiate the detonation of ammonium nitrate. Fires involving ammonium nitrate must be vented to the greatest practicable extent because air acts as a diluent for the hazardous gases, minimizing the probability of explosion.

- (2) In high pan (evaporating) operations, deluge systems must be provided over the pans for use in case of fire. Temperatures used to heat the liquor shall not exceed 317° F. (Saturated steam at 100 psi.) High pan operations must be located at class 9 distances from adjacent structures other than the graining building (see sec. 17). The graining building, however, must be protected from the high pans by an approved barricade. The class 9 distances specified above may be based on the maximum quantity of ammonium nitrate contained in any one high pan.
- (3) Fires involving nitrate should be fought with large quantities of water but never with steam. Solid hose streams enable the

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fire to be fought from a greater distance but introduce the hazard of steam explosion particularly if the nitrate is molten; therefore, the hose streams should be directed from behind a protective barrier. Under some circumstances where the fire is in the incipient stage and accessible, water fog may be used to advantage but it will have no smothering action since the burning material provides its own oxygen.

(4) **Storage of ammonium nitrate in explosives storage magazines is preferred.** When stored in an area where there is a possibility that explosives may be projected into the nitrates, the regulations for class 9 explosives are applicable. When stored in an area with fire hazards only and separated by inhabited building distances from areas containing ammunition, ammonium nitrate may be stored in accordance with the regulations governing the storage of class 2 solid propellant.

(a) Buildings, other than earth-covered magazines, used for the storage of ammonium nitrate should be of a type easily vented in the event of fire in order that the gases produced during combustion, and considered potential sources of explosion to the commodity, are dissipated. The floors of such buildings should be of a type to prevent hazardous impregnation by the nitrate.

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- (b) Stacking within storage buildings other than earth-covered magazines should anticipate stacks not larger than 12 by 12 feet plan dimension and not higher than 7 feet. Aisles not less than 3 feet wide should be maintained around each stack and between the sides of the building. The use of wood dunnage should be reduced to reduce the quantity of combustible materials present.
- (c) Broken packages or containers shall be removed from the building and the spilled material swept up promptly and destroyed.

#### **1316. POWDERED METALS: ALUMINUM, MAGNESIUM, AND ALUMINUM-MAGNESIUM ALLOYS**

*a.* Since a rise in the temperature of metal powders can result from contact with water and ignition may ensue, all practicable precautions should be taken to prevent water from contacting the material. All buildings where powdered metals are stored or processed must be adequately vented at the highest point of the room or building to prevent the accumulation of evolved hydrogen gas which results from the reaction between powdered metals and moisture, except when stored in water-tight containers.

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b. Exposed material which may be at a low temperature should be brought to or near the room temperature under conditions of low relative humidity before being placed in the operating room.

c. Heating facilities (to be approved by the Chief of Ordnance for safety prior to installation) should be installed in service magazines, where required to bring the closed containers and contents to a temperature approximating that of operating buildings.

d. Efforts shall be made to maintain relative humidity between 50 and 55 percent in locations where metal powders are exposed, so as to avoid the hazard of static electricity and, yet, at the same time, to prevent condensation.

e. Operators should be cautioned to wear sweat bands on their foreheads and take other precautions to avoid perspiration falling upon powdered metals.

f. Care should be exercised regarding the location of pipes to prevent droplets of water from forming by condensation upon cold pipes and falling upon hazardous material. The possibility of leaking water pipes causing ignition should not be overlooked.

g. Powdered metals in metal containers with tight covers may be stored in general warehouses provided that they are remote from oxidizing agents. The storage place should be dry.

h. When compounded with oxidizing agents, powdered metals present a dangerous fire and explosion hazard.

*i.* Very fine suspended dust from powdered metals is an explosive hazard comparable to that of explosive gases and may be easily initiated by discharges of static electricity.

*j.* Powdered metals exposed to air are dangerous fire hazards and burn with intense heat. When in drums, in all probability the fire will confine itself to the place of origin if not disturbed, since experience indicates that it will be effectively blanketed by the metallic oxide formed by the burning.

*k.* The amount of powdered metal which may become involved in a fire should be limited. Fires must not be fought with ordinary streams of water because of the danger of liberating large quantities of hydrogen gas which may be a severe explosion hazard. Fires involving small quantities of powdered metals may be successfully combatted with a fog nozzle or specially designed commercial extinguishing powders applied gently so as not to spread the fire. **If large quantities of powdered metals become involved in a fire and escape from their storage containers, firefighting efforts should be primarily directed to prevention of fire spread to other facilities.** In certain locations where friction sensitivity is not of concern, smothering fires with sand may be effective.

*l.* Proper personal protective equipment shall be provided for personnel handling powdered metals.

*m.* Competent personnel only should be permitted to repair or maintain buildings or equipment where

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metallic powders are involved, and then only with the following precautions: powder or dust should be removed, nonsparking tools should be used, hammer impacts that may cause sparks should be avoided, flashlights should be of approved type,

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equipment should be grounded, undue friction should be prevented, and open flames should not be utilized. See NFPA National Fire Codes, volume II and NBFU Pamphlet No. 63.

### 1317. CHARCOAL

a. Charcoal is subject to spontaneous ignition in the presence of moisture although pit charcoal is less likely to react than the chemical by-product charcoal, and soft wood charcoal is less so than hardwood charcoal. The following conditions promote the spontaneous ignition of charcoal: forced cooling after burning; drying after absorbing moisture; contact with alcohols and oils, and particularly charcoal in which a fire has been extinguished. Pulverized charcoal is a definite fire hazard. The gases from burning charcoal contain carbon monoxide and are toxic (table 1117).

b. Permanent or reserve storage of large quantities of charcoal is not recommended. Bulk storage of charcoal is prohibited. It should be stored in airtight containers or in bags piled in tiers with skeleton or gridwork floors between tiers to provide ventilation. It should be isolated and remote from oxidizing agents.

### 1318. SULFUR

a. Sulfur compounded with chlorates and several other oxidizing agents form highly sensitive explosive mixtures. Sulfur presents a spontaneous ignition hazard when mixed with carbon, lamp black, fats and oils. Burning sulfur produces toxic vapors.

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b. Sulfur may be stored in wooden boxes, kegs, or barrels. Large quantities may be stored in bulk. It should be isolated and remote from oxidizing agents with which it forms highly sensitive explosive mixtures.

### 1319. DEGREASING

In degreasing operations chlorinated hydrocarbons may be used if care is taken to prevent water and moisture from getting into the degreasing agent and to assure that the magnesium, aluminum, or other metal pieces being processed are dry before entering the tank. Water hydrolyzes chlorinated hydrocarbons to form hydrochloric acid. A reaction takes place in the bottom of the degreasing tank, heat is generated, and a serious fire and explosion hazard is created.

### 1320. INDUSTRIAL GASES

a. Compressed gas cylinders shall be stored and handled as required by **AR 700-8120-1** and changes thereto, and **other current applicable directives**. When cylinders of flammable gases or oxygen are stored in the open, a separate storage area shall be provided at a minimum distance of 100 feet from important buildings and open combustible storage areas. Storage areas for oxygen cylinders should be separated by not less than 30 feet from areas used for storing flammable gases. **Cylinders should be stored in groups as small in area and height as is practicable, with aisles between groups wide enough to minimize the spread of fire.** Cylinders shall be

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arranged to permit inspection at periodic intervals. Defective or leaking containers shall be removed immediately from the storage area or area of use. Covers of noncombustible (par. 245) or fire-retardant (par. 221) materials should be used to protect cylinders from the direct rays of the sun and accumulations of ice and snow. Tarpaulins used as covers must be flameproofed (par. 224). Ventilation must be provided under outside storage covers to carry off gas leakage. An airspace of at least 18 inches shall be provided between the cover and the cylinders to keep the temperature of cylinders below 125° F. Empty cylinders shall be stored with valves closed and caps in place. Anhydrous ammonia cylinders should be stored on their sides and in a cool place. When cylinders are not in use, the cylinder valve as well as the regular valve should be closed.

b. Oxygen (par. 1521) may create a dangerous fire hazard if it escapes or leaks into combustible materials. Compressed oxygen in the presence of oils is almost certain to cause fire.

c. Hydrogen (par. 1520), acetylene, natural, and similar gases form explosive mixtures with air. Where hydrogen and acetylene are used together, special equipment complying with pertinent industrial standards must be provided. Buildings where cylinders of hydrogen and acetylene are stored should be isolated and used solely for that purpose when practicable.

d. Anhydrous ammonia is generally encountered on Ordnance establishments as a liquefied gas under

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pressure in cylinders. The hazards and precautions to be taken in the storage and handling of anhydrous ammonia are covered in paragraph 1512.

e. If a patient is unconscious from prolonged exposure to ammonia gas, he should be removed to pure air and given artificial respiration. Skin burns should be flushed with water and medical treatment should be obtained promptly.

f. Nonsparking tools shall be used in the vicinity of cylinders of flammable compressed gas. Containers of compressed gases shall be handled carefully to avoid striking them against any solid object; common rope slings and electromagnets are not suitable metals for safe handling.

g. Smoking should be prohibited within 50 feet of compressed gas cylinder storage and "No smoking" signs conspicuously posted.

h. (Added) Compressed gas cylinders shall be marked in accordance with MIL-STD-101A, Color Code for Compressed Gas Cylinders and Pipelines.

### **1321. FLAMMABLE SOLIDS**

Guanidine nitrate, dinitrophenol, DNT, and dinitrobenzene are sometimes considered low explosives. These materials are stored in wooden boxes or bar-

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rels lined with moisture-proof paper. They are preferably stored in magazines but in any event should be stored in a fire-resistant location. When strongly initiated they may act as explosives. Dinitrobenzene is toxic. Dinitrophenol may explode at elevated temperatures. It is extremely toxic and respiratory equipment may be required as well as gloves and special clothing.

### 1322. VOLATILE FLAMMABLE LIQUIDS

(See pars. 226, 278 and 1516.)

a. Common examples of volatile flammable liquids are ether, acetone, gasoline, ethyl alcohol, methyl alcohol (wood alcohol), benzene, toluene, xylene and amyl acetate. These liquids are quite volatile and at room temperature, if unconfined, may evolve vapor in concentrations in air within the explosive range for the vapor concerned. Volatile flammable liquids must not be used to wash or clean equipment or parts of buildings except where specifically authorized as process requirements.

b. Some flammable liquids such as linseed oil, paints, varnishes and enamels may, under certain conditions, be subject to spontaneous ignition and must be kept where any heat produced will readily dissipate. They shall also be kept away from any outside source of heat. Only noncombustible sweeping compounds should be used for cleaning up materials of this type.

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### **1323. TOXIC NONEXPLOSIVE MATERIALS**

Dimethylaniline, mononitronaphthalene, nitrobenzene, phenol, potassium cyanide, potassium ferrocyanide and sodium azide are toxic but are not considered to be particular fire hazards. Potassium cyanide is lethal if taken internally in very small amounts. It must be kept separate from acids. Phenol (carbolic acid) is toxic. It should not be stored in large quantities unless extra quality chemical lead-lined drums are used. All the above-mentioned chemicals are listed as poisonous substances, class B, for the purposes of ICC regulations. Hexamethylenetetramine (Hexa or hexamines) produce a severe dermatitis.

### **1324. INERT RAW MATERIALS**

Antimony sulfide, carbamide (urea), dibutylphthalate, diphenylamine, ethyl centralite, glycerin, hexachlorethane, hexachlorbenzene, methyl centralite, pentaerythritol and phthalic anhydride are substantially inert in their behavior and present no particular fire or toxic hazard as used in Ordnance establishments.

### **1325. CALCIUM CARBIDE**

Small quantities of calcium carbide may be stored in general warehouses in airtight tin cans or iron drums. A separate building of noncombustible construction, or detached weatherproof shed should

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be used solely for the purpose of storing large quantities of this material. The storage place should be dry and well ventilated and special precautions should be taken against moisture. Calcium carbide in itself is a slight fire hazard, but reacts violently with water to liberate large quantities of acetylene gas which forms explosive mixtures with air.

### 1326. CARBON TETRACHLORIDE

a. Carbon tetrachloride may be stored in general warehouses in airtight drums. It is very toxic and its use should be avoided whenever possible by substituting chemicals of lesser toxicity. Where carbon tetrachloride is used, adequate ventilation must be provided to reduce vapor concentrations to a safe limit for workers. Since this vapor is heavier than air, exhaust intakes should be located at or near the floor. Carbon tetrachloride is not combustible but gives off toxic vapor.

b. The use of "vaporizing liquid extinguishers" (those with liquids consisting mainly of carbon tetrachloride) on fires in small confined spaces may introduce a toxic hazard. The NFPA standards on First Aid Fire Appliances include the following statement: "In using extinguishers of this type, especially in unventilated spaces, such as small rooms, closets or confined spaces, operators and others should take precautions to avoid the effects which may be caused by breathing the vapor or gases liberated or produced."

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### **1327. SODIUM HYDROXIDE (CAUSTIC SODA) AND POTASSIUM HYDROXIDE**

These materials may be stored in general warehouses in airtight iron drums. Permanent storage of large stocks is not recommended. These chemical products may become a fire hazard when mixed with nitro compounds or other material. They are also very corrosive and caustic in their action. When mixed with water, large quantities of heat are evolved.

### **1328. METALLIC SODIUM**

Metallic sodium may be stored in airtight steel drums. It combines violently with water, liberating hydrogen gas and evolving heat, and produces a very serious fire and explosion hazard under such circumstances.

### **1329. NITROCELLULOSE AND DERIVATIVES**

*a. General.* Nitrocellulose includes various types of nitrated cotton or wood pulp depending on the nitrogen content. Nitrocellulose when dry is extremely sensitive to shock and friction and readily accumulates static charges. It is highly flammable and explosive, burning rapidly producing very little smoke and leaving no residue. Impure, it is subject to spontaneous ignition. Storage of dry nitrocellulose is not permitted as it possesses all the hazards of a sensitive and easily ignited high explosive. Nitrocellulose containing 25 to 30 percent moisture

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be used solely for the purpose of storing large quantities of this material. The storage place should be dry and well ventilated and special precautions should be taken against moisture. Calcium carbide in itself is a slight fire hazard, but reacts violently with water to liberate large quantities of acetylene gas which forms explosive mixtures with air.

### 1326. CARBON TETRACHLORIDE

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*b.* The use of "vaporizing liquid extinguishers" (those with liquids consisting mainly of carbon tetrachloride) on fires in small confined spaces may introduce a toxic hazard. The NFPA standards on First Aid Fire Appliances include the following statement: "In using extinguishers of this type, especially in unventilated spaces, such as small rooms, closets or confined spaces, operators and others should take precautions to avoid the effects which may be caused by breathing the vapor or gases liberated or produced."

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is stored in zinc lined boxes or metal drums and is substantially nonexplosive when stored in an area where explosives or ammunition cannot be projected into it. See section 17 for quantity-distance regulations for nitrocellulose.

b. *Nitrocellulose film.* See AR 850-65 for hazards, storage and handling regulations for nitrocellulose films.

### 1330. WHITE PHOSPHORUS

White phosphorus is preferably stored under water in small quantities in sealed metal vessels inclosed in wood boxes or metal drums. It need not be kept above freezing temperatures to avoid bursting of containers if sufficient void space exists above the water. White phosphorus melts at 111° F. (44° C.). Containers or ammunition containing white phosphorus should not be allowed to reach that temperature as sufficient pressure may be generated to rupture the container. Upon exposure to air, white phosphorus will burst into flame and, therefore, is a dangerous fire hazard.

### 1331. RED PHOSPHORUS

Red phosphorus forms very sensitive mixtures with oxidizing agents and is a dangerous fire hazard. It may be stored in general warehouses in metal drums or metal containers inclosed in wood boxes.

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## SECTION 14

### EXPLOSIVES AND AMMUNITION

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#### 1401. PROPERTIES OF INITIATING EXPLOSIVES

Initiating explosives include lead azide, mercury fulminate and lead styphnate. They are very sensitive to friction, heat, and impact. When involved in a fire, they can be expected to detonate without burning. Quantities in storage and in process must be limited to the smallest practicable amounts. Initiating explosives are stored wet with water or with water-alcohol mixtures. Every effort shall be made to prevent the liquid from freezing, and if frozen, explosives material itself shall not be handled. Dust from initiating explosives shall be prevented from entering dry type exhaust systems since dust deposits have caused explosions. Small wet aspirator exhaust equipment may be used. Emphasis must be placed upon cleanliness and general housekeeping since contamination of these explosives with foreign or gritty material increases markedly their sensitivity. Rooms in which initiating explosives are handled shall be equipped with soft flooring material complying with the requirements of paragraph 508 and, unless the static electricity hazard is otherwise eliminated, with conductive flooring (par. 706). Walls of the rooms should be covered with waterproof material having a smooth hard gloss finish.

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Frequent washing of the rooms with a neutralizing solution is necessary. Drying of the explosives is usually accomplished in muslin squares on a drying table or by a special air blowing device with temperatures limited to between 122° and 140° F. (50° and 60° C.).

#### **1402. CARRYING BULK INITIATING EXPLOSIVES**

Bulk initiating explosives shall be carried between service storage and "tubbing" house in leather or rubber pouches placed under water in rubber pails. Transportation from storage to service magazines is generally accomplished in the wet condition utilizing rubber containers.

#### **1403. LEAD AZIDE**

Lead azide is a crystalline, cream-colored compound which is practically insoluble in water. Care must be taken, however, to assure that the water used is free of bacteria-forming impurities which may react with the dextrinated lead azide to form gas. Rooms in which lead azide is handled shall be washed thoroughly and regularly with a desensitizing solution. (See par. 802d.) Lead azide shall not be exposed to copper, zinc or alloys containing such metals because of the possible formation of other azides which are more sensitive than the original lead azide.

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#### 1404. LEAD STYPHNATE

This explosive is particularly sensitive to discharge of static electricity, and the dry material can be readily ignited by discharges from the human body. Lead styphnate is approximately as sensitive as mercury fulminate to impact and has about the same order of friction sensitivity as lead azide. It should be stored under water in conductive rubber containers. Where practicable, lead styphnate should be in the water wet state while being processed. Water should be removed by decanting. Conventional methods of dewatering explosives, such as suction filtering, placing material in cloth then squeezing and draining on inclined smooth surfaces such as glass are not recommended. To remove styphnate from receptacles, a stream of water should be used to wash the material from the inclined container. Where removal with a stream is impractical, it may be carefully removed by hand when using rubber gloves. The use of spatulas, rakes or scoops should be prohibited. Containers equipped with removable rubber liners facilitates handling of the wet explosives and are recommended. Lead styphnate tends to form a sensitive scaly deposit on the sides of containers and collection sumps. The scale can be removed with 5 to 10 percent sodium hydroxide or sodium acetate solutions. The removal of the scale with tools or other instruments shall not be attempted. Operations should be safeguarded with

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operational shields and face shields shall be provided for eye protection. Conductive flooring and table tops, without cracks or crevices in which explosives can lodge, are required. Conductive footwear is also required. All equipment shall be electrically grounded.

#### **1405. MERCURY FULMINATE**

The precautions given for lead styphnate and lead azide shall be used as guides for the handling of this explosive. Mercury fulminate either wet or dry shall not be permitted to come into contact with certain materials such as aluminum, magnesium, zinc, brass, or bronze.

#### **1406. BOOSTERING EXPLOSIVES**

Explosives of this type include tetryl, PETN and RDX (cyclonite). These explosives have intermediate sensitivity between initiating explosives and explosives used as bursting charges such as TNT. They may be ignited by heat, friction or impact and may detonate when burned in large quantities.

#### **1407. PETN**

PETN is more sensitive than either tetryl or RDX, and is considered an initiating agent by the ICC. In its pure form PETN is a white crystalline material, but it may be a light grey color due to impurities. It must be shipped wet with not less than 40

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percent by weight of water in metal barrels, drums, wooden barrels or kegs in which the material is packed in cloth or rubber bags. It is extremely sensitive to initiation.

#### **1408. RDX**

RDX is a white crystalline solid. It is usually used in mixtures with other explosives, oils or waxes and is rarely used alone. It has a high degree of stability in storage.

#### **1409. TETRYL**

Tetryl is a fine crystalline yellow material, insoluble in water, but soluble in acetone, benzene and other similar solvents. It is toxic when taken internally or by skin contact and special precautions are necessary to protect personnel. Tetryl is stable at all temperatures encountered in storage.

#### **1410. BURSTING CHARGE EXPLOSIVES**

Bursting charge explosives include Explosive D (ammonium picrate), amatol, picric acid, TNT, tetryl, pentolite, picratol, tritonal, RDX compositions, torpex, DBX and HBX. Most bursting charge explosives involve a toxic hazard, discussion of which is given in section 11. Alkaline cleaning agents or other alkaline products shall not be permitted in buildings where bulk high explosives are handled.

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#### **1411. AMATOL**

Amatol is a hygroscopic mixture of TNT and ammonium nitrate in various percentages. It is mixed at the time of loading and there should be no occasion for storing. In general, the sensitivity is slightly less than TNT. Drenching or deluge systems controlled automatically by instantaneous devices are desirable to protect melting units and other process machinery. It is believed to form sensitive compounds with copper and brass.

#### **1412. EXPLOSIVE D (AMMONIUM PICRATE)**

Explosive D (ammonium picrate) is stored in the same manner as TNT, but is less hazardous. Lead in any form shall not be permitted in buildings where this explosive is handled. Sprinkler and deluge systems are recommended in connection with drying and assembling process but lead fusible links and solder type heads shall not be used in the systems. Sprinkler and deluge systems will be of service in preventing the spread of fires rather than extinguishing fires of the burning material. Fire involving large quantities of this material may result in an explosion. Cleanliness in all processes involving the handling of this material should be assured. Special precautions must be taken against its toxicity. Ammonium picrate is soluble in water.

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**1413. DBX**

DBX is an aluminized explosive which closely resembles torpex in sensitivity, strength, and brisance.

**1414. HBX**

HBX is an aluminized explosive having the same order of sensitivity as composition B. Like certain torpex explosives, HBX may produce pressure within a casing due to gassing.

**1415. PENTOLITE**

Pentolite is a mixture of PETN and TNT. Pentolite may have a tendency to separate into its ingredients, consequently, pentolite should be handled as carefully as PETN. Pentolite lumps found in screening operations should not be broken with the aid of hand tools or by rubbing through the screen. Melt units for pentolite should be steamed out at least once every 24 hours. Acetone should not be used for thread cleaning.

**1416. PICRATOL**

Picratol is a mixture of TNT and Explosive D (ammonium picrate). It has the same general properties as TNT. All the precautions made necessary by the characteristics of TNT and ammonium picrate must be observed in the handling of picratol.

**1417. PICRIC ACID**

Picric acid which is used in the manufacture of ammonium picrate is a nitrated product of phenol.

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It may be stored either wet or dry in magazines. It is highly acidic and corrosive as well as a toxic hazard. The hazards of manufacture include those of handling its various raw material components. Drowning, deluge, and automatic sprinkler systems are successfully used in combating fires in the manufacture and handling of this material. Fires involving picric acid may be extinguished with automatic sprinkler systems. Large quantities have burned completely without explosions; however, the possibility of detonations should not be overlooked. In the nitration processes, ample ventilation must be provided. Lead compounds with picric acid are very dangerous and lead in any form shall not be permitted in buildings where picric acid is handled. Picric acid is lemon yellow in color, slightly soluble in water and soluble in organic solvents. It stains the skin and hair of workers, and colors clothing and whatever else it contacts. It is stable and has no tendency to decompose at temperatures normally encountered in storage.

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#### 1418. RDX COMPOSITIONS

a. RDX Compositions are mixtures of RDX, other explosive ingredients, and desensitizers or plasticizers.

b. The RDX Compositions most frequently encountered are:

- (1) Composition A.
- (2) Composition B (see par. 2615).
- (3) Composition B-2.
- (4) Composition C.
- (5) Composition C-2.
- (6) Composition C-3.

c. Composition C-3 is a mixture of RDX, other ingredients and a plasticizer.

#### 1419. TETRYTOL

Tetrytol is a mixture of tetryl and TNT, intermediate to tetryl and TNT in sensitivity. Care must be taken in the manufacture and subsequent use of tetrytol to insure a uniform mixture and to avoid a partial segregation of tetryl which would increase its sensitivity over that normally expected. Tetrytol is stable in storage but exudes at 65° C. (149° F.). Magnesium-aluminum alloys are slightly corroded by dry tetrytol. Wet tetrytol will corrode slightly copper, brass, aluminum, magnesium, magnesium-aluminum alloy, mild steel, and mild steel plated with cadmium.

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#### 1420. TNT

TNT is a light brown or straw color material whose appearance varies with the degree of purity. It is insoluble in water but soluble in ether, acetone, alcohol, and the like. Although TNT is less sensitive to friction and impact than many other high explosives, it can be detonated by moderate force when confined between metal surfaces such as on threads of bolts, etc. In thin unconfined layers it usually burns without explosion. Burning or rapid heating under confinement may cause detonation. TNT is stable and does not form sensitive compounds with metals. It will, however, form sensitive materials in the presence of alkalis. TNT exhibits well-recognized toxic properties.

#### 1421. TORPEX

Torpex is an aluminized explosive used mainly in under-water ordnance. Torpex is nonhygroscopic and noncorrosive. It is stable in storage although it may gas and produce pressure in its casing as a result of the gas. Precautions must be taken in the manufacture and loading of torpex to avoid inclusion of moisture. Torpex may be washed or steamed out of items of ammunition under certain circumstances. details of which should be obtained from the Chief of Ordnance.

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## 1422. TRITONAL

Tritonal is a mixture of TNT and aluminum powder and exhibits a greater blast effect than TNT or Composition B. It is more sensitive to impact than TNT. Because of the aluminum content, the inclusion of moisture into the mixture must be avoided. Special precautions to be taken in the loading of tritonal are given in section 26.

## 1423. PROPELLANTS AND OTHER EXPLOSIVES

*a. Black powder.* Black powder is an intimate mechanical mixture of potassium or sodium nitrate, charcoal and sulfur. It is very sensitive to friction, heat, and impact. These properties make black powder one of the most dangerous explosives to handle. It will deteriorate rapidly on absorption of moisture but retains its explosives properties indefinitely if kept dry. Black powder may be desensitized by placing it in water and discarding the water separately from the residue, for wet black powder when permitted to dry out may resume its explosive properties. Combustible materials which have absorbed liquors leached from black powder constitute a severe fire hazard and may become explosive. In black powder manufacture and operations, every precaution in the way of permanent magnetic-type separation of iron particles, dust prevention or control, and other safety precautions must be observed. Deluge systems are of value in preventing the spread of fire in black powder operations. Lumber or com-

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bustible material from black powder buildings must not be released for reuse.

*b. Nitroglycerin.* Nitroglycerin is usually manufactured only as required in the manufacture of other products of which it is a constituent. It is stored only in buildings constructed for the specific purpose where it must be kept under constant surveillance until used. Nitroglycerin is extremely sensitive to impact and friction and the manufacturing processes are hazardous. All machinery, equipment, and tools used are specifically designed for the particular process and with full consideration of safety features. Buildings in which nitroglycerin vapor is present may become dangerously contaminated and frequent cleaning of the building and equipment with a neutralizing solution (sec. 3) is required. The vapor is also toxic. Nitroglycerin spillage or exudation shall be taken up immediately by the methods described in section 3. Frozen nitroglycerin is hazardous to handle and upon thawing may produce internal changes accompanied by sufficient evolution of heat to cause an explosion.

*c. Solid propellants (smokeless powder).* Solid propellants (smokeless powder) are a severe fire hazard. They burn rapidly and under suitable conditions of initiation may detonate. Double base propellant powders containing nitroglycerin and small web thickness single-base propellant powder may detonate under special conditions of burning. Upon being initiated in the manner of a high ex-

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plosive, detonation will propagate readily from box to box and the propellant powder may be expected to behave as any other high explosive. Propellant powder dust and E. C. powder are sensitive to friction, flame, and sparks. The stability of propellant powder is adversely affected if stored for long periods in a damp atmosphere and/or subjected to high temperatures; the eventual effect of such conditions may be the spontaneous ignition of the propellant powder.

#### 1424. MILITARY PYROTECHNICS

*a. General.* Standard military pyrotechnic compositions in general consist of such compounds as perchlorates and nitrates to provide oxygen; powdered metals for fuel; salts of sodium, barium, or strontium for color; and binding and water-proofing materials. They are sensitive to heat, flame, static electricity discharges and particularly to friction. Compositions containing chlorates are especially hazardous as regards fires and explosions. Since pyrotechnic compositions contain powdered metals, they may become hazardous in the presence of moisture. Compositions in process and pyrotechnics in storage must be protected from moisture, and items showing evidence of moisture should be destroyed.

*b. HC smoke mixtures.* HC smoke mixture is sensitive to heat, flame, friction, and static electrical discharges from the human body. Moisture reacts with HC mixture to produce heat, and in some cases

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hydrogen gas, hence the use of small quantities of water on a fire in HC smoke mixture is dangerous. Large quantities of water will effectively reduce the severity of fires. Fire fighters must avoid breathing heavy concentrations of HC smoke. HC smoke pots must not be used inside buildings to simulate fire during fire-drill demonstrations.

*c. Thermit (thermite).* Thermit is a fire hazard. Fires are extremely difficult to extinguish when thermit is ignited. Control frequently lies in holding fires in check until the thermit has burned itself out.

#### **1425. Rockets (short range)**

*a. Characteristics.* Because of the nature of the rocket complete round, explosive charge and propelling charge assembled in a single heavy housing, the item presents special safety problems different from those encountered with other types of ammunition items. Some rockets are shipped disassembled—heads, propellant charges (motors) separately boxed—and when in this category they present hazards very little different from separate loaded shell and shell propelling charges respectively. Because of the great potential ranges of complete rocket ammunition as compared with fixed ammunition, and the subsequent area of danger exposed in the event of accident, it is essential that even greater efforts be taken to prevent ignition than with other types of ammunition. Greater damage can be expected from the explosion of high-explosive, antitank rockets

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(HEAT), than from ordinary high-explosive filled rocket heads because of the brisance and penetrating power of the type of high-explosive charge.

*b. Safety precautions.*

- (1) Complete rounds should at all times be kept pointed in the direction which would cause least damage in event of accidental ignition of the propelling charge.
- (2) The transporting or handling equipment required for rockets or rocket components is not greatly different from that required for the safe handling of fixed ammunition, separate loaded shell, or propelling charge of similar size and weight.
- (3) In assembly and loading operations, quantities of explosive materials shall be kept to the minimum required for safe and efficient operation. Loading and assembly procedures shall be established to assure that exposure of rockets to accidental initiation and concentration of personnel engaged in processing rocket ammunition will be at the minimum. Inasmuch as rocket propelling charges can be ignited easily by electrical means, care must be maintained at all times during loading, assembly and packing operations to prevent rockets from being initiated by stray electrical currents from electric cords, lights or electric tools. After rockets or motors have been packed accord-

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ing to specifications, the chance of accidentally igniting a propelling charge by electrical means, is not different than with other packaged ammunition. The hazard of fire caused by faulty electrical circuits in the assembly or loading plant is always present. The use of electrically energized soldering irons is prohibited for soldering squib lead wires, unless such soldering is done before the propelling charge is in place and then only if personnel are adequately protected against the results of ignition. Soldering irons may be heated by an electrical heating element which is separate from the iron, provided the element is properly grounded. When soldering of squib lead wires is required with propellant in position, this should be done before the explosive head is assembled to the motor; such an operation shall be done in a location physically separated from other operations by distances or walls of sufficient size and stability to prevent an accidentally ignited rocket motor from jeopardizing the adjacent operations.

c. The following requirements will apply at Ordnance installations where requirements call for the application of electrical energy to the ignition system of a rocket or JATO unit for circuit continuity testing during manufacture, renovation, or maintenance and prior to shipment:

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- (1) The device selected for testing purposes will not be used unless approved by Office, Chief of Ordnance.
- (2) Testing will be conducted in an area where determination has been made that there is no possibility of induced currents from other sources of electricity initiating the unit under test. (See par. 2716b.)
- (3) To provide maximum protection to personnel and property in the event of an incident during testing operations, the unit tested shall be placed behind substantial structures (capable of withstanding the full thrust of the rocket motor), held rigidly in such a manner that flight will be prevented in the event of an accidental motor function; preferably in a vertical position, nose down. In addition, a proper vent must be provided to dissipate hot gases from the test bay to open atmosphere should the propellant explosives contained in the motor become ignited.
- (4) Test connection arrangements will be conducted in such manner that no individual is exposed to the unit at the time of the test. Mirrors or other remote control features should be utilized to perform testing operations.

#### 1426. CLASS 1 AMMUNITION

Small arms ammunition is not an explosive hazard although under adverse conditions of storage it may

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become a fire hazard. With reasonable care in storage and under proper surveillance procedures, small arms ammunition may be stored in any approved magazine or warehouse, the only restriction being that it shall not be stored within 450 feet of locations where bulk quantities of flammable liquids including gasoline are handled or stored aboveground. Adverse storage conditions include dampness, lack of ventilation and extreme heat. Where such conditions exist, free circulation of air shall be provided between boxes. Small arms ammunition shall be handled and packed with care to prevent inadvertent striking of a primer by the nose of another round or by any other solid object. In no case shall loose rounds of small arms ammunition be thrown or shoveled into containers. If a fire occurs in small arms ammunition the greatest hazard is from flying bullets and cases. However, they are relatively light and most missiles will fall within a 450-foot radius. Substantial portable shields may prove of value to enable fire fighters to approach the fire.

#### **1427. CLASS 3 FUZES AND ARTILLERY PRIMERS**

Class 3 fuzes (without boosters) and artillery primers shall be handled and packed so that they will not strike against each other. In the event of the detonation of one fuze or component under standard packing and storage conditions, boxes will usually explode progressively, not more than a box or two at a time. Missiles are light and most will fall within a 300-foot radius.

15 August 1952

## 1428. CLASS 4 AMMUNITION

Fires are not likely to occur in class 4 ammunition unless deterioration has proceeded to a state that spontaneous ignition takes place or burning embers or shell are projected into the magazine from an adjacent fire. Tests have shown that a fire involving this ammunition, packed and stored in accordance with Ordnance Corps drawings, will result in progressive detonation or explosion of a few rounds or boxes at a time with many low order detonations of individual rounds.

## 1429. SEPARATE LOADING AMMUNITION

a. Separate loading ammunition includes items of classes 5 and 7.

b. If involved in a fire, explosive D loaded items (class 5) may detonate as soon as the fire becomes intense enough that the heated explosive becomes ignited. If the fire is not severe or if only one item is accidentally initiated the items except for those designated as "high capacity ammunition" (ammunition having a high explosive weight ratio) usually explode one at a time and in practically all cases with low order. "High capacity" explosive D loaded items will detonate en masse if one in a stack is initiated. High capacity items (15 percent or greater charge to total weight ratio) must be stacked as prescribed for class 7 ammunition, or stored in accordance with the requirements for class 10 ammunition.

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c. If involved in a fire, the entire stack of class 7 ammunition may detonate high order. If one item in a stack is detonated, the detonation en masse of the entire stack may also be expected. Structural damage may be severe and the missile hazard may extend to 1,800 feet or more. An initial explosion of class 7 items can be confined to one stack if ample distances are maintained between adjacent stacks. If a detonation occurs in one stack of class 7 items, adjacent stacks can be expected to be disarranged and scattered. Should a second detonation then occur, propagation through the disarranged stacks could be expected. The distance between stacks necessary to prevent transmission of detonation is greater for items fitted with die-cast white metal fuze-hole plugs. The lateral distance at which detonations are transmitted is several times greater than the nose-to-nose or base-to-base distance.

#### 1430. CLASS 6 ITEMS

Class 6 items usually explode progressively by stacks when the piles are segregated in accordance with Ordnance drawings. Missiles are light and are usually thrown within 600 feet.

#### 1431. CLASS 8 ITEMS

Percussion primer elements, detonators, and other ammunition items of this class are expected to detonate en masse if involved in a fire. Principal dam-

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age is usually due to blast or shock effect as the missiles are light and limited in range.

#### **1432. CLASS 10 ITEMS**

a. If involved in a fire, class 10 ammunition may be expected to detonate high order and all the ammunition in one magazine may detonate en masse simultaneously.

b. Photoflash bombs which have become damaged in handling or storage and those which have failed to function when dropped should be destroyed as described for artillery shell. The safety precautions attached to the outside of each case must be observed.

#### **1433. NUCLEAR WEAPONS (Special Weapons)**

(Added)

Pending publication of an Ordnance Manual devoted to safety requirements for nuclear weapons, organizations handling such items should utilize publications in the TM 39 series for specific information. Problems of safety which cannot be resolved by the use of these technical manuals should be referred to the Office, Chief of Ordnance.

**SECTION 15****QUANTITY-DISTANCE STORAGE  
CRITERIA FOR LIQUID PROPELLANTS****1501. APPLICATION**

a. These criteria establish quantity-distances, storage compatibility groupings, and high explosives equivalencies for liquid propellants. They apply to all types of liquid propellant storage facilities (including missiles, rockets, and multi-compartment tanks in which both liquid fuels and liquid oxidizers are stored).

b. Hazard classifications and storage compatibility groupings for liquid propellants that are not listed will be obtained from the Safety Division, Administrative Office, Headquarters, AMC.

**1502. DEFINITIONS**

a. *Compatible propellants.* Propellants that may be mixed together without increasing the hazard. See compatibility groupings, table 1501.

b. *Compatible storage.* The storing together of compatible propellants. See compatibility groupings, table 1501.

c. *Hypergolic.* The term used to describe the self-ignition of certain fuels and oxidizers upon contact with each other.

d. *Launch pads.* The load-bearing base, apron, or platform upon which the rocket, missile, or

space vehicle and its launcher rest during launching.

*e. Nitrogen padding (or blanket).* Filling the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical therein, and to avoid formation of a flammable atmosphere above the liquid. Nitrogen padding (or blanket) also means maintaining a nitrogen atmosphere in or around an operation, piece of equipment, etc.

*f. Liquid propellants.* Those liquid and gaseous substances (as listed in table 1501) used for propulsion or operation of missiles, rockets, or related devices.

*g. Protected.* As used in this section, "protected" means that terrain or an effective artificial barrier is interposed to prevent fragments from a propellant facility from endangering inhabited buildings and other exposures.

*h. High explosive equivalent or explosive equivalent.* The amount of high explosive which if detonated will produce damage comparable to that which is expected upon the detonation or explosion of a given amount of the propellant concerned under similar conditions. It is usually expressed as a percentage of the propellant weight, and for the purposes of this section TNT is used as the comparison standard. For specific

explosive equivalents of propellant combinations, use table 1505.

### **1503. DETERMINATION OF PROPELLANT QUANTITY**

a. For quantity-distance purposes, the net weight of propellant in a tank, drum, cylinder, or other container will be used. If individual storage containers, or groups of storage containers, are not separated from each other by a minimum of magazine distance, the quantities of propellant therein must be added together for quantity-distance purposes. The quantity of propellant in associated piping (to the point(s) where positive means is provided for interrupting the flow through the pipe in event of an incident) must be included in the net weight of propellant in a storage container.

b. Where fuels are not separated from oxidizers by distances prescribed in tables 1502, 1503, and 1504, or provisions for preventing their mixing are not available, the combined quantity of the two must be used with appropriate H.E. equivalency (table 1505) to determine the quantity-distances (table 1506).

c. Table 1507 lists conversion factors (gallons to pounds) for the various liquid propellants.

#### **1504. MEASUREMENT OF SEPARATION DISTANCES**

a. Separation distances will be measured from the nearest hazard source (containers, buildings, or positive cutoff point in piping, whichever is controlling).

b. If a building contains a small number of drums or cylinders, or if quantities of propellant in the building are effectively subdivided, distances may be measured from the nearest container or controlling subdivision.

#### **1505. QUANTITY-DISTANCE CONSIDERATIONS**

a. Quantity-distance criteria in this section are based on the premise that materials of construction will be compatible with propellants to which they may be exposed; design will take into account the properties of the propellant; required fire protection and drainage controls will be provided; and other special controls (e.g., nitrogen padding, tank cooling, etc.) will be provided when required.

b. If groups I, II, and III propellants are contaminated, tables 1502, 1503, and 1504 are not applicable. In such cases, group IV quantity-distance requirements will apply except where use of other criteria is specifically approved by the Safety Division, Administrative Office, Headquarters, AMC.

c. The Handling and Storage of Liquid Propellants, January 1963, published by Office of the Director of Defense Research and Engineering, Washington, D.C. (available from Superintendent of Documents, Government Printing Office, Washington, D.C., 20402), contains information of the various characteristics of liquid propellants. Standing operating procedures for the storing and handling of specific liquid propellants will take into account these characteristics.

#### **1506. HAZARD GROUPINGS**

Liquid propellants constitute various types and degrees of hazards. Based on these hazards, the following propellant groupings are established.

a. *Group I.* Materials in this group are considered to be the least hazardous. They have a fire hazard potential and require separation distance as specified in table 1502. When group I materials are stored with more hazardous materials, under conditions described in paragraph 1507, tables 1505 and 1506 will be used to determine quantity-distance requirements.

b. *Group II.* Materials in this group are strong oxidizers. Serious fires may result when they come in contact with materials such as organic matter (which is difficult to exclude). Table 1503 specifies quantity limitations and minimum distance requirements for this group. When group II materials are stored with more hazardous ma-

terials, under conditions described in paragraph 1507, tables 1505 and 1506 will be used to determine quantity-distance requirements.

*c. Group III.* Hazards with this group are primarily from pressure rupture of the storage container, deflagration, and vapor-phase explosions. Hazardous fragmentation of the container, its protective structure, or other nearby material may be produced by pressure rupture of the storage container or a vapor-phase explosion. Table 1504 specifies quantity limitations and minimum distance requirements for this group. When group III materials are stored with more hazardous materials, under conditions described in paragraph 1507, tables 1505 and 1506 will be used to determine quantity-distance requirements.

*d. Group IV.* The hazards from materials in this group are the same as for mass-detonating explosives (e.g., airblast overpressures and fragments from the containers and surrounding equipment and material). Table 1506 will be used to determine quantity-distance requirements.

### **1507. HAZARDS**

Aside from the fact that the propellants differ from each other, as explained for the above groups, the predominant hazard of the individual propellant can vary depending upon the location of the propellant storage and the operation(s) in-

volved. In order of decreasing hazard, these conditions are—

*a. Range launch pads.* Activities at range launch pads include research, development, testing, The close proximity of fuel to oxidizer, the frequency of launchings, and the possibility of fall-back (with resultant dynamic mixing on impact) make operations at these facilities very hazardous. Explosives equivalents (table 1505) must be used to determine quantity-distances (table 1506).

*b. Operational launch pads.* Except for being less frequent, activities at operational launch pads are similar to those at range launch pads. Operations at these launch pads are defense or combat-type operations and can well be one-time events. Except as provided in paragraph 1508, explosives equivalents (table 1505) must be used to determine quantity-distances (table 1506). When an operational launch pad is used for training launches, it will be considered a range launch pad.

*c. Static test stands.* Although these can involve experimental operations, the units remain static and are subject to better control than dynamic ones. Except where run tankage for fuel and oxidizer are mounted one above the other, it is possible to separate the tankage to reduce the hazard over that for a rocket or missile on a launch pad. Except as provided in paragraph

1508, explosives equivalents (table 1505) must be used to determine quantity-distance (table 1506).

*d. Ready storage.* Ready storage may be located a minimum of intraline distance from launch and static test stands, based on the propellant requiring the greater distance. Normally, propellant from ready storage is not fed directly into an engine, as is the case with run tankage. (See h below.) H.E. equivalents (table 1505) must be used for propellants, in ready storage if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand or launch pad. If prevention of detonation of ready storage is assured, quantity-distances will be based on the prevailing fire or fragment hazards (tables 1502, 1503, or 1504).

*e. Cold-flow test operations.* Fire and fragment hazards (tables 1502, 1503, and 1504) govern if the design is such that the system is closed (except for approved venting); is completely airtight; fuel and oxidizer are never employed concurrently and each has a completely separate isolated system, and fittings are of such types that intermixing is impossible; and the propellants are of required purity. Otherwise, H.E. equivalents (table 1505) must be used to determine quantity-distances (table 1506).

Table 1501. Liquid Propellants Hazard and Compatibility Groupings

Propellant	Hazard group <sup>1</sup>	Compatibility storage group <sup>2</sup>
The Alcohols CH <sub>3</sub> OH, C <sub>2</sub> H <sub>5</sub> OH, (CH <sub>3</sub> ) <sub>2</sub> CHOH.	I	C
Anhydrous Ammonia NH <sub>3</sub> -----	I	C
Aniline C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub> -----	I	C
Hydrocarbon Fuels JP-4, JP-5, RP-1.	I	C
Nitrogen Tetroxide N <sub>2</sub> O <sub>4</sub> -----	I	A
Otto Fuel II -----	I	G
Red Fuming Nitric Acid HNO <sub>3</sub> -	I	A
Bromine Pentafluoride BrF <sub>5</sub> ----	II	A
Chlorine Trifluoride ClF <sub>3</sub> -----	II	A
Hydrogen Peroxide Greater Than 52% H <sub>2</sub> O <sub>2</sub> .	II <sup>3</sup>	A
Liquid Fluorine LF <sub>2</sub> -----	II	A
Liquid Oxygen LO <sub>2</sub> -----	II	A
Perchloryl Fluoride ClO <sub>3</sub> F -----	II	A
Oxygen Difluoride OF <sub>2</sub> -----	II	A
Ozone Difluoride O <sub>3</sub> F <sub>2</sub> -----	II	A
Ethylene Oxide C <sub>2</sub> H <sub>4</sub> O -----	III	D
Hydrazine N <sub>2</sub> H <sub>4</sub> -----	III	C
Hydrazine-UDMH Mixtures -----	III	C
Liquid Hydrogen LH <sub>2</sub> -----	III	C
Mixed Amine Fuels -----	III	C

<sup>1</sup> For some of the materials listed, the toxic hazard may be an overriding consideration. Consult applicable regulations, and, if necessary, other authorities or publications for determination of toxic siting criteria.

<sup>2</sup> All propellants in a compatibility group are considered compatible. Groupings are not to be confused with ammunition and explosives compatibility groupings with like letters.

<sup>3</sup> Under certain conditions, this propellant can detonate. However, its sensitivity to detonation is no greater than that of a standard energetic double base solid propellant under the same conditions.

Table 1501. Liquid Propellants Hazard and Compatibility Groupings—(Continued)

Propellant	Hazard group <sup>1</sup>	Compatibility storage group <sup>2</sup>
Monomethylhydrazine CH <sub>3</sub> NHNH <sub>2</sub>	III	C
Pentaborane B <sub>5</sub> H <sub>9</sub> -----	III	D
UDMH (CH <sub>3</sub> ) NNH <sub>2</sub> -----	III	C
Nitromethane CH <sub>3</sub> NO <sub>2</sub> -----	IV	F <sup>4</sup>
Tetranitromethane C(NO <sub>2</sub> ) <sub>4</sub> ----	IV	F

<sup>4</sup>Nitromethane is chemically compatible with compatibility storage group C propellants, but due to difference in hazards should be stored separately.

*f. Bulk storage.* This is the most remote storage with respect to launch and test operations, never being directly connected to any of them. It consists of the area, tanks, and other containers therein, used to hold propellant for supplying ready storage and, indirectly, run tankage where no ready storage is available. Individual bulk storage facilities must be separated from each other and from unrelated exposures in accordance with tables 1502, 1503, 1504, and 1506. If positive measures are not taken to prevent mixing of groups I, II, or III fuels and oxidizers, TNT equivalents (table 1505) must be used to determine quantity-distances (table 1506).

*g. Rest storage.* This is a temporary type storage and most closely resembles bulk storage. Barges, trailers, tank cars, and portable hold-tanks (used for topping operations) may be used

as rest storage facilities. Fire and fragment hazards (tables 1502, 1503, and 1504) govern. The transporter becomes a part of that storage to which it is connected during propellant transfer.

*h. Run tankage (operating tankage).* Run tankage (operating tankage) consists of the tank and/or other containers and associated piping used to hold the propellants for direct feeding into the engine or device during operation. (See c above.)

*i. Pipelines.* Pipelines used for the transfer of propellants between unloading points and storage areas or between storage area and points of use. A distance of 25 feet free of inhabited buildings will be maintained on either side of pipelines used for the transfer of group II and III propellants.

### **1508. INCOMPATIBLE STORAGE**

Except where they are effectively subdivided by intervening barriers or where other positive means for preventing mixing is provided, separation distance between propellants of different compatibility groups will be the inhabited building distance for the propellant quantity and group which requires the greater distance. Where prevention of mixing is assured, incompatible storages will be separated from each other by intra-group distance. If different hazard classes are involved, the class requiring the greater distance will be controlling.

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### **1509. COMPATIBLE STORAGE**

Compatible storages of propellants of different hazard groups will be separated by the greater intragroup storage distance.

Table 1502. Hazard Group I

Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group I storage— Distance in feet	Intraclass, intraline, and compatible group I storage—** Distance in feet	Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group I storage— Distance in feet	Intraclass, intraline, and compatible group I storage—* Distance in feet
Over	Not over			Over	Not over		
Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 5	Column 4
	100*	30	25	5,000	6,000	80	60
100	200*	35	30	6,000	7,000	85	65
200	300*	40	35	7,000	8,000	85	65
300	400*	45	35	8,000	9,000	90	70
400	500*	50	40	9,000	10,000	90	70
500	600	50	40	10,000	15,000	95	75
600	700	55	40	15,000	20,000	100	80
700	800	55	45	20,000	25,000	105	80
800	900	60	45	25,000	30,000	110	85
900	1,000	60	45	30,000	35,000	110	85
1,000	2,000	65	50	35,000	40,000	115	85
2,000	3,000	70	55	40,000	45,000	120	90
3,000	4,000	75	55	45,000	50,000	120	90
4,000	5,000	80	60	50,000	60,000	125	95

Table 1502. Hazard Group I--Continued

Pounds of propellant		Intracolumn, Intrainline, and compatible group I storage--** Distance in feet	Inhabited buildings, railroads, highways, and incompatible group I storage-- Distance in feet	Pounds of propellant		Intracolumn, Intrainline, and compatible group I storage--** Distance in feet	Inhabited buildings, railroads, highways, and incompatible group I storage-- Distance in feet
Over	Not over			Over	Not over		
Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 3	Column 4
60,000	70,000	130	95	500,000	600,000	185	140
70,000	80,000	130	100	600,000	700,000	190	145
80,000	90,000	135	100	700,000	800,000	195	150
90,000	100,000	135	105	800,000	900,000	200	150
100,000	125,000	140	110	900,000	1,000,000	205	155
125,000	150,000	145	110	1,000,000	2,000,000	235	175
150,000	175,000	150	115	2,000,000	3,000,000	255	190
175,000	200,000	155	115	3,000,000	4,000,000	265	200
200,000	250,000	160	120	4,000,000	5,000,000	275	210
250,000	300,000	165	125	5,000,000	6,000,000	285	215
300,000	350,000	170	130	6,000,000	7,000,000	295	220
350,000	400,000	175	130	7,000,000	8,000,000	300	225
400,000	450,000	180	135	8,000,000	9,000,000	305	230

450,000	500,000	180	135	9,000,000	10,000,000	310	235
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\* A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc., may be handled or stored without regard to distances prescribed, subject to specific approval by Safety Division, Administrative Office, Headquarters, AMC.

\*\* See paragraphs 1508 and 1509.

Table 1503. Hazard Group II

Pounds of propellant	Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group II storage— Distance in feet	Intracolumn, intraline, and compatible group II storage—** Distance in feet	Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group II storage— Distance in feet	Intracolumn, intraline, and compatible group II storage— Distance in feet
	Over	Not over			Over	Not over		
Column 1	Column 2	Column 3	Column 4	Column 4	Column 1	Column 2	Column 3	Column 4
100	100*	60	30	800	900	115	60	
200	200*	75	35	900	1,000	120	60	
300	300*	85	40	1,000	2,000	130	65	
400	400*	90	45	2,000	3,000	145	70	
500	500*	100	50	3,000	4,000	150	75	
600	600	100	50	4,000	5,000	160	80	
700	700	105	55	5,000	6,000	165	80	
800	800	110	55	6,000	7,000	170	85	

Table 1503. Group II—Continued

Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group II storage— Distance in feet	Intragroup, intraline, and compatible group II storage—* Distance in feet	Pounds of propellant		Inhabited buildings, railroads, highways, and incompatible group II storage— Distance in feet	Intragroup, intraline, and compatible group II storage— Distance in feet
Over	Not over			Over	Not over		
Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 3	Column 4
7,000	8,000	175	85	200,000	250,000	320	160
8,000	9,000	175	90	250,000	300,000	330	165
9,000	10,000	180	90	300,000	350,000	340	170
10,000	15,000	195	95	350,000	400,000	350	175
15,000	20,000	205	100	400,000	450,000	355	180
20,000	25,000	215	105	450,000	500,000	360	180
25,000	30,000	220	110	500,000	600,000	375	185
30,000	35,000	225	110	600,000	700,000	385	190
35,000	40,000	230	115	700,000	800,000	395	195
40,000	45,000	235	120	800,000	900,000	405	200
45,000	50,000	240	120	900,000	1,000,000	410	205
50,000	60,000	250	125	1,000,000	2,000,000	470	235
60,000	70,000	255	130	2,000,000	3,000,000	505	255
70,000	80,000	260	130	3,000,000	4,000,000	535	265

80,000	90,000	265	135	4,000,000	5,000,000	555	275
90,000	100,000	270	135	5,000,000	6,000,000	570	285
100,000	125,000	285	140	6,000,000	7,000,000	585	295
125,000	150,000	295	145	7,000,000	8,000,000	600	300
150,000	175,000	305	150	8,000,000	9,000,000	610	305
175,000	200,000	310	155	9,000,000	10,000,000	620	310

\* A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc., may be handled or stored without regard to distances prescribed, subject to specific approval by Safety Division, Administrative Office, Headquarters, AMC.

\*\* See paragraphs 1508 and 1509.

Table 1504. Hazard Group III

Pounds of propellant	Inhabited buildings, railroads, highways and incompatible group III storage		Distance in feet		Intragroup, intraline and compatible group III storage** Distance in feet
	Over	Not over	Distance in feet		
			Unprotected	Protected	
Column 1	Column 2	Column 3	Column 4	Column 5	
100	100*	600	80	30	
200	200*	600	100	35	
300	300*	600	110	40	
300	400*	600	120	45	
400	500*	600	130	50	

Table 1504. Group III—Continued

Pounds of propellant		Inhabited buildings, railroads, highways and incompatible group III storage Distance in feet		Protected Column 4	Intragroup, intraline and compatible group III storage ** Distance in feet Column 5
Over Column 1	Not over Column 2	Unprotected Column 3	Protected Column 4		
500	600	600	135	50	
600	700	600	140	55	
700	800	600	145	55	
800	900	600	150	60	
900	1,000	600	150	60	
1,000	2,000	600	175	65	
2,000	3,000	600	190	70	
3,000	4,000	600	209	75	
4,000	5,000	600	210	80	
5,000	6,000	600	220	80	
6,000	7,000	600	225	85	
7,000	8,000	600	230	85	
8,000	9,000	600	235	90	
9,000	10,000	600	240	90	
10,000	15,000	1,200	260	95	
15,000	20,000	1,200	275	100	
20,000	25,000	1,200	285	105	

25,000	30,000	1,200	295	110
30,000	35,000	1,200	300	110
35,000	40,000	1,200	310	115
40,000	45,000	1,200	315	120
45,000	50,000	1,200	320	120
50,000	60,000	1,200	330	125
60,000	70,000	1,200	340	130
70,000	80,000	1,200	350	130
80,000	90,000	1,200	360	135
90,000	100,000	1,200	365	135
100,000	125,000	1,800	380	140
125,000	150,000	1,800	395	145
150,000	175,000	1,800	405	150
175,000	200,000	1,800	415	155
200,000	250,000	1,800	425	160
250,000	300,000	1,800	440	165
300,000	350,000	1,800	455	170
350,000	400,000	1,800	465	175
400,000	450,000	1,800	475	180
450,000	500,000	1,800	485	180
500,000	600,000	1,800	500	185
600,000	700,000	1,800	515	190
700,000	800,000	1,800	530	195
800,000	900,000	1,800	540	200

Table 1504. Group III—Continued

Pounds of propellant		Inhabited buildings, railroads, highways and incompatible group III storage		Protected Distance in feet	Intraclass, intraline and compatible group III storage** Distance in feet
Over	Not over	Unprotected	Protected		
Column 1	Column 2	Column 3	Column 4	Column 5	Column 5
900,000	1,000,000	1,800	550	205	
1,000,000	2,000,000	1,800	630	235	
2,000,000	3,000,000	1,800	675	255	
3,000,000	4,000,000	1,800	710	265	
4,000,000	5,000,000	1,800	740	275	
5,000,000	6,000,000	1,800	760	285	
6,000,000	7,000,000	1,800	780	295	
7,000,000	8,000,000	1,800	800	300	
8,000,000	9,000,000	1,800	815	305	
9,000,000	10,000,000	1,800	830	310	

\* A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc., may be handled or stored without regard to distances prescribed, subject to specific approval by Safety Division, Administrative Office, Headquarters, AMC.

\*\* See paragraphs 1508 and 1509.

Table 1505. Liquid Propellant Explosive Equivalents

Propellant combination	Other than range launch pads	Range launch pads
LO <sub>2</sub> --LH <sub>2</sub> LO <sub>2</sub> --LH <sub>2</sub> + LO <sub>2</sub> --RP-1	60% (60% for LO <sub>2</sub> --LH, (10% for LO <sub>2</sub> --RP-1	60% (60% for LO <sub>2</sub> --LH <sub>2</sub> (20% for LO <sub>2</sub> -- RP-1
LO <sub>2</sub> --RP-1 or LO <sub>2</sub> --NH <sub>3</sub>	10%	20% up to 500,000 pounds plus 10% over 500,000 pounds.
IRFNA--Aniline*	10%	10%
IRFNA--UDMH*	10%	10%
IRFNA--UDMH + JP-4*	10%	10%
N <sub>2</sub> O <sub>4</sub> --UDMH + N <sub>2</sub> H <sub>4</sub> *	5%	10%
N <sub>2</sub> O <sub>4</sub> --UDMH + N <sub>2</sub> H <sub>4</sub> --Solid*	5% plus the explosive equiva- lent of the solid propellant.	10% plus the explosive equivalent of the solid propellant.
Tetranitromethane (alone or in combination).	100%	100%
Nitromethane (alone or in combination).	100%	100%

\* These are hypergolic combinations.

*Table 1506. Spacing Distances for Separation of Propellant Static-Testing, Launching and Storage Sites From Other Facilities*

Weight of explosives or group IV propellant in pounds	Distance in feet from propellant explosive hazard						
	To inhabited buildings		To public highways and passenger railroads		Intraline		
	Column 2 Barricaded	Column 3 Unbarricaded	Column 4 Barricaded	Column 5 Unbarricaded	Column 6 Barricaded	Column 7 Unbarricaded	
Not over							
100	190	380	115	230	40	80	
200	235	470	140	280	50	100	
300	270	540	160	320	60	120	
400	295	590	175	350	65	130	
500	320	640	190	380	70	140	
600	340	680	205	410	75	150	
700	355	710	215	430	80	160	
800	375	750	225	450	85	170	
900	390	780	235	470	90	180	
1,000	400	800	240	480	95	190	
1,500	460	920	275	550	105	210	
2,000	505	1,010	305	610	115	230	
3,000	580	1,160	350	700	130	260	
4,000	635	1,270	380	760	140	280	
5,000	685	1,370	410	820	150	300	

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6,000	730	1,460	440	880	160	320
7,000	770	1,540	460	920	170	340
8,000	800	1,600	480	960	180	360
9,000	835	1,670	500	1,000	190	380
10,000	855	1,730	520	1,040	200	400
15,000	990	1,780	595	1,070	225	450
20,000	1,090	1,950	655	1,170	245	490
25,000	1,170	2,110	700	1,265	265	530
30,000	1,245	2,200	745	1,355	280	560
35,000	1,310	2,410	785	1,445	295	590
40,000	1,370	2,550	820	1,530	310	620
45,000	1,425	2,680	835	1,610	320	640
50,000	1,470	2,800	880	1,680	330	660
55,000	1,520	2,920	910	1,750	340	680
60,000	1,570	3,030	940	1,820	350	700
65,000	1,610	3,130	965	1,880	360	720
70,000	1,650	3,220	990	1,930	370	740
75,000	1,690	3,310	1,015	1,985	385	770
80,000	1,725	3,390	1,035	2,035	390	780
85,000	1,760	3,460	1,055	2,075	395	790
90,000	1,790	3,520	1,075	2,110	400	800
95,000	1,825	3,580	1,095	2,150	410	820
100,000	1,855	3,630	1,115	2,180	415	830

Table 1506. Spacing Distances for Separation of Propellant Static-Testing, Launching and Storage Sites From Other Facilities—(Continued)

Weight of explosive, or group IV propellant in pounds	Distance in feet from propellant explosive hazard						
	To inhabited buildings		To public highways and passenger railroads		Intrudance		Column 7 Unbarricaded
	Column 2 Barricaded	Column 3 Unbarricaded	Column 4 Barricaded	Column 5 Unbarricaded	Column 6 Barricaded	Column 6 Unbarricaded	
Column 1 Not over							
125,000	2,115	3,670	1,270	2,200	450	900	
150,000	2,350	3,800	1,410	2,280	475	950	
175,000	2,565	3,930	1,540	2,360	500	1,000	
200,000	2,770	4,060	1,660	2,435	525	1,050	
225,000	2,965	4,190	1,780	2,515	550	1,100	
250,000	3,150	4,310	1,890	2,585	575	1,150	
275,000	4,430	4,430	2,660	2,660	585	1,170	
300,000	4,550	4,550	2,730	2,730	600	1,200	
325,000	4,670	4,670	2,800	2,800	620	1,240	
350,000	4,780	4,780	2,870	2,870	635	1,270	
375,000	4,890	4,890	2,935	2,935	650	1,300	
400,000	5,000	5,000	3,000	3,000	665	1,330	
500,000	5,410	5,410	3,245	3,245	715	1,430	
600,000	5,900	5,900	3,540	3,540	780	1,560	
700,000	6,220	6,220	3,730	3,730	825	1,650	

800,000	6,500	6,500	3,900	3,900	800	1,720
900,000	6,760	6,760	4,055	4,055	895	1,790
1,000,000	7,000	7,000	4,200	4,200	925	1,850
1,500,000	8,010	8,010	4,805	4,805	1,060	2,120
2,000,000	8,820	8,820	5,290	5,290	1,170	2,340
2,500,000	9,500	9,500	5,700	5,700	1,260	2,520
3,000,000	10,090	10,090	6,055	6,055	1,340	2,680
3,500,000	10,630	10,630	6,380	6,380	1,405	2,810
4,000,000	11,110	11,110	6,665	6,665	1,470	2,940
5,000,000	11,970	11,970	7,180	7,180	1,585	3,170

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Notes—table 1506.

Where solid propellants or other explosives are present, TNT equivalents for liquid propellants must be increased by corresponding amounts in order to determine required Distance in feet from propellant explosive hazard when the following substitutions are made for combinations listed in table 1505:

- (a) Alcohols, or other hydrocarbons for RP-1.
- (b)  $H_2O_2$ , F,  $BrF_3$ ,  $ClF_3$ , or  $O_3F_2$  for  $LO_2$ .
- (c) Monomethylhydrazine for hydrazine or UDMH.
- (d) Ethylene oxide for any propellant.
- (e) Ammonia for any fuel, and a hypergolic combination results.
- (f) Pentaborane plus a fuel for  $LO_2$ -RP1.
- (g) Pentaborane plus an oxidizer for  $LO_2$ -LH<sub>2</sub>.

