ELECTRO-MOTIVE

MAINTENANCE INSTRUCTION

M.I. 1748
*Rev. C

ENGINE COOLANT

DESCRIPTION

Coolant is circulated throughout the engine to provide the means for heat transfer from the engine components. Water, corrosion inhibitor and, in some applications, antifreeze are used in coolant solutions.

Because the function of the coolant is so necessary to the operating efficiency of the engine, it is important that the selection of a coolant solution be carefully considered.

Failure to meet any *one* of the following requirements will inevitably result in costly system damage. Typical corrosion failures are shown in Figs. 1, 2, and 3.

COOLANT SOLUTIONS

A coolant suitable for use in EMD engine cooling systems must meet four basic requirements:

1. It must adequately transfer heat energy through the cooling system.
2. It must not form scale or sludge deposits in the cooling system.
3. It must not cause corrosion within the cooling system.
4. It must not deteriorate any of the cooling system seal materials.

These requirements are normally satisfied by combining a suitable water with a reliable corrosion inhibitor. Certain operating conditions may dictate the use of antifreeze-coolant. In this case the basic requirements can be satisfied with a combination of suitable water and an ethylene-glycol type antifreeze which contains an adequate corrosion inhibitor. However, the use of antifreeze involves special consideration regarding Items 1 and 3 above. This will be discussed in detail under "Antifreeze."

It should be recognized that coolants which perform satisfactorily in other applications may not be satisfactory for use in EMD engine cooling systems. Differences in coolant volume-to-cooling system surface area ratios, coolant velocities, temperatures, and the types of materials employed make such comparisons meaningless.

The formulation of home made inhibitors and antifreezes is not recommended since such compounds are difficult to monitor and control. The ready availability of suitable proprietary products makes these practices uneconomical and impractical.

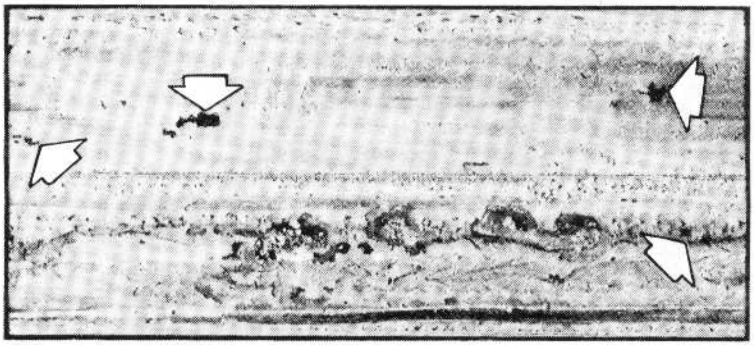
Water quality should be evaluated whenever a new water source is to be used, or when changes in existing water sources occur. Likewise, quality of the coolant solution should be tested when a new engine is put into service, and at regular intervals thereafter. The quality of coolant should always be known and should be maintained as required.

WATER

The water used in the cooling system of EMD engines should be of such quality that it does not contain excessive solids, hardness salts, or corrosive elements such as chlorides. Water containing these constituents in undesirable amounts can either be softened or de-ionized to make it suitable for use. Steam condensate is also suitable for use in the cooling system as an equivalent to distilled water.

*This bulletin is revised and supersedes previous issues of this number.

Areas of change are indicated by vertical bars in the margins.



Cooling water radiator tube cut apart and enlarged to show severe corrosion after approximately 1000 hours operation. Coolant consisted of fairly soft well water and an ethylene glycol antifreeze, without additional inhibitor.

This tube was photographed against a black background. The dark black areas show complete penetration of the tube wall.

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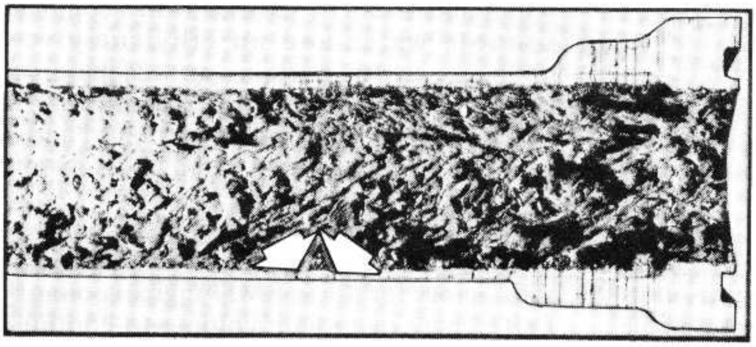
Fig.1 – Section Of Cooling Water Radiator Tube



Cylinder liner water jumper sectioned to show corrosion after approximately 5000 hours operation. Coolant consisted of hard water, an ethylene glycol antifreeze and a corrosion inhibitor which obviously did not provide adequate protection.

NOTE

Severe reduction of tube section. This jumper was removed because of leakage from several holes corroded through the tube wall.

