

METRIC

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MILITARY STANDARD

INORGANIC SALTS AND COMPOUNDS, TECHNICAL GRADE

(MAGNESIUM CARBONATE THROUGH PHOSPHORUS TRICHLORIDE)



AMSC N/A

FSC 6810

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FOREWORD

Inorganic Salts and Compounds, Technical Grade (Magnesium Carbonate through Phosphorus Trichloride)

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Edgewood Research, Development and Engineering Center, Attn: SMCCR-PET-S, Aberdeen Proving Ground, MD 21010-5423, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.
3. This standard is approved for use by all Departments and Agencies of the Department of Defense in the selection of items for application. It is intended to prevent the entry of unnecessary items (sizes, types, varieties) into the Department of Defense logistics system. This document is not intended to restrict any service in selecting new items resulting from state-of-the-art changes.

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1. SCOPE

1.1 Coverage. This standard is a presentation of nomenclature, Chemical Abstracts Service Registry Numbers, formulas, physical and chemical properties, specification requirements, military and typical commercial uses, safety information, storage information and disposal information for inorganic salts and compounds, technical grade (magnesium carbonate through phosphorus trichloride). This standard does not include all of the items represented by the title or all those items which are commercially available. It does contain items preferred for use in the selection of inorganic salts and compounds, technical grade (magnesium carbonate through phosphorus trichloride), for application by the Department of Defense.

1.2 Application. Inorganic salts and compounds, technical grade (magnesium carbonate through phosphorus trichloride), are used in formulating products such as cements, electrochemicals, lubricants, explosives, propellants, pyrotechnics, smoke mixtures, rust preventives and chlorinating agents. They are also used as chemical intermediates.

1.3 Classification. The items in this standard are classified on the basis of chemical composition as inorganic salts and compounds.

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2. APPLICABLE DOCUMENTS**2.1 Government documents.**

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS**FEDERAL**

PPP-C-2020 Chemicals, Liquid, Dry and Paste; Packaging of

MILITARY

MIL-M-3821 Manganese Dioxide, Technical
 MIL-M-7866 Molybdenum Disulfide, Technical, Lubrication Grade
 MIL-P-10398 Phosphorus Trichloride, Technical
 MIL-M-11361 Magnesium Carbonate
 MIL-M-13667 Magnesium Carbonate, Technical
 MIL-M-14779 Magnesium Oxide, Calcined (For Use In Ammunition)
 MIL-M-51103 Magnesium Oxide, Technical
 DOD-N-51512 Nickel Salts, Electroplating (Metric)

STANDARDS**FEDERAL**

FED-STD-313 Material Safety Data Sheets, Preparation And The
 Submission Of

MILITARY

MIL-STD-12 Abbreviations For Use On Drawings, And In
 Specifications, Standards And Technical Documents

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(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Naval Publications and Forms Center, (ATTN: DODSSP), - Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Bldg. 4D, Philadelphia, PA 19111-5094.

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

CODE OF FEDERAL REGULATIONS (CFR)

- Title 29 - Department of Labor, Occupational Safety and Health Administration (OSHA); General Industry Standards And Interpretations
- Title 40 - Environmental Protection Agency (EPA); Hazardous Waste And Consolidated Permit Regulations
- Title 49 - Department Of Transportation (DOT); Hazardous Materials Regulations

- DOD 4145.19-R-1 - Storage And Materials Handling
- DOD 4160.21-M - Defense Utilization And Defense Disposal Manual
- DOD 6050.5-LR - DOD Hazardous Materials Information System, Hazardous Item Listing
- TB MED 502 - Occupational And Environmental Health Respiratory Protection Program
(DLAM 1000.2)
- TB MED 506 - Occupational And Environmental Health Occupational Vision
-

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

- Registry of Toxic Effects of Chemical Substances
- Recommendation for Environmental Exposure Limits

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

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AMERICAN CONFERENCE OF GOVERNMENT INDUSTRIAL HYGIENISTS (ACGIH)

Threshold Limit Values (TLVs) for Chemical Substances in the Work Environment Adopted by American Conference of Governmental Industrial Hygienists (ACGIH) with Intended Changes.

(Application for copies should be addressed to American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, D-7, Cincinnati, OH 45211-4438.)

ASTM

- ASTM E 11 - Standard Specification for Wire-Cloth Sieves For Testing Purposes
- ASTM E 323 - Standard Specification For Perforated - Plate Sieves For Testing Purposes
- ASTM E 380 - Standard For Metric Practice

(Application for copies should be addressed to ASTM, 1916 Race Street, Philadelphia, PA 19103.)

CHEMICAL ABSTRACTS SERVICE REGISTRY

The Chemical Abstracts Service (CAS) Registry number provides a key to access the wealth of information available through CAS.

(For details on how to search the CAS files and database using the registry number, contact Chemical Abstracts Services, Customer Service, P.O. Box 3012, Columbus, OH 43210.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

National Fire Codes

(Application for copies should be addressed to National Fire Protection Association, Battery March Park, Quincy, MA 02269.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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3. DEFINITIONS**3.1 Definitions of Technical Terms.**

3.1.1 Technical grade - Denotes a quality of chemicals which are generally used for industrial, solvent, and manufacturing applications. Generally, specific processes are not employed by the manufacturer to limit all the impurities, aside from the normal precautions which are taken in the manufacturing process. A technical chemical may be specially processed to reduce specific impurities so as to suit the chemical to a given industrial application. In such cases, the identification of the items must be further expanded to indicate the specific impurities limitation.

3.1.2 pH - A numerical measure of the hydrogen ion concentration, indicating degree of acidity or alkalinity of a solution. It is expressed as $\text{pH} = -\log_{10}[\text{H}^+]$. At the neutral point, $\text{pH} = 7$. At a pH lower than 7, a solution is acidic. At a pH higher than 7, a solution is basic.

3.1.3 Oxidizing agent - A substance that gains electrons as a result of an oxidation-reduction reaction. It causes an increase in the oxidation state of another substance.

3.1.4 Reducing agent - A substance that loses electrons during an oxidation-reduction reaction. It causes a decrease in the oxidation state of another substance.

3.2 Definitions of abbreviations. The use of abbreviations shall be in accordance with MIL-STD-12 where applicable. Metric system abbreviations and symbols shall be in accordance with ASTM E 380.

Additional abbreviations are as follows:

CAS	Chemical Abstracts Service Registry Number
DRMO	Defense Reutilization and Marketing Office
FW	Formula Weight
HMIS	Hazardous Materials Information System
PEL	Permissible Exposure Limit
TLV	Threshold Limit Value

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4. GENERAL REQUIREMENTS

4.1 Packaging data and labeling. All chemicals included in this standard shall be packaged in accordance with Federal Specification PPP-C-2020 and all applicable documents referenced therein. Shipping containers shall be labeled in accordance with current Department of Transportation (DOT) Hazardous Materials Regulations applicable to each chemical. When shipping by military aircraft, the requirements of TM 38-250 shall apply. In addition, each item shall be packaged and labeled as specified in the applicable contract or order. All labels shall also comply with Hazard Communication Standard, 29 CFR 1910.1200 (f).

4.2 Hazardous materials information. DOD 6050.5-LR, DOD Hazardous Materials Information System (HMIS) requires Material Safety Data Sheet (MSDS) information for all hazardous materials used by DOD. The contractual acquisition of a MSDS is accomplished through use of Federal Acquisition Regulation, paragraph 52.223-3, Hazardous Material Identification and Material Safety Data. The MSDS is prepared in accordance with the instructions in FED-STD-313.

4.3 Safety.

4.3.1 Personal protective measures. The necessary respiratory, eye and skin protection to be used when handling chemicals shall be prescribed by the responsible installation industrial hygiene, medical and safety authorities.

