MIL-STD-1420

1 AUGUST 1979

MILITARY STANDARD

ION EXCHANGE COMPOUNDS

(NOT FOR NUCLEAR APPLICATIONS)

FSC 6810

DEPARTMENT OF DEFENSE
Washington, D.C. 20301

Ion Exchange Compounds

MIL-STD- 1420

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletion) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Armament Research and Development Command, Attn: DRDAR-TSC-S, Aberdeen Proving Ground, MD 21010, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This is the first book format standard generated on ion exchange compounds. 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 is not a procurement document.

CONTENTS

Page

TABLES

1. SCOPE

1.1 Coverage. This standard is a presentation of nomenclature, symbols, physical and chemical properties and requirements, military and typical commercial uses, directions for use, packaging data, labeling, general safety precautions, storage information, disposal data, toxicity data and shelf life of all military standard ion exchange compounds. This standard does not necessarily include all classifications of the items represented by the title or those which are commercially available. It does contain items preferred for use in the selection of ion exchange compounds for application by the Department of Defense. This standard does not cover ion exchange resins required for nuclear application. This standard covers the following seven items.

NAME	NO. OF ITEMS
STRONGLY ACIDIC, CATION EXCHANGE	2
WEAKLY ACIDIC, CATION EXCHANGE	1
STRONGLY BASIC, ANION EXCHANGE	3
WEAKLY BASIC, ANION EXCHANGE	1

1.2 Application. Items listed herein accommodate essential requirements of the military and defense agencies, and will effect continued economies in all logistics functions when properly employed in new applications.

2. REFERENCED DOCUMENTS

The issue of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein.

Federal Specifications

O-I-1279	Ion Exchange Compound
PPP-C-300	Chemical, Liquid, Packaging and Packing of
PPP-C-301	Chemical, Dry and Paste, Packaging & Packing of

Military Specifications

MIL-I-52695	Ion Exchange Compounds

3. GLOSSARY

3.1 Definitions.

Commercial grade ion exchange resin - The grade of ion exchange resins that are used for routine laboratory work.

Gel ion exchange resins - Transparent, homogeneous, single-phase resins that hold the absorbed water uniformly throughout the resin. The fixed charges in the resins are held immobile but counter ions are able to diffuse through the gel water at a rate considerably less than free water. Penetration of small inorganic ions by diffusion into and out of the gel is uniform and the rate is dependent on the degree of cross-linking of the polymer.

Ion exchange - An irreversible, chemical reaction between a solid ion exchanger and a fluid, usually a water solution, in which ions may be interchanged from one substance to another.

Ion exchange capacity - The total number of ion exchange sites in a unit volume is a measure of the ion exchange capacity of a resin. The exchange capacity is usually expressed in Kgr/cu ft.

Macroporous ion exchange resins - These resins are opaque and diffuse rapidly in the pore phase. The penetration of the resin is slow and generally has a lower ion exchange capacity than gel resins.

Pharmaceutical and medicinal grade ion exchange resins - These resins are used in processing or production of food and drugs for humans and animals. The compounds must comply with the Food and Drug Administration Regulations No. 121.1148.

Porosity - The porosity of a solid is defined as the ratio of the volume of interstices to that of its solid content.

Regeneration - Regeneration is the reversibility of ion exchange reactions which makes it possible to replenish the supply of the desired ions when the resin is exhausted.

Resin life - The number of cycles or years of operation before the resin has to be replaced.

4. GENERAL REQUIREMENTS

4.1 Chemical and physical requirements. All values given in tables of chemical and physical requirements are in percent by weight unless otherwise indicated.

4.2 Nomenclature. The Department of Defense item names, as used throughout this standard, are in capital letters. Other names that are sometimes used commercially are in small letters immediately beneath.

4.3 Packaging data and labeling. All chemicals included in this standard shall be packaged in accordance with Federal Specification PPP-C-300 and PPP-C-301 and all applicable documents mentioned in this specification.

4.4 Safety. Personal Protective Measures.

4.4.1 Respiratory Protection. Respirators approved by NIOSH for the ion exchange compound being used, should be used for intermittent exposure or for supplementing other control measures (refer to TB MED 223).

4.4.2 Skin Protection. Personnel using these resins should be provided with and required to use impervious gloves, sleeves and aprons whenever indicated. Face shields must be provided and worn whenever splashing may occur. Protective creams and ointments, commonly known as "barrier creams", may be of value in certain cases.