Table 1507. Factors To Be Used When Converting Gallons of Propellant Into Pounds\*

Item	Pounds/gallon	At temperature °F
Anhydrous Ammonia	5.1	68
Aniline	8.5	68
Bromine Pentafluoride	20.7	68
Chlorine Trifluoride	15.3	68
Ethyl Alcohol	6.6	68
Ethylene Oxide	7.3	68
Fluorine	12.6	-306
Furfuryl Alcohol	10.7	68
Hydrogen Peroxide (90%)	11.6	68
Hydrazine	8.4	68
Isopropyl Alcohol	6.6	68
Liquid Hydrogen	0.59	-423
Liquid Oxygen	9.5	-297
Methyl Alcohol	6.6	68
Mono Methyl Hydrazine	7.3	68
Nitramethane	9.5	68
Nitrogen Tetroxide	12.1	68
Oxygen Difluoride	12.7	-229
Ozone Difluoride	14.6	-297
Pentaborane	5.2	68
Perchloryl Fluoride	12.0	68

Red Fuming Nitric Acid (III A)	12.5	68
RP-1	6.8	68
Tetranitromethane	13.6	78
UDMH	6.6	68
UDMH/Hydrazine	7.5	68

\* Conversion of quantities of propellant from gallons to pounds:  
Pounds of propellant = Gallons X density of propellant in pounds per gallon

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## SECTION 16

### SAFETY REQUIREMENTS IN SPECIFIC HAZARDOUS AREAS

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#### 1601. PERSONNEL AND MATERIALS LIMITS

a. The cardinal principle to be observed in any location or operation involving explosives, ammunition, severe fire hazards or toxic materials is to limit the exposure of a minimum number of personnel, for a minimum time, to a minimum amount of the hazardous material consistent with safe and efficient operations. All operations shall be scrutinized to devise methods for reducing the number of people exposed the time of exposure or the quantity of material subject to a single incident. Determination of personnel limits requires that, first, jobs not necessary to a particular hazardous operation not be accomplished there; second, unnecessary personnel are not permitted to visit the location; and third, too many consecutive operations not be permitted in the same room or building without adequate dividing walls, fire walls or operational shields, depending upon the nature of the hazard. Personnel limits must allow for necessary supervision and transients. Key employees should be appointed as monitors to assist in enforcing the established limits.

b. Determination of limits for hazardous materials requires a careful analysis of all facts including

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operation timing, transportation methods, size of the items, and the chemical and physical characteristics of the material. More strict limits are required for the more sensitive or hazardous materials. Limits should be established for each operation rather than on an overall basis so that each worker may be charged with the responsibility of not exceeding the established limit. Limits need not be expressed in units of weight or in the number of items as such. They may be given in terms of trays, boxes, racks, or any other unit which may be more easily observed and controlled. Explosive limits should not be established on the basis of the maximum quantity of explosives allowable as defined by the existing quantity-distance separation to nearby exposures when lesser quantities of explosives will suffice for the operations.

c. All rooms, cubicles, and buildings containing hazardous materials shall have posted in a conspicuous place a placard stating the maximum amount of the material and the maximum number of workers and transients permitted in the room at any one time. In addition, other placards shall be posted to set forth important local regulations as needed. Personnel and materials limits and the placards must be kept current. The supervisor, foreman or worker-in-charge shall prevent accumulations of excess materials or excess personnel. Any accumulated excess materials, when found, should be removed immediately. Likewise, proper steps should be taken to have excess personnel, when found, leave the prem-

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ises. The personnel and quantity limits for buildings or process divisions shall be recorded on a plant layout and maintained on file.

#### **1602. STORAGE IN OPERATING BUILDINGS**

Hazardous materials, including explosive materials, shall not be stored within an operating building except for the minimum quantities necessary to maintain individual operations. Normally, supplies exceeding approximately a 4-hour work requirement shall be kept in a **service** storage building. In the case of explosive materials, the service storage building (service magazines) shall be located at appropriate intraline distance from the operating building, based on the quantity of explosives in the service storage building.

#### **1603. SMOKING**

**a. Measures shall be taken to prohibit indiscriminate smoking at Ordnance installations.**

**b. Smoking within areas containing explosives, ammunition, highly combustible materials or flammable strategic items shall be strictly regulated and controlled. Where it is believed that smoking can be safely regulated within areas and buildings containing such materials, specifically designated smoking locations, approved by the commanding officer, must be established. Smoking in vehicles passing through such areas is not considered controlled nor regulated.**

**Proper ash receivers and at least one acceptable type fire extinguisher shall be provided at desig-**

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nated smoking locations. At approved smoking locations in areas where matches and flame-producing devices are prohibited, permanently installed lighters shall be provided. Smoking shall be prohibited when wearing clothing contaminated with explosives or flammable materials to the degree that may endanger the safety of personnel.

#### **1604. HUNTING**

Issuance of written permits is authorized for hunting in an establishment under carefully controlled conditions that will not endanger life, property, or hazardous materials. Hunting shall not be permitted within 1,200 feet of explosives or ammunition locations. Cartridges having a muzzle velocity greater than 2,300 feet per second shall not be used for hunting within an establishment containing explosive materials. Where hunting is permitted on an establishment a map shall be prepared clearly defining the hunting and no hunting areas. Prior to issuance of a written permit, each hunter must become thoroughly familiar with the respective areas and local arrangements made to insure that hunting on other than the permitted areas will not prevail. All hunting shall conform to all applicable State and Federal regulations.

#### **1605. MATCHES AND FLAME PERMITS**

No personnel shall take matches, lighters, or other fire, flame or spark-producing devices into any restricted area except by written authority of the com-

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manding officer or his designated agent. When such authority has been received, a metal carrying device, too large to fit into the pockets, should be used for matches, lighters, and similar materials. The carrying of and the use of "strike anywhere" (kitchen) matches are prohibited.

#### **1606. HEAT-PRODUCING EQUIPMENT**

Where explosives, highly flammable, or critical materials are involved, a written permit should be required for the temporary use of heat-producing equipment producing a temperature higher than 228° F. (109° C.). The permit shall state the location, time, duration, purpose of use, details of safety and firefighting equipment required, and names of the workmen who will operate the equipment or the name of the immediate supervisor. The permit shall be kept at the location named so that it can be checked by supervisory personnel. Persons authorized to list requirements and to sign permits should be independent of the department doing the work and of the department for which the work is being done. **Work involving the use of heat producing equipment shall not be accomplished without the knowledge of the responsible supervisor of the building, line or area in which the work is to be done.**

They must be qualified by experience in explosive work, fire prevention, and general safety precautions, particularly with regard to the purging of equipment, presence of flammable mixtures, and the avoidance of electrical and mechanical hazards

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which might be incident to repair work. An agreement should be reached on the site by three persons, the man whose name appears as the one responsible for doing the work, the foreman of the building or area in which the work is to be done and the person authorized to sign the permit. The permit should be signed only after thorough consideration and compliance with safety requirements have been achieved.

#### **1607. FENCING AND PLACARDING RESTRICTED AREAS**

a. Restricted areas shall be placarded at each entrance. The sign should require each entrant to present the proper credentials and turn over all prohibited articles to the guard on duty or to place them in suitable containers provided for that purpose before entering the area. Restricted areas containing explosives shall be separated from administration, residential and entirely unrelated inert and warehouse areas by fences and unauthorized persons shall be prohibited from entering the explosives area. If the installation is surrounded by a type FE-6, FE-3, or 6-foot barbed wire fence modified in accordance with paragraph *d* below, explosives areas may be separated from administration, residential and entirely unrelated inert and warehouse areas by 6-foot barbed wire fences with barbed-wire overhang as described in paragraph *d* below, unless other type fencing is required for other than safety reasons. If bound-

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any fencing is of other type, explosives areas must be separated from the other areas by type FE-6 or FE-3 fences. The explosives areas may be inclosed individually, in groups of 2 or more areas or a single fence may be used to inclose all such areas as a unit

b. Fencing should not be placed closer to magazines than magazine distance nor closer to explosives operating buildings than intraline distance.

c. Reservation boundaries, in general, should be fenced. In certain cases topography and/or other physical considerations may make such action unnecessary. Boundaries shall be placarded as required by paragraph 1608.

d. For future permanent construction, type FE-6 fencing as shown on Office, Chief of Engineers' Drawing SK-40-16-03 should be used to inclose explosives and ammunition areas. Where existing areas of this type are inclosed by 6-foot high barbed wire fences with barbed wire overhangs, the fences should be modified by adding 12½ gauge smooth wire ties vertically at 2-foot intervals. For future emergency construction, type FE-3 fencing as shown on Office, Chief of Engineers' Drawing E-40-16-02 may be used, and, if chain link is in critical supply, woven wire fabric of mesh and gauge approximating that of the type FE-3 fencing may be substituted.

e. Boundary fencing may be type FE-1 as shown on Office, Chief of Engineers' Drawing E-40-16-02 unless it is to serve also as explosives and/or am-

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munition area fencing, in which case types specified in paragraph *d* above should be used.

**1608. BOUNDARY OF RESERVATIONS**  
(Revised)

The boundary of each Government reservation in which restricted areas are located shall be posted at 500-foot intervals to show that the area within is a Government reservation and to warn against trespassing.

## 1609. PARKING OF PRIVATELY-OWNED AUTOMOBILES

Parking of privately-owned automobiles within an Ordnance establishment shall be controlled to minimize fire and explosion hazards and prevent congestion in event of emergency. Automobiles shall be parked in designated areas only and preferably outside of the restricted area fences. Automobiles should not be parked near enough to a building or structure to either enable spread of fire from an automobile to the building or prevent easy access by fire fighters.

## 1610. HOUSEKEEPING

a. All buildings and magazines shall be kept clean at all times.

b. In explosives areas, waste materials such as oily rags, combustible and explosive scrap, and paper shall be kept separate from each other. Such waste should be placed in approved marked containers for each, preferably located outside the buildings. Containers for scrap black powder, scrap initiating explosives, scrap explosives of similar sensitivity, and rags contaminated with these explosives must be provided with covers and contain enough water (No. 10 mineral oil or fuel oil for certain pyrotechnic, tracer, flare, and similar mixtures) to cover the scrap or rags. Where water is used in containers for scrap pyrotechnic, tracer, flare, and similar

mixtures, the possibility that dangerous gases may be evolved must be recognized. In order to minimize the hazards from such gases, scrap should be introduced in a manner to provide for immediate immersion.

c. Exudate from ammunition shall be removed by use of approved solvents such as acetone (sec. 25). Unpacked ammunition, loose explosives, or those not in process, and combustible materials shall not be permitted to accumulate and must be placed in designated receptacles or in designated storage space.

d. Explosives, explosives dusts, and other hazardous materials shall not be allowed to accumulate on structural members, radiators, heating coils, steam, gas, air, or water supply pipes, nor on electrical fixtures.

e. Spillage of explosives and other hazardous materials shall be prevented so far as practicable by proper design of equipment, training of employees, provision of catch pans, etc. For example, hoppers shall be large enough to accommodate comfortably the size of charges used. A painted stripe on the inside of the hopper will serve as a reminder of the proper filling height. Catch pans or splash pans shall be provided beneath drawoff pipes and TNT flakers, around transfer piping, beneath powder bags on small arms ammunition charging machines, etc. Spillage must be removed promptly.

A regular program of cleaning shall be carried on as frequently as local conditions require for maintaining safe conditions. General cleaning should not be conducted while hazardous operations are

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being performed. Explosives and ammunition should be removed from the building prior to general cleaning operations, when practicable.

#### **1611. SWEEPING COMPOUNDS**

Hot water or steam should be used wherever practicable for cleaning floors in buildings containing explosives. Sweeping compounds which are non-abrasive and compatible with the explosives involved may be used where the use of steam or hot water is not practicable. Such compounds may be combustible but must not be volatile (closed cup flash point must not be less than 230° F.). Sweeping compounds containing wax should not be used on conductive flooring. Where nitrated organic explosives are involved, which may form sensitive explosive compounds with caustic alkalies, the use of cleaning agents containing caustic alkalies is prohibited.

#### **1612. BRUSHES**

Wire brushes may be used in cleaning explosives processing equipment only when other methods of cleaning are ineffective. If wire brushes are used, thorough inspection should be made after cleaning to insure that wire bristles do not remain in the equipment. Where practicable, nonferrous wire brushes should be used. This applies also to cleaning magnesium ingot molds and molds for any other metal which may be used as an explosive constituent. Use of fiber brushes in place of hair brushes is recommended to reduce generation of static.

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### **1613. PACKING MATERIALS**

The working supply of packing materials, such as excelsior and shredded paper, should not exceed the capacity of bins or boxes provided for the purpose. These bins should be built of metal-lined wood or incombustible material, having an automatic or self-closing cover.

### **1614. SAFETY HAND TOOLS**

a. Safety hand tools are constructed of wood or other nonsparking or spark resistant materials such as bronze, lead, beryllium alloys, and "K" Monel metal which, under normal conditions of use, will not produce sparks. Properly maintained, non-ferrous hand tools should be used for repair work in buildings which may contain explosives or hazardous concentrations of flammable gases or vapors. Hand tools or other implements used in the vicinity of hazardous materials must be handled carefully and kept clean. All tools should be checked in before beginning work and checked out at its completion.

b. If the use of ferrous metal hand tools is required because of strength characteristics, the immediate area should be free from exposed explosives and other highly combustible materials except in specific operations approved by the Chief of Ordnance.

### **1615. EXPLOSIVES IN PROCESS DURING SHUT-DOWN**

When buildings containing explosives are evacuated as during periods of electrical storms, operations requiring attention at all times shall continue to be

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manned by the minimum number of personnel consistent with safety requirements. When the process has been brought to a condition in which it is considered safe to leave and when it would not produce rejected components requiring reworking with accompanying hazards, the building shall be completely evacuated. Every effort shall be made to anticipate shutdown and, during such critical periods, any explosives process requiring complete attention should not be started unless absolutely necessary. Because of the possibility of power failure, alternate emergency power equipment should be manned during such times.

#### 1616. PROCEDURE IN EVENT OF ELECTRICAL STORMS

a. Whenever an electrical storm approaches the establishment, personnel shall be evacuated from locations at which there is a hazard from explosives which could be initiated by lightning. Such locations include

- (1) Operating buildings or facilities without approved lightning protection systems (sec. 8), which contain explosives or explosive-loaded ammunition, and locations within intraline distance of such facilities.
- (2) Buildings containing explosives dust or vapors, whether or not equipped with approved lightning protection systems and locations within intraline distance of such buildings.

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(3) Magazines, open storage sites or loading docks, which are not equipped with approved lightning protection systems, and vehicles and railroad cars on ungrounded tracks, containing explosives and explosive-loaded ammunition, and locations within magazine distance of such structures, sites, vehicles, or cars.

b. When personnel are to be evacuated from explosives operations, the operations should be shut down in accordance with paragraph 1615, windows and doors closed, and electric switches thrown to the off-position.

c. A responsible and qualified person should be empowered with final decision as to the necessity for evacuation. Where operations are of such nature as to require advance warning from shutdown, a net of volunteer observers or an electronic static detector may be utilized.

d. In an operating line, evacuated personnel should be retired to approved suitable protective shelters located at intraline distance from operating buildings or other hazardous locations. In a magazine area, evacuated personnel should be retired to such approved shelters at magazine distance from magazine or other hazardous locations, or to empty earth-covered magazines. When such shelters are not available, personnel should be withdrawn to places at inhabited building distances from the hazardous locations.

e. Personnel in direct charge of railroad trains and motor trucks containing explosives should, when

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possible, move the equipment to locations of comparative safety before retiring to designated bomb proofs or change houses.

#### **1617. SEARCHES**

It shall be the responsibility of the commanding officer to restrict all persons, except personnel issued permits referred to in paragraph 1606, from entering a restricted area when carrying matches, lighters, flame-producing equipment, or any other articles which may be forbidden such as keys, coins, knives, and metal objects. If necessary, thorough search of all persons entering or in the areas may be conducted.

#### **1618. PHOTOGRAPHING HAZARDOUS AREAS**

Magnesium flashlights or photoflash bulbs are not permitted in photographing locations where explosives, explosive dusts, flammable gases, or vapors may be present unless all explosive or highly flammable materials have been removed and equipment prepared as for major repairs. Adequate approved lighting with time exposures have proven satisfactory for photographing such locations.

#### **1619. EXPERIMENTS**

No experiments or tests other than routine work shall be undertaken in an explosives building without first notifying the persons in charge. If the tests add to the general hazard and can be performed elsewhere, they must not be done during operations or with more than the minimum necessary number of persons present.

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## **1620 EXPLOSIVES RECOVERY AND REUSE**

a. All loose explosives recovered as sweepings from floors of operating buildings shall be destroyed. Explosives which are recovered from other than ammunition breakdown operations or from operation equipment shall be thoroughly inspected by operating supervision and reused, screened, reprocessed, or destroyed as the situation warrants. Explosives which are contaminated with dirt, dust, grit, or metallic objects must be reprocessed to remove all foreign matter before they can be reused, otherwise they must be destroyed. Melt-loaded explosives known to be contaminated shall not be reused unless it is practicable to remelt and draw off clean material.

b. **Explosives salvaged from loaded ammunition should be stored in buildings by themselves.**

## **1621. MAINTENANCE AND REPAIRS TO EQUIPMENT AND BUILDINGS**

a. Before being placed into routine operations, all new or newly repaired process equipment for use in hazardous operations must be examined and actually tested by a specifically designated competent person to assure that it is in safe working condition. If machinery or equipment does not appear to function properly, operations shall be discontinued if the immediate stoppage does not create a new hazard.

b. Before repairs are permitted on any equipment that has been exposed to explosives, a tag signed by operating supervision shall be placed on the equipment certifying that all explosives have been re-

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moved. If it has been impossible to clean some part, it shall be noted on the tag together with adequate instruction to maintenance personnel concerning safe methods of handling.

*c.* Major repairs or changes shall not be undertaken in a hazardous building during regular operations without removal of the hazard material or without the knowledge of the employee in immediate charge of the building (par. 1813).

*d.* Only competent persons shall be permitted to effect repairs. Before repairs are started in an explosives location, the immediate area shall be inspected for the presence of explosives and dust and all such material shall be removed from equipment, crevices, beneath floors, within walls and pipes, and under fittings where explosives may be ignited. The entire area should preferably be wet or should be washed down thoroughly.

When machines and equipment have been oiled, repaired, or adjusted, all tools used for the repairs shall be removed. All operators must inspect their equipment to be assured of its safe operating condition before resuming work.

*f.* Certain operations require that nonsparking tools be used. If the maintenance department, in repairing a machine where nonsparking items are normally required, must use steel tools, not only shall the machine and surrounding area be cleaned, as indicated in subparagraphs *b*, *c*, and *d* above, but all explosive operations in the immediate vicinity shall be discontinued to guard against accidental ignition of materials by flying sparks. Where steel

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tools are used in such maintenance operations all contact surfaces should be oiled to reduce likelihood of sparks.

*g.* Maintenance men entering buildings in which conductive shoes are required shall wear conductive shoes or conductive overshoes with ankle straps. Since electricians shall not be allowed to work on live electrical equipment while wearing conductive shoes, all explosives must be removed before electrical work is done. (par. 705).

*h.* Safe practices elsewhere specified in this manual shall apply to maintenance employees as well as to those engaged in actual production.

*i.* Maintenance and tool rooms in an operating line should be separated from explosives by intraline distance. When intraline distance separation cannot be provided, protection equivalent to that afforded by a substantial dividing wall must be provided.

## **1622. AGITATION**

Nitrators, washers, and other machines which because of the hazard of the process and the possibility of decomposition of the process material are equipped with mechanical agitators should have at least two means of agitation, each operating from independent sources of power to maintain agitation in event of failure.

## **1623. NITRATION**

Nitration involves explosion, fire, and toxic hazards in addition to those incident to handling acids. Efficient ventilating systems are required. Nitra-

tion buildings should be provided with adequate safety exits and necessary safety appliances such as suitable neutralizing solutions, and emergency showers. When necessary, personnel should be provided with personal protective clothing and equipment which is impermeable to acid or which is acid resistant.

#### **1624. FIRE PROTECTION SYSTEMS**

(See pars. 1228 and 1229.)

a. Equipment for powder cutters, cotton pickers, and other processes involving solids in which there is a process fire hazard should be equipped with deluge systems and quick opening valves controlled both automatically and manually. The deluge system should be charged with steam, water, or chemicals depending upon the character of the fire to be controlled (See National Board of Fire Underwriters' pamphlet No. 13, "Sprinkler Equipments"). "Rate of rise" (of temperature) and light-actuated devices for quick action automatic control are recommended.

b. In order to prevent the propagation of a fire and to reduce damage to personnel and property, melt-mix kettles, volumetric loading machines, incorporators, and similar equipment handling molten explosives should be equipped with automatic and manually operated fire-extinguishing equipment.

- (1) The distributing outlets (nozzles, sprays, heads, etc.) should be located as close to the exposed surface of the explosive as possible

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and should be so positioned as to insure immediate drenching of all parts of the machine under extreme conditions. When explosives are located inside of machines, under tight hoods or covers, the distributing outlets should be located inside of the inclosed space. For example, on the volumetric loading machine:

- (a) Outlets should be placed inside of the inclosed reservoir over the TNT.
  - (b) Outlets should be placed inside of the machine over the measuring cups.
  - (c) Consideration should be given to the advisability of providing outlets so located that the top of the radiator and the tops of shall in the skid under the machine will be drenched in case of fire.
- (2) It is recommended that not less than 50 gallons of water per minute at not less than 40 p. s. i. residual pressure be supplied to each distributing outlet. The distributing heads should be of open type and must be properly maintained so as to be in working condition at all times. Where explosive vapors, gases, or dusts may get into the outlet and interfere with the operation of same, it may be advisable to cap them. However, care must be exercised in selecting a cap which will release immediately upon exertion of pressure within the outlet.
- (3) It is recommended that deluge systems be cleaned and tested periodically (as often as

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necessary) to insure that they are in proper operating condition at all times. A log should be kept in connection with these tests.

- (4) The above extinguishing systems should be provided in addition to general sprinkler protection and extinguishing systems.

### 1625. STANDING OPERATING PROCEDURES

a. Prior to starting any operation involving ammunition or explosives an adequate standing operating procedure shall be developed and then approved by the commanding officer of the establishment or by a **qualified member of his staff who has been delegated the responsibility for review of and authority for approval of S. O. P.** Controlled tests may be necessary in order to establish S. O. P. for certain operations. This standing operating procedure shall include, as a minimum, such items as safety requirements, personnel and explosives limits, equipment designation, and location and sequence of operations. No deviation from this procedure shall be permitted without the approval of the commanding officer or **his designated representative.**

b. All personnel involved in these operations shall become cognizant of their respective duties. Supervision should be responsible for this indoctrination.

c. Applicable portions of the approved standing operating procedure shall be conspicuously posted convenient to all stations involved in the operation for the guidance of all personnel. Supervisory personnel shall maintain copies of the overall S. O. P.

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and be responsible for the enforcement of its provisions.

*d.* Action to be taken in the event of electrical storms, utilities or mechanical failures and the like, occurring during the manufacturing, handling, or processing of explosives and other hazardous materials shall be set forth in standing operating procedures required by paragraph *a* above or shall be set forth in separate SOP, prepared specifically for such purposes. The emergency action thus prescribed shall conform with paragraphs 1615, 1616 and 1625a-c, where applicable.

#### **1626. ELECTRICAL TESTING OF AMMUNITION AND AMMUNITION COMPONENTS**

(Added)

*a. Type of test equipment.* Electrical (including electronics) test equipment should utilize the weakest possible power source. Battery-powered equipment should be used in lieu of that with a 110-volt source. The power source should be incapable of initiating the explosive item under test. Where greater power must be used, positive means must be provided to prevent delivery of power to the explosive item, in quantities sufficient to initiate the item. The possibility of malpractice on the part of operators and other personnel must be recognized and safeguards provided.

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*b. Layout of test equipment.* As indicated in section 6, test equipment should not be placed in hazardous atmospheres unless absolutely necessary. When the test equipment or parts thereof must be placed in hazardous atmospheres, its suitability must be attested by Underwriters' Laboratories approval or specific approval must be obtained from the Chief of Ordnance. Special attention must be given to equipment containing vacuum tubes because of inherent ventilation requirements. Unless the test equipment, under any circumstances, is incapable of initiating the item being tested, operational shields are required for protection of personnel. The most reliable means for attaining and retaining this initiation incapability is to protect the test equipment, including leads, from electromagnetic (induction and radiation fields) and electrostatic energy and to provide the test equipment with a weak power source. Where reliance is placed on resistors and other devices for limiting power delivered to the item being tested, operational shields should be provided.

*c. Use of test equipment.* Test equipment should be used only in the manner and for the purpose for which approval is granted. The equipment should be maintained in good working order by qualified personnel. Operator adjustments should be limited to those required by design of the equipment.

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**SECTION 17**  
**QUANTITY-DISTANCE TABLES**  
**(REVISED)**

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**1701. SCOPE**

This section outlines the quantity-distance regulations applicable to the storage and handling of ammunition and explosives at Ordnance establishments. Explosives and ammunition are classified according to the damage expected if they explode or ignite. Where circumstances exist at an Ordnance installation that may modify the normal behavior of the material, the Chief of Ordnance may reclassify that material for the specific instance upon request of the commanding officer. The grouping of explosives and ammunition into the several classes does not necessarily mean that the different items in a class may be stored together. Items which may be stored together at one location are set forth in section 19. The maximum amount of explosives permitted in any location is specified in the quantity-distance tables within this section. It is mandatory that local limits be established in amounts no greater than those consistent with safe, efficient operation. Operations and personnel shall be so arranged (consistent with safe, efficient operation; see par. 1601) as to constitute the smallest exposure to any one explosion or fire hazard.

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## 1702. INHABITED BUILDING DISTANCE

a. Inhabited building distances are the minimum permissible distances between an inhabited building, as defined in par. 233, and an ammunition or explosives location. Inhabited building distances are also used for protection of administration areas, adjacent operating lines (par. 1711a) and for other exposures within an establishment. Except as otherwise specifically prescribed herein, inhabited building distances also shall be provided between ammunition and explosives locations and the boundaries of Ordnance establishments.

b. Inhabited building distances as set forth in this section protect buildings against "substantial" structural damage which is defined as follows:

- (1) Masonry buildings—serious weakening or displacement of portions of supporting walls (foundations, side walls, or interior supports), the breaking of rafters or other important roof or floor supporting members.
- (2) Frame buildings—serious weakening or displacement of foundations, breaking of any main support within side walls or interior supporting walls, or breaking of rafters or other important roof or floor supporting members.
- (3) Reinforced concrete structures—displacement of any floor, wall, or ceiling structural member or the failure of any supporting member.
- (4) No damage which is readily repairable

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should be considered substantial within the definition established by this Manual.

c. Inhabited building distances do not provide protection against glass breakage or injury to personnel from glass breakage; therefore, greater distances should be used, if practicable. The inhabited building distances for mass-detonating ammunition and explosives (classes 6, 8, 9, 10, and other classes stored as classes 9 or 10) are based on damage from blast effects; however, they do provide a high degree of protection from missiles except for small quantities where the missile hazard may be more severe than the blast hazard. Inhabited building distances for ammunition and explosives which are not mass-detonating are based on the most severe hazard involved.

### 1703. PUBLIC RAILWAY DISTANCE

a. This distance is the minimum permitted between a public railway as defined in paragraph 253 and an explosives hazard. The distance at which cars are considered safe from the blast effects of explosions has been fixed as 60 percent of the inhabited building distance. These decreased distances are used in tables for classes 6, 8, 9, and 10 materials. The use of lesser distances is based on the smaller height and area of the railway cars exposed to blast; the greater resistance of cars to blast as compared with buildings, and the fact that while a building is stationary and subject to risk constantly, the presence of a train is only temporary. For other than classes 6, 8, 9, and 10 materials, inhabited building distances are required to public railways.

b. The minimum separation between privately-owned railways over which passengers are not carried, and magazines and storage sites shall be not less than 400 feet unless the public railway distance specified in the appropriate quantity-distance table is less. However, the railways must be separated by public railway distances from operating buildings.

#### **1704. PUBLIC HIGHWAY DISTANCE**

This distance is the minimum permitted between a public highway as defined in paragraph 252 and an explosives hazard. The public highway distances are based on criteria similar to those applicable to public railways and are identical to public railway distances (par. 1703a). Persons in the open are considered safe from the blast effects (not missiles) of explosions when separated from the explosion site by distances equal to one-half the public highway distance.

#### **1705. INTRALINE DISTANCE**

a. This distance is the minimum permitted (except as indicated in c below) between any two buildings within one operating line (par. 248). Intraline distances are also used for separating certain specified areas, buildings, and locations even though actual line operations are not involved. All ammunition and explosives except classes 1, 2, 2A, and 8 in such a line are considered classes 9 or 10. Intraline distance is expected to protect buildings from propagation of explosion due to blast effects but not against the possibility of propagation due to missiles. Buildings, separated by intraline distances will probably

suffer substantial structural damage.

b. A service type magazine (para 266) shall be located at intraline distance, based on the quantity of explosives within the magazine, from the nearest operating building of the line of which it forms a part. Service-type magazines shall be separated from each other by intraline distances.

c. Facilities (excluding service magazines) servicing a single operating building which is not a part of an operating line may be located at less than intraline distances but not less than 100 feet from the operating building. Such facilities include low pressure heating boilers and paint storage buildings.

#### **1706. MAGAZINE DISTANCE**

This distance is the minimum permitted between any two storage magazines. Distance required is determined by the type or types of magazines and also the type and the quantity of ammunition or explosives stored therein. It is expected to prevent propagation of explosion from one magazine to

another from blast and, except as indicated in paragraph 1712, provides a reasonable degree of protection against propagation of explosion due to missiles. It does not, except possibly for earth-covered magazines, protect the magazines from severe structural damage. Magazine distance is also used for certain quantity-distance computations where other than two magazines are involved (para 1711 and 1717).

### **1707. MISSILE DISTANCE**

The missile distance, identified as inhabited building distance for ammunition in classes 3, 4, 5, and 6, is based on the limiting range of a majority of missiles for the type of ammunition involved. The distances do not take into account occasional missiles which may be projected farther. For class 7, the inhabited building distance is based upon blast damage and does not represent the distance to which some missiles can be projected.

### **1708. QUANTITY-DISTANCE DETERMINATIONS**

a. The location of explosives facilities with respect to each other and to other exposures shall be based on the total quantity of explosives in the individual facilities unless the total quantity is so subdivided that an incident involving any one of the smaller concentrations will not produce "simultaneous" initiation of others.

b. The quantity of explosives to be permitted in each of two or more nearby similar magazines or oper-

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ating buildings shall be determined by considering each as a potential explosion site and limiting the quantity of explosives to be permitted in the maga-

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zines or operating buildings to the least amount allowed by the appropriate tables for the distances separating the magazines or operating buildings concerned.

c. The quantity of explosives permitted in each of two or more nearby magazines for which different quantity-distance tables apply shall be determined as follows:

- (1) Consider each magazine, in turn, as a potential explosion site.
- (2) Refer to the table applicable to each target magazine.
- (3) Determine the quantity of explosives permitted for the distance between the explosion site and each target magazine.
- (4) Record the quantity in each instance as that to be permitted in the site magazine and the least quantity recorded shall be the maximum permitted.

d. Measurement of distance for determining the maximum allowable quantity of explosives shall be made from the nearest outside point or wall of the room, cubicle, or building proper involved which contains the explosives to the nearest outside point or wall of the other location under consideration. Separation distances are measured along a straight line.

e. Where the total quantity of explosives in a magazine or operating building is so separated into piles or stacks that the possibility of "simultaneous" detonation is limited to the quantity in any one pile or stack, distances shall be measured from the outside

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of the wall nearest the controlling explosives pile or stack to the nearest outside wall of another structure. If the separation to prevent "simultaneous" detonation is provided by one or more substantial dividing walls, distances may be measured from these walls, if appropriate, instead of from the outside walls of the building. Where not so separated, the total quantity subject to "simultaneous" detonation shall be used for quantity-distance computations.

*f.* Where railroad cars or motor vehicles containing explosives and ammunition are not separated from an operating building containing explosives and ammunition in such manner as to prevent their "simultaneous" detonation (par. 1719), the total quantity of explosives in the operating building, cars, or motor vehicles shall be considered as a unit and the separation distance measured from the nearest outside wall of the operating building, car, or vehicle, as applicable, to the target. If the explosives in the operating building are separated into smaller concentrations so that "simultaneous" detonation may not occur when the explosives in the railroad cars and motor vehicles are added to the appropriate inside concentrations, the distance shall be measured from the wall nearest the controlling unit, car, or vehicle, as applicable, to a target.

*g.* When items of different explosives hazard classes are stored together, quantity-distance requirements are determined as follows:

- (1) The explosives weights for the individual classes are determined in accordance with paragraph 1709.

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- (2) The explosives weights for the individual classes are added together to determine the total weight stored.
- (3) Using the total explosives weight so determined and referring to the quantity-distance tables applicable to the individual explosives hazard classes involved, the distance required for each class is established. The maximum distance so established is the minimum acceptable for the storage facility.

#### 1709. QUANTITY OF EXPLOSIVES

The explosives content of ammunition or components is shown on Ordnance Corps drawings. If these are not available, the information desired should be requested from the Chief of Ordnance. The quantities intended for use in the tables herein shall be computed in the following manner:

*a.* Solid propellants (smokeless powder). Net weight of the propellants in containers for bulk propellants or propelling charges.

*b.* Metal powders and pyrotechnics. Total weight of the pyrotechnic composition and of the explosives involved in pyrotechnic items; net weight of metal powders in containers.

*c.* Fixed, semi-fixed, and separated loading ammunition. Net weight of explosives in projectiles exclusive of propelling charge.

*d.* Rockets and guided missiles. Weight of explosive in the warhead plus the weight of propellant in the rocket motor; except when the motor contains a class 2 propellant not susceptible to detonation

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on initiation of the warhead. In this exception, distance will be computed on either the weight of explosive in the warhead or the weight of propellant in the rocket, but not the total weight of both, and the greater distance so determined will apply. In some instances, however, only a portion of the propellant will participate in a detonation. In this instance, distance will be determined by the weight of explosive in the warhead plus the portion of propellant which contributes to the detonation. Each item under this exception will be referred to the Chief of Ordnance for approval.

e. Separate loading projectiles, Jatos, rocket motors, bombs, mines, mortar ammunition, boosters, fuzes, and other loaded components. Net weight of explosive filler.

#### 1710. MAGAZINE BLOCK ARRANGEMENT

a. Ammunition and explosives storage areas shall be subdivided into blocks of storage facilities. The number of facilities in a block shall be limited as follows:

- (1) Not more than 200 magazines with earth-cover on the top and at least 3 sides and with earth-covered or reinforced concrete front walls, or
- (2) Not more than 100 storage facilities of other types, or
- (3) Not more than 100 revetted outdoor sites in a block containing a combined maximum of 200 magazines of the earth-covered type described in paragraph a(1) above and revetted outdoor sites.

b. It is preferred that magazines with earth-cover on the top and at least 3 sides and without door end barricades (separated by distances as specified in tables 1738, 1739 and 1739A) be oriented as follows:

- (1) Unbarricaded door ends facing the same direction.
- (2) Exterior faces of unbarricaded front walls of adjacent magazines are all on one imaginary straight line.

c. Storage blocks consisting of magazines with earth-cover on the top and at least 3 sides and with earth-covered or reinforced concrete front walls shall be separated from each other and from blocks consisting of magazines of other types by a distance of not less than 1,400 feet.

d. Storage blocks consisting of facilities of other than the earth-covered type shall be separated from each other by a minimum distance of 1,200 feet if storage therein is restricted to classes 1 through 5; 1,800 feet if classes other than 1 through 5 are stored therein.

e. Magazines within a storage block shall be separated from each other by distances not less than those prescribed in applicable quantity-distance tables in this section.

## **1711. SEPARATION OF AND WITHIN AREAS**

a. In establishments handling explosives and ammunition, each operating line, explosives or ammunition storage area, inert storage area and administrative area shall constitute a separate group of buildings and facilities, so that any group handling explosives must

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be separated from all others and from installation boundaries by appropriate inhabited building distances. Where the explosives or ammunition in adjacent operating lines differ, the lines shall be separated by inhabited building distances based on the explosive or ammunition requiring the greater distance. In manufacturing works, adjacent operating lines may be separated by intraline distance when these lines are producing the same explosives.

b. A building, group of buildings, or operation conducted in the open, when serving more than one line or magazine area, constitutes a special area and shall be separated from other groups or areas by inhabited building distance. If the facility or activity serves one operating line, block of magazines or area, intraline distance separations apply, provided the function is separated from all other lines or blocks by inhabited building distances. These general principles shall govern in all cases except:

- (1) Facilities listed in paragraphs 1711d(1) and 1711d(2).
- (2) Normal maintenance and minor modification operations may be performed in an empty magazine within a magazine area, or in the open at intraline distance (based on the quantity at the operation) from the nearest storage facility containing explosives or ammunition, but in no case less than 100 feet from the storage facility when authorized

by the Commanding General, AMC (AMCAD -S), or the installation commander in accordance with paragraph 2502*d*. Under conditions enumerated in paragraph 1809*g*, normal maintenance of small arms ammunition may be performed in magazines containing small arms ammunition only.

*c.* Buildings forming an operating line shall be separated from each other by intraline distance. Outdoor operations or operations conducted under sheds within an operating line shall also be located at intraline distances. Where missiles may be a hazard, intraline distances may not provide sufficient protection, in which case a barrier or barricade should be provided as additional protection. This is particularly important where personnel concentrations are high, such as in lunchrooms and change houses.

*d.* Miscellaneous structures in a magazine area:

- (1) Guard shelters, field offices, ammunition surveillance buildings, packing and shipping buildings, bombproofs, and other personnel shelters shall be separated from all magazines by a minimum of magazine distance and shall be separated by intraline distance from magazines containing class 7 materials.
- (2) Change houses, lunchrooms, dunnage preparation buildings, and lumber storage for magazine areas shall be located at a minimum of intraline distance from magazines.

- (3) Ammunition workshops shall be located at a minimum of inhabited distance from magazines based on the quantity and type of material in the magazines.

### **1712. SEPARATION OF AMMUNITION AND EXPLOSIVES IN STORAGE**

a. Solid propellants and materials of class 7, stored in exposed locations, shall be separated from materials of classes 4, 5, and 6 by the missile distance (inhabited building distance) for materials of the latter classes involved.

b. The materials cited above as requiring protection (i.e., solid propellant and materials of class 7) are considered to be in exposed locations when stored in aboveground magazines or in the open.

c. In areas consisting entirely of magazines with earth-cover on the top and at least 3 sides and earth-covered or reinforced concrete front walls, all classes of ammunition and explosives may be stored without regard to the above.

### **1713. CLASSIFICATION YARD**

Cars of explosives and ammunition in the yard should be switched for transfer as soon as possible. They should not remain in the yard for more than 24 hours. Classification yards through which cars containing ammunition and explosives are handled shall be separated from inhabited buildings, administration areas, magazines containing ammunition or explosives, operating buildings handling explosives, and installation

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boundaries by a minimum distance of 1,800 feet. This distance may be reduced to 1,400 feet when magazines with earth cover on the top and at least 3 sides, and earth-covered or

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reinforced concrete front walls are involved and door ends do not face the classification yard. Barricades will not be interposed for the purpose of reducing these distances. Efforts should be made to segregate cars into groups to reduce concentrations of explosives and potential hazards.

#### 1714. HOLDING YARDS

Explosives loaded rail cars, trucks, or trailers in holding yards, are considered as aboveground magazines for quantity-distance purposes. To provide flexibility of storage, the yard should be laid out so that the tracks and trailer parking areas are at least 380 feet apart if barricaded, or 695 feet if unbarricaded. The rail cars, trucks, or trailers shall be in groups so that each group is limited to 250,000 pounds of high explosives, and the distance between groups is not less than 380 feet barricaded and 695 feet unbarricaded.

#### 1715. TEMPORARY STORAGE YARD

Loaded rail cars, trucks, or trailers which cannot be readily unloaded are considered as aboveground magazines for quantity-distance purposes. When it is necessary to hold such cars, trucks, or trailers for periods of 2 days to 2 weeks, they should be grouped so that each group is limited to 250,000 net pounds high explosives and groups separated from each other by a minimum distance of 695 feet. If full distances cannot be obtained, the groups of loaded rail cars may be spaced 380 feet apart in all directions, provided one or more cars of nonexplosive materials are spotted between the groups. Cars

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containing flammable liquids, flammable solids, oxidizers and corrosives shall not be used for this purpose.

#### **1716. SUSPECT CAR SPUR TRACK**

When inspection of a car of explosives or ammunition indicates that it may be in a hazardous condition (par. 2120), it should be moved at once to a suspect car spur track or an isolated section of track. This spur or section of track should lead directly from the inspection point and be located so that suspect cars can be moved there without entering the classification yard. The distance between the spur or track and installation boundaries, classification yards, inhabited buildings, administration areas, operating buildings, magazines, inert storage locations, public railways, and public highways should be 1800 feet if barricades meeting the requirements of paragraph 1725 are provided, 3600 feet if such barricades are not provided. Only one car is permitted at this location at any time. Incoming explosives or ammunition laden motor vehicles shall be expected at a station located in accordance with requirements of paragraph 2210.

#### **1717. LOADING DOCKS**

a. Loading docks, including elevated docks, pads, or other locations at which ammunition or explosives are transferred between vehicles, including railway cars, shall be located at not less than the following distances:

- (1) Eight-hundred feet from unbarricaded magazines in magazine areas (existing loading

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- docks are acceptable at unbarricaded magazine distance).
- (2) Four-hundred feet from barricaded magazines in magazine areas (existing loading docks are acceptable at barricaded magazine distance).
  - (3) Intraline separation from the operating line the dock serves.
  - (4) Inhabited building distance from: Administrative areas, inert areas, load lines which are not served by the dock, installation boundaries, and other unrelated facilities.
  - (5) Eight-hundred feet from magazines containing in excess of 250,000 pounds of classes 9 or 10 explosives and ammunition.
  - (6) Magazine distance from other loading docks.
  - (7) Intraline separation from LCL buildings.
  - (8) Intraline distance from surveillance buildings and ammunition workshops.

b. Provided all pertinent explosives quantity-distance separations are complied with, the maximum quantity of classes 9 and 10 materials permitted at one loading dock shall not exceed 250,000 pounds.

#### **1718. LOADING DOCKS USED FOR OTHER THAN NORMAL SHIPMENTS**

The use of loading docks for purposes other than for which they were originally intended should be discouraged. When used for purposes other than shipping or receiving explosives and ammunition, the quantity of explosives being worked on at the dock shall not exceed that quantity of explosives

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permitted by the appropriate quantity-distance tables.

#### **1719. SPOTTING FREIGHT CARS AND AUTOMOTIVE EQUIPMENT AT BUILDINGS**

Freight cars and automotive equipment containing explosives or ammunition, which are nearer than intraline distances to an explosives operation or building and not separated from the explosives operation or building by a barrier capable of precluding "simultaneous" detonation shall be included in computations as part of the explosive limits of the operation or operating building. This is not intended to permit cars or trucks containing explosives and ammunition to be used as service magazines and to be placed at less than intraline distances from the building or operation. The total quantity within the cars and building shall not exceed the maximum permitted in the building or rail cars by the quantity-distance requirements.

#### **1720. DAMS**

Important dams, the loss of which might seriously affect surrounding areas or the normal functioning of the establishment shall be protected from explosives and ammunition hazards by the appropriate inhabited building distance separation.

#### **1721. GASOLINE HANDLING AND STORAGE FACILITIES**

a. The minimum distance permitted between underground gasoline storage facilities and the nearest explosives or ammunition handling facilities,

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except those involving class 1 materials, shall not be less than 300 feet. For class 1 materials this minimum distance shall be not less than 100 feet. Dispensing pumps must be of approved type.

b. The minimum distance permitted between aboveground gasoline storage and dispensing facilities (excluding mobile units used to dispense retail quantities of gasoline) and class 1 ammunition facilities is 450 feet. The minimum separation where other classes of ammunition and explosives are involved shall be 1,800 feet or inhabited building distance, whichever is less, except that the distance shall not be less than 450 feet. Retail quantities may be dispensed from mobile units (maximum 350-gallons capacity) at a minimum distance of 100 feet from explosives and ammunition handling facilities.

c. Gasoline stored in aboveground tanks or in drums should be diked in accordance with paragraph 58, NBFU Pamphlet No. 30, "Containers for Storing and Handling Flammable Liquids."

#### **1722. SCREENING BUILDINGS AT LOADING PLANTS**

a. In the construction of new load lines or of new screening buildings on existing lines, the screening building shall be separated from melt pour buildings by intraline distances based upon the greatest limiting quantity of explosives within substantial dividing walls in either the screening, melt pour, or pressing buildings. Screening buildings should not, in future construction, be located so as to expose the weak walls of bays in melt pour buildings.

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b. Where on existing lines the screening building is located 100 feet from the melt pour building, only the minimum amount of explosives necessary for continuous efficient operation shall be permitted in the screening building but in no case shall this quantity exceed 15,000 pounds. In TNT and Explosive D screening buildings, the total quantity in the screening building and melt pour bays as a unit shall not exceed that permitted by existing distances to other structures and lines. Tetryl or pentolite screening buildings so located shall be modified by interposing an approved barricade between the screening and the melt pour buildings so as to shield all bays of the melt pour building which are not at the required intraline distance.

### **1723. SPACING OF UNITS CONTAINING EXPLOSIVES ON CONVEYORS**

a. Containers of explosives and explosives loaded items which are being transported on conveyors, except for transfer between trucks or rail cars and storage facilities, should be separated by not less than the minimum distances shown in the table on the following page.

Item	Quantity	Containers	Distance
TNT (Bulk)	50 pounds	Box, carton or fiber container	20 feet.
TNT (Bulk)	100 pounds	Box, carton or fiber container	35 feet.
Explosive D (Bulk)	50 pounds	Box or container	15 feet.
Tetryl (Bulk)	50 pounds	Box, carton or fiber container	25 feet.
Pentolite (Bulk)	50 pounds	Box, carton or fiber container	35 feet.
40-mm (TNT)	1 round	Projectile only or complete round	In contact.
57-mm (TNT)	1 round	Projectile only or complete round	6 in. between items.
60-mm (TNT)	1 round	Projectile only or complete round	3 1/4 in. between items.
75-mm (TNT)	1 round	Projectile only or complete round	5 in. between items.
76-mm (TNT)	1 round	Projectile only or complete round	5 in. between items.
81-mm (M56) (TNT)	1 round	Projectile only or complete round	7 in. between items.
90-mm (TNT)	1 round	Projectile only or complete round	7 in. between items.
105-mm (TNT or Comp B)	1 round	Projectile only	15 in. between items.
105-mm (TNT or Comp B)	32 projectile pallets	Projectile only	109 in. between pallets.
Mine, AT, HE, Heavy, M15.	1 mine	Mine only	25 ft. between mines.
Mine, AT, HE, Heavy, M15.	4 mine trays	Mine only	25 ft. between trays.
Grenade, Hand, Frag., M26.	1 grenade	Fuzed grenade only	12 in. between grenades.

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b. Openings in substantial dividing walls for installation of conveyors are not recommended. Where such openings are deemed necessary, the size shall not be larger than the minimum which will permit safe passage of the item being transferred. When conveyors are not being utilized for the operation, adequate closures for the openings should be provided.

c. Where shells or bombs are transported between buildings in an operating line in trucks, or on skids or racks by conveyors, the spacing between trucks, or racks or skids, should be according to the quantity of explosives and the intraline class 7 quantity-distance table.

**1724. Rescinded.**

## 1725. BARRICADES

*a. General.* Properly constructed separate artificial or substantial natural barricades are effective means for protecting structures or operations, thereby permitting the reduction of quantity-distance requirements for bulk explosives and explosives loaded items having mass detonating characteristics. Such barricades are generally ineffective and normally shall not be used to reduce distances for fire hazard materials such as class 2 propellant and missile-producing items such as classes 4, 5, and 6 ammunition. Protection is considered effective when a line from the top of any side-wall of the building containing explosives to all parts of the other locaton to be protected will pass through the intervening barricade. For railways and highways to be considered barricaded, such a line must pass 12 feet above the center of the highway or railroad. Such a barricade must be separated from both the building it is to screen and the building containing the hazard. The nearest toe of the barricade must be not less than 4 nor more than 40 feet from the building. The separation should be as near to the minimum (4 feet) as practicable. Although it is permissible to locate a barricade adjacent to either the building to be protected or the building containing the hazard, the former procedure is recommended. It is not the policy of AMC to erect barricades around aboveground magazines, but if necessary to meet local conditions, single-revetted or natural slope barricades shall be constructed in accordance with drawings and specifications approved by the Commanding General, AMC

(AMCAD-S). Barricades may be natural, artificial earth mound having natural sloping sides or single revetted either wood or concrete, with an earth mound of a minimum width of 3 feet at the top and having natural slope on one side. Barricades in excess of 20 feet in height will have a minimum width of not less than 5 feet at the top. Double revetted artificial barricades of a minimum width of 3 feet at the top with sides sloped and with proper anchorage to give stability against overturning forces are approved for reducing quantity-distance requirements for a maximum of 50,000 pounds of high explosives. For quantities in excess of 50,000 pounds, natural or single-revetted barricades as described above are the only types approved, the one exception being the barricade incorporated in the design of ammonium nitrate grain-ing buildings. Material for earth cover over magazines and for barricades shall be a select cohesive material, free from deleterious organic matter, trash, debris, frozen material and stones heavier than 10 pounds or larger than 6 inches. The larger stones should be predominantly limited to the lower center of fills, and to the extent practicable, restricted from earth cover over magazines. Compaction and surface preparation shall be provided as necessary to maintain structural integrity and erosion protection. The minimum depth of earth cover to be maintained over magazines shall not be less than 2 feet. The revetted sides of barricades may be a concrete, masonry, or timber wall.

*b. Inspection.* Barricades shall be inspected periodically to determine the degree of settling. When

settling has occurred to the extent that the barricade no longer provides effective protection, fill shall be added in the amount necessary. Inspection shall also be made of wood-revetted barricades, and rotted timbers of planking, affecting the strength or effectiveness of the barricade, shall be replaced.

## **1726. MAGAZINES AS BARRICADED STRUCTURES**

a. For quantity-distance purposes, ammunition and explosives storage magazines utilized by AMC are referred to by type as follows:

- (1) Standard igloo magazines—earth-covered, reinforced concrete, arch-type magazines (includes Stradley (Yurt) magazines).
- (2) Special use igloo magazines—standard igloo magazines used for maximum quantities of 100,000 pounds or less of mass-detonating ammunition or explosives.
- (3) Earth-covered, corrugated steel, arch-type, magazines—igloo-type magazines constructed of corrugated rolled structural steel plate according to the approved standard drawings specified in table 1739A.
- (4) Special type magazines—igloo-type magazines with steel (except (3) above) or wood (instead of reinforced concrete) arches and steel, wood or reinforced concrete end walls, and earth-covered reinforced concrete magazines (such as Corbettas, dome or box-type).

(5) Aboveground magazines—any types of magazines constructed above grade, other than earth-covered igloo magazines and special-type magazines. Richmond-type magazines are considered to be barricaded aboveground magazines.

*b.* The “barricaded” distance columns of tables 1736 and 1737 are applicable to igloo and special-type magazines, except when exposure is within the area (in front of the magazines) bounded by lines drawn from the center of the door and inclined  $30^\circ$  on either side of a perpendicular to the door. If the door end is provided with an effective separate barricade (para 1725*a*), the barricaded distance columns are applicable for all exposures.

*c.* The barricaded distance columns of tables 1736 and 1737 are also applicable to effectively barricaded aboveground magazines. To be effectively barricaded, aboveground magazines must be earth-mounded on at least three sides (Richmond type

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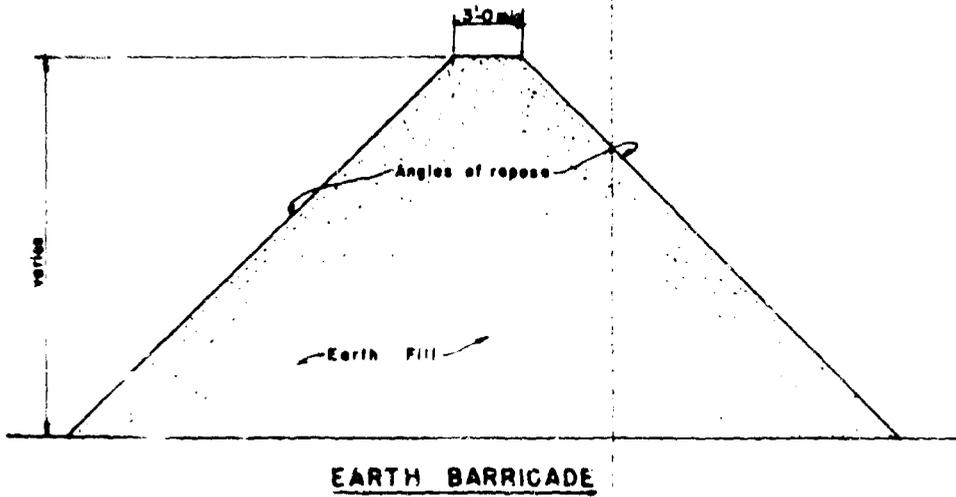
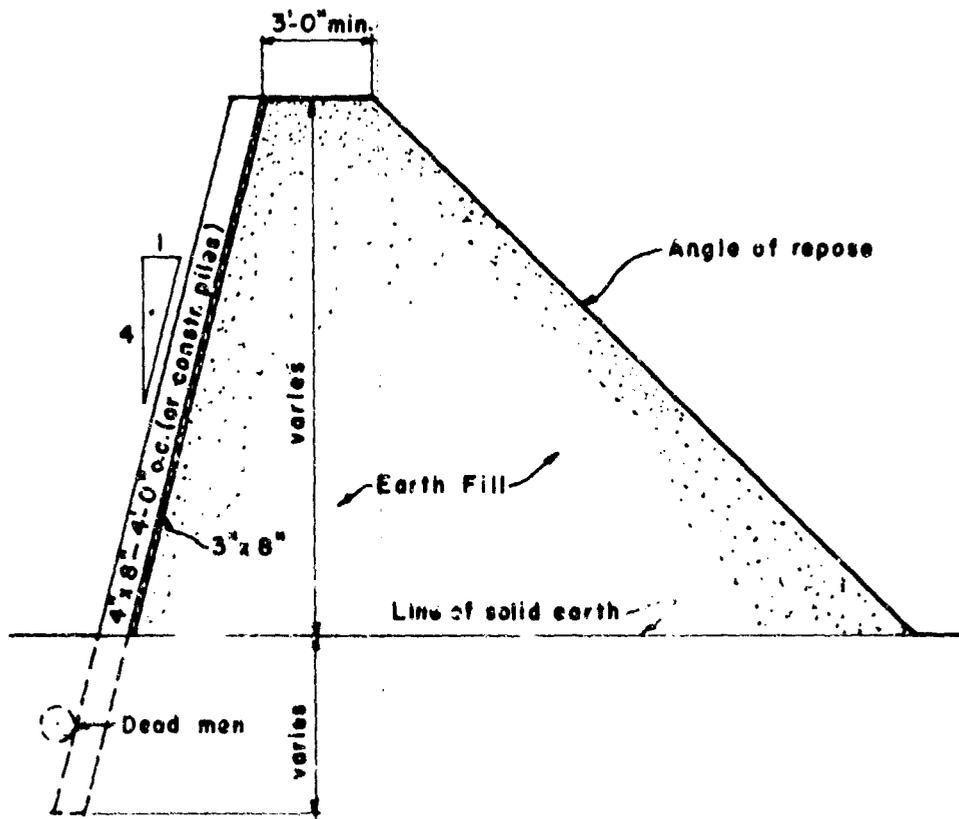


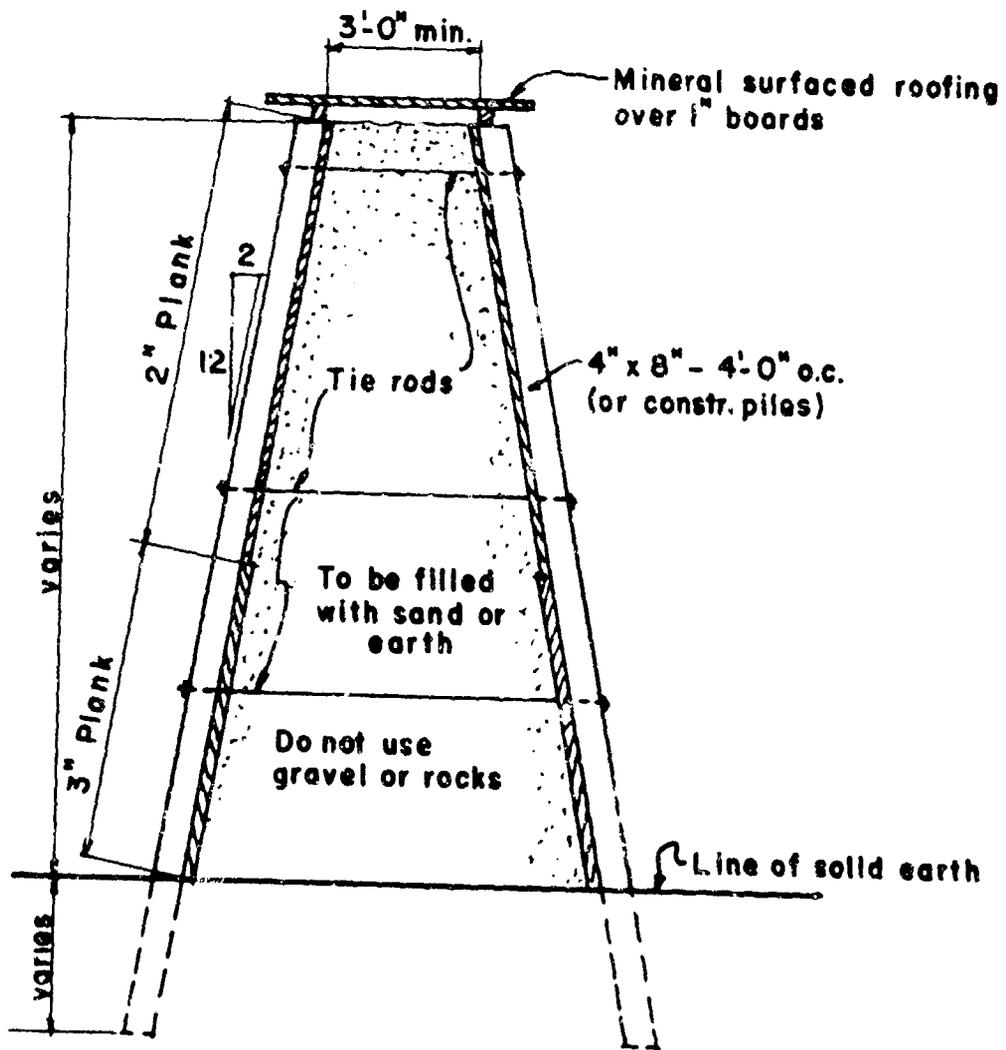
Figure 1725A. Earth barricades.



EARTH BARRICADE REVETTED ON ONE SIDE

Figure 1725A—Continued.

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**EARTH BARRICADE**  
**REVETTED ON TWO SIDES**

Figure 1725A—Continued.

17-28.2

TAGO 7131-C

15 May 1958

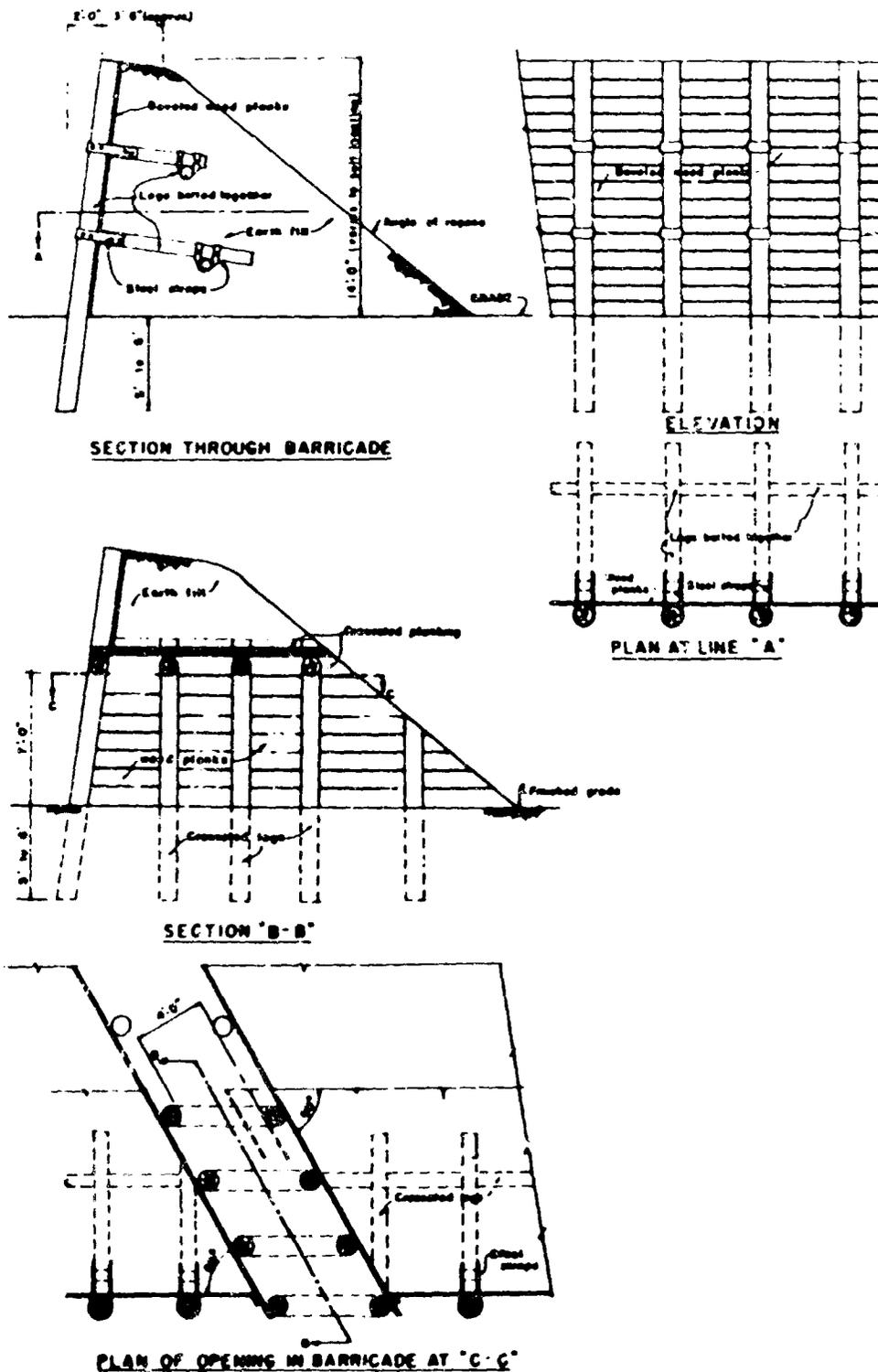


Figure 1725B. Typical earth barricade revetted on one side.



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magazines) or must be separated from other facilities and exposures by natural or artificial barricades meeting the requirements of paragraph 1725a. Unless provided with separate barricades, door ends of Richmond-type magazines are unbarricaded.

*d.* Igloo and special-type magazines are not considered barricaded for material of classes 3, 4, 5, and 6. Distances prescribed in tables 1732 through 1735 for these classes will not be reduced where storage of these classes is in igloo or special-type magazines.

