TECHNICAL BULLETIN

TREATMENT OF COOLING WATER IN MARINE DIESEL ENGINES

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* This manual supersedes TB 55-1900-207-24, 15 July 1974

HEADQUARTERS, DEPARTMENT OF THE ARMY
30 September 1991

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HEADQUARTERS
DEPARTMENT OF THE ARMY

NO. 55-1900-207-24

WASHINGTON D.C., 30 SEPTEMBER 1991

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CHAPTER 1. INTRODUCTION

SECTION I. GENERAL

1-1. Purpose. This bulletin provides information for maintaining the cooling water systems of the marine diesel engines installed in all US Army watercraft. Specifically, it provides guidance in the chemical treatment of cooling water and cooling water systems to prevent corrosion and scaling of metal heat transfer surfaces.

1-2. Scope. This bulletin applies to all US Army organizations, installations, activities, National Guard Units, and US Army Reserve components worldwide who are involved in the maintenance of US Army watercraft.

Table 1-1. Materials and Test Equipment

NOMENCLATURE	NSN	QTY	REFERENCE
Anodes, Corrosion Preventive	See Technical Manual	As Required	MIL-A-18001
Antifreeze, Arctic-Type	6850-00-174-1806	55-GAL DR	MIL-A-11755
*Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package	6850-00-181-7929 6850-00-181-7933 6850-00-181-7940	1-GAL 5-GAL 55-GAL DR	MIL-A-46153 MIL-A-46153 MIL-A-46153
Antifreeze Extender Additive	6850-01-160-3868	QUART	MIL-A-53009
Cleaning Compound with Conditioner and Inhibitor for Engine Cooling Systems	6850-00-598-7328	KIT	MIL-C-10597
Sodium Chromate, Anhydrous Technical	6810-00-240-2119	1 LB CAN	O-S-588
Sodium Tetraphosphate Technical	6810-00-949-8332	100 LB DR	O-S-635
Test Kit, Chromate	6630-00-074-0394	Each	No Spec
Test Kit, Test Strips and Color Chart, Antifreeze, Freeze Point and Corrosion	6630-01-011-5039 (one container with 50 test strips)	KIT	CID A-A-5146
Tester, Antifreeze Solution	66300-247-2968	Each	No Spec

*Note: The single package antifreeze, ethylene glycol, will not require the addition of corrosion inhibitor to the antifreeze solution.

SECTION II. GENERAL INSTRUCTIONS

1-3. Heat Exchangers.

a. This bulletin is primarily concerned with the chemical treatment of the recirculating fresh water which passes through the heat exchanger.

b. Retarding corrosion of the saltwater side of a heat exchange is best accomplished by the use of corrosion-resistant alloys or coating and sacrificial anodes (zinc plugs).

c. Precautions must be taken to prevent the entrance of marine organisms which may adhere to the heat exchanger surfaces and thus impair the rate of heat transfer and accelerate corrosion. Screens are normally installed to prevent this.

1-4. Need for Treatment. Fresh water used for cooling marine diesel engines contains varying concentrations of impurities depending upon its source. It contains gases which are corrosive, such as carbon dioxide and oxygen. It also contains harmful scale-forming elements, such as calcium, magnesium, chlorides, sulfates, silica and organic matter. The mineral content makes the water 'hard." Watercraft are apt to take on make-up water from different localities. Therefore, this bulletin will prescribe the treatment of cooling water of average hardness and mineral content.

1-5. Scale Formation. Some of the dissolved salts in the circulating water have a tendency to form either hard scale or soft sludge. Scale formation and sludge deposits may cause the failure of cylinder liners, heads, and the engine block. Scale formed on heat transfer surfaces slows up heat exchange and can cause local overheating or "hot spots." Overheating causes breakdown of lubricating oil, sticky piston rings and increased engine wear. The capillary spaces that exist under scale and sludge deposits are breeding places for rust and corrosion.