4.4.3 Eye Protection. Personnel using these resins should be provided with and required to wear spectacles with side shields.

4.5 Shelf life. Factors such as moisture, temperature, type and condition of container, exposure to sunlight and the atmosphere cause variations in shelf life. Ideal storage conditions are outlined for each item. An approximate period of time after which the material will no longer be suitable for its intended use is also presented. The term "cool" denotes temperatures from above freezing up to 110 degrees Fahrenheit (43°C) when stored out of direct sunlight. The term "dry" is usually used to denote an area where condensation does not come in contact with the packages or contents (for example, storing on pallets away from walls in an enclosure or building). Periodic examinations of the contents or material should be made more frequently when storage conditions vary from the ideal. For applications where quality may be critical, each compound shall be analyzed prior to use. Shelf life is dated from the date of manufacture. All chemicals in this standard shall be the latest date of manufacture, when purchased.

4.6 Temperature. If the temperature at which a property was determined is not specified, it is to be room temperature (20 to 25°C or 68 to 77°F).

4.7 Toxicity data. Toxicity data is determined from the Handbook of Toxicity, American Conference of Government Industrial Hygienists and Material Safety Data Sheets.

4.8 Use data. Typical commercial uses are given without regard to specific grades. Ion Exchange Resins for military use are used for water treatment, metals recovery, organic purification, waste disposal, ion exclusion, ion retardation, laboratory analysis, pharmaceutical and medical use, reaction catalysis, acid-base separations, chromatography, isolation of desirable ionic constituents from contaminated solution and electrodialysis.

4.9 Pollution Potential. All items described in this MIL-STD should be assumed to have a pollution potential, however, to minimize the potential, use, storage and disposal instructions must be strictly observed.

4.10 Disposal. To minimize disposal problems, it is recommended that no more than a one year supply of each item listed in this MIL-STD be stocked. When stocks have been declared excess to Department of Defense requirements, they will be disposed through property disposal channels or by selling to commercial users or processors. Disposal guidelines in section 5 will be limited to spills and leaks of issue indicated for each chemical. For assistance on large spills that grossly contaminate the environment, call toll free, the Chemical Transportation Emergency Center (CHEMTREC) at 800-424-9300. Before applying the disposal methods for each section, it should be coordinated with the installation's Environmental Coordinator for the applicability to state and local requirements. In all cases where the wastes are to be collected, stored, transported and disposed of at a state or local permitted disposal facility, every effort should be made to retain the identity of the waste. Should excess or unserviceable material occur, dispose of the material as outlined in the Defense Utilization Manual, DOD 4140.34-M or the Defense Disposal Manual, DOD 4160.21M. Prior to initiating disposal procedures as outlined in each part of the MIL-STD, the items should be reported to the local Property Disposal Office (PDO) as outlined in DOD 4160.21-M

4.11 DISCLAIMER. RECOMMENDED DISPOSAL INSTRUCTIONS IN SECTION 5 ARE FORMULATED FOR USE BY ELEMENTS OF THE DEPARTMENT OF DEFENSE. THE UNITED STATES OF AMERICA IN NO MANNER WHATSOEVER EITHER EXPRESSLY OR IMPLIEDLY WARRANTS, STATES OR INTENDS SAID INSTRUCTION, TO HAVE ANY APPLICATION, USE OR VIABILITY BY OR TO ANY PERSON OR PERSONS 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 THEIR PARTICULAR SITUATION REGARDLESS OF SIMILARITY TO A CORRESPONDING DEPARTMENT OF DEFENSE OR OTHER GOVERNMENT SITUATION.

5. DETAIL REQUIREMENTS

5.1 Name: ION EXCHANGE COMPOUND, STRONG ACID, CATION EXCHANGE

5.1.1 Specifications. O-I-1279, Ion Exchange Compound and MIL-I-52695, Ion Exchange Compounds

5.1.2 Technical description. Strong acid-cation exchange compounds are made of general purpose synthetic resins that are highly acidic in nature. Strong acid resins react with other chemicals in a manner analogous to that of sulfuric acid. The exchange method is that the acid resin hydrolyzes the neutral salt to its corresponding acid and the resin to its corresponding salt. Nitrogen bases, including amines, amino acids, polypeptides and proteins, are readily absorbed but the larger molecules are sometimes difficult to elute. At low concentrations (aqueous) and ordinary temperatures, the extent of exchange (the exchange potential) increases with an increase in the valence of the exchanging ion. For example Na^{+} Ca^{+2} La^{+3} Th^{+3}. If the valence of the ions is constant, the relative affinity increases with an increase in atomic number. For example Li^{+} Na^{+} K^{+} Rb^{+} Cs^{+}; Mg^{+2} Ca^{+2} S^{+2} Ba^{+2}. At high concentrations, the differences in the exchange potentials of ions of different valence diminish and in some cases, reverse. The exchange potential of the hydrogen ion depends upon the strength of the acid formed between the ion and the functional group of the resin. The stronger the acid formed, the lower the exchange potential. In order to regenerate strong acid resins to their hydrogen form, a large excess of strong acid is required.