*e.* Quantities of classes 2 and 2A explosives up to 500,000 pounds maximum may be stored in igloo or special-type magazines which are spaced in accordance with the requirements of tables 1738, 1739, and 1739A. Other distances (viz., inhabited building distance, public highway distance, and public railway distance) shall be on an unbarricaded basis, except as specifically indicated by notes applicable to the classes 2 and 2A quantity-distance tables.

*f.* Distances prescribed in classes 3, 4, 5, and 6 quantity-distance tables shall not be reduced where storage of materials of these classes is in barricaded aboveground magazines.

*g.* Separate barricades and earth mounding for aboveground type magazines (*a*(5) above) must be at least 1 foot higher than stacks in the magazines; the requirements of paragraph 1725 are also applicable.

**1727. BARRICADES FOR PYROTECHNICS**

For 100 pounds or less of class 7 pyrotechnic materials in operations or storage, barricading requirements for reducing distances are satisfied by a substantial dividing wall (para 506), provided the explosives are not less than 4 feet from the wall. For more than 100 pounds of class 7 pyrotechnics, the requirements of normal barricading apply.

**1728. QUANTITY-DISTANCE STANDARDS FOR AIRFIELDS, HELIPORTS AND SEADROMES (Revised)**

a. Ammunition, explosives and ammunition facilities shall not be located in areas where prohibited (figures 1728A and 1728B) at airfields, heliports, and seadromes, nor at distances less than specified in tables 1728 and 1729 from facilities listed in table 1728B. The provisions of this paragraph do not apply to:

- (1) Ammunition and explosive facilities built underground or into the sides of hills; because of the variables involved, such sitings will be given special consideration on a case-by-case basis.
- (2) Ammunition and explosive items contained in survival and rescue kits aboard aircraft.

b. For the purpose of this manual:

- (1) *Non-DOD components* shall mean any entity (Government, private, or corporate) which is not a part of the Department of Defense.

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- (2) *Ammunition and explosives* as used herein includes (but is not necessarily limited to) all items of ammunition; chemical propellants, liquid and solid, high and low explosives; guided missiles; warheads; devices; signals; components thereof, including chemical, biological, and radiological (CBR) fillers and substances associated therewith presenting real or potential hazards to life and property.
- (3) *Aircraft parking area* is any area set aside for parking aircraft not containing explosives.
- (4) *Combat aircraft parking area* is any area specifically designated for:
  - (a) Loading or unloading combat-type aircraft with ammunition and explosives.
  - (b) Parking combat-type aircraft loaded with ammunition and explosives.
- (5) *Ammunition and explosives cargo area* is any area specifically designated for:
  - (a) Ammunition and explosives loading/unloading cargo-type aircraft.
  - (b) Parking loaded cargo-type aircraft containing ammunition and explosives as cargo.
- (6) *Explosives facility* is any structure or location containing ammunition and explosives, excluding combat-aircraft parking areas or ammunition and explosives cargo areas.
- (7) *Prohibited area* is a specifically designated

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area, at the ends of each runway, in which all ammunition and explosives facilities are prohibited (see sketches).

(8) *Runway.*

(a) Any surface on land designated for aircraft take-off and landing operations.

(b) A designated lane of water for take-off and landing operations of seaplanes.

(9) *Taxiway/taxilane* is any surface, designated as such in the basic airfield clearance criteria specified by DOD component publications and Federal Aviation Regulation, as published at 14CFR77.

c. These quantity-distances apply:

(1) To all airfields, heliports, and seadromes used exclusively by DOD components or used jointly with non-DOD components at which ammunition and explosives are handled or stored.

(2) To all construction started after 17 April 1967. Reasonable efforts should be made to bring existing facilities or those in late stages of planning up to these standards. (Formal waivers or exemptions are required for all violations, whether existing or new, in order that commanders of military installations may be kept aware of the existence of such violations.)

(3) In conjunction with airfield clearance criteria as prescribed by DOD component publications and Federal Aviation Regula-

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tion, as published at 14CFR77. In the application of airfield clearance criteria, these quantity-distance standards will be applied as indicated below:

- (a) DOD components use only airfields, heliports, and seadromes. Combat-aircraft parking areas, ammunition and explosives cargo areas, alert hangars and shelters may be located within the airfield clearance zone insofar as these quantity-distance standards are concerned, except in the explosives prohibited areas as shown on figures 1728A and 1728B.
- (b) Joint use DOD/non-DOD component airfields, heliports, and seadromes. Combat-aircraft parking areas, ammunition and explosives cargo areas, alert hangars and shelters will be located as prescribed in Tables 1728 and 1729, except that these locations in relation to the taxiways which are used exclusively for DOD component aircraft and are constructed as a part of the location, no quantity-distance separation is required.
- (c) Passenger transport operations conducted at DOD component airfields shall be made subject to the same quantity-distance requirements as joint use DOD/non-DOD component airfields, heliports, and seadromes except when operational necessity dictates no quantity-distance is assigned

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from runways and taxiways to aircraft containing ammunition and explosives.

*d.* Ammunition and explosives facilities shall be separated from inhabited buildings, passenger-carrying railroads, public highways and other ammunition and explosives facilities in accordance with Section 15 and Tables 1730 through 1736.

*e.* In applying the standards prescribed in Tables 1728 and 1729, distances shall be measured as follows:

- (1) Loaded Aircraft to Loaded Aircraft—measure the shortest distance between explosives on one aircraft to explosives on adjacent aircraft.
- (2) Ammunition and Explosives Location to Taxiways and Runways—measure from the nearest point of the ammunition and explosives location to the nearest point of the taxiway and to the centerline of the runway or the runway extended.

*f.* Separation distances between the following areas and from these areas to other targets shall be determined by applying Tables 1728 and 1729:

- (1) Combat Aircraft Parking Area.
- (2) Ammunition and Explosives Cargo Area.
- (3) Ammunition and Explosives Storage Facilities.
- (4) Ammunition and Explosives Operating Facilities.

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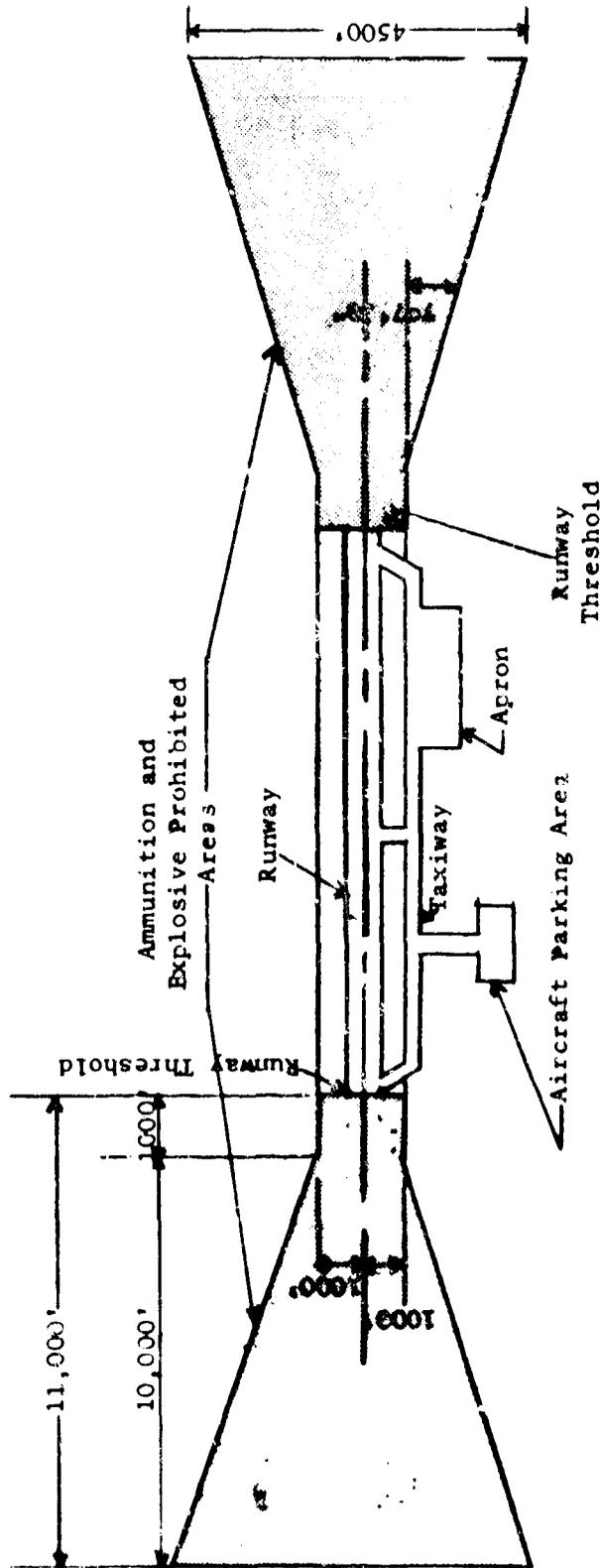


Figure 1728A. Diagram of ammunition and explosives prohibited areas. Airfields for rotary wing aircraft under IFR conditions and airfields for fixed wing aircraft under IFR and VFR conditions.

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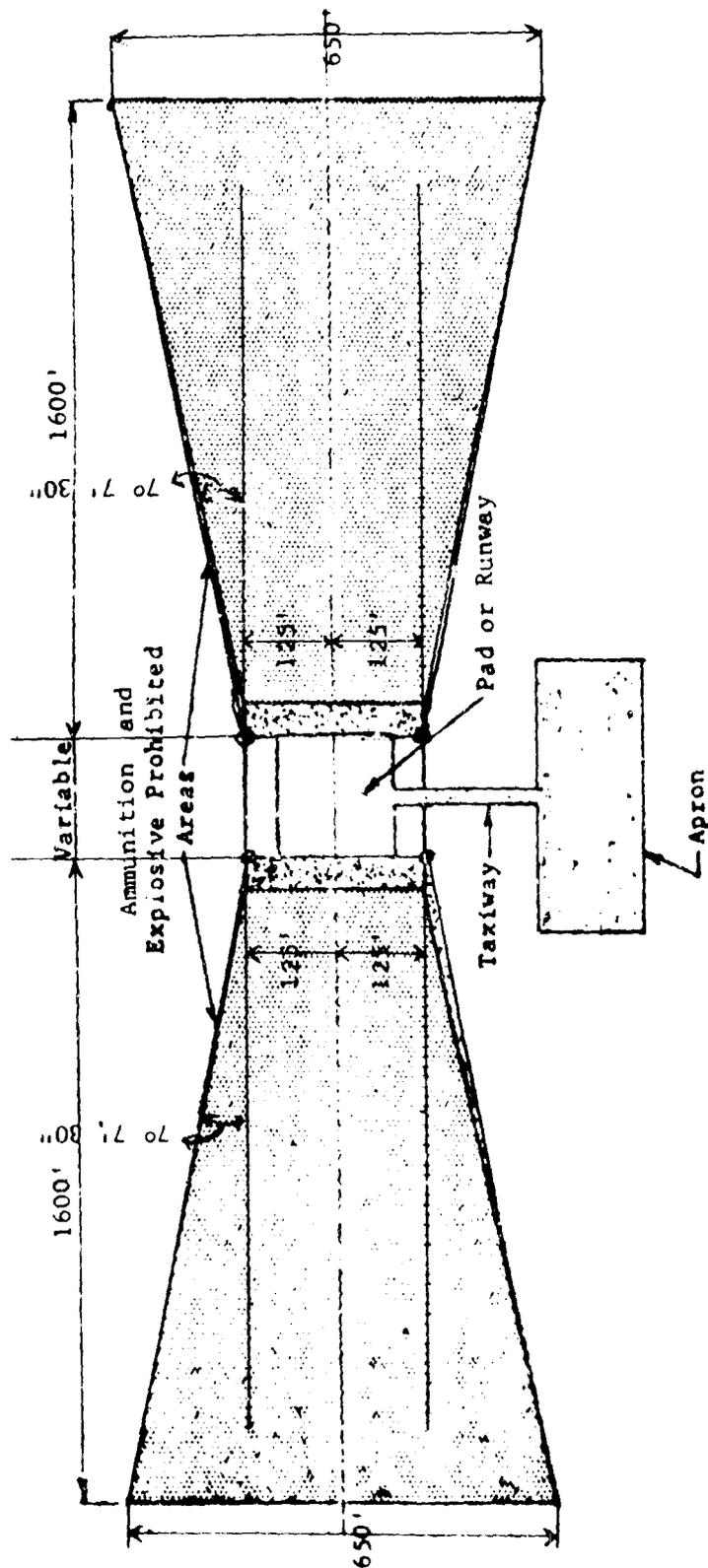


Figure 1728B. Diagram of ammunition and explosives prohibited areas for rotary wing aircraft under VFR conditions.

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Table 1728. Quantity-Distance Standards for Mass-Detonating Military Explosives and Ammunition

Net pounds of explosives		Distance in feet from ammunition and explosives facilities and locations to runways, taxiways, and aircraft parking areas		Distance in feet for specific targets indicated in Table 1729
		Joint DOD/Non-DOD component		
Over	Not over	Bar	Unbar	Unbarricaded**
1	2	3	4	5
0	50	75	1235	110
50	100	120	1235	140
100	200	180	1235	175
200	300	260	1235	200
300	400	320	1235	220
400	500	360	1235	240
500	600	400	1235	255
600	700	430	1235	265
700	800	460	1235	280
800	900	490	1235	290
900	1000	510	1235	300
1000	1500	530	1235	345
1500	2000	630	1235	380
2000	3000	720	1235	435
3000	4000	795	1235	480
4000	5000	855	1235	515
5000	6000	910	1235	545
6000	7000	955	1235	575
7000	8000	1000	1235	600
8000	9000	1040	1235	625
9000	10,000	1075	1235	645
10,000	*15,000	1235	1235	740
15,000	20,000		1355	815

See footnotes at end of table.

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Table 1728. Quantity-Distance Standards for Mass-Detonating Military Explosives and Ammunition—Continued

Net pounds of explosives		Distance in feet from ammunition and explosives facilities and locations to runways, taxiways, and aircraft parking areas		Distance in feet for specific targets indicated in Table 1729
		Joint DOD/Non-DOD component		
Over	Not over	Bar	Unbar	Unbarricaded**
1	2	3	4	5
20, 000	25, 000	-----	1460	875
25, 000	30, 000	-----	1555	935
30, 000	35, 000	-----	1635	980
35, 000	40, 000	-----	1710	1025
40, 000	45, 000	-----	1780	1070
45, 000	50, 000	-----	1840	1105
50, 000	55, 000	-----	1900	1140
55, 000	60, 000	-----	1960	1175
60, 000	65, 000	-----	2010	1205
65, 000	70, 000	-----	2060	1235
70, 000	75, 000	-----	2110	1265
75, 000	80, 000	-----	2155	1295
80, 000	85, 000	-----	2200	1320
85, 000	90, 000	-----	2240	1345
90, 000	95, 000	-----	2280	1370
95, 000	100, 000	-----	2320	1390
100, 000	125, 000	-----	2500	1500
125, 000	150, 000	-----	2655	1595
150, 000	175, 000	-----	2795	1675
175, 000	200, 000	-----	2925	1755
200, 000	225, 000	-----	3040	1825
225, 000	250, 000	-----	3150	1890
250, 000	275, 000	-----	3250	1950

See footnotes at end of table.

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Table 1728. Quantity-Distance Standards for Mass-Detonating Military Explosives and Ammunition—Continued

Net pounds of explosives		Distance in feet from ammunition and explosives facilities and locations to runways, taxiways, and aircraft parking areas		Distance in feet for specific targets indicated in Table 1729
		Joint DOD/Non-DOD component		
Over	Not over	Bar	Unbar	Unbarricaded**
1	2	3	4	5
275, 000	300, 000	-----	3345	2005
300, 000	325, 000	-----	3440	2065
325, 000	350, 000	-----	3525	2115
350, 000	375, 000	-----	3605	2165
375, 000	400, 000	-----	3685	2210
400, 000	425, 000	-----	3760	2250
425, 000	450, 000	-----	3830	2300
450, 000	475, 000	-----	3900	2340
475, 000	500, 000	-----	3970	2380

\* For quantities up to 15,000 lbs. which are effectively barricaded, the barricaded distances may be used if the field clearance criteria permits.

\*\* To protect against low angle high speed missiles, barricades should be provided; however, these distances shall not be reduced.

Table 1729. Application of Ammunition and Explosives Safety Distances

From: ↓	To: ↑	Combat aircraft parking area	Ammunition and explosives cargo area	Ammunition and explosives storage facilities	Ready ammunition storage facilities	Ammunition and explosives operating facilities	Inhabited buildings	Passenger carrying railroads and public highways	Runways and taxiways (DOD component use only)	Runways and taxiways (Joint DOD/Non-DOD component use)	Aircraft parking area	Recreational area	Aircraft passenger loading/unloading area
Combat aircraft parking area		*5	*5	7	*5	7	1	2	None	6	9	8	2 and 10
Ammunition and explosives cargo area		*5	*5	*3	*3	*4	1	2	None	6	9	11	2 and 10
Ammunition and explosives storage facilities		7	3	3	3	4	1	2	7	6	12	11	2 and 10
Ready ammunition storage facilities		*4	*3	4	4	4	1	2	7	6	12	11	2 and 10
Ammunition and explosives operating facilities		*3	*3	3	3	4	1	2	None	6	9	8	2 and 10

Key to Table 1729

1. Use inhabited building distances specified in Section 15 or Tables 1730 through 1736.

2. Use public highway distances specified in Section 15 or Tables 1730 through 1736.
3. Use aboveground magazine distances specified in Section 15 or Tables 1730 through 1735 and 1739.
4. Use intraline distances specified in Section 15 or Tables 1730 through 1735 and 1737.
5. Use aboveground magazine distances specified in Section 15 or Table 1739. For non-mass-detonating explosives, no separation distance is required.
6. Mass-detonating—use Table 1728, columns 3 or 4. Non-mass-detonating—use public highway distance in Section 15 or Tables 1730 through 1735.
7. Mass-detonating—use Table 1728, column 5. Non-mass-detonating—use public highway distance in Section 15 or Tables 1730 through 1735.
8. No distance required to recreational areas which are used exclusively for alert personnel manning the combat loaded aircraft. Other recreational areas, where people are in the open, shall be separated by public highway distance, as specified in Section 15 or Tables 1730 through 1736. When structures, including bleacher stands, are a part of such area, inhabited building distances, as specified in Section 15 or Tables 1730 through 1736 shall be used.
9. DOD components use airfields, heliports and seadromes, the separation of aircraft parking areas from combat-aircraft parking areas and their ready ammunition storage facilities and ammunition and explosives cargo area are considered to be a command function. Joint DOD/non-DOD components use airfields, heliports and seadromes, the combat-aircraft parking area and its ready ammunition storage facilities and ammunition and explosives cargo area will be separated from Non-DOD component aircraft as specified in Item 6 above.
10. This area pertains to the location in the open where passengers emplane or deplane. It does not include any structure where passengers assemble, such as passenger terminal buildings.
11. Recreational areas, where people are in the open, shall be separated by public highway distances, as specified in Section 15 or Tables 1730 through 1736. When structures, including bleacher stands are a part of such area, inhabited building distances, as specified in Section 15 or Tables 1730 through 1736 shall be used.
12. Separation of ammunition and explosives storage or operating facilities from DOD component aircraft parking areas use Table 1728, Column 5, and Item 6 above from Non-DOD component aircraft.

**\*CAUTION—**The magazine and intraline distances specified above will provide protection only, against the simultaneous detonation of mass-detonating explosives on adjacent aircraft. This distance does not provide protection against the propagation from the source of the explosions by blast, fragments, debris, or fire to the ammunition and explosives on adjacent aircraft. Explosives loaded aircraft separated at magazine or intraline distances will probably suffer structural damage so severe as to necessitate salvage or result in complete loss of the aircraft. If protection to aircraft is desired, inhabited building distance or some other means must be provided.

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## 1729. INTERPRETATION OF TABLES

a. Explosives and ammunition are segregated into classes as indicated in the following tables.

b. The list of items in each class is representative of the type of product in that class, but does not necessarily contain all articles which may be included in the classification.

*Table 1730. Class 1—Quantity-Distance*

The items of this class are principally fire hazards and no quantity-distances are assigned for storage of limited quantities of supply necessary to service operating or manufacturing buildings, proof or test ranges, or other locations where relatively small quantities of this class of material are required. For bulk storage, the following distances apply:

Quantity	Unbarricaded distance in feet			
	Inhabited building	Public highway and railway	Intraline	Magazine
No limit.....	100	100	100	180

<sup>1</sup> If storage structure is combustible, 100 feet is required.

### *Items Included in Class 1*

1. Aluminum powder (packed and stored in original shipping containers or equivalent).
2. Ammunition, caliber 20mm or less (including AP-I, but excluding HE and HE-I, and 20mm incendiary rounds).
3. Charge, spotting, AP, practice M8.
4. Chlorates (packed and stored in original shipping container or equivalent).
5. Corporal, actuator, assembly propellant valve, quick release.
6. Cutter, reefing line.
7. Explosive bellows.
8. Firing devices.
9. Fuse lighters.
10. Fuse, safety.

(Next page is 17-45)

11. Fuzes (packed in accordance with approved Ordnance drawings depicting issue package) without boosters, of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT T316E2, MT T342, MT M522, MT M523, and TSQ M55.
12. Ignition cartridges for mortar ammunition.
13. Magnesium powder (packed and stored in original shipping containers or equivalent).
14. Mines, AP, practice, T34.
15. Nitrates, inorganic (packed and stored in original shipping containers or equivalent) (par. 1315b(4)).
16. Perchlorates (packed and stored in original shipping containers or equivalent).
17. Peroxides (except high strength hydrogen peroxide, packed and stored in original shipping containers or equivalent).
18. Primed cartridge cases (without propellant).
19. Squibs, commercial.
20. Thermite.
21. Zirconium (types I & II, spec. FED.-1655, packed and stored in original shipping containers or equivalent).

Table 1731. Class 2—Quantity—Distance

Materials packed in approved storage containers and/or cartridge cases.

Quantity		Unbarricaded distance in feet*		
Pounds (over)	Pounds (not over)	Inhabited building distance	Public highway and public railway distances	Magazine and intraline distance
100	1,000	75	75	50
1,000	5,000	115	115	75
5,000	10,000	150	150	100
10,000	20,000	190	190	125
20,000	30,000	215	215	145
30,000	40,000	235	235	155
40,000	50,000	250	250	165
50,000	60,000	260	260	175
60,000	70,000	270	270	185
70,000	80,000	280	280	190
80,000	90,000	295	295	195
90,000	100,000	300	300	200
100,000	200,000	375	375	250
200,000	300,000	450	450	300
300,000	400,000	525	525	350
400,000	500,000	600	600	400

\* Distances are not to be reduced due to the presence of barricades (para. 1726a and 1726e).

Table No. 1731. Class 2—Quantity-distance—Continued

Solid propellants (smokeless powder) in bulk and not in containers such as found in dry houses, blending operations, bag loading, etc.

Quantity		Unbarricaded distance in feet*		
Pounds (over)	Pounds (not over)	Inhabited building distance	Public highway and public railway distances	Magazine and intra-line distance
100	1,000	100	100	50
1,000	5,000	150	150	75
5,000	10,000	200	200	100
10,000	20,000	250	250	125
20,000	30,000	285	285	145
30,000	40,000	310	310	155
40,000	50,000	330	330	165
50,000	60,000	345	345	175
60,000	70,000	360	360	185
70,000	80,000	375	375	190
80,000	90,000	390	390	195
90,000	100,000	400	400	200
100,000	200,000	500	500	250
200,000	300,000	600	600	300

\*Distances are not to be reduced due to the presence of barricades (pars. 1725a and 1726e).

*Items Included in Class 2*

1. Ball, cellulose nitrate, powder-filled.
2. Bomb, photoflash, M122, w/o burster.
3. Chemical ammunition, groups C and D when not assembled with explosive components.
4. Grenades, illuminating.
5. Military pyrotechnics (exclusive of classes 4 and 9 items).
  - a. Flares.
  - b. Illuminants.
  - c. Incendiary ammunition including projectiles, bombs, grenades, and exclusive of HE-I rounds.
  - d. Igniters and tracer units (for ammunition).
  - e. Signals, including signal lights, smoke signals, and obscuring smoke.

*Note.* When the above listed items are packed and ready for shipment they may be stored at one-half the applicable class 2 quantity-distance requirements.

6. Deleted.
7. Projectiles, illuminating, when not assembled with explosive components.
8. Propellant, type N-5, in carpet rolls.
9. Propellant grains, polysulfide-perchlorate, containing not more than 74 percent oxidizer.

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10. Pyrotechnic materials (exclusive of class 7 items) when not packed or stored in original shipping containers or equivalent, such as:
  - a. Chlorates.
  - b. Illuminating, flare or signal compositions which have been consolidated in the final press operations.
  - c. Perchlorates.
  - d. Peroxides.
  - e. Powdered metals (including zirconium, types I and II, specification FED-1655).
  - f. Thermite and other similar incendiary compositions.
11. Rocket heads WP loaded, when not assembled with explosive components.
12. Rockets (in the nonpropulsive state), with inert heads and rocket motors loaded with class 2 propellant.
13. Spotting charges (cartridges for miniature practice bombs).
14. Rocket motors, in nonpropulsive state, containing class 2 propellant.
15. Rockets, Mk2 with inert heads, in Mk1 Mod 0 metal containers.
16. Propellant, solid (smokeless powder), single base, multiperforated having a web thickness greater than 0.019 inch (excluding single base propellant containing 98 percent or more nitrocellulose).
17. Double-base and composite rocket propellants that have been determined to be nonmass

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detonating in tests conducted in accordance with TB 700-2.

18. (Added) Ammonium nitrate (not packed and stored in original shipping container or equivalent) that is exposed only to such fire hazard materials as other items in this class.
19. (Added) DNT that is exposed only to such fire hazard materials as other items in this class.
20. (Added) Nitrocellulose, wet, containing from 8 to 30 percent water that is exposed only to such fire hazard materials as other items in this class.
21. (Added) Detonating cord (PRIMACORD) that is exposed only to such fire hazard materials as other items in this class.

*Table 1731 A. Class 2A—Quantity-Distance*

Quantity of explosives		Unbarricaded distance in feet from nearest—		
Pounds (over)—	Pounds (not over)—	Inhabited building	Public railway or highway	Magazine (inraline distance)
(1)	(2)	(3)	(4)	(5)
50	250	50	50	35
250	500	75	75	50
500	2,500	115	115	75
2,500	5,000	150	150	100
5,000	10,000	190	190	125
10,000	15,000	215	215	145

Table 1731A. Class 2A—Quantity-Distance—Continued

Quantity of explosives		Unbarricaded distance in feet from nearest—		
Pounds (over)—	Pounds (not over)—	Inhabited building	Public railway or highway	Magazine (intraline distance)
(1)	(2)	(3)	(4)	(5)
15, 000	20, 000	235	235	155
20, 000	25, 000	250	250	165
25, 000	30, 000	260	260	175
30, 000	35, 000	270	270	185
35, 000	40, 000	280	280	190
40, 000	45, 000	295	295	195
45, 000	50, 000	300	300	200
50, 000	100, 000	375	375	250
100, 000	150, 000	450	450	300
150, 000	200, 000	525	525	350
200, 000	<sup>1</sup> 250, 000	600	600	400
250, 000	300, 000	675	675	450
300, 000	350, 000	750	750	500
350, 000	400, 000	825	825	550
400, 000	450, 000	900	900	600
450, 000	<sup>2</sup> 500, 000	975	975	650

<sup>1</sup> Maximum quantity permitted in a single aboveground magazine or operating building.

Distances in cols. 3, 4, and 5 apply to unbarricaded magazines. If the magazines or operating buildings are barricaded, the quantity of propellant may be limited in accordance with the unbarricaded class 2 distances, but the maximum quantity will not exceed 250,000 pounds except as provided in para. 1726e.

Distances in col. 5 are applicable between all operating buildings and/or service magazines in a single line or area within the plant boundary and are applicable between magazines in storage areas.

Distances shown in col. 3 are applicable between separate operating lines or areas except as provided in para. 1731a.

<sup>2</sup> Maximum quantity permitted in earth-covered magazine (para. 1726e).

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*Items Included in Class 2A\**

1. Any double-base propellants containing not more than 20 percent nitroglycerin and having a web thickness of 0.0075 inch or greater.
2. M15 and M17 nitroguanidine propellants.
3. Multiperforated cannon and rifle propellant having a web thickness not greater than 0.019 inch.
4. Single base (FNH and NH compositions), single perforated cannon propellant having a web thickness not greater than 0.035 inch.
5. Single base, single perforated rifle propellant.
6. Single base pistol, shotgun, and similar low-pressure propellants.

*Table 1732. Class 3—Quantity-Distance*

Quantity	Unbarricaded distance in feet		
	Inhabited building distance	Public railway and highway distances	Intraline and magazine distance
Pounds of explosives (not over)			
No limit	400	400	200

*Items Included in Class 3*

1. Charge, igniter, assembly, for fuze, M10 and M10A1.

\*Propellants listed are considered class 2A when stored in metal-lined wooden boxes; class 7 when stored in all-metal boxes.

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2. Detonator, concussion type, M1.
3. Fuzes (packed in accordance with approved drawings depicting issue package)—fuzes (with boosters assembled thereto) of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT T316E2, MT T342, MT M522, MT M523, and TSQ M55; artillery-type proximity fuzes with boosters, and other fuzes without boosters, except fuzes chemically actuated containing ampules which may initiate, directly or indirectly, explosives and explosives loaded components, which are assembled in the conventional manner to form the finished explosive fuze.
4. Grenades, practice, with spotting charge.
5. Igniters, rocket motor, electric (except those listed as class 7).
6. Igniters for rockets (e.g., M12, M18, and M20).
7. Mines, practice, with spotting charge and/or fuze (except mine, AP, practice, T34).
8. Primers, artillery and cannon.
9. Primer detonators.
10. Simulator, M116.
11. (Added) Ammunition, caliber 20mm or less, HE and HE-I and 20mm incendiary rounds (excluding 20mm API).

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Table 1733. Class 4—Quantity-Distance

Quantity	Unbarricaded distance in feet			
	Inhabited building	Public highway and railway	Intraline	Magazine
Pounds of explosives (not over)				
500,000	800	800	See note	300

*Note.* Use intraline distances in table 1737 for like amounts of high explosives. The maximum required intraline distance for this class is 400 feet.

*Items Included in Class 4*

Items in this class must be packaged for shipment in accordance with approved drawings and specifications.

1. Ammunition, blank and saluting, cannon.
2. Ammunition, fixed and semifixed, 37mm through 81mm (excluding 81mm M56), loaded with Ammonal, Amatol, Composition B, Explosive D, or TNT.
3. Ammunition, fixed and semifixed, 37mm through 106mm, with inert projectiles.
4. Cartridge, HE, colored marker.
5. Cartridge, Illuminating.
6. Mines, Antipersonnel (bounding type).

Table 1734. Class 5—Quantity-Distance

Quantity	Unbarricaded distance in feet*			
	Inhabited building	Public highway and railway	Intraline	Magazine
500,000	1,200	1,200	See note	300

*Note.* Use intraline distance in table 1737 for like amounts of explosives. The maximum required intraline distance is 600 feet.

\*Paragraphs 1726d and 1726f regulate the reduction of distances due to the presence of barricades.

#### Items Included in Class 5

Items in this class must be packaged for shipment in accordance with approved drawings and specifications.

1. Ammunition, fixed and semifixed, 90mm through 106mm, loaded with Ammonal, Amatol, Composition B, Explosive D, or TNT.
2. Ammunition, fixed and semifixed, above 106mm, with inert projectiles.
3. Bombs, chemical loaded, with explosive burster.
4. Chemical ammunition (except rockets) groups A, B, C, and D, assembled with explosive components.
5. Rocket motors (without explosive warheads), containing class 2 propellant and in a propulsive state.
6. Rockets, chemical, complete round, when assembled with explosive components.
7. Projectives loaded with Explosive D, not assembled to or packed with cartridge cases.

Table 1735. Class 6—Quantity-Distance

Quantity	Unbarricaded distance in feet*			
	Inhabited building	Public highway and railway	Intraline	Magazine
500,000	1,800	1,800	See note	300

*Note.* Use intraline distances in table 1737 for like amounts of high explosives. The maximum required intraline distance for this class is 450 feet.

\*Paragraphs 1726d and 1726f regulate the reduction of distances due to the presence of barricades.

*Items Included in Class 6*

Items in this class must be stored in stacks containing not more than 15,000 pounds of HE, with stacks spaced in accordance with Ordnance drawing 19-48-3318(2E11). If these stacking requirements are not satisfied, the quantity-distance requirements (including the maximum permitted in a magazine) for class 7 ammunition must be satisfied, however, distances shall not be less than those specified in this table (1735).

1. Projectile, HE fuzed or unfuzed, loaded with Ammonal, Amatol, or TNT (except projectile, HE for 280mm gun).
2. Projectiles, 120mm, loaded with Composition B.
3. Projectiles and propelling charges, 120mm HE (packed in accordance with approved drawings depicting issue package).

*Table 1736. Class 7—Quantity-Distance—Inhabited Buildings, Public Railways and Public Highways*

Net pounds explosives		Distance in feet from explosive hazard—			
Over	Not over	To inhabited buildings		To public railways and public highways	
		Bar	Unbar	Bar	Unbar
0	1	40	80	25	50
1	2	50	100	30	60
2	5	70	140	40	85
5	10	90	180	55	110
10	20	110	220	65	130
20	30	125	250	75	150
30	40	140	280	85	170
40	*50	150	300	90	180
50	100	190	380	115	230
100	200	235	470	140	280
200	300	270	540	160	320
300	400	295	590	175	350
400	500	320	640	190	380
500	600	340	680	205	410
600	700	355	710	215	430
700	800	375	750	225	450

See footnote at end of table.

Table 1736. Class 7—Quantity-Distance—Inhabited Buildings,  
Public Railways and Public Highways—Continued

Net pounds explosives		Distance in feet from explosive hazard—			
Over	Not over	To inhabited buildings		To public railways and public highways	
		Bar	Unbar	Bar	Unbar
800	900	390	780	235	470
900	1,000	400	800	240	480
1,000	1,500	460	920	275	550
1,500	2,000	505	1010	305	610
2,000	3,000	580	1160	350	700
3,000	4,000	635	1270	380	760
4,000	5,000	685	1370	410	820
5,000	6,000	730	1460	440	880
6,000	7,000	770	1540	460	920
7,000	8,000	800	1600	480	960
8,000	9,000	835	1670	500	1000
9,000	10,000	865	1730	520	1040
10,000	15,000	990	1780	595	1070
15,000	20,000	1090	1950	655	1170
20,000	25,000	1170	2110	700	1265
25,000	30,000	1245	2260	745	135
30,000	35,000	1310	2410	785	1445
35,000	40,000	1370	2550	820	1530
40,000	45,000	1425	2680	855	1610
45,000	50,000	1470	2800	880	1680
50,000	55,000	1520	2920	910	1750
55,000	60,000	1570	3030	940	1820
60,000	65,000	1610	3130	965	1880
65,000	70,000	1650	3220	990	1930
70,000	75,000	1690	3310	1015	1985
75,000	80,000	1725	3390	1035	2035
80,000	85,000	1760	3460	1055	2075
85,000	90,000	1790	3520	1075	2110

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Table 1736. Class 7—Quantity-Distance—Inhabited Buildings, Public Railways and Public Highways—Continued

Net pounds explosives		Distance in feet from explosive hazard—			
Over	Not over	To inhabited buildings		To public railways and public highways	
		Bar	Unbar	Bar	Unbar
90,000	95,000	1825	3580	1095	2150
95,000	100,000	1855	3630	1115	2180
100,000	125,000	2115	3670	1270	2200
125,000	150,000	2350	3800	1410	2280
150,000	175,000	2565	3930	1540	2360
175,000	200,000	2770	4060	1660	2435
200,000	225,000	2965	4190	1780	2515
225,000	250,000	3150	4310	1890	2585
250,000	275,000	4430	4430	2660	2660
275,000	300,000	4550	4550	2730	2730
300,000	325,000	4670	4670	2800	2800
325,000	350,000	4780	4780	2870	2870
350,000	375,000	4890	4890	2935	2935
375,000	400,000	5000	5000	3000	3000
400,000	425,000	5110	5110	3065	3065
425,000	450,000	5210	5210	3125	3125
450,000	475,000	5310	5310	3185	3185
475,000	500,000	5410	5410	3245	3245

\*The distances for 1 to 50 lbs. may be used only when structures or blast mats can completely confine fragments and debris. Lesser distances in specific cases may only be approved if both blast and fragments can be completely confined as in certain test-firing barricades.

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Table 1737. Class 7—Quantity-Distance—Intraline Separations

Net pounds of explosives		Distance in feet	
Over—	Not over—	Barricaded	Unbarricaded
	50	30	60
50	100	40	80
100	200	50	100
200	300	60	120
300	400	65	130
400	500	70	140
500	600	75	150
600	700	80	160
700	800	85	170
800	900	90	180
900	1, 000	95	190
1, 000	1, 500	105	210
1, 500	2, 000	115	230
2, 000	3, 000	130	260
3, 000	4, 000	140	280
4, 000	5, 000	150	300
5, 000	6, 000	160	320
6, 000	7, 000	170	340
7, 000	8, 000	180	360
8, 000	9, 000	190	380
9, 000	10, 000	200	400
10, 000	15, 000	225	450
15, 000	20, 000	245	490
20, 000	25, 000	265	530
25, 000	30, 000	280	560
30, 000	35, 000	295	590
35, 000	40, 000	310	620
40, 000	45, 000	320	640
45, 000	50, 000	330	660
50, 000	55, 000	340	680

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Table 1737. Class 7—Quantity-Distance—Intraline Separations—Continued

Net pounds of explosives		Distance in feet	
Over—	Not over—	Barricaded	Unbarricaded
55, 000	60, 000	350	700
60, 000	65, 000	360	720
65, 000	70, 000	370	740
70, 000	75, 000	385	770
75, 000	80, 000	390	780
80, 000	85, 000	395	790
85, 000	90, 000	400	800
90, 000	95, 000	410	820
95, 000	100, 000	415	830
100, 000	125, 000	450	900
125, 000	150, 000	475	950
150, 000	175, 000	500	1, 000
175, 000	200, 000	525	1, 050
200, 000	225, 000	550	1, 100
225, 000	250, 000	575	1, 150
250, 000	300, 000	600	1, 200
300, 000	350, 000	635	1, 275
350, 000	400, 000	665	1, 330
400, 000	450, 000	690	1, 380
450, 000	500, 000	715	1, 430

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Table 1738. Class 7—Quantity-Distance Intermagazine Separations Standard Igloo (Arch Type) Magazines

Net pounds of explosives		Distance in feet between magazines			
Over—	Not over—	Igloo magazine		Special use magazine <sup>a</sup>	
		Barri- caded <sup>b</sup>	Unbarri- caded <sup>c</sup>	Barri- caded <sup>b</sup>	Unbarri- caded <sup>c</sup>
0	4, 000	-----	-----	35	70
4, 000	10, 000	-----	-----	50	100
10, 000	30, 000	-----	-----	75	140
30, 000	50, 000	-----	-----	85	165
50, 000	70, 000	-----	-----	95	185
70, 000	100, 000	-----	-----	110	210
0	250, 000	<sup>d</sup> 185	<sup>d</sup> 360	-----	-----
0	500, 000	<sup>e</sup> 185	<sup>e</sup> 360	-----	-----

<sup>a</sup> Construction is relatively comparable to that described by note <sup>e</sup> below (para. 1726a(2)).

<sup>b</sup> Barricaded, as used in this table, means that an earth-covered side or back of one magazine faces an earth-covered side or back of another magazine. If door-end barricades are provided, barricaded distances may be used regardless of orientation.

<sup>c</sup> Unbarricaded, as used in this table, means that an unbarricaded door-end of one magazine faces an earth-covered side or back of another magazine.

<sup>d</sup> Construction is not equivalent in strength to the requirements of OCE drawings 652-686 through 652-693, 27 December 1941, revised 14 March 1942.

<sup>e</sup> Construction is at least equivalent in strength to the requirements of OCE drawings 652-686 through 652-693, 27 December 1941, revised 14 March 1942.

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Table 1739. Class 7—Quantity-Distance Intermagazine Separations Special Type and Aboveground

Net pounds of explosives		Distance in feet between magazines			
Over—	Not over—	Special type		Aboveground	
		Barri- caded <sup>a</sup>	Unbarri- caded <sup>b</sup>	Barri- caded	Unbarri- caded
0	100	20	40	30	50
100	500	35	70	50	85
500	1, 000	45	90	60	110
1, 000	2, 000	55	110	75	140
2, 000	3, 000	65	130	85	160
3, 000	4, 000	70	140	95	175
4, 000	5, 000	75	150	105	190
5, 000	7, 500	85	170	115	215
7, 500	10, 000	95	190	130	235
10, 000	20, 000	120	240	165	300
20, 000	30, 000	140	280	185	340
30, 000	40, 000	155	310	205	375
40, 000	50, 000	165	330	220	405
50, 000	60, 000	175	350	235	430
60, 000	70, 000	185	370	245	455
70, 000	80, 000	195	390	260	475
80, 000	90, 000	200	400	270	495
90, 000	100, 000	210	420	280	510
100, 000	125, 000	225	450	300	550
125, 000	150, 000	240	480	320	585
150, 000	175, 000	250	500	335	615
175, 000	200, 000	265	530	350	645
200, 000	225, 000	275	550	365	670
225, 000	250, 000	285	570	380	695
250, 000	300, 000	300	600	400	735
300, 000	350, 000	315	630	425	775

See footnotes at end of table.

Table 1739. Class 7—Quantity-Distance Intermagazine Separations Special Type and Aboveground—Continued

Net pounds explosives		Distance in feet from explosive hazard			
Over	Not over	Special type		Aboveground	
		Bar <sup>a</sup>	Unbar <sup>b</sup>	Bar	Unbar
350,000	400,000	330	660	440	845
400,000	450,000	345	690	470	875
450,000	500,000	355	710	475	875

<sup>a</sup> Barricaded, as applied to special-type magazines, means that an earth-covered side or back of one magazine faces and earth-covered side or back of another magazine. If door-end barricades are provided, barricaded distances may be used regardless of orientation.

<sup>b</sup> Unbarricaded, as applied to special-type magazines, means that an unbarricaded door end of one magazine faces an earth-covered side or back of another magazine.

<sup>c</sup> Maximum quantity permitted in any one special-type or aboveground magazine.

Table 1739A. Class 7 <sup>c</sup>—Quantity-Distance—Intermagazine Separations Earth-Covered, Corrugated Steel, Arch-Type, Magazines <sup>a</sup>

Net pounds of explosives		Side to side and side to rear wall	Rear wall to rear wall	Front wall to rear wall or side
Over	Not over			
0	100	<sup>b</sup> 7	<sup>b</sup> 7	<sup>b</sup> 21
100	200	7	9	26
200	300	8	10	30
300	400	9	11	33
400	500	10	12	36
500	600	11	13	40
600	700	11	13	40
700	800	12	14	42

See footnotes at end of table.

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Table 1739A. Class 7<sup>c</sup>—Quantity-Distance—Intermagazine Separations Earth-Covered, Corrugated Steel, Arch-Type, Magazines<sup>a</sup>—Continued

Net pounds of explosives		Side to side and side to rear wall	Rear wall to rear wall	Front wall to rear wall or side
Over	Not over			
800	900	12	14	43
900	1,000	13	15	45
1,000	1,500	14	17	52
1,500	2,000	16	19	57
2,000	3,000	18	22	65
3,000	4,000	20	24	72
4,000	5,000	21	26	77
5,000	6,000	23	27	82
6,000	7,000	24	29	86
7,000	8,000	25	30	90
8,000	9,000	26	31	94
9,000	10,000	27	32	97
10,000	20,000	34	41	122
20,000	30,000	39	47	140
30,000	40,000	43	51	154
40,000	50,000	46	55	165
50,000	60,000	49	59	176
60,000	70,000	52	62	185
70,000	80,000	54	65	194
80,000	90,000	56	67	202
90,000	100,000	58	70	209
100,000	125,000	63	75	225
125,000	150,000	66	80	239
150,000	175,000	70	84	252
175,000	200,000	73	88	263
200,000	225,000	76	91	274
225,000	250,000	79	95	284

See footnotes at end of table.

Table 1739A. Class 7<sup>c</sup>—Quantity-Distance—Intermagazine Separations Earth-Covered, Corrugated Steel, Arch-Type, Magazines<sup>a</sup>—Continued

Net pounds of explosives		Side to side and side to rear wall	Rear wall to rear wall	Front wall to rear wall or side
Over	Not over			
250,000	300,000	54	100	301
300,000	350,000	88	106	317
350,000	400,000	92	111	332
400,000	450,000	96	115	345
450,000	500,000	99	119	357

<sup>a</sup> Structures must be at least equivalent in strength to those shown on Corps of Engineers Drawings Nos. AW 33-15-63 (5 March 1963), AW 33-15-64 (10 May 1963), 33-15-65 (10 January 1963), and the Corps of Engineers standard specifications cited therein.

The earth fill or earth cover between these steel arch magazines may be either solid or sloped in accordance with the requirements of other construction features, but a minimum of 2 feet of earth cover must be maintained over the top of each magazine and a minimum slope of two horizontal to one vertical starting directly above the springline of each arch must be maintained.

<sup>b</sup> Minimum spacing permitted between magazines.

<sup>c</sup> These magazines may be used for the storage of all classes of ammunition and explosives. The magazines will be separated from each other as required by the distances shown, based on the net weight of explosives contained in the magazines. The net weight of explosives will be determined in accordance with paragraph 1709.

#### Items Included in Class 7

1. Baratol.
2. Benite.
3. Black powder, in charges or containers.
4. Boracitol.
5. CBS.
6. Charges, supplementary (HE).
7. Composition A, A-2, and A-3.
8. Composition B.
9. Composition C, C-2, C-3, and C-4.
10. Cyclotol.

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11. Dynamite.
12. EC powder.
13. Explosive D.
14. Explosives, cratering.
15. Flash reducers (black powder with potassium sulfate).
16. HMX.
17. Lead Azide.
18. Lead Styphnate.
19. Mercury fulminate.
20. Minol.
21. MOX.
22. Nitroglycerin.
23. Nitroguanidine.
24. Nitrostarch.
25. Octol.
26. PBX.
27. Pentolite.
28. PETN.
29. Petrin.
30. Photoflash powder.
31. Picric acid.
32. Propellants, solid (class 9):
  - (a) Class 2A propellant in all metal containers not specifically designed for quick release of pressure.
  - (b) Double base, with web thickness of less than 0.0075 inch, regardless of nitroglycerin content.
  - (c) Double base (for artillery ammunition), containing more than 20 percent nitroglycerin.
  - (d) Double base and composite rocket propellants that have been determined to be mass.

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detonating in tests conducted in accordance with paragraph 22, TB 700-2.

- e. Single base propellant, containing 98 percent or more nitrocellulose by weight.
33. Pyrotechnic materials.
- a. In addition to individual listed items in this table, such as items Nos. 3, 15, and 30, this group includes illuminating, flare, signal, tracer, igniter, or explosive incendiary and first fire compositions up to and including final pressing or consolidating operations and including unassembled pellet material and rejected composition held for reworking.
  - b. Quickmatch.
- 34. RDX.
  - 35. Tetracene.
  - 36. Tetranitrocarbazole.
  - 37. Tetryl.
  - 38. TNT.
  - 39. Ammunition, fixed and semifixed, loaded with high explosives other than Ammonal, Amatol, Composition B, Explosive D, or TNT.
  - 40. Ammunition, separate loading, loaded with high explosives other than Ammonal, Amatol, TNT, or Explosive D.
  - 41. Bangalore torpedoes.
  - 42. Bombs, demolition.
  - 43. Bombs, fragmentation. (See table 1904.)
  - 44. Bombs, photoflash (except M122 w/o burster).
  - 45. Booster, Auxiliary.
  - 46. Bursters.

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47. Cartridge, HE, heavy mortar, over 81mm (including 81mm M56).
48. Cartridge, photoflash.
49. Charges, springing, earth rod, blast driven.
50. Classes 4 and 5 items (except chemical and nonexplosive projectiles) not packed in accordance with approved drawings.
51. Class 6 items not stacked in accordance with approved drawings.
52. Demolition blocks.
53. Demolition charges, snake.
54. Destructor, HE, M10.
55. Firecracker, M80.
56. Grenade, fragmentation.
57. Grenade, hand offensive.
58. Grenades, rifle, AT.
59. Igniters, rocket motor, electric, such as M29.
60. Rocket motors containing class 7 propellants.
61. Mines, antipersonnel (cast iron block).
62. Mines, HEAT.
63. Projectile, HE, for 280mm gun.
64. Quick arming device, 318mm rocket.
65. Rocket, HE, complete rounds.
66. Rocket heads, LE loaded.
67. Shaped charges (Engineers).
68. Simulator, M115.
69. Warheads, HE.
70. Adapter-boosters.\*
71. Boosters.\*
72. Cutter, Cable, M1.\*

See footnote on page 17-66.1

73. Fuzes of other than series listed as class 3, with boosters assembled thereto.\*
74. Fuzes, class 3, not packed in accordance with approved drawings depicting issue package.\*
75. Mine, APERS, NM, M14 with integral fuse.\*
76. (Added) Ammonium nitrate that is exposed to detonation hazards at less than intraline distances.
77. (Added) Ammonium perchlorate that is exposed to detonation hazards at less than intraline distances.
78. (Added) DNT that is exposed to detonation hazards at less than intraline distances.
79. (Added) Nitrocellulose, wet, containing from 8 to 30 percent water that is exposed to detonation hazards at less than intraline distances.
80. (Added) Detonating cord (PRIMACORD) that is exposed to detonation hazards at less than intraline distances.
81. (Added) Blasting caps.
82. (Added) Detonators (except concussion type, M1).
83. (Added) Percussion elements.
84. (Added) Primers, electric (for small arms and 20mm ammunition).
85. (Added) Primers, percussion (small arms ammunition).

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\*If these items are stored in stacks containing not more than 5,000 pounds of HE that are separated from each other by at least 2 feet, safety distances may be based on the quantity of HE in the single stack requiring the greatest distance.

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*Table 1740. Class 8—Quantity-Distance*

No quantity-distance tables are established for class 8 items inasmuch as the items assigned to class 8 are not considered explosive hazards.

*Items Included in Class 8*

1. Chemical ammunition, groups A and B, when not assembled with explosive components.

*Table 1741. Hillside and Underground Magazines\**

*Hillside and underground magazines.* When it is necessary to store ammunition and explosives in magazines that will be located beneath the ground or in hillsides, the details of the proposed magazine area, and the type of ground in the area must be submitted to the Commanding General, AMC, ATTN: AMCAD-S, for approval. The accompanying table giving magazine-to-magazine distances may be helpful in planning the area. These magazines are considered barricaded (except the door end of the hillside magazine), and inhabited building distances and public railway and public highway distances will be calculated accordingly, based on the class and quantity of explosives and/or ammunition involved.

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\*This table applies to magazines so constructed that they are covered by earth at least to the highest point reached by explosives stored within them, and separated from each other by continuous ground in such a manner that the level of the separating material does not fall below a plane joining the highest points reached by explosives stored within adjacent magazines.

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*Quantity-Distance Table for Hillside and Underground Magazine Separation*

<i>Quantity of explosives (not over)</i>	<i>Magazines distance (in feet)</i>
20,000.....	100
30,000.....	110
40,000.....	120
50,000.....	130
60,000.....	135
70,000.....	140
80,000.....	145
90,000.....	150
100,000.....	155
125,000.....	165
150,000.....	175
175,000.....	185
200,000.....	190
250,000.....	200

*Table 1745. Underground Utilities Installations—Quantity-Distance*

*Underground utilities installations.* Permanent Government-controlled underground utilities installations (excluding building service lines) as defined in paragraph 276, should be separated from explosives locations containing classes 6, 7, 8, 9, and 10 materials according to the following table. Utilities installations (aboveground and underground) which are privately owned or operated, preferably should be separated from explosives locations by inhabited building distances as set forth in preceding quantity-distance tables for the particular class and quantity of explosives or ammunition involved, particularly when these installations include structures. In no case shall such installation be separated from

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explosives locations by less than public highway distance.

*Schedule of Quantity-Distance Separation for Protection of Underground Service Installations*

<i>Quantity of explosives (not over)</i>	<i>Distance (feet)</i>
100.....	15
200.....	20
500.....	30
1,000.....	40
2,000.....	50
5,000.....	80
10,000.....	100
20,000.....	135
50,000.....	200
100,000.....	275
250,000.....	400

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## SECTION 18

### STORAGE OF EXPLOSIVES AND AMMUNITION

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#### 1801. GENERAL

The types of existing magazines listed below are considered standard for the storage of the types of items specified. For future construction earth-covered reinforced concrete, hillside, and subsurface type magazines should be considered for the storage of ammunition or explosives.

#### 1802. MAGAZINE

*a. Earth-covered magazines.* Earth-covered magazines are preferred and may be used for the storage of all items of ammunition or explosives.

*b. Standard ammunition magazines (commonly called "Standard Magazines"),* classes as above-ground magazines. These magazines were designed for the storage of fixed rounds or separate loading projectiles. For future use, they should be restricted to the storage of classes 1 through 4 materials. The magazines measure 51 feet 7 inches by 218 feet 8 inches, are usually spaced 300 feet apart, and have concrete foundation walls and piers, hollow-tile walls, steel frames, and concrete floors. The storage capacity of the magazines is not stated in definite figures since the number of items which can be stored is regulated by the appropriate quantity-distance tables.

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*c. High explosives and black powder magazines, classed as aboveground magazines.* These magazines were designed for the storage of bulk explosives, such as black powder, TNT, Tetryl, and Explosive D, and may be used for this purpose where more desirable storage space cannot be obtained. These magazines are 27 feet 6 inches wide and 43 feet 4 inches long and are usually spaced 800 feet apart. They have concrete foundation walls and piers, hollow-tile walls filled with sand, steel frames and concrete floors covered with sparkproof, mastic or equal topping. The magazines were originally designed for the storage of 250,000 pounds of explosives but by virtue of aisle space for inspection and shipping and convenient height of piles, the amount of storage is usually limited to approximately 100,000 pounds.

*d. Primer and fuze type magazines, classed as aboveground magazines.* These magazines were designated for storing primers, primer detonators, adapters and boosters and fuzes of all types. In the future, when it is necessary to use magazines of this type, they should be restricted to the storage of classes 1, 2, and 3 ammunition. The magazines are 27 feet 6 inches wide, 43 feet 4 inches long and are usually spaced 300 to 400 feet apart. With respect to construction details, they are similar to explosives type magazines.

*e. Other structures.* Structures, not of approved magazine type as listed in paragraph 238, shall not be used for the storage of explosives and ammunition except by special approval of the Chief of Ordnance.

### 1803. PREFERRED MAGAZINE USAGE FOR EXPLOSIVES AND AMMUNITION STORAGE

a. Earth-covered magazines are the preferred type of storage structure for all explosives and ammunition. Their use for storage is preferred in all future depot construction, and is desirable but not required for storage areas in explosives manufacturing and loading establishments. Solid propellants (smokeless powder) and pyrotechnics are also stored preferably in these magazines because of better temperature control but they may be stored in aboveground type magazines.

b. With reasonable care in storage, class 1 materials exclusive of fuzes and 20-mm ammunition may be stored in any weatherproof warehouse. Small quantities of ball ammunition (not to exceed 500 rounds) may be kept in a barracks storeroom.

### 1804. SAFETY PRECAUTIONS NECESSARY IN CONSTRUCTION OF MAGAZINES

a. When wood floors are used, the finished floors shall be laid and maintained to avoid cracks and crevices where explosives may lodge. Wood floors and the use of "rubberoid" or other floor coverings are prohibited in magazines used for storage of ammunition and components with chemical group A filling.

b. Construction which might allow the accumulation of explosive dust must be avoided.

c. All doors and doorframes to aboveground type magazines must be made of or covered with a fire-resistive material having some insulating value, such as rigid asbestos composition sheet, to fit as tightly as possible to seal the opening. Exteriors of magazines should be kept completely covered with fire-resistive materials, having some insulating value and being easily friable.

d. Magazines usually are not wired for electric lights, but when electricity is used, the installation shall conform to the requirements of section 6.

#### 1805. TEMPERATURE CONTROL

a. Sudden changes in temperature may damage airtight containers, or may result in excessive condensation of moisture. If the temperature in a magazine exceeds 100° F. for a period of more than 24 hours, the magazine should be cooled by wetting the exterior of the building with water or by opening the doors and ventilators after sunset and closing them in the morning. If these methods do not prove effective in lowering the temperature, the commander shall decide whether the materials should be removed to some other magazine.

b. Storage magazines, in general, should not be provided with heat. Exception is made in the case of magazines where heating may be necessary to prevent condensation of moisture, to

maintain constant temperature, or for other reasons. Steam coils should be so arranged that explosive material cannot come in contact with the coils. The coils must be kept clean.

#### 1806. MAGAZINE OPERATIONAL REGULATIONS

The following regulations shall be complied with where any ammunition and explosives are stored:

a. Instructions as printed on magazine placards, DA Label 85, must be posted on or near each door of the magazine so that they are visible when work is being done in the magazine.

b. Loose components or loose rounds of ammunition, packing material, conveyors, lift trucks, skids, dunnage, empty boxes, and other similar material shall not be stored in a magazine containing ammunition or explosives.

c. Vegetation around magazines shall be controlled as specified in paragraph 1216.

d. Doors and locks must be kept in good working order. Magazines shall be locked at all times except when permitted operations are in progress in the magazine and as provided for in paragraph 1805a. A crew must not be permitted to work in a position in an aboveground type magazine which requires passing the work aisle or position of a second crew to reach an exit. The number of crews shall not exceed the number of exits. Two or more doors must be unlocked and open when

personnel work in magazines having more than one door.

*e.* Flammable material, such as excess dunnage and boxes, shall be removed from magazines and igloos. Flammable liquids shall not be stored in magazines containing explosives.

## 1807. STACKING

*a.* Ammunition and explosives shall be stored in containers as prescribed in Ordnance Corps drawings and specifications and shall be stacked and arranged in a magazine in accordance with instructions set forth in Army regulations and Ordnance Corps drawings and directives. Explosives or ammunition in stacks should be grouped and identified according to lots. When military explosives or ammunition are not packed in accordance with approved drawings and specifications, they must be stored in accordance with special instructions from the Chief of Ordnance. General rules set forth in paragraphs *b* and *c* below should be followed in the absence of applicable storage drawings.

*b.* Methods used for stacking must provide for good ventilation to all parts of the stack. Adequate dunnage shall be used when necessary for this purpose.

*c.* Aisles shall be maintained so that units in each stack may be inspected, inventoried, and removed for shipment or surveillance test. Block

storage is permitted, provided adequate ventilation of stacks exists, but sufficient aisles shall be maintained to permit ready egress for personnel. Aisles should not be blocked.

#### 1808. LOOSE ROUNDS, DAMAGED CONTAINERS, ETC.

Loose rounds of ammunition, or single fiber containers with rounds therein, shall not be stored in magazines containing ammunition items which are packed in accordance with approved Ordnance drawings; however, they may be stored in magazines set aside for their exclusive storage. Incomplete boxes of ammunition and explosives may be stored in magazines containing items which are packed in accordance with approved Ordnance drawings provided the explosives and ammunition are in standard packages. The boxes must be marked conspicuously to identify the contents and quantities and placed in designated locations. Explosives and ammunition in damaged containers shall not be stored in a magazine with ammunition in serviceable containers. Such containers should be repaired or the contents transferred to new or serviceable containers. Open containers and containers with covers not securely fastened must not be allowed in magazines. Containers that have been opened shall be properly closed again before being restored. Containers should be free from loose dust and grit when stored.

## 1809. OPERATIONS PERMITTED IN MAGAZINES CONTAINING EXPLOSIVES AND AMMUNITION

a. Operations incident to storage and the following operations when incident to shipping: palletizing, removing and replacing shipping bands on bombs, removing and replacing grommets on separate loading shell, replacing damaged or loose strapping on boxes of ammunition and explosives, and placing inner cover retainer springs in one-round metal containers in which the ammunition is overpacked in a fiber container as well as the metal container. Where insufficient space exists in the magazine to permit these operations without crowding, they should be performed immediately outside the magazine.

b. Stenciling or restenciling containers. No open containers of flammable liquids used for stenciling should be permitted in or around magazines. Where essential (as with the use of flammable adhesive for MAP labels), flammable liquids may be used immediately outside of magazines, on aprons or platforms. In such cases, quantities of flammable liquids in open containers shall be the minimum absolutely necessary for the operation.

c. Removal of nose or tail plugs from projectiles and bombs for surveillance purposes, when accomplished without resort to undue force. Loosening or removal of plugs is not permitted

where there is evidence of exposed explosives in the threads or cavities in the form of dust, spillage, or explosives contaminated exudate. When such contamination is encountered, plug removal must be accomplished in a separate area. When there are no exposed explosives, threads and cavities may be cleaned and preservatives applied, provided that power driven tools, highly flammable or toxic solvents, or ferrous brushes are not used. Plugs shall be removed from the magazine for cleaning.

*d.* Operations incident to the inspection of propelling charges and bulk solid propellants (smokeless powder).

*e.* Air-testing of solid propellants (smokeless powder) or propelling charge containers. Motor-driven air compressors shall not be parked closer than 50 feet to a magazine in which explosives or ammunition are stored. Defective gaskets and covers of the containers may be replaced within a magazine but precautions must be taken to guard against sparks and fires. Safety tools shall be used for opening and closing containers. No other repair operations on solid propellants (smokeless powder) or propelling charge containers shall be permitted in a magazine containing explosives or ammunition.

*f.* Adjustment of the level or composition of liquid in which an explosive is stored. Sensitive explosives shall be maintained wet only by ad-

justment of the level of the liquid. Care should be taken to guard against use of nondistilled water since bacteria may produce gassing. Explosives, which may become dry due to evaporation of some of the liquid, shall not be pushed or forced down into any liquid remaining in the storage container.

*g.* Normal maintenance of small arms ammunition, unpacking, linking, and repacking provided there is sufficient room in the magazine and normal precautions are taken.

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#### **1810. OPERATIONS PERMITTED OUTSIDE OF MAGAZINES**

Except as enumerated in paragraph 1809, containers of explosives and ammunition shall not be opened or repaired in any magazine containing explosives or ammunition. If special facilities are not available for this type of work, it may be done in the open at least 100 feet from magazines containing ammunition and explosives, but in no case at a distance less than that prescribed in the intraline quantity-distance table for the quantity of explosives involved in the operation.

#### **1811. PROTECTION FROM MOISTURE**

Ammunition, pyrotechnics, solid propellants (smokeless powder), and propelling charges are adversely affected by dampness and extreme heat due to lack of proper ventilation. If these conditions exist, layers of boxes shall be separated by dunnage to permit free circulation of air to all parts, and the conditions rectified as may be required.

#### **1812. STORAGE DISTRIBUTION**

Storing of an establishment's complete stock of one item of ammunition or of explosives in a single magazine should be avoided where possible.