1-6. Corrosion.

a. Corrosion is a natural process affecting all metals, but it can be considerably retarded by chemical and physical means. Dissolved carbon dioxide will form carbonic acid. Water with high acid content will dissolve iron and steel. Water with high alkalinity will dissolve many of the non-ferrous metals.

b. Elevated engine operating temperatures will also accelerate corrosion. (For example, iron, solder, and copper will corrode twice as fast at 175°F than at lower temperatures.)

c. Dissimilar metals not insulated from each other will corrode at a much faster rate than if they are insulated from each other.

d. Severe pitting on the water side of cylinder liners is caused by mechanical vibration (cavitation) at high speeds. The localized stress produced is great enough to rapidly erode the metal surface. It has been found that chromate chemicals are effective in reducing this type of damage.

CHAPTER 2. CONTROL AND MAINTENANCE

SECTION I. CONTROL

2-1. Prevention of Scale.

a. Only fresh water will be used in closed cooling systems. Sea water (raw water) will not be used in any closed cooling system. Water from the ship's potable water system or direct from shore fresh water connection may be used when condensate, distilled, or mineral-free water is not available. Where means are available, fresh water being introduced into the cooling system should be softened prior to use in order to remove the scale forming elements. This can be accomplished by using sodium tetraphosphate, technical (Specification O-S-635).

b. As softened water is not always readily available, it is necessary to soften the water inside the cooling system by chemical means. The conditioning chemicals used in treatment of cooling water tend to hold the scale-forming elements in suspension and to convert the sludge-forming elements into a relatively harmless solution, which can be removed by periodic cleaning of the cooling system.

2-2. Scale and Corrosion Control. Treatment of cooling water to prevent formation of scale and corrosion include:

a. Mechanical filtration to remove dirt and foreign matter.

b. Water softening procedures to prevent mineral deposit buildup.

c. Addition of antifreeze extender to prevent rust and corrosion and control pH value.

2-3. Specific Control Measures. The factors contributing to and accelerating harmful conditions in the cooling system are controlled as follows:

a. Dirt and solid matter are removed by straining and filtering the untreated cooling water prior to use.

b. Carbonic acid and other acidity is controlled by the addition of antifreeze extender additive (MILA-53009) which contains sodium borate (borax). pH values below 6.5 indicate acid activity and possible corrosion. pH values above 9.5 indicate high alkalinity conditions which favor deposition of scale and may cause damage to brass fittings, aluminum, solder, and pump packing/seal. The borax keeps the pH of the cooling water stabilized around 9.2 in the summer. This value corresponds to a low alkalinity condition. In winter when military anti-freeze, MILA-46153, is used in the cooling system, the pH value will range from 7.5 to 8.0. The antifreeze extender additive is compatible with military antifreeze only and is used to reinhibit used MILA-46153 in order that it can be used for up to two additional years.

c. The concentration of oxygen is reduced by sodium chromate which acts as an oxygen scavenger. This chemical also inhibits the corrosion and pitting of cylinder liners. It reacts with iron and oxygen to form a protective coating on the metal surface.

d. Scale forming elements are held in suspension by the sodium salts in sodium tetraphosphate. This process is called water-softening.

e. Non-ferrous metals are protected from corrosion by the sodium mercaptobenzothiazole (NaMBT) contained in the antifreeze extender additive.

2-4. Treatment Chemicals.

a. Antifreeze extender additive conforming to Military Specification MIL-A-53009 contains borax, NaMBT, and potassium silicate. The borax acts as an alkalizer and buffering agent. NaMBT prevents copper and brass corrosion and provides additional buffering action. The potassium silicate prevents aluminum corrosion.

b. Sodium chromate (anhydrous, technical, conforming to Technical Specification O-S-588) is added to insulate metal surfaces from the corrosive environment. In addition, the chromate helps to maintain proper alkalinity and acts as an oxygen scavenger.