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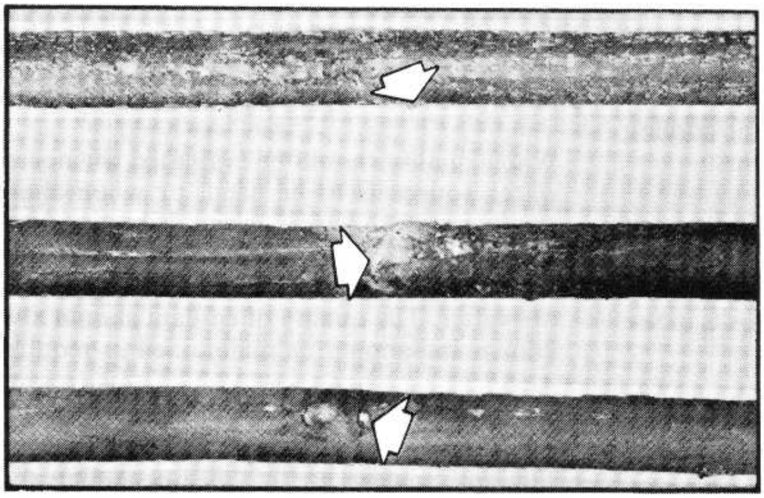
Fig.2 – Section Of Cylinder Liner Water Jumper



Heat exchanger tubes sectioned to show corrosion failures after approximately 6 months operation. Coolant consisted of untreated brackish water.

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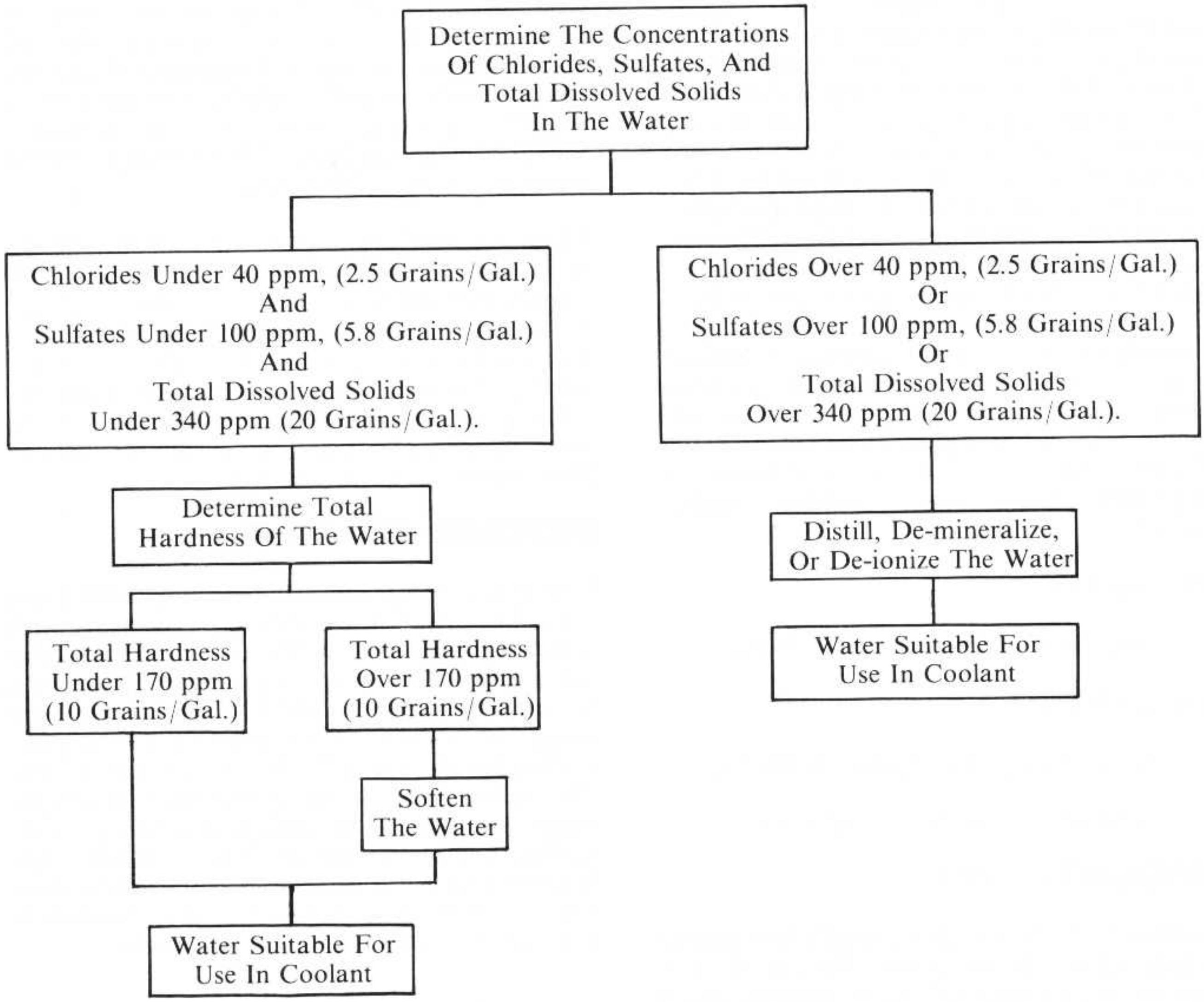
Fig.3 – Section Of Heat Exchanger Tubes

TABLE 1



Water exceeding these limits can cause scale and sludge deposits, corrosion, or a combination of these.