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### 1813. REPAIRS TO MAGAZINES

a. Repairs to magazines must not be made until prevailing conditions have been evaluated and it has been decided whether or not the contents are first to be removed. Under no circumstances shall repairs be made to the interior of magazines containing bulk explosives. Under normal conditions, roofs, ventilators, lightning rods, door and other parts of or appendages to the exteriors of magazines containing bulk explosives may be repaired without first removing the explosives. In addition to repairs of this type, minor repairs may be made to the interiors of magazines containing finished ammunition or ammunition components.

b. When magazines are repaired, the general safety regulations set forth in this manual shall be complied with—particularly those relating to the elimination of fire hazards. The following special requirements are also applicable:

- (1) All work shall be done by competent workmen, under competent supervision.
- (2) Safety tools must be used when indicated.
- (3) The floor in the immediate vicinity of the repair must be scrupulously cleaned.
- (4) No work requiring soldering, the melting of asphalt, or the use of flame or heat producing equipment shall be done in a magazine containing explosives or ammunition.
- (5) Magazines in which repair work has been

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done shall be inspected by competent **authorized personnel** after completion of the work.

- (6) When melting pots or any other heat producing apparatus are authorized by the commanding officer for use in any ammunition and explosives storage area, the equipment must be kept at least 100 feet from the ammunition or explosives location. When necessary, baffles and screens should be used to confine sparks and flames to heating apparatus.

#### **1814. PERMITTED OUTDOOR STORAGE**

In event of emergency, explosives and ammunition other than expressly prohibited herein may be temporarily stored outdoors provided prior approval is obtained from: NSC/MP-A or NSC/MP-GMA, as appropriate, for Field Service stocks; OAC for Industrial stocks, and OCO for Research and Development stocks. Solid propellants, pyrotechnics, bulk high explosives and critical items shall not be stored outdoors. Mixed storage, in stacks, as permitted by the Storage Compatibility Tables (section 19) is permissible. Every effort shall be made to eliminate the necessity for outdoor storage as soon as practicable. Temporary plugs set down against suitable washers must be used in the storage of loaded but incompletely assembled items to prevent dirt and moisture from entering.

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### **1815. OUTDOOR STORAGE SITES**

**a. Sites for outdoor storage shall be separated from magazines, other facilities and each other in accordance with the requirements of paragraph 1816 and section 17.**

**b. The storage sites shall be level, well-drained, and free from readily ignitable and flammable materials. The supporting timbers or platform upon which the ammunition is stored shall be well constructed to prevent falling, sagging and shifting of the ammunition. In order to assure stack stability and free circulation of air, not less than 3 inches of dunnage should be used between the bottom of the stacked earth floor. Provisions should be made also for circulation of air through stacks. Nonflammable or fire-resistant, waterproof overhead covers should be provided for all ammunition containing solid propellants, torpex, tritonal, minol, or chemical agents, since each of these materials may be adversely affected by exposure to the elements. An air space of not less than 18 inches should be maintained between the top of the stack and the cover. If adequate ventilation is assured, overhead covers are also desirable for outdoor stacks of bombs and shell. Sides of covered stacks also may be protected by nonflammable, fire-resistant, waterproof covers provided air space is maintained between the cover and the ammunition.**

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c. Frequent inspections shall be made to detect sagging piles and accumulations of trash between and under stacks.

d. If revetments are to be provided around outdoor storage sites, they must comply with the requirements of paragraph 1725. Stacks of ammunition must be kept at least **2 feet** from the revetments.

e. Excess dunnage should not be stored between outdoor sites and magazines nor between magazines. **Excess dunnage storage sites should comply with applicable quantity-distance requirements, except that during outdoor storage operations, service supplies of dunnage may be located not closer than 50 feet from the stack being processed.**

f. Suitable types of firefighting equipment and symbols should be provided in accordance with paragraph 1222.

g. All excess vegetation (par. 1216) and extraneous materials shall be removed from within open sites where ammunition and explosives are present and sites shall be kept free of such material to eliminate fire hazards.

#### **1816. SPECIAL REQUIREMENTS FOR OUTDOOR STORAGE**

a. *Class 1 ammunition.* Class 1 ammunition may be stored at suitable sites subject to no quantity-distance limitation other than the 450-foot separation required in relation to flammable liquid facilities (par. 1721).

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b. *Sites between earth-covered magazines.* Sites may be located midway between adjacent earth-covered magazines which are 400 feet apart provided the sites are separated from the barricaded sides of the nearest magazine by 185 feet. Ammunition in such sites should not be stored beyond lines drawn through the fronts and backs of magazines in the same row. The barricading of stacks of class 7 ammunition shall not reduce the required unbarricaded distance. Classes 6, 7, 8, and 10 shall not be stored without barricades as the distances to the nearest earth-covered magazines do not permit unbarricaded stacks. The storage of classes 3, 4, and 5 between earth-covered magazines is not desirable and should be resorted to only when necessary. Sites containing classes 4 and 5 may not be located within 1200 feet of sites containing classes 6, 7, 8, and 10. In addition, the following quantity limitations are applicable.

<i>Pounds of HE (Maximum)</i>	<i>Inter-site distance (Minimum)</i>
	Classes 4 and 5
100,000.....	800 ft. (barricaded or unbarricaded).
	Classes 6, 7, 8, and 10
250,000.....	400 ft. barricaded

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c. *Sites not between earth-covered magazines.* Sites containing classes 4 and 5 shall not be stored within 1,200 feet of sites containing classes 3, 7, 8, and 10. No outdoor storage sites shall be located within 1,200 feet of aboveground magazines. The following limitations also apply:

Classes 4 and 5

<i>Pounds of HE (Maximum)</i>	<i>Inter-site distance (Minimum)</i>
125,000.....	800 ft. unbarricaded
250,000.....	1,100 ft. unbarricaded
500,000.....	1,600 ft. unbarricaded

Classes 6, 7, 8, and 10

<i>Pounds of HE (Maximum)</i>	<i>Inter-site distance (Minimum)</i>
100,000.....	200 ft. barricaded
100,000.....	400 ft. unbarricaded
250,000.....	400 ft. barricaded
250,000.....	800 ft. unbarricaded

d. *General.* Inhabited building distance, public railway distance, and public highway distance shall be maintained around outdoor sites as specified in section 17.

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### **1817. STORAGE OF BULK INITIATING EXPLOSIVES**

Bulk initiating explosives must be stored alone or with similar compounds. They must not be stored dry and shall not be exposed to the direct rays of the sun. They may be stored in shipping containers only as an expedient, and then must be stored in frost-proof earth-covered magazines with barrels on end, only one tier high, with passageway for inspection and handling. Glazed earthenware crocks of ample size to hold the double bag of material, and with covers of the plastic cap type to prevent evaporation and eliminate friction or abrasion when removed, are used for normal storage. If long-term storage in shipping containers is contemplated, the container must be equipped with a cover having a port for observation of the level of liquid therein. The viewing port must be covered with a transparent plastic which is known to be compatible with the initiating explosive being stored. Bags of initiating explosives in storage containers must be under distilled water. Alcohol may be added to the distilled water to prevent freezing. Storage in magazines at manufacturing plants should be as outlined above (par. 1401).

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**1818. SOLID PROPELLANTS (SMOKELESS POWDER)**

Propellant powder shall not be stored or shipped in damaged containers. When leaking containers are discovered, an examination of the contents shall be made for the odor of decomposing powder. If any such conditions are observed, the powder shall be segregated or disposed of in accordance with current instructions. Propellants and propelling charges in containers should be stored so that they can be readily inspected. They shall not be exposed to the direct rays of the sun.

**1819. MILITARY PYROTECHNICS**

Loaded assemblies shall not be stored in operating buildings except for the minimum quantities necessary to supply the operations.

**1820. SMALL ARMS AMMUNITION**

Boxed small arms ammunition shall not be used as barricades or substantial dividing walls between stacks of other types of ammunition.

**1821. SEPARATE-LOADING AMMUNITION, HE  
LOADED EXCEPT EXPLOSIVE D**

a. Separate-loading projectiles must be handled with care and projectiles shall not be stored without fuze-well plugs. Metal dunnage should be used where practicable.

b. In aboveground magazines, class 7 separate-loading ammunition should be arranged in single stacks with the noses in one stack pointing toward

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the noses in the next stack, or with the bases in one stack pointing toward the bases in the next stack. Each stack shall contain not more than 15,000 net pounds of explosives. The distances necessary to prevent transmission of explosion between stacks are given on Ordnance Corps drawing 19-48-3818 (2E11). When those distances are not provided, separate loaded items normally designated as class 7 shall be stored in accordance with class 10 quantity-distance requirements (see par. 1724).

#### **1822. SEPARATE-LOADING AMMUNITION, EXPLOSIVE D LOADED, CLASS 5**

This type of shell may be stored with distances between stacks not more than that required to permit inspections.

#### **1823. FIXED AND SEMIFIXED AMMUNITION**

Boxed fixed and semifixed ammunition shall not be used as substantial dividing walls between stacks of other types of ammunition.

#### **1824. CLASS 6 AMMUNITION**

Class 6 ammunition must be stored in stacks separated by distances specified on Ordnance Corps drawings. Stacks shall contain not more than 5,000 pounds each and shall be separated from each other by a minimum distance of 2 feet. When not so stored, ammunition of this class shall be considered as class 10 ammunition.

## 1825. ROCKETS AND JATOS

a. Rockets, rocket motors, and Jato units that are in a propulsive state should be stored nose down. If such items cannot be stored nose down, they should be pointed in one direction (not toward the door of the magazine). If they are in a nonpropulsive state, they may be stored without regard to direction in which they are pointed.

b. In aboveground magazines where nose down storage is not practicable, the items shall be pointed in the direction which offers the least exposure to personnel and property in event of fire or explosion.

c. Rockets should be stored in a dry cool magazine and never in the direct rays of the sun. They should not be stored in locations where temperatures exceed 120° F. (par. 1805). Prolonged exposure of rocket ammunition to either high or low temperatures may increase the normal rate of deterioration or render the motors more susceptible to ignition if subsequently handled improperly.

## 1826. DUNNAGE RESTRICTIONS IN STORING CLASS 10 AMMUNITION

In storage, combustible material in the magazine must be held to a minimum, steel dunnage should be used where practicable and available.

## 1827. MAGAZINES AND MAGAZINE AREAS

A segregated area shall be set aside for the exclusive storage of ammunition and explosives, with the following exceptions:

a. All magazines or open revetted sites in the magazine area may be used for the storage of inert related ammunition items.

b. When no other suitable storage space is available, sites located at the appropriate intra-line distance based upon the controlling maximum quantity of explosives in nearby magazines and/or open sites but under no circumstances less than 800 feet, may be selected in the magazine area for the storage of motor vehicles, artillery, tanks, etc.

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**SECTION 19**  
**STORAGE COMPATIBILITY FOR EXPLOSIVES**  
**AND AMMUNITION**  
**(REVISED)**

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**1901. GENERAL**

Explosives and ammunition shall be stored in accordance with table 1905. Storage compatibility groups for explosives and ammunition items are listed alphabetically in table 1904, Summary of Storage Compatibility and Explosives Hazards (Quantity-Distance) Class for Explosives and Ammunition.

**1902. FACTORS WHICH DETERMINE GROUPING**

Explosives and ammunition are grouped for compatibility with respect to the following factors:

- a. Effects of explosion of the item.
- b. Rate of deterioration.
- c. Sensitivity to initiation.
- d. Type of packing.
- e. Effects of fire involving the item.
- f. Quantity of explosive per unit.

**1903. RELATION TO QUANTITY-DISTANCE REQUIREMENTS**

Storage compatibility groupings should not be confused with the hazard classification established for quantity-distance requirements (sec. 17).

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Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
Adapter—booster.....	B	<sup>1</sup> 6 or 10
Aluminum powder.....	C	1
Ammonium nitrate.....	D	12
Ammunition, blank and saluting, cannon.....	E	4
Ammunition, caliber 20-mm or less, except HE or HE-I rounds and 20-mm incendiary rounds.....	B, E, and N	1
Ammunition, caliber 20-mm or less HE and HE-I rounds and 20-mm incendiary rounds....	E	4
Ammunition, caliber 120-mm (propelling charges and HE projectiles) packed in accordance with approved Ordnance drawings depicting issue package.....	E	7
Ammunition, caliber 120-mm (propelling charges and solid projectiles) packed in accordance with approved Ordnance drawings depicting issue package.....	E	4
Ammunition, fixed and semifixed, loaded with Ammanol, Amatol, Composition B, Explosive D or TNT.....	E	4

<sup>1</sup> See par. 1724a and b.

Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued

Item	Storage compatibility group (see table 1905)	Explosive hazard class (quantity-distance) (see sec. 17)
Ammunition, fixed or semifixed, loaded with HE other than Ammanol, Amatol, chemical, Composition B, Explosive D, pentolite or TNT.	E	10
Ammunition, HEP, loaded -----	G	10
Ammunition, pentolite loaded ----	A	10
Ball, cellulose nitrate, powder-filled	N	2
Bangalore torpedoes -----	G	10
Baratol -----	I	9
Benite -----	O	9
Black powder, in charges or containers.	O	9
Blasting caps -----	P	8
Bombs, chemical filled, assembled with explosive components.	A	4
Bombs, demolition -----	G	10
Bombs, fragmentation -----	G	<sup>2</sup> 10 or 4
Bombs, photoflash (except M122, w/o burster).	Q	10
Bombs, photoflash, M122 w/o burster.	C and Q	2
Boosters -----	B	<sup>1</sup> 6 or 10
Boosters, auxiliary -----	B	10
Koracitol -----	I	9
Boron potassium nitrate -----	O	9
Bursters -----	B	10
Cartridge cases, primed (w/o propellant).	B, E, N	1

<sup>1</sup> See par. 1724a and b.

<sup>2</sup> Use class 10 distances; however, no distance shall be less than required for class 4 ammunition.

*Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued*

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
Cartridge, heavy mortar, over 81-mm (including 81-mm M56) except chemical loaded.	G	10
Cartridge, illuminating	E	4
Cartridge, light mortar, 81-mm and less (excluding 81-mm M56) except chemical loaded.	E	4
Cartridge, photoflash	Q	10
CBS	I	9
Charge for snake, demolition	G	10
Charge, igniter assembly, for fuzes M10 and M10A1.	B	3
Charges, propelling, not assembled to projectiles.	J	2, 2A, or 9
Charge, spotting, AP, practice, M8.	B, E, and N	1
Charge, springing earth rod, blast driven, M2A1 and M3.	I	10
Charges, supplementary, HE loaded	B and I	10
Chemical ammunition, group A, except items assembled with explosive components.	A	11
Chemical ammunition, group A, assembled with explosives components.	A	4
Chemical ammunition, group B, except items assembled with explosive components.	A	11
Chemical ammunition, group B, assembled with explosives components.	A	4

Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
Chemical ammunition, group C, except items assembled with explosive components.	A	2
Chemical ammunition, group C, fixed and semifixed rounds.	A	4
Chemical ammunition, group D, except items assembled with explosive components.	A	2
Chemical ammunition, group D, fixed and semifixed rounds.	A	4
Chlorates -----	K	1
Composition A, A-2, A-3, and A-4	I	9
Composition B and B-3 -----	I	9
Composition C, C-2, C-3, and C-4	I	9
Corporal, actuator, assembly pro-B, E, and N pellant valve, quick release.		1
Cutter, reefing line -----	B, E, and N	1
Cyclonite (RDX) -----	L	9
Cyclotol -----	I	9
Demolition blocks -----	I	10
Destructor, HE, M10 -----	B	10
Detonating cord (Primacord) -----	I	12
Detonator concussion type, M1 --	B	3
Detonators (except concussion type, M1.	P	8
DNT -----	D	12
Dynamite (commercial type) -----	A	9
Dynamite (military type) -----	I	9
EC Powder -----	J	9
Eimite -----	O	9

Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued

Item	Storage compatibility group (see table 1905)	Explosive hazard class (quantity-distance) (see sec. 17)
Explosives bellows	B, E, and N	1
Explosives, cratering	I	9
Explosive D	I	9
Firecracker, M80	Q	10
Firing devices	B, E, and N	1
Flash reducers (black powder with potassium sulfate).	O	9
Fuse lighters	B, E, and N	1
Fuse, safety	B, E, and N	1
Fuzes (packed in accordance with approved Ordnance drawings depicting issue package) without boosters, of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT T316E2, MT T342, MT M522, MT M523, and TSQ M55.	B, E, and N	1
Fuzes (packed in accordance with approved Ordnance drawings depicting issue package)—fuzes (with boosters assembled thereto) of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT	B	3

Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec 17)</i>
T316E2, MT T342, MT M522, MT M523, and TSQ M55; artillery type proximity fuzes with boosters, and other fuzes without boosters, except fuzes chemically actuated containing ampoules which may initiate, directly or indirectly, explosives and explosives loaded components which are assembled in the conventional manner to form the finished explosive fuze.	B	1 6 or 10
Fuzes, proximity, artillery type (not packed in accordance with approved drawings).	B	1 6 or 10
Fuzes of other than the series listed above as class 3, with boosters, except fuzes VT and fuzes chemically actuated containing ampoules which may initiate, directly or indirectly, explosives and explosive loaded components which are assembled in the conventional manner to form the finished explosive fuze.	A	1 6 or 10
Fuzes, chemically actuated, containing ampoules which may initiate directly or indirectly, explosives and explosive loaded		

<sup>1</sup> See par. 1724a and b.

**Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued**

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
components which are assembled in the conventional manner to form the finished explosive fuze.		
Grenades, fragmentation -----	E and G	10
Grenades, hand offensive -----	I	10
Grenades, illuminating -----	N	2
Grenades, practice, with spotting charge.	E	3
Grenades, rifle, AT (pentolite loaded).	A	10
Grenades, rifle, AT (except pentolite loaded).	G	10
HMX, wet -----	M	9
HMX, dry -----	L	9
Igniters for rockets (e.g., M12, M18 and M20).	B	3
Igniters, Jato, electric -----	B	3
Igniters, Jato, electric (such as M29).	O	10
Ignition cartridges for trench mortar ammunition.	B, E, and N	1
Lead azide, wet -----	M	9
Lead styphnate, wet -----	M	9
Magnesium powder -----	C	1
Mercury fulminate, wet -----	M	9
Military pyrotechnics (see tables 1731, 1738, and 1739 for detailed description of items included and the establishment of the explosives hazard classes).	N	2, 9, 10

Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued

Item	Storage compatibility group (see table 1905)	Explosive hazard class (quantity-distance) (see sec. 17)
Mines, antipersonnel (bounding type).	E	4
Mines, antipersonnel (cast iron block).	G	10
Mines, antipersonnel, NM, M14	B	6
Mines, HEAT	H	10
Mines, practice, with spotting charge and/or fuze.	E	3
Minol	I	9
MOX	I	9
Nitrate (inorganic)	K	1
Nitrocellulose, wet	M	12
Nitroguanidine	I	9
Nitrostarch	I	9
Octol	I	9
Pentolite	I	9
Perchlorates	K	1
Percussion elements	P	8
Peroxide, solid	K	1
PETN, wet	M	9
Petrin	I	9
Photoflash powder	A	9
Picric acid	I	9
Primers, artillery and cannon	B	3
Primer detonators	B	3
Primers, electric	P	8
Projectiles, HE (except loaded with Explosive D) fuzed or unfuzed.	A	1 7 or 10

<sup>1</sup> See par. 1724a and b.

**Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition--Continued**

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
Projectiles, HE (loaded with Explosive D) fuzed or unfuzed.	A	5
Projectiles, illuminating -----	E and N	2
Propellants, solid (class 2) -----	J	2
Propellants, solid (class 2A) -----	J	2A
Propellants, solid (class 9) -----	J	9
Pyrotechnic materials (see tables 1730, 1731, and 1741 for detailed description of items included and the establishment of the explosive hazard classes).	A, C, and K	1, 2, 9
Quick arming device, 318-mm rocket.	O	10
RDX (Cyclonite) (dry) -----	L	9
RDX (Cyclonite) (wet) -----	M	9
Rockets, chemical, complete rounds	A	4
Rockets, complete rounds, any HE filler.	F	10
Rocket heads, any HE filler -----	F	10
Rocket heads, HE (except pentolite loaded).	F and G	10
Rocket heads, WP loaded, except items assembled with explosive components.	A	2
Rocket motors (exclusive of heads)	F	2, 4, or 10
Rockets, practice -----	F	2, 4, or 10
Simulators, M110, M117, M118, and M119.	N	2
Simulator, M115 -----	Q	10

<sup>2</sup> See tables 1731, 1733, and 1741.

**Table 1904. Summary of Storage Compatibility and Explosive Hazards (Quantity-Distance) Class for Explosives and Ammunition—Continued**

<i>Item</i>	<i>Storage compatibility group (see table 1905)</i>	<i>Explosive hazard class (quantity-distance) (see sec. 17)</i>
Simulator, M116 -----	B and Q	3
Simulator, XM142 -----	Q	10
Spotting charges, cartridge for miniature practice bombs.	N	2
Tetranitrocarbazole -----	I	9
Tetryl -----	L	9
TNT -----	I	9
Warheads, HE -----	G	10
Zirconium (types I and II, spec. FED 1655).	C	1

**Table 1905. Storage Compatibility Groups for Explosives and Ammunition**

**GROUP A—Separate Storage**

*Note.* Items in this group must be stored alone.

1. Chemical ammunition, group A.
2. Chemical ammunition, group B.
3. Chemical ammunition, group C.
4. Chemical ammunition, group D.
5. Dynamite (commercial types).
6. Fuzes, chemically actuated (see exceptions in table 1904).
7. Grenades, rifle, AT (pentolite loaded).
8. Pentolite loaded ammunition (except pentolite loaded rockets and rifle grenades—see item 7 above).
9. Photoflash powder.
10. Projectiles, HE (except Explosive D loaded) fuzed or unfuzed.
11. Projectiles, HE (Explosive D loaded) fuzed or unfuzed.

*Table 1905. Storage Compatibility Groups for Explosives  
and Ammunition—Continued*

**GROUP A—Continued**

12. Pyrotechnic materials except items in groups C and K in this table (see tables 1730, 1731, and 1738).

*Note.* Items in the following groups may be stored with other items within the individual group in any combination.

**GROUP B**

1. Adapter—boosters.
2. Ammunition, caliber 20-mm or less (including AP-1 but excluding HE and/or HE-I rounds and 20-mm incendiary rounds).
3. Boosters.
4. Boosters, auxiliary.
5. Burstern.
6. Cartridge cases, primed (w/o propellant).
7. Charge, igniter, assembly, for fuze M10 and M10A1.
8. Charge, spotting, AP, practice, M8.
9. Charges, supplementary.
10. Corporal, actuator, assembly propellant valve, quick release.
11. Cutter, reefing line.
12. Destructor, HE, M10.
13. Detonator, concussion type, M1.
14. Explosive bellows.
15. Firing devices.
16. Fuse lighters.
17. Fuse, safety.
18. Fuzes, with or without booster, except chemically actuated (see alphabetical listing for the inclusions of certain types of chemically actuated fuzes).
19. Fuzes, without boosters, except chemically actuated.
20. Igniters for rockets (M12, M18, M20, etc.).
21. Igniters, Jato, electric (class 3 only).
22. Ignition cartridges for trench mortar ammunition.
23. Mines, APERS, NM, M14.

**Table 1905. Storage Compatibility Groups for Explosives  
and Ammunition—Continued**

**GROUP B—Continued**

24. Primers, cannon and artillery.
25. Primer detonators.
26. Simulator, M116.
27. Squibs, commercial.

**GROUP C**

1. Aluminum powder.
2. Bombs, photoflash, M122, w/o burster.
3. Magnesium powder.
4. Zirconium powder (class 1).

**GROUP D**

1. Ammonium nitrate.
2. DNT.

**GROUP E**

1. Ammunition, blank and saluting, cannon.
2. Ammunition, caliber 20-mm or less.
3. Ammunition, caliber 120-mm.
4. Ammunition, fixed or semifixed except chemical, HEP and pentolite loaded.
5. Cartridge cases, primed (w/o propellant).
6. Cartridge, illuminating.
7. Cartridge, light mortar, 81-mm or less (excluding 81-mm M56) except chemical loaded.
8. Charge, spotting, AP, practice, M8.
9. Corporal, actuator, assembly propellant valve, quick release.
10. Cutter, reefing line.
11. Explosive bellows.
12. Firing devices.
13. Fuse lighters.
14. Fuse, safety.
15. Fuzes (packed in accordance with approved Ordnance drawings depicting issue package) w/o

*Table 1905. Storage Compatibility Groups for Explosives  
and Ammunition—Continued*

**GROUP E—Continued**

boosters, of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT T316E2, MT T342, MT M522, MT M523, and TSQ M55.

16. Grenades, hand fragmentation and practice with spotting charge.
17. Ignition cartridges for trench mortar ammunition.
18. Mines, AP (bounding type).
19. Mines, practice, with fuze and/or spotting charge.
20. Projectiles, illuminating.
21. Squibs, commercial.

**GROUP F**

1. Rockets, HE, complete rounds.
2. Rocket heads, HE (w/o motor).
3. Rocket motors.
4. Rockets, practice.

**GROUP G**

1. Ammunition, HEP loaded.
2. Bangalore torpedoes.
3. Bombs, demolition.
4. Bombs, fragmentation.
5. Cartridge, heavy mortar, over 81-mm (including 81-mm M56) except chemical loaded.
6. Grenades, fragmentation.
7. Grenades, rifle, AT (except pentolite loaded).
8. Mines, AP (cast iron block).
9. Rocket heads, HE (w/o motor).
10. Snake, demolition.
11. Snake, mine clearing.
12. Warheads, HE.

**Table 1305. Storage Compatibility Groups for Explosives  
and Ammunition—Continued**

**GROUP H**

1. Mines, HEAT (to be combined with group G upon completion of replacement of chemically actuated fuzes of the M600 type).

**GROUP I**

1. Baratol.
2. Boracitol.
3. CBS.
4. Charge, springing earth rod.
5. Composition A, A-2, and A-3.
6. Composition B.
7. Composition C, C-2, C-3, and C-4.
8. Cyclotol (not to exceed maximum 85 percent RDX).
9. Demolition blocks.
10. Detonating cord (Primacord).
11. Dynamite, military type.
12. Explosives, cratering.
13. Explosive D.
14. Grenades, hand offensive.
15. Minol.
16. MOX.
17. Nitroguanidine.
18. Nitrostarch.
19. Octol.
20. Pentolite.
21. Petrin.
22. Picric acid.
23. Shaped charges.
24. Supplementary charges.
25. Tetracene.
26. TNT.

**GROUP J**

1. Charges, propelling.
2. EC Powder in bulk.

*Table 1905. Storage Compatibility Groups for Explosives  
and Ammunition—Continued*

**GROUP J—Continued**

3. Propellant, solid, class 2.
4. Propellant, solid, class 2A.
5. Propellant, solid, class 9.

**GROUP K**

1. Chlorates.
2. Nitrates (inorganic).
3. Perchlorates.
4. Peroxides, solid.

**GROUP L**

1. Cyclonite (RDX).
2. HMX.
3. Tetryl.

**GROUP M**

1. HMX (wet).
2. Lead azide (wet).
3. Lead styphnate (wet).
4. Mercury fulminate (wet).
5. Nitrocellulose (wet).
6. PETN (wet).
7. RDX (wet).
8. Zirconium powder (wet).

**GROUP N**

1. Ammunition, caliber 20-mm or less, including API but excluding HE, HE-1 and 20-mm incendiary rounds.
2. Ball, cellulose nitrate, powder-filled.
3. Cartridge cases, primed (w/o propellant).
4. Charge, spotting, AP, practice, M8.
5. Corporal, actuator, assembly propellant valve, quick release.
6. Cutter, reefing line.
7. Explosive bellows.
8. Firing devices.

*Table 1905. Storage Compatibility Groups for Explosives and Ammunition—Continued*

**GROUP N—Continued**

9. Fuse lighters.
10. Fuse, safety.
11. Fuzes (packed in accordance with approved Ordnance drawings depicting issue package) w/o boosters, of the following series: PD M48, PD M51, PD M57, PD M78, PD M81, PD T177, PD M507, PD M508, MTSQ M500, MTSQ M501, MTSQ M502, MTSQ M518, MT M43, MT M61, MT M67, MT T316E2, MT T342, MT M522, MT M523, and TSQ M55.
12. Grenade, illuminating.
13. Ignition cartridges for trench mortar ammunition.
14. Military pyrotechnics except items in this classification listed separately in groups A and M of this table (see tables 1731, 1738, and 1739 for details).
15. Projectiles, illuminating.
16. Simulators, M110, M117, M118, and M119.
17. Spotting charges (cartridge for miniature practice bombs).
18. Squibs, commercial.

**GROUP O**

1. Benite.
2. Black powder in charges or containers.
3. Black powder spotting charges.
4. Boron potassium nitrate.
5. Eimite.
6. Flash reducers (black powder with potassium sulfate).
7. Igniters, Jato electric (class 10).
8. Quick arming device, 318-mm rocket.

**GROUP P**

1. Blasting caps.
2. Detonators.

*Table 1905. Storage Compatibility Groups for Explosives  
and Ammunition—Continued*

GROUP P—Continued

3. Percussion elements.
4. Primers, electric.

GROUP Q

1. Firecracker, M80.
2. Photoflash bombs (including M122, w/o burster).
3. Photoflash cartridges.
4. Simulators, M115 and M116.

## 1906. COMBINING STORAGE GROUPS

When the quantity of explosives in items or in bulk does not exceed 1,000 pounds net, the following combinations of groupings (see table 1905) may be utilized for storage provided the materials are approved and packaged in accordance with approved Ordnance drawings:

Items 4, 8, 10, and 11 of group A.

Group B.

Group C.

Group D.

Group E.

Group G.

Group I.

Group J.

Group L.

Group N.

Group O.

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**SECTION 20**  
**PREPARING EXPLOSIVES AND AMMUNITION**  
**FOR SHIPMENT**

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**2001. GENERAL REGULATIONS, COMPLIANCE WITH ICC REGULATIONS**

The general regulations governing the marking, packing, and shipping of military supplies are set forth in applicable current Army regulations. The operations shall also comply with Interstate Commerce Commission regulations. This section, section 21, and section 22 contain additional regulations applying to the marking, packing, and shipping of explosives and ammunition. **Except for fuzes, initiating devices and the like, containing small quantities of explosives, and constructed or packaged so that the force of the explosion will be self-contained should the component function, and ammunition containing high explosives filler but without fuzes or initiating devices, no live ammunition or ammunition component which has been subjected to undue or abnormal forces for test purposes and has failed to function shall be offered for shipment by commercial carrier or transported over public transportation systems by Government conveyance unless specifically approved by the Chief of Ordnance. Material of this nature must be specially packaged, blocked, or stayed to reduce to a minimum the movement of the item during transit.**

**2002. MARKING**

- a. When an Ordnance establishment repaints or

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re-marks explosives or ammunition containers and ammunition or ammunition components, the new painting or marking shall correctly identify contents or items.

b. Explosives, ammunition, and loaded ammunition components obtained from salvage operations, and material which has lost its identification markings shall be clearly marked to show the explosive nature of the material. Explosive material or items which cannot be definitely identified as to their explosive nature, in order that they can be correctly marked for shipment, should be disposed of by technically trained personnel in accordance with paragraph 2708.

### **2003. TEMPORARY STORAGE IN SHIPPING AND RECEIVING BUILDINGS**

a. *LCL buildings.*

(1) In buildings specifically designated and used as packing and shipping buildings, ammunition and explosives may, subject to the following limitations, be stored in accordance with the Loading and Storage Chart of Explosives and Other Dangerous Articles as contained in the Interstate Commerce Commission Regulations. Incoming shipments must not be allowed to accumulate but must be distributed as soon as practicable after receipt. Items for outgoing shipments shall not be accumulated prior to receipt of orders covering each specific shipment.

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- (2) Special rooms shall be provided for the temporary storage of ammunition and explosives awaiting shipment, and for their preparation for shipment before assembling, crating, marking, etc. The rooms shall be separated from each other by substantial dividing walls and shall be separated from offices and rooms in which inert operations such as the preparation of stencils, packing, and crating are performed, by substantial dividing walls so constructed that they comply with the requirements for fire walls also.

*b. All shipping and receiving buildings.* Where material is stored in accordance with the ICC requirements, not more than three cars of ammunition or explosives at one time shall be permitted at a shipping or receiving building or at a combined shipping and receiving building. When materials in the cars, buildings or on platforms are stacked in accordance with the Storage Compatibility Groups of this Manual (sec. 19), a larger number of cars may be located at such places. The total amount of explosives in the cars, buildings and platforms combined must be used as the controlling quantity for determining distance requirements to other lines, buildings and areas (see par. 1719). If there is a proper barricade between the cars and the adjoining building or platform, then the quantity on each side of the barricade may be considered individually in determining quantity distance.

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#### **2004. CONTAINERS**

Hazardous materials in loose or liquid form must be transported in containers which will prevent the escape of contents. Containers for intraplant transportation and service storage of the more sensitive explosives and explosive mixtures such as initiating, incendiary, flare, signal, igniter, and tracer materials should be made of material in the following preference order:

Conductive rubber

Nonferrous metal-lined wood boxes without seams or rivet heads under which explosive dust can accumulate

Conductive plastics

Paper-lined wood boxes

Fiber containers

Fiber containers wear rapidly and should not be used when they show signs of damage or wear. Glass containers should not be used because of their fragility and severe missile hazard.

#### **2005. BLACK POWDER CONTAINERS**

a. Standard containers for Army black powder built in accordance with Ordnance Corps drawings meet ICC specifications.

b. When black powder is shipped or received, each container shall be inspected for holes and weak spots, particularly small holes such as those made by nails and which are visible only upon close examination. Damaged containers must not be repaired; the con-

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tants shall be transferred to new or serviceable containers. Metal containers for export shipment shall be crated, usually two containers per crate.

c. Empty containers which have held black powder may be reused, and may be transported empty provided each container is clean. Empty metal containers which are not to be reused shall be thoroughly

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washed inside with water before disposition is made. Wooden containers shall be destroyed by burning and special precautions shall be taken in view of the nature of the contamination.

d. To open the metal keg type container of 25-pound, capacity, the four metal clips on the bung should be pried up with a sharpened wood stick and pressed back with the same tool or with the fingers. The metal cap and underlying paper washer should be lifted out with the fingers. Holes shall not be driven into black powder containers with any instrument unless the container has been thoroughly cleaned except that in cases where it is necessary to provide openings by puncturing, to empty the contents, such operations will be performed while the operator is protected by an operational shield. Black powder in the form of igniting charges may be packed in airtight metal-lined containers limited to 50 pounds capacity.

e. Paragraph 2004 applies to intraplant containers for black powder.

#### **2006. CONTAINERS FOR SOLID PROPELLANTS (SMOKELESS POWDER)**

a. Solid propellants shall be packed in accordance with approved Ordnance Corps drawings or packing instructions and to comply with ICC regulations.

b. Most double base solid propellants, single perforated solid propellants, and all solid propellants with web thickness not greater than 0.019 inch should not be packed in all-steel boxes which would provide too much confinement if boxes became exposed to fire.

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c. Salvaged or deteriorated solid propellants must be shipped under water in containers, such as boxes, barrels, or tank cars, unless the condition of the solid propellants is such that they are safe to ship dry.

## **2007. CONTAINERS FOR AMMUNITION AND BULK HIGH EXPLOSIVES**

a. Ammunition and bulk high explosives shall be packed in accordance with approved Ordnance Corps drawings or packing instructions and to comply with ICC regulations.

b. Containers used for packing bulk high explosives should be lined with strong cloth or paper bags, or liners with cemented seams to prevent sifting.

## **2008. HANDLING**

a. *Explosives.* Explosives loaded ammunition and bulk explosives shall not be handled roughly, thrown about, tumbled, dropped, or walked over other explosives or ammunition. Massive ammunition items, packaged in Ordnance approved containers designed to permit dragging or towing, may be so moved when necessary during handling for storage and transportation.

b. *Propelling charges.* Rough handling may open seams in the containers, or loosen the covers. The contents of damaged containers shall be examined

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carefully for moisture or other signs of deterioration before repacking. Propelling charges must not be exposed to the direct rays of the sun. If bagged propelling charges other than as contained in cartridge cases become damaged in such a manner that the igniter charge has been broken, they should be handled using the safety precautions prescribed for black powder.

*c. Bombs and separate loading shell.* Booster cavities shall always be closed with suitable plugs. Such items may be rolled with care. Base fuzeed separate loading projectiles should not be rotated since fuzes may become armed.

*d. Fuzes, primers, boosters, and detonators.* All loaded components, even when properly packed, must be handled with special care, as these are extremely sensitive to shock and friction.

*e. Other loaded items.* Suitable plugs or closures shall be used to protect exposed explosives in items during transfer within the installation, such as transfer of shell from defuzing or deboosting building to the explosives washout building or to the burning or demolition ground.

*f. Use of conveyors, chutes, and fork lift trucks* (see sec. 24). So long as the precautions noted in subparagraph *a* above are observed, and the provisions of paragraphs 2403 and 2404 are satisfied, properly packaged explosives and ammunition and bombs may be handled on power and roller conveyors, chutes, or fork lift trucks. Safety shoes,

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conductive and sparkproof type, are not required in handling ammunition and bombs provided there are no exposed explosives. (See sec. 10.) Hard toe, sparkproof, safety shoes are, however, recommended for this work since personnel may be required to work in other areas where explosives may be exposed.

*g. Spotting charges.* Spotting charges for practice bombs which consist of black powder shall be stored, handled, and shipped under the regulations for black powder with the exception that spotting charges are not removed from their boxes but are stored as received.

## SECTION 21

### RAILROAD TRANSPORTATION

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#### 2101. REFERENCE

The operation of railroads within an Ordnance establishment shall be in accordance with applicable current directives—particularly *TM 55-200, Railroad Operating Rules, and this manual.*

#### 2102. SPECIFICATIONS FOR EQUIPMENT

a. The Interstate Commerce Commission safety regulations pertaining to safety devices, safety guards, design of equipment, etc., are mandatory for railway equipment involved in transporting materials between establishments. The same regulations should be followed for transportation within an establishment.

b. Locomotives and other rail vehicles used within an establishment shall be designed and equipped to prevent starting or communicating fires. Coal-burning equipment shall have spark arresters on smokestacks and shall have double ashpans. Diesel or gasoline powered and other self-propelled rail vehicles shall have spark arresters properly installed on exhaust stacks. The spark arresters shall be adequately maintained. Portable fire extinguishers must be car-

ried on all diesel locomotives and self-propelled vehicles. Carbon dioxide extinguishers are recommended for diesel locomotives.

c. Locomotives and rail equipment shall be painted to increase their visibility in accordance with current directives.

d. Minimum clearance from center line of standard gage track to near edge of loading docks, walls near depressed tracks, building loading platforms, etc., should not be less than 5 feet 9 inches. The minimum distance between track centers should be not less than 13 feet. The minimum overhead clearance from top of rail to a wire or structure should be 22 feet; the minimum vertical clearance from top of rail to any high tension wire shall be in accordance with the requirements of the Association of American Railroads' Specifications.

e. Where side clearance is inadequate for a man on the side of a car, warning signs shall be posted at approaches to the obstruction. Where overhead clearance of 22 feet is not obtainable, telitale (head tappers) should be installed above the rails 100 to 200 feet from both sides of the obstacles.

f. Tracks in classification yards should be so arranged that the center to center distance between tracks is not less than 13 feet. Enough crossovers shall be provided to switch cars and permit rapid removal of cars in case of a threat-

ened disaster in the classification yards, holding yards and holding tracks at backup stations. Classification, holding, and temporary storage yards shall be located in accordance with the provisions of paragraphs 1713, 1714, and 1715, respectively.

*g.* Narrow gage or industrial tracks shall have a horizontal clearance not less than 18 inches from the side of the widest car used and a minimum headroom of 7 feet. Center to center of parallel tracks shall be at least 2½ feet more than the width of the widest car.

*h.* Railroad lines serving hazardous areas should be looped and provide at least two ways of exit out of the areas for railroad cars containing explosives or highly flammable materials.

*i.* Deleted.

*j.* Dead end tracks shall be provided with substantial bumper blocks or similar equipment.

### 2103. RAILWAYS

*a.* Periodic surveys should be made of road beds, sleepers, rails, spikes, switches, signals, derails, bumpers, etc. Where the system is electrified or grounded, inspection for proper bonding and grounding of rails should be included in the surveys.

*b.* Grating should be installed to cover track hoppers under tracks used for unloading materials from dumping cars.

c. On trestles where persons may walk, a walkway should be provided on one side extending at least 5 feet from the nearest rail. Standard handrails 42 inches high with midrail and standard toeboards shall be installed at the outer edge. On multitrack trestles the walkway may be between the tracks and a guardrail need not be provided.

d. Grass and brush along railroad right-of-way which present a fire hazard should be controlled.

#### 2104. SIGNS AND SIGNALS

Suitable types of switch target lights which are visible to switch crews working at night should be used. Hand signal lanterns shall be of an approved electric type.

#### 2105. GRADE CROSSINGS

a. A survey shall be made of railroad grade crossings to determine the hazard at each based upon volume of traffic, visibility, and past experience at the location. Grade crossings shall be prominently posted on each side with standard railroad crossing signs, electric crossing lights, crossing gates, or electric crossing bells. The highway pavement should be marked 100 feet ahead to warn motor vehicle operators of the location of railroad crossing. During periods when crossings are heavily traveled (shift changes), a traffic patrolman should be assigned to

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control vehicular and pedestrian traffic, or engines should be required to stop at all main highways within the area until a member of the crew can act as a flagman and direct the leading railcar across the highway. Openings between rails should be suitably filled at grade crossings.

b. Locomotives shall approach crossings under full control. When approaching a grade crossing the locomotive whistle should be sounded (two long, one short, and one long blast) and the bell rung continuously until the locomotive has cleared the crossing. The speed of the locomotive should not be greater than 10 miles per hour while making the crossing.

#### **2106. GENERAL INTRAPLANT OPERATION**

a. The operating requirements given in this paragraph are in addition to the rules and regulations in other current applicable directives (see par. 2101).

b. Personnel should be on the alert at all times to detect defective or unserviceable track or equipment, suspicious or unusual conditions or any condition which may be dangerous to effective operation, and should promptly report such conditions to proper officials.

c. Personnel shall be informed of the location of obstructions where clearances are close. They must not stand on track in front of an approaching engine or car to board it.

d. All trains and engines must be run carefully during and after heavy storms, particularly where tracks may be affected. When fogs, storms, or other

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conditions obscure the track, the speed of the train must be reduced to permit strict observance of rules and insure safety.

e. Trains and engines must be fully protected against any known conditions which may interfere with their safe operation.

f. Unauthorized persons must not be permitted on engines and trains.

g. All movements in the classification yards are considered as switch movements. All other movements are considered as transfer movements. Before any movement of a car or cars containing explosives or other hazardous material and before making transfer movements, irrespective of the contents of a car or cars, all air hose shall be coupled, air brakes cut-in and in proper working order. Cars should not be uncoupled while in motion nor pulled apart by locomotive power. Proper safety precautions shall be observed in breaking air hose connections. (See paragraph 2107d.)

h. When single cars are spotted the hand brakes shall be set and the wheels properly chocked. When more than one car is spotted and the engine detached, the hand brakes shall be set on a sufficient number of cars of a cut of cars to assure that sufficient brakeage is provided. The hand brakes shall be set on the down-grade end of the cut of cars. Reliance must not be placed on the automatic air brakes to hold spotted cars.

i. While moving a car by using a car mover, a man must be stationed at the handbrake.

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*j.* For transfer movements within installations, when cars are moved by locomotives, loads in partly and completely loaded cars shall be blocked and braced sufficiently to prevent movement or shifting of the lading. The car doors shall be closed when the cars are moved by a locomotive.

*k.* When transfer movements are made at night, a member of the crew must take a position on the leading end of the lead car and display a light. Crew member riding the top of a car must, at all times, take a position near the center of the car.

*l.* Locomotives must not be left in front of buildings and loading docks containing hazardous materials longer than necessary to "spot" cars for loading or unloading. Cars at a building should be located so that employees in the building will not be required to run the length of the building should an emergency arise and personnel must be evacuated quickly.

*m.* (Added) Blue flags or signals must be placed at both ends of a car or cut of cars when personnel are working in, on, or under the cars. Tank cars shall be so protected when connected for loading or unloading. When thus protected the car or cars shall not be coupled to or moved. The supervisor or foreman in charge of the personnel loading or unloading the car or cars shall be responsible for placing the blue flag or signal and their removal. Train crews shall be informed of all installation regulations relative to the use of blue flags or signals.

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## 2107. TRANSPORTATION OF HAZARDOUS MATERIALS

*a.* In addition to the requirements of other parts of this section, the rules in *b* through *i* below shall be followed.

*b.* When cars containing explosives or other hazardous materials are received at the establishment or held in yards, precautions must be taken to prevent accidents—particularly at night. These precautions must include provisions for quickly removing and isolating the cars in case of fire.

*c.* Cars loaded with hazardous materials must be loaded and placarded as prescribed by the ICC before being offered for transportation. The carrying of hazardous materials on locomotives or other self-propelled rail vehicles is prohibited.

*d.* Before cars are moved by a locomotive, the air brake hose must be coupled and tested to assure that the air brakes are in proper working condition, and the car doors shall be closed.

*e.* No empty cars shall be removed from warehouses, magazines, buildings, or loading docks until all warning placards have been removed.

*f.* Special care must be taken to avoid rough handling of cars. Cars must not be "cut off" while in motion, and must be coupled carefully to avoid unnecessary shocks. Other cars must not be "cut off" and allowed to strike a car containing explosives. Cars must be so placed in yards or on sidings that they will be subject to a minimum of handling and

be readily removed from danger of fire. Such cars must not be placed under bridges or in or alongside passenger sheds of stations; and where avoidable, engines on parallel tracks should not be allowed to stand opposite or near them.

*g.* "Dropping," "humping," "kicking," or the use of the flying switch is prohibited.

*h.* Adequate measures such as guarding, patrolling, and safety inspection must be provided at all times. All such activity should be under definite and positive administrative control.

*i.* In accordance with paragraph 1222, fire symbols shall be placed on each railroad car while transporting explosives or ammunition within an AMC establishment in order to provide a ready means of identifying the potential hazard should a fire occur.

*j. Rescinded*

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**2108. "EXPLOSIVE" OR "DANGEROUS" PLA-  
CARDED CARS**

(Superseded)

Cars used for the shipment of explosives and ammunition which require "EXPLOSIVE" or "DANGEROUS" placards shall meet the requirements of the ICC for the item being shipped. The cars shall be loaded and braced in accordance with drawings approved by the Ordnance Corps and the Bureau of Explosives.

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### **2109. RAIL BAGGAGE AND EXPRESS CARS**

*a.* When ammunition or explosives are loaded in baggage and express cars, the requirements of subparagraph *b* through *h* below must be met in addition to the requirements of other parts of this section.

*b.* **ICC Regulations must be followed.**

*c.* Oil burning lamps shall be emptied and the oil thoroughly wiped out. Electric-light switches shall be cut off before unloading is started.

*d.* End and side doors shall be locked and sealed. Suitable doorway protection shall be provided in cars when lading extends into the space between side doors of the car.

*e.* End walls of the car shall be properly dunnaged.

*f.* All glass windows in side or end doors of the car shall be covered with lumber.

*g.* Composite cars; i. e., one-half passenger or mail, shall not be used for transporting ammunition and explosives.

*h.* Steam heating valves inside the car shall be shut off. Explosives and ammunition shall not be loaded against steam pipes.

### **2110. CAR INSPECTION**

A car must not be loaded with any of the dangerous explosives (ICC class A) or solid propellant (smokeless powder) for small arms in quantities exceeding 50 pounds until it has been thoroughly inspected by a competent employee of the carrier who shall certify that its condition conforms to these regulations and who shall sign certificate No. 1 (figure

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211A). After a certified car as prescribed herein has been furnished by the carrier, the shipper or his authorized employee must, before commencing the loading of any such car, inspect the interior thereof and after loading, certify to its proper condition as specified in paragraph 2108 above by signing car certificate No. 2 (figure 2111B). A shipper must decline to use a car not in proper condition.

#### **2111. CAR CERTIFICATES**

a. The following certificates, figures 2111A and 2111B, printed on strong tag board measuring 7 by 7 inches, or 6 by 8 inches, must be duly executed in triplicate. The original copy must be filed by the carrier at the forwarding station and the other two must be attached to either the outside of car doors or the side of car, one on each side. The lower edge of the certificate should be located not less than 4½ feet above the floor level.

b. Both certificates must be signed; certificate No. 1 by a representative of the carrier. For all shipments loaded by the shipper, he or his authorized agent must sign certificate No. 2, and the representative of the carrier must certify as to loading and staving and general conditions. When the car is not loaded by shipper, certificate No. 2 must be signed only by the representative of the carrier.

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.....	Railroad
<b>CAR CERTIFICATE</b>	
No. 1 .....	Station..... 19.....
I hereby certify that I have this day personally examined .....	
Car No. .... and that the roof, sides and ends have no loose boards, holes or cracks or unprotected decayed spots liable to hold sparks and start a fire; that the kingbolts and draft bolts are properly protected and that there are no uncovered pieces of metal or nails projecting from the floor or sides of the car which might injure packages of explosives; also that the floor is in good condition and has this day been cleanly swept before the car was loaded; that I have examined all the axle boxes and that they are properly covered, packed and oiled, and that the air brakes and hand brakes are in condition for service.	
..... Railway employee inspecting car.	

Figure 2111A. Car Certificate No. 1.

## 2112. LEAKING PACKAGES

A constant alertness must be maintained to detect through characteristic odors the leakage of hazardous materials from faulty packages. Leaking packages should be removed from cars and repaired, or if in tank cars, the contents should be transferred.

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### CAR CERTIFICATE

No. 2 ..... Station.....19.....

I hereby certify that I have this day personally examined the above car; that the floor is in good condition and has been cleanly swept and that the roof, sides and ends have no loose boards, holes, cracks or unprotected decayed spots liable to hold sparks and start a fire; that the kingbolts and draft bolts are protected, and that there are no uncovered pieces of metal or nails projecting from the floor or sides of the car which might injure packages of explosives; that the explosives in this car have been loaded and stayed, and that the car has been placarded according to the regulations for the transportation of explosives prescribed by the Interstate Commerce Commission; that the doors fit or have been stripped so that sparks cannot get in at the joints or bottom.

Shipper.....

..... Railway employee inspecting loading and staying.

*Figure 2111B. Car Certificate No. 2.*

If artificial light is necessary, only approved electric lights should be used. Leaking tank cars containing compressed gases should be switched to a location distant from habitation and highways and proper action taken for transferring contents under com-

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petent supervision. Cars containing leaking packages or leaking tank cars must be protected to prevent ignition of liquid or vapors by flame from inspectors' lanterns or torches, burning fuses, switch lights, switch thawing flames, fires on side of track, hot coal from locomotives, or from other sources. All unnecessary movement of a leaking car discovered in transit must cease until the unsafe condition is remedied.

### **2113. TOOLS FOR LOADING AND UNLOADING EXPLOSIVES AND AMMUNITION**

For loading and unloading containers of bulk explosives, no metal tools other than hammers and pinch bars should be used inside freight cars. Saws and hatchets may be used outside of cars to cut lumber. This restriction does not apply when loading or unloading ammunition in which explosives are not actually exposed. Steel tools may be used inside cars containing ammunition, provided no explosives are exposed. Safety tools must be used and operations must be performed with the utmost care where explosives are actually exposed.

### **2114. BLOCKING AND BRACING OF "KEYSTONE" OR "CARPENTER" TYPE FIBER CONTAINERS IN FREIGHT CARS**

"Keystone" or "Carpenter" type containers used to ship solid propellant (smokeless powder), tetryl, DNT, etc., should be inspected immediately prior to shipment and only those in good condition used. Containers should be loaded in accordance with

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**sketch No. 39 of appendix No. 2, Bureau of Explosives Pamphlet No. 6A.**

### **2115. CAR LOADING OF ITEMS CONTAINING AMMUNITION AND EXPLOSIVES**

Bureau of Explosives pamphlets Nos. 6 and 6A, or latest revision thereof, and methods prescribed by Ordnance Corps drawings should be followed for the loading and bracing of railway car shipments of military explosives and ammunition. The packages should be placed in position with no more force than is needed to secure a compact load and to prevent shifting and damage en route. **When striking force is necessary a short piece of lumber shall be placed against the container.** Excessive or violent use of mauls shall not be permitted.

### **2116. SEALING CARS CONTAINING EXPLOSIVES AND AMMUNITION**

In addition to any other seals which may be used, cars containing explosives or ammunition shall be sealed with the standard railway type car seal on which is stamped an identifying number. If the seal is not in place when the car is received the car

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shall be treated as suspicious and shall be inspected. A permanent record of car numbers and seals shall be kept by shipper.

#### 2117. CHANGING CAR SEALS

When a car seal is changed on a car of explosives, a record must be made showing the following information:

Railroad----- Place----- Date---  
Number or description of seal broken-----  
Number or description of seal used to reseal car-----  
Reason for opening car-----  
Condition of load-----  
Name and occupation of persons opening car-----

This record shall be shown on waybill or other form or memorandum which accompanies car to destination.

#### 2118. HANDLING WRECKS ON INSTALLATIONS OF CARS PLACARDED "EXPLOSIVES" OR "DANGEROUS"

a. *Preventing fire.* When an accident does not cause the immediate ignition or detonation of the explosive, the first and most important precaution after caring for the injured is to prevent fire. To that end, and before beginning to clear a wreck, all unbroken packages of explosives should be removed to a place of safety and as many of the broken packages and as much of the contents as possible gath-

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ered up and removed for destruction or repacking. In this and subsequent work, the danger of sparks igniting and causing the detonation of loose explosives that cannot be immediately removed should be reduced by covering or mixing earth with the explosive. In the case of mercury fulminate, PETN, lead azide and black powder spillage, the area should be wet down thoroughly and after removal of the wreckage, the wet ground dug up, removed to a safe place and burned. Otherwise, when the ground and explosives become dry, small explosions may occur when the area is stepped upon or struck.

*b. Fire fighting* (see pars. 1223 and 1224). In event of fire burning near a car containing explosives, every effort should be made to remove the car to a safe place. No attempt shall be made to fight a fire where dangerous articles are directly involved, and all persons shall be evacuated to a distance of not less than 2,000 feet.

*c. Broken packages.* Packages of explosives found damaged or broken may be repaired or the material repacked when it is practicable and not dangerous to do so. A broken box of high explosives that cannot be repaired should be reinforced by stout wrapping paper and twine, placed in another strong box and surrounded by dry fine sawdust or dry, clean cotton waste, or wads made from dry newspapers. A ruptured can or keg should be inclosed in a grain bag of good quality and boxed. Damaged packages thus protected and properly marked may be forwarded.

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The box and waybill should be marked to indicate that it has been repacked. Explosives should be repacked wet if so packed in original containers.

**2119. HANDLING WRECKS ON INSTALLATIONS OF CARS PLACARDED "DANGEROUS" (FLAMMABLE LIQUIDS)**

*a. Preventing spread of fire.* In event of fire, endangered cars which are in condition to be moved should be pulled away. Holes should be dug or earthen dikes thrown up in the path of burning liquid to limit its spread. The burning liquid should be smothered with sand, dirt, or wet blankets. Foam or carbon dioxide fire extinguishers are effective if available. Hose streams of water, however, are not likely to quench such a fire. A watch should be posted for all tank cars involved in a fire for the appearance of red-hot spots which indicate probable rupture point of the tank. Personnel should be kept out of a direct line of these spots since a stream of hot liquid or burning vapor may be projected 50 feet or more. Tank cars shall not be punctured deliberately.

*b. Care of safety valves.* If tank cars have been forced into such a position that the safety valves may be jammed, an effort should be made to roll the car over so that the valves may function properly. When vapors are escaping from the safety valve, they may ignite and burn like a torch. It is usually the best procedure not to extinguish this flame until

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all other fires in or near the wreck have been extinguished. Otherwise, the leaking vapor may spread over a large area and gradually increase in concentration until the explosive vapor-air mixture is reached to be ignited finally by fire in other parts of the wreckage. The safer procedure is to let the vapor escaping from the safety valves burn until the car can be cooled and the vapor pressure reduced to the point where the safety valves will close.

*c. Preventing ignitions.* For the same general reasons given in *b* above, the hazards involved in salvaging affected equipment and cargo may be greater when fire does not occur. To guard against ignition, all lights and fires (lighted pipes, cigars, and cigarettes included) in the vicinity should be extinguished and only approved electric flashlights or electric hand lanterns should be used. When practicable, the work of handling wrecks involving tank cars should be done during daylight hours. Cranes should be kept as far as possible to the windward. All leaks should be located and if possible stopped by wooden plugs. Ample time should be allowed for the dissipation of flammable vapors before starting to clear away damaged cars or to transfer their contents. Records show ignition has occurred as far as 1,500 feet from the source of leakage. The least damaged cars should be removed to safety avoiding sudden shock or jars. No attempt should be made to transport a damaged car from which flammable liquid is leaking unless absolutely necessary.

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## 2120. INSPECTION OF CARS

a. Rail cars containing explosives and ammunition entering an Ordnance establishment must be inspected. This inspection comprises the examination of the outside and underside of each car for damage such as defective brakes, couplings, wheel flanges, hot boxes, etc.; to detect unauthorized and suspicious articles; to check correctness of individual car numbers and seal numbers against bills of lading. When the probability of sabotage is remote, such inspections may be accomplished from ground level without the aid of an inspection pit to discover unsafe structural and mechanical deficiencies of the car. During periods of emergency when sabotage may be attempted, and also to aid in the rapid inspection and movement of cars, an inspection pit should be provided.

b. Cars of ammunition or explosives on which foreign and suspicious articles have been secreted or attached outside or underneath the car, or cars which show defect that might affect the safety of the establishment or contents of the car, should be removed to the suspect car siding for additional inspection. During times of national emergency, cars on which the seal numbers do not correspond to those shown on the bill of lading shall be treated as suspect cars and should be removed to the suspect car siding for additional inspection (par. 1716).

c. Cars which satisfactorily pass the inspection outlined above may be considered reasonably safe but care should be exercised in breaking car seals and opening car doors because of the possibility of

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damage or shifting lading, leaking containers, etc. When the quantity and class of ammunition present in the classification yard does not exceed that permitted by the appropriate quantity-distance table, based on distance to adjacent targets, cars may be opened for inspection at that point, otherwise interior inspection should be accomplished after the cars have been spotted at the unloading point.

#### **2121. INSPECTION OF INCOMING SHIPMENTS**

Cars in which explosives or ammunition are received shall be inspected after unloading to see that they are clean and free from loose explosives or other flammable materials, and that the placards and car certificates are removed. Explosive sweepings shall be destroyed.

#### **2122. DAMAGED SHIPMENTS**

Any shipment received in damaged condition or not loaded in accordance with appropriate Ordnance Corps drawings shall be reported on **DD Form 6 (Report of Damaged or Improper Shipment)** in accordance with **AR 700-58** and **ORDM 3-9**.

#### **2123. CONTAINERS**

Containers of explosives or ammunition must not be opened or repaired on any railway car containing explosives or ammunition, excluding railway cars used as operating or inspection points.

**2124. TECHNICAL AID AND ASSISTANCE TO  
RAIL CARRIERS IN EVENT OF AN INCI-  
DENT INVOLVING AMMUNITION  
AND EXPLOSIVES**

(Added)

*a.* AR 55-355 authorizes the Chief of Ordnance to extend technical aid and assistance as deemed necessary in connection with the moving, salvage, demolition, neutralization, or other disposition of Government-owned shipments of explosives and other dangerous articles being transported or stored by carrier. Commanders of Ordnance Corps installations where explosives and ammunition (including guided missile items and heavy rockets) are handled are authorized to act for the Chief of Ordnance in this regard. AR 55-355 outlines the responsibilities to be assumed by carriers when assistance is rendered and procedures to be followed when assistance is requested.

*b.* In extending requested assistance, commanding officers should instruct their representatives to cover the following points as a minimum:

- (1) Upon arrival at the scene, report should be made to the official in charge that request was received for an Ordnance representative to be present to render technical advice and assistance in questions involving explosives and ammunition, including guided missile ammunition items and heavy rockets.
- (2) Determine if the scene of the wreck is adequately patrolled (day and night) by rail-

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road personnel or local peace officers and if persons other than those working on the wreck are prohibited from approaching the scene. If this matter is not being properly handled, suggestions should be made to the official in charge for correction. Emphasis should be placed on the danger of picking up ammunition for souvenirs.

- (3) Suggest to the official in charge that smoking and the use of matches or flames in the area be prohibited if such action has not already been taken.
- (4) The condition and position of wrecked cars and the condition of bracing and contents should be noted. Inspect containers noting particularly any leaking containers of explosives or ammunition.
- (5) Confer with officials (including wreck master) and discuss, from the safety viewpoint, procedures for handling the wreck, with emphasis being placed on the following:
  - (a) Instruction of wrecking crew concerning the hazard of handling explosives roughly.
  - (b) Removal of broken containers and loose explosives or ammunition that can be accomplished before handling of wrecked railroad cars.
  - (c) Appraisal of condition of railroad car and contents to allow safe rerailling of car without reloading.
  - (d) Furnish advice as to which containers can

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be recovered or repaired for reshipment.

- (e) Furnish advice as to which containers and ammunition should not be shipped and as to their disposal, either by transfer to an Ordnance establishment for disposition or by destruction at the scene of the incident. If need for destruction of explosives or ammunition at the scene of the incident is determined, the Ordnance Officer of the appropriate Army Area should be contacted and the services of an Explosives Ordnance Disposal Officer requested.
- (f) Furnish other advice relative to handling the particular types of explosives and ammunition involved.
- (g) Inspect area to insure that all ammunition and explosives have been cleaned up or disposed of.

c. In order to permit accomplishment of necessary supply and surveillance functions, whenever the commander of an Ordnance installation has rendered assistance due to an incident as outlined above, he shall immediately contact—

- (1) Commanding Officer, Ordnance Ammunition Command, Joliet, Ill., Attn: ORDLY-Q, when ammunition items other than guided missiles and heavy rockets are involved.
- (2) Commanding General, Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala., Attn: FSD, when guided missile am-

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munition items or heavy rockets are involved. Such report will be made by the most rapid means of communication available, stating all pertinent facts concerning the incident.

*d.* Any action required, other than that outlined above, will be directed by the—

- (1) Commanding Officer, Ordnance Ammunition Command, for ammunition items other than guided missiles and heavy rockets.
- (2) Commanding General, Army Rocket and Guided Missile Agency, for guided missiles and heavy rockets.

*e.* Incidents resulting in explosions of ammunition or explosives shall be reported by the installation rendering assistance in accordance with OCO 19-51.

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## SECTION 22

### MOTOR VEHICLE TRANSPORTATION

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#### 2201. REFERENCES

The operation of motor vehicles within an Ordnance establishment shall be in accordance with applicable current directives and as further qualified by this Manual.

#### 2202. MOTOR VEHICLE SAFETY PROGRAM

Current directives, particularly SR 385-10-20, Army Safety Program, dated 24 November 1948, requires the institution of a motor vehicle safety program as part of the over-all safety program of an Ordnance establishment. SR 385-155-1, Safety Prevention of Motor Vehicle Accidents, dated 16 May 1950, contains detailed information for inclusion in such a program. This paragraph and paragraph 2203 outline a recommended motor vehicle safety program.

#### 2203. ADMINISTRATION OF PROGRAM

*a. General.* An effective traffic accident prevention program is administered by an individual familiar with traffic problems and motor vehicle safety. He cooperates with the various supervisors whose

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functions are pertinent to traffic activities and whose active cooperation is essential to the successful accomplishment of the program. These may include the—

- (1) Supervisor responsible for spot control of traffic when necessary.
- (2) Motor vehicle maintenance supervisor when accidents indicate maintenance deficiencies.
- (3) Engineering supervisor where accidents indicate physical hazards and non-existence or improper functioning of traffic signals, etc.
- (4) Transportation supervisor when high accident locations, driver deficiencies, and congested location are pertinent.
- (5) Training supervisor.
- (6) Traffic Control Committee or Inquiry Board.