4.3.1.1 Respiratory protection. Respirators, approved by the National Institute for Occupational Safety and Health (NIOSH) or the Mine Safety and Health Administration (MSHA) or by particular respiratory schedules of the Bureau of Mines (BM) for the compounds being used, may be employed for intermittent exposure or for supplementing other control measures (refer to TB MED 502 or DLAM 1000.2). Ventilation shall be adequate to remove hazardous concentrations.

4.3.1.2 Skin protection. Personnel using these compounds shall be provided with and required to use impervious gloves, sleeves, aprons, and boots whenever indicated. Protective creams and ointments commonly known as "barrier creams" may be of value in certain cases. However, barrier creams shall not be used to replace protective clothing. In case of contact with the skin, wash affected areas thoroughly with water. Eye lavages and emergency showers shall be located where there is a potential for direct contact with harmful chemicals.

4.3.1.3 Face and eye protection. Personnel using these compounds shall be provided with and required to wear chemical splash-proof safety goggles. In addition, face shields shall be provided and worn over the goggles if splashing could occur. In

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case of contact with the eyes, immediately irrigate with copious amounts of water for at least 20-30 minutes, and obtain medical attention. (Refer to TB MED 506.)

4.3.1.4 Training. Employers shall provide employees with training and information, including MSDSs, on all chemical items in their work area, in accordance with 29 CFR 1910.1200 (h), to ensure that employees know potential hazards of the chemicals with which they come in contact and the symptoms of exposure, as well as how these chemicals affect the body and bodily functions. Employees shall be adequately trained to render first aid.

4.3.1.5 Exercises. Participation in training exercises shall be stressed to demonstrate skills in the use of personal protective equipment and emergency response equipment.

4.3.2 Storage conditions. DOD 4145.19-R-1 describes general storage practices and requirements for hazardous materials in the DOD supply system. Specific requirements provided in the following paragraphs are supplementary in nature and shall be observed in consonance with the DOD storage regulations.

4.3.2.1 Flammable, combustible, pyrophoric and ignitable materials. A flammable material is generally any solid, liquid, vapor or gas that ignites easily and burns rapidly. Combustible materials are generally those that are difficult to ignite and burn slowly. The DOT, in Part 173, Subpart D, Section 173.115 of 49 CFR, defines a flammable liquid as one having a closed cup flash point below 37.8°C (100°F). A combustible liquid is defined, by DOT in the above reference, as one having a closed cup flash point at or above 37.8°C (100°F) and below 93.3°C (200°F). A pyrophoric liquid is defined, by DOT in the above reference, as one that ignites spontaneously in dry or moist air at or below 54.5°C (130°F). Materials with flash points of 93.3°C (200°F) or higher are to be considered as burnable. The Environmental Protection Agency (EPA), in Part 261, Subpart C, Section 261.21 of 40 CFR*, designates the criteria for flammable and combustible materials and oxidizers that exhibit the characteristic of ignitability (I). Liquids with closed cup flash points of less than 60°C (140°F) are defined by EPA as ignitable. The autoignition point (temperature) of a substance is generally defined as the minimum temperature required to initiate or cause self-sustained combustion in the absence of a spark or flame. Materials that ignite easily under normal industrial conditions are considered to be dangerous fire hazards. Such materials shall be stored in a manner to prevent ignition and combustion. Easily ignitable substances, such as reducing agents, shall be kept away from strong oxidizing agents. All containers shall be tightly sealed. It is

*Refers only to materials that have become waste.

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important to provide adequate ventilation in storage areas, and to locate the storage areas of these items away from fire hazards. Ample fire-control equipment shall be easily accessible. Storage buildings, rooms and cabinets shall comply with provisions of the National Fire Codes. The building shall be electrically grounded and signs posted to prevent the lighting of matches or smoking in the area. Flammable storage areas shall be equipped with smoke or fire detection equipment.

4.3.2.2 Water-sensitive fire and explosive hazardous materials. These are materials that react on contact with water or steam to ignite or evolve heat or explosive gases. Such materials exhibit the characteristic of reactivity (R) as designated by the EPA in Section 261.23 of the above reference.* These materials shall be stored in well-ventilated, cool, dry areas. All containers shall be tightly sealed. These materials are a fire hazard in contact with water or moisture; therefore, it is essential that no sprinkler be used. Otherwise, the building shall conform to that required for storage of flammable materials. The building shall be waterproof, located on high ground, separated from other storage areas and meet National Fire Codes.

4.3.2.3 Incompatible materials. Materials that are chemically incompatible shall be segregated in the storage of both serviceable and unserviceable items. The degree of segregation will depend upon DOD 4145.19-R-1 and local supplementary requirements that insure safe storage conditions. Hazardous storage compatibility codes are provided in the HMIS referred to in 4.2.

4.3.3 Chemical hazardous exposure limits. Chemical hazardous exposure limits for airborne concentrations of substances are obtained from the current TLVs for Chemical Substances in the Work Environment adopted by the American Conference of Governmental Industrial Hygienists (ACGIH); current Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL), 29 CFR, Part 1910, Section 1910.1000; and NIOSH Recommended Exposure Limits. Such information is also shown in MSDSs and the HMIS referred to in 4.2.

Carcinogenic substances are listed by OSHA in Category I for confirmed carcinogens, and in Category II for suspected carcinogens. Category I substances have standard exposure limits set at the lowest possible levels. Category II substances have standard exposure limits set to prevent acute or chronic effects.

4.3.4 Toxicity. Toxicity information for chemical compounds is available from various publications and from MSDSs.

*Refers only to materials that have become waste.

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4.3.4.1 EPA Toxic (T). Some chemical compounds have been designated by the EPA as toxic (T) in accordance with the criteria shown in Part 261, Subpart B, Section 261.11(a)(3) of 40 CFR. Some commercial chemical products are listed as toxic under Subpart D, Section 261.33 (f).

4.3.4.2 EPA Acute Hazardous Toxicity (H). Some chemical compounds have been designated by the EPA as acutely hazardous (H) in toxicity in accordance with the criteria shown in Subpart B, Section 261.11(a)(2) of the above reference.* Some commercial chemical products are listed as acutely hazardous in toxicity under Subpart D, Section 261.33(e).

4.3.4.3 EPA Toxicity Characteristic Leaching Procedure (TCLP). This is a procedure used to determine the properties of a waste that are directly related to the potential of the waste to pose a hazard to groundwater when disposed of in a landfill environment. It replaces the EPA EP toxicity test. The TCLP procedure is contained in EPA Method No. 1311, SW -846. Some 40 chemical contaminants have been designated by the EPA as being a hazard to groundwater in a landfill environment. (See Section 261.24 of 40 CFR.)*

4.4 Pollution and disposal.

4.4.1 Pollution potential. All items described in this standard shall be assumed to have a pollution potential. However, to minimize this potential, the proper use, storage and disposal methods shall be strictly followed.

4.4.2 Disposal of excess or unserviceable material. To minimize disposal problems, it is recommended that no more than a one year's supply of each item listed in this standard be stocked. When stocks have been declared excess or unserviceable, they will be disposed of in accordance with the Defense Utilization and Disposal Manual, DOD 4160.21-M, and applicable DOD Policy Memoranda. Guidance can be obtained from your servicing Defense Reutilization and Marketing Office (DRMO) on procedures required for proper reporting and turn-in.

4.4.3 Disposal and storage of hazardous wastes. Items are classified and managed as hazardous wastes as defined by the Resource Conservation and Recovery Act (RCRA) (Public Law 94-580). Items have been identified as either having met the characteristics for ignitable, corrosive, or reactive waste and are subject to Toxicity Characteristic Leaching Procedure (TCLP); or have been listed as toxic or acutely hazardous according to Identification and Listing of Hazardous Waste, Part

*Refers only to materials that have become waste.