NOTE

Chromate chemicals will not be used with glycol-type antifreeze. These chemicals react with each other to form harmful acids and heavy sludge deposits.

c. Sodium tetraphosphate, Technical, Specification O-S-635, tends to hold scale-forming elements in suspension and to convert the sludge-forming elements into a relatively harmless solution, which can be removed by periodic cleaning of the cooling system.

d. Antifreeze compound conforming to Military Specification MIL-A-46153 (Antifreeze, Ethylene Glycol, Heavy Duty, Single Package) is a mixture of special kinds of alcohols called "glycols." A 60 percent solution which protects to -55°F, boils at about 230°F, compared to 212°F, for pure water. Solutions containing more than 60 percent antifreeze give less protection. Antifreeze compound without any water added will freeze at about 0°F. Where temperatures below -55°F are expected, antifreeze compound conforming to Military Specification MIL-A-11755 (Antifreeze, Arctic Type) will be used undiluted.

WARNING

Do not mix commercial antifreezes with each other or with military specification-type antifreezes.

e. Cleaning compound conforming to Military Specification MIILC-10597 (Cleaning Compound with Conditioner and Inhibitor for Engine Cooling Systems), contains various chemicals to clean and condition engine cooling systems. For a complete description of the kit, see paragraph 2-11.b.

2-5. Summer Treatment.

a. Prior to filling with clean, fresh water and corrosion inhibitor, the cooling system must be cleaned as outlined in Section II.

WARNING

Chromates must be handled properly as they are classified as a health hazard. If any chromate, solid or spray, comes in contact with eyes, immediately flush eyes and affected area with plenty of fresh water. See doctor immediately. If contact is made with the skin, use soap and water to wash the affected skin area. See a doctor immediately. If chromate dust or spray is inhaled, see a doctor immediately. Protective equipment such as goggles, face shields, rubber gloves, aprons, and dust respirators should be used.

b. Fill system to 1/3 capacity with clean, fresh water.

c. Dissolve in water 1/2 ounce sodium chromate (Specification O-S-588) for each gallon capacity and add solution to cooling system. Replenish also at this rate. (For example, when the cooling system capacity is 10 gallons, use 5 ounces of chromate.)

d. Dissolve in water 3 3/4 ounces antifreeze extender additive (Military Specification MIL-A-53009) for every gallon capacity. (For example, when cooling system capacity is 10 gallons, use 37 1/2 ounces extender additive.)

e. Fill to capacity with clean, fresh water.

f. Run engine at fast idle speed for at least 5 minutes to mix solution.

g. Chromate replenishment required as a result of testing coolant will be as stipulated in Section II, paragraph 2-10.c.

h. Replenish coolant with 3 3/4 ounces antifreeze extender additive (Military Specification MILA-53009) for each gallon of water added hereafter.

2-6. Winter Treatment.

a. Prior to adding antifreeze solution, clean the cooling system as outlined in Section II.

b. Fill system to 1/3 capacity with clean, fresh water.

c. Add amount of antifreeze for protection desired (see para. 2-7).

d. Fill cooling system to capacity with clean, fresh water but leave room for expansion of coolant.

e. Run engine at fast idle for at least 10 minutes to mix solution.

f. Replenish any lost coolant with antifreeze of the concentration required for the freeze protection needed (see para. 2-7).

2-7. Limits of Protection.

a. Antifreeze conforming to Military Specification MIL-A-46153 will afford the following limits of protection in the concentrations listed below:

Table 2-1.

Temperature Degrees Fahrenheit	Pints of Antifreeze Per Gallon of Solution
20	1-1/2
10	2
0	2-3/4
-10	3-1/4
-20	3-1/2
-30	4
-40	4-1/4
-50	4-1/2
-55	4-3/4

b. Where temperatures are expected to drop below -55°F, antifreeze compound conforming to Military Specification MILIA-11755 (Antifreeze, Arctic Type) will be used. This solution will protect an engine to -90°F without dilution