INHIBITOR

CAUTION

Uninhibited water should never be used to fill a cooling system (even temporarily) because of the possibility of rapid corrosion and rusting. This applies to all uninhibited water but is especially true for distilled, de-ionized, or demineralized waters, including steam condensate. Prior to application, the water should be mixed with the inhibitor or inhibited antifreeze which is to be used in the coolant. The use of soluble oil type inhibitors is not recommended.

Two basic types of inhibitors, chromate and borate-nitrite, are the most commonly used in EMD cooling systems. Environment restrictions in some localities have led to the development of a non-polluting silicate-nitrite inhibitor. It is considered non-polluting because it does not contain chromium or boron.

Dry Measure:

16 Ounces = 1 Pound = 453.6 Grams

Liquid Measure:

32 Fluid Ounces = 1 Quart = 0.946 Liter

4 Quarts = 1 Gallon = 3.785 Liters

CHROMATE TYPE

Chromate type inhibitors are generally furnished in the form of powder or pellets. The pH of these inhibitors, when mixed with water, ranges from 7.5 to 9.0. The recommended inhibitor dosage for an initial fill is 4.5 grams per liter (0.6 ounce per gallon [4500 ppm]). Thereafter, the inhibitor concentration should be maintained above 3.0 grams per liter (0.4 ounce per gallon [3000 ppm]). Dissolve the inhibitor in water before adding it to the cooling system. When coolant is lost from the system, the makeup coolant should contain inhibitor in the recommended dosage (0.4 ounce/gallon).

Chromate type inhibitors should not be used in cooling systems containing ethylene-glycol type antifreeze. The use of chromate with ethylene-glycol may, under certain conditions, result in an insoluble sludge forming in the cooling system.

BORATE-NITRITE TYPE

Borate-nitrite type inhibitors are furnished in the form of powder, pellets, and liquids. The pH of these inhibitors, when mixed with water, ranges from 8.5 to 10.0. They also contain a dye, which is distinctive in color and stable at 88° C (190° F). The recommended inhibitor dosage for the powder or pellets at the initial fill is 7.5 grams per liter (1.0 ounce per gallon of water [7500 ppm]). Dissolve the inhibitor in water before adding it to the cooling system. Thereafter, the inhibitor concentration should be maintained above 5.6 grams per liter (0.75 ounce per gallon [5625 ppm]).

The recommended dosage of liquid inhibitor for an initial fill is 23.4 cubic centimeters per liter (3.0 fluid ounces per gallon). Thereafter, the inhibitor concentration should be maintained above 15.6 cubic centimeters per liter (2 fluid ounces per gallon). When coolant is lost from the system the makeup coolant should contain inhibitor in the recommended 15.6 cubic centimeters per liter (2 fluid ounces per gallon) dosage.

SILICATE-NITRITE TYPE

Silicate-nitrite type inhibitors are supplied in liquid form. The pH of these inhibitors, when mixed with water, ranges between 9.0 and 11.0. They also contain a distinctive color dye, which is stable at a temperature of 88° C (190° F). The recommended dosage of inhibitor for an initial fill is 23.4 cubic centimeters per liter (3.0 fluid ounces per gallon). Thereafter, the inhibitor concentration should be maintained above 15.6 cubic centimeters per liter (2 fluid ounces per gallon). When coolant is lost from the system, the makeup coolant should contain inhibitor in the recommended 15.6 cubic centimeters per liter (2 fluid ounces per gallon) dosage.

Experience to date has shown that the performance of this inhibitor is more sensitive than chromates and borate-nitrites to fluctuations in concentration levels. Therefore, the concentration of silicate-nitrite solutions must be carefully monitored during service.

Silicate-nitrite type inhibitors are considered non-polluting because they do not contain chromium or boron. However, federal, state, and local pollution restrictions should be investigated before discharging these inhibitors.

INHIBITOR GUIDELINES

WARNING

Safety and hygienic precautions should always be exercised when handling corrosion inhibitors to avoid possible irritation of eyes, nose, and skin. This is especially important when handling chromate inhibitors.

1. The recommended inhibitor concentrations have been found suitable for most corrosion inhibitors. However, the user should always contact the inhibitor supplier for recommendations as to the proper concentration level for his application.

2. When used in EMD systems, inhibitors should contain specific concentrations of a strong tracer element to help determine the degree of water contamination in lube oil analysis.

3. It is important that the inhibitor concentration be determined. Most suppliers are prepared to furnish a kit for this purpose. Instructions for EMD recommended laboratory and field evaluation appear later in this instruction.

4. The chemicals in corrosion inhibitors are slowly depleted in service. The effective life of an inhibitor depends on such factors as the cooling system condition, hours of operations, coolant and metal temperatures, aeration, and rate of contamination of the coolant. As a general rule the coolant should be discarded at least annually, and the cooling system filled with new inhibited coolant.