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261, 40 CFR; or have been determined to be hazardous wastes by declaration of the Defense Reutilization and Marketing Service (DRMS) in accordance with procedures set forth in DOD 4160.21-M. Disposal of such items shall be managed in accordance with the Installation Environmental Office, the DRMO, or the Safety and Health Office to insure proper reporting of disposal and treatment actions to the US EPA and State, and shall be managed in accordance with federal, state and local laws. The three main disposal methods are turn-in to the DRMO, on-post disposal by installation personnel, or disposal by commercial contract. Hazardous wastes that cannot be disposed of as stated in 4.4.3.2 shall be stored under environmentally safe conditions until suitable methods of disposal are determined. Short-term storage (less than 90 days) requires proper containment (i.e., packaging and facilities) in accordance with Section 262.34, Part 262, of the above reference. Long-term storage (greater than 90 days) requires permitting by the EPA or by the state under Public Law 94-580 (RCRA), in compliance with the requirements of 40 CFR, Parts 264 and 265. Physical custody will be accomplished by the activity with conforming storage or most nearly conforming storage. When physical custody is in question, the Post Commander will make the final decision. In all cases where the wastes are to be collected, stored, transported and disposed of at a state or local permitted disposal facility, the identity and description of the waste shall be maintained and recorded in accordance with Part 262 of the above reference. Transportation of the waste must be in accordance with Part 263 of the above reference, Standards Applicable to Transporters of Hazardous Waste. State and/or local regulations may be more stringent than Federal requirements. It is essential that the installation Environmental Office review all disposal actions for compliance with all applicable regulations.

4.4.3.1 Cleanup of liquid spills. To control the migration of spilled or leaking liquids, dike around the item with an inert, dry absorbent (e.g., clay, sawdust or vermiculite) or follow installation spill plans (Spill Prevention Control and Countermeasure Plan and Installations Spill Contingency Plan). Control entry to the spill site and segregate salvageable materials away from the spill area. Initiate waste cleanup operations immediately in accordance with local procedures. The residue shall be safely handled and transported to an approved or permitted disposal or storage facility. Packaging, labeling, transportation and record-keeping requirements for this waste material are determined by the appropriate federal and state agencies and local procedures. It is recommended that all activities involving disposal preparation and transportation to commercial facilities be properly coordinated with the appropriate federal and state agencies responsible for health and environmental aspects of hazardous materials. It is imperative that the proper description of waste accompany the packaged item at all times. Final disposal of the waste item shall be accomplished by either reutilization, transfer, donation or sales by DRMS in accordance with DOD 4160.21-M or by ultimate disposal as described in 4.4.3.2. Spill residue, including contaminants, to be turned into the DRMO shall first be properly

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identified, containerized, and labeled. For large scale spills that grossly contaminate the environment, the Chemical Transportation Emergency Center (CHEMTREC) can be called for assistance (1-800-424-9300). Applicable procedures of the local spill control plan shall be followed. Necessary respiratory, eye, and skin protection measures are to be used while performing cleanup operations.

4.4.3.2 Ultimate disposal. Ultimate disposal shall be accomplished at a permitted or approved hazardous waste treatment or disposal facility designated by the Installation Environmental Office, DRMO, or Safety and Health Offices.

4.4.4 DISCLAIMER. RECOMMENDED DISPOSAL INSTRUCTIONS ARE FORMULATED FOR USE BY ELEMENTS OF THE DEPARTMENT OF DEFENSE. THE UNITED STATES OF AMERICA IN NO MANNER WHATSOEVER, EITHER EXPLICITLY OR IMPLICITLY, WARRANTS, STATES, OR INTENDS SAID INSTRUCTION TO HAVE ANY APPLICATION, USE OR VIABILITY BY OR TO ANY PERSON OR PERSONS CONTRACTING OUTSIDE THE DEPARTMENT OF DEFENSE OR ANY PERSON OR PERSONS CONTRACTING WITH ANY INSTRUMENTALITY OF THE UNITED STATES OF AMERICA, AND DISCLAIMS ALL LIABILITY FOR SUCH USE. ANY PERSON USING THESE INSTRUCTIONS WHO IS NOT A MILITARY OR CIVILIAN EMPLOYEE OF THE UNITED STATES OF AMERICA SHOULD SEEK COMPETENT PROFESSIONAL ADVICE TO VERIFY AND ASSUME RESPONSIBILITY FOR THE SUITABILITY OF THESE INSTRUCTIONS TO HIS PARTICULAR SITUATION, REGARDLESS OF SIMILARITY TO A CORRESPONDING DEPARTMENT OF DEFENSE OR OTHER GOVERNMENT SITUATION.

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5. DETAILED REQUIREMENTS

5.1	<u>Name.</u>	MAGNESIUM CARBONATE, BASIC, HYDRATED	
	Hydromagnesite (natural)	$3\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$	FW 365.34
	Magnesium alba (precipitated)		
	Artinite (natural)	$\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$	FW 196.69
			CAS 23389-33-5

5.1.1 Specification. MIL-M-11361 Magnesium Carbonate.

5.1.2 Technical description. Basic magnesium carbonate (pure) exists in two trihydrate forms as white rhombic crystals with the formulas shown above. It decomposes on heating with release of CO_2 . It is practically insoluble in water, with solubility dependent on the CO_2 content of the water. It is dissolved by dilute acids with formation of $\text{Mg}(\text{HCO}_3)_2$, and by excess acid with the evolution of CO_2 . The theoretical MgO content of $3\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$ is 43.8 percent, and the theoretical MgO content of $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$ is 40.8 percent. Another hydrated form with the approximate formula $4\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 5\text{H}_2\text{O}$ has a theoretical MgO content of 41.5 percent.

Table I. Magnesium carbonate, basic, trihydrates - physical properties.

Hydromagnesite	
Density, g/cm^3	2.16
Solubility in water, $\text{g}/100 \text{ cm}^3$	
(Cold)	0.04
(Hot)	0.011
Artinite	
Density, g/cm^3	2.02

The military specification requirements for magnesium carbonate, technical grade, are shown in Table II.

Table II. Magnesium carbonate, technical grade - chemical and physical requirements.

	<u>Percent by Weight</u>
Assay as MgO	40.0 to 43.0

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Table II. Magnesium carbonate, technical grade - chemical and physical requirements (continued).

	<u>Percent by Weight</u>
Sulfate and sulfite, as SO ₄ , max	0.05
Water-soluble substances, max	0.50
Moisture, max	1.0
Coarse particles, max	
Total residue retained on a 75 micrometer (No. 200) sieve	5.0
Total residue retained on a 45 micrometer (No. 325) sieve	7.0

† Standard sieve designations from ASTM E 11.

Magnesium carbonate, basic, hydrated, technical grade, is commercially available with a magnesium oxide content of 40.0 to 43.5 percent.

5.1.3 Use. Magnesium carbonate, basic, hydrated, technical grade, is intended for military use in chemical smoke mixtures. Commercial applications include the production of magnesium salts, heat insulation and refractories; use as a rubber reinforcing agent; and as a filtering medium.

5.1.4 Packaging. Refer to 4.1

5.1.5 Safety precautions.

a. Health hazard. Magnesium carbonate dust can be irritating to the eyes, and upper respiratory tract. The PEL for a nuisance dust is 5 mg/m³ for the respirable fraction and 15 mg/m³ as total dust. The TLV for magnesite as a nuisance particulate is 5 mg/m³ as respirable dust and 10 mg/m³ as total dust. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Magnesium carbonate will not burn. If present in a fire, it can decompose and release carbon dioxide and magnesium oxide fumes. The carbon dioxide can help extinguish the fire. The magnesium oxide fumes are toxic by inhalation. The PEL for magnesium oxide fumes is 15 mg/m³, and the TLV is 10 mg/m³.