*b. Accident reporting and follow-up.*

- (1) Each motor vehicle accident which occurs on the reservation and each occurring off the reservation involving Government-owned vehicles assigned to the establishment is investigated by competent personnel and reported as required by current directives.
- (2) Each traffic accident and investigation report is transmitted to the administrator referred to in *a* above, for a complete analysis of the accident and dissemination of resultant information. This function is the key

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to the entire traffic accident prevention program.

- (3) Incomplete reports of accidents submitted by drivers are returned through their immediate supervisor for complete information. Without accurate and adequate information, interested departments and personnel will be unable to take effective action.

*c. Accident records.* The individual selected for administration and coordination of a motor vehicle safety program may find it helpful to maintain the following records:

- (1) Accident spot map of the reservation on which is recorded the specific location of each accident, and the identifying number which designates the particular accident report from which the information was obtained. As an adjunct to the map, there may be maintained a similarly numbered list showing the identifying numbers, location, hour of the accident, and the specific questionable driver action or physical hazard involved.
- (2) A monthly and cumulative tabulation sheet containing a complete breakdown of all reported accidents.
- (3) A simple card record of drivers showing the name, badge, or pay roll number of the driver, and such data as the time and place of accident or violation, and the driver ac-

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tion involved. The file is designed to assure prompt identification of repeaters or "accident-prone" drivers.

- (4) Monthly summaries of the information compiled are forwarded to interested supervisors designated in *a* above for appropriate action.

*d. Warning signs.* Stop, railroad crossing, curve, speed zone, and no-passing signs or signals are used as local conditions dictate. Standard highway signs are recommended but irrespective of the type of warning signs used, uniformity is desirable throughout the establishment. Consideration may be given to reflectorizing warning signs for marking hazards which are increased during periods of poor visibility.

- (1) The use of an excessive number of warning signs is avoided to prevent unreasonable impedence of traffic flow and the breeding of disregard for all traffic controls.
- (2) Warning signs in the speed zones specified are placed at the minimum following distances from hazards to assure drivers sufficient time to adjust driving to cope with the hazard.

<i>Speed zone</i> (mph)	<i>Distance</i> (feet)
15-----	36
25-----	55
35-----	101

- (3) Heavily traveled gate entrances and exits, particularly at shift change, are channelized

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so that two or more traffic lanes can be formed to expedite traffic flow. Channelizing is usually accomplished by road striping and instructional signs.

- (4) Hazardous curves are posted and the road striped if the road surface permits. At sharp turns crash fences are erected and striped in contrasting colors for visibility.
- (5) Blind intersections are appropriately posted. At blind intersections in congested areas, reduced speed limits are enforced, and, if necessary, stop signs installed for the lesser flow of traffic. At dead end streets, crash fences are erected and striped in contrasting colors for visibility.

*e. Road, parking, and pedestrian traffic layouts.*

- (1) Pedestrian lanes are used where large numbers of pedestrians cross heavily traveled roads at recurring intervals such as shift change times. The lane is designated by stripes or portable standards. Conflicts between pedestrian and vehicular traffic are reduced to a minimum number of controllable points. Posted signs require vehicular traffic to stop for pedestrians unless personnel are stationed at such locations to control vehicular and pedestrian traffic.
- (2) Adequate clear passage lanes are provided in parking lots for through traffic. No parked vehicle is permitted to encroach upon clear passage lanes. One-way entrances and exits for parking lots are desig-

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nated where necessary to facilitate traffic movement with a minimum of conflict. Parking lots have safety aisles for pedestrians.

- (3) Parking of vehicles, other than those necessary for efficient operation, is not permitted in close proximity to operating buildings or other structures where there is considerable traffic congestion. Parking of vehicles is not permitted on shoulders of roads in congested areas during heavy traffic periods (par. 1609).

(4) Rescinded.

*f. Driver training.*

- (1) Each driver is trained in the operation of the specific type of vehicle to which he will be assigned before he is permitted to operate the vehicle. Additional training is given if necessary when assignments are changed.
- (2) Drivers who have been involved in violations or an accident are given specific training in the particular driver action which caused or contributed to the violation or accident. This training is simple, as brief as will be effective, focussed upon the phase of operation in which the driver is considered

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deficient, and include actual operation of the vehicle under realistically simulated conditions in the immediate presence of a competent instructor.

- (3) A simple set of traffic rules and regulations appropriate to the establishment may be prepared and given the widest practicable distribution to personnel engaged in the operation of vehicles on the reservation. Accident trends and violations trends disclosed through accident reports might also be highlighted and disseminated to personnel through supervisors' meetings, safety meetings, plant organs, and similar media.

*g. Educational enforcement.* Driving practices of motor vehicle operators are developed and controlled by educational enforcement. Educational enforcement consists of the assignment of personnel, preferably guards, to point duty at intersections or locations which are high in accident frequency or traffic congestion. Prior to each assignment, the designated person is fully informed of the specific problem or driver action which has caused trouble at that point in the past. The duties of such a person include controlling traffic at the hazardous location to prevent accidents that might arise because of the problem or driver action which has necessitated his assignment.

*h. Preventive enforcement.* After educational enforcement has been applied and safe driving practices develop in the majority of motor vehicle operators,

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recalcitrant operators may be controlled by preventive enforcement. In the event that an authorized person observes a driver action which is contrary to existing regulations, a written warning is issued to the offending driver, with a copy routed to the individual in charge of the program and another copy to the driver's superior. After a second warning has been issued to the same driver, he is given specific training to remedy the violating practices reported. If three warnings are issued to the same driver within 12 months, punitive action may be taken as deemed necessary upon the facts involved in all three violations. However, punitive action is wholly permissible and in many cases desirable, on either the first or second warning, depending upon the gravity of the violation.

*i. Punitive enforcement.* Punitive enforcement measures may be applied to employees who have received three warnings within 12 months, employees involved in outstanding flagrant traffic violations, and employees whose actions have caused a motor vehicle accident on the reservation or an accident involving a government vehicle off the reservation. Punitive enforcement is applied through the medium of a board consisting of not less than three and preferably five persons. The board reviews all the facts involved in the case of a third warning and all facts disclosed by investigation reports in the case of an accident. The drivers appearing before the board are afforded full opportunity to be heard after which the Traffic Board agrees on prompt disposition and

recommended such disposition to the commanding officer.

#### **2204. MOTOR VEHICLE SHIPMENT REGULATIONS**

Motor vehicle shipments on public highways are governed by the Interstate Commerce Commission Motor Carrier Safety Regulations. All motor vehicle shipments from an Ordnance establishment shall comply in full with the applicable portions of ICC, state, and municipal regulations except as provided for in these regulations. Before any motor vehicle designated for movement over public highways may be loaded with dangerous articles, as defined by the Interstate Commerce Commission, the vehicle must be inspected and approved by a qualified inspector for compliance with AR 55-355 (DD Form 626). After loading, lading must be inspected and approved. Driver selection, training, etc., for intraplant shipping and for operation of Government-owned trucks on public highways shall be in accordance with pertinent requirements of the Motor Carrier Safety Regulations, TM 21-300, Driver Selection and Training; and TM 21-305, Manual for the Wheeled Vehicle Driver.

#### **2205. MOTOR VEHICLES FOR EXPLOSIVES SHIPMENT**

Cargo type trucks and truck-tractor drawn semitrailer vans are the preferred types of equipment for transporting ammunition and explo-

sives. Other types of trailers should not be used by Ordnance installations for this purpose except where the material is sufficiently large to make handling by vans impractical, but this restriction need not apply to licensed common carriers and contract equipment. Equipment used for transporting ammunition or explosives must meet the following requirements and these should be supplemented by local regulations as deemed necessary by the commander:

a. Special precautions must be taken to avoid ignition of explosives or vapors by the exhausts of automotive vehicles.

b. The lighting system shall be electric. Batteries and wiring shall be so located that they will not come into contact with containers of explosives or ammunition. Portable lights, other than those approved for use in magazines, shall not be allowed in a truck carrying explosive material.

c. The interior of the truck body shall have all exposed ferrous metal covered with nonsparking material when transporting scrap and bulk explosives in containers which may be damaged and explosives become exposed. If the explosives transported consist of ammunition or explosives packaged for shipment in accordance with ICC specifications, it will not be necessary to cover the ferrous metal. Open body vehicles other than the flat-bed trailer type used to transport large items such as missile, Jatos, and rocket motors

must have sides that are strongly made and securely fastened so that explosives are safely retained. Where a top is required, it should be of a noncombustible or flame-proof material.

d. Each truck shall be equipped with at least 2 standard class B, C portable fire extinguishers. As a minimum these shall have a classification of 1-B, C. On Government vehicles, one of the extinguishers shall be mounted on the outside of the cab on the driver's side and the other in the cab. When trucks are equipped with an interior carbon dioxide flooding device, one extinguisher should be carried.

e. Red lights are not permitted on the front of vehicles transporting explosives and ammunition on public roads and highways nor should they be used on the front of vehicles transporting explosives and ammunition within an Ordnance establishment. Motor vehicles that transport explosives and ammunition within the establishment but outside explosives areas shall have conspicuously attached thereon four placards exhibiting the word "Explosives," one on each side of the vehicle, one on the front and one on the rear, so attached that whenever the vehicle is not so loaded, the placards can be removed or covered. Reflectorized placards are preferred. This can be accomplished by attaching the placard so that it can be reversed or removed. In addition, two appropriate fire symbols shall be attached in similar

locations to the "Explosives Placards," when required by paragraph 1222.

*f.* Trucks fueled with LP gas shall not be used to transport ammunition and explosives in ammunition areas.

## **2206. INSPECTION OF VEHICLES**

Government-owned motor vehicles used for transportation of hazardous materials shall be inspected at frequent regular intervals by a competent person to see that mechanical condition and safety appliances are in good working order and that oil and motor pans under engines are clean. Daily inspection shall be made to determine that:

*a.* Fire extinguishers are filled and in good working order.

*b.* Electric wiring is in good condition and properly attached.

*c.* Fuel tank and piping are secure and not leaking.

*d.* Brakes, steering, and other equipment are in good condition.

## **2207. OPERATING REQUIREMENTS**

The following requirements shall be observed in the operation of Government-owned vehicles transporting explosives and ammunition:

a. During loading and unloading of motor vehicles on a grade, the brakes must be set and the wheels chocked.

b. When a motor vehicle approaches within 25 feet of the doors of a structure through which a shipment is to be moved, the doors must be kept closed until the motor has been switched off unless all of the following requirements are met:

- (1) The exhaust system is not exposed to accumulations of grease, oils, gasoline, or other fuels; has ample clearance from fuel lines and from other combustible materials; and is equipped with an effective spark and flame arresting device in the exhaust line.

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A standard muffler is not an effective flame or spark arresting device.

- (2) No exposed explosive material is being transported or handled.
- (3) No explosive material is located on the platform ramp or otherwise outside of the structure or trailer while the motor is running.

c. If a motor vehicle containing dangerous articles is to use a ferryboat or other passenger carrying vessel the driver shall be furnished an identification letter requesting transportation on the vessel and signed by a responsible officer. The letter must be presented to the master of the vessel or his representative. The letter shall refer to the bill of lading (copy of which shall be in the possession of the driver) and shall state the truck license numbers and the name of the owner. Such transportation is regulated by the United States Coast Guard's "Explosives and Other Dangerous Articles on Board Vessels," CG 187.

d. Trucks containing ammunition or explosives should not be refueled within magazine or explosives areas of Ordinance establishments, including refueling from mobile units. A central refueling station should be used. The requirements of paragraph 1721 should also be observed when applicable.

e. A permanent record of motor vehicle numbers and seals applied to the vehicle shall be kept by the establishment.

f. No person shall be allowed to ride in or on the truck body or van of a motor vehicle transporting

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ammunition or explosives except in cases involving limited quantities of small arms ammunition with nonexplosive bullets. In the latter case the small arms ammunition must be in closed containers which are properly secured in the truck body and seats shall be provided for personnel, restricted in number to the minimum required.

*g.* No explosives or ammunition shall be loaded into or unloaded from motor vehicles while their motors are running unless the motor is required to provide power to vehicle accessories such as mechanical handling equipment utilized in the loading and unloading of the vehicle, provided:

- (1) The accessory is an integral part of the vehicle.
- (2) The exhaust gases from the motor are emitted at least 6 feet from the point at which the loading operation is conducted and are directed away from this point.
- (3) The exhaust pipe is equipped with a spark arrestor.
- (4) Materials being loaded or unloaded which may evolve flammable vapors are enclosed in containers equipped with tight fitting lids so that the vapors may not escape from the containers.

#### **2208. MIXED LOADING**

The types of dangerous articles which may be transported on the same motor vehicle traveling over public highways are given in the Loading and Stor-

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age Chart of ICC Regulations for Transportation of Explosives and Other Dangerous Articles by Motor, Rail and Water. The requirements of the chart shall be complied with for shipments over public highways.

## **2209. INSTRUCTIONS TO DRIVERS**

a. Drivers must be thoroughly familiar with the ICC Motor Carrier Safety Regulations.

b. Before motor vehicles loaded with hazardous materials leave an AMC establishment, drivers

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shall be informed of the nature of their cargo and methods of fighting fires involving the truck or its cargo. DD Form 836 (Special Instructions for Drivers) will be completed in accordance with the requirements of AR 55-355 and furnished such drivers. AR 55-355 does not contain instructions for fighting fires involving liquid propellants. The following instructions will be issued to drivers of motor vehicles transporting these commodities:

(1) Fuming nitric acid.

(a) Fuming nitric acid is neither explosive nor will it burn, but because of its violently oxidizing nature, the flammability of all combustible material in direct contact with it is greatly increased.

(b) It is violently corrosive and will destroy human flesh. If it comes in contact with the skin or eyes, flush immediately with large quantities of water.

(c) The fumes from this item are highly toxic and must not under any conditions be inhaled. As these fumes can be both seen and smelled, the driver must be constantly on the alert for leaking or ruptured containers with resulting air contamination.

(d) When two or more trucks are travel-

ing together, they shall keep not less than 50 feet apart.

- (e) In case of accident or fire, the driver shall attempt to notify the nearest police and fire departments and upon their arrival at the scene, inform them of the nature of the cargo, its hazard, and the proper precautions necessary for the safe control of the situation. Occupants of buildings, other vehicles, and persons in the open (particularly downwind) in the vicinity of the accident or fire shall be warned to stay at least 1,000 feet away.
- (f) In case of an accident, the personnel engaged in handling the wreckage shall be warned of the corrosive and toxic qualities of the cargo and instructed as to necessary safety precautions. Appropriate protective clothing should be worn and, if fumes are present, a self-contained breathing apparatus.
- (g) Fire fighting procedures:
  - ! If any part of the vehicle except the portion containing the lading catches fire, the driver should use his extinguisher immediately in an attempt to put out the fire and should make every

attempt to prevent the spread of fire  
to the lading.

2 Fires involving fuming nitric acid  
should be fought with large quanti-

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ties of water. Water in the form of mist or fog is also very effective in suppressing the fumes and extinguishing the fire. Care should be taken in applying water to this item as considerable heat is generated and splashing or spattering may result, endangering fire-fighting personnel in the immediate vicinity. The area surrounding the fire should be thoroughly wet down to prevent grass, brush, or other organic material from being ignited.

3. Fire fighters should wear appropriate protective clothing and approach the fire from the upwind direction.

4. Should the heat of the fire cause one or more drums to rupture, the liberated acid and nitrous fumes will increase the hazards present and greater safety precautions will be necessary. In such a case, all fire-fighting personnel shall wear full protective clothing, including a self-contained breathing apparatus of an approved type.

(2) Aniline—furfuryl alcohol mixtures.

(a) These mixtures are not explosive but are highly flammable and will react violently when in contact with most ox-

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idizing agents. Most of these mixtures are considered noncorrosive but they will slowly attack rubber, cork and most plastics.

- (b) They are toxic by absorption through the skin. If they come in contact with the skin or eyes, flush immediately with large quantities of water, wash thoroughly with soap and rinse.
- (c) The fumes from these mixtures are highly toxic and must not be inhaled under any condition. These fumes have a musty, moldy odor.
- (d) When two or more trucks are traveling together, they shall keep not less than 50 feet apart.
- (e) In case of accident or fire, the driver shall attempt to notify the nearest police and fire departments and upon their arrival at the scene, inform them of the nature of the cargo, its hazard, and the proper precautions necessary for the safe control of the situation. Occupants of buildings, other vehicles, and persons in the open (particularly downwind) in the vicinity of the accident or fire shall be warned to stay at least 1,000 feet away.
- (f) In case of an accident, the personnel engaged in handling the wreckage shall

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be warned of the toxic and flammable characteristics of the cargo and instructed as to the necessary safety precautions. Appropriate protective clothing should be worn and, if fumes are present, a self-contained breathing apparatus.

**(g) Fire-fighting procedure:**

- 1. If any part of vehicle, except that portion containing the lading, catches fire, the driver should use his extinguisher immediately in an attempt to put out the fire and should make every attempt to prevent the spread of fire to the lading.**
- 2. Fires involving aniline-furfuryl alcohol mixture may be fought with dry powder extinguishers, foam extinguishers, chemical extinguishers, and water in the form of a spray or fog. Solid streams of water should not be used.**
- 3. Fire-fighters should wear appropriate protective clothing and approach the fire from the upwind direction.**
- 4. Should the heat of the fire cause one or more of the containers to rupture, the liberated fuel will increase the hazards present and greater precautions will be necessary. In such a**

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case all fire-fighting personnel shall wear full protective clothing, including a self-contained breathing apparatus of an approved type.

**(3) Unsymmetrical Dimethylhydrazine (UDMH).**

- (a) UDMH is insensitive to detonation by either shock or temperature; however, the vapor from UDMH forms an explosive mixture with air and is easily ignited by either spark or flame. In liquid form UDMH reacts violently with certain acids and oxidizing agents. In addition, UDMH is highly flammable.**
- (b) UDMH is exceedingly corrosive and will destroy human flesh. The vapors are extremely irritating to the eyes and are toxic by inhalation. In case of contact with liquid UDMH or its vapor, the skin and eyes must be immediately flushed with large quantities of water.**
- (c) The fumes from UDMH are highly toxic and must under no conditions be inhaled. As the fumes present a dangerous toxic and fire hazard, the driver must be constantly on the alert for their presence. These fumes have a characteristic ammonia-like odor.**

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- (d) When two or more trucks are traveling together, they shall keep at least 300 feet apart.
- (e) In case of accident or fire, the driver shall attempt to notify the nearest police and fire departments and upon their arrival at the scene, inform them of the nature of the cargo, its hazard, and the proper precautions necessary for the safe control of the situation. Occupants of buildings, other vehicles, and persons (particularly downwind) in the vicinity of the accident or fire shall be warned to stay at least 1,000 feet away.
- (f) In case of an accident, the personnel engaged in handling the wreckage shall be warned of the corrosive, toxic, and vapor explosion characteristics of the cargo and instructed as to the necessary safety precautions. Appropriate protective clothing should be worn and, if fumes are present, a self-contained breathing apparatus.
- (g) Fire-fighting procedure:
  1. If any part of the vehicle except that portion containing the lading catches fire, the driver should use his extinguisher immediately in an attempt to put out the fire and should make

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- every attempt to prevent the spread of fire to the lading.
2. Fires involving UDMH may be fought with large quantities of water or with chemical extinguishers; water is preferable. Fire fighters must use extreme caution and utilize all available protective cover in approaching the fire. As many hose streams as possible, directed at the base of the fire is considered the most effective means of extinguishment.
  3. Fire fighting will be done from the upwind side only, and the fire fighters should wear adequate protective clothing and a self-contained breathing apparatus.

#### **2210. INSPECTION AND MOVEMENT OF INCOMING SHIPMENTS**

- a. Motor vehicles loaded with explosives or ammunition shall be carefully inspected in accordance with DD Form 626 (Inspection Report—Motor Vehicles Transporting Class A or B Ammo and Explosives over Public Highways) by a competent representative of the commanding officer at a designated inspection station. The inspection station should be located remote from hazardous and populated areas.
- b. When inspection reveals that an incoming tractor is in an unsatisfactory condition, it should be dis-

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connected from the trailer (at the inspection station) and moved to a position where it will not endanger any explosives.

c. When inspection reveals that the trailer or its load is in an unsatisfactory condition, it shall be removed to a location which is at least inhabited building distance (not less than missile distance for missile producing items) for the material involved from inert and administration areas, hazardous locations, and the installation boundary. At this location, correction of unsatisfactory conditions shall be accomplished prior to movement to the destination of the vehicle within the installation. The route when moving from the inspection station to the isolated location, insofar as possible, should be removed from built-up areas and areas where personnel concentrations are high.

d. Vehicles which cannot be dispatched immediately to points where they are to be unloaded may be moved to an interchange yard which shall be separated from inhabited buildings, administration areas, magazines, operating buildings, and installation boundaries by a minimum of **inhabited** building distance or 1,800 feet, **whichever is less**. **The 1,800-foot distance may be reduced to 1,400 feet where the exposure consists of barricaded portions of earth-covered magazines.** Loaded vehicles should be moved from the interchange yard as soon as possible. This interchange yard may also be used for the interchange of tractors or drivers on outgoing shipments. **Railway classification yards may be used as motor vehicle interchange yards.**

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e. Vehicles which cannot be dispatched within 24 hours to points where they are to be unloaded should be moved to locations meeting the requirements of appropriate quantity-distance tables. In such instances, the vehicles shall be considered as aboveground magazines, except that they need not be separated from each other as required by paragraph 1712.

#### **2211. DAMAGED SHIPMENTS**

Any shipment received in damaged condition or not loaded in accordance with appropriate Ordnance Corps drawings shall be reported on DD Form 6 (Report of Damaged or Improper Shipment) in accordance with **AR 700-58** and **ORDM 3-9**:

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**2212. TECHNICAL AID AND ASSISTANCE TO  
MOTOR CARRIERS IN EVENT OF AN  
INCIDENT INVOLVING AMMUNITION  
AND EXPLOSIVES**

(Added)

a. AR 55-355 authorizes the Chief of Ordnance to extend technical aid and assistance as deemed necessary in connection with the moving, salvage, demolition, neutralization or other disposition of Government-owned shipments of explosives and other dangerous articles being transported or stored by carrier. Commanding officers at Ordnance Corps installations where explosives and ammunition (including guided missile items and heavy rockets) are handled are authorized to act for the Chief of Ordnance in this regard. AR 55-355 outlines the responsibilities to be assumed by carriers when assistance is rendered and procedures to be followed when assistance is requested.

b. In extending requested assistance, commanding officers should instruct their representatives to cover the following points as a minimum:

- (1) Upon arrival at the scene, report should be made to the official in charge that request was received for an Ordnance representative to be present to render technical advice and assistance in questions involving explosives and ammunition, including guided missile ammunition items and heavy rockets.
- (2) Determine if the scene of the wreck is adequately patrolled (day and night) by carrier

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personnel or local peace officers and if persons other than those working on the wreck are prohibited from approaching the scene. If this matter is not being properly handled, suggestions should be made to the official in charge for correction. Emphasis should be placed on the danger of picking up ammunition for souvenirs.

- (3) Suggest to the official in charge that smoking and the use of matches or flames in the area be prohibited if such action has not already been taken.
- (4) The condition and position of wrecked vehicles and the condition of bracing and contents should be noted. Inspect containers noting particularly any leaking containers of explosives or ammunition.
- (5) Confer with officials and discuss, from the safety viewpoint, procedures for handling the wreck, with emphasis being placed on the following:
  - (a) Instruction of wrecking crew concerning the hazard of handling explosives roughly.
  - (b) Removal of broken containers and loose explosives or ammunition that can be accomplished before handling of wrecked vehicles.
  - (c) Furnish advice as to which containers can be recovered or repaired for reshipment.
  - (d) Furnish advice as to which containers and ammunition should not be shipped and

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as to their disposal, either by transfer to an Ordnance establishment for disposition or by destruction at the scene of the incident. If need for destruction of explosives or ammunition at the scene of the incident is determined, the Ordnance Officer of the appropriate Army Area should be contacted and the services of an Explosives Ordnance Disposal Officer requested.

- (e) Furnish other advice relative to handling the particular types of explosives and ammunition involved.
- (f) Inspect area to insure that all ammunition and explosives have been cleaned up or disposed of.

c. In order to permit accomplishment of necessary supply and surveillance functions, whenever the commanding officer of an Ordnance installation has rendered assistance due to an incident as outlined above, he shall immediately contact—

- (1) Commanding Officer, Ordnance Ammunition Command, Joliet, Ill., Attn: ORDLY-Q, where ammunition items other than guided missiles and heavy rockets are involved.
- (2) Commanding General, Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala., Attn: FSD, where guided missile ammunition items or heavy rockets are involved. Such report will be made by the

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most rapid means of communication available, stating all pertinent facts concerning the incident.

*d.* Any action required, other than that outlined above, will be directed by the:

- (1) Commanding Officer, Ordnance Ammunition Command, for ammunition items other than guided missiles and heavy rockets.
- (2) Commanding General, Army Rocket and Guided Missile Agency, for guided missiles and heavy rockets.

*e.* Incidents resulting in explosions of ammunition or explosives shall be reported by the installation rendering assistance in accordance with OCO 19-51.

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## SECTION 23

### AIR AND WATER TRANSPORTATION

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#### 2301. CIVIL AIRCRAFT

Air transportation by civil aircraft is regulated by the Civil Aeronautics Board, and all air shipments on civil aircraft originating from an Ordnance establishment shall comply with Civil Air Regulations.

#### 2302. MILITARY AIRCRAFT

Military aircraft used for shipments shall be inspected in accordance with USAF Technical Order 00-20A-1. The transportation of ammunition, explosives and other dangerous articles by military aircraft shall conform to the requirements of USAF Technical Order 01-1B-40, Handbook of Weight and Balance Data, dated 1 June 1944.

#### 2303: PERMISSIBLE AIR SHIPMENTS

In general, the dangerous articles which may be shipped by air are the same as those which may be transported by rail freight. Packages must conform to the requirements of ICC Regulations. Dangerous articles and other cargo must be firmly lashed to the aircraft structure or otherwise secured to prevent shifting in flight. Signaling devices, equipment necessary to promote safety in operation, and small arms equipment in moderate quantities for per-

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sonal use may be carried without complying with the above requirements. Dangerous articles must be placed in a baggage compartment inaccessible to passengers during flight.

#### **2304. AIRCRAFT OPERATING REGULATIONS**

*a.* If an aircraft carrying dangerous articles makes a forced landing and only minor repairs are necessary, the cargo need not be unloaded but repairs should be accomplished at a location separated from dissimilar exposures and other aircraft by the appropriate inhabited building distance for the cargo on board. For major repairs, the plane shall be unloaded and the cargo stored in accordance with appropriate quantity-distance requirements. If a landing is made for refueling purposes only, the cargo need not be unloaded. Refueling shall be accomplished at a location suitable for the performance of minor repairs as described above.

*b.* Prior to take-off or landing, the pilot must contact the tower for taxi, take-off, or landing and parking instructions. The pilot shall, when requesting instructions, make known the contents of the cargo and shall request priority for his aircraft.

*c.* When an aircraft containing explosives and ammunition is parked, four "explosives" placards shall be displayed. One placard shall be placed on the nose, one on the tail, and one on each side of the plane. The placards may be attached with masking tape and removed just prior to take-off. Fire symbols (see

par. 1222) should be placed beside the "explosive" placards.

## 2305. LOADING AND UNLOADING AIRCRAFT

a. Prior to loading or unloading ammunition and explosives the aircraft shall be electrically grounded as described in USAF Technical Order No. 19-1-105 so that the resistance to ground does not exceed 10,000 ohms.

b. "Explosives" placards shall be displayed as described in paragraph 2304c and fire symbols should be placed accordingly.

c. Loading and unloading shall be done in accordance with quantity-distance requirements (par. 2304a).

d. All ignition switches must be in the off position.

e. Front and rear wheel chocks shall be in place.

f. Military aircraft shall be loaded in accordance with USAF Technical Order 01-1B-40, Handbook and Weight and Balance Data, dated 1 June 1944. The person supervising loading shall assure compliance with USAF Regulation 55-3, Operations—Weight and Balance Control of Heavier-Than-Air-Aircraft. Nonmilitary aircraft shall be loaded to comply with Civil Air Regulations, part 03, sections 03.200 to 03.254.

## 2306. DAMAGED SHIPMENTS

Air shipments of explosives or ammunition received at an Ordnance establishment in a damaged condition or not loaded in accordance with applicable requirements shall be reported on DD Form 6 (Report of Damaged or Improper Shipment) to the Office of the Chief of Ordnance. See AR 700-58.

## 2307. CONTAINERS

Containers of explosives in aircraft shall not be opened or repaired.

## 2308. WATER TRANSPORTATION

a. Transportation of explosives, ammunition, and other hazardous materials by water in vessels engaged in commercial service is regulated by the United States Coast Guard. Shipments overseas shall be made in accordance with the regulations of the carrier, the United States Coast Guard, or the Transportation Corps, Department of the Army. (See AR 55-228, Transportation by Water of Explosives and Hazardous Cargo.) Where route of travel requires passage under bridges, prior authorization from the responsible agency shall be obtained.

b. Damaged shipments or shipments not stowed in accordance with pertinent regulations when received at an Ordnance establishment shall be reported on DD Form 6 (Report of Damaged

or Improper Shipment) in accordance with AR 700-58 and ORDM 3-9.

c. Containers of explosives and ammunition shall not be opened or repaired on board a vessel except as required for dumping at sea or servicing weapons.

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*d.* Vessels in which explosives or ammunition are received shall be inspected after unloading to see that they are clean and free from loose explosives or other flammable materials and that warning placards, etc., are removed. Explosives sweepings shall be destroyed.

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## SECTION 24

### MATERIALS HANDLING EQUIPMENT

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#### 2401. GENERAL

(Revised)

Specifications, operation, and maintenance of materials handling equipment shall be in accordance with current applicable directives.

#### 2402. POWER TRUCKS AND TRACTOR SPECIFICATIONS

*a. General.* Trucks with end-operating platforms or pedals should be equipped with platform guards of heavy channel iron and heavy steel plate or materials of equal strength. The guards should be at least 18 inches high on the sides and should extend a sufficient distance beyond the platform or pedal to protect the operator. In addition, overhead protection against falling objects should be provided for the operator. A red flag should always be placed on material that projects any appreciable distance from the truck body. Lift trucks shall be designed to prevent the sudden dropping of the load in the event of a power failure.

*b. Battery-powered equipment.* Battery-powered equipment used for handling inert materials shall have all electric cables mounted to prevent catching on stationary objects or damage by cutting or abrasion and shall otherwise be protected to prevent short circuiting as far as is practicable. Batteries shall be

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securely fastened in place. Battery boxes shall be arranged for ample ventilation and the ventilation openings shall be guarded to prevent access to the cell terminals from the outside. The grid work on the battery box should be backed by a fine mesh screen or a set of baffles to keep foreign objects, including wire, from being inserted to cause an arc between the terminals and the truck frame. All equipment shall be provided with either a 1-quart vaporizing liquid or a 4-pound carbon dioxide fire extinguisher.

*c. Gasoline-powered equipment.*

- (1) Gasoline-powered equipment for handling inert materials shall be equipped with back-fire deflectors securely attached on the throat of the carburetor and shall be of the oil-bath or screen type (certain types of air cleaners will serve the purpose). A tight fitting cap, properly vented, shall be in place on the gasoline fill pipe at all times except during refueling. A flame arrester should be installed in the fill pipe. If necessary, a deflector plate shall be installed to prevent any overflow from the gasoline tank from reaching the motor or the exhaust pipe. On gravity feed systems or on pump systems where siphoning might occur, a shut-off valve shall be installed at the fuel tank or in the feed line to permit shutting off the flow of gasoline in event of emergency or break in the fuel line or carburetor. Provisions shall be made against vibrational rupture of the fuel lines.

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- (2) All electrical connections fastened with terminal nuts shall have a spring lock-washer or a similar device back of the nut to prevent loosening. This does not apply to spark plugs of the snap type.
- (3) All equipment shall be provided with either a 1-quart vaporizing liquid or a 4-pound carbon dioxide fire extinguisher.

#### **2403. BATTERY POWERED EQUIPMENT FOR HANDLING EXPLOSIVE MATERIAL**

a. Battery-powered equipment complying with the requirements of the preceding paragraph and this paragraph may be operated in all locations where exposed explosives materials and/or flammable vapors are not present. Such battery-powered equipment is approved for handling all classes of explosives packed in accordance with ICC regulations, and ammunition (fuzed, if approved for shipment in this condition) when completely loaded and closed, provided the exterior of cartons, sheels, bombs, boxes, etc., are not visibly contaminated with explosives and the item being handled does not have any exposed explosives.

b. All such equipment shall have a main service switch. It shall be placed or connected so that it can be operated from the driving position. All trucks shall be equipped with a "dead-man" switch placed or connected in the same manner.

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c. If battery-powered equipment is to be used for handling partially loaded ammunition and is to be operated in corridors or ramps connecting hazardous operations, such equipment must not enter areas high in concentrations of explosives dusts or explosives vapors or gases, such as screening buildings, pouring bays or melt pour units, drilling bays, consolidating bays, etc. This equipment must also conform with the following requirements:

- (1) The electrical system shall be protected to minimize accumulations of explosives dusts on or around electrical sparking points.
- (2) The running plug shall be locked in its "receptacle" to prevent removal by unauthorized persons.
- (3) Electric motors and switches should be of type approved by the Underwriters' Laboratories, Inc., or other approved testing agency, for the specific hazardous locations in which they are used (class I or class II, or both if applicable).
- (4) Equipment **should** be grounded at all times. The use of two or more electrically conductive tires is recommended.

#### **2404. GASOLINE- AND DIESEL-POWERED EQUIPMENT FOR HANDLING EXPLOSIVE MATERIALS**

When it is impossible to obtain battery-operated equipment, gasoline- and diesel-powered equipment with the precautionary measures and devices de-

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scribed in paragraph 2402c are approved for handling all classes of ammunition and bulk explosives packed in accordance with ICC regulations and closed ammunition containing explosives (fuzes, if approved for shipment in this condition) except in Richmond or earth-covered magazines or locations where exposed explosives are present. The equipment should not be permitted to pass open windows or doors of buildings where there are exposed explosives. Dangerous concentrations of toxic gases shall not be permitted in buildings where the equipment is used. The item being handled must not be visibly contaminated with explosives or have any explosives exposed.

#### 2405. REFUELING PROCEDURES

a. Gasoline- and diesel-powered equipment shall not be refueled inside warehouses or similar essential buildings. If the fuel supply is exhausted while the equipment is inside a building, the equipment shall be towed outside to a safe location for refueling. Refueling shall be done at least 20 feet from warehouses, other inert buildings and inert loading docks, and 100 feet from an explosives location or building. During refueling, doors and windows through which vapors may enter the building shall be closed. Refueling trucks or portable wheeled tanks shall not be located on loading docks during refueling and shall be parked as far as practicable from buildings in accordance with the above standards. Tank trucks containing large quantities of

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gasoline shall not be permitted to enter explosives areas (pars. 2207*d* and 1721).

b. During gasoline refueling, an electrically continuous path shall be maintained between the tank being filled and the tank being emptied. The entire system shall be grounded. Smoking or open flame devices shall not be permitted within 50 feet of gasoline or diesel refueling operations and at least one person shall be present during the entire operation. Motors of both the lift truck or tractor and the refueling truck (unless refueling truck motor drives the pump) shall be stopped during the refueling operation.

c. In event of a fuel spill during refueling, the motors of the refueling truck and materials handling equipment shall not be started until the area is thoroughly washed down with water or until the equipment is first moved by hand at least 50 feet from where the spillage occurred. If the latter alternative is used, the area over which the spill occurred must still be washed down with water.

d. The motor of the equipment shall be run after refueling for a sufficient length of time to assure that any fire which might result from fuel vapors on the equipment will not occur in the operating or storage building.

#### **2406. EQUIPMENT FOR REFUELING**

In addition to the requirements given in the preceding paragraph, refueling equipment is subject to the following:

a. (Revised) Refueling truck construction should comply with applicable NFPA standards outlined in

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"Tank Truck Ordnance" National Fire Codes, Vol. VI. An approved discharge hose with self-closing nozzle should be provided. Refueling trucks shall be provided with a portable ground wire to be clamped to the equipment before refueling. If a conductive hose is used, the resistance shall be checked at frequent and regular intervals.

b. If portable wheeled tanks are used (50- to 60-gallon capacity) they shall be of a type approved by Underwriters' Laboratories, Inc., or other recognized testing agency.

c. The refueling truck or portable wheeled tank should be equipped with a 15-pound carbon dioxide or 30-pound dry powder extinguisher or this equipment should be available nearby. Employees who refuel or operate materials handling equipment shall be trained in the proper use of the extinguishers supplied and in reporting fires.

d. If portable containers are used for refueling they shall be approved safety cans, with flame arrestor screen, not exceeding 5-gallon capacity.

#### **2407. STORAGE OF GASOLINE- OR DIESEL-POWERED EQUIPMENT**

a. Gasoline- or diesel-powered equipment shall not be stored in buildings containing explosives or ammunition or on explosives loading piers when explosives or ammunition are present. Such equipment may be stored overnight in warehouses or other suitable locations but a minimum separation of 10 feet shall be maintained between the equipment and combustible material. Aisles shall be

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kept clear at all times. Individual pieces of equipment stored should be spaced to minimize the spread of fire from one truck to another.

b. A central storage location for gasoline- or diesel-powered equipment is preferred. Such a building should be located at least 50 feet from other buildings so as not to constitute a fire exposure hazard.

c. If gasoline equipment is stored out of doors or in unheated buildings, care should be taken to prevent moisture which collects from freezing and cracking the sediment bowl.

d. The wheels of the vehicle should be blocked to prevent movement of the truck in event of brake failure.

#### **2408. STORAGE OF BATTERY-POWERED EQUIPMENT**

Battery-powered equipment shall not be stored in buildings containing explosives or ammunition. Such equipment may be stored in warehouses provided the following requirements are met:

a. The equipment shall be inspected, before it is left, for mechanical defects, such as hot brake bands or leaking electrolyte that may cause trouble during the night. Vehicles with mechanical defects shall be removed from the warehouse.

b. The wheels of the vehicle should be blocked to prevent movement of the truck in event of brake failure.

c. The equipment shall not be stored within 10 feet of combustible material, dunnage, boxes, and crates.

## 2309. MAINTENANCE

Inspection and maintenance of materials handling equipment shall be accomplished in accordance with paragraph 2206 of this manual and other applicable regulations. A daily inspection check made by the operator shall include items listed on the currently authorized checklist. The hoisting and tilting mechanism and water type mufflers, if installed, shall be checked before and after each day's operation. Records of inspections, repairs, and service shall be kept up to date. Neither maintenance nor repair of equipment shall be accomplished in explosives storage or operating buildings. Battery charging stations and maintenance shops for battery-powered equipment preferably should be located in an inert area. When these facilities serve a single explosives operating line, they may be located at intraline distance from the operating buildings; locations having exposures to minimum quantities of explosives in the line (inert end of line) are preferred. Battery charging stations for materials handling equipment used in magazine areas only may be located at magazine distances from the magazines. First echelon preventive maintenance may be performed on noncombustible docks of explosives operating buildings pro-

vided the docks are clear of ammunition and explosives.

#### 2410. OPERATOR SELECTION AND TRAINING

Operators shall be carefully selected, thoroughly trained, and required to pass an operating test before they are permitted to operate powered materials handling equipment. The selection and training of operating personnel shall be in accordance with the program described in TM 743-200. All operators should undergo an examination to eliminate those physically unfit for this type of work.

#### 2411. OPERATING REQUIREMENTS

- a. A distance of at least three truck-lengths shall be maintained between trucks in operation.
- b. Battery and gasoline-powered equipment is approved for handling bulk explosives, packed in

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approved containers, and fuzed ammunition when completely loaded and closed, provided the exterior of cartons, shells, bombs, and boxes are not visibly contaminated with explosives. Transportation and/or moving of fuzed ammunition, including bombs, directly or indirectly on the forks of lift trucks is prohibited unless the ammunition, including bombs, are in standard approved shipping containers (as shown on Ordnance drawings) or other approved suitable containers affording similar protection against hazards. Containers of explosives are not to be carried directly on the forks of the lift truck without skids or pallets unless such containers are so designed to be safely carried in this manner. Loaded, unfuzed bombs may be carried directly on the forks of lift trucks. Boxes of finished ammunition when of sufficient length so as to be firmly supported on both forks may be carried directly on the forks.

c. Riders, lunch boxes, newspapers, extra clothing (not being worn), etc., shall not be permitted on lift trucks at any time.

d. Trucks used outside after dark should have red reflectors on the rear and be equipped with headlights (front and rear).

e. Operators shall not make any repairs on these machines nor tamper with any mechanical devices. A report shall be made to the foreman indicating repairs necessary so that the trucks may be kept in safe operating condition at all times.

*f.* Gasoline-powered equipment shall be started and the motors thoroughly warmed up before entering any building.

## **2412. HAND TRUCKS**

*a.* Hand trucks may be two, three, or four-wheeled. Each type is constructed for special purposes and a careful survey shall be made to assure that the proper equipment is being employed on the various jobs since special hazards are inherent in each type of truck.

*b.* Hand trucks with broken or damaged wheels shall be removed from service immediately and repaired. Nails, pieces of wire, or other substitutes shall not be used in place of cotter pins to hold wheels in place on axles. Trucks should not be stored in passageways and the handles should be in a vertical position. Each truck should be numbered for identification to facilitate inspection and maintenance.

*c.* Flooring over which trucks must travel shall be kept free from holes and depressions. Aisles and passageways should be marked and kept free of materials and obstructions. When trucks must be wheeled up and down ramps, the surface of the ramp should have a rough finish to prevent men from slipping or falling. Walkways should have devices to prevent wheels from running off walks, particularly where inclines must be steep. Loading plates or gangplanks used between platforms, freight cars, motor trucks and trailers shall be fastened securely

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to prevent movement while in use. When trucks are placed on elevators, the wheel should be chocked.

d. Hand trucks and buggies, particularly those used for transporting explosives materials, should have the following features: "dead-man" brakes that will automatically stop the vehicle if the operator lets go of the handle; low center of gravity; tread gauge wider than body width; pneumatic or cushion, conductive tires; and design that will permit easy washing and cleaning. Trucks and buggies carrying explosives should have four wheels and should be conspicuously painted. Those used on plant roads at night should have headlights and reflectors.

e. Two wheeled trucks are of different types for various functions, and no one truck is appropriate for all jobs. The ordinary truck used by freight handlers is not usually suitable for transporting cylindrical objects, but can be adapted by constructing a specially designed cradle. The center of gravity of the load should be kept as near wheels as possible. Heavy objects should be placed at the bottom of the load. Two-wheeled trucks should be pushed rather than pulled. Brakes are desirable. Knuckle guards should be provided at the handle grips. Specially constructed trucks should be provided for handling acid carboys.

f. The method and sequence of unloading should be considered before loading a truck, particularly if hoisting equipment is used. Blocks should be used to separate sections of the load to permit easy fastening of slings at the unloading point. If selective stacking

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is required at the unloading end, the material should be loaded on the truck in proper sequence. Trucks should not be loaded to a height that will obstruct visibility in both directions unless it can be assured by assigning at least two men to move the truck. Loads shall be placed to prevent tipping, shifting or falling.

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## SECTION 25

### AMMUNITION—NORMAL MAINTENANCE, MODIFICATION, RENOVATION, AND DE- MILITARIZATION

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#### 2501. STANDING OPERATING PROCEDURES

Standing operating procedures shall be established, approved, and posted as required by paragraph 1625.

#### 2502. LAYOUT OF OPERATIONS

a. Ammunition.—normal maintenance, modification, renovation and demilitarization operations should be performed in buildings within the ammunition workshops area. Buildings within this area shall be separated from each other by a minimum of intraline distance and from magazines, other operating buildings, inert areas, etc., by a minimum of inhabited building distance. Whenever possible a single type of operation should be performed within all buildings in the workshops area. If necessary, concurrent renovation, modification, normal maintenance, or demilitarization of all items is permitted within the workshop area except as follows:

- (1) The repacking of bulk black powder shall not be accomplished concurrently with operations on items having a missile producing hazard.

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- (2) Bulk initiating explosives shall not be processed, loaded, or otherwise handled while other operations are in process.
- (3) Ammunition containing blister gases or toxic chemical agents shall not be processed concurrently with other items.

b. Work on permissible items scheduled for concurrent operations in the ammunition workshops area preferably should be accomplished in separate buildings located at the appropriate intraline distance from other operating buildings in the workshop area. Where it is essential to perform concurrent operations in a single building, the layout of operations must be arranged in a manner to segregate the items so that dissimilar hazards are separated by substantial dividing walls, or by other means, to insure that the exposure of personnel is not greater than if a single item was being processed (e. g., the operator working on the renovation of 60-mm mortar ammunition should not be exposed to the hazards of a concurrent operation involving disassembly of 90-mm rounds). The quantities of explosives and number of personnel exposed at each concurrent operation shall be held to the minimum consistent with safe and efficient operating procedures.

c. Where the facilities described above are not available, and when approved by the Chief of Ordnance, normal maintenance, and in some cases modification and renovation operations, may be performed in an empty magazine or in the open at intraline distance from the nearest explosives storage location,

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based on the maximum quantity of explosives at the operation, but in no case less than 100 feet. These operations must be separated from other operating locations (including loading docks) in the magazine area by intraline distance based on the larger quantity of explosives involved. The site chosen must be devoted exclusively to the work and all necessary safeguards, such as operational shields, must be provided. Since personnel performing such operations will be exposed to large quantities of stored explosives, the hazards are inherently greater than would be present if the operation were performed outside the magazine area, therefore, plans and procedures for all such operations should be carefully scrutinized.

*d.* (Added) The performance of minor normal maintenance operations in the magazine area in accordance with the provisions of paragraph 2502c, may be approved by the installation commanding officer. Such operations will be limited to hand de-rusting and brush painting of bombs and separate loading projectiles, opening and repairing boxes and metal containers of ammunition, repacking of ammunition into serviceable boxes and fiber containers, spot painting projectiles, maintenance of fuze cavities and base covers of separate loading projectiles, and other relatively safe operations of the same general type. Any operation requiring the removal or replacement of explosives components and all operations to be performed on chemical ammunition, will require prior approval by the Chief of

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Ordinance before being performed in the magazine area.

e. The quantity of explosives or ammunition involved or present in any operation, at one time, in one location shall be the minimum necessary to carry out the operation. Personnel exposure shall be kept at the minimum consistent with safe, efficient, and continuous operation.

### **2503. REQUIREMENT FOR SHIELDING DISASSEMBLY OPERATIONS**

a. Certain disassembly operations are hazardous and operational shields must be employed for the protection of employees performing such work and for those in the vicinity. The requirements for shielding the operations cannot be clearly defined because of the great variety of circumstances that can surround a given operation. Only the general principles are established together with mandatory regulations. The safety of disassembly operations will depend on the careful scrutiny of the work planned and the farsightedness of those responsible for safety in the establishment. Special consideration must be given to operations involving the more sensitive explosives such as pentolite, Composition B., etc. Where operational shields are necessary, those provided must be securely braced and of proven sufficient strength to withstand the high order detonation of the item being handled. Disassembly must be performed in locations and with quantities of explosives or components that will not unduly expose other personnel and equipment to the hazard.

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b. Adequate operational shields shall be provided for operations such as:

- (1) Disassembly of loaded boosters, bursters, fuzes, primers, and blank ammunition.
- (2) Removal of base plugs from loaded projectiles.
- (3) Removal of fuzes from pentolite loaded shell.
- (4) Disassembly of loaded bombs, except for removal of shipping bands, nose and tail closing plugs, fin locknut protectors, fin locknuts, and washout of high explosives bursting charge.
- (5) Removal of fuzes from hand grenades loaded with high explosives except as noted in paragraph 2503c.
- (6) Pull-apart of fixed ammunition, 20mm and larger. In the pull-apart of rounds containing self-destroying tracer, the dimensions of the shield should anticipate initiation of the propellant and the projectile.

In addition, foreign ammunition or other ammunition items of uncertain design and condition shall not be tampered with unless the operator is adequately shielded.

c. The following and similar operations may not require operational shields for the protection of operators if the assembly has been normal and the normal equipment, tools, and methods used in the assembly are sufficient to accomplish the disassembly without the application of undue force. Tools used for disassembly shall not have a greater lever

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advantage than those required for the assembly. In these cases, care must be taken to ascertain that the assembly has been normal and the surfaces to be separated are not corroded and are not sealed with metallic caulking.

- (1) Removal of loaded fuzes and fuze well cups from loaded shell.
- (2) Removal of 60-mm and 81-mm primers.
- (3) Removal of ignition cartridges from mortar ammunition.
- (4) Removal of boosters or bursters from loaded projectile.
- (5) Removal of setscrew from loaded projectiles. When drilling equipment is used to remove stake-punch marks and back out setscrews, positive stops must be provided to prevent the contact of the drill with the component parts of the fuze or booster which contain explosives or with the explosives in the shell. Drills should be changed and positive stop set only by competent mechanics. Only fully trained personnel should be used for such operations and before the operation is begun, the projectile must be examined for the presence of exudate or other abnormal conditions.
- (6) Removal of hand grenade fuzes from Mk 2 type hand grenades loaded

With EC Powder and M26 type grenades loaded with high explosives provided:

- (a) The operation is performed immediately in front of a suitable protective tank having effective baffles and into which the grenade can be desposited should a premature ignition of the fuze occur.
- (b) Each disassembly station is separated from similar or dissimilar operations by operational shields designed to protect the adjacent operator at any operation from the blast and missiles arising from a possible explosion at any other adjacent operation. (See par. 2503d.)
- (c) Shielded trays are employed to receive fuzes removed from the grenades and the maximum number of fuzes allowed at each disassembly station does not exceed fifty.
- (d) Fuzes which will not readily disassemble with the equipment adjusted to the appropriate torque are immediately removed from the holding fixture and transferred to adequately shielded locations where the fuzes can be disassembled in accordance with the requirements contained in para-

graph 2503b(5) (full protection for operating personnel at the defuzing station). Fuzes in this category should be inspected for any defects which would render the item unsafe for handling or further processing.

d. Each disassembly operation shall be separated from adjacent similar or dissimilar operations by operational shields designed to protect the operator at any operation from the blast and missiles arising from a possible explosion at any other adjacent operation. This requirement applies even where a disassembly operation is completely shielded from all operators unless the shields protect against the service supply of components either awaiting disassembly or resulting from disassembly. Components should be protected from a possible explosion occurring at the disassembly operation.

e. When the disassembly of types of ammunition or components not generally included in the preceding paragraphs is contemplated, specific approval of the proposed methods and locations of the operations must be obtained from the Chief of Ordnance before starting the work.

#### **2504. OPERATIONAL SHIELDS FOR DISASSEMBLY**

a. A 12-inch reinforced concrete wall constitutes adequate protection for disassembly operations involving an item containing 15 pounds or

less of explosives when the nearest part of the item is at least 3 feet from the wall and the item is 2 feet from the floor; a reinforced concrete wall 30 inches thick is satisfactory for protection against the effects of an item containing not more than 50 pounds of explosives; reinforced concrete walls 36 inches thick are suitable for quantities of explosives not exceeding 70 pounds. When protection is required against ammunition containing more than 70 pounds of explosives, a personnel protection shelter, placed at intraline distance for the quantity of explosives in the item, must be used. In addition, an earth, sand, or reinforced concrete barricade at least 3 feet thick must be interposed between the shelter and the ammunition when the shelter is not constructed to prevent missile penetration. Details of construction for the barricades and shelters must be approved by the Chief of Ordnance. Shields for protection against items containing less than 15 pounds of explosives may be of steel or other suitable material. The adequacy of these operational shields, including thickness, size, fastening and location should be proved by actual test, with a minimum safety factor of 25 per cent above the maximum expected charge, before its use is permitted in regular operations. Operational shields previously tested for given quantities of explosives need not be retested for exposures of the same magnitude. The results of such

tests shall be made known to the Chief of Ordnance.

b. The concrete walls required for disassembly must be constructed to comply, except for height, with the requirements for substantial dividing walls (see par. 506) with adequate bracing to prevent overturning. Where it is necessary to protect against missiles, wing walls with reinforcing rods interlocked with those of the wall, flared away from the hazardous side are desirable. A concrete top with interlocked reinforcing rods or other suitable cover installed over the heads of operating personnel for protection from missiles, is recommended. Whenever possible during disassembly, ammunition items other than those with shaped charges, should be placed with their longitudinal axes perpendicular to the wall, at least 3 feet from the wall and 2 feet from the floor. Cones of shaped charges should not be pointed toward protective shields or walls. Personnel should not be closer than 2 feet from the opposite side of the wall. Disassembly equipment penetrating the wall must be so designed.

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that personnel will not be injured by movement of the tool in event of a detonation.

c. Operational shields for quantities of bulk high explosives should be of the same physical dimensions as those for ammunition containing a comparable quantity of explosives.

### **2505. SOLID PROPELLANT COLLECTION**

a. In demilitarization or renovation operations where complete rounds are being broken apart, the solid propellant recovered from the rounds shall be removed from the pull-apart machine as soon as practicable. This removal is best accomplished by a properly designed vacuum-type collecting system. Operations and equipment shall be arranged so that the operators and equipment are not exposed to more than 15 pounds of solid propellant at any one time.

b. Vacuum collecting systems for solid propellants shall be designed, located and operated in accordance with the requirements of paragraphs 2706 and 2707 and where practicable should include wet collection features.

c. The common header connected to the primary collectors should not serve, or be connected to, more than three pull-apart machines; not more than one header connected to the same collectors shall be operated simultaneously. Additional collecting units should be installed complete for any additional pull-apart machines, limiting each additional collecting system to not more than three machines.

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d. Pull-apart machines shall be electrically interconnected with vacuum collecting systems (piping and collectors) and grounded.

e. Where vacuum collecting systems are not installed, the collection of solid propellants may be accomplished by means of a closed tube or chute leading from the pull-apart machine to a collection point located in a separate room or inclosure. This system is dependent on unimpeded gravity flow. Each tube or chute shall be equipped with a properly designed flash-back damper to prevent exposure of personnel to flame, toxic gas and heat in event of an incident within the collection station. The tubes, troughs, and containers at the collection station shall be of non-sparking metal properly cross bonded and electrically grounded. The collection station inclosure or room should be vented directly to the outside preferably through the roof to prevent exposure of personnel to flame, toxic gases and heat and to prevent the rupture of the rooms or inclosures. The total poundage of solid propellants at the collection station should be

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limited to a minimum amount necessary to fill one container (not over 200 pounds).

#### **2506. SOLDERING CONTAINERS**

Containers to be soldered shall be free from explosives, explosive dust, and flammable vapors. This does not prohibit soldering covers to metal liners containing completely closed ammunition. Examples of such operations are covers on metal liners for small arms ammunition and tear strips on metal cans containing fuzes.

#### **2507. METAL SCRAP**

All scrap derived from renovation, normal maintenance, modification and demilitarization operations shall be inspected to detect contaminated items and shall be certified to be free from explosives and harmful chemicals prior to sale or reuse. Inspection shall include the opening of all closed components. Where there is the slightest doubt concerning the presence of any explosive material, the scrap shall be subjected to whatever treatment will insure that it is inert before it is sold.

#### **2508. DEMILITARIZING OF FUZES AND OTHER LOADED COMPONENTS**

a. Fuzes, primers, boosters, and other items containing explosives shall be disassembled into their separate components for destruction, to assure elimination of the contamination hazard and provide ready means of inspection after burning or detonation. Where the methods used for demilitarization are such that the residue can be certified as being

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of explosives contamination, disassembly prior to burning or detonation is not required.

b. During disassembly operations each step of the operation shall be performed within approved shielded stations to protect adjacent personnel in event of an explosion.

### **2509. SAND OR SHOT BLASTING OPERATIONS**

a. Because of possible hazards resulting from hidden explosives, thin or eroded cases, and certain characteristics of explosive filler, sand or shot blasting of such items as thin cased chemical-filled bombs, torpex-filled depth bombs, thin cased depth bombs, thin cased land mines, rockets, JATOS, and fixed rounds of ammunition when assembled to the cartridge case and cartridge storage cases containing propellant is prohibited. Explosive-filled or chemical-filled ammunition items assembled with tracers, fuzes, or other explosives loaded components, which are not or cannot be adequately protected from direct contact with the abrasives, will have such components removed prior to blast cleaning. Where explosive-filled or chemical-filled items containing explosives loaded components such as fuzes are, or can be, protected in a manner to permit blast cleaning, satisfactory safeguards must be installed to prevent rotational velocities and accelerations that will harm or otherwise affect the component parts. In instances where items of ammunition are contained within a structurally suitable outer container, the container, if necessary, may be cleaned by sand or shot blasting.

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b. Prior to sand or shot blasting any explosive-filled or chemical-filled item, each unit must be carefully inspected for the presence of exuding explosives, chemical and/or inert seal material. If exudation is present, the unit shall be removed from the hazardous location to a point where the exudation can be properly removed with the application of approved solvents; the unit may then be returned for sand or shot blast cleaning. The use of alcohol for cleaning exudate is prohibited. Before blast cleaning of any item containing chemical or explosives, all openings shall be closed by plugs or other suitable devices to prevent the entry and infiltration of the abrasives.

c. Blast cleaning of fragmentation bombs introduces certain inherent hazards because of the possibility of explosives being present between the body and tube, as well as between the helix of the body and other component parts. Before blast cleaning loaded fragmentation bombs, all explosives in cracks or crevices that may cause difficulty when exposed to the abrasive cleaning medium shall be removed with a nonferrous wire brush or by other satisfactory methods.

d. Blast cleaning rooms, cabinets, duct work, dust collection chambers, and abrasive separation chambers shall be maintained in a manner and cleaned at sufficiently frequent intervals to preclude the accumulation of excessive dusts containing hazardous explosive residue.

e. All metal processing equipment used at the sand or shot blasting operations shall be electrically grounded and tested at frequent intervals to assure

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satisfactoriness of the grounding system at all times.

*f.* All operators directly engaged in sand or shot blasting operations shall be required to wear the necessary personal protective equipment.

*g.* Approved type automatic or semiautomatic sand or shot blasting equipment should be installed where practicable. **Remote control of equipment, from behind an adequate barrier, is preferred.**

*h.* The quantity of loaded items being sand or shot blasted at one time should be maintained at the minimum consistent with safety and efficiency. The sand or shot blasting equipment location shall be separated from the remainder of the operations and personnel by an adequate barrier, dividing wall, or appropriate quantity-distance in a manner to effectively limit the forces of an explosion during the process to the immediate area.

*i.* The use of steel wool should be prohibited for cleaning purposes where possible contact with exposed explosives exists; nonferrous wood should be substituted in these instances.

*j.* Operations involving the processing of related inert components should not be performed in close proximity to the sand or-shot blasting operation involving explosives-filled items but should be accomplished at a location where safety from an explosion can be reasonably assured. Wherever practicable, the independent processing of inert components such as cleaning metal grommets and the like should be accomplished at not less than the appropriate intraline quantity-distance separation from the explosive hazard.

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**2510. LOCATION OF SAND OR SHOT BLASTING OPERATIONS IN EXPLOSIVES STORAGE AREAS**

a. **Intraline distance** shall be maintained from an **earth-covered magazine** or open storage site to the point of operation, when the point of operation is other than a permanent or semipermanent structure. Permanent or semipermanent structures for such operations shall be located at a minimum of inhabited building distance from explosives storage locations, based on the larger quantity of explosives involved. Operations located at less than 100 feet from an **earth-covered** magazine or open storage site containing ammunition or explosives are prohibited under any circumstances. In instances where loading docks or other outdoor areas are used for sand and shot blast cleaning activity, unrelated concurrent operations should not be conducted in magazines or outdoor storage sites located closer than intraline quantity-distance separation based on the larger quantity of explosives and hazard involved.

b. A **temporary earth barricade** or other suitable protective barrier shall be erected around sand or shot blasting operations conducted in the open within an ammunition storage area to protect adjacent personnel and the source of supply of explosive-filled items in the event of an accident occurring during the blast cleaning operation.

c. Air compressors and motor generator sets used at the operation are to be located not closer than 50 feet from the operational site and from the nearest

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**earth-covered** magazine or outdoor storage site. Care must be exercised in the selection of the location to preclude exposure of the entrance to the operation or to the **earth-covered magazine**.

a. When it is necessary to utilize loading docks as operating sites for sand or shot blast cleaning operations, the docks shall not be used for normal shipping and receiving activities other than those directly associated with the blast cleaning operations.

#### **2511. SAND OR SHOT BLASTING OPERATIONS WITHIN A BUILDING IN AN OPERATING LINE**

The following safety **measures** are required in addition to the applicable precautions listed in paragraphs 2509 and 2510, above, when sand and shot blasting operations are carried on within a building in an operating line:

a. The actual sand or shot blasting operation of the line must be separated from the preceding and/or succeeding operations by means of a substantial reinforced concrete dividing wall to protect all other personnel in event of an unusual incident occurring

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at this location. Openings in the dividing wall should be limited to the minimum size requirements to facilitate the handling of items to and from the operation, and these openings arranged in a manner to effectively baffle fragments and prevent projection into adjoining rooms. Openings of the size to allow entry and exit of materials handling equipment, such as fork lift trucks or tow motors shall not be permitted within the walls intended as dividing or barricading walls. A door opening of sufficient size for use of personnel only may be provided in the dividing wall if required. Where dividing walls are required in existing buildings, the 12-inch reinforced concrete dividing wall will extend from wall to wall of the building and the height of the concrete wall will be the maximum practicable to permit construction thereof without opening the roof. In no event will the height of the concrete wall be lower than the bottom chord of the roof truss. The remaining opening between the top of the concrete wall and the underside of the roof will be closed on both faces with rigid fire-resistant material securely fastened to the wall and the underside of the roof. The dividing walls should comply with the requirement outlined in paragraph 506.

b. Equipment for sand or shot blasting operations should preferably be of the type not requiring the presence of operators in the immediate vicinity of the machine for its control and should be of the type that is automatically controlled and provided with interlocking switches to stop the equipment in the

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event of failure of any of its parts. Manually controlled STOP switches should be provided at proper intervals to permit prompt stopping of the equipment in event of accident.

#### **2512. ROTATIONAL SPEEDS FOR EQUIPMENT USED IN AMMUNITION OPERATIONS**

The following rotational speeds shall be the maximum permitted for equipment used in field ammunition operations:

*a.* Drilling exposed explosives—75 revolutions per minute.

*b.* Cleaning metal parts seated in explosives, such as fuze seat liners in projectiles and bombs—125 revolutions per minute. The speeds cited above are applied speeds of light feed. Rotational speeds for equipment used in explosives loading are set forth in paragraph 2615*f*.

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## SECTION 26

### SAFETY IN EXPLOSIVES OPERATIONS

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#### 2601. SCOPE

This section outlines safety requirements for certain explosives operations and is supplementary to other pertinent regulations of the Manual.