5. Draining an inhibited coolant from one engine and reusing in another is not recommended. If drained coolant is reused, particular attention should be given to piping and holding tanks to *ensure freedom from dirt and oil.*

6. Most manufacturers advise against mixing of different brands of corrosion inhibitors. This restriction recognizes the fact that some corrosion inhibitors may not be compatible with other brands. This incompatibility may lead to foaming, precipitation, or accelerated corrosion. EMD concurs with the manufacturer's advice in this respect.

7. Prior to fleetwide application of a new inhibitor formulation, it is advisable to test these formulations in a few engines. This will determine whether the inhibitor is compatible with the operating environment to which it will be exposed.

ANTIFREEZE

ALCOHOL TYPE

Alcohol type antifreeze is not recommended for use in EMD engine cooling systems because of the high coolant operating temperatures.

ETHYLENE-GLYCOL TYPE

Where EMD engine cooling systems must be protected from freezing, ethylene-glycol type antifreeze is recommended. This type of antifreeze must contain a balanced blend of inhibitor ingredients to prevent corrosion. This antifreeze also must contain a distinctive color dye that is stable at a temperature of 88° C (190° F).

Ethylene-glycol type antifreeze should be used at concentrations between 33% and 68% by volume, as required to prevent freezing. Antifreeze concentrations below 33% do not provide sufficient inhibitors to give adequate corrosion protection. Using antifreeze concentrations above 68% will raise the freezing point and will not provide good heat transfer. Because antifreeze affects heat transfer rates, it should not be used without prior consultation with EMD Service representatives regarding the specific engine installation and possible engine derating requirements.

The corrosion inhibitors incorporated in antifreeze are slowly depleted in service. How long these inhibitors will remain effective depends on factors, such as, the cooling system condition, hours of operation, coolant and metal temperatures, aeration, and rate of contamination of the solution. Usually the antifreeze manufacturers recommend using their products for only one year.

In special applications involving large capacity systems, such as EMD engines, the antifreeze solutions may be usable for a longer period of time. The customer should contact the manufacturer for instructions which may include periodic tests of the antifreeze solution by the antifreeze manufacturer.

Chromate type inhibitors should not be used in cooling systems containing ethylene-glycol type antifreeze. The use of chromate with ethylene-glycol, under certain conditions, may result in insoluble sludge forming in the cooling system.

Fig. 4 depicts the freezing points of typical ethylene-glycol antifreeze and water solutions. The freezing points of specific brands may vary slightly from prints shown on the graph. However, the graph is sufficiently accurate for use in estimating antifreeze requirements, regardless of brands.

ETHYLENE-GLYCOL TYPE WITH DE-IONIZED WATER

Because hardness, total solids, and corrosiveness of water varies throughout the world, antifreeze