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c. Reactivity. Magnesium carbonate reacts with acids to release carbon dioxide gas.

5.1.6 Storage. Magnesium carbonate shall be stored in a dry space away from acidic fumes or vapors. Refer to 4.3.2.

5.1.7 Disposal. In case of spills, gather up the dry powder and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.2 Name. MAGNESIUM CHLORIDE, HEXAHYDRATE $MgCl_2 \cdot 6H_2O$
Bischofite (natural) FW 203.31

CAS 7791-18-6

5.2.1 Specification. Manufacturers requirement (No Government specification).

5.2.2 Technical description. Magnesium chloride, hexahydrate (pure) exists in the form of colorless monoclinic deliquescent crystals with the physical properties shown in Table III. The crystals are ionic in structure. It is very soluble in water and soluble in alcohol. The hydrated ion, $Mg(H_2O)_6^{2+}$, exists in solution. When heated to decomposition, the salt undergoes hydrolysis and forms the metal oxide, hydrogen chloride and water, as shown by the following equation:



Table III. Magnesium chloride, hexahydrate - physical properties.

Density, g/cm ³	1.569
Soluble in water, g/100cm ³ (0°C)	281
(100°C)	918

Magnesium chloride, hexahydrate, technical grade, is commercially available with a purity of from 98 to 99.995 percent by weight.

5.2.3 Use. Magnesium chloride, hexahydrate, technical grade, is intended for military use in the preparation of magnesium oxychloride cement. Commercial applications include use as a raw material for the production of magnesium metal, by electrolysis of fused $MgCl_2$, and the preparation of other magnesium compounds.

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5.2.4 Packaging. Refer to 4.15.2.5 Safety precautions.

a. Health hazard. Magnesium chloride particles can be irritating to the eyes and upper respiratory tract. The PEL for a nuisance dust is 5 mg/m³ for the respirable fraction and 15 mg/m³ as total dust. The TLV for nuisance particles is 5 mg/m³ as respirable dust and 10 mg/m³ as total dust. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Magnesium chloride, hexahydrate, is not burnable. If present in a fire, it can decompose and release irritating and toxic fumes of hydrogen chloride and magnesium oxide. The PEL and TLV for hydrogen chloride as a ceiling limit is 7 mg/m³. The PEL for magnesium oxide fumes is 15 mg/m³ and the TLV is 10 mg/m³.

c. Reactivity. Magnesium chloride reacts with sulfuric acid to release irritating and toxic fumes of hydrogen chloride.

5.2.6 Storage. Magnesium chloride shall be stored in a cool, dry space in tightly sealed containers to prevent contact with moisture vapor. Refer to 4.3.2.

5.2.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.3 Name. MAGNESIUM NITRATE, HEXAHYDRATE
Mg(NO₃)₂·6H₂O

FW 256.41

CAS 13446-18-9

5.3.1 Specification.

5.3.2 Technical description. Magnesium nitrate, hexahydrate (pure), exists in the form of colorless monoclinic deliquescent crystals with the physical properties shown in Table IV. The crystals are ionic in structure. It is very soluble in water, and soluble in alcohol. The hydrated ion, Mg(H₂O)₆²⁺, exists in solution. When heated, it starts to dehydrate at 89° to 95°C. When heated to decomposition, above 330°C, it releases fumes of nitric acid and nitrogen tetroxide.

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Table IV. Magnesium nitrate, hexahydrate - physical properties.

Density, g/cm ³	1.6363
Solubility in water, g/100cm ³ (0°C)	223

Magnesium nitrate, hexahydrate, technical grade, is commercially available with a purity of from 99 to 99.995 percent by weight.

5.3.3. Use. Magnesium nitrate, hexahydrate, is intended for military use in the production of pyrotechnics. Commercial use is the same.

5.3.4 Packaging. Refer to 4.1

5.3.5 Safety precautions.

a. Health hazard. Magnesium nitrate particles can be irritating to the eyes and upper respiratory tract. The PEL for nuisance dust is 5 mg/m³ for the respirable fraction and 15 mg/m³ as total dust. The TLV for nuisance particles is 5 mg/m³ as respirable dust and 10 mg/m³ as total dust. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Magnesium nitrate will not burn. If present in a fire, it can support combustion as an oxidizing agent. In contact with easily oxidizable material, violent combustion or an explosion can result in ignition. When heated to decomposition, it releases irritating and toxic fumes of magnesium oxide, nitric acid and nitrogen tetroxide (nitrogen dioxide). The PEL for magnesium oxide fumes is 15 mg/m³, and the TLV is 10 mg/m³. The PEL and TLV for nitric acid is 5 mg/m³. The PEL for nitrogen dioxide, as a ceiling limit, is 9 mg/m³, and the TLV is 6 mg/m³.

c. Reactivity. Magnesium nitrate reacts with sulfuric acid to release irritating and toxic fumes of nitric acid. It is also reactive as an oxidizing agent.

5.3.6 Storage. Magnesium nitrate, hexahydrate, shall be stored in a cool, dry space in tightly sealed containers to prevent contact with moisture vapor. It shall be stored away from combustible or oxidizable material. Refer to 4.3.2.

5.3.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - Ignitable; Waste No. D001.

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5.4	<u>Name.</u> MAGNESIUM OXIDE, TECHNICAL Magnesia Periclase (natural)	MgO	FW 40.31 CAS 1309-48-4
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5.4.1 Specification. MIL-M-14779 Magnesium Oxide, Calcined (For Use in Ammunition); and MIL-M-51103 Magnesium Oxide, Technical.

5.4.2 Technical description. Magnesium oxide (pure) exists in the form of colorless cubic crystals with the physical properties shown in Table V. The crystals are ionic in structure. It is practically insoluble in water, and is insoluble in alcohol. It can absorb carbon dioxide and moisture from the atmosphere. It is dissolved by acidic solutions, including those of ammonium salts. Magnesium oxide, prepared by heating magnesite ($MgCO_3$) at 600° to $800^\circ C$, is a low density powder containing a small percentage of carbon dioxide. It is slowly reactive with water, forming $Mg(OH)_2$, and it is dissolved by aqueous carbon dioxide solution, forming soluble $Mg(HCO_3)_2$. Magnesium oxide, prepared by heating $MgCO_3$ above $1400^\circ C$, is a high density powder that does not contain carbon dioxide, and is not reactive with water.

Magnesium oxide, technical grade, is commercially available with a minimum purity of 97.0 percent by weight in low reactivity, high reactivity, and very high reactivity grades. The low reactivity grade is a high density material.

Table V. Magnesium oxide - physical properties.

Density, g/cm^3	3.58
Refractive index	1.736
Melting point, $^\circ C$	2800
Boiling point, $^\circ C$	3600
Solubility in water, $g/100cm^3$	
(Cold)	0.00062
($30^\circ C$)	0.0086

Military specification MIL-M-14779 covers one type of calcined magnesium oxide with the chemical and physical requirements shown in Table VI.

Table VI. Magnesium oxide - chemical and physical requirements.

	Min	Max
Magnesium, as MgO , wt %	97.2	---
Calcium, as CaO , wt %	---	1.00
Silica, as SiO_2 , wt %	---	0.34
Iron, as Fe_2O_3 , wt %	---	0.18

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Table VI. Magnesium oxide - chemical and physical requirements (continued).