2-8. Reuse of Antifreeze. New military antifreeze MIL-A-46153 will be limited to 4 years use provided the antifreeze tests safe for use using the testing and inspection procedures in Section II. Used military antifreeze MILA-46153 which tests unsafe for use when using the Test Kit, Test Strips and Color Chart, Antifreeze Point and Corrosion, A-A-51461 (see Section II) may be reinhibited on a one-time basis with antifreeze extender additive MILA-53009. Reinhibited used antifreeze will be limited to an additional 2 years use, provided the antifreeze tests safe for use using the testing and inspection procedures in Section II. When reinhibiting used antifreeze, allow the drained antifreeze to stand until all particles have settled out. Carefully decant the anti- freeze and mix in MIL-A-53009 extender additive at the rate of 3 3/4 ounces per gallon of used antifreeze. Cooling systems filled with inhibited used antifreeze will be tagged with the date of reinhibition to preclude using the solution for more than the maximum allowable 2 years.

2-9. Sea Water Side Protection. The sea water side of the cooling systems is normally protected by zinc anodes (plugs) or plates (slabs) which must conform to MIL-A-18001 (Anodes, Corrosion Preventative, Zinc, Slab, Disc, and Rod Shaped). The anodes or plates should be inspected once a month and replaced when 50 percent eroded. The zinc being a dissimilar metal is attacked by the electrolytic action and eroded.

SECTION II. PREVENTIVE MAINTENANCE

2-10. Testing and Inspection. During the scheduled maintenance services, or during climatic change service, applicable testing of the system coolant and inspection of the cooling system, a. through d. below will be performed.

a. Test for antifreeze protection, when applicable, by use of a tester, antifreeze solution, see Table 1-1.

NOTE

A freeze protection indication beyond the limits shown in Table 2-1 or below -55°F (-48°C) when MILA-46153 antifreeze is used, will require partial coolant drain and replacement with water. Freeze protection must not exceed -55°F (-48°C) when MILA-46153 is used.

b. Test for reserve alkalinity (corrosion protection) by means of the test kit, test strips and Color Chart, Antifreeze, Freeze Point and Corrosion, A-A-51461. (See Table 1-1). Color indication of the test kit stick, after the test, will determine condition of the coolant and its potential corrosion protection. Instructions for use of the test kit stick and color interpretation are as follows:

(1) Dip stick into coolant (water or antifreeze solution) and remove immediately. Do not use test stick at temperatures below +50°F (+10°C).

(2) Fifteen seconds after dipping, compare color on the stick with the color chart on the container and annotate.

(a) Blue indicates coolant is safe to use.

(b) Green indicates reserve alkalinity and corrosion protection of coolant is marginal but may be used safely until the next service inspection.

NOTE

Do not use antifreeze extender additive (MILA-53009) when arctic type antifreeze is used in the cooling system.

(c) Yellowish green indicates the coolant is unsafe to use. If the log (DD Form 314) identifies the coolant as the original charge, then add three percent by volume (1 pint per 17 quarts) of the antifreeze extender additive (MIL-A-53009) to the cooling system. Addition of extender (MIL-A-53009) to antifreeze is a one-time service. When the extender is added to the antifreeze, the date must be recorded in the "remarks" block of DD Form 314. If the log (DD Form 314) identifies the unsafe coolant as having been extended before, or the coolant as arctic antifreeze, then the coolant must be drained and replaced with fresh coolant.

c. Text Kit, Chromate, Table 1-1, will be used to test coolant for chromate concentration. For best results, chromate concentration should be maintained at about 2000 parts per million (ppm). Concentrations below 1000 ppm may lead to localized corrosion. Concentrations above 3000 ppm may cause accelerated cavitation on cylinder liners.

d. Visual inspection for coolant cleanliness is done by withdrawing a small amount of coolant into a clean container. Visual examination will be made for excessive rust, foreign particles, and/or sediment.

2-11. Engine Cooling System Cleaning.

a. Engine cooling system cleaning compound (MIL-C-10597) (see Table 1-1), will not be used as a routine maintenance procedure each time antifreeze is added or drained from the cooling system. The compound will be used only when necessary to clean heavily rusted or partially clogged cooling systems, to neutralize residual cleaning acids, and to coat the interiors with a silicate.

b. Engine cooling system cleaning compound is a kit (see Table 1-1) and consists of a 2-part cleaner, a 2-part conditioner, a corrosion inhibitor, and an instruction sheet. The components of the kit are listed below:

(1) Cleaner, part 1, Oxalic Acid.