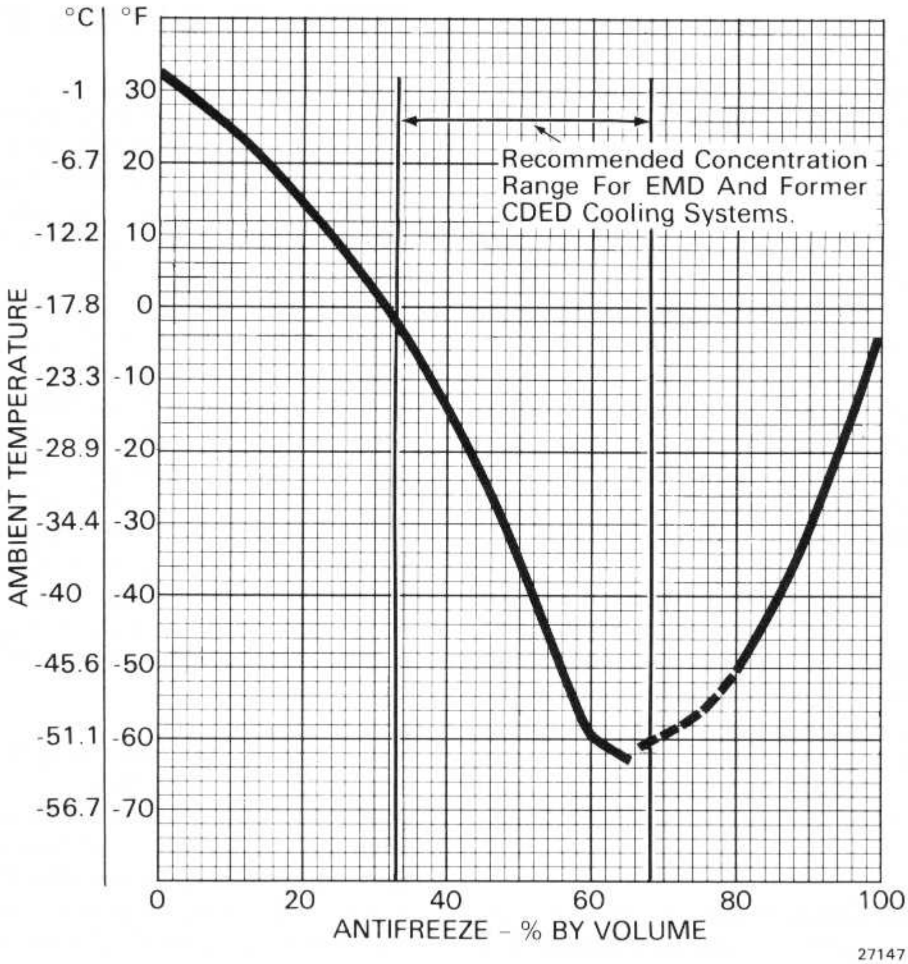


Fig.4 - Freezing Points Of Aqueous Solutions Of Ethylene-Glycol Antifreezes

containing inhibitors and de-ionized water should be used in areas where the water does not meet the standards listed in Table 1 "Water." This type of antifreeze contains the proper amount of ethylene-glycol to protect the cooling system from freezing to 40° C (-40° F).

METHOXY PROPANOL TYPE

The principal advantage of methoxy propanol is that oil contamination from coolant leaks is minimized. The 50% methoxy-propanol-water mixture, which boils at 98.3° C (209° F), vaporizes out of the hot lubricating oil and thus does not form a sludge as would ethylene-glycol.

The disadvantages of using methoxy propanol are:

1. Corrosion Protection

   Inhibitors commonly used in ethylene-glycol antifreeze have limited solubility in the methoxy propanol.

2. Freezing Protection

   The freezing point depressant characteristics are not as good as ethylene-glycol. For example, a 50% aqueous solution has a freezing point of -28.3° C (-19° F) as compared with -36.7° C (-34° F) for a 50% solution of ethylene-glycol.

3. Fire Hazard

   The flash point of a 50% aqueous solution is 47.8° C (118° F). The flash point of the concentrate is 34.4° C (94° F) as compared with 132° C (270° F) for ethylene-glycol.

GENERAL COMMENTS

Most manufacturers advise against the addition of supplemental inhibitors or additives to either fresh or used antifreeze solutions. They also advise against mixing of different antifreeze brands. These restrictions recognize the fact that some supplemental inhibitors, additives, and antifreeze brands contain materials which may not be compatible with the corrosion inhibitors initially incorporated in the antifreeze. The addition of these compounds could increase corrosion in the cooling system. EMD concurs with the antifreeze manufacturer's advice.

Some antifreeze manufacturers market inhibitor concentrates specifically designed for reinhibiting their antifreeze. These inhibitors are designed only for their antifreeze and should be added only on their advice.

Some brands of antifreeze contain anti-leak compounds which may cause plugging and eventually reduce the heat transfer qualities of the cooling system. EMD advises against the use of antifreeze containing anti-leak compounds.

FIELD QUALIFICATION TESTS FOR CORROSION INHIBITORS AND ANTIFREEZE CONCENTRATES

Before a cooling system additive is placed in general service, field qualification tests should be undertaken on a sample of both new and old cooling systems.

No inhibitor or antifreeze is considered suitable for use in EMD engine cooling systems unless it passes the laboratory glassware tests described below.

CAUTION

Do not place an unqualified additive in general service. Such additives may cause widespread cooling system damage, and result in very expensive repair.

LABORATORY EVALUATION TESTS

The purpose of the laboratory tests is to ensure complete water solubility of corrosion inhibitor ingredients within an at-use pH concentration of 7.5 to 10. (An engine coolant having a pH factor of approximately 11 will result in erosion-corrosion of the non-ferrous metals in the cooling system.)

All corrosion inhibitors and antifreeze concentrates contain a blend of chemical compounds which protect metals, common to the cooling system, from corrosion. To ensure adequate protection, these compounds must be present in the coolant in proper proportions.

NOTE

It is essential to follow the blending sequence, especially when using liquid concentrated formulations. Improper blending sequence or inadequate reaction time will result in an excessive amount of precipitate in the liquid concentrate and reduce the effectiveness of the inhibitor.

GLASSWARE CORROSION TESTS FOR INHIBITORS AND ANTIFREEZE

The glassware corrosion test will generally differentiate between products having good corrosion inhibiting properties and those which are detrimental to the metal test specimens. This test must conform with the standards set forth in ASTM D1384-80 "Corrosion Test for Engine Coolants in Glassware." However, the glassware corrosion test should be modified to reflect the metals in the EMD cooling system, and the operational characteristics in the field. These modifications are as follows:

1. Do not incorporate aluminum in the coupon bundle, Fig. 5, since it is not present in EMD engine cooling systems. However, red brass (85% copper - 15% zinc) should be included in the coupon bundle since this metal is used in the cooling system.

2. Because some inhibitors react differently, the glassware corrosion test should be performed in both soft and hard waters. Corrosive water obtained by adding sodium salts to distilled water, as specified in D1384, is considered a soft water. Hard water containing calcium and magnesium compounds will often be used in the engine cooling system, but must be limited to 170 ppm. The laboratory sample of hard water should observe the same limitation.

NOTE

Before conducting glassware corrosion tests on unknown products, it is suggested that the user conduct tests on known quality products. Conducting glassware tests on a quality product will familiarize laboratory personnel with the test procedure and the variations which may be encountered.

