



**M.I. 1748**

Rev. H

## **MAINTENANCE INSTRUCTION**

### **ENGINE COOLANT**

Changes in Revision H are indicated by the box **H** in the margin of the affected text.

#### **SAFETY PRECAUTIONS**

Please refer to the EMD Safety Precautions section in the applicable Locomotive Running Maintenance Manual or Locomotive Service Manual whenever routine service or maintenance work is to be performed.

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## 1.0 Purpose

Revision **G** of this Maintenance Instruction (MI) is issued to update guidelines for the proper use and selection of coolant for EMD engines.

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 necessary for the efficient operation 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, downtime, and repair costs.

## 2.0 Coolant Solutions

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

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

These requirements are normally satisfied by combining **suitable water** with a **reliable, quality corrosion inhibitor**.

Water quality is **the** key element to acceptable coolant performance. A suitable source of coolant water meets the basic chemical requirements of section III, Cooling Water Requirements. Adding a reliable corrosion inhibitor product to an acceptable quality water source, will produce a coolant formula that will prevent scale build-up, sludge formation and prevent corrosion of the multiple metals present in the engine cooling system. The quality of both the water and the corrosion inhibitor formulation are integral to successful coolant performance.

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

Coolants that 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 invalid.

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 or propylene glycol type antifreeze. The antifreeze shall contain adequate inhibitors to protect the cooling system from corrosion. However, the use of antifreeze coolant involves special consideration regarding Items 1, 3 and 5 above. This will be discussed in detail in Section 5 "Antifreeze Coolant".

The formulation of home-made corrosion inhibitors and antifreeze coolants is not recommended. These formulations may lack individual inhibitor chemicals that are necessary to protect all the cooling system metals from corrosion. Improper blending sequences of the individual inhibitor chemicals may result in excessive precipitation of the total inhibitor package. This condition may result in reducing the effectiveness of the corrosion inhibitor. Further, the home-made corrosion inhibitor packages may be difficult to monitor and control. The ready availability of suitable proprietary products makes these practices uneconomical and impractical.

Aids in determining the effectiveness of a corrosion inhibitor or antifreeze coolant are as follows:

1. Glassware corrosion test and Elastomer Immersion test.
2. Visual inspection of the coolant relative to its clarity.
3. Regular inspection of engine components, such as the coolant jumper lines, coolant inlet deflectors, oil cooler tubes, and water pump impeller and seals.
4. Maintaining the recommended inhibitor concentration by regularly scheduled tests.

### **3.0 Cooling Water Requirements**

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 deionized to make it suitable for use. Steam condensate is also suitable for use in the cooling system.

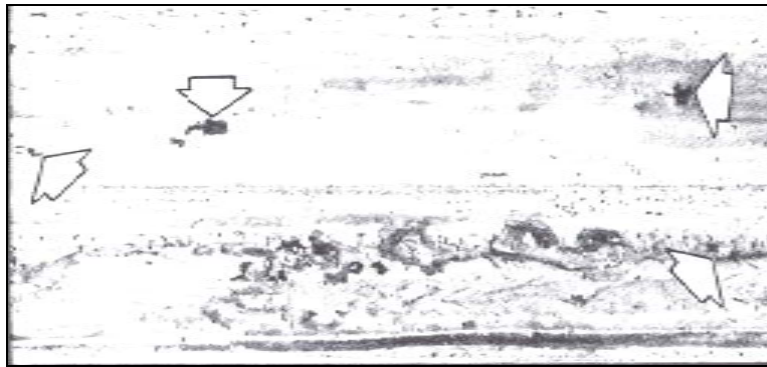


Fig 1 – Section Of Cooling Water Radiator Tube

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 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.

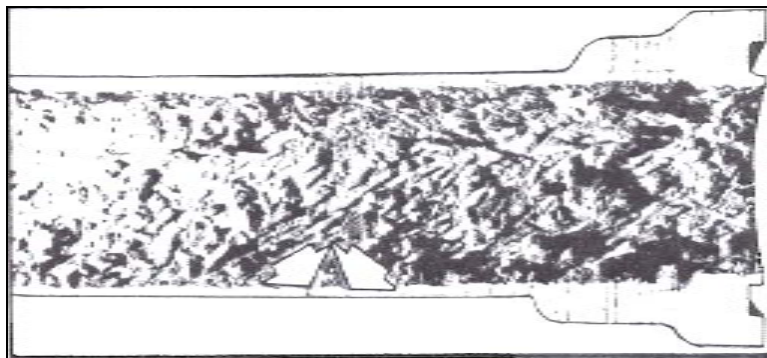


Fig 2 – Section Of Cylinder Liner Water