	Min	Max
Aluminum, as Al ₂ O ₃ , wt %	---	---
Loss of ignition, wt %	---	0.15
Iodine number, meq/100g	85	10.0
Bulk density, loose, 1lb/ft ³	8.0	---
kg/m ³	128	---
g/100mL	12.8	---
† Screen size, % by wt		
Retained on 75 micrometer sieve (No. 200), wet	---	0.2
Retained on 45 micrometer sieve (No. 325), wet	---	0.5

† Sieve designation in accordance with ASTM E 11 or ASTM E 323 as applicable.

Military specification MIL-M-51103 covers two types of magnesium oxide, technical grade, with the chemical and physical requirements shown in Table VII.

Type I - Low density

Type II - High density, calcined

Table VII. Magnesium oxide, technical - chemical and physical requirements.

	Type I		Type II	
	Min	Max	Min	Max
Ignition loss, wt %	---	8.0	---	8.0
Calcium (as CaO), calcined basis, wt %	---	2.0	---	2.0
Magnesium (as MgO) calcined basis, wt %	96.0	---	92.0	---
Carbon dioxide (CO ₂), wt %	---	---	---	2.0
Water-soluble alkali (as Na ₂ CO ₃), wt %	---	---	---	0.2
Total water-soluble matter, wt %	---	---	---	1.0
Hydrochloric acid-insoluble matter, wt %	---	---	---	1.5
Iron (as Fe ₂ O ₃), wt %	---	---	---	0.3
Iodine number, meq/100g	---	---	20	50
Apparent density, g/100mL	6	12	---	60

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5.4.3 Use. Magnesium oxide, low density, is intended for military use as an antacid and in the manufacture of munitions. Magnesium oxide, high density, calcined, is intended for military use as a reinforcing agent for propellants and in aerial mines. Commercial applications include use in refractories, electrical insulation, for the production of other magnesium compounds, and for removal of sulfur dioxide fumes from stack gases.

5.4.4 Packing. Refer to 4.1.

5.4.5 Safety precautions.

a. Health hazard. Magnesium oxide particles can be irritating to the eyes and upper respiratory tract. The PEL as a nuisance dust is 5 mg/m³ for the respirable fraction and 15 mg/m³ as total dust. The TLV for nuisance particles is 5 mg/m³ as respirable dust and 10 mg/m³ as total dust. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Magnesium oxide will not burn. If present in a fire, it can release irritating and toxic fumes of magnesium oxide. The PEL for magnesium oxide fumes is 15 mg/m³, and the TLV is 10 mg/m³.

c. Reactivity. Magnesium oxide is reactive with acids.

5.4.6 Storage. Magnesium oxide shall be stored in a dry space in tightly sealed containers to prevent contact with moisture vapor. It shall be stored away from acids or acidic materials. Refer to 4.3.2.

5.4.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.5	<u>Name</u> . MANGANESE CARBONATE, TECHNICAL	MnCO ₃	FW 114.95
	Manganese(II)carbonate		
	Manganous carbonate		CAS 598-62-9
	Rhodochrosite		

5.5.1 Specifications. MIL-M-13667 Manganese Carbonate, Technical.

5.5.2 Technical description. Manganese carbonate (pure) is in the form of rose-colored rhombic crystals with the physical properties shown in Table VIII. The crystals are ionic in structure. It oxidizes on exposure to air and turns light brown in

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color. It decomposes on heating. It is practically insoluble in water, with solubility dependent on the CO_2 content of the water. It is dissolved by dilute acids with formation of $\text{Mn}(\text{HCO}_3)_2$ and by excess acid with the evolution of CO_2 . The theoretical Mn content of MnCO_3 is 47.8 percent.

Table VIII. Manganese carbonate - physical properties.

Density, g/cm^3	3.125
Solubility in water (25°C), $\text{g}/100\text{cm}^3$	0.0065

Military specification MIL-M-13667 covers one technical grade of manganese carbonate with the chemical requirements shown in Table IX.

Table IX. Manganese carbonate, technical - chemical requirements.

	Percent by Weight	
	Min	Max
Assay, as Mn	44.6	---
Chloride, as Cl	---	0.02
Sulfate, as SO_4	---	0.06
Alkalies and earths	---	0.80

Manganese carbonate, technical grade, is commercially available with a minimum manganese content of 44.0 percent.

5.5.3 Use. Manganese carbonate, technical grade, is intended for military use in rustproofing processes. Commercial applications include the manufacture of manganese salts and other compounds.

5.5.4 Packaging. Refer to 4.1

5.5.5 Safety precautions.

a. Health hazard. Manganese carbonate dust can be irritating to the eyes, skin and upper respiratory tract. It is toxic by inhalation. The TLV for manganese dust and compounds, as Mn, is 5 mg/m^3 as a ceiling limit. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Manganese carbonate is not burnable. If present in a fire, it can decompose and release carbon dioxide and manganese oxide

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fumes. The carbon dioxide can help extinguish the fire. The manganese oxide fumes are toxic by inhalation. The TLV for manganese fumes is 1 mg/m³.

c. Reactivity. Manganese carbonate reacts with acids to release carbon dioxide gas. The manganese(II) ion can be oxidized.

5.5.6 Storage. Manganese carbonate shall be stored in dry space away from acidic fumes or vapors. Containers shall be tightly sealed to prevent access by air. Refer to 4.3.2.

5.5.7 Disposal. In case of spills, gather up the dry powder and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.6	<u>Name</u> . MANGANESE DIOXIDE, TECHNICAL	MnO ₂	FW 86.94
	Manganese binoxide		
	Manganese(IV)oxide		CAS 1313-13-9
	Pyrolusite (natural)		

5.6.1 Specification. MIL-M-3281 Manganese Dioxide, Technical.

5.6.2 Technical description. Manganese dioxide (pure) is in the form of black rhombic crystals or a brown-black powder with a density of 5.026 g/cm³. It decomposes on heating to 535°C, forming Mn₃O₄ and releasing oxygen. It is insoluble in water and acetone. It functions as an oxidizing agent, and also as a catalyst for the decomposition of chlorate salts. It dissolves in concentrated KOH to give a blue dilution containing Mn(V) and Mn(III). It is dissolved by concentrated hydrochloric acid to give a solution of unstable manganese(IV)chloride. The unstable MnCl₄ decomposes to manganous chloride and chlorine. The overall equation for the reactions are: $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$. With warm sulfuric acid, it forms the unstable manganese(IV)sulfate, Mn(SO₄)₂, which decomposes to oxygen and a manganese(III) acid sulfate. Manganese dioxide can be fused with other metal oxides to give metal manganites, the salts of the hypothetical manganous acid, H₂MnO₃, such as CaMnO₃. The theoretical manganese content of MnO₂ is 63.3 percent.

Military specification MIL-M-3281 covers two types of manganese dioxide with the chemical requirements shown in Table X, and the particle size requirements shown in Table XI.

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Table X. Manganese dioxide, technical - chemical requirements.

	Percent by Weight	
	Type I	Type II
Manganese content, min	55.0	50.0
Available oxygen, min	15.6	14.5
Moisture content, max	2.5	1.0

Table XI. Manganese dioxide, technical - particle size distribution.

Sieve Size †	Percent by Weight Retained			
	Type I		Type II	
	Min	Max	Min	Max
300 micrometer sieve (No. 50)	0	---	1.0	---
150 micrometer sieve (No. 100)	---	---	80.0	---
75 micrometer sieve (No. 200)	66.0	40.0	---	75.0

† Sieve designation in accordance with ASTM E 11 or ASTM E 323 as applicable.

In addition, Type II manganese dioxide shall have a surface area of not more than 10.0 square meters per gram.

5.6.3 Use. Manganese dioxide, technical grade, is intended for military use as follows:

Type I - For use in pyrotechnics.