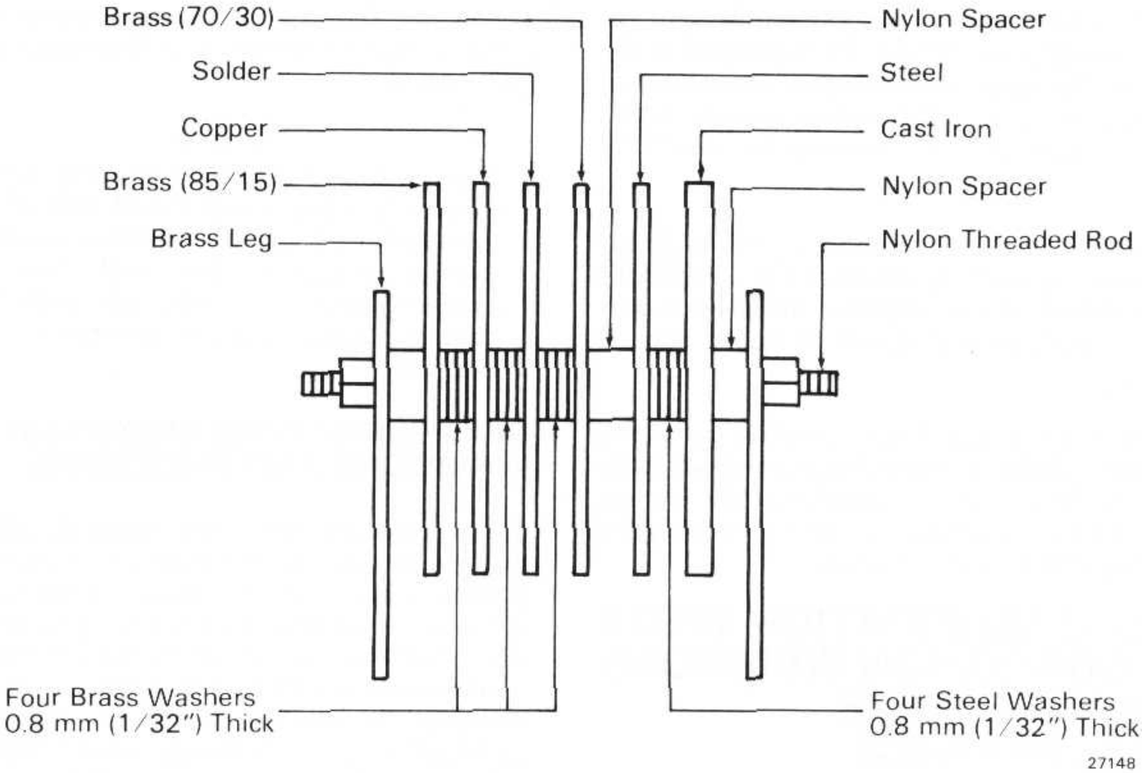


Fig.5 - Arrangement Of Metal Test Specimens

INTERPRETATION OF GLASSWARE CORROSION TEST RESULTS

In general, an inhibitor or antifreeze is considered unsuitable for use in EMD engine cooling systems when the weight loss of the metal test specimens exceeds the following recommended limits:

Cast Iron and Steel	5 milligrams per coupon.
Solder	20 milligrams per coupon.
Brass and Copper	10 milligrams per coupon.

If the weight losses of the metal test coupons do not exceed the above limits but the coupons show signs of pitting or crevice-type corrosion, the corrosion protection properties of the coolant are considered inadequate. Further, an excessive amount of precipitate is undesirable. An excessive amount of precipitate may cause fouling or erosion in the cooling system.

ELASTOMER IMMERSION TEST

The elastomer immersion test determines whether exposure to a corrosion inhibitor or antifreeze solution will have adverse effects on the elastomeric seals used in the EMD engine cooling system. This procedure is a standard compression set determination utilizing excerpts from ASTM D1384, D395 (Method C), and D471 as follows:

APPARATUS

1. Container - D1384
2. Condenser - D1384
3. Oil Bath - D1384
4. Aerator Tube - D1384
5. Air Supply - D1384
6. Two compression set fixtures each consisting of:
   a. Two 60 mm (2-1/4") diameter steel discs with 10 mm (3/8") diameter holes drilled into the center of each disc.
   b. An 8 mm (5/16") threaded bolt for insertion through drilled discs.
   c. An 8 mm (5/16") nut to fit the bolt for compressing discs together upon tightening.

7. Several 13 mm (1/2") square spacers of a thickness necessary to produce a 30% deflection of elastomers as specified below in "Test Specimens" section.

TEST SPECIMENS (Figs. 6 and 8)

Silicone Rubber Seals (See Service Data)

Fluoroelastomer Seals (See Service Data)

TEST SOLUTIONS

The concentration of the engine coolant to be tested shall be as follows:

1. Corrosion Inhibitor

   Corrosion inhibitor shall be mixed with the proper quantity of distilled water to give the resulting solution twice the minimum concentration as specified by the manufacturer.

2. Antifreeze

   Antifreeze shall be mixed with distilled water in the ratio of 50% by volume (1 to 1).