TABLE I. Chemical Classification of Strong Acid Resins

Matrix	Structure	Active Group	Particle Size
Polystyrene	Gel - Macroporous	Sulfonic Acid $-C_6H_4SO_3H$	Spherical
Phenolic	Gel - Macroporous	CH_2SO_3H	Granular
Phenolic	Gel	$C_6H_3(OH)SO_3H$	Granular

TABLE II. QUANTITATIVE REQUIREMENTS

	Minimum	Maximum
Effective size, mm	0.40	0.55
Uniformity coefficient	-	2.0
Compound passing 50-mesh sieve, % by volume	-	2.0
Compound retained on 16-mesh sieve, % by volume	-	5.0
Whole bead content, %	90.0	-
Wet density, lb/cu ft (g/cm^3)	46.0 (0.736)	52.0 (0.832)
Solids content, as received, % by weight	45.0	-
Moisture holding capacity, % by weight	51.0	56.0
Conversion to hydrogen form (as received) %	90.0	-
Total exchange capacity, meq/g	4.30	N/A
Meg/ml, wet compound	1.60	N/A
Oxidation stability, percent moisture holding capacity after oxidative attack	-	65.0
Resistance to breakdown on wet-dry cycling % resin passing 50-mesh sieve	-	3.0

5.1.3 Use data. For military use strong-acid cation exchange compounds are used to demineralize or treat water. Typical commercial uses are: water conditioning, separation of rare earths, separation of amino acids and in high flow rate deionization such as condensate polishing.

5.1.4 Packaging data and labeling. For military use strong-acid cation exchange resins shall be packaged in a 1 cu ft (28 liter) drum or bag and in a 5 cu ft (140 liter)drum. In addition to any special marking required by contract or order, marking shall include the following:

Batch number_____
Date of manufacture_____
Net content_____

5.1.5 Safety. Strong-acid cation exchange resins are considered to pose no significant health hazard. It is a non-flammable resin and not volatile. In contact with flames, strong-acid exchange resins may give off toxic fumes. It is necessary to wear NIOSH approved respirators when fighting a fire exposed to strong-acid exchange resins. Avoid contact with concentrated nitric acid or any other strong oxidizing agents at all times because contact may result in explosive reactions.

For additional precautions, see Section 4.4.

5.1.6 Storage. Ion exchange resins should be stored in a cool, dry area. The term "cool" denotes temperature from above freezing up to 110 degrees Fahrenheit (43°C) when stored out of direct sunlight. The term "dry" is usually used to denote an area where condensation does not come in contact with the packages or contents (for example, storing on pallets away from walls in an enclosure or building). The resins can be stored out of doors but they must be protected from repeated freeze - thaw cycles. Dry ion exchange resins expand when wetted, which may cause the columns to shatter. If stored in a cool, dry area, the shelf life of the ion-exchange resins is indefinite.

5.1.7 Disposal. One method of disposal is to take the waste to a permitted chemical waste landfill. Disposal instructions are not for ion exchange resins that have been exposed to radioactive material.

5.2 Name. Ion Exchange Compound, Weak Acid, Cation Exchange.

5.2.1 Specifications. None.

5.2.2 Technical description. Weak-acid cation exchange compounds are general purpose synthetic resins that react with other chemicals in a manner analogous to that of acetic acid. Weak acid resins work most effectively at a pH above 6. The exchange method is that the monovalent salts are hydrolyzed and give alkaline reactions. The carboxylic acid resins that form chelated complexes with alkaline earths and heavy metal ions, are effective in separating multivalent from monovalent ions. Weak acid resins are highly selective in their affinities for multivalent cations. Chelate complexes are formed with metals such as copper, cobalt and nickel. Most of the acrylic acid and methacrylic acid resins have a high exchange capacity and undergo large volume changes when converted from their acidic to basic forms and vice versa. Weak acid form resins can be easily regenerated to their hydrogen form by adding little more than stoichiometric quantities of strong acids.