#### 2602. SCREENING AND BLENDING HIGH EXPLOSIVES

a. Bulk high explosives, in granular or flake form, intended for processing shall be passed through a screen to remove extraneous material prior to use. Wet or lump explosives that cannot be screened, shall be visually inspected. Screen openings may be circular, square, or rectangular. If circular or square, the size of the opening shall not exceed  $\frac{1}{4}$  inch in diameter or on each side. If rectangular the screen dimensions should not exceed  $\frac{1}{4}$  inch by  $\frac{4}{10}$  inch. Screen sizes may be selected to classify the material according to particle size if required for the work. Screening equipment shall be constructed to prevent explosives from becoming subjected to pinching, friction, and impact. Screens shall be electrically interconnected and grounded. Screening should be supplemented by a permanent type magnetic separator, if practical. In general, hand-screening is not recommended because of health, fire, and explosion hazards to personnel. When necessary a maximum of  $\frac{1}{2}$  pound of explosives may be

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hand-screened provided precautions are taken to reduce to the minimum aforementioned hazards to personnel.

b. Operational shields, suitable for the quantity of explosives involved, should be provided to protect personnel from screening and blending operations involving black powder, tetryl, pentolite, explosives of similar sensitivity and metal powders where the quantity of such explosives screened does not exceed 70 pounds. Hand-screening, as specified in paragraph *a* above, is the one exception to this rule. When more than 70 pounds of such explosives are being screened or blended, all personnel should be located at a minimum of intraline distance from the operation. Controls for the screening and blending equipment should also be located at a minimum of intraline distance from the operation. The same protection should be given for the screening of metal powders but is not necessary for the screening of TNT, Explosive D, and explosives of similar sensitivity. For the screening of sensitive primer mixtures and initiator explosives, the operational shields should protect personnel while the screens are in operation, being loaded or being discharged.

c. When operational shields are provided to protect personnel from the screening of tetryl, pentolite, and high explosives of similar or greater sensitivity, the shields should comply with the provisions of paragraph 2629. For the screening of black powder, sensitive primer mixtures and initiator explosives, the operational shields

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should protect personnel while the screens are in operation, being loaded and being discharged.

*d.* In those installations where operational procedures and design of equipment precludes the possibility of developing at any time, within the screening room, concentrations of explosives dust in excess of the maximum allowable (see Table 1118, Section 11) for the item being screened; exhaust ventilation may be omitted from the screening unit. Rooms in which screening units, not equipped with exhaust ventilation, are operated, must be thoroughly and completely cleaned at the end of each shift or more often if necessary to eliminate hazardous accumulations of explosives dust. If toxic and explosive hazards are not controlled in the foregoing manner, exhaust ventilation must be provided for explosives screening equipment. A wet type dust collecting system is recommended.

*e.* The same piece of screening equipment shall not be used for two or more materials unless it is definitely established that a mixture of the two will not present an increased hazard. Complete decontamination of screens is difficult.

*f.* In tritonal loading, aluminum is usually fed into the melt-mix kettles in the melt-pour building. When adding aluminum, there should be provided at the juncture of the drum and drumhead, a screen having 0.25-inch openings as a maximum. A second screen of 0.50-inch maximum should be placed near the top of the chute leading to the melt-mix

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kettle. A magnetic separator of permanent magnet type should be installed at the chute to remove ferrous metal from the aluminum. To prevent dangerous dust dispersions, aluminum powders should be introduced in a manner to permit intermediate immersion in the melted ingredients.

g. TNT used for feathering must have first been screened in the screening building. A second screen, of the dimensions specified below, shall be installed between the top of feathering chutes and melt-mix kettles, that will prevent sliding or moving to create friction with the sides of the chute. Slide valves shall not be used.

- (1) (Added) For circular opening screens, the diameter of the opening shall not exceed  $\frac{3}{8}$  of an inch.
- (2) For square opening screens, the side dimensions of the opening shall not exceed  $\frac{3}{8}$  of an inch.
- (3) For rectangular opening screens, the dimension of the opening shall not exceed  $\frac{5}{16}$  by  $\frac{7}{16}$  of an inch.

### 2603. INSPECTION OF HIGH EXPLOSIVES

In addition to being screened, bulk explosives in granular or flake form shall be visually inspected to detect extraneous material. Explosive material in the form of large pellets or slabs need not be screened but it shall be visually inspected between box opening and charging of the melting equipment to assure removal of foreign material.

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#### **2604. EXPLOSIVES MELTING**

a. Temperatures used for melting explosives and keeping explosives molten shall not exceed 228° F. (109° C.) which corresponds to 5 p. s. i. saturated steam, except in the following cases:

- (1) (Added) Melting and keeping molten Composition B and similar binary explosives for which saturated steam pressures up to 15 p. s. i. (250° F., 121° C.) may be used if required by the established process.
- (2) Steam at pressures not in excess of 10 p. s. i. (240° F.) may be used for TNT core melting equipment.

b. Water legs shall be installed in steam lines, where pressure does not exceed 5 p. s. i. to prevent a build-up in pressure. Where steam line pressures exceed 5 p. s. i., a counter balance, sealed to prevent tampering, or a rupture disc should be used in addition to installed pressure relief valves if water legs are impracticable.

c. Steam heated fingers may be used in melt-mix kettles handling tritonal and Composition B and are preferred for TNT handling to prevent build-up of solidified explosives. Stationary steam fingers must be fastened to the kettle frame in a positive manner (welding is preferred) and cracks and crevices must be eliminated. The fixed part of the lid should be jacketed for tritonal operations. Steam heated splash guards should be installed where needed to prevent build-up of explosives. Steam heated "fin-

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gers" shall not be used in kettles used for remelting risers or other forms of explosives which are of such size that the explosives would be subjected to a crushing or pinching action between the stationary steam "fingers" and the agitator of the kettle.

#### **2605. SCREENS FOR MOLTEN HIGH EXPLOSIVES**

a. At least two screens shall be interposed between the melt unit grids and the melt-mix kettle for the handling of any explosives. One of these should extend the full width of the melt unit reservoir and be of wire mesh with maximum openings of  $\frac{1}{8} \times \frac{1}{4}$  inch. For TNT and similar explosives, the second screen should be an effective conical screen over the opening into the melt unit draw-off pipe. For tritonal loading, the second screen should be perforated bucket type placed in the melt unit draw-off pipe. The bucket type screen shall be of a strong nonsparking material such as brass with holes  $\frac{3}{32}$ -inch diameter on  $\frac{1}{8}$ -inch centers, and shall be free from burrs. The ledge in the draw-off pipe upon which the bucket

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screen rests shall be sloped to allow drainage of explosive. Screen shall be securely fastened in place and shall not be removed for cleaning while melt unit reservoirs contain molten explosives. Screens shall be examined frequently and replaced promptly as needed. Spare screens shall be kept near the melt unit to allow ready replacement. Melt units shall not be operated without the screens described.

b. A heavy wire screen or a metal grid must be installed at the outlet of the melt-mix kettle. A grid with openings 1×3 inches is satisfactory. The grid must be welded or brazed in place or so designed that it will not become dislodged during agitation or when extraneous matter is removed from it. A steam jacket is not recommended for the screen or grid frame in the case of tritonal because of the possibility of water leakage. The melt-mix kettles shall not be operated without the screen described and spare screens or grids shall be kept handy for immediate replacement when necessary. When wooden or other types of nonsparking rods are used to dislodge lumps from the grids, the force used shall be strictly limited so that deformation of grids will not result. Grids or screens shall not be removed from melt-mix kettles for any reason until the bulk of the explosive material is first removed from the screens and equipment.

#### **2606. VALVES FOR MOLTEN EXPLOSIVES**

a. Melt unit valves should be of the plug type made from neoprene or equivalent; steam-jacketed

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Saunders', or Hills-McCanna rubber diaphragm type valves may be used. Springs shall not be used on valves. Sash cord or nonferrous chain should be used on valve controls to prevent application of undue force when closing valve. The length of travel of the plug should be limited to  $\frac{3}{4}$ -inch.

b. Valves used in melt-mix kettle draw-off pipes and in all other lines carrying molten explosives shall be of rubber diaphragm (Saunders, Hills-McCanna, or equal) or rubber tube ("nut cracker") types only. The weir and compressor spider in diaphragm valves should be machined smooth on surfaces effecting closure of the valve. To assure complete closure while preventing metal contact between the diaphragm stud and the weir, the valve stem should be adjusted so that the compressor spider is separated from the weir by two-thirds the thickness of the diaphragm when the valve is in the closed position. The weir side of the valve should be steam jacketed. It is vital that diaphragm type valves be disassembled and inspected at frequent and regular intervals, at least weekly. Diaphragms shall be replaced before they become cracked and allow metal to metal contact. Records of diaphragm changes should be recorded and filed. Weep holes shall be provided in the bonnet of Hills-McCanna and Saunders' type valves and the valves positioned so that weep holes will drain the valve by gravity flow if diaphragm leaks.

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### 2607. DRAW-OFF PIPES

a. The melt unit draw-off pipe must be steam or hot water jacketed. It should be attached to the melt unit reservoir in such a manner that no threads on the fastening screw or bolts are exposed either outside or between the flanges. A sealing compound should be used to prevent TNT seepage or vapor condensation on contacting surfaces of the bolts, flanges, screws, and nuts. A copper covered fiber gasket or equivalent high temperature gasket should be used in joints of pipes carrying molten explosives.

b. Melt-mix kettle draw-off pipes should be electrically connected to bombs or shells during draw-off operations. Each bomb or shell should be individually grounded unless tests show that grounding through mutual contact surfaces is adequate in spite of intervening paint films.

### 2608. DELUGE EQUIPMENT

(Revised)

Melt units, melt-mix kettles, and other equipment containing reservoirs of molten explosives should be equipped with water deluge systems delivering copious quantities of water. The portion of the water pipe within the equipment should be of the dry type and should be protected by nonferrous or nonmetallic caps which will rupture and allow water to flow. The valve should be outside the equipment and a weep hole provided near the valve to guard against accidental leakage into the pipe. A 1¼-inch pipe under a head of at least 40 p. s. i. is recom-

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mended. Deluge systems should be provided with individual automatic and manual activation. In addition, the deluge system should be arranged so that activation of one deluge pipe may activate the deluge heads in all pieces of equipment of the same type (pars. 1229 and 1624).

### **2609. MELT-MIX EXHAUSTING SYSTEM**

(See pars. 2705, 2706, and 2707.)

a. Local exhausting and dust-collecting equipment must be installed on each melt-mix kettle. A wet type collector, effective in removing dust and vapors from the exhausted air, is recommended. The explosives in the collector must be maintained wet except that tritonal accumulations are to be kept submerged, and the equipment must function so that any flammable gas generated is promptly removed from the equipment and building. Water in the wet collector should not be recirculated but should be discharged to a sump constructed to maintain retained explosives wet unless system removes hazardous suspensions. If a fan is used with the blades within the exhaust duct, the blades should be of nonferrous material and should be adequately sprayed with water when in operation. A drain should be provided in the fan scroll. Provision must be made for frequent inspection and cleaning out of explosives accumulations in the exhaust and collecting equipment. Each kettle should be equipped with a complete dust and

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vapor exhausting system so that no part of a system serves more than one kettle.

b. To reduce dust to a minimum, the equipment used for charging solid material into a melt-mix kettle should be constructed so that the solids will be incorporated as they are added into the molten explosives. Melt-mix kettle covers should be designed high enough to minimize the amount of finely divided solids exhausted. This is particularly important when aluminum is being added.

#### **2610. AGITATORS**

Motor-driven, melt-mix kettle agitators should be provided with overload relays having a rating not greater than 15 hp. Shear pins are not recommended. The speed of agitators shall be limited to prevent spilling explosives outside the kettle. (See par. 1622.)

#### **2611. POUR AND PROBE MACHINES**

All multiple pour and probe machines shall be equipped with an effective vapor-venting system arranged to draw vapors away from the moving parts of the machines and to protect health of personnel. Care should be taken to prevent the creation of "cold air" areas adjacent to these machines as a result of excessive air intake to the venting system. Sublimed explosives shall be prevented from collecting on the machines or overhead structures. The quick-acting valves on multiple pour machines shall be designed to prevent appreciable impact on molten explosives when the valves are closing.

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### **2612. HOPPERS**

In locations where aluminum, tritonal, or other hazardous dusts may be on the floor or in the air, the legs of skids, hoppers, and similar equipment should be covered with nonsparking material where they may contact the floor or other objects capable of striking a spark from them. The section of floor where ferrous metal drums of aluminum powder are handled, should have a spark-resisting surface.

### **2613. INERT SEALING**

Inert wax sealing or other inert operations requiring more personnel than the minimum needed to conduct explosives melt pour operations efficiently, should be removed to a room or cubicle not containing explosives where practicable.

### **2614. FORMING TOOLS**

Booster cavity forming tools should be maintained in a polished condition and shall be handled to prevent marring of surfaces. For removing forming tools, implements which exert thrust in direction of the longitudinal axis of the item involved are recommended rather than those affording a sideward motion. The forming tool should be rotated on its own axis prior to removal.

### **2615. MACHINING OF EXPLOSIVES**

a. Items containing explosives may be drilled either while in a vertical or horizontal position. Ver-

tical drilling is preferred since withdrawal of explosives chips and dust is facilitated by such positioning and proper drill alignment is more easily attained and maintained in such a position.

b. To protect adjacent operators, high explosives shall be drilled, faced, milled, sawed, or otherwise machined within rooms or cubicles having reinforced concrete walls complying with the requirements of paragraph 506 except as permitted by paragraph 2622.

- (1) The following high explosives, cased or uncased, may be machined without protection being afforded the operator and without coolant: Amatol, black powder (in components, only), composition B, explosive D, and TNT.
- (2) The following high explosives, cased or uncased, may be machined without protection being afforded the operator provided a suitable noncombustible, non-toxic coolant is directed on the tool and explosives at the point of contact: baratols, cyclotols, pentolite (50-50 and 10-90), and tetrytol.
- (3) When essential, any other high explosives may be machined by remote control, with the operator protected by a suitable operational shield (par. 2622). Initiating explosives should not be machined if other means (i.e., form-

ing) may be utilized to obtain desired shapes or sizes. When machining explosives containing aluminum and using a noncombustible, nontoxic coolant, the coolant must not consist of nor contain water.

c. If drilling is being accomplished without the operator being afforded protection, only a single drill shall be used and the drill must have a diameter greater than  $\frac{1}{4}$  inch. Operations involving the use of multiple drills or drills  $\frac{1}{4}$  inch or less in diameter must be performed by remote control, with the operator protected by an operational shield.

d. Machining of cased explosives is permitted if the operation requires the tool to remove metal prior to or after contact with the explosives filler, provided it is performed by remote control with the operators protected by operational shields complying with the requirements of paragraph 2622.

e. Where wet machining is to be performed, positive automatic interlocking devices shall be provided to insure that machining cannot be started until coolant is flowing. These controls must also be capable of stopping the machining if the flow of coolant is interrupted. When it is essential to cut off the flow of coolant to adjust machining tools, positive means must be devised to insure that, once adjusted, flow of coolant is

restored and all automatic control devices are in operation before machining is permitted to continue. The manipulation of the manual means employed for making the automatic control devices temporarily inoperative should be under the direct

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control of some assigned, responsible person other than the operator.

f. The lineal and rotational speeds of tools used for the machining of cased or uncased explosives shall be maintained at the minimum necessary to safely and efficiently perform the operation. Speeds shall not exceed 210 linear feet per minute nor 525 revolutions per minute. So far as practicable, machining equipment should be used that is capable of accurately controlling the rate of feed. The rate of feed used should be the lowest consistent with safe and efficient operations, dependent upon the explosive materials being machined. When equipment provided with feed control mechanisms are used for machining high explosives, the rate of feed utilized should not exceed .035 inch per revolution. Cavities required in explosives preferably should be made with forming tools rather than drills.

g. Pneumatic or hydraulic driven machine tools are preferred for all machining operations on high explosives. Electric tools may be used if the motors, switches, and wiring are of types suitable for the specific hazardous exposure being produced (see par. 603e). Control mechanisms for hydraulic or pneumatic equipment shall provide positive control of speed and should include a means for "sealing" at the speed selected, to prevent tampering by unauthorized personnel. Pressure relief devices should be installed where necessary.

h. Wherever practicable, and when forming tools

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cannot be used, "fly-cutter" type tools and forming cutters should be used for producing cavities in high explosives. When fluted drills must be used, the flutes shall extend from the tip of the drill to a point beyond the entry of the drill into the cased or uncased explosives. High explosives shall not be drilled to a greater depth than 4 inches unless the drill is stopped at increments of depth not greater than 4 inches, withdrawn and the loose explosives removed from the cavity and drill before continuing. When producing cavities in high explosives with a "fly-cutter" type drill, a flow of air shall be directed at or near the interior bottom of the cavity to aid in clearing explosives chips and dust through the exhaust system.

i. In all machining operations on cased or uncased high explosives, tool adjustments shall be controlled by positive means to insure proper depth, diameter, and contour of the cut. These positive control measures shall include guides, bushings, or other alignment aids to prevent contact between moving parts of the machining equipment and metallic parts of the case or holding fixtures. Minor adjustments of machining tools may be made while operations are in progress, however, the total personnel exposure must not exceed that permitted for normal operation. Major repairs, modification, or adjustment of machine equipment shall not be undertaken while machining of explosives is in progress.

j. Dull or damaged tools shall not be used for machining high explosives. Tools should be made of

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material which will take and retain a satisfactory cutting edge and be compatible with the explosives being processed. Nonferrous tools should be utilized wherever practicable.

k. The explosives products resulting from drilling and other machining operations shall be removed by an approved type exhaust system or by immersion in a stream of water flowing away from the operation. The waste products should be collected at a point outside of the operating room or cubicle. Collected waste products shall be removed from the operating area at intervals sufficiently frequent to prevent hazardous accumulations. The use of large capacity sumps immediately adjacent to the operating room or cubicle should be discouraged.

l. The quantity of cased or uncased explosives being machined shall be the minimum necessary for safe and efficient operation. When the explosives intended for processing are on trays or transfer "dollies," the unit being processed must be located as far as is practicable from the remaining units awaiting processing.

m. Unless protection in the form of operational shields is provided for operators, not more than 2 persons shall be permitted in a room or cubicle, where dry machining of explosives is being accomplished. Where wet machining of explosives is being performed and the work is of a special nature which requires the presence of more than 2 persons, the number of personnel exposed shall not exceed 5.

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## **2616. ASSEMBLY AND CRIMPING OF COMPLETE ROUNDS**

Each assembly and crimping machine should be separated from other similar or dissimilar operations by walls or operational shields sufficiently strong to retain any fragment that may be produced.

## **2617. PRESSING EXPLOSIVES**

a. Each pelleting operation involving black powder, tetryl, TNT, pyrotechnic mixtures, and other explosives of similar sensitivity and operations involving pressing or reconsolidating of explosives in medium and major caliber rounds shall be conducted in a separate room or cubicle having walls of sufficient strength (par. 2622a) to withstand an explosion of the total quantity of explosives at the operation. Operators must be protected by the room or cubicle walls during such operations.

b. Pressing or reconsolidating of explosives in minor caliber rounds, tracer bodies, tetryl lead-ins, detonators, and in similar items shall be performed when the consolidating stations on machines are protected from each other by adequate operational shields. Operators must be behind protective barriers when such operations are conducted.

c. Punches and dies must be in matched sets and released for use by the gauge laboratory or the unit established capable of performing the necessary measurements. In this connection, it is intended

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that the sets of tools as released be matched for acceptable dimensional and finish characteristics, but they need not be the original tools comprising the set; in other words, odd punches of suitable characteristics may be matched (by the control laboratory) with a die to form a satisfactorily matched set. All punches and dies used in explosives pressing operations must be subjected to a rigid test such as magnaflux or X-ray prior to use and at regular intervals after such tools have been utilized in pressing operations.

*d.* Replacement of punches and dies in the pelleting press must be by matched sets known to have been checked and calibrated by the control laboratory. Replacement of single components by the operating staff to complete a set of punches and dies is prohibited.

*e.* Tetryl, TNT, and RDX pelleting presses should be cleaned with acetone or acetone dampened rags.

*f.* Black powder pelleting presses should be cleaned with water dampened rags.

*g.* Tracer and incendiary pelleting presses should be cleaned with a petroleum solvent similar to Stanisol, Varsol, or other equivalent.

*h.* Polishing pastes or other media containing grit or alkali are prohibited.

#### **2618. PROTECTION OF PRIMERS**

Preventive measures must be taken in the design of equipment, transportation, and operations to pro-

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tect not only loose primers but also primers in rounds or in components from accidental impact or pressure. Where feasible, a protecting cap should be placed over the primer. Bodies of hand trucks and other conveyances used for transporting primed items must be free from stones, protruding nails and other projections which might cause the primer to function. When primed items are transported on their bases, the container or truck bed should be recessed at the point primers would otherwise make contact.

#### **2619. CONCURRENT OPERATIONS IN LOADING PLANTS**

a. If production schedules make necessary concurrent loading of ammunition of different item designations, or the concurrent loading of different components in the same line simultaneously, the grouping of work should be so arranged that mutual exposure of items presenting dissimilar hazards is avoided. The following separation by groups is preferred, but not required, if concurrent loading is necessary, so that exposure of items of one group to items of other groups is avoided:

- (1) Percussion elements.
- (2) Artillery primers and delays.
- (3) Detonators and relays.
- (4) Fuzes.
- (5) Boosters.
- (6) Shell, separate loading.
- (7) Propelling charges, separate loading.
- (8) Complete rounds and mortar ammunition.

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- (9) Bombs.
- (10) Spotting, saluting and practice charges.
- (11) Pyrotechnics.
- (12) Chemical ammunition.
- (13) Small arms ammunition.
- (14) Rockets and rifle grenades.
- (15) Hand grenades.
- (16) Mines.

*b.* When more than one explosive material is handled on a line or within a building or room, mutual contamination must be avoided. Particular attention should be given to both portable and stationary vacuum systems in this respect. This also applies to explosives scrap collection. Inadvertent mixing of explosive material, in addition to presenting a hazard in equipment and in buildings, can be hazardous if loaded in ammunition in such condition.

*c.* Even when an item of ammunition is designed to contain more than one explosive material, the appropriate rules regarding inadvertent contamination apply.

*d.* When two or more explosives are used in a line or within a building, and mixing is not intended, it is recommended that they be placed at separate locations. It is also recommended that where differentiation of the explosives cannot be made readily by color or crystalline form, the boxes be plainly marked with the name of the material or by color code.

*e.* Some explosives operations are inherently more hazardous than others. The personnel exposure in locations where concurrent operations must be per-

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formed should be controlled by installation of dividing walls so that the number exposed is no greater than if a single type of ammunition were worked on.

f. Those operations requiring the presence of a relatively large quantity of explosives material, and usually carried on with small personnel exposure, should not be performed on the same line with operations requiring a large number of people and perhaps a relatively small amount of explosives material.

g. Care should be exercised to properly segregate material in service magazines as well as in operating buildings.

h. If concurrent loading is done, undue congestion should be avoided by rearrangement of working areas.

i. When loading of a new item of ammunition is contemplated, on a given line or in a building, the current job should be completed and the excess material removed promptly so that the hazards of mixed materials will be eliminated.

## **2620. EVACUATION OF BUILDINGS**

(See par. 1616.)

a. Evacuation plans shall be developed and coordinated with storm prediction systems. When an electrical storm is anticipated a first warning should be given whereupon the quantity of explosives in process should be reduced to a minimum until danger of the storm has passed.

b. If a melt-pour building is equipped with an

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effective lightning protection system, melt loading may continue after the second warning (indicating the storm is imminent) until all molten explosives in the building can be run into the item or receptacle involved. All persons not required for these operations shall be evacuated to a safe place. As soon as equipment is drained, all remaining personnel shall be evacuated.

c. In operating lines or buildings where serious explosive incidents are possible, suitable means for warning personnel to evacuate the building line, or area should be installed. A visual or audible warning system or combination of both is considered satisfactory.

#### **2621. EXPLOSIVES WASHOUT**

Explosives washout operations are considered line operations and are, therefore, subject to the provisions of paragraph 1711c. Where washout operations are to be placed in operating buildings, they must be placed in separate bays or cubicles or be separated from other operations in the buildings by suitable operational shields.

#### **2622. OPERATIONAL SHIELDS**

(Added)

a. A 12-inch reinforced concrete wall, constructed in accordance with the requirements of paragraph 506a, except for height, constitutes an adequate operational shield for quantities of explosives not exceeding 15 pounds when the explosives are at least 3 feet

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from the wall and 2 feet from the floor; reinforced concrete walls 30 inches thick are suitable for quantities of explosives not exceeding 50 pounds and reinforced concrete walls 36 inches thick are suitable for quantities of explosives not exceeding 70 pounds.

b. Operational shields for protection against quantities of explosives less than 15 pounds may be of steel or other suitable material. In the absence of reliable data, the adequacy of these operational shields, including thickness, size, fastening and location should be proved by actual test with a minimum safety factor of 25 percent above the maximum expected charge before its use is permitted in operations. Operational shields previously tested for given quantities of explosives need not be retested for exposures of the same magnitude. The results of such tests shall be made known to the Chief of Ordnance.

c. When personnel protection is required for operations involving quantities of explosives in excess of 70 pounds, providing a suitable protective shield at the operation often becomes impractical. In such cases the operator should perform the work by remote control, from a barricaded position not closer to the operation than the appropriate barricaded intra-line distance.

d. On any equipment used for explosives processing, the doors of which function as operational shields; interlocking devices should be installed which will prevent the operator from opening such doors while the equipment is in operation.

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### **2623. HEAT SEALING EQUIPMENT**

(Added)

Electric heat sealing machines (e. g., Doughboy Electric Sealers) should be separated from all similar or dissimilar operations by an operational shield of such proportions as to limit the effect of an incident originating at the sealing operation to the immediate vicinity. Such sealing equipment should be limited to one machine per operating room, bay or cubicle.

### **2624. REBOWLING OPERATIONS**

(Added)

Rebowling operations involving lead azide and primer mixes shall be performed by remote control, with the operator protected by operational shields complying with the requirements of paragraph 2622.

### **2625. THREAD CLEANING**

(Added)

a. Projectile loading techniques should preclude the deposition of explosives in threaded openings in the projectiles. When thread cleaning is necessary, it should be accomplished by the judicious use of non-ferrous "picks." The operator and adjacent operators need not be protected by means of operational shields, however, thread cleaning operations should be separated from unrelated operations.

b. Power actuated "Thread-chasing" tools may be used to clean loaded projectile threads that are im-

perfect because of previously applied Pettman cement or other sealers, provided the operation is performed within a separate cubicle, by remote control, with the operator protected by an operational shield meeting the requirements of paragraph 2622. Hand operated "thread chasing" tools may be utilized provided no explosives are present in the threads.

c. Thread cutting shall not be performed on projectiles containing explosives.

**2626. PROFILE AND ALIGNMENT GAGING OPERATIONS**  
(Added)

Each profile and alignment gaging operation should be so inclosed that adjacent operations are protected by operational shields complying with the requirements of paragraph 2622.

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## SECTION 27

### COLLECTION AND DESTRUCTION OF EXPLOSIVES AND AMMUNITION

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#### 2701. COLLECTION OF CONTAMINATED INDUSTRIAL WASTES

Industrial wastes which may contain explosives materials shall not be disposed of in sanitary sewers, septic tanks or sanitary filter tanks. Sumps, settling beds or leaching pits shall be provided in all cases where the quantities and types of explosives in the waste water are such that streams may become polluted or their banks contaminated (see paragraph 517 for construction requirements for drains and sumps). When sumps, settling beds or leaching pits are used precautions must be taken to assure that no contaminated waste water will enter or pollute potable sources of water by percolation through the soil as the result of poor or inadequate treatment. If chemical destruction of explosive material is authorized, it may be done periodically in the settling basin. Explosive materials to be removed from settling basin should be maintained wet until removed. The more sensitive explosives should be maintained wet until destroyed. Materials containing powdered metals should be kept under water to prevent dan-

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gerous rise in temperature which might otherwise be developed in the reaction between the metals and a small quantity of water.

#### **2702. DEPOSITION FROM WASTE LIQUIDS**

When sumps or basins are properly designed, the wash water which passes beyond filters and basins should be free from significant amounts of explosives materials; that is, the amount dissolved in neutral water near atmospheric temperature is small and can be expected to produce no toxic or explosive hazard when connected with the natural drainage of the area. However, consideration should be given to the possibility of deposition of explosive materials on the banks of streams or marshes during periods of drought, as well as to any possible subsequent precipitation of explosives with change of temperature, acidity or concentration of the waste water. Where uncertainty exists regarding the composition of waste waters, adequate and competent technical consultation should be obtained.

#### **2703. HANDLING WATER-SOLUBLE MATERIALS**

Where ammonium picrate (Explosive D) black powder or other materials which are appreciably soluble in water are handled, the amount of dissolved material should be kept as low as practicable. Floors should be swept before washing down to reduce the quantity of dissolved material in the wash water.

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#### **2704. DESTRUCTION OF COLLECTED SOLID WASTES**

Contaminated solid waste material should be taken in closed containers, as soon as practicable, to buildings set apart for its treatment or to the burning ground to be destroyed in an appropriate manner. Collected explosive wastes must not be disposed of by being buried, or thrown in any streams or tide-water unless they are decomposed by water. This latter disposition will be allowed only if not prohibited by State laws or local ordinances.

#### **2705. COLLECTION OF EXPLOSIVES DUSTS**

a. Dust collecting systems may be used to aid cleaning, to lessen explosion hazards, and to minimize industrial job-incurred poisoning and dermatitis.

b. The high explosives dusts which may be removed by a vacuum system are TNT, tetryl, Explosive D, Composition B, and pentolite. A "wet collector" which moistens the dust close to the point of origin and keeps it wet until the dust is removed for disposal is preferred except for Explosive D which should be collected in a dry system.

c. More sensitive explosives such as black powder, lead azide, mercury fulminate, tracer, igniter, incendiary compositions, and pyrotechnic materials may be collected by vacuum in this manner, provided it is maintained wet with the wetting agent, close to the point of intake. The vacuum (aspirator) systems must be so arranged that the various types of explosives are collected separately or in a manner to

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avoid mixture of dissimilar hazards; i. e., black powder with lead azide. Provision should be made for the proper liberation of gases that may be formed. The use of vacuum systems for collecting these more sensitive materials should be confined to operations involving small quantities of explosives; for example, in operations with fuzes, detonators, small arms ammunition, and black powder igniters. Collection of scrap pyrotechnic, tracer, flare, and similar mixtures in No. 10 mineral motor oil is recommended to minimize the potential fire and explosion hazard of the material. The oil may be in catch pans and scrap-transporting containers at the various operations throughout the plant, or materials collected in the dry state may be placed in an oil containing receptacle at intervals throughout the shift, prior to disposition by burning. While containers are in use, the oil level should be about 1 inch above the level of any pyrotechnic mixture in the container. Containers or buckets used for collection of the material may be of heavy oil-resistant cardboard, and should be removed from the operating buildings for burning at least once per shift. Where oil is used, firefighting equipment satisfactory for class B fires should be available. Carbon dioxide or foam extinguishers are recommended.

#### **2706. LOCATION OF COLLECTION CHAMBERS**

*a.* **Wherever practicable, dry type explosives dust collection chambers, except portable units as specifically provided for in paragraph 2707c, should be located outside operating buildings, in**

the open or in buildings exclusively set aside for the purpose. In order to protect operating personnel from blast or missiles in event of an incident involving the collection chamber, a protective barrier must be provided between the operating building and the outside location or separate building where the collection chamber is placed. If the collection chamber contains 25 pounds of explosives or less, the protective barrier may be a substantial dividing wall (par. 506) located a minimum of 8 feet away from the operating building. The collection chamber must be located at least 3 feet from the wall. If the collection chamber contains more than 25 pounds of explosives and is separated from the operating building by a 12-inch reinforced concrete wall, the wall must be separated from the operating building by a minimum of unbarricaded intraline distance. If the protective barrier meets the requirements of paragraph 2622 for operational shields (including the required 3-foot distance between the barrier and the explosives), for the quantity of explosives in the collection chamber, or if it meets the requirements of paragraph 1725 for barricades, the protective barrier shall be placed at a minimum of barricaded intraline distance from the operating building.

b. When it is not practicable to locate these dry type collection chambers outside the operating building, a separate room within the building may be set aside for the purpose. This room

shall not contain other operations nor shall it be used as a communicating corridor or passageway between other operating locations within the building when explosives are being collected. Walls separating the room from other portions of the operating building must meet the requirements of paragraph 2622 for the quantity of explosives in the collection chamber. If more than one collection chamber is to be located in the room, the room must be subdivided into cubicles and not more than one collection chamber shall be in a single cubicle.

c. Stationary and portable wet type collectors may be placed in the explosives operating bays or cubicles provided the quantity of explosives in the collectors does not exceed 5 pounds. If placed in separate cubicles, the explosives limits for the collectors may be increased to 15 pounds. (See par. 2707c.) When wet collectors are to contain more than 15 pounds, the location requirements set forth in paragraphs 2706a and 2706b are applicable.

## 2707. DESIGN AND OPERATION OF COLLECTION SYSTEMS

a. Collection systems and chambers shall be designed to prevent pinching explosives (especially dust or thin layers) between metal parts. Pipes or tubes through which dusts are conveyed should have flanged, welded, or rubber connec-

tions. Threaded connections are **prohibited**. The system shall be designed to minimize accumulation of explosives dusts in parts other than the collection chamber. Accordingly, **pipes or ducts through which high explosives are conveyed shall have long radius bends. Short radius bends may be used in systems for propellant powder provided they are stainless steel, with polished interiors.** The number of points of application of vacuum should be kept to a minimum. So far as practicable, each room requiring vacuum collection should have a separate exhaust line to the primary collection chamber; but not more than two bays shall be serviced by a common header to the primary collection chamber. Wet primary collectors are preferred. The length of vacuum line from points of application of vacuum to the wet collectors should be short as possible. The number of wet primary collectors serviced by a single secondary collector should be kept to a minimum. Not more than two dry primary collectors should be connected to a single secondary collector (wet or dry type). If an operation does not create a dust concentration which may produce a severe health hazard, manual operation of the suction hose to remove explosives dusts is preferred to a permanent attachment to the explosive dust-producing machine which increases the likelihood of propagation through the collection system of a detonation occurring at the machine. Interconnection of manually operated

hose connections to explosives dust-producing machines should be avoided.

b. In dry vacuum collection systems, to prevent explosives dust from entering the vacuum producer, two collection chambers should be installed in series ahead of the pump or exhauster.

c. Dry type portable vacuum collectors shall not be located in a bay or cubicle where explosives are present, but may be positioned outside the building or in a separate cubicle having substantial dividing walls, for quantities of explosives not exceeding 5 pounds. Wet type portable vacuum collectors may be placed in explosives operating bays or cubicles provided the quantity of explosives in the collector is limited in accordance with the requirements of paragraph 2706c. For dry collection of quantities in excess of 5 pounds or wet collection of quantities in excess of 15 pounds, the further provisions of paragraph 2706 shall apply.

d. The design of wet collectors shall provide for

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proper immersion of explosives, breaking up air bubbles to release air-borne particles and removal of moisture from the air before it leaves the collector to prevent moistened particles of explosives from entering the small piping between the collector and the exhaustor or pump.

*e.* Explosives dust shall be removed periodically from the collector chamber at intervals to eliminate unnecessary and hazardous concentrations of explosives but not less frequently than once every shift. The entire system should be cleaned weekly, dismantling the parts if necessary.

*f.* The entire explosives dust collecting system shall be electrically grounded and the grounds tested frequently.

#### **2708. GENERAL REQUIREMENTS FOR DESTRUCTION OF EXPLOSIVES MATERIALS**

Explosives and ammunition which are dangerously deteriorated or cannot be definitely identified shall be destroyed. Destruction shall be accomplished by burning, detonation or dumping at sea. Burying explosives or ammunition or dumping them into waste places, pits, wells, marshes, shallow streams or inland waterways is prohibited except as may be authorized elsewhere in this Manual for black powder, chemical munitions and other specified explosives. Destruction shall not be undertaken without prior approval of the Chief of Ordnance unless the commanding officer decides that immediate destruction of deteriorated explosives or ammunition is nec-

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essary for the protection of life and property. When destruction is authorized, the provisions of all current Army directives involving lost, destroyed, damaged, or unserviceable property must be observed. Prior approval for destruction of routine wastes is not required. The prescribed methods for the destruction of chemical munitions are given in section 29.

#### **2709. DESTRUCTION SITES**

a. The site selected for the destruction of explosives and ammunition shall be located at the maximum practicable distance available from all magazines, inhabited buildings, public highways, railways and operating buildings; the separation, however, shall not be less than 2,400 feet unless pits or similar aids are used to limit the range of fragments, in which case the appropriate missile distance will apply. Sites must also be located in relation to the direction of prevailing winds, so that sparks will not be blown towards explosives locations. Where possible, natural barricades shall be utilized between the site and operating buildings or magazines. When destroying explosives by burning, the possibility that the mass may detonate must be recognized and appropriate protective barriers or distance separation utilized for the protection of personnel and property. Instances are on record of the following explosives (which normally burn) detonating while being burned: TNT, tetryl, pentolite, and Explosive D.

b. In all disposal and destruction activities, the

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number of units or quantity of explosives that may be destroyed safely at one time shall be determined carefully by starting with a limited number or quantity and then gradually increasing that quantity until the amount consistent with safe and efficient operations is determined.

c. Dry grass, leaves, and other extraneous combustible material shall be removed within a radius of 200 feet from the point of destruction. The grounds should be of well packed earth and shall be free from large stones and deep cracks in which explosives might lodge. Explosive materials shall not be burned or detonated on concrete mats.

d. Fire-fighting facilities shall be readily available to extinguish brush or grass fires and, if necessary, to wet down the ground between burnings and at the close of each day's operations.

e. Ordinary combustible rubbish should be destroyed at a location removed from places where explosives and explosives contaminated material are destroyed. Where limited space does not permit separate burning areas, a part of the explosives destruction ground may be reserved for burning rubbish provided the two areas are not operated simultaneously, and the area where rubbish has been burned is wetted down and inspected before explosives burning is resumed. Combustible material should be burned in an incinerator complying with National Board of Fire Underwriters Pamphlet No. 82 or in a substantial wire-mesh enclosure (not over  $\frac{3}{4}$ -inch openings).

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f. The demolition area or burning ground shall be serviced with telephones or two-way radio communication. A change house serviced with electricity is desirable.

#### **2710. MATERIAL AWAITING DESTRUCTION**

Material awaiting destruction shall be stored at not less than intraline distance from adjacent temporary stores of explosive materials and from explosives being destroyed. The material shall be protected against accidental ignition or explosion from fragments, grass fires, burning embers, or detonating impulse originating in materials being destroyed.

#### **2711. PERSONNEL PROTECTION**

a. Sufficient and suitable protection for personnel should be provided in the form of operational shields with overhead and frontal protection as a minimum. Where circumstances warrant their use complete personnel protection shall be provided. Such structures should preferably be located at the appropriate inhabited building distance for the quantity and type of materials being detonated but in no case will this distance be less than 300 feet. Employees must use such protection when explosive materials are destroyed by detonation or when explosive materials which may detonate are being burned. Personnel must remain at the greatest practicable distance from the burning site but in no case shall personnel be permitted closer than the applicable public highway

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distance to "burnings" involving class 2 or similar materials until the fire is out.

b. During disposal and destruction operations, the number of people in the area exposed to the hazard must be kept to a minimum. Warning signs or road blocks shall be posted to restrict the area and to insure proper segregation of activities. The number of personnel engaged in the disposal and destruction operations shall be no fewer than two and operations shall be arranged so that not all of the personnel are exposed to an incident. Personnel engaged in burning explosives should be provided with flameproof outer clothing.

#### **2712. SUPERVISION AND TRAINING**

a. The disposal area and its operations shall be under the direct control and supervision of an experienced and trained supervisor charged with the responsibility for all activities within the area. He shall be present during all burning and demolition ground operations. He shall also be charged personally with the sole custody of all ignition devices.

b. Supervisors, foremen, and operators employed at the destruction area shall be thoroughly trained regarding the nature of the materials handled, the hazards involved, and the precautions necessary. The danger of using short-cut methods and other deviations must be thoroughly instilled in the minds of the employees. It is essential that thorough training and vigilant supervision be provided.

c. In the absence of specific regulations or information covering any phase of the destruction of ex-

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plosive material, instructions should be requested from the Chief of Ordnance.

### **2713. CONTAINERS FOR WASTE EXPLOSIVES**

Explosives destined for the burning ground shall be in original closed packages or in containers of fire-retardant materials that will not contribute to the existing hazard by readily producing sparks when contacting rocks, steel, or other containers. Bags or containers made from easily ignited material shall not be used. Containers shall have closures that will prevent spilling or leakage of contents when handled or if overturned. Closures shall be of a type that will not pinch or rub explosives during closing and opening. The closures and surfaces of container openings shall be thoroughly cleaned of explosive contamination to minimize the hazard during closing or opening.

### **2714. SERVICING OF DESTRUCTION SITE**

a. Trucks transporting explosive material to burning or demolition grounds shall meet the requirements of section 22. No more than two persons shall ride in the cab.

b. Upon arriving at a burning or demolition ground, trucks may distribute explosives containers or explosives items to be destroyed at sites where destruction is to take place. As soon as all items have been removed, trucks shall be withdrawn from the burning or demolition area to a safe location until destruction is completed. Containers of explosives shall not be opened until the truck has been withdrawn.

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c. Containers of explosives or ammunition items to be destroyed at the destruction site shall be spotted and opened at least 10 feet from each other and from explosives material previously laid for destruction, to prevent rapid transmission of fire in event of premature ignition.

d. Empty containers shall be closed and moved a sufficient distance away to prevent charring or damage during burning of the explosives. Empty containers may be picked up by truck on the return trip after delivery of the next quantity to be destroyed.

e. When materials being processed at burning grounds do not lend themselves to handling other than by fork lift truck, and the terrain features are such that solid-tired, electrical-powered lift trucks cannot be maneuvered, pneumatic-tired, gasoline- or diesel-powered lift trucks meeting the requirements of paragraph 2402c may be employed to handle properly packaged explosives and ammunition containing no exposed explosives and upon which there is no visible explosives contamination.

#### **2715. GENERAL BURNING REQUIREMENTS**

a. Except in specific cases, such as Explosive D loaded projectiles, ammunition and explosives shall not be burned in containers nor should explosives be burned in large lump form because of the danger of detonation.

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b. Bulk initiating explosives and others used predominantly in detonators shall be destroyed by detonation except that small quantities (should not exceed 28 grams) may be decomposed chemically.

c. Loose explosives, other than initiating explosives, may be burned in beds not more than 3 inches deep. Wet explosives may require a thick bed of readily combustible material such as excelsior underneath and beyond to assure that all the explosives will be consumed once the materials are ignited. From the end of the layer of explosives the combustible material should be extended in a train to serve as the ignition point. When an ignition train of combustible material leading to the explosives is used, it must be arranged so that both it and the explosives burn in the direction from which the wind is blowing. The combustible train or the explosive, if ignited directly, must be ignited with the aid of safety fuse of such length to permit personnel to reach the protection shelter, or ignited with a black powder squib initiated by an electric current controlled from a distance or structure which assures safety to personnel should the total quantity of explosives detonate. In cases of misfires, personnel shall not return to the point of initiation for at least 30 minutes, after which not more than two qualified persons shall be permitted to examine the misfire. It may be necessary to tie two or more squibs together to assure ignition of the combustible train. No bed of combustible material is needed for burning solid propellants which may be ignited by squibs as described above.

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- (1) Loose, dry explosives may be burned without being placed on combustible material if burning will be complete and the ground does not become unduly contaminated. The ground must be decontaminated as frequently as is necessary for the safety of personnel and operations. Qualified inspectors shall examine the sites after each burning to determine if these requirements are met. Volatile flammable liquids (par. 278) shall not be poured over explosives or the underlying combustible material to accelerate burning, either before or while the materials are burning.

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(2) Wet explosives shall not be burned without first preparing a bed of nonexplosive combustible material upon which the explosives are placed to assure complete burning. It is usually necessary to burn RDX wet to prevent detonation.

(3) Pyrotechnic materials collected as described in paragraph 2705c, may be burned by emptying the containers or buckets containing the oil and pyrotechnic mixture onto a shallow metal pan and igniting as described above. The open containers may be burned with the explosives.

d. Parallel beds of explosives prepared for burning shall be separated by not less than 150 feet. In repeated burning operations, care must be taken to guard against material being ignited from smoldering residue or from heat retained in the ground. Burnings shall not be repeated on previously burned-over plots within 24 hours unless the burning area has been thoroughly soaked with water and an inspection of the plot by competent personnel has been made to assure the safety of personnel during a subsequent burning operation.

e. Some types of explosives and tracer or igniter compositions give off toxic fumes when being destroyed by burning. Proper respiratory protective equipment, such as hose masks, airline masks, and self-contained breathing apparatus shall be worn where such fumes are likely to be encountered.

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## **2716. MATERIALS FOR DETONATING AMMUNITION**

*a.* Detonation of explosives or ammunition should, where practicable, be initiated by electric blasting caps using blasting machines or permanently installed electric circuits energized by storage batteries or conventional power line. Improvised methods for exploding electric blasting caps shall not be used. Instantaneous type fuse must not be used. When items to be detonated are covered with earth, as specified in paragraph 2717, blasting caps should not be buried beneath the ground level with the initiating charge. The initiating explosives should be primed with primacord of sufficient length to reach up through the covering to a point where the blasting cap may be connected thereto, above the ground level.

*b.* Special requirements for using electric blasting caps and electric blasting circuits:

- (1) **Electric blasting caps, other electric initiators, electric blasting circuits and the like may be energized to dangerous levels by extraneous electricity of types and sources such as: static electricity, galvanic action, induced electric currents, high tension wires and radio frequency energy from radio, radar and television transmitters. Safety precautions shall be taken to reduce probability of a premature initiation of electric blasting caps and explosives charges of which they form a part.**

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- (2) The shunt shall not be removed from the lead wires of the blasting cap until the moment of connecting them to the blasting circuit.

*Note.* If it is desired to test the blasting cap prior to priming the charge, the lead wires must be short-circuited by twisting the bare ends of the wires together immediately after testing. The wires shall remain short-circuited until the time to connect them to the blasting circuit.

- (3) When uncoiling the leads of blasting caps, the cap should not be held directly in the hand but rather should be held by the wires, approximately six inches from the cap. The lead wires should be straightened out as far as necessary by hand and shall not be thrown, waved through the air, or snapped as a whip to unloosen the wire coils.
- (4) **Firing wires shall be twisted pairs.** At the power source of the firing wires of the blasting circuit, the ends of the wires shall at all times be shorted or twisted together and connected to ground except when actually firing the charge or testing the circuit. The connection between blasting caps and the circuit firing wires must not be made unless the power end of the circuit leads (firing wires) are shorted and grounded.
- (5) **Electric blasting or demolition operations and unshielded electric blasting caps should**

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be separated from radio frequency energy transmitters by the minimum distances specified below. These distances apply to all parts of the operation, including the lead wires of the cap and the firing wire circuit.

Table 2716. *Transmitter Power—Safe Distance for Electric Blasting Operations\**

<i>Transmitter power (watts)</i>	<i>Minimum distance (feet)</i>
5-25.....	100
25-50.....	150
50-100.....	220
100-250.....	350
250-500.....	450
500-1,000.....	650
1,000-2,500.....	1,000
2,500-5,000.....	1,500
5,000-10,000.....	2,200
10,000-25,000.....	3,500
25,000-50,000.....	5,000
50,000-100,000.....	7,000

\*Table is not applicable to very high-powered transmitters with highly directionalized beams. Distances are also satisfactory for other electrical initiators of approximately the same electrical sensitivity of commercial electric blasting caps.

- (6) Before connecting electric blasting caps to the firing wires, the blasting circuit shall be tested for the presence of extraneous electricity. If exposure is to RF energy and the transmitter operates at AM broadcast frequencies, separating distances less than specified in table 2716 are permissible provided the location is proven free from extraneous electricity by the following test:

- (a) Arrange a dummy test circuit, essentially the same as the actual blasting circuit except that a No. 47 radio pilot lamp of known good quality inserted in place of the blasting cap shall be used without applying electric current to the circuit. Any glow of the radio pilot lamp, viewed in darkness, is to be construed as evidence of the presence of possible dangerous amounts of RF energy, and blasting operations in such areas must be performed with nonelectric blasting caps and safety fuse, or
- (b) Other instruments such as the Du Pont "Detect-A-Meter" and/or "Volt-ohmeter" may be substituted for the No. 47 radio pilot lamp. If the exposure is to radar, television, or other microwave transmitters, the actual blasting circuit, with blasting cap included but without other explosives, shall be used to test for extraneous electricity. Personnel performing such tests must be provided protection from the effects of an exploding blasting cap. Distances prescribed in table 2716 should be used as a guide in the selection of sites for electric blasting operations in the vicinity of radar,

television, and other microwave transmitters.

- (7) Blasting or demolition operations shall not be conducted during an electrical storm or when the storm is approaching. All operations shall be suspended, cap wires and lead wires should be short circuited, and all personnel must be removed from the demolition area to a safe location when an electric storm approaches.
- (8) Prior to making connections to the blasting machine, the firing circuit shall be tested with a galvanometer for electrical continuity. The individual assigned to make the connections shall not complete the circuit at the blasting machine or at the panel nor give the signal for detonation until he has satisfied himself that all persons in the vicinity are in a safe place. When used, the blasting machine or its actuating device shall be in this individual's possession at all times. When he uses a panel, the switch must be locked in the open position until ready to fire and the single key must be in his possession.
- (9) Blasting caps must be in closed metal boxes when being transported by vehicles equipped with 2-way radios and also when in areas where extraneous

electricity is known to be present or is suspected of being present.

c. Safety fuse may be used in the detonation of explosives and ammunition where methods described in *a* above cannot be accomplished. Safety fuse when used must be tested for burning rate at the beginning of each day's operation and whenever a new coil is used. Sufficient length of fuse shall be used to allow personnel to retire to a safe distance but under no circumstances should a length be less than 3 feet having a minimum burning time of 120 seconds. Crimping of fuse to detonators must be accomplished with approved crimpers. Crimping by biting with teeth or by other expedient means shall not be permitted. Safety fuse which is too large in diameter to enter the blasting cap without forcing shall not be used. Before igniting the safety fuse, all personnel, except the superintendent and not more than one assistant, shall retire to the personnel shelter or be evacuated from the demolition area.

#### **2717. Detonation of Ammunition**

a. Ammunition or explosives to be destroyed by detonation should be detonated in a pit not less than 4 feet deep and covered with not less than 2 feet of earth. The components should be placed on their sides or in the position to expose the largest area to the influence of the initiating

explosives with an adequate number of demolition blocks placed in intimate contact on top of the item to be detonated and held in place by earth packed over the demolition blocks. Under certain circumstances other materials such as bangalore torpedoes and bulk high explosive may be substituted for demolition blocks.

Where space permits and the demolition area is located remote from inhabited buildings, boundaries, work areas, and storage areas, detonation of shell and explosives may be accomplished without the aid of a pit. In either event, however, the total quantity to be destroyed at one time, dependent on local conditions, should be established by trial methods to assure that adjacent and nearby structures and personnel are safe from the blast effect or missiles resulting from the explosion. This procedure should be used for the destruction of fragmentation grenades, HE projectiles, mines, mortar shells, bombs, and HE rocket heads which have been separated from motors. Rocket motors containing solid propellants should not be destroyed by detonation (par. 2727).

b. After each detonation a search shall be made of the surrounding area for unexploded material and items. Items or material such as lumps of explosives or unfuzed ammunition may be picked up and prepared for the next detonation. Fuzed ammunition or items which may have internally

damaged components should be detonated in place unless the item can be safely handled by using mechanical retrievers which will provide protection to personnel.

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c. In case of misfires personnel shall not return to the point of detonation for at least thirty minutes after which not more than two qualified personnel shall be permitted to examine the misfire.

#### **2718. DYNAMITE**

Unopened boxes of exuding dynamite to be destroyed should be burned on a bed of combustible material without being opened. Precautions must be taken to protect personnel and property from a possible detonation. Individual cartridges may be burned in single layer not greater in width than the length of one cartridge, on a bed of combustible material. Dynamite awaiting destruction shall be shielded from the sun. Frozen dynamite is more likely to detonate during burning than normal cartridges. Destruction of dynamite by detonation may be accomplished where the location will permit this method of destruction. Care in priming, to assure complete detonation of the quantity, must be taken.

#### **2719. INITIATING EXPLOSIVES**

When relatively large quantities of initiating explosives such as lead azide or mercury fulminate are to be destroyed, detonation usually is the best method. The bags containing the explosives should be kept wet while being transported to the demolition area. A predetermined number of bags (see par. 2712) should be removed from the container, carried to the destruction pit, placed in intimate con-

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tact with each other and blasting caps be used to initiate the explosives. The remaining explosives shall be kept behind a barricade with overhead protection during the destruction operations and located at a distance that will assure safety.

#### **2720. RDX AND PETN**

RDX and PETN may be burned as described in paragraph 2715. Since RDX and PETN are usually collected wet, they should be spread out and partially dried prior to burning. If it is found that the wet material will burn only incompletely and with difficulty on the combustible bed, fuel oil may be sprinkled over the bed of combustible material upon which the explosive is placed.

#### **2721. PROPELLING CHARGES**

Propelling charges with igniters may be burned without slitting but in all cases igniter protector caps shall be removed from the charges to be burned. Protection must also be provided against possible projection of the charges and explosion. Propelling charges must not be piled one on the other but shall be burned in a single layer of charges laid side by side. Core igniter type charges in the single layer should be separated one from the other by a distance equal to one caliber. Propelling charges and igniter pads may be slit open with a nonsparking knife.

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### **2722. BLACK POWDER**

Black powder is best disposed of by dumping in a suitable stream if not prohibited by law. It may also be burned as previously described. Wet, black powder on drying out may obtain some of its explosive properties since the nitrate may not have been removed completely.

### **2723. PARACHUTE FLARES**

Parachute flares with pressed charges such as the M26 type may be burned. Individual flares should be 4 feet apart and be placed upon a layer of combustible material. When burning flares and similar materials occasional explosions may occur, therefore, adequate protection from such hazards must be provided.

### **2724. SMALL ARMS AMMUNITION**

Small arms ammunition and primers, including artillery primers, may be destroyed in the same manner as detonators, small primers, and relays, using the methods described in paragraph 2728c, d, and e, using equipment shown on figure 2728B.

### **2725. ITEMS WITH MIXED HAZARDS**

Items having two or more explosive hazards, such as spotting charge M1A1 where the black powder charge may be destroyed but the initiating device (primed cartridge) may be intact after being projected from the burning area, shall be destroyed in such manner that projected units will be restricted

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in flight and returned automatically (gravity) to the burning pit to eliminate the hazard of manually retrieving unexploded items.

#### **2726. BURNING OUT LOADED HE PROJECTILES**

a. TNT, Explosive D, Composition B, pentolite, and other explosives filler in open projectiles may be burned out when destruction by detonation or washing out and burning the explosive filler separately is impracticable. The area selected for the operation should be based on the same principles as outlined in paragraph 2709.

b. (Revised) Projectiles to be burned out should preferably be placed on their sides and arranged in groups or not more than six projectiles, with all open ends facing in one direction. Each group of six projectiles should be separated from adjacent groups by not less than 12 inches in order to reduce the possibility of mass detonation in the event of incident in any one group. Where it has been determined, by trial, that adequate safety is provided from a detonation of an established quantity of explosives in projectiles, this established quantity may be used as the criterion for consolidation when burning out items.

c. Combustible material such as excelsior, scrap lumber, or oil soaked waste should be used to ignite the explosive filler. Flammable liquids having low flash points (volatile flammable liquids) shall not be used to intensify the burning of explosive material. Class 2 solid propellant (smokeless powder) may

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also be used where ignition of the projectile filler can be accomplished by such means.

d. Personnel shall not be permitted to return to the scene of operation until a competent observer has determined that all explosives have been burned.

e. Burned out projectiles shall be reprocessed to assure that explosive residue does not remain. The projectile shall be thoroughly inspected to assure that all explosives have been destroyed prior to releasing the components for salvage (par. 2507).

#### **2727. DESTRUCTION OF ROCKET AND JATO COMPLETE ROUNDS**

a. Disposition of HE loaded rocket duds shall be made in accordance with section 28, paragraph 2825.

b. White phosphorus loaded rockets shall be destroyed in accordance with paragraph 2927; infantry and aircraft type HE and practice rockets shall be destroyed as follows:

(1) **Wherever practicable, separate the rocket motor from the HE head and dispose of the head as specified for HE artillery ammunition. If separation of the motor and head is impracticable, rockets may be destroyed in pits in the manner prescribed by paragraph 2717. Sufficient charge must be used to assure destruction, in place, of the motor and head.**

(2) Remove the nozzle or nozzle plate from the rocket motor and take out the igniter and solid propellant charge. The igniter and solid propellant charge shall then be

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destroyed or salvaged in accordance with preceding instructions.

- (3) In certain rocket motors the propellant cannot be removed from the motor. In this case, the nozzle shall be removed and the motors placed in a vertical position, firmly held, with the open end up, and the propellant burned. Rocket motors greater than 6 inches in diameter shall be disposed of according to paragraph c below.
- (4) **Propellant in 3.5-inch (and smaller) practice rockets and rocket motors (without heads) may be destroyed by static firing with the nozzle in place.**

c. Wherever practicable, propellant must be removed from JATO units and destroyed by burning. In the event removal of the propellant is not practicable, the JATO units should be positioned or restricted to prevent their movements and propellant in the units be destroyed by static firing. When units are to be destroyed by static firing, complete details of the procedures must be submitted to the Office, Chief of Ordnance for approval.

d. JATO propellant charges may weight as much as several thousand pounds per grain, and the polymer-oxidizer type may be extremely difficult to ignite at atmos-

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pheric pressures. Although both double base and polymer-oxidizer grains are not susceptible to high order detonations, they should be treated as high explosives in burning ground disposal operations.

#### **2728. DESTRUCTION CHAMBERS AND INCINERATORS**

a. Figure 2728A "Explosive Scrap Incinerator and Feeder Building" describes an explosives scrap incinerator and feeder building for the burning of tracer and igniter compositions, small quantities of solid propellants, magnesium powder, sump cleanings, absorbent cleaning materials, or similar materials contaminated with these explosives.

b. Details of operation of the incinerator are—

- (1) The materials to be burned should be wet with water and sent to the feeder building in conveniently sized containers. The amount of material permitted in the building should be limited to that in one container but shall not be greater than permitted by appropriate quantity-distance requirements.
- (2) The feeding conveyor shall not be operated until the furnace temperature has reached 1600°-1800° F., as indicated on the thermometer recording device in the feeder building.
- (3) Not more than two cardboard containers of explosives (approximately 75 cubic inches capacity each) should be fed into

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the incinerator at one time. The boxes should be burned with their contents.

- (4) The furnace shall be shut down and cooled thoroughly when it becomes necessary to remove accumulated residue. Repairs shall be made only during shut-down. If it is necessary for personnel to enter the furnace for clean-out purposes, adequate respiratory protection should be provided to prevent inhalation of toxic dusts or fumes, such as mercury from tracers and lead from small arms ammunition.

c. To destroy small loaded components of ammunition such as detonators, delays, relays and small primers, unsuitable for destruction by detonation or burning, a destruction chamber such as shown on Figure 2728B "Detonator Destruction Furnace" should be used.

d. Operators shall not approach the unprotected side of the concrete barricade shown on the drawing to replenish fuel, adjust the oil flame or for other reasons, until ample time has elapsed for destruction of all explosives within the chamber. The detonator feed pipe should also be inspected periodically to make certain that it is free from obstructions.

e. It is important that components be fed into the chamber a few at a time and that no more are added until the greater majority of the items previously fed have detonated. The exact number permitted at one time for each type of component should be





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posted in a conspicuous place near the operator's working position. No person shall be permitted to feed additional components into the chamber until there is reasonable assurance that the quantity previously introduced has been exploded.

### **2729. DUMPING AT SEA**

When disposal or destruction of explosives of ammunition by other means is impracticable, ammunition may be dumped at sea. Disposition instructions are to be requested through the Chief of Ordnance from the Chief of Transportation, who has sole responsibility in the Department of the Army for selection of sites and methods of operation. Items of ammunition must be removed from their packing containers prior to dumping at sea and positive measures must be taken to assure that dumped materials will remain submerged. Only bulk explosives containing a water soluble constituent, which, when removed renders the material nonexplosive may be disposed of by dumping at sea. (See SR 75-70-10).

### **2730. TOXIC HAZARDS OF CERTAIN EXPLOSIVES AND CHEMICAL MUNITIONS**

a. Lewisite is a war gas which liberates arsenic oxide upon being destroyed by burning. The surrounding atmosphere may become hazardously contaminated when this gas is burned in open pits.

b. Chemical munitions containing CN-DM mixtures also liberate arsenic oxide when burned and may produce hazardous atmospheric contamination.

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c. Components of ammunition, such as tracers, that contain calomel (mercury chloride) release toxic matter when burned.

d. Propelling charges may contain lead or other metallic substances as decoppering agents. Dust, fumes, mists, and the like from lead and certain other of these metals produce hazardous work conditions due to their toxicity. The provision of adequate ventilation and proper respiratory protective devices are among the precautions which should be taken to offset these hazards.

e. Nitroglycerin in production processes and from exuding dynamite is toxic by absorption. Skin contact should be avoided.

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## SECTION 28

### PROVING GROUNDS

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#### 2801. SCOPE

The requirements of this section apply primarily to Ordnance establishments whose principal mission is the proof testing of materiel, but pertinent requirements are applicable to proof test activities at any Ordnance establishment. This section supplements other applicable portions of this Manual. Additional requirements, such as approval by appropriate airspace subcommittee prior to use of danger or controlled firing areas are set forth in AR 385-63 and changes thereto. The Ordnance Proof Manual should also be used as a reference. Establishments which do not conform to these regulations may require certain precautions and modifications of existing facilities to safeguard life and property. Plans for major modifications shall be submitted to the Chief of Ordnance for review before modifications are undertaken.

#### 2802. DEFINITIONS

The following definitions apply specifically to this section:

*a. Craft.* Any ship, vessel, or floating object used for transportation over water. The term "small craft" includes rowboats, lifeboats, dinghies, rubber rafts, and similar nonpower craft.

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*b. Clearance.* An authorization to conduct a proof test, to enter or exit from a danger area, or to conduct work in a danger area. Clearance may be granted only by the safety observer having jurisdiction over the danger area in which the operation is to be conducted.

*c. Danger area.* Those areas of the establishment in which tests are conducted and into which no one is permitted to enter, be within, or conduct tests within until he has obtained clearance from a safety observer. Danger areas shall be posted, and maps of the areas shall show the location of the safety control tower for each area.

*d. Danger zone.* A zone within a danger area, the size of which varies with the class of firing, which is hazardous to life and property because of the dangers incident to the use of material or ammunition. The location of danger zones shall be kept on file and shall be clearly indicated on maps of danger areas.

*e. Elevation (quadrant).* The angle that the axis of the piece makes with the horizontal.

*f. Firing point or position.* The exact location from which a projectile, bomb, grenade, flare, ground troop signal, rocket, or other device, is to be ignited, propelled, or released.

*g. Piece.* A gun, howitzer, mortar, launcher, projector of any type, or airplane used for propelling projectiles or releasing bombs in connection with proof tests.

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*h. Patrol craft.* A powered craft for patrolling hazardous waters.

*i. Proof officer (director).* Any individual, military or civilian, charged with the conduct of a proof test.

*j. Proof test.* Any research, experimental, development, surveillance (par. 273), or acceptance test of Ordnance materiel or ammunition.

*k. Range.* Horizontal distance only.

*l. Recovery field.* A cleared area used for the purpose of observing the burst or impact of projectiles or bombs.

*m. Safety observer (range controlman).* A qualified individual having detailed jurisdiction over safety in a danger area.