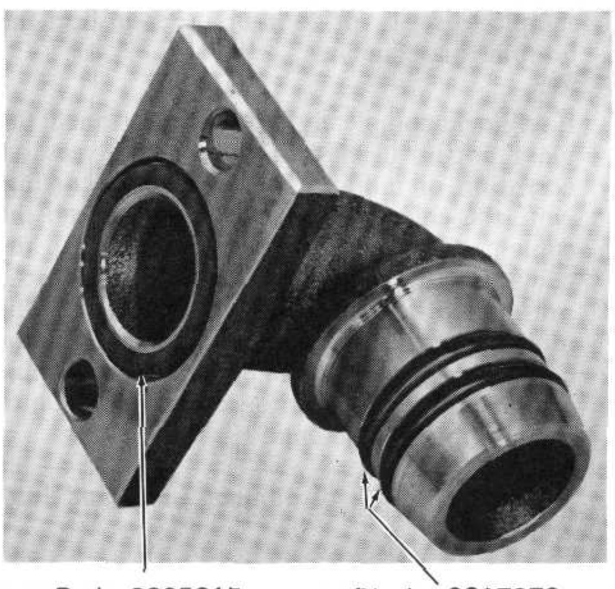


Fig.6 – Usage Reference For Test Sample Seals

PROCEDURE

Cut a 30 mm (1-1/4") length from each of five silicone rubber and fluoroelastomer seals. Use three of each seal type in the test for compression set. The remaining seals will be used for volume change and durometer hardness change determination.

1. Compression set determination (according to ASTM D395, Method C), except as follows:

   Measure initial thickness of three silicone rubber seals. Prepare two sets of spacers of appropriate thickness to obtain a 30% deflection of the seals. Place the spacers on the flat side of a steel disc at the outside edges, diametrically opposed, Fig. 7.

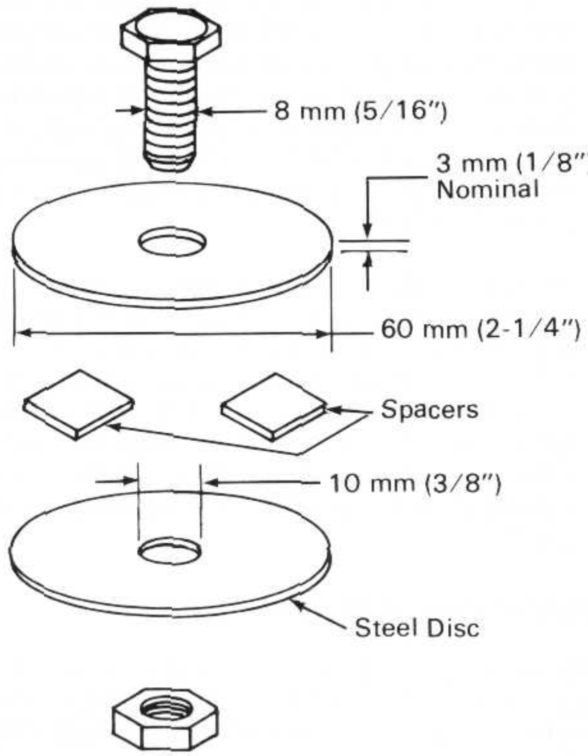


Fig.7 – Compression Set Fixture And Spacers

   Place the silicone seals on the disc allowing sufficient space between samples. Place the second disc on top, and insert bolt through the center holes from the bottom. Carefully tighten the nut with a wrench, using care not to dislodge the spacers. Tighten until solid contact is made between the spacers and steel disc.

   Repeat procedure outlined above for fluoroelastomer seals using the second compression set fixture.

2. Volume Change and Duro Hardness Change

NOTE

Measure the initial durometer hardness and initial weight in air and water of the two silicone seals and the two fluoroelastomer seals per ASTM D471.

Place the two compression set fixtures and all the seals measured for volume change into the glassware corrosion container which has been filled with 600 ml of the test solution and insert the rubber stopper and aerating tube, as outlined in D-1384. Place the container in the oil bath heated to 88° C (190° F). Adjust air supply at a rate of 100 ml/min. Insert condenser tube into the rubber stopper.

After 70 hours in the heated oil bath, remove the container from the bath. Immediately remove the compression fixtures and disassemble. Remove the seals from the fixture and allow to cool on a thermally non-conducting surface, such as wood, for 30 minutes before measuring thickness and determining the compression set per ASTM D395.

Allow the volume change samples to remain in the container (do not drain any coolant). Place container in a water bath and cool to 25° C (77° F). After 30 to 60 minutes, remove the samples from the container, blot the surface, and quickly weigh in air and then weigh in water. Measure durometer hardness. Determine volume change and hardness change per ASTM D471.

INTERPRETATION OF TEST RESULTS

If the changes in the elastomeric properties after the immersion tests exceed the limits listed below, the inhibitor or antifreeze is considered unsuitable for use in EMD cooling systems:

Volume change for – Fluoroelastomer (EMS 641, Gr .76), Silicone Rubber (EMS 644, Gr .71)	0 to +10%
Duro hardness change for – Fluoroelastomer, Silicone Rubber	0 to -10%
Compression set for – Fluoroelastomer, Silicone Rubber	20% Max.