TABLE III. Chemical Classification of Weak Acid Ion Exchange Resins

Matrix	Structure	Active Group	Particle Size
Acrylic	Semiporous Gel	-COOH	Spherical
Methacrylic	Macroporous	-COOH	Spherical
Phenolic	Macroporous Gel	$-C_6H_3(OH)CH_2COOH$	Granular
Phenolic	Gel	$-OCH_2COOH$	Granular
Polystyrene	Macroporous	$-OP(O)(OH)_2$	Spherical

TABLE IV. Quantitative Requirements

Requirements	"Gel" Weak Acid	Macroporous Weak Acid
Particle size or effective size, mm	0.38 to 0.46	0.33 to 0.55
Compound passing 50-mesh sieve, % by volume	95%	95%
pH range	4 - 14	5 - 14
Total exchange capacity Kgr $CaCo_3/ft^3$	76.3	43.6 - 76.3
Meq/ml, wet	3.5	2.0 - 3.5 1.2 - 3.5
Wet density	1.19 g/cc	1.17 - 1.25 g/cc
Moisture content%	43 - 50	43 - 73
Functional groups	Carboxylic	Carboxylic
Matrix	Styrene - DVB Acrylic - DVB Condensate Phenolic Acrylic Epoxyamine	Methacrylic Acid-DVB Acrylic - DVB Polyacrylic Phenolic

5.2.3 Use data. For military use weak-acid cation exchange compounds are used to demineralize or treat water. Typical commercial uses include antibiotic purification and recovery, copper and nickel recovery, isolation of basic antibiotics, alkoloids, amino acids and polypeptides.

5.2.4 Packaging data and labeling. For military use weak-acid cation exchange resins shall be packaged in 1 cu ft (28 liter) drums. In addition to any special marking required by contract or order, marking shall include the following:

Batch number_____
Date of manufacture_____
Net content_____

5.2.5 Safety. Refer to section 5.1.5.

5.2.6 Storage. Refer to section 5.1.6.

5.2.7 Disposal. Refer to section 5.1.7.

5.3 Name. Ion Exchange Compounds, Strong-Base, Anion Exchange.

5.3.1 Specifications. O-I-1279, Ion Exchange Compounds.

5.3.2 Technical description. Strong-base, anion exchange compounds are general purpose synthetic resins that are highly basic in nature. The chemical activity of the hydroxyl form of the resin is that it removes acids, even weak acids, from the solution. The exchange method is that the hydroxyl form resins hydrolyze neutral salts, converting the resin to its corresponding salt. The relative affinities of the resins for ions in dilute solutions tends to increase with an increase in valence and atomic number. Organic acids tend to be absorbed irreversibly by the strong base resins. In order to regenerate the resins, it is necessary to use large excesses of sodium hydroxide. The concentration of the sodium hydroxide has to be above 0.5N in order to regenerate the resin thoroughly.

TABLE V. Chemical Classification of Strong Base Ion Exchange Resins

Matrix	Structure	Active Group	Particle Size
Polystyrene	Gel Macroporous "isoporous" semiporous	$-N^{+}(CH_3)_3\ Cl^{-}$	Spherical
Polystyrene	Gel macroporous semiporous	$-N^{+}(CH_3)_2\ (C_2H_4OH)\ Cl^{-}$	Spherical

TABLE VI. Quantitative Requirements

Requirements	Macroporous Strong Base
Particle size or effective size, mm	0.30 to 0.55
Uniformity coefficient	1.3 to 1.6
Compound retained on 16-mesh sieve, % by volume	20 to 50
pH range	0 - 14
Total exchange capacity Kgr $CaCO_3/ft^3$	11.5 to 24.0
meq/ml, wet	0.53 to 3.0
Wet density	1.07 to 120 g/cc
Moisture content, %	55 to 69% (OH^- form) 105° to 170°F(40.6° to 76.7°C) 38 to 77% (Cl^- form) 105° to 170°F(40.6 to 76.7°C)
Functional groups	Quaternary ammonium functionalty
Matrix	Styrene - DVB Polystyrene

5.3.3 Use data. For military use strong-base, anion exchange compounds are used to demineralize or treat water by removing or replacing positive (metal) ions through hydroxyl (OH^-) ion exchange. Commercial uses include recovery of high molecular weight organics from process streams, sugar decolorization and deashing and high flow rate deionization.