### 2803. LAYOUT OF EXPLOSIVES BUILDINGS

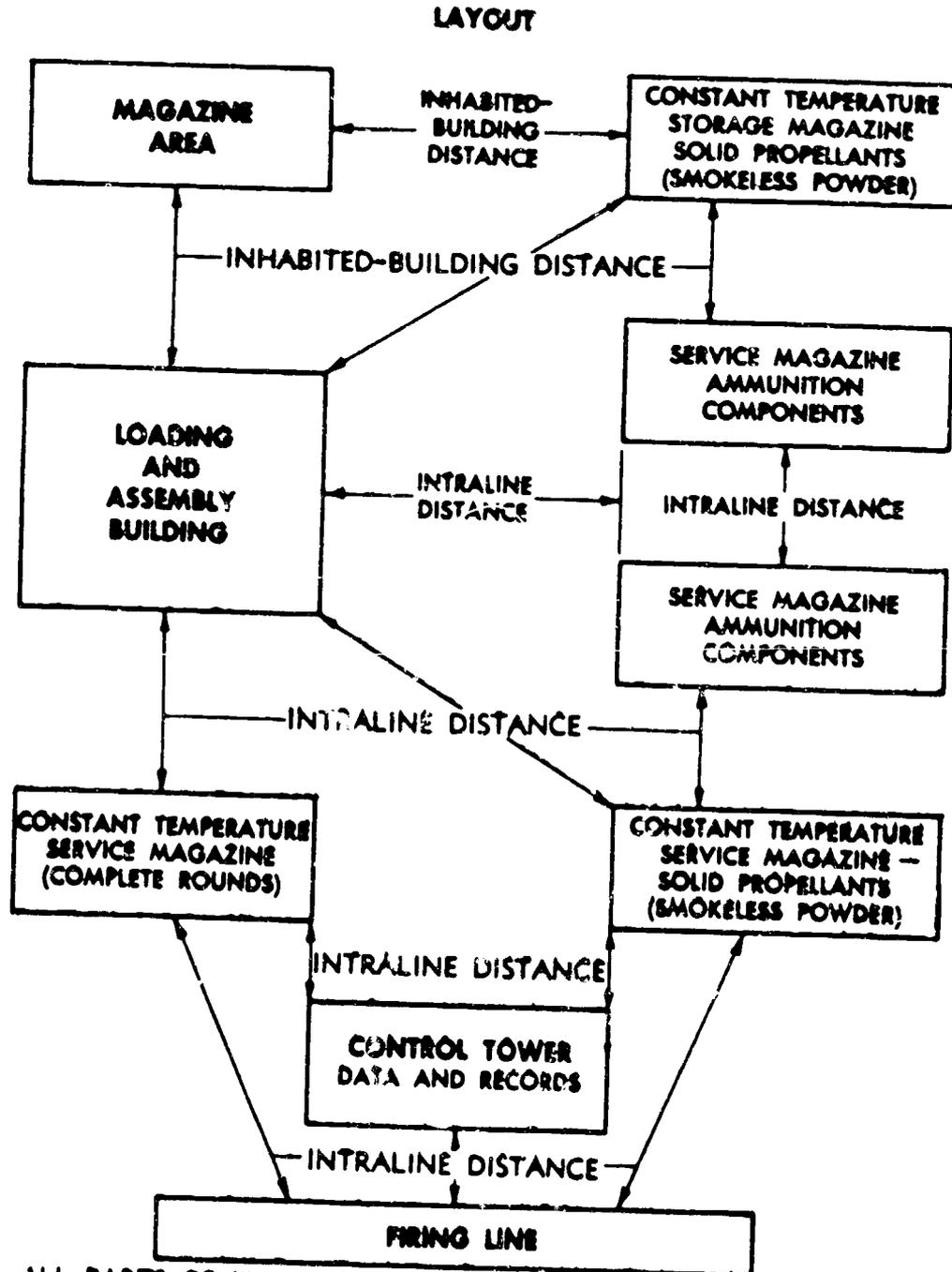
*a.* In all future construction, the layout of explosives buildings necessary for proof firing activities shall be in accordance with the principles shown on figure 2803. In separating one facility from another as shown in figure 2803, the distance must be based on the quantity and/or class of material requiring the greater separation. Distance so determined is not intended to afford protection against prematures or weapon failures. Such protection must be obtained from increased distances or appropriately designed firing barricades (stockades).

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b. In emergencies a need will probably exist for a solid propellant (smokeless powder) constant temperature magazine which will contain a working supply of many different lots of propellants. This building is designated as "Constant Temperature Storage Magazine Solid Propellants (smokeless powder)" on figure 2803. For operating convenience, a "constant temperature service magazine solid propellants (smokeless powder)," to contain the service supply of material necessary for the immediate job at hand (not to exceed a two-day supply nor applicable quantity-distance requirements), should be provided near the loading and assembly building. For maintaining complete rounds at a constant temperature, a "Constant Temperature Service Magazine (Complete Rounds)" is also shown as the source of supply to the firing point. Where classes 1, 3, 4, and 5 ammunition only are involved, the two constant temperature service magazines may be combined into one building provided a substantial dividing wall separates the ammunition from the propellant. For all other classes of ammunition, separate buildings must be provided for service supplies of solid propellants (smokeless powder) and ammunition.

c. Insulated containers or conveyances may be needed to avoid significant temperature changes in the propellants or items during transportation. Where necessary, insulated containers may be stored in the constant temperature magazines. The containers should be of noncombustible materials so far as is practicable.

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ALL PARTS OF "LINE" SHOWN ABOVE SHALL BE LOCATED AT A MINIMUM OF INHABITED-BUILDING DISTANCE FROM INDUSTRIAL OR INHABITED AREAS.

Figure 2805. Layout.

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d. Cartridge case resizing operations and other operations on inert materials or components may be located at intraline distance from explosives buildings in a line if the inert operations serve only one line. If the inert operations serve more than one line they shall be located at inhabited building distance from the line buildings. A line is considered to be the operations incident to one loading and assembly building.

e. Small quantities of explosives may be detonated in cubicles of an operating building, provided the cubicle is capable of withstanding and confining the effects of the explosion and personnel are properly safeguarded. Normally a quantity of explosives larger than one-half pound should not be favorably considered.

f. Laboratory supplies of explosives, not to exceed 15 pounds per cubicle, may be stored without regard to the compatibility required by section 19; however, the principle of separating high explosives, primary explosives, and chemicals shall be observed.

#### **2804. LOADING AND ASSEMBLY BUILDING**

a. The building or buildings used for the assembly and loading of ammunition shall be designed and constructed in accordance with established explosives safety principles. Personnel and explosives or ammunition shall be kept at the minimum consistent with safe and efficient operations. Substantial dividing walls shall be used to limit exposures and to separate operations involving dissimilar hazards. Explosives and personnel limits shall be posted for each operation.

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b. Extended storage of assembled rounds shall not be permitted within the building. A service magazine should be provided at intraline distance from surrounding explosives operations if a temporary storage point is necessary.

#### **2805. EXPLOSIVES OPERATING PRECAUTIONS**

a. *Primers.* Precautions must be taken in the design of equipment, transportation and operations to protect the primer of rounds or components from accidental impact or pressure. Where feasible, a protecting cap should be placed over the primer. Hand trucks and similar conveyances used for transporting primed rounds or components must be free from stones, protruding nails, and other projections upon which the primer might be caused to function. Where cartridge cases and complete rounds are transported on their bases, the container should be recessed at the point primers would otherwise make contact.

b. *Manual handling.* When **cartridges and projectiles** larger than 60-mm are hand carried, they shall be handled one at a time.

c. *Scrap materials.* Scrap explosives materials and items shall be segregated and handled as outlined in paragraph 1610.

d. Fuzed projectiles shall not be handled by the fuzes alone. A positive manner should be provided to prevent dropping and accidental contact with other objects.

e. Powder charges shall be transported in suitable metal or fiber containers in order to prevent accidental ignition from sparks or other sources.

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**f. Operations on explosive loaded ammunition components shall be performed only by competent trained personnel at approved locations.**

**g. No work, adjustment, or observation shall be permitted on any piece while a round is in the firing chamber, except to check and adjust azimuth and elevation. In case of small arms, the bolt shall be kept open at all times except when actually firing. In no case shall a lanyard be attached until the piece is ready to be fired and no one shall step over the lanyard once it is attached. On weapons equipped with safety locks, the lock may be released after the lanyard has been attached.**

**h. Loaded shell, components, etc., must not be delivered to machine shops or other location (not specifically approved for this work) for modification without special approval.**

#### **2806. RESPONSIBILITY FOR PROOF TEST FIRING PROGRAMS**

Proof officers shall be responsible for the safe conduct of firing programs assigned to them for action. This responsibility includes insuring that proper protection is worn in the case of personnel exposed to high noise levels, injurious pitch frequencies, objectionable reverberations, or other sound factors which may injure hearing. These conditions may exist when firing weapons or when detonating explosives. Safety observers shall be notified promptly concerning changes in assignment of those directly responsible for the conduct of any firing program.

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**2807. PRELIMINARY EXAMINATION FOR TEST HAZARDS**

*a.* Every proposed program for proof test for ammunition shall be examined by the proof officer or other designated responsible official for all foreseeable hazards involved in the test. This must be done with a knowledge of the construction and operation of all items, standard and nonstandard, to be used. When a specific hazard can be foreseen, alternate means for attaining the objectives of the test shall be adopted where possible.

*b.* Inert loaded or minimum charge ammunition instead of HE shall be used in all cases where the substitution will still yield the objectives of the test. Particular efforts shall be made to use minimum hazard ammunition in these instances:

- (1) When protection cannot be provided for assigned personnel firing ground or aircraft guns.
- (2) When testing fuzes for fuze action only.
- (3) When making firing tests of fire-control equipment of tanks and combat vehicles.

*c.* The following rules apply where tests are to be conducted on temperature conditioned material:

- (1) All tests involving temperature conditioning of material and explosives shall be properly scheduled. Adequate information shall be furnished by the proof officer to establish properly required danger zones for each type of test. Explosive limits for temperature conditioning rooms shall be established by a designated person who has

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full knowledge of the intended activities in the rooms during the tests.

- (2) During tests, one member of the crew shall serve as safety observer and shall be stationed outside the lookout window at all times when personnel are within the temperature controlled room. He shall be on the alert for personnel affected by the temperature and for the various firing signals.
- (3) (Revised) Working time in temperatures from  $0^{\circ}$  F. to  $-40^{\circ}$  F. shall not exceed 1 hour; and from  $-40^{\circ}$  F. to  $-90^{\circ}$  F., 30 minutes. A close check on the time shall be maintained by the safety observer. At temperatures below  $-40^{\circ}$  F., breathing aids shall be used, such as air line respirators properly equipped to avoid fogging of the eye piece. No person shall work alone in temperatures below  $-10^{\circ}$  F.
- (4) All firings conducted from temperature controlled facilities shall be on an azimuth approved by designated competent authority. No piece shall be fired in any room unless the gun muzzle, even in recoil, is located outside the port opening. Destruction tests, excess pressure tests, and tests of known unsafe classes of guns where the possibility of breech failures exists shall be conducted with portable sandboxes placed to the side of the breech and a plate to the rear of the mount. Sandboxes shall

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be so placed as to form an effective operational shield.

- (5) All equipment employed in the temperature conditioning of explosives shall be of approved type. The location of all such equipment (including all hot and cold boxes), not located in established buildings when employed for storage of explosives, shall be in accordance with appropriate quantity-distance requirements. The hazards of each test should be recognized and the required safety distance established.
- (6) Exhausts shall be piped to the outside of the building.
- (7) Adequate protective clothing shall be worn by all personnel who are required to enter the temperature controlled room.
- (8) Temperature conditioning equipment and rooms using heating mediums for conditioning operation should be provided with dual automatic controls to regulate temperatures and to shut off the heat source.

#### **2808. RANGE CLEARANCES**

a. *General.* A clearance shall be granted only by the safety observer having jurisdiction of the danger area in which the operation is to be conducted. If a proof test endangers two or more danger areas, the safety observer of the area in which the piece is located should obtain the necessary coordination and clearance from the other safety observers involved. Each proof officer shall obtain a firing clearance from the safety observer prior to conducting a proof test. Having obtained the clearance, the proof offi-

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cer shall be responsible for safety at the firing point. He should not be authorized to transfer the clearance to any other person. In event the test is to be assumed by another proof officer, the original clearance should be canceled and the new proof officer should renew the clearance prior to resumption of firing. At the completion of any firing, the proof officer shall notify the safety observer who shall cancel the clearance.

*b. Establishing danger zones.* The safety observer shall plot and determine the danger zone of each test in accordance with the danger zone prescribed for that class of fire, using the submitted information concerning location of the gun, azimuth of fire, type of ammunition to be fired, expected range to impact or burst, and any other pertinent data furnished. To determine the range for a given program, the range-elevation curve applicable to the data submitted shall be used. When a curve is not available for a prescribed velocity of shell, the curve for the next higher velocity and the shell giving the longest range should be used. Frequently the danger zone will extend to the side and rear of the piece and adequate precautionary measures should be taken accordingly. Signs or flags other than those displayed by the safety observer should be posted or displayed at various locations throughout the reservation to further define the danger zone. The proof officer should be responsible for placing these warning signs or flags, under the instructions of the safety observer. The signs or flags, when posted or displayed, shall

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not be passed unless authority to do so has been given by the safety observer.

*c. Firing over water.* Where necessary, patrol boats should be manned when firing tests involve impacts and air bursts on or over water areas, to assist in ascertaining the safety of the water areas. The safety observer-in-charge shall determine the safety for firing after establishing the danger zone of a particular test. Establishment of the danger zone may require prior information from other safety observers and patrol boats. Clearance must be obtained from the safety observer before any test which will endanger water areas is undertaken. Before granting a clearance, the safety observer-in-charge shall check with all other safety observers and with patrol boats assisting in checking the safety of the water area. Firings shall not be permitted over water unless the danger zone has been determined to be clear of personnel and boats.

*d. Entrance clearances.* The person in charge of a working party entering a danger area shall obtain a clearance from the safety observer immediately before entering. The clearance should include the nature and location of the work to be done, the name of the person in charge of the party, the number in the group, and the expected duration of stay in the danger area. Each party must confine its activities to the area for which the clearance is granted and to the prescribed routes to and from that area. The person in charge of the party shall be responsible

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for canceling clearances when his group leaves the area.

### **2809. AMMUNITION AND EQUIPMENT AT FIRING FRONTS**

Quantity of ammunition or explosives delivered to the firing position shall not exceed the amount required to conduct the test efficiently and without delay. All ammunition at the firing position must be so located as to reduce the possibility of ignition, explosion, or detonation in case of an accident at the gun. The ammunition should be piled in a dry location, free of combustible material, protected from the rays of the sun by a tarpaulin or other cover, with an air space between top cover and the items to provide for ventilation, and should be stored in a manner to prevent ignition from grass fires. White phosphorous shell must be piled well away from personnel. If it should be necessary to leave any live ammunition at a firing position overnight, the vicinity shall be appropriately marked by signs. All ammunition so stored **should** be unfuzed. No firings shall be conducted which will endanger, either by fragments or blast, any equipment such as cranes, shovels, locomotives, trucks, etc., which might be parked in the vicinity of firing fronts. It shall be the responsibility of the proof officer to take the necessary action to protect, by location or distance, equipment and personnel that might be endangered by the firing under his control.

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## 2810. SAFETY SIGNALS

Standardized signals shall be used to warn personnel of firing in the area. For the sake of uniformity, the following signals should be used. All proof officers or directors must be thoroughly familiar with the various signals.

*a. Firing signal.* The signal to fire shall be given by the proof officer. It should be given with a whistle by sounding two distinct blasts with a two-second interval between blasts. The first blast should be considered a warning signal and the second the signal of execution. During the interval between the two blasts the proof officer shall check for the safety of personnel at the firing point and so far as is possible, down the range. In the event the signal is not completed for some reason, the entire signal must be repeated. Bursts of fire from automatic weapons, except as indicated immediately below, should be preceded by two blasts of a whistle prior to each firing. The firing of small arms conducted as a prearranged program may be accomplished without sounding a signal. Safeguards shall be provided to assure that all indoor ranges are clear of personnel before firing is begun, and that no one can gain access to the range while the weapons are being fired. Remote control of firing is preferred for all firing and is required where chamber pressures of the order of 115 percent or greater of maximum rated pressure are expected. Toxic and noise hazards shall be adequately safeguarded.

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*b. Flag signals.* During daylight (unless other means such as lights have been employed), warning flags should be displayed as follows:

Red—firing with inert projectiles.

Yellow—firing with high explosives.

Black—firing against armor plate.

Flags should be flown in combination when necessary to designate clearly the firing being accomplished. For example, a black flag and a yellow flag should be flown when high explosive projectiles are being fired against armor plate. When a flag is lowered, all firing shall cease and shall be resumed only when the flag is raised and an all-clear signal is given.

*c. Light signals.* During hours of darkness, a flashing red light should be used to indicate that night firing is being done or is planned in that danger area. A steady red light should be used as a warning to aircraft.

*d. Sound signals.* Some system of sound signals should be instituted to enable the safety observer to control firings. Sirens have been used successfully with the following code:

- (1) One long blast to indicate cease firing at once. The flag should be lowered at the same time.
- (2) One long and one short blast to indicate all clear and that firing may be resumed.
- (3) Short blasts with a definite time interval between blasts to mean that dangerous firing is to take place within three minutes and all personnel must take cover.

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### **2811. TESTING FACILITIES**

No tests shall be conducted unless safe testing facilities are available. The proof officer shall determine the adequacy of available facilities and the need for additional safeguards prior to beginning tests.

a. Maximum use shall be made of mechanical devices to replace manual manipulation.

b. Guns operated by remote control shall be equipped with devices by which operations can be halted at will upon noticing a hazardous condition. These devices shall be independent of those regularly used for controls so that the operation can be stopped if the regular control should fail.

### **2812. RANGE PARTIES**

A range party shall consist of at least two persons, and no firings shall be performed on any recovery field or impact area with less than two present at the location. The person in charge of the party shall be responsible for the safety of the party. He shall not permit any personnel to remain outside the bombproof until after the first round of a series of inert projectiles is fired and the location of impact is known to be safe. He shall permit no personnel to remain outside the bombproof during high-explosive firing and the bombproof door shall be kept closed. He shall maintain constant communication with the firing point or the safety observer during the firing program and he shall not give approval to fire until all safety precautions have been fulfilled.

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### **2813. HALTING HAZARDOUS PROGRAMS**

The proof officer shall be on the alert to detect any evidence of malfunctions which may create a hazard to personnel or equipment. He shall be required to stop any program when a hazardous condition appears. He should take precautions against possible errors in assembly or preparation of materiel and ammunition. Examples of the points to be checked are—

a. Adequate filling of recoil mechanisms.

b. Safe function of the firing mechanism. Firing mechanisms must be tested prior to use particularly in the case of electric firing mechanisms to insure that mere insertion of the round or closing of the breech will not result in firing.

c. Absence of obstructions in the bore.

d. Correct selection and assembly of fuzes.

The proof director shall take all normal precautions to see that aircraft flying in the vicinity are not endangered.

### **2814. TEST FIRING RECOILLESS WEAPONS AND AMMUNITION**

a. *General.* All personnel shall be adequately protected from both breech blast and possible premature or malfunction of the round. In order to afford protection against flying missiles in open range firing as a result of the blast, breech blast danger areas shall extend to the rear of the weapon, 100 yards for all calibers up to and including 75mm and 150 yards for larger calibers. When effective barricades are used to confine the blast effect, the danger

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zone may be reduced. The distance and type of protection shall be such that safety of personnel is assured. Weapons mounted for vehicular firing should be given special consideration for protection of the loader and other members of the crew. Deflector plates or shields have been found suitable for such carriages or mountings.

*b. Safety switches.* If the rifle is equipped with a safety switch, it shall be in the safe position while the weapon is being loaded, and shall not be advanced to the firing position until the breechblock is closed and all preparations for firing are completed.

*c. Multiple firing.* Ripple firing should be conducted for programs requiring multiple firing, due to the rear blast possibly obscuring a misfire. When salvo firing must be done, at least two minutes shall be allowed to pass after a one-volley salvo before opening any breechblock. When several salvos are to be fired, a designated crewman shall be responsible for observing whether or not his piece has fired. If a rifle has not fired or if there is doubt as to whether it has fired, the breechblock shall not be opened unless the provisions covering misfires are followed, and the rifle should be eliminated from the salvo program.

*d. Special precautions.* Unburned propellant from test firing of recoilless weapons shall not be allowed to accumulate in the surrounding area. Decontamination by means of controlled flashing is permissible if other explosives, flammable and combustible material are at least 100 feet away from the outermost edge of the contaminated area

and an approved SOP is in effect and readily available to the cleanup crew.

## 2815. VERTICAL FIRING

a. Vertical firing or firing in the immediate vicinity of 90° elevation shall be conducted only in an isolated area that will safely accommodate the maximum dispersion expected under the conditions. For calibers up to and including the 57-mm gun, this area shall have at least 1,000 yards radius from the gun. Such firing should not be conducted on days when excessive wind velocities prevail, particularly when winds exceed 50 miles per hour. No gun above 57-mm shall be fired without previous wind data, and a corresponding increase in the danger zone. Where the impact cannot be determined when firing with an elevation that would ordinarily give safe impacts, the firing shall be suspended until wind data are obtained.

b. The gun should be located on the upwind side of the prevailing winds for the particular ordinate and particular season with respect to the selected impact area, and shall have been previously set with minimum cant. The gun shall be sighted on the center of the impact area and elevated in the vicinity of 90°.

c. Vertical firing of high explosives filled projectiles may be performed only if initiating components of the projectiles are inert and provided

the danger zone is increased to accommodate fragmentation in event of detonation of the projectile. Projectiles containing small charges of black powder (amounts, not to exceed 4 ounces, that will not produce fragmentation of the projectiles) and live initiating components may be fired vertically.

d. The gun crew and observers shall be located in bombproofs which are adequate to withstand penetration of the particular caliber to be fired.

#### 2816. FIRING OVER HEADS OF PERSONNEL

No firing over the heads of personnel shall be permitted unless the personnel are under adequate cover.

#### 2817. TESTS FOR SPECIFIC ITEMS

a. *Hand grenades.* Live hand grenades shall be tested only with a mechanical grenade thrower or specially designed and approved apparatus or facilities. All personnel shall be under cover during the test.

b. *Rifle grenades.* Live rifle grenades shall be tested only with the rifle secured in a rest and with all personnel under cover.

c. *Chemical ammunition.* In testing projectiles, bombs, and grenades filled with poisonous gases, the firing and observation personnel and other personnel likely to be endangered must be equipped with gas masks and other necessary pro-

protective equipment. Proof officers must take into consideration the direction and velocity of the wind to prevent the liberated gases from endangering nearby localities.

*d. Land mines.* No tank or vehicle shall be driven across a live, high-explosive land mine, even though auxiliary devices to function these mines are employed. In all cases the tank or vehicle shall be towed over the mine by another vehicle and no personnel shall be permitted in the towed tank or vehicle. A sufficient distance shall be provided between the two vehicles to prevent injury to personnel in the towing vehicle.

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*e. Antipersonnel mine.* This ammunition shall be fired by means of wires, sash cords, or some other type of cords having negligible stretch. The wires or cords should be encased in a permanent or semi-permanent conduit from the mine to a firing barricade. The mine shall be secured in a fixture so that the mine barrel cannot be tipped from the vertical position either by pulling the wires or cords or by the recoil of the mine base. The wires or cords shall not be attached to the mine until the latter is in the fixture. Separate cords shall be used to pull the firing pin safety pin, the release pin safety pin, and the release pin. The cords shall be attached to the mine the last thing before leaving the mine. The ends of the cords at the barricade shall be locked in position while the operator is attaching the cords to the mine and shall be unlocked only by the same operator after his return to the barricade or bombproof. A special clamp and cable should be attached to the firing device when the mine is set to permit breaking off the firing device in event of failure of the mine to eject its projectile. The clamp shall be operated from the barricade or bombproof. After waiting 30 minutes, the unarmed mine may be removed and destroyed.

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**2818. COOK-OFF**

a. In tests involving a high rate of fire, particularly with machine guns and antiaircraft guns, automatic function or "cook-off" of a round left in the hot gun for a period of time is possible. The possibility of cook-off depends largely upon the rate of heat dissipation of the gun, and factors such as high air temperature, low wind velocity, low elevation of the gun, confinement of the gun will increase the possibility of cook-off. To prevent cook-off, the barrel of the empty gun should be periodically cooled with water during the test; or if the use of water is prevented for some reason, the empty and opened gun should be aircooled. In case a round is retained or remains in a hot gun with the breech closed, all personnel in the vicinity shall remain under adequate cover either until sufficient time has elapsed to assure that a cook-off will not occur or unless some means of water cooling the gun by remote control is available. If a round jams and the breech fails to close, personnel in the danger zone shall be placed under adequate cover immediately and the gun cooled. The following table shall be followed to assure adequate cooling of the piece:

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Water-cooling----- 5 minutes  
Air-cooling, machine guns----- 15 minutes  
Air-cooling, other guns----- 30 minutes

b. When the possibility of a cook-off exists, the danger zone for personnel in the vicinity of the gun when firing explosive ammunition shall be—

Machine guns----- 200 yards radius  
Guns up to and including 75-mm----- 400 yards  
radius  
Guns over 75-mm. to 105-mm-- 600 yards radius  
Guns over 105-mm----- 800 yards radius

When inert ammunition is used, the radii given above may be halved. When effective barricades are used to confine blast effect the danger zone may be reduced. The distance and type of protection shall be such that safety of personnel is assured. In all cases of possible cook-off, the danger zone down range shall be maintained as for actual firing until the danger has passed.

#### **2819. PREMATURE BURSTS**

The proof officer shall notify the safety observer immediately of a premature burst. The safety observer shall either suspend the proof test or increase the lateral limits of the danger zone in accordance with prescribed safety distances prior to allowing the test to continue. The increased lateral limits shall be maintained until the particular test is completed.

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## 2820. MISFIRES

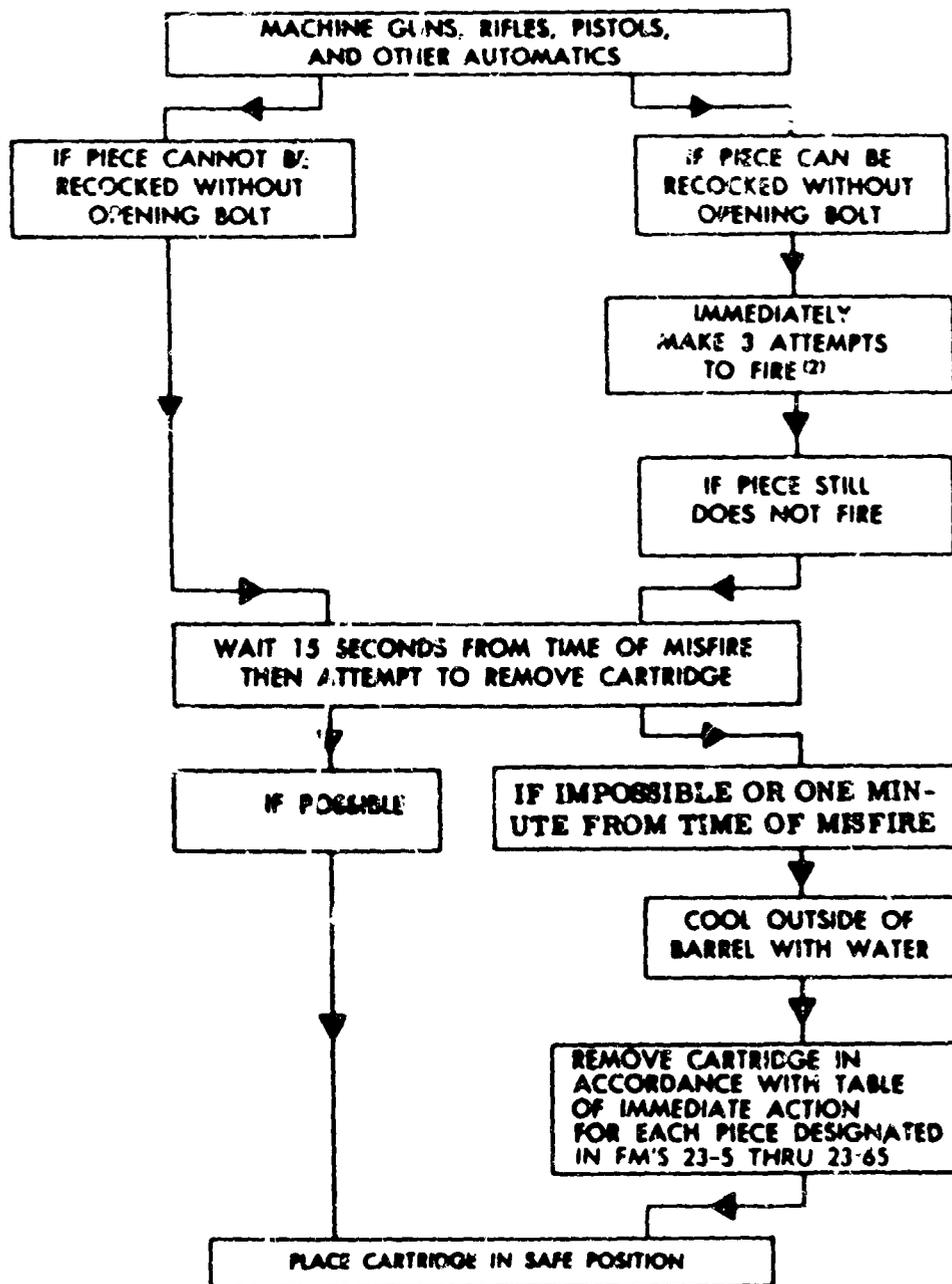
*a. General precautions.* While waiting after a misfire, all persons shall stand clear of the breech in case the round functions and the piece recoils. At the same time, all electrical connections which can cause firing of the gun shall be disconnected. The appropriate danger zone for the actual firing shall be maintained during the waiting period when a cook-off is expected. After the round has been removed, it shall be immediately placed where subsequent detonation will not cause injury or damage. In the case of misfires involving small caliber rockets and small arms ammunition, the rounds should normally be placed in water immediately, unless subsequent analyses and investigations preclude such practice. Before resuming fire after a misfire, the firing pin and mechanism shall be checked for proper functioning and the barrel of the gun shall be examined to assure that it is clear.

*b. Saluting ammunition.* After misfires, the breechblock shall not be opened within 10 minutes after the last attempt to fire.

*c. Other pieces.* The handling of misfires for weapons is covered in the following figures.

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MISFIRES OF MACHINE GUNS, RIFLES, PISTOLS AND OTHER AUTOMATICS (1)



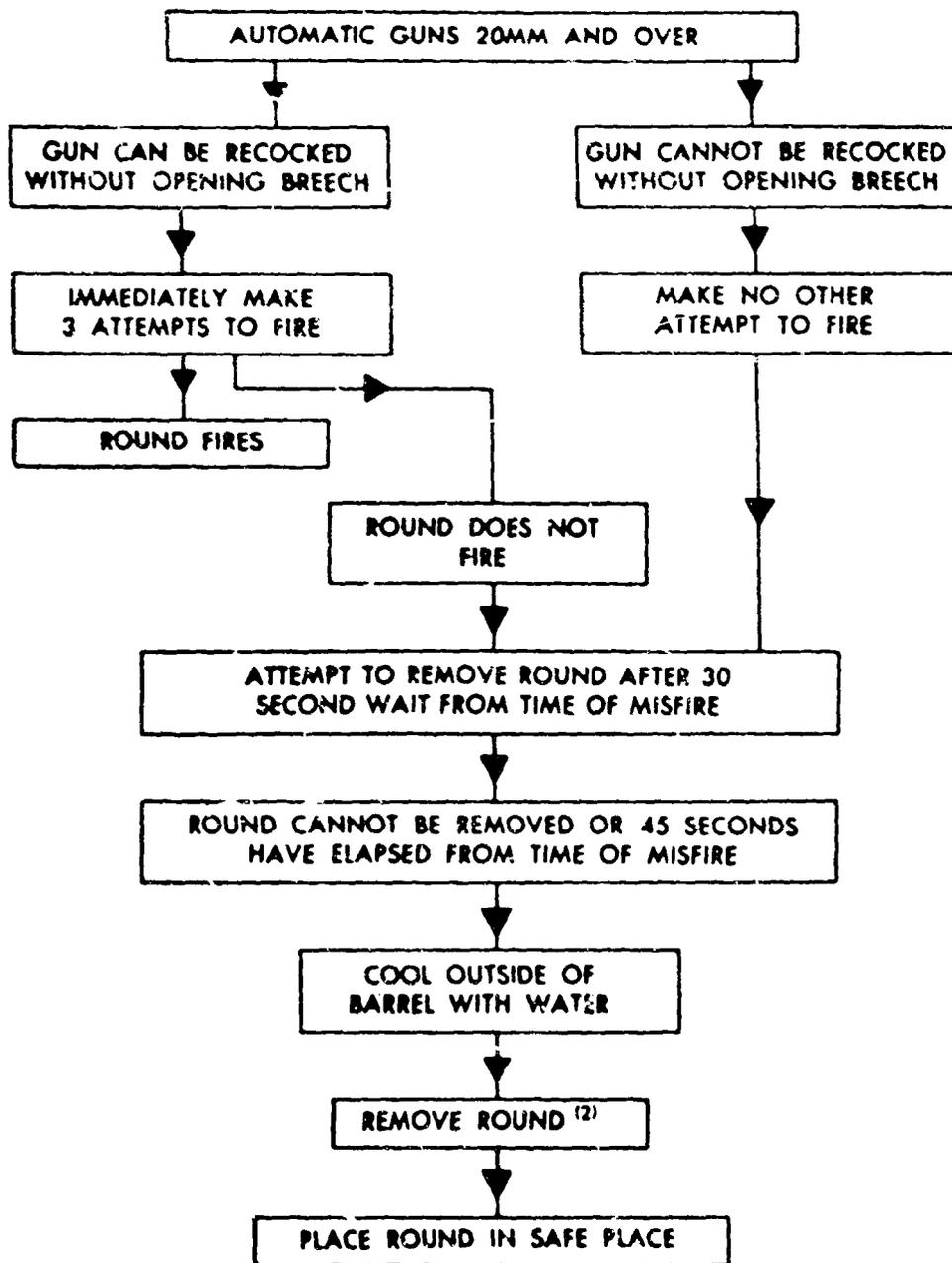
(1) FOR MISFIRE OF MACHINE GUNS WHEREIN NO POSSIBILITY OF AUTOMATIC FUNCTION OR COOK-OFF EXISTS (SEE PAR. 2818). FOR MISFIRE OF MACHINE GUNS UNDER POSSIBLE COOK-OFF CONDITIONS SEE FIGURE 2820D.

(2) TO AVOID INJURY, IN CASE OF HANGFIRE, HOLD THE HAND SO THAT NO PART OF THE PALM OR WRIST CAN BE STRUCK BY THE OPERATING SLIDE IN RAPID REAR MOVEMENT.

Figure 28-20A. Misfire of machine guns, rifles, pistols, and other automatics.

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MISFIRE OF AUTOMATIC GUNS 20MM AND OVER <sup>(1)</sup>



(1) WHEREIN NO POSSIBILITY OF AUTOMATIC FUNCTION OR COOK-OFF EXISTS (SEE PAR. 2818). FOR MISFIRE UNDER POSSIBLE COOK-OFF CONDITIONS SEE FIG. 2820D.

(2) IN EVENT ROUND SEPARATES FOLLOW PROCEDURES SHOWN IN FIG. 2820C. NOTE: THE SAFEST TIME TO REMOVE A MISFIRED ROUND OF FIXED AMMUNITION IS BETWEEN 30 AND 45 SECONDS AFTER ITS OCCURRENCE.

Figure 2820B. Misfire of Automatic Guns 20-mm and Over.

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MISFIRE OF FIXED OR SEMIFIXED AMMUNITION

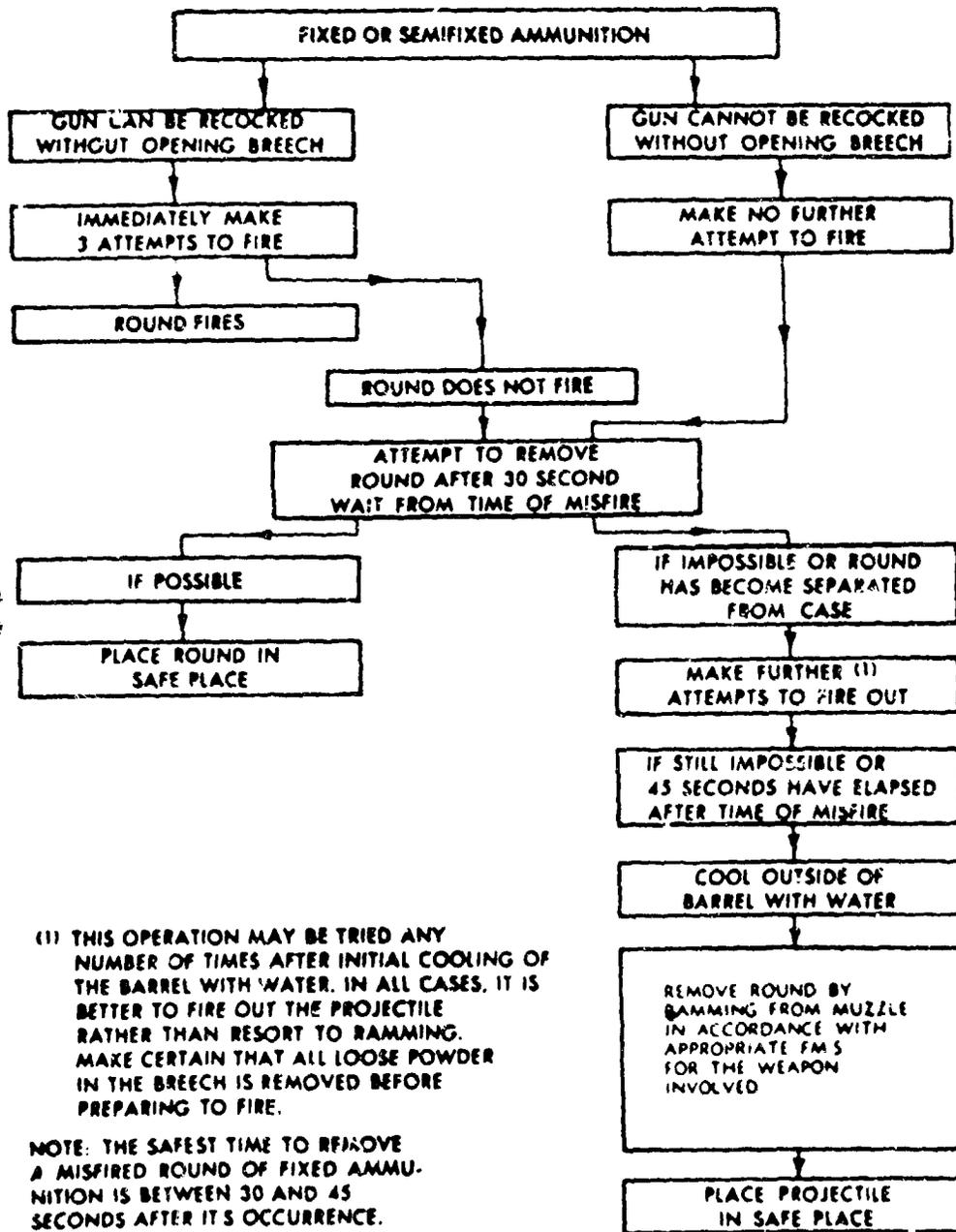
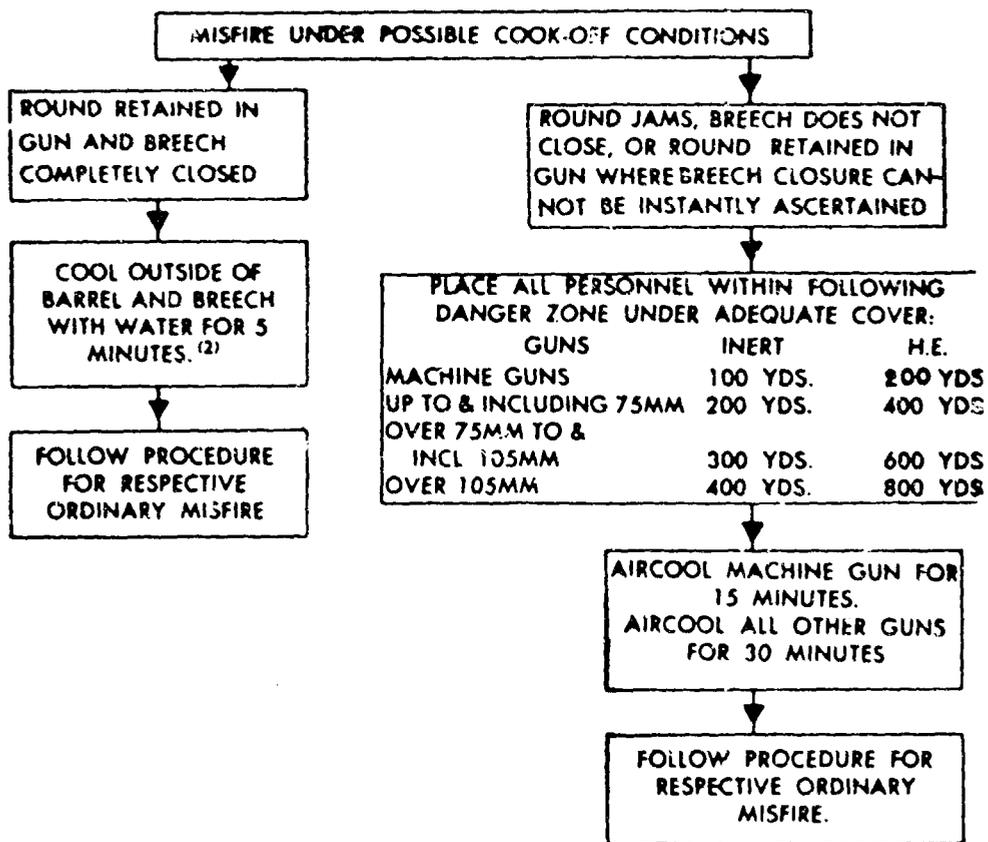


Figure 2820C. Misfire of Fixed or Semifixed Ammunition.

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MISFIRE UNDER POSSIBLE COOK-OFF CONDITIONS <sup>(1)</sup>



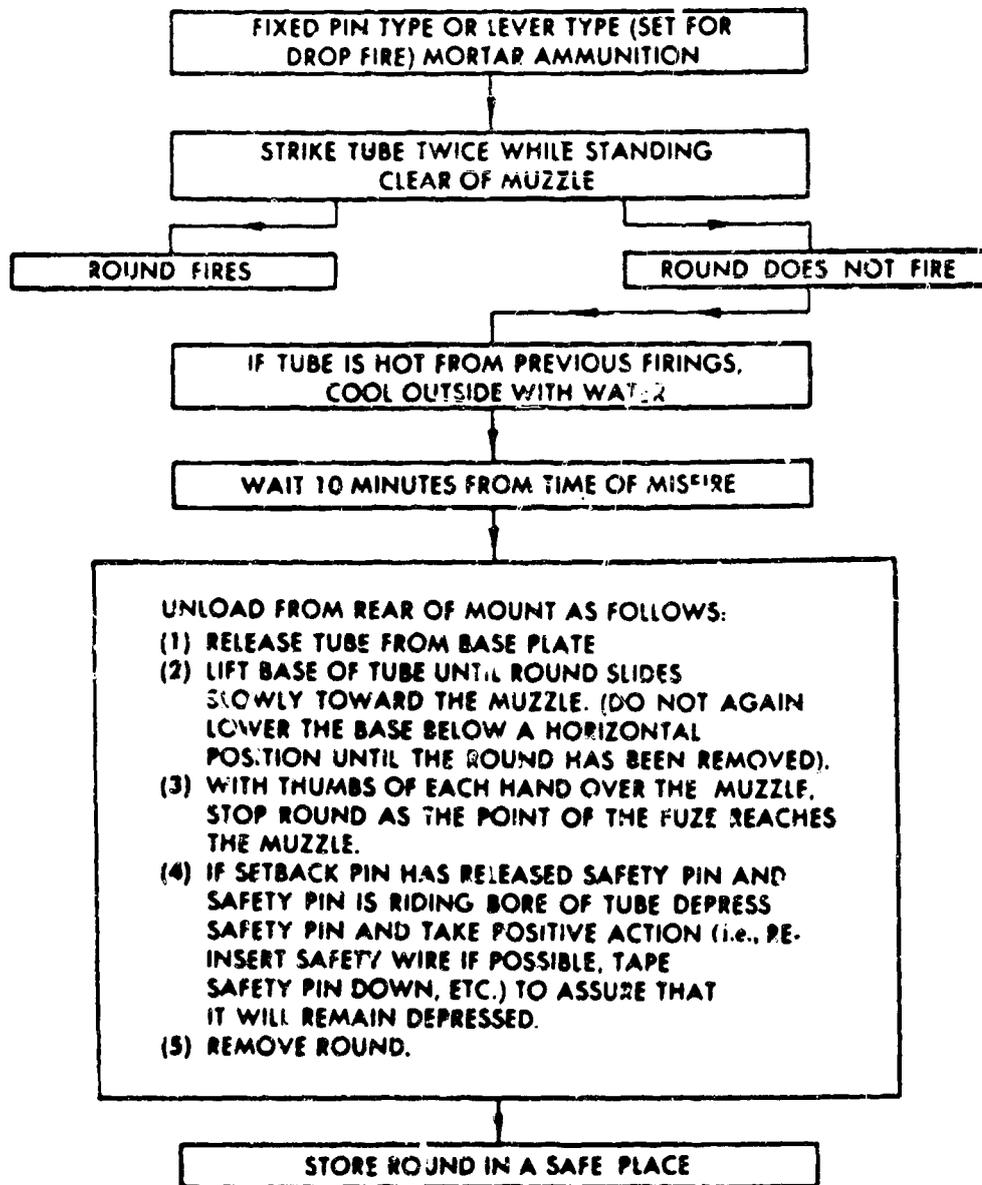
(1) FOR MACHINE GUNS, ANTI-AIRCRAFT GUNS, OR OTHER GUNS FIRED AT HIGH RATES OF FIRE FOR EXTENDED PERIODS OF TIME (SEE PARAGRAPH 2818).

(2) IN TESTS WHEREIN WATER CANNOT BE APPLIED, THE DANGER ZONE AS DEFINED IN RIGHT COLUMN WILL APPLY.

Figure 2820D. Misfire Under Possible Cook-Off Condition.

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**MISFIRE OF FIXED FIRING PIN TYPE OR LEVER TYPE  
(SET FOR DROP FIRE) MORTAR AMMUNITION**



*Figure 2820E. Misfire of Fixed Firing Pin-Type or Lever-Type (set for Drop Fire) Mortar Ammunition.*

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MISFIRE OF LEVER (TRIGGER) FIRED MORTAR AMMUNITION

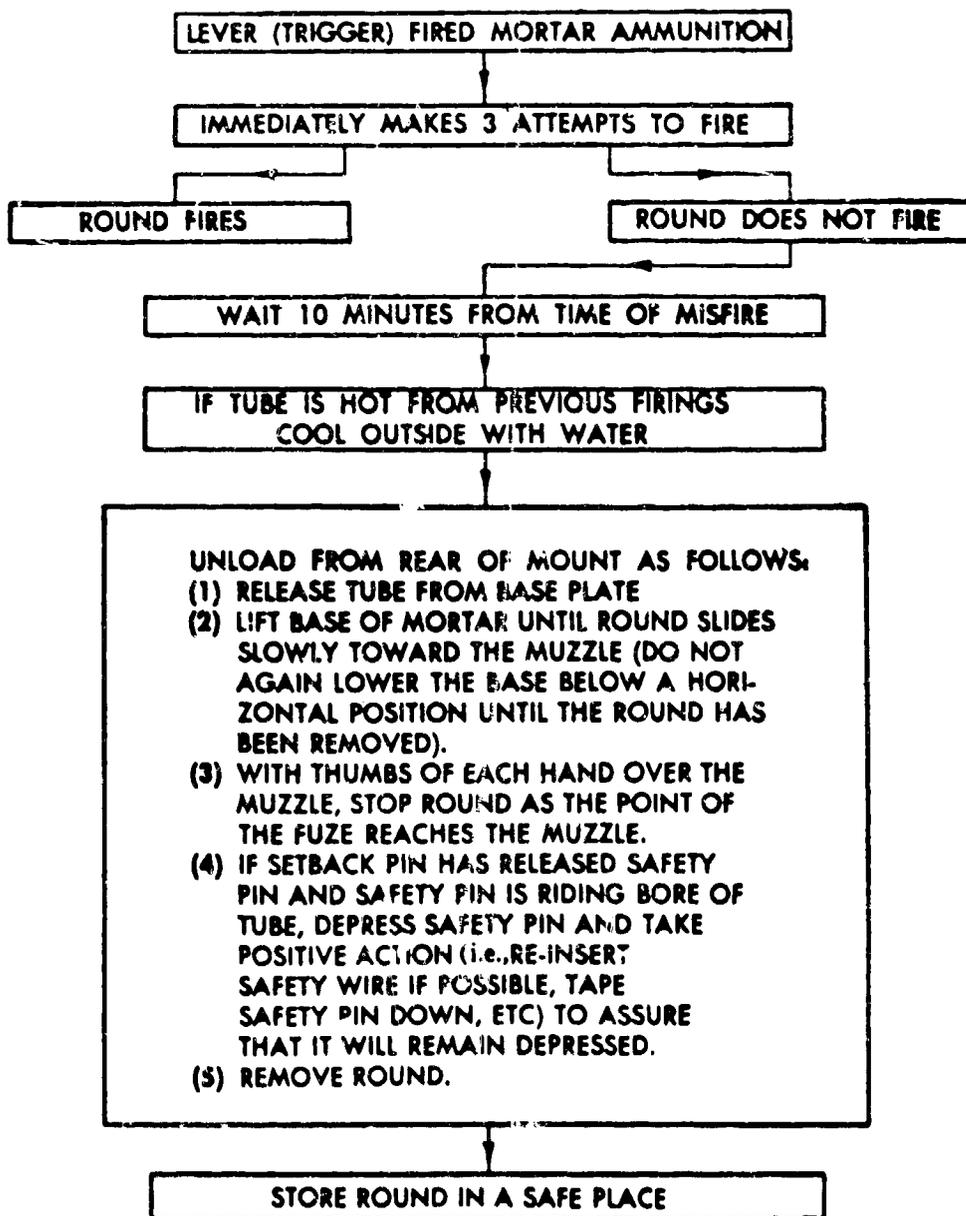


Figure 2820F. Misfire of Lever (Trigger) Fired Mortar Ammunition.

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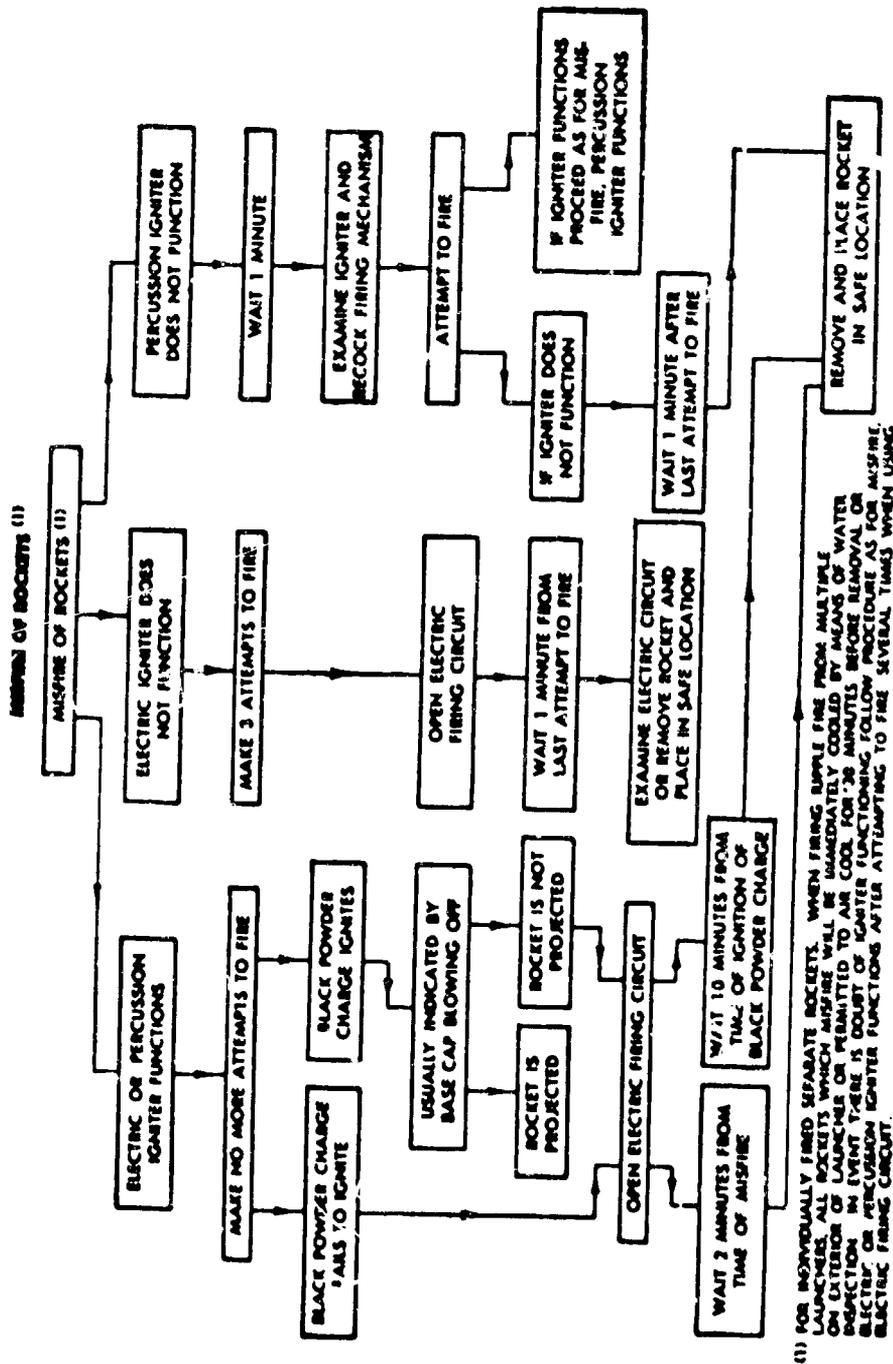


Figure 2820G. Misfire of Rockets.

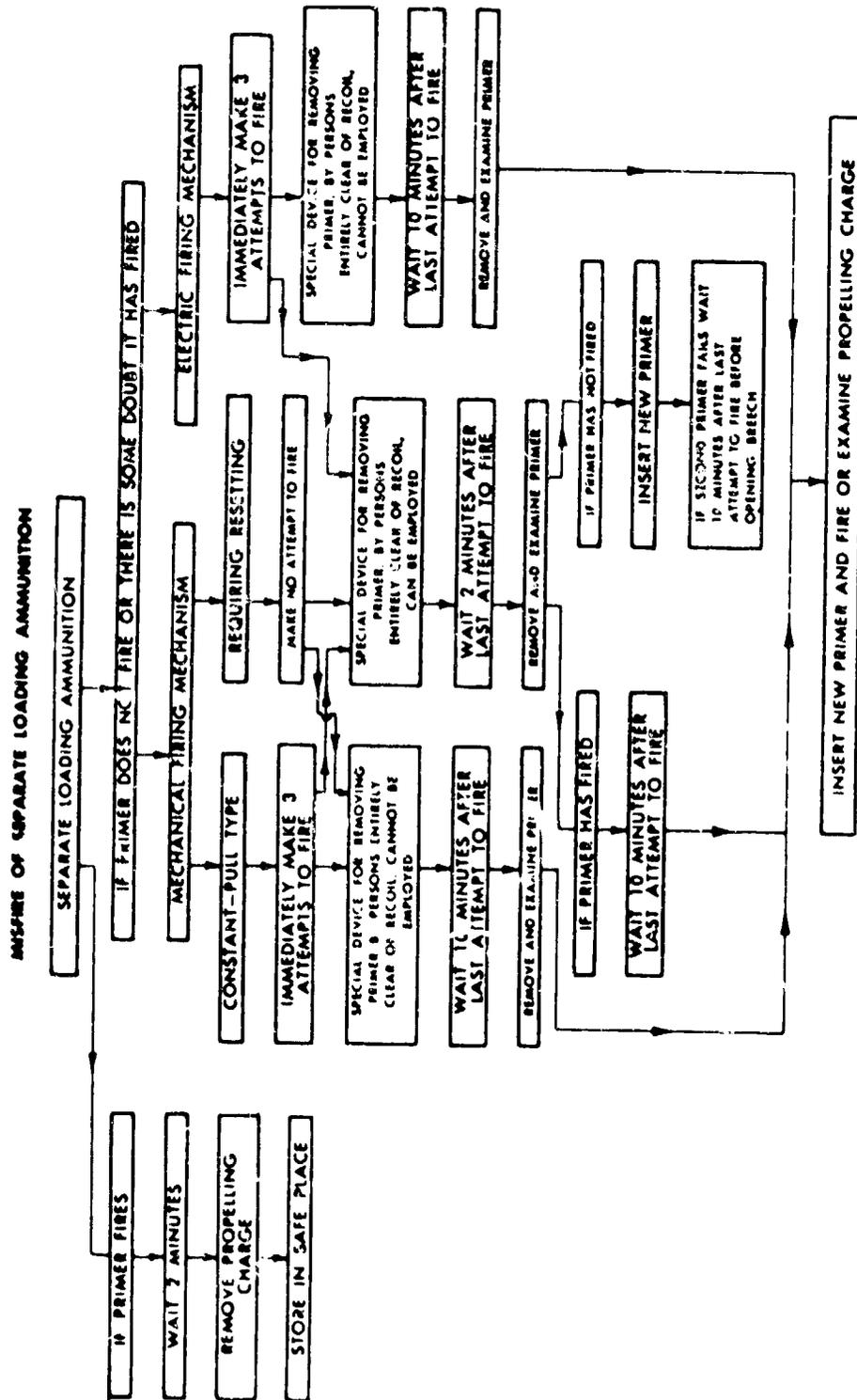


Figure 28-20H. Misfire of separate loading ammunition.

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## 2821. COVER

*a. General.* During proof tests involving explosives, all materiel shall be located in a substantial emplacement, or forward of a screen or parapet, with adequate cover for all operating personnel within the danger zone. On tests where there is a possibility of fragmentation, the proof officer shall require all personnel within the danger zone to take cover. The person charged with the duty of attaching the lanyard, however, shall be the last to leave the emplacement or stockade, and no firing shall be attempted until he has informed the proof officer that all personnel are clear of the stockade and screens.

*b. Portable bombproofs.* The following structures used for the protection of personnel within the danger zones of firing have been found satisfactory:

<i>Type</i>	<i>Location and use</i>	<i>Wall thickness</i>
Portable reinforced concrete bombproof (open back).	At firing fronts when alongside or to rear of gun and offset from line of fire for any class of fire.	12 inches.
Armored railway mounts.	At firing fronts when alongside or rear of gun and offset from line of fire except plate firing.	Armor plate.

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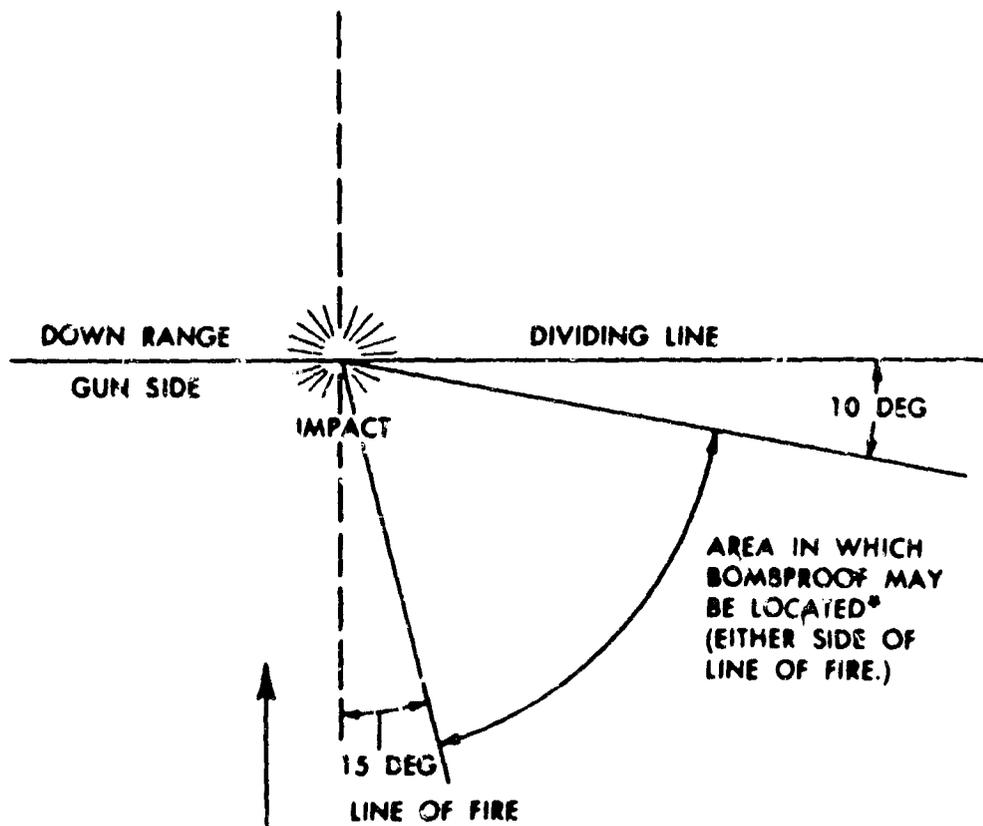
<i>Type</i>	<i>Location and use</i>	<i>Wall thickness</i>
Portable boiler plate bomb-proof.*	At firing fronts for inert, shrapnel, or low explosive up to and including 155-mm and all small arms ammunition.	¾-inch steel plate.
Portable armor plate barrier.	At firing fronts when to rear and offset from line of fire for any classes except high explosive or plate firing.	3-inch armor plate.
Armor plate sheets.	At firing fronts for grenades, primer detonators, and ground troop signals.	½-inch armor plate.

\*This type may be used for fire observation in the field provided the bomb-proof is offset from the line of fire depending upon the caliber of guns used, and in accordance with the requirements of the following:

*c. Portable bombproofs for fire observation.* All portable bombproofs used for fire observations **should** be offset from the line of fire and located on the gun side of impact—a line perpendicular to the line of fire and passing through the impact being the dividing line between gun side and down range side of impact. When the impact results in fragmentation, the bombproof **should** be located in the gun side area on either side of the line of fire, located more than 10° from impact on the dividing line and more than 15° from impact on the line of fire (fig. 2821). After being properly located as described in figure 2821, the bombproof **should** be so oriented with respect to the impact that no wall surface is presented to fragmentation at an angle greater than

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**BOMBPROOFS FOR FIRE OBSERVATION**



\*See paragraph 2921b

*Figure 2821. Portable bombproofs for fire observation.*

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60°. This can usually be done by centering one intersection of the walls of the bombproof in the case of a square or U type, or pointing the apex of the bombproof in the case of a pointed V type toward the impact. Under no circumstances shall the bombproof be oriented to expose the rear to gunfire and fragmentation. Observations from bombproofs shall be indirect—by mirrors, periscopes, or other suitable devices.

## **2822. DEFLECTION AND ELEVATION**

*a. Deflection.* When firings are to be conducted and the azimuths of fire have not been established or no Range and Deflection Chart is available, the azimuth of the line of fire or deflection used must be such as to place the first impact of a series at least 200 yards from the bombproof. **No firing shall be permitted unless the piece has been previously laid by qualified competent personnel.** The proof officer shall be responsible for checking the deflection prior to firing each round; and in rapid fire, he shall insure that the gun will not drift in traverse. The proof officer is responsible for determining and correcting for any errors in the sighting system.