FIELD QUALIFICATION TESTS FOR CORROSION INHIBITORS AND ANTIFREEZE

The glassware corrosion test should be recognized as a controlled laboratory test. It is possible that a coolant which appears satisfactory in glassware corrosion tests may fail in the field. The glassware corrosion test is conducted statically; the final evaluation of a coolant must be made in the field where the inhibitor will be subjected to the cooling system turbulence, heat, and flow rates.

Whenever possible, the recommended concentration of inhibitor or antifreeze should be tested in five new and five old engine cooling systems. The engines used in the qualification test should be in heavy duty service on the highest horsepower units available. New inlet water jumper lines and inlet deflectors should be installed on the right bank front and rear of the NEW engines tested in order to establish a valid baseline. The engines should be identified as test units. The first inspection of the cooling system components should be made 3 months after the initiation of the tests. This inspection should include the following:

1. Coolant Sample

   Operate the engine for a minimum of 15 minutes before obtaining a representative coolant sample. Purge the sight glass to remove any accumulated sediment by draining a minimum of one quart of coolant. After sediment is purged from the glass, collect one quart in a clear, clean glass bottle. Allow the sample to settle for 24 hours; then inspect the bottom for sediment.

   If sediment completely covers the bottom of the glass bottle, it may indicate that excessive corrosion or inhibitor depletion is occurring. Note the color of both the sediment and the coolant. (The density of the color dye in the coolant should be strong enough to indicate the presence of the inhibitor or antifreeze.) The inhibitor or antifreeze manufacturer should be contacted to analyze the coolant to determine whether there has been excessive depletion of the inhibitor ingredients.

2. Visual Inspection of Jumper Lines and Inlet Deflectors

   Remove two water jumper lines and inlet deflectors from the right bank front and rear of engine. With a strong light, visually inspect the interior of the jumper lines for corrosion as indicated by well defined irregular spots or corrosion products 1 mm (1/32") or more in thickness. (Note that the removal of the solid corrosion products by pickling or abrasion will reveal pitting.)

   Inspect both sides of the deflectors for signs of pitting which may indicate corrosion-erosion or impingement corrosion. Generally, the surface of the deflectors will have a tarnish coating. If the surfaces are clean and bright, this condition may indicate metal deterioration caused by inadequate inhibitor protection.

3. Visual Inspection of the Oil Cooler

Remove the most accessible oil cooler flexible coupling clamp plate from the oil ring and the water inlet pipe. With a strong light and telescoping mirror, inspect the interior of the oil cooler tubes. Clean bright metal or pitting are indications of corrosion. Also inspect the top of the tubes for erosion (wearing away of the metal).

4. Visual Inspection of the Water Pump

Remove and disassemble one of the water pumps. Inspect the carbon seal for excessive wear, and check the water pump impeller for bright shiny surfaces which may indicate corrosion.

INTERPRETATION OF FIELD QUALIFICATION TEST RESULTS

If there are no indications of corrosion problems after 3 months, the field test may be continued. However, the cooling system should be inspected at 3-month intervals in the same manner as described for the 3-month inspection.

After completion of the 12-month field tests, if the results are considered satisfactory by EMD, the corrosion inhibitor or antifreeze can be considered suitable for use in EMD engine cooling systems.

SERVICE DATA

Silicone Rubber Seals	8305815
Fluoroelastomer Seals	9317972

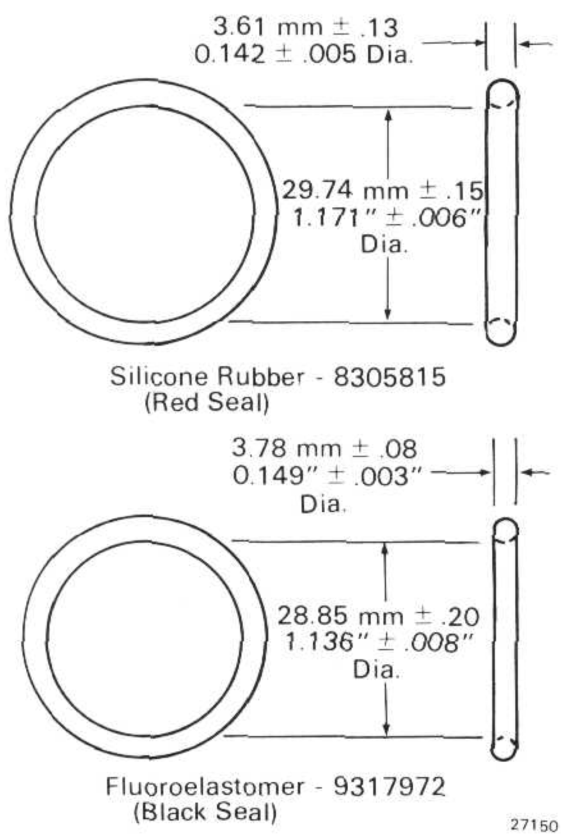


Fig.8 – Dimensional Reference For Seal Applications

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