Type II - For use in smoke mixtures.

Commercial applications include use as an oxidizing agent, as a depolarizer in dry cell batteries, and as a decolorizer for glass. It is a raw material for the production of pure manganese by reduction with aluminum, and for the production of iron alloys by reduction of the mixed oxides of manganese and iron with coke.

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5.6.4 Packaging. Refer to 4.15.6.5. Safety precautions.

a. Health hazard. Manganese dioxide dust can be irritating to the eyes, skin and upper respiratory tract. It is toxic by inhalation and ingestion. The TLV for manganese dust and compounds, as Mn, is 5 mg/m³ as a ceiling limit. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Manganese dioxide will not burn. If present in a fire, it can decompose and release manganese oxide fumes and oxygen. The oxygen can support combustion and increase the burning rate. The manganese oxide fumes are toxic by inhalation. The TLV for manganese fumes is 1 mg/m³.

c. Reactivity. Manganese dioxide is reactive as an oxidizing agent. It can react with concentrated hydrochloric acid to release toxic chlorine fumes.

5.6.6 Storage. Manganese dioxide shall be stored in a cool, dry space away from burnable materials. Containers shall be tightly sealed to prevent access by moisture vapor. Refer to 4.3.2.

5.6.7 Disposal. In case of spills, gather up the dry powder and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.7	<u>Name</u> . MERCUROUS CHLORIDE, TECHNICAL	Hg ₂ Cl ₂	FW 472.09
	Calomel		
	Mercury(I)chloride		CAS 10112-91-1

5.7.1 Specification. Manufacturers Requirement (No Government Specification).

5.7.2 Technical description. Mercurous chloride (pure) is in the form of white tetragonal crystals with the physical properties shown in Table XII. The dimeric compound Hg₂Cl₂ has a linear covalent structure with a metal to metal bond between the two mercury atoms. It is practically insoluble in water, and it is insoluble in alcohol and ether. It is oxidized and dissolved by nitric acid and aqua regia. It decomposes to Hg and HgCl₂ on exposure to light. It reacts with alkali hydroxides, forming unstable Hg₂O which decomposes into Hg and HgO. It reacts with aqueous ammonia, forming finely divided black mercury and the white mercury(II)amidochloride (HgNH₂Cl). It is readily reduced to metallic mercury by reducing agents.

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Table XII. Mercurous chloride - physical properties.

Density, g/cm ³	7.150
Sublimation point, °C	400
Solubility in water, g/100cm ³	
(25°C)	0.00020
(43°C)	0.001

Cancelled military specification JAN-M-201 covered one grade of mercurous chloride with the chemical and physical requirements shown in Table XIII.

Table XIII. Mercurous chloride - chemical and physical requirements.

Mercurous chloride, % min	99.6
Moisture, % max	0.1
Nonvolatile matter, % max	0.2
Apparent density, g/mL	2.2 ± 0.2
† Granulation, % by wt	
Retained on 75 micrometer sieve (No. 50)	5.0
Retained on 180 micrometer sieve (No. 200)	0.1

† Sieve designation in accordance with ASTM E 11 or ASTM E 323 as applicable.

5.7.3 Use. Mercurous chloride is intended for military use in the manufacture of tracer compositions. Commercial applications include use in pyrotechnics and as a fungicide.

5.7.4 Packaging. Refer to 4.1.

5.7.5 Safety precautions.

a. Health hazard. Mercurous chloride particles can be irritating to the eyes, skin and mucous membranes. The TLV for inorganic mercury compound is 0.1 mg/m³, as Hg-skin. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Mercurous chloride will not burn. It can be vaporized and oxidized to the more toxic mercuric form if present in a fire.

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c. Reactivity. Mercurous chloride reacts with oxidizing agents to form the more toxic mercuric compounds. It reacts with reducing agents to form metallic mercury.

5.7.6 Storage. Mercurous chloride shall be stored in a cool, dry space away from oxidizing agents and fire hazards. Refer to 4.3.2.

5.7.7 Disposal. In case of spills, gather up the dry powder and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. Mercury is listed in 40 CFR, Section 261.24 Table 1 for toxicity characteristics. Mercurous chloride will exhibit the characteristic of toxicity for mercury. Designations of TCLP waste apply only to material declared as waste.

5.8	<u>Name.</u> MERCURY FULMINATE, TECHNICAL	Hg(CNO) ₂
	Mercury cyanate	FW 284.62
	Mercury(II)fulminate	CAS 628-86-4

5.8.1 Specification. Manufacturers Requirement (No Government Specification).

5.8.2 Technical description. Mercury fulminate (pure) is in the form of white cubic crystals with a density of 4.42 g/cm³. It is slightly soluble in cold water, and is soluble in hot water and alcohol. It is dissolved by aqueous NH₄OH. Mercury fulminate is an explosive compound with a detonation temperature of 180°C. It also explodes when struck.

Cancelled military specification JAN-M-219 covered one grade of mercury fulminate consisting of crystals of sparkling appearance which are white, gray, or light gray with a yellowish tint in appearance. The chemical and physical requirements are shown in Table XIV.

Table XIV. Mercury fulminate - chemical and physical requirements.

Mercury fulminate, % min	98.0
Acidity	None
Insoluble matter, % max	2.0
Free Hg, % max	1.0
Chlorine, % max	0.05

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Table XIV. Mercury fulminate - chemical and physical requirements (continued).

† Granulation (US Standard Sieves)	
Retained on 75 micrometer sieve (No. 200), % by wt	25
Retained on 150 micrometer sieve (No. 100), % by wt	15

† Sieve designation in accordance with ASTM E 11 or ASTM E 323 as applicable.

5.8.3 Use. Mercury fulminate is intended for military use in detonators and primers. Commercial applications are the same, and include use in percussion caps.

5.8.4 Packaging. Refer to 4.1.

5.8.5 Safety precautions.

a. Health hazard. Mercury fulminate particles can be irritating to the eyes, skin and upper respiratory tract. It can be very toxic as a mercuric compound. The TLV for inorganic mercury compounds is 0.1 mg/m³, as Hg-skin. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Mercury fulminate is a severe explosive hazard, and is very sensitive to heat, impact and friction when dry.

c. Reactivity. Mercury fulminate is very reactive as an explosive. It can be converted to nonexplosive products by reaction with cold sodium thiosulfate solution.

5.8.6 Storage. Mercury fulminate shall be stored in approved containers in a cool space approved for explosives, and away from other explosives and fire hazards. It shall be kept moist until used. Refer to 4.3.2.

5.8.7 Disposal. In case of spills, keep the material moist and place in approved containers for use or disposal. Spill residues shall be neutralized with cold sodium thiosulfate solution. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - Acute Hazardous (R, T); Waste No. P065.

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- 5.9 Name. MOLYBDENUM DISULFIDE, TECHNICAL MoS₂ FW 160.07
 Molybdenite (natural)
 Molybdenum(IV)sulfide CAS 1317-33-5
 Molybdic sulfide

5.9.1 Specification. MIL-M-7866 Molybdenum Disulfide, Technical, Lubrication Grade.

5.9.2 Technical description. Molybdenum disulfide is in the form of black lustrous hexagonal crystals in which the repeating unit is a sandwich consisting of a hexagonal sheet of molybdenum atoms between two hexagonal sheets of sulfur atoms. The sulfur sheets are superimposed and the molybdenum sheet shifted so that each molybdenum atom is at the center of a trigonal prism formed by six sulfur atoms. The forces between sulfur atoms of adjacent layers are weak, and MoS₂ has lubricating properties similar to those of graphite. It has a density of 4.80 g/cm³ and a melting point of 1185°C. It is insoluble in water. It can be dissolved by strong oxidizing acids such as aqua regia, hot nitric acid, and boiling concentrated sulfuric acid. It can be attacked by chlorine and oxygen at elevated temperatures to give MoCl₅ and MoO₃.