(2) Cleaner, part 2, Aluminum Chloride.

(3) Sodium Silicate Conditioner.

(4) Alkaline Conditioner.

(5) Inhibitor.

(6) Inspection Sheet (furnished with each kit).

c. The instructions must be followed to prevent damage to the engine or cooling system.

2-12. Maintenance Recording.

a. Cooling systems serviced with antifreeze, MILA-46153, or water and antifreeze extender MIL-A-53009 require the degree of protection, the condition of the cooling system, and the use of antifreeze extender be recorded in the remarks block of DD Form 314 (Preventive Maintenance Schedule and Record). The antifreeze extender data must be recorded to ensure that original charges of coolant are extended at least one time and to ensure that already extended coolant will not be re-extended, but drained and replaced with fresh coolant.

b. When cooling systems are serviced with arctic-type antifreeze (MILA-11755), commercial brand antifreeze, or when the equipment is still under warranty, the installation date and the degree of protection will be recorded in the "remarks" block of DD Form 314.

APPENDIX A
GLOSSARY OF TERMS

The following definitions apply to terms used in this bulletin:

ACIDITY-A sour condition of the coolant. This condition accelerates corrosion of iron and other metals.

ALKALINITY-A bitter condition of the coolant. This condition accelerates corrosion of non-ferrous metals.

AMBIENT TEMPERATURE-The atmospheric temperature of the immediate surrounding area.

ANODES-Active metals such as zinc and magnesium which, when attached to steel or other metal in a water environment, prevent the corrosion of the metal. The anodes corrode and are sacrificed instead of the steel.

ANTIFREEZE-A solution which, when mixed with water, lowers the freezing point.

ANTIFREEZE EXTENDER-A solution containing buffering agents and corrosion inhibitors for use in reinhibiting used MILA-46153 antifreeze or inhibiting water.

BORAX (SODIUM BORATE)-A chemical used to impart a condition of low alkalinity to a water solution.

BUFFERING AGENT-A chemical which stabilizes (neutralizes) the acid and bases in water.

CAPILLARY SPACES-Extremely small pores which are formed under rust and scale.

CARBONIC ACID-A mild acid which is formed when carbon dioxide gas dissolves in water.

CAVITATION-A form of corrosion resulting in the formation of deep and shallow cavities. Cavities formed by cavitation are larger than those formed by pitting.

CHEMICAL TREATMENT-The process of adding correct portions of proper chemicals to cooling water in order to inhibit corrosion and the formation of scale.

CHROMATES-A class of salts derived from chromic acid. Sodium potassium chromates and dichromates are widely used in water treatment because they are very soluble and react with metal surfaces to form a surface relatively immune to corrosion.

CONCENTRATION-The weight of a specific material per unit volume of coolant.

CONDITIONING CHEMICALS-The remedial chemicals added to untreated fresh water to neutralize the harmful effects of the corrosive environment and the scale-forming elements.

COOLANT-The circulating element, generally fresh water, which carries away the heat generated by the friction of moving parts of an engine.

COOLING SYSTEM-The structural parts of an engine through which the coolant circulates.

COOLING WATER-The chemically treated water (coolant) circulating in an engine.

CORROSION INHIBITORS-Chemical agents which prevent (inhibit) corrosion.

CORROSIVE ENVIRONMENT-The corrosive gases and liquids bathing a metal surface.

DECANT-The process of allowing a dispersed solid material to settle out of a liquid and then carefully pouring off the liquid.

DISSIMILAR METAL-Different metals coupled together, in a water environment, constitute a galvanic couple which is destructive to one of the metals; an example, zinc anodes slabs coupled to a steel surface of brass fitting coupled to steel.