5.3.4 Packaging data and labeling. For military use strong-base anion exchange compounds are packaged in 1 lb (454g) bag or drum, 1 cu ft (28 liter) bag and 7 cu ft (194 liter) drum. In addition to any special marking required by the contract or order, marking shall be in accordance with MIL-STD-129. Unit packages shall include the following:

Batch number_____
Date of manufacture_____
Net content_____

5.3.5 Safety. See Section 5.1.5.

5.3.6 Storage. See Section 5.1.6.

5.3.7 Disposal. See Section 5.1.7.

5.4 Name. Ion Exchange Compound, Weak-Base Anion Exchange.

5.4.1 Specifications. MIL-I-52695, Ion Exchange Compounds.

5.4.2 Technical description. Weak-base, anion exchange compounds are general purpose synthetic resins that react with other chemicals in a manner analogous to those of ammonia and amines. The exchange method is that the weak-base exchange resins are capable of amine formation with heavy metal cations, notably copper and silver, making possible selective separation of the ions. The relative affinity of the resins for acids increases with the acid strength. The weak-base resins are more stable than the strong-base resins, particularly those with only tertiary amine groups attached. Oxidation of the resin can result in weak-acid activity. In high concentrations the weak-base resins absorb strong acids such as HCl, H_2SO_4 and HNO_3. Also when the resin is used in high concentrations, salts tend to hydrolyze in water, releasing free acids. To regenerate the resins, only stoichiometric quantities of alkali are needed. Another method of regeneration is to use ammonia or soda and and caustic soda.

TABLE VII. Chemical Classification of Weak-Base Ion Exchange Resins

Matrix	Structure	Active Group	Particle Shape
Polystyrene	"Equiporous" Macroporous	$-NR_2$, $-NHR$, $-NH_2$	Spherical
	Gel	$-NR_2$, $-NHR$, $-NH_2$, $-N(C_2H_5)_2$	Spherical
Epoxy-amine	Gel	$-NR_2$, $-N^+R_3$, $-NHR$	Spherical
	Gel	$-NC_6H_5R$	
	Gel	$-NHR$, $-NR_2$	Clusters
	Gel	$-NR_2$, $-N^+R_3$	Granular
Phenolic	Gel	$-NHR$, $-NR_2$, $-NH_2$	Granular
	Macroporous	$-NR_2$, $-NHR$, $-NH_2$	Granular
Condensate	Gel	$-NHR$, $-NH_2$	Granular
		$-C_6H_4NH_2$	

TABLE VIII. *Quantative Characteristics*

Requirements	Macroporous Weak Base	Gel Weak Base
Particle size or effective size, mm	0.40 to 0.50	0.35 to 0.45
Compound passing 50-mesh sieve, % by volume	95%	95%
Compound retained on 16-mesh sieve % by volume	0 - 14, 0 - 9	0 - 7
Total exchange capacity Kgr $CaCO_3/ft^3$	4.3 min, 26.9	34.9 - 69.8
Meq/ml, wet	1.25, 2.6 - 3.0	1.6 - 3.2
Wet density	1.05 g/cc	1.06 - 1.11 g/cc
Moisture content	*46 - 58*	*40 - 70*
Functional group	Tertiary Amine Polystyrene Polyamine	Polyamine
Matrix	Methacrylic Acid - DVB Acrylic - DVB Polyacrylic Phenolic	Styrene - DVB Acrylic - DVB Condensate Phenolic Acrylic Epoxyamine

5.4.3 Use date. For military use weak-base anion exchange resins are used in military demineralizer, water, ion exchange units. Typical commercial uses include deacidification and deionization of water (where the removal of strong mineral and organic acids is desired) and the deionization of process liquors. Weak-base resins are also used, commercially for the removal of organic materials from surface water supplies and sugar deashing and decolorization.

5.4.4 Packaging data and labeling. For military use weak-base anion exchange resins are packaged in 4 cu ft (112 liter) unit quamtity drums. In addition to any special marking required by the contract or order, marking

shall be in accordance with MIL-STD-129. In addition unit packages marking shall include the following:

Type_____
Batch number_____
Date of manufacture_____
Net content_____

5.4.5 Safety. See section 5.1.5.

5.4.6 Storage. See section 5.1.6.

5.4.7 Disposal. See section 5.1.7.

Assignee: GS

Custodians:
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Navy - SH
Air Force - 68

Review activities:
Army - CT, GL, MD, MI, SM
Navy - SH
Air Force - None

User Activities:
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Navy - MC
Air Force - None

Preparing activity: Army - EA

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