Military specification MIL-M-7866 covers one grade of powdered molybdenum disulfide with the chemical and physical requirements shown in Table XV.

Table XV. Molybdenum disulfide, technical - chemical and physical requirements.

Molybdenum disulfide, % min	98.0
Moisture (loss of weight), % max	0.7
Water solubles, % max	0.5
Oil content (acetone extractable), % max	0.5
Total insolubles, % max	1.0
Corrosion resistance <u>1/</u>	Pass
Steel and copper corrosion <u>2/</u>	Pass
Fineness (average particle size) micrometer <u>3/</u>	4 to 10

- 1/ The molybdenum sulfide, when in the form of a bonded solid film, shall show or cause no discoloration, pitting, formation of white deposits, or other evidence of corrosion.
- 2/ The molybdenum disulfide shall cause no pitting, etching, or heavy staining on polished copper or sandblasted steel surfaces. A slight stain or discoloration shall not be cause for rejection.
- 3/ Determined by using a Fisher Sub-Sieve Sizer or equivalent.

5.9.3 Use. Molybdenum disulfide, technical, lubrication grade, is intended for military use as a lubricant, contained in grease and solid films for application to

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surfaces over a wide temperature range, under conditions where boundary lubrication exists. Commercial applications of molybdenum disulfide include use in lubricants, such as greases, oil dispersions, resin-bonded films, and dry powders. It is also used as a hydrogenation and isomerization catalyst.

5.9.4 Packaging. Refer to 4.1

5.9.5 Safety precautions.

a. Health hazard. Molybdenum disulfide particles can be irritating to the eyes, skin and upper respiratory tract. The PEL for insoluble molybdenum compounds, as Mo, is 15 mg/m³, and the TLV 10 mg/m³. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Molybdenum disulfide will burn and can release toxic fumes of molybdenum trioxide and sulfur dioxide if present in a fire. The PEL of sulfur dioxide is 13 mg/m³, and the TLV is 5 mg/m³.

c. Reactivity. Molybdenum disulfide is reactive with strong oxidizing agents at elevated temperatures.

5.9.6 Storage. Molybdenum disulfide shall be stored in a cool, dry space away from concentrated acid solutions and oxidizing agents. Containers shall be tightly closed to prevent access by moisture vapor. Refer to 4.3.2.

5.9.7 Disposal. In case of spills, gather up the dry powder and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. EPA Hazardous Waste Classification - None.

5.10 Name. NICKEL AMMONIUM SULFATE, HEXAHYDRATE, TECHNICAL
 $\text{NiSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ FW 395.00
 $(\text{NH}_4)_2\text{SO}_4 \cdot \text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
 $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Ni}(\text{H}_2\text{O})_6\text{SO}_4$ CAS 7785-20-8
 Ammonium nickel sulfate, hexahydrate
 Ammonium sulfate-hexaaquonickel(II)sulfate

5.10.1 Specifications. DOD-N-51512 Nickel Salts, Electroplating (Metric).

5.10.2 Technical description. Nickel ammonium sulfate, hexahydrate, (pure) is in the form of dark blue-green monoclinic crystals. It is a double salt with the physical properties shown in Table XVI. It is soluble in water, and insoluble in alcohol. The aqueous solutions are acidic. The hexaaquo nickel(II)ion $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ imparts a green color to the aqueous solution of the salt, and to the crystals of the sulfate salt. The

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water molecules of the hydrated ion can be displaced by NH_3 in aqueous ammonia solutions, forming blue or purple ammine complexes.

Table XVI. Nickel ammonium sulfate, hexahydrate - physical properties.

Density, g/cm ³	1.923
Solubility in water, g/100 cm ³ (20°C)	10.4
(80°C)	30

The theoretical nickel content, as Ni, is 14.9 percent. Military specification DOD-N-51512 covering electroplating nickel salts includes type II as nickel ammonium sulfate (double salt), $\text{NiSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$, with the chemical requirements shown in Table XVII.

Table XVII. Nickel ammonium sulfate - chemical requirements.

Nickel content (plus cobalt), as Ni, % min	14.6
Iron, as Fe, % max	0.02
Zinc, as Zn, % max	0.025
Copper, as Cu, % max	0.005
Free acid, as H_2SO_4 , % max	0.10
Insoluble matter, % max	0.05

5.10.3 Use. Nickel ammonium sulfate is intended for military use in electroplating. Commercial uses are as a nickel electrolyte in electroplating.

5.10.4 Packaging. Refer to 4.1

5.10.5 Safety precautions.

a. Health hazard. Nickel ammonium sulfate particles can be irritating to the eyes, skin and upper respiratory tract. It is a suspected carcinogen. The PEL for soluble nickel compounds, as Ni, is 1 mg/m³, and the TLV is 0.1 mg/m³. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Nickel ammonium sulfate will not burn. If present in a fire, it can decompose and release irritating and toxic fumes of sulfur dioxide.

c. Reactivity. Nickel ammonium sulfate is not dangerously reactive.

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5.10.6 Storage. Nickel ammonium sulfate shall be stored in a cool, dry space in tightly closed containers. Refer to 4.3.2.

5.10.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4.

5.11 Name. NICKEL CHLORIDE, HEXAHYDRATE $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ FW 237.70
 Nickel(II)chloride, hexahydrate
 Nickelous chloride, hexahydrate CAS 7791-20-0

5.11.1 Specification. DOD-N-51512 Nickel Salts, Electroplating.

5.11.2 Technical description. Nickel chloride, hexahydrate (pure), is in the form of green monoclinic crystals that are deliquescent. The physical properties are shown in Table XVIII. It is very soluble in water and alcohol. The aqueous solutions are acidic. The hexaquo nickel(II) ion $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ imparts a green color to the aqueous solutions of the salt. The water molecules of the hydrated ion can be displaced by NH_3 in aqueous ammonia solutions, forming blue or purple ammine complexes. The hydrated salt crystals of $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ contain trans- $[\text{NiCl}_2(\text{H}_2\text{O})_4]$ units. The hydrated salt can be converted to the anhydrous NiCl_2 by heating in a stream of HCl.

Table XVIII. Nickel chloride, hexahydrate - physical properties.

Refractive index	1.57
Solubility in water, g/100cm ³	
(20°C)	254
(100°C)	599

The theoretical nickel content, as Ni, is 24.6 percent. Nickel chloride, hexahydrate is commercially available with a nickel content, as Ni, of 24.55 percent.

Military specification DOD-N-51512 covering electroplating nickel salts includes type III as nickel chloride, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, with the chemical requirements shown in Table XIX.

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Table XIX. Nickel chloride - chemical requirements.

Nickel content (plus cobalt), as Ni, % min	24.5
Iron, as Fe, % max	0.02
Zinc, as Zn, % max	0.025
Copper, as Cu, % max	0.005
Free acid, as HCl, % max	0.10
Insoluble matter, % max	0.05

5.11.3 Use. Nickel chloride is intended for military use in electroplating. Commercial uses are as a nickel electrolyte in electroplating.

5.11.4 Packaging. Refer to 4.1

5.11.5 Safety precautions.

a. Health hazard. Nickel chloride particles can be irritating to the eyes, skin and upper respiratory tract. It is a suspected carcinogen. The PEL for soluble nickel compounds, as Ni, is 1 mg/m³, and the TLV is 1 mg/m³. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Nickel chloride is not burnable.

c. Reactivity. Nickel chloride is not dangerously reactive.

5.11.6 Storage. Nickel chloride shall be stored in a cool, dry space in tightly closed containers to prevent access by moisture vapor. Refer to 4.3.2.