DISSOLVE-The process of reducing a solid to a liquid solution.

DISSOLVED OXYGEN-Oxygen dissolved in water. The concentration of dissolved oxygen in water is greater than in air.

DOSE/DOSAGE-The correct amount of remedial chemicals to be added to the coolant.

FEED WATER-Treated or untreated fresh water fed into a cooling system of an engine.

FERROUS METAL-A metal consisting largely of iron.

FILTRATION-The process of filtering a liquid to remove solid impurities.

GLYCOLS-A group of chemicals used to lower the freezing point of water.

HARD WATER-Water with a large concentration of dissolved minerals characterized by difficulty in making suds.

HIGH ALKALINITY-Water with pH value over 9.5.

INHIBITED GLYCOL-Antifreeze treated to neutralize the acids formed by its decomposition.

IRON OXIDE-Chemical name for the main constituent in iron rust.

LOW ALXALINTY-Water with pH range of 7.5 to 9.5.

MINERALS-Natural inorganic compounds.

NATIONAL STOCK NUMBER (NSN)-Successor to Federal Stock Number (FSN).

NEUTRALIZER-A chemical used to change an acid or a base into a neutral salt.

NEUTRALIZING SOLUTION-Water solution containing a dissolved neutralizer.

OXYGEN SCAVENGER-A chemical having an affinity for oxygen and the ability to prevent it from combining with iron.

PASSIVATING CHEMICALS-Chemicals that have the capability to inactivate metal surfaces.

pH-A numbered value used as a measure of the acidity and alkalinity of a solution. pH7 is neutral. Below pH7 is acid. Above pH7 is alkaline.

PITTING-Corrosion attack in localized areas, resulting in the formation of tiny cavities. The cavities formed by pitting are smaller than those formed by cavitation. ppm-Abbreviation for parts per million by weight.

RAW WATER-For the purpose of this bulletin, untreated fresh water used for engine cooling.

REINHIBITING-The process of replenishing water treatment chemicals.

SALTS-Chemical compounds formed when acids react with bases.

SCALE-Insoluble materials that settle out of cooling water and adhere to the metallic surfaces; build-up of hard materials which interfere with the transfer of heat.

SLUDGE-A soft sedimentary deposit that forms throughout the coolant. It may stay in suspension or it may settle on any surface.

SODIUM MERCAPTOBENZOTBIHAZOLE (NaMBT)-A chemical used to prevent the corrosion of brass or copper.

SOFT WATER-Fresh water that has been treated to lower the mineral content. Characterized by large amounts of suds.

SUSPENSION-Extremely small particles that do not settle out in the cooling water.

TRI-SODIUM PHOSPHATE-A form of phosphate; a rather strong alkali used for cleaning.

By Order of the Secretary of the Army:

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THE METRIC SYSTEM AND EQUIVALENTS

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3.2808.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu in.
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Square measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.5 inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 feet
1 sq. dekameter (are) = 100 sq. meters = 1.076.4 sq. ft.
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 hectometers = .386 sq. miles

Liquid Measure

1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons
1 liter = 10 deciliters = 33.81 fl. ounces
1 centiliter = 10 milliliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3 38 fl. ounces
1 metric ton = 10 quintals = 1.1 short tons

Approximate Conversion Factors

To change	To	Multiply by
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
sq. inches	sq. centimeters	6.451
sq. feet	sq. meters	.093
sq. yards	sq. meters	.836
sq. miles	sq. kilometers	2.590
acres	sq. hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29.573
pints	liters	.472
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound inches	newton-meters	.11296

To change	To	Multiply by
ounce inches	newton-meters	.0070062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
sq. centimeters	sq. inches	.155
sq. meters	sq. yards	10.764
sq. kilometers	sq. miles	1.196
sq. hectometers	acres	2.471
cubic meters	cubic feet	35.315
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102
pound-feet	newton-meters	1.356

Temperature (Exact)

°F Fahrenheit temperature — 5/9 (after subtracting 32) — Celsius Temperature °C

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