*b. Elevation.* The elevation shall be obtained from past firings, records, firing tables or range-elevation curves. The proof officer shall be responsible for checking the elevation prior to firing each round.

## **2823. PROOF FIRING INVOLVING AIRCRAFT**

*a. Air courses.* Each establishment at which bombs are dropped in proof tests shall establish safe

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air courses to be used in flying to, over, and from the bombing areas, and these courses must be followed as closely as possible.

*b. Clearance.* Before the start of any aircraft flight that will enter danger areas, the proof officer shall obtain clearance from the appropriate safety observer. In obtaining the clearance, the proof officer should describe completely the item to be tested, speed, and altitude, the expected point of impact, and the course number to be followed by the airplane. When ground observers are used, no bombs shall be dropped until an additional clearance is obtained for the airplane from the ground observers by prearranged signal. Proof tests shall not be cleared unless it can be assured that the ammunition will fall within the selected danger areas nor shall tests be cleared if there is any doubt concerning the visibility of the target.

*c. Bombing.* Airplanes loaded with bombs shall not fly over private property, buildings, or assemblages of persons unless bomb racks are locked, bomb bay doors closed, and all release mechanisms are in the "off" position. The dropping of bombs must be carefully controlled to assure bombs will fall within the prescribed danger zone and without injury to personnel who may be required as observers in the area. The use of a bomb sight or an equally positive signaling device controlled from the ground is recommended for all bombing.

- (1) *VT-Fuzed bombs.* For tests in which VT-fuzed bombs are dropped from aircraft, an arming delay or similar device should be

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used as an extra safety device when the objectives of the test permit. The altitude from which the bombing is conducted shall be increased sufficiently to permit proper functioning of the arming delay.

- (2) *Hung bomb.* In case of a hung bomb, the pilot shall immediately notify the safety observer and endeavor to release the bomb in a safe place designated by the safety observer who shall give the necessary warnings. If the bomb cannot be released and if, in the opinion of the pilot, it is necessary to land on the air base, the pilot shall obtain the necessary clearance to land. Prior to permitting the landing, the field shall be cleared and all emergency units shall be informed to be at their stations.

*d. Rocket firing.* All rocket firing conducted from an airplane shall be with only practice loaded **non-fragmenting heads**; inert loaded or high-explosive loaded rockets of accepted type and caliber fitted with inert fuzes or inert boosters. Firing of HE ammunition with live fuzes and live boosters shall be done only when accepted components are used, and then only with the approval of competent authority at post level.

*e. Airplane commanders.* Only fully qualified personnel who are thoroughly familiar with established range regulations shall be permitted to drop bombs or fire projectiles from aircraft. The commander or pilot should be responsible for instructing all personnel assigned to, engaged in, or observing bomb-

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ing mission tests from aircraft concerning the standard regulations of the USAF regarding emergency exit procedures from aircraft.

#### **2824. MARKING DUDS AND RECOVERABLE AMMUNITION**

a. When a test program requiring the use of projectiles or bombs containing high explosives, or armed with live fuzes or live boosters, is fired for impact on, or burst over a recovery field, observers shall be stationed in a protected place to note and locate the impacts and duds and to observe the functioning of each round. Stakes bearing flags should be used to designate the location of ammunition duds or ammunition fired for recovery. The flags used to designate the location of ammunition to be recovered should be---

- (1) Red flag for inert projectiles.
- (2) Yellow flag for HE shell, bomb, or live fuze or combination of these.
- (3) White flag for undetermined loading.

b. Before leaving any recovery field and impact area, the observers and the foreman in charge of cleaning the fields should mark the location of the fired ammunition and duds with the appropriate flag or device. If the locations cannot be marked, then the field shall be appropriately posted with warning signs and entry shall be restricted.

#### **2825. CLEANING OF RANGES**

Observation fields shall be "policed" for live ammunition as soon as practicable after each test

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but in no case shall this interval exceed 3 weeks. Ammunition collected as a result of these policing operations shall be disposed of as follows:

a. Slugs shall be collected and placed in a designated and safe location and the stack identified.

b. Sand-loaded ammunition with inert fuzes shall be collected in a separate stack in a designated and safe location and the stack identified.

c. Ammunition containing high explosives with live fuzes, and all duds shall be detonated in place by properly trained personnel.

d. Live fuzes in sand-loaded projectiles shall be destroyed in place by properly trained personnel and the projectiles placed in an identified stack at a designated and safe location.

e. Projectiles containing high explosives with dummy fuzes shall be detonated in small piles.

All persons, except certain authorized individuals, shall be prohibited at all times from touching or disturbing in any manner, dud ammunition wherever found. Unfuzed or inert fuzed live ammunition or ammunition components which have failed to function during test will not be recovered unless it has been determined by competent local authority that recovery will be necessary for purposes of examination. Live ammunition with live fuzes, which have failed to function during test, will not be recovered without prior authorization from the Chief of Ordnance. Recovery of dud or malfunctioned items must be accomplished only by qualified personnel. Test programs must be planned so as to utilize inert components insofar as practicable to

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facilitate safe recovery, if necessary. Transportation of such items will be in accordance with paragraph 2001.

**2826. DISASSEMBLY AND DESTRUCTION OF AMMUNITION**

The disassembly of ammunition fired for recovery shall be accomplished in accordance with the principles set forth in section 27.

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## SECTION 29

### CHEMICAL MUNITIONS

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#### 2901. TYPES OF CHEMICAL MUNITIONS

The term "chemical munitions" is used to designate a variety of forms of artillery shell, mortar shell, spray tanks, airplane bombs, grenades, candles, rockets, and containers of chemical agents which are not high explosives or shrapnel. Chemical munitions are filled with war gases, smokes, or incendiaries.

#### 2902. GROUPING OF FILLINGS

For the purpose of storage, chemical munitions are divided into four groups according to the nature of the fillings. The groups, together with fillings and markings, are listed in table 2902. Not all of the fillings listed in the tabulation are currently used, but they may be encountered. The odors of the various chemical agents are described in paragraphs which deal with the specific agents in each group. Since odors are not always easily detected and since some war gases are almost odorless, the latest vesicant detector paints, detector paper, detector crayon and the chemical agent detector kit should be used as described in TM 3-290 for determining the presence of war gases.

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**Table 2902. Fillings and Markings of Chemical Munitions in Storage Groups A-D**

**Group A (Blister Gases)—Chemical Agents Requiring Complete Protective Clothing Plus Gas Masks.**

Cml C symbol	Name	Markings	
		Present	Old
H	Mustard.....	H GAS and 2 bands (all in green).	HS-GAS and 2 green bands. <sup>1</sup>
HD	Mustard (distilled)...	HD GAS and 2 bands (all in green).	None.
HT	Mustard (T-mixture).	HT GAS and 2 bands (all in green.)	None.
L	Lewisite.....	L GAS and 2 bands (all in green).	None.
HN-1	Nitrogen mustard...	HN-1 GAS and 2 bands (all in green).	None.

**Group B (Toxic and Smoke)—Chemical Agents Requiring Gas Masks**

CG	Phosgene.....	CG GAS and 1 band (all in green).	2 white bands.
Cl	Chlorine.....	Cl GAS and 1 band (all in green).	None.
AC	Hydrocyanic acid...	AC GAS and 1 band (all in green).	None.
OK	Cyanogen chloride..	CK GAS and 1 band (all in green).	CC-Gas and 1 band (all in green).
ON	Chloroacetophenone. <sup>2</sup>	CN GAS and 1 band (all in red).	CN (in red) or CN and 2 red bands.
CNS	Tear gas solution....	CNS GAS and 1 band (all in red).	None.
CNB	Tear gas solution....	CNB GAS and 1 band (all in red).	None.
PS	Chloropicrin.....	PS GAS and 2 bands (all in green).	1 red and 1 white band.
DM	Adamsite <sup>3</sup> .....	DM GAS and 1 band (all in red).	DM TOXIC.
DA	Diphenylchloroarsine.	DA GAS and 1 band (all in red).	1 white band.

See footnotes at end of table.

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Table 2902. *Fillings and Markings of Chemical Munitions in Storage Groups A-D—Continued*

Group B (Toxic and smoke)—Chemical Agents Requiring Gas Masks—Con.

Cml C symbol	Name	Markings	
		Present	Old
FS	Sulfur trioxide-chlorosulfonic acid mixture.	FS SMOKE and 1 band (all in yellow).	None.
FM	Titanium tetrachloride.	FM SMOKE and 1 band (all in yellow).	2 yellow bands.

Group C—Spontaneously Flammable Chemical Agents

WP	White phosphorus...	WPSMOKE and 1 band (all in yellow).	1 yellow band.
PWP	White phosphorus (plasticized).	PWP SMOKE and 1 band (all in yellow).	None.

Group D—Incendiary and Readily Flammable Chemical Agents

IM	Incendiary oil.....	IM INCENDIARY and 1 band (all in purple).	None.
NP	Incendiary oil.....	NP INCENDIARY and 1 band (all in purple).	None.
PTI	Incendiary mixture..	PTI INCENDIARY and 1 band (all in purple).	None.
TH	Thermite <sup>1</sup> .....	TH INCENDIARY and 1 band (all in purple).	Thermite.
HC	Hexachloroethane burning mixtures.	HC SMOKE and 1 band (all in yellow).	None.
CN	Burning mixtures of CN. <sup>2</sup>	CN GAS and 1 band (all in yellow).	None.
CN-DM	Burning mixtures of CN & DM. <sup>2</sup>	CN-DM GAS and 1 band (all in red).	None.
.....	Burning mixtures, colored.	Smoke (name of color) and 1 band (all in yellow).	

<sup>1</sup> Prior marking was 3 red bands.

<sup>2</sup> CN and DM as listed in group B refer to these chemicals in bulk or as chemical filling in shell only. When mixed with solid propellant, they are considered in group D.

<sup>3</sup> Incendiary bombs marked TH have a magnesium case and TH filling. Some bombs may contain Thermite which consists of Thermite, Barium Nitrate, Sulfur, and lubricating oil.

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### 2903. STORAGE REGULATIONS

a. The general rules for storage set forth in section 18, with the additions stated below, shall be followed. Detailed information covering chemical munitions is found in the following publications: TM 3-250, TM 9-1900, TB CW 4, TB CW 22, TB CW 26, TB CW 29S13, TB CW 31, and TB 3-300-11S18.

b. Above-ground-type magazines in which toxic chemical munitions are stored should be located from all types of magazines in which high explosives are stored by inhabited building distance. All types of magazines containing toxic chemical munitions should be so located from inhabited, operating, inert, and other storage areas to provide protection from the effects of toxic chemical agents.

c. Whenever possible, each kind of chemical munitions should be stored separately, however, unless prohibited as indicated below, chemical munitions of the same group may be stored together. Gas-filled munitions of two or more groups of fillings should not be stored together, except upon specific approval of the head of the Technical Service having storage responsibility.

d. Chemical munitions shall be handled carefully. They should not be dropped or jarred. The same equipment used for handling high explosive filled shell may be used for handling chemical munitions.

e. When it is necessary to store chemical munitions outdoors they should be covered with tarpaulins to

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protect them from the direct rays of the sun and exposure to the elements except where the type of container in itself is such as to afford reasonable protection. Munitions should be stacked to permit free circulation of air. The edges of covering tarpaulins should be supported in such a way that the free flow of air under the tarpaulins is not prevented.

*f.* Representative samples of chemical munitions should be inspected at regular intervals, at least every 6 months, to determine the state of condition in storage. Based on the state and nature of deterioration found, corrective measures should be initiated. Procedures for surveillance are set forth in Department of the Army Technical Instructions or Special Regulations dealing with specific chemical munitions. (Refer to appropriate Special Regulation for a listing of the latest publications.) Magazines containing chemical munitions should be inspected at least monthly and preferably semi-monthly, to note any unusual conditions.

#### **2904. REPORT ON LEAKING AMMUNITION**

*a.* Personnel shall be instructed to report immediately to the person in charge of the magazines, any chemical ammunition found to be damaged or leaking.

*b.* A report shall be made to the Chief of Ordnance on all chemical munitions found in a damaged or leaking condition with an information copy to Chief of the Chemical Corps. This report shall include the following data:

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- (1) Type and amount.
- (2) Lot number.
- (3) Date discovered.
- (4) Detailed information regarding the nature of the leak and whether it was caused by defective material or improper handling or packing.
- (5) Disposition or, in the event that immediate disposition is not required, recommendations for disposition.

c. This report shall be coordinated by the Technical Service first receiving the report with other interested Technical Services.

#### **2905. PERSONAL PROTECTIVE EQUIPMENT**

a. All personnel who work in magazines or buildings assigned to chemical storage must have available appropriate personal protective equipment.

b. Personal protective equipment is placed as prescribed in paragraphs 2911, 2918, 2925, and 2932 and a list showing the quantity of each item required to be on hand shall be posted with the equipment. Regular inspection of centrally located protective equipment shall be made to determine its condition. Protective equipment that has become unserviceable shall be promptly replaced. Equipment shall be replenished as required to maintain the full quantity in serviceable condition.

c. Individual first-aid equipment shall be made available for all employees handling chemical muni-

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tions. For further information on first-aid measures, see FM 21-11 and FM 21-40. For treatment (as distinguished from first aid) of casualties from chemical agents, see TM 8-285.

d. Personnel shall be directed to wash their hands thoroughly with soap and water, particularly before eating, after handling chemical munitions.

#### **2906. MAGAZINE MARKINGS**

a. *Signs.* On the outside doors of magazines or entrances to storage areas containing chemical munitions, appropriate signs shall be posted as indicated below:

- (1) *Group A chemical munitions.* "This magazine contains group A chemical munitions (blister gases) requiring the carrying of gas masks. If leaking munitions or odor is present, wear gas mask and protective clothing," or "This storage area contains group A (blister gases) chemical munitions requiring protective clothing and gas masks. Wear complete protective clothing. If leaking munitions or odor is present, wear gas mask."
- (2) *Group B chemical munitions.* "This magazine (or storage area) contains group B (toxic and smoke) chemical munitions requiring gas masks. If leaking munitions or odor is present, wear gas mask."
- (3) *Group C chemical munitions.* "This magazine (or storage area) contains group C

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(spontaneously flammable) chemical munitions."

- (4) Group D chemical munitions. "This magazine (or storage area) contains group D (incendiary and readily flammable) chemical munitions. If odor or smoke is present, wear gas mask."

*b. Hazard Markers.* Fire symbols shall be used to identify, for fire-fighting purposes, chemical ammunition storage facilities. The type or types of fire symbols selected for this purpose will depend not only upon the type of chemical agent in the ammunition but also the absence or presence of explosives components in the ammunition. Subparagraphs (1), (2), and (3) below describe the fire symbols used for the identification of chemical ammunition which contains no explosives components. If the ammunition does contain explosives components, the symbols described in subparagraphs (1), (2), and (3) below should be used in conjunction with explosives fire symbols as described in paragraph 1222; if this is not practicable a single explosives fire symbol modified in accordance with paragraph 1222a may be used to denote the combined explosion and chemical agent hazard. The fire symbols shall be conspicuously posted on all aboveground magazines. If the chemical ammunition is stored in outdoor sites, fire symbols shall be posted at individual sites unless all sites in the storage area

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require the same fire symbols; in such cases, the appropriate fire symbols may be posted at all entrances to the storage area rather than at the individual storage sites. Fire symbols used for the identification of chemical ammunition which contain no explosives components should be on circular plaques approximately 24 inches in diameter. The stripes required below for chemical agent hazard identification should be 4 inches wide, and spaced 4 inches apart.

- (1) Persistent poison gases shall be indicated by two black parallel stripes painted diagonally on a yellow background with the stripes extending from the upper right to the lower left.
- (2) Nonpersistent poison gases shall be indicated by a single stripe painted as in (1) above.
- (3) Incendiaries and other material for which water is not a suitable extinguishing agent shall be indicated by the letter "D" painted black on a yellow background.
- (4) Igloo type or Corbetta type magazines need not be marked.

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## **2907. DISPOSITION OF DEFECTIVE MUNITIONS**

The methods prescribed in the following sections for the disposition of defective chemical munitions contemplate the destruction of small amounts of munitions which may be encountered. Under emergency circumstances destruction may be accomplished by methods decided upon by the responsible officer. Methods employed shall be based on the properties of the fillings but they need not follow literally the methods of destruction prescribed herein. Further information on methods for destroying large quantities of chemical munitions, shall be obtained, through channels, from Office of the Chief, Chemical Corps.

## **2908. PACKING, MARKING AND SHIPPING**

Chemical munitions and components shall be packed, marked, and prepared for shipment in accordance with current drawings and specifications for the item involved. In addition all applicable ICC regulations governing the shipment of chemical munitions shall be observed.

## **2909. GROUP A CHEMICAL MUNITIONS**

*a. General.* Chemical agents of this group (blister gases) are the most dangerous to handle. Personnel can be exposed to or contaminated by the chemical agents in these munitions and not be aware of it until the effects first become noticeable several minutes or

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hours after exposure. Complete protective clothing (TM 3-220), including shoes heavily coated with protective dubbing or heavy rubber boots and impregnated or heavy rubber gloves, should be worn by personnel handling the following chemical agents described in subparagraph *b* to *d* below.

*b. Mustard gases (Cml C symbol: H or HD).* Mustard gas as filled in munitions is a liquid, light yellow to dark brown or black in color, freezing at 46° F. to 50° F. (The pure product freezes at 58° F.) Its odor is faint and somewhat like horseradish or garlic; distilled mustard gas (HD) has the least odor. Both the liquid and vapor cause intense inflammation which may blister the skin or mucous membranes with which they come in contact. In addition, mustard gas causes reddening and inflammation of the eyes, burning the nose and throat, and inflammation of the respiratory tract. No warning is given at the time of exposure but symptoms develop 4 to 21 hours afterward. Exposure to slight concentration causes severe burns. Mustard gas can usually be detected by its odor in any concentration likely to produce burns, although HD is more difficult to detect. One rapidly becomes accustomed to the odor of mustard gas, consequently after a few minutes' exposure, the odor is no longer noticed. Therefore, the chemical agent detector kit should be used at regular intervals for detection of dangerous concentrations. When such a concentration is detected, it is essential that all unprotected personnel leave the area at once. Any work done there-

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after should be performed by men completely protected by gas masks, protective clothing, protective gloves or mittens, protective shoes or boots and heavy rubber aprons. Each man should carry an M5 protective ointment kit (tubes of protective ointment and BAL eye ointment) in his gas mask carrier. Mustard gas is persistent and decontamination is not started at once the area may remain dangerous for periods varying from several days to weeks or even years. Mustard gas is best destroyed by using bleach or by DANC solution. (See FM 21-40.)

*c. Nitrogen mustard gas (Cml C symbol: HN-1).* There are several combinations of nitrogen mustard gas. In general, nitrogen mustard gas is a colorless to pale yellow liquid, having a faint odor varying from fishy to almost odorless. It is especially damaging to the eyes and may injure them permanently. It produces blisters on the skin similar to those produced by mustard gas but acts more quickly. It is much less vesicant than H, since greater amounts are required to produce similar injuries. Because nitrogen mustard gas may be virtually odorless, harmful effects may be produced without warning. It attacks the respiratory tract as mustard gas does, but to a lesser degree and has especially dangerous effects on the eyes and may result in permanent injury or blindness. Both the vapor and liquid are dangerous. Nitrogen mustard gases are comprised of compounds ranging from solid to liquid of varying degrees of toxicity, therefore, the chemical agent detector kit should be used at regular intervals for detection of

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dangerous concentrations. When dangerous liquid or vapor concentrations of HN-1 are encountered, gas masks and protective clothing shall be worn by personnel. When working with nitrogen mustard gases, personnel shall carry a protective ointment kit in the gas mask carrier. HN-1 is destroyed by bleach or by DANC solution. Nitrogen mustard is also persistent and precautions should be taken similar to those for mustard gas.

*d. Lewisite (Cml C Symbol: L).* When pure, lewisite is a colorless or slightly yellow liquid which may be almost odorless. The product as it is usually prepared for filling is a dark green oily liquid having a faint odor resembling that of the geranium plant. Its freezing point is approximately 15° F. The vapor causes a very disagreeable burning, or biting and stinging sensation in the nose and throat, and sometimes causes violent sneezing. The liquid on the skin causes pain almost immediately, and the eyes are especially susceptible to both vapor and liquid. Like mustard gas, lewisite has strong blistering properties and is a powerful lung irritant. Its blistering action is somewhat delayed but is faster than that of mustard gas. The blisters differ in appearance from those caused by mustard gas because lewisite produces the development of gray areas similar to corrosive burns. Since lewisite is an arsenic compound, it poisons the blood stream after being absorbed through the skin. Its vapors are irritating to the respiratory tract and eyes causing unprotected workers to leave areas where dangerous

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vapor concentrations exist. Protective clothing and a gas mask are necessary for protection against lewisite gas burns. When working near lewisite, each man should carry a protective ointment kit. Lewisite is not as persistent as mustard gas but contaminated areas may remain dangerous for a week or more, depending on climatic conditions. Lewisite is best destroyed with bleach, DANC solution, or an alcoholic solution of caustic soda. Bleach is usually used in the field. If lewisite is destroyed by burning, the residue, containing arsenic, is still poisonous and must be buried. Lewisite is readily hydrolyzed, but the resulting solid is very toxic and must be disposed of.

#### 2910. STORAGE OF GROUP A CHEMICAL AGENTS

*a. General.* Munitions with Group A chemical filling should not be stored in magazines with wooden floors. Concrete floors treated with sodium silicate to render them nonabsorbent should be used. Rubberoid or other floor coverings should not be used; such coverings absorb and retain spilled blister gases. Group A chemical munitions should be stored in igloo type or Corbetta type magazines.

*b. Odors.* The slight odor of mustard gas or other gases in a magazine may not indicate the presence of leaking ammunition but the detector kit should be used to determine whether or not a hazard exists. Excessive concentrations of vapors, however, do indicate leaking ammunition. Foremen, inspectors or other authorized persons who are thoroughly fa-

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miliar with work in magazines containing blood poisons and blister gases must be present when a magazine is opened to determine whether or not the magazine contains leaking ammunition. When any doubt exists (as with nitrogen mustard), the chemical agent detector kit shall be used.

*c. Leaking munitions.* If a magazine contains leaking Group A chemical munitions, all personnel must put on complete protective clothing, gas masks, and hoods before they enter the magazine. All windows and doors must be opened and the magazine aired. After the magazine is ventilated, a search must be conducted under the direct supervision of a qualified person until the leaking munitions are located.

*d. Inspections.* The commanding officer of an installation where Group A chemical munitions are stored shall institute frequent inspections to insure compliance with regulations and to detect leaking ammunition.

*e. Fire hazard.* Some unboxed shells now in storage may be covered with "Cosmoline." These shells must not be set on combustible material such as wood, because in warm weather this coating impregnates the wood, thereby increasing the fire hazard.

#### **2911. SPECIAL PROTECTIVE EQUIPMENT FOR GROUP A CHEMICAL AGENTS**

*a. General.* The following special protective equipment and facilities must be readily available to personnel working where group A chemical muni-

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tions are stored. (See FM 21-40 and TM 3-290 for complete descriptions and use of protective equipment.)

b. *Personal protective equipment.* Personal protective equipment consisting of gas masks, two layers of protective clothing, protective footwear and protective gloves or mittens sufficient in number to equip all personnel required to work with group A chemical munitions shall be centrally stored and maintained under close supervision. This equipment shall be issued simultaneously with the issue of keys whenever entry to a group A chemical magazine is to be effected.

- (1) When a magazine is opened, the person in charge of the working group shall be responsible to determine whether or not it is necessary to wear complete protective clothing. He shall first determine whether any odors (par. 2910b) or other hazards are present. If odor is present, he shall put on complete protective clothing and personally inspect the magazine for hazards. If he positively determines that there are no hazards present, he may permit the remainder of the group to enter the magazine without wearing protective clothing, but carrying the gas mask.
- (2) When group A chemical munitions are stored outdoors, complete protective clothing shall be worn by each person before he is admitted to the toxic storage area; except

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that permission may be given to casuals by the commanding officer to enter the area for a specific purpose without wearing protective clothing, but they must carry gas masks and first-aid packets. This permission shall be canceled if any hazards are discovered in the area.

*c. First-aid equipment.* The following first-aid equipment shall be centrally stored and issued to the one in charge of a group of personnel required to work with group A chemical munitions:

- (1) M5 protective ointment kit (includes protective ointment and BAL eye ointment).
- (2) Clean flannel or absorbent cotton cloths, each 1 square foot or equivalent.
- (3) Gas casualty first-aid kit.

*d. Decontaminating and first-aid station.* There shall be installed in a heated building, centrally located to the magazines or storage area, showers and/or suitable decontaminating facilities, clothing exchange facilities, and first-aid facilities.

*e. Shoe decontamination.* Where contamination is probable, there shall be installed at the exits to group A magazines and storage areas a shoe decontamination box containing a mixture of earth or sand and bleach (TM 3-220). Personnel leaving a magazine or storage area in which group A chemical munitions are stored shall shuffle their shoes in the decontamination box. When the magazine or storage area is known to be contaminated, personnel shall also

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shuffle their shoes in the decontamination box before entering.

*f. Materials for decontamination.* There shall be located near magazines and storage areas decontaminating material consisting of the following items:

- (1) Shovels and commercial bleach containing not less than 35 percent chlorine.
- (2) DANC solution and swabs.
- (3) Iron tanks, preferably with handles, large enough to contain readily the biggest shell in storage (par. 2913c).

## 2912. FIRST-AID MEASURES FOR GROUP A CHEMICAL MUNITIONS

*a. General.* No first-aid measures are completely effective against Group A gas *vapor* burns of the skin. The damage has been done when the symptoms appear. Washing with soap and water, however, may lessen the harmful effects.

*b. Mustard gases.* First aid for *liquid* contamination must be prompt to be effective. Whenever possible, first aid should be applied within 5 minutes after contact, although for skin burns it may be effective up to 15 minutes after contamination, depending to some extent on how hot and moist the skin is.

- (1) If the eyes are contaminated with liquid, excess liquid should be blotted away, eyes should be flushed with plenty of water, and BAL eye ointment should be squeezed into

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the eyes and the eyes massaged gently. (If the eyes cannot be opened, BAL eye ointment should be worked in between the lids.) Eyes should then be flushed with water from an uncontaminated source. The washing should be continued for  $\frac{1}{2}$  minute to 2 minutes, the eyes being rolled about during the washing. If BAL ointment is not immediately available, the eyes should be flushed with water alone. Water poured slowly from a canteen or other container is effective in flushing the eyes. If a drinking fountain is available, a stream of water from it can be directed into the eyes.

- (2) Contaminated clothing should be removed or cut away.
- (3) Absorbent cotton or cloth should be used to pinch-blot liquid from skin. Blister gas should not be rubbed into the skin, and an effort should be made to prevent spreading of the contamination to surrounding areas.
- (4) Protective ointment should be applied to the affected area for 30 seconds and the excess wiped off. Application should be repeated and a visible film of the ointment left on the skin. Soap and water should be used if protective ointment is not available, or bleach paste made of equal parts of water and bleach should be used. Bleach paste must be washed off in 3 minutes and should

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not be applied if the skin has reddened or has started to blister.

- (5) If vapor has been breathed, treatment should be the same as for a choking gas casualty (par. 2919).

*c. Nitrogen mustard gas.* First aid for nitrogen mustard gas contamination is generally the same as that for mustard gas except that, since damage to the eyes from nitrogen mustard gas can be extremely severe, the eyes should be decontaminated immediately. For decontamination of the skin, thorough washing with soap and water should follow the application of protective ointment.

*d. Lewisite.* To be of any value, first aid must be accomplished immediately following exposure to lewisite.

- (1) If the eyes are contaminated, BAL eye ointment should be applied in the same way as that specified above for mustard gas contamination. Lewisite causes immediate pain when it enters the eyes and the lids may be difficult or impossible to open. Therefore, BAL should be rubbed on the slits between the lids until the eyes can be forced open. First aid is then continued as directed.
- (2) Contaminated clothing should be removed or cut away.
- (3) Absorbent cotton or cloth should be used to pinch-blot liquid from the skin. Care

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should be taken not to rub the liquid in, nor to spread it.

- (4) Protective or BAL ointment should be applied to the skin as directed above for mustard gas contamination. Protective ointment removed lewisite from the skin only. BAL penetrates the skin, neutralizing the lewisite which has been absorbed. BAL should be spread on in a thin film and allowed to remain for 5 minutes, and the excess removed.

### 2913. LEAKING GROUP A CHEMICAL MUNITIONS

*a. General.* When munitions are found to be leaking, the person in charge should be notified immediately and the leaking item disposed of at his direction.

*b. Protective clothing.* Complete protective clothing and gas mask with hood shall be worn at all times during the handling or disposal of leaking munitions.

*c. Removal of leaking munitions.* Leaking munitions should be immersed in freshly prepared bleach solution (slurry) and removed downwind from the storage area. The slurry should be prepared in Iron tanks large enough to contain the shell. The solution is composed of 3 pounds of bleach to each gallon of water; it should be thoroughly mixed.

*d. Disposal.* All explosive components or toxic fillings of chemical munitions shall be inactivated

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or neutralized before burial of residue so that no permanent hazard remains. Using the facilities available, final disposal shall be made of leaking munitions by one of the following methods:

- (1) Whenever possible, gas-filled munitions should be dropped into deep ocean water in accordance with provisions of SR 75-70-10.
- (2) Group A gas-filled munitions may be destroyed by placing these munitions in a suitable burning pit on a closely packed pile of wood. Oil or kerosene should be sprayed on the pile, and the wood ignited. The munitions are ruptured by the heat of the fire and the war gases burn as they are discharged. Personnel should be excluded from the upwind area to a distance of 200 yards and not less than 1 mile downwind while the material is being consumed. All destruction activities shall be conducted by personnel who have been trained in the knowledge of war gases.
- (3) Where personnel can be excluded for a distance of 500 yards in all directions and at least 1 mile downwind for a period of 48 hours, a single leaking gas-filled projectile or similar item may be exploded by static firing. The projectile is placed in the bottom of an open pit at least 6 feet deep and not backfilled. Blasting mats should be used to control missiles. Explosive demolition material is placed on the projectile and

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exploded using electric blasting caps or non-electric caps and safety fuse. Ground around the exploded item should be thoroughly decontaminated to eliminate a permanent toxic hazard and signs posted in the area prohibiting personnel from digging in this vicinity.

- (4) Information on destroying munitions filled with arsenical war gases (such as lewisite), should be secured from the Office, Chief of Ordnance.

#### **2914. REMOVAL OF SPILLED GROUP A CHEMICAL AGENTS**

*a. General.* If group A chemical agent from a leaking container has contaminated other containers or the floor, contamination must be removed. This can be accomplished by washing thoroughly with freshly prepared bleach slurry, or strong caustic solution. (Soapy water is ineffective.) Mustard gas may burst into flame upon contact with dry bleach. Unmixed bleach must not be used unless there is no hazard from the resulting fire and the heavy vapor concentration. If woodwork is contaminated it should be removed and burned, since no simple treatment will remove group A war gas from wood.

*b. Decontamination.* After metal containers or concrete floors have been washed with slurry, DANC solution should be applied to containers. Slurry should be allowed to remain on brick, stone or concrete floors for from 6 to 24 hours. If it is imprac-

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ticable to decontaminate wood floors, contaminated portions should be removed. In the event that treatment with slurry does not remove all war gas from the floor, the procedure should be repeated. If repetition does not suffice, the contaminated portion of the floor must be replaced with new material. Protective clothing must be worn during removal and replacement of the floor.

*c. Safety.* The doors and windows of the magazine shall be allowed to remain open until tests show that war gas is no longer present. Complete protective equipment shall be worn during performance of any of the above procedures and at all times thereafter until the war gas has been removed completely from the magazine. Tests with the chemical agent detector kit are important, for the odor of war gases remains after the danger is gone. Since the solvent employed in DANC solution is highly toxic, masks should always be worn in enclosed spaces where it has been used even after danger from the war gas is gone.

*d. References.* Further information pertaining to group A war gases is included in FM 21-40 and TM 3-220.

#### **2915. FIRE IN GROUP A CHEMICAL MUNITIONS MAGAZINE**

If a fire involves or threatens buildings in which group A chemical munitions are stored, all persons within the danger zone shall be notified to vacate until all danger is passed. Members of the fire de-

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partment and all others fighting the fire who may be exposed must wear complete protective equipment. Fires in magazines shall not be fought. Since a fire involving chemical ammunition is dangerous to inhabitants of the vicinity, special precautions must be taken to prevent fires in areas where this ammunition is stored.

## 2916. GROUP B CHEMICAL AGENTS

*a. General.* Chemical agents of this group (non-persistent war gases and smokes) require gas mask protection. Gas masks are required for certain chemical agents only when encountered as smoke in the degree given in subparagraph l and m below. The nonpersistent war gases are under pressure when in containers, bombs, or shells; the internal pressure increases rapidly when exposed to heat. Bombs have a venting device which relieves excessive pressure when manually operated (see TB CW 22). The chemical agents most likely to be encountered in munitions are listed below.

*b. Phosgene (Cml C symbol: CG).*

- (1) Below 47° F., or under pressure in munitions, phosgene is a colorless liquid. It boils at 47° F. and has an odor resembling ensilage or fresh-cut hay. When inhaled, it irritates the lungs and causes pulmonary edema. The first symptoms noted in a strong concentration are pronounced and almost uncontrollable coughing, together

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with a choking sensation, a feeling of tightness in the chest, occasional vomiting, headache, and lacrimation. The danger, however lies in the fact that low concentrations that are not particularly irritating may, after an interval of several hours, produce serious symptoms and even death. Symptoms appearing after a time interval are difficulty in breathing, rapid pulse, weakness, coughing with watery expectoration and cyanosis. The chemical agent detector kit should be used if any doubt exists as to presence of dangerous concentrations of CG.

- (2) The delayed action of phosgene makes it imperative that masks be worn whenever the odor is present. Long exposures to low concentrations are dangerous. Further, because of the extremely rapid action of phosgene in high concentrations, men working with shell or containers filled with phosgene must always keep gas masks available for immediate use.
- (3) Phosgene is nonpersistent. In case it is spilled, it quickly and completely evaporates. Hydrolysis (and consequent destruction of phosgene) can be hastened by sprinkling it with water. Gas masks must be worn at all times while handling any spilled phosgene. Because of its low boiling point, phosgene in closed containers or ammunition maintains a high pressure,

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which may be 150 pounds per square inch under certain conditions.

c. *Chloropicrin* (Cml C symbol: PS).

- (1) Chloropicrin is a colorless liquid, boiling at 234° F. It has a sweetish odor (like that of flypaper) which is readily noticed in any dangerous concentration. Its first effect is irritation of eyes with lacrimation, and some irritation of the nose and throat. As concentrations increase, it causes nausea. The first effects are followed by pains in the chest, abdominal discomfort, and vomiting. Like CG, however, its principal action is on the lungs. Suffocation follows from pulmonary edema. Prolonged exposure to a very low concentration may cause serious symptoms to develop; pulmonary edema does not develop until several hours after exposure.
- (2) The delayed effect of chloropicrin requires that masks be worn when the odor is present.
- (3) Chloropicrin when spilled evaporates slowly. It can be removed only with great difficulty, especially from woodwork. The most effective treatment is scrubbing with a liberal application of alcoholic sodium sulfite solution (TM 3-220).
- (4) Liquid chloropicrin has a moderate corrosive action on the skin or any membrane with which it comes in contact. If the liquid is spilled on the skin, the affected

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part should be washed repeatedly with soap and water and alcoholic sodium sulfite solution should be applied as soon as possible afterwards.

d. *Hydrocyanic acid (Cml C symbol: AC).*

- (1) Used in munitions, AC is a colorless liquid. It boils at 78° F. In the air above 78° F., it is a colorless gas. It is quickly lethal in high concentrations—only a few breaths paralyzing the respiratory center. Very low concentrations are detoxified by the body, but a mask should be worn whenever there is reason to suspect the presence of AC. Its odor is that of bitter almonds, but since the concentration at which the odor is detectable varies with different persons, odor is not a dependable guide. The chemical agent detector kit should be used to determine the presence of AC.
- (2) Since AC acts rapidly, men working with munitions containing AC should always have masks available. Before personnel are permitted to enter magazines, tests shall be made with the chemical agent detector kit to determine whether hazards exist because of leaking ammunition.
- (3) AC is nonpersistent and if spilled quickly evaporates. Aeration is the best means of removing it from magazines and other closed spaces.

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*e. Cyanogen chloride (Cml C symbol: CK).*

- (1) In munitions, CK is a colorless liquid, boiling at 55° F. In the air above 55° F., it is a colorless gas. It is intensely irritating to the eyes and respiratory tract at low concentrations. It is detected by irritation to the eyes and breathing passages before its odor can be smelled. It is quickly lethal at high concentrations. Even lower concentrations are lethal after delayed action. Gas masks shall be available during all operations with CK; masks shall be worn when the presence of CK is suspected.
- (2) Before entering magazines containing CK-filled munitions, tests shall be made with the chemical agent detector kit to detect leaking gases.
- (3) CK is nonpersistent, and since it evaporates quickly at ordinary temperatures, it should be let alone when spilled. Aeration is the best means of removing it from magazines. The irritant solid remaining after evaporation is persistent and harrassing. It can be removed by strong caustic, followed by flooding with water.

*f. Diphenylchloroarsine (Cml C symbol: DA).*

The plant product is a viscous semisolid mass, varying in color from white to black. It melts at 111° F. Its other properties and its action are the same as those described in subparagraph *g* below.

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*g. Adamsite (Cml C symbol: DM).* DM is a greenish yellow to black solid, melting at 383° F. Smoke from the burning war gas causes irritation in the nose and throat even in minute concentration. Longer exposure causes tightness of the chest, headache, sneezing, coughing, intense nausea and weakness. The symptoms increase in severity for some time after exposure, and temptation to remove the mask should be resisted. Irritation produced by this gas is so intense that an intolerable concentration is reached long before it becomes dangerous to life. The effects may last for several hours, but no permanent injury is caused. If DM is spilled, it should not be swept or handled in any way so as to cause dust formation; DM should be wet thoroughly before it is swept.

*h. Chloroacetophenone (Cml C symbol: CN).* CN is a white to gray or black solid, melting at 129° F. It is a strong tear gas but does not cause permanent damage to the eyes. It has a somewhat fruity odor. Usually it is put in grenades with smokeless powder which, when it is ignited, vaporizes the CN. It may also be used in liquid form in which CN is dissolved in suitable solvents. The odor of the solvent as well as that of the chloroacetophenone is usually discernible in solution. Its tear gas effects require the use of masks for the comfort of workers. It can be removed best from skin by scrubbing with soap and water, followed by liberal applications of alcoholic sodium sulfite solution, or by the use of the sodium sulfite solution alone. Actual contact with pure

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solid material or high concentrations of the material in the air produces a burning sensation of the skin; such contact should be avoided.

*i. Chlorine (Cml C symbol: Cl).* Chlorine, a greenish-yellow gas which boils at minus 30° F., has a pungent biting odor. The first effect produced by inhalation of small portions of chlorine is an active irritation of the upper respiratory passages, causing coughing and a sensation of suffocation. The odor of chlorine is very strong in any concentration that would cause irritation or symptoms of poisoning. When chlorine is present in amounts strong enough to cause irritation, masks should be worn. All personnel not equipped with gas masks should leave the vicinity. In case of leaking chlorine, dangerous quantities should be removed by ventilation. When sealed in containers, chlorine generates internal pressure, which may be 200 pounds per square inch under field conditions.

*j. Tear gas solution (Cml C symbol: CNS).* This is a solution of chloroacetophenone (CN) in chloropicrin (PS) and chloroform, freezing at 35° F. Its odor is somewhat like that of flypaper. In strong concentrations, it causes violent eye irritation and may cause vomiting. An individual exposed to extremely high concentrations for a relatively short time may suffer serious effects, such as pains in the chest, abdominal discomfort, vomiting and an action upon the upper air passages and bronchial tubes. Prolonged exposure, even to a very low concentration, may cause these effects. The gas mask gives

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complete protection against vapors. Liquid should be removed from skin by washing with soap and water or with alcoholic sodium sulfite solution.

*k. Tear gas solution (Cml C symbol: CNB).* CNB is a solution of Cn in benzene and carbon tetrachloride, freezing at 19° F. Its odor is like that of benzene. It is less severe in physiological action than CNS, but it causes intense irritation to the eyes and irritates the skin. Liquid CNB may injure the eyes if it splashes into them. The gas mask gives complete protection to the eyes and breathing passages; if the liquid is spilled on the skin, it should be flushed away with water or an alcoholic solution of sodium carbonate. If spilled on the floor, CNB may be neutralized with an alcoholic solution of sodium hydroxide.

*l. Titanium tetrachloride (Cml C symbol: FM).* Titanium tetrachloride is a heavy, colorless liquid with a pungent odor. It can be readily detected by the large quantity of smoke produced when it leaks. It is used solely to produce smoke and has practically no toxic effects. Large quantities of the smoke produce a choking sensation and causes difficulty in breathing, thus a gas mask is required for the comfort of the worker. Heavy concentrations in enclosed places can result in serious injury. The liquid can be removed from the skin by the application of large quantities of water. In extremely heavy concentrations, canisters of gas masks may become clogged to such an extent as to render breathing difficult. If this occurs, masks should be exchanged for

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others in serviceable conditions. Leakers should be removed from the magazine and destroyed by pouring contents on the ground in a suitable area. Spillage can be removed by washing with large quantities of water.

*m. Sulfur trioxide-chlorosulfonic acid mixture (Cml C symbol: FS).* This is a heavy liquid which fumes strongly in air and decomposes above 154° F. It has an acrid odor. It is used solely as a smoke-producing agent, and there is no evidence that it is harmful to man in concentrations normally attained in the field. Inhalation of concentrated fumes causes coughing and strangulation, a feeling of constriction around the chest, burning of the nose and throat, and hoarseness. When the mixture comes in contact with moisture, it forms hydrochloric acid and sulfuric acid. These acids are very corrosive to metals and fabrics. If FS is applied directly to the skin, a burning sensation is felt at once and an acid burn follows. Any FS mixture on the skin or clothing should be thoroughly wiped off with a dry cloth and the contaminated area flushed with large amounts of water. FS mixture is nonflammable, but may cause fires if spilled on flammable material, particularly under damp conditions. Leakers should be removed from the magazine and contents poured on the ground in a suitable area. Spillage can be removed by washing with large quantities of water. Small quantities of water added to FS react violently.

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## 2917. STORAGE OF GROUP B CHEMICAL MUNITIONS

*a. General.* Munitions with group B filling should not be stored in magazines with wooden floors. Concrete floors treated with sodium silicate should be used. Rubberoid or other floor covering should not be used. At all storage points, group B munitions should be stored in igloo type or Corbetta type magazines, or under cover protected from the direct rays of the sun.

*b. Surveillance.* Containers of war gases require periodic surveillance to determine development of excessive and dangerous internal pressure by means of pressure testing and, in some instances, sampling (TB CW 22). Surveillance includes inspections to detect leaks, breaks or other defects in containers and valves.

*c. Valves.* Valves of containers filled with non-persistent war gases must be opened slowly with the correct wrench or tool. The valve should first be "cracked" by opening it one-quarter turn and then closing immediately.

*d. Inspections.* When a magazine containing group B chemical munitions is opened, a foreman or other responsible person familiar with work in magazines containing this material must be present to determine whether or not munitions in the magazine are leaking. If munitions are leaking, masks shall be worn and doors and windows will be opened. The leaking shell or container shall be located and disposed of (par. 2920).

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*e. Safety.* Masks must be readily available to all men working in these magazines. Unboxed shell and containers may be handled without protective gloves unless contamination is noted.

#### **2918. SPECIAL PROTECTIVE EQUIPMENT FOR GROUP B CHEMICAL MUNITIONS**

*a. General.* The following special protective equipment must be readily available to personnel working where group B chemical munitions are stored:

*b. Personal protective equipment.* Personal protective equipment consisting of gas masks and protective gloves or mittens sufficient in number to equip all personnel required to work with group B chemical munitions shall be centrally stored and maintained under close supervision. Appropriate articles will be issued simultaneously with the issue of keys whenever entry to a group B chemical magazine or storage area is to be effected. Normally, personnel shall be issued only service gas masks and protective gloves or mittens. Personnel handling liquid acid-type chemical agents shall be issued and shall wear rubber boots, aprons, and gloves.

*c. First-aid equipment.* The following first-aid equipment shall be centrally stored and issued to the person in charge of a group of personnel required to work with group B chemical munitions:

- (1) Gas casualty first-aid kit; amyl nitrite ampoules; and individual first-aid kits.
- (2) Stretchers or litters.

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- (3) Woolen blankets.
- (4) A bottle containing a mixture of 4 ounces of pure grain alcohol (95 percent) and 4 ounces of chloroform to which has been added a few drops of ammonia.
- (5) A small carboy of saturated solution of sodium sulfite in pure grain alcohol (95 percent). Carboy must be kept sealed to prevent evaporation. This solution is used for removing chloroacetophenone and chloropicrin from the skin.
- (6) A bottle of alcoholic sodium bicarbonate solution, made by dissolving 3½ ounces of sodium bicarbonate in a pint of water and then adding a pint of alcohol. This solution is used to treat skin rash resulting from tear gas burns.

*d. Decontaminating material.* There shall be centrally located a carboy of saturated solution of sodium hydroxide (caustic soda) in alcohol. The carboy shall be kept sealed to prevent evaporation and shall be labeled as follows:

“Sodium hydroxide (caustic soda). This solution is for use in removing CNB from materials.

**Warning:** Causes severe burns to skin and eyes. Avoid contact with skin, eyes, and clothing. When handling use goggles or face shield. In case of contact, immediately flush skin with plenty of water and wash with vinegar; for eyes flush with water for 15 minutes and get medical attention.

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## 2919. FIRST AID FOR GROUP B CHEMICAL MUNITIONS

*a. General.* One man should never be permitted to work alone when handling group B war gases. In addition, the working crew should include a safety man equipped with a gas mask with an HCN M2 or M9A2 canister and a first-aid kit, ready for instant use. When AC is being handled, the safety man should observe the operation constantly from a safe distance upwind. He should be prepared to and be capable of rescuing any member of the work group who shows distress, and of administering first aid promptly and efficiently.

*b. Choking gases.* First aid is the same for choking gases such as phosgene, chloropicrin, and chlorine. Absolute rest and warmth are essential. The patient should be removed immediately on a litter to fresh air; he should be kept absolutely quiet and his normal body temperature maintained. A light stimulant such as hot coffee may be given, but no alcoholic drinks should be given. Shock is the reaction to be avoided. A glass of milk or cream, if available, will give marked relief from throat irritation. In case liquid has splashed on the skin, it should be washed off at once with alcoholic sodium sulfite solution in order to prevent ulcerations. Skin scratches and abrasions exposed to chloropicrin vapor or liquid develop a high degree of inflammation and easily become infected. The patient should be hospitalized. Artificial respiration should not be given

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unless the patient has stopped breathing. Exercise is to be avoided.

*c. Blood and nerve poison.* If the victim is in a closed space, he should be masked and removed to fresh air immediately. Too great concentrations may penetrate the gas mask canister. If he has stopped breathing, he should be moved to fresh air and given artificial respiration until medical aid is available. Meanwhile, two amyl nitrite ampoules from the gas casualty first-aid kit should be crushed and held close to the victim's nose, or placed into the gas mask facepiece if he is masked. This is repeated at 3-minute intervals until eight ampoules have been crushed. Artificial respiration should be continued. If there is liquid on the skin, it should be washed off with water or a weak solution of baking soda and water. Cloths splashed with the liquid should be removed and allowed to air.

*d. Tear gases.* Tear gas effects produced by chloroacetophenone (and chloropicrin) produce no permanent damage. Removing the patient to fresh air and facing him into the wind are sufficient first-aid treatments in most cases. In more aggravated cases, or for personnel exposed to a strong concentration of the gas, the eyes should be washed with a saturated solution of boric acid. The eyes should not be rubbed or bandaged. Where there is a skin rash, skin should be washed with alcoholic sodium bicarbonate solution. This solution must be taken before using because the addition of alcohol causes some of the bicarbonate to be precipitated.

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*e. Vomiting gases.* Vomiting gases in the concentrations usually encountered will not cause permanent injury. The patient should be removed from the contaminated atmosphere and away from heat. The nose should be flushed with salt water or bicarbonate of soda solution. All outer clothing should be removed and the surface of the body, including the scalp, washed with soap and water. This solution should be allowed to dry upon the skin and the skin dusted with borated talcum. The patient should be allowed to breathe weak chlorine atmosphere for 10 minutes from a handful of dry bleach in a wide-mouthed bottle or can. If patient's symptoms are severe, he should be allowed to breathe chloroform from the gas casualty first-aid kit. If patient becomes delirious, he should be watched closely to prevent self-injury.

*f. Smoke.* FM or FS in smoke form usually do not produce any effects requiring treatment. Smoke in high concentrations from CN-DM and CN are toxic. Anyone subjected to a very strong concentration of smoke without the protection of a mask should be removed to fresh air until recovered. Severe cases should be hospitalized. Since liquid FS or FM on the skin is very corrosive, it should be washed immediately from the skin with copious quantities of water, followed by soap and water.

## **2920. LEAKING GROUP B CHEMICAL MUNITIONS**

*a. General.* When leaking Group B chemical munitions are discovered, they must be disposed of

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at the direction of the person in charge. Personnel handling leaking items containing corrosive filling shall wear rubber boots, rubber aprons and rubber gloves in addition to gas masks normally worn. No leaking filling should be allowed to come into contact with skin or clothing. Pending final disposal, leaking munitions shall be removed from the magazine.

*b. Small quantity.* If the number of leaking munitions is small, they should be disposed of as described below:

- (1) Dumping in deep ocean water if convenient is the safest method (see SR 75-70-10).
- (2) Disposal by detonation must be attempted only under certain conditions of weather and wind (TB CW 22). The method outlined in paragraph 2913d (2) can be used. Ground on which group B chemical agent has spilled need not normally be decontaminated; ground contaminated with chloropicrin, however, should be decontaminated. The irritant solid remaining after CK evaporates should be neutralized with strong caustic solution, followed by water.

*c. Large quantity.* If a large number of group B gas-filled munitions are involved, the magazine will be ventilated and placed under guard, and the Chief of the Technical Service having storage responsibility shall be notified by the most rapid means of communication available. The Technical Service first receiving the report shall co-ordinate this information with other interested Technical Services.

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### **2921. REMOVAL OF SPILLED GROUP B CHEMICAL AGENTS**

If group B chemical agents have leaked from shell or containers and have contaminated the floor or other containers, one of the treatments outlined in paragraph 2920 shall be used, depending upon the type of chemical agent involved. Gas masks and protective gloves shall also be worn during the procedure; if a corrosive agent is involved, rubber boots and aprons shall be worn.

### **2922. FIRE IN GROUP B CHEMICAL MUNITIONS MAGAZINE**

The same precautions shall be observed during a fire in a group B chemical munitions magazine as are outlined in paragraph 2915, except that protective clothing is not required. Danger to personnel downwind from a fire involving group B gas-filled munitions is not great, except when noncombustible war gases such as phosgene are involved. Any shell or container that has been exposed to fire shall be considered dangerous and shall be inspected to determine its condition after the fire. A report of the fire shall be prepared in accordance with provisions of SR 385-10-41, SR 385-45-20, and SR 385-10-46.

### **2923. GROUP C CHEMICAL AGENTS**

*a. General.* At present, white phosphorus (Cml C symbol: WP) and plasticized white phosphorus (Cml C symbol: PWP) are the only two chemical

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agents in this group; they have somewhat similar characteristics.

*b. White phosphorus.* WP is a yellowish, wax-like substance, melting at 110° F. Its most characteristic property is that it spontaneously ignites when exposed to the air, burning with a yellow flame and giving off a large volume of white smoke. Smoke in field concentrations is not toxic; fumes are toxic. WP is intensely poisonous when taken internally.

*c. Plasticized white phosphorus.* PWP is finely divided WP suspended in gel of rubber and xylene.

#### **2924. STORAGE FOR GROUP C CHEMICAL MUNITIONS**

*a. General.* Group C chemical munitions should be stored in fire-resistive magazines with concrete floors. Storage in igloo type or Corbett type magazines is preferred. Group C chemical munitions shall be stored in accordance with current drawings and/or directives. In any case, group C chemical munitions should be stored in such a manner as to permit proper inspection.

*b. Temperature control.* White phosphorus filling in munitions becomes liquid at 111° F. When exposed to air WP will ignite; in cases where a burster is in the projectile it may explode. Below 111° F., the filling is solid and will not leak, for this reason, it is important that the temperature be kept below 111° F.

*c. Position of munitions.* Where temperature is likely to reach 111° F. WP munitions shall be stacked in such a manner that a subsequent drop in temper-

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ature will not solidify the WP in such a position as to affect the flight of the item.

## 2925. SPECIAL PROTECTIVE EQUIPMENT FOR GROUP C CHEMICAL MUNITIONS

*a. General.* The following special equipment must be readily available to personnel working where group C chemical munitions are stored, processed or handled:

*b. Personal protective equipment.* Personal protective equipment consisting of flame-proof gloves and coveralls, and chemical safety goggles sufficient in number to equip all personnel required to work with group C munitions shall be centrally stored and maintained under close supervision. These items shall be issued to personnel working with WP or PWP filled items and shall be worn whenever leakers develop.

*c. First-aid equipment.* The following first-aid equipment shall be centrally stored and issued to the one in charge of a group of personnel required to work with group C chemical munitions:

- (1) Copper sulfate pads sufficient for each worker.
- (2) A 5-gallon pail or other vessel and two sponges.
- (3) A 1-gallon bottle of 5 percent copper sulfate solution and gauze sponges.

*d. First-aid station.* There should be installed in a heated building, centrally located to the magazine or storage area, a bathtub or similar container and a means of heating water.

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*e. Fire-fighting equipment.* Tubs, barrels, or tanks filled with water large enough to contain the items of WP-filled munitions should be located adjacent to magazines or outdoor stacks, when actually working with such items.

#### **2926. FIRST AID FOR GROUP C CHEMICAL MUNITIONS**

Phosphorus burns are especially severe because phosphorus buried in the flesh is absorbed and poisons the entire body. The tissues immediately around the burn are particularly affected by the absorbed phosphorus. Any part burned by phosphorus should be plunged under water as soon as possible. This stops the phosphorus from burning. Large amounts of copper sulfate (5 percent solution) should be applied or copper sulfate pads should be used according to directions. This treatment should be continued for 3 minutes. The phosphorus particles (copper-plated and black-colored) should be removed by washing or with forceps, and the injury treated like an ordinary burn. Since WP is soluble in oil, oily-base salves should not be used to treat burns. Such salves may cause systemic poisoning.

#### **2927. LEAKING GROUP C CHEMICAL MUNITIONS**

*a. General.* Leaks in WP munitions can be detected immediately by the white smoke arising from the leak. As air contacts the WP, spontaneous ignition occurs. With leaking shell of this group, the

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great risk is fire; this can be combated successfully only by prompt action.

*b. Immediate action on discovering leaking munitions.* During operations the person discovering the leaking munitions shall where practicable submerge any leaking shell or container in one of the tubs provided. Rubber protective equipment will give protection against burns only; it is not effective when exposed to high temperatures such as burning phosphorus. When burning phosphorus adheres to gloves, the gloved hands should be dipped in water.

*c. Disposal of leaking munitions.* When a single leaking item has been discovered and has been immersed in water, it should be disposed of in an area where fragmentation will not be a hazard, where smoke will not create a nuisance, and where there is no dry vegetation which may be ignited, by one of the following procedures:

- (1) When the item does not contain a fuze or burster, it will be removed to a point where fire risk is negligible and destroyed by static firing. All personnel must retire to a safe distance before the shell is exploded.
- (2) If the item is not in a container and it is fitted with a fuze or burster, the fire must be extinguished before the item is handled or moved. This condition is extremely hazardous, and the handling of the shell shall be carried out under the direction of an officer, a foreman or other employee familiar with chemical munitions. After the

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flame has been extinguished, the instructions given in (1) above shall be followed.

#### **2928. REMOVAL OF SPILLED WHITE PHOSPHORUS**

*a. General.* When phosphorus has leaked on the floor or other parts of a magazine and has been extinguished, a fire guard must be stationed within the building until the spilled phosphorus has been completely removed; the water used in fire fighting will evaporate and permit the phosphorus to reignite. Phosphorus may remain on the floor for some time before it reignites. Phosphorus which has extinguished itself by forming a crust can be reignited if the crust is broken.

*b. Procedures.* Small amounts of phosphorus can be removed best by first scraping off as much as possible with an implement such as a putty knife and then removing the rest by burning with a blowtorch or similar appliance. This method of removing phosphorus must not be attempted until all loaded munitions in the vicinity have been removed.

*c. Surveillance.* The magazine will be kept under surveillance for at least 2 weeks, as fire may break out again. Any deep cracks or crevices in the floor will be filled up with cement mortar before munitions are restored in the magazine.

#### **2929. FIRE IN GROUP C CHEMICAL MUNITIONS MAGAZINES**

*a. General.* In the event of a fire in a magazine containing group C ammunition fitted with fuze or

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burster and packed in containers, the magazine shall be abandoned if the fire cannot be controlled; (fires in igloo type or Corbetta type magazines will not be fought); fire-fighting efforts shall be confined to saving adjacent magazines. In all other fires involving group C chemical munitions which are stored without fuzes or bursters, the following precautions shall be observed in fighting the fire.

*b. Control of flames.*

- (1) Phosphorus once extinguished shall either be immersed under water or continually sprayed to prevent the flames breaking out anew.
- (2) Because of the great amount of smoke liberated, there is an extra hazard of men becoming lost in the magazine while attempting to fight the flames. Men with portable extinguishers shall not be permitted in the magazine after a fire gains headway unless they are equipped with lifelines.
- (3) The lowest pressure streams consistent with possibility of approach should be used; a high velocity stream of water tends to spread the fire.

*c. Safety.* Fire-fighting personnel shall be closely supervised when fighting fire in WP munitions magazines because components becoming highly heated in a fire will explode with moderate violence, throwing burning containers and WP for some distance.

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Fire-fighting personnel must be withdrawn to safe distances when this danger becomes apparent.

*d. Procedure after fire.* After a fire has been extinguished in a magazine, all unburned munitions shall be considered dangerous. An immediate report of the fire shall be made to the Office, Chief of Ordnance. When inspecting munitions involved in a fire, containers shall not be opened less than 100 feet from any building containing explosives or munitions.

#### 2930. GROUP D CHEMICAL AGENTS

*a. General.* Chemical agents in this group include incendiaries and readily flammable munitions.

*b. Thermite (Cml C symbol: TH).* Thermite, a mixture of iron oxide and aluminum and other substances, is in the form of a dark gray granular mass. TH requires an igniter to start it burning; it burns with great rapidity at a temperature of 4,300° F., and iron oxide being reduced to molten iron. Thermate—is a mixture of thermite, grained aluminum, barium nitrate, sulfur, and lubricating oil.)

*c. Incendiary bombs.* Incendiary bombs may consist of a combustible body of magnesium metal alloy inside of which is an igniter composition such as thermate. When ignited, the body of the bomb burns at a temperature of about 3,700° F. Other types (such as IM, NP, or PTI) have steel cases filled with thickened fuel. These operate by ejecting the burning thickened fuel over a wide area. The mixture is very difficult to extinguish.

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*d. Hexachloroethane mixture (Cml C symbol: HC).* HC consists largely of hexachloroethane, zinc oxide and aluminum and is a gray colored powder without characteristic odor. HC reacts with water which can start it burning; it burns rather slowly with the evolution of a dense cloud of smoke. HC smoke in concentrations encountered in the field is not harmful if breathed for short periods. Heavy concentrations of HC smoke are likely to have a toxic effect when breathed. A gas mask shall be worn in fairly high concentrations and for long exposure to low concentrations. In order to remain an appreciable time in an atmosphere having a high concentration of HC smoke, a self-contained oxygen mask is required.

*e. Burning mixture CN-DM (Cml C symbol: CN-DM).* CN-DM is a mixture of chloroacetophenone and diphenylaminechloroarsine with solid propellant. Gas mask protection is required when this mixture burns.

*f. Chloroacetophenone burning mixture (Cml C symbol: CN).* A mixture of CN and small-grain solid propellant, is employed in hand and rifle grenades. Gas mask protection is required when this mixture burns producing heavy concentration.

*g. Colored smoke mixtures (no Cml C symbol).* These mixtures contain a dye for the color of smoke desired and certain types of fuels but do not contain hexachloroethane. Gas masks should be worn for protection against heavy concentrations of smoke.

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### **2931. STORAGE OF GROUP D CHEMICAL MUNITIONS**

Chemical munitions containing fillings of group D may be stored in any dry fire-resistive magazine. Inspection and guard of chemical munitions of this group is the same as that maintained for other groups. Stacks of incendiary clusters stored outdoors will be spaced not less than 600 feet apart, irrespective of the quantity in each stack. Stacks of incendiary clusters shall normally contain not more than 3,000 units of 500-pound bombs or 10,000 units of 100-pound bombs per stack.

### **2932. SPECIAL PROTECTIVE EQUIPMENT FOR GROUP D CHEMICAL MUNITIONS**

Unboxed munitions containing group D chemical agents may be handled without special protective equipment but it is advisable to have gas masks available where CN, CN-DM, and HC are involved.

### **2933. FIRST AID FOR GROUP D CHEMICAL MUNITIONS**

No unusual first aid treatment is required for personal injuries occurring in handling group D chemical munitions except as provided for CN and CN-DM under paragraph 2919. Burns should be treated in the same manner as those caused by flame. Persons severely affected from high concentrations of smoke should be hospitalized.

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#### **2934. LEAKING GROUP D CHEMICAL MUNITIONS**

Any leaking munitions containing group D chemical agents will be segregated. Instructions for disposing of large quantities of such munitions shall be requested from the Office, Chief of Ordnance. If necessary to destroy small quantities of leaking munitions of this group, they should be burned in the same manner as intended for service use, in a standard burning pit. Leaking bombs may be fired statically in a pit located in an area where the fire risk is negligible. Where barricade protection for personnel is not available, a distance of 300 yards shall be maintained if the bombs do not contain an explosive charge; 700 yards if the bombs do contain an explosive charge (X bombs).

#### **2935. REMOVAL OF SPILLED GROUP D CHEMICAL AGENTS**

If munitions are broken open, or leaking, the filling shall be swept up, removed from the magazine or storage area, and burned.

#### **2936. FIRE IN GROUP D CHEMICAL MUNITIONS MAGAZINE**

The primary efforts of fire fighters shall be confined to preventing the spread of the fire in magazines containing group D chemical munitions (fires in igloo type or Corbetta type magazines will not be fought). Normally, water is not used to fight fires

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of HC mixtures, thermite or mixtures containing fine metallic powders such as magnesium or aluminum. Incipient fires may be smothered with sand. Fire in a magazine containing group D munitions will not be fought with water except where large quantities are used in proportion to relatively small quantities of these type munitions.

### **2937. SPECIAL DISPOSAL SQUADS**

*a. General.* A special disposal squad of appropriate size shall be designated at establishments storing chemical munitions. The number of men composing the detail shall depend on the size of the installation or on the amount of chemical munitions stored.

*b. Training.* Members of the disposal squad shall be thoroughly trained in the proper disposal of leaking munitions, and in the proper handling of chemical agents during emergencies. They should also be thoroughly trained in proper protective techniques outlined in FM 21-40. Further specialized training for disposal squads will be given by the Technical Escort Detachment upon application to the Chief, Chemical Corps.

*c. References.* Disposal squads should be familiar with the disposal methods outlined in *Disposition of Chemical Corps Items*, Office of the Chief, Chemical Corps, 15 September 1948; TB CW 22; TM 9-1900.

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