5.11.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4.

5.12 Name. NICKEL SULFATE, HEXAHYDRATE NiSO₄·6H₂O FW 262.86
Nickel(II)sulfate, hexahydrate
CAS 10101-97-0

5.12.1 Specification. DOD-N-51512 Nickel Salts, Electroplating.

5.12.2 Technical description. Nickel sulfate, hexahydrate (pure), has two crystalline forms, α and β . The α -form consists of blue tetragonal crystals and the β -form consists of green monoclinic crystals, with the physical properties shown in Table XX. It is very soluble in water, and less soluble in methyl and ethyl alcohols.

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Table XX. It is very soluble in water, and less soluble in methyl and ethyl alcohols. The aqueous solutions are acidic. The hexaquo nickel(II) ion $[\text{Ni}(\text{H}_2\text{O}_6)]^{2+}$ imparts a green color to the aqueous solutions of the salt, and to the crystals of the β -form. The water molecules of the hydrated ion can be displaced by NH_3 in aqueous ammonia solutions, forming blue or purple ammine complexes. The theoretical nickel content, as Ni, is 22.4 percent.

Table XX. Nickel sulfate, hexahydrate - physical properties.

Density, g/cm ³	2.07
Transition point, °C	53.3
Dehydration point, °C	103
Solubility in water, g/100cm ³	
(0°C)	62.52
(100°C)	340.7
Solubility in methyl alcohol, g/100cm ³	12.5

Military specification DOD-N-51512 covering electroplating nickel salts includes type I as nickel sulfate, $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$, or a mixture of it with $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$. The chemical requirements are shown in Table XXI.

Table XXI. Nickel sulfate - chemical requirements.

Nickel content (plus cobalt), as Ni, % min	21.4
Iron, as Fe, % max	0.02
Zinc, as Zn, % max	0.025
Copper, as Cu, % max	0.005
Free acid, as H_2SO_4 , % max	0.10
Insoluble matter, % max	0.05

Nickel sulfate, hexahydrate, is commercially available with a nickel (plus cobalt) content, as Ni, of 22.3 percent.

5.12.3 Use. Nickel sulfate is intended for military use in electroplating. Commercial applications include the above, and use as an intermediate in the manufacture of nickel ammonium sulfate and nickel catalysts.

5.12.4 Packaging. Refer to 4.1

5.12.5 Safety precautions.

a. Health hazard. Nickel sulfate particles can be irritating to the eyes, skin and upper respiratory tract. It is a suspected carcinogen. The PEL for soluble

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protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Nickel sulfate will not burn. If present in a fire, it can decompose and release irritating and toxic fumes of sulfur dioxide.

c. Reactivity. Nickel sulfate is not dangerously reactive.

5.12.6 Storage. Nickel sulfate shall be stored in a cool, dry space in tightly closed containers. Refer to 4.3.2.

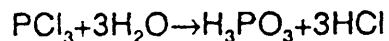
5.12.7 Disposal. In case of spills, gather up the dry material and place in containers for use or disposal. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4.

5.13 Name. PHOSPHORUS TRICHLORIDE, TECHNICAL PCl_3 FW 137.33
Phosphorus(III)chloride

CAS 7719-12-2

5.13.1 Specification. MIL-P-10398 Phosphorus Trichloride, Technical.

5.13.2 Technical description. Phosphorus trichloride (pure) is a colorless liquid with the physical properties shown in Table XXII. It is soluble in ether, benzene chloroform, carbon disulfide, and carbon tetrachloride. It is irreversibly hydrolyzed by water with formation of phosphorous acid and hydrogen chloride, as shown by the reaction:



It is also decomposed by alcohols. It fumes in moist air, as concentrated hydrochloric acid does, because of the hydrolysis reaction. It reacts with oxygen to give phosphorus oxychloride, POCl_3 , also called phosphoryl chloride. It is reactive with excess Cl_2 forming PCL_5 .

Table XXII. Phosphorus chloride - physical properties.

Density, (21°C), g/cm ³	1.574
Refractive index (14°C)	1.516
Melting point, °C	-112
Boiling point (745 mm Hg)	75.5

Military specification MIL-P-10398 covers one technical grade of phosphorus trichloride with the physical requirements shown in Table XXIII.

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Table XXIII. Phosphorus trichloride - physical requirements.

	Minimum	Maximum
Color, Pt-Co scale	---	No. 5
Specific gravity (15.5°/15.5°C)	1.582	1.588
Distillation range (760 mm Hg), °C		
Initial boiling point	74.5	---
Dry point	---	79.0
Total range	---	3.0

Phosphorus trichloride, technical, is commercially available with a minimum assay of 99.5 percent.

5.13.3 Use. Phosphorus trichloride is intended for military use as a chlorinating agent and as a phosphorus solvent. Commercial applications include: the production of phosphorus oxychloride, alkyl and aryl phosphites, and phosphite and phosphonate esters. It is also used as a chlorinating agent for the production of acid chlorides, as a chlorination catalyst, and as a condensing agent in organic synthesis.

5.13.4 Packaging. Refer to 4.1

5.13.5 Safety precautions.

a. Health hazard. Phosphorus trichloride vapors and hydrochloric acid fumes, resulting from reaction with atmospheric moisture, are toxic and highly irritating to the eyes, skin and upper respiratory tract. The liquid is corrosive and very injurious to eyes and skin. The PEL for phosphorus trichloride is 3 mg/m³ and the TLV is 1.5 mg/m³. For personal protective measures, refer to 4.3.1.

b. Fire and explosion hazard. Phosphorus trichloride can react with oxygen in the air or water or with moisture. The heat of reaction can cause ignition and fire.

c. Reactivity. Phosphorus trichloride is reactive with halogens and other strong oxidizing agents.

5.13.6 Storage. Phosphorus trichloride shall be stored in a cool, dry space in tightly sealed containers to prevent contact with air or moisture. Refer to 4.3.2.

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5.13.7 Disposal. In case of small liquid spills, cover with a dry absorbent and place in sealed containers for disposal. In case of large liquid spills, dike to prevent spreading, cover with a dry absorbent and place in sealed containers for disposal. Absorbents can be mixed with soda ash or lime as an acid neutralizer. For appropriate procedures, contact the Installation Environmental Office, the DRMO, or Safety and Health Offices. Refer to 4.4.4. Phosphorus trichloride is on the EPA list of hazardous substances.

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6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended to cite nomenclature, Chemical Abstract Service Registry Numbers, formulas, physical and chemical properties, specification requirements, military and typical commercial uses, safety information, storage information and disposal information for Inorganic Salts and Compounds, Technical Grade (Magnesium Carbonate through Phosphorus Trichloride) preferred for application by the Department of Defense.

6.2 Subject term (key word) listing.

Exposure limits, hazardous chemicals
Hazardous wastes, disposal and storage of
Information, hazardous chemicals
Magnesium carbonate, basic hydrated, technical
Magnesium chloride, hexahydrate, technical
Magnesium nitrate, hexahydrate, technical
Magnesium oxide, technical
Magnesium carbonate, technical
Magnesium dioxide, technical
Mercurous chloride, technical
Mercury fulminate, technical
Molybdenum disulfide, technical
Nickel ammonium sulfate, hexahydrate, technical
Nickel chloride, hexahydrate, technical
Nickel sulfate, hexahydrate, technical
Phosphorus trichloride, technical
Safety, hazardous chemicals

6.3 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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3. DOCUMENT TITLE INORGANIC SALTS AND COMPOUNDS, TECHNICAL GRADE (MAGNESIUM CARBONATE THROUGH PHOSPHORUS TRICHLORIDE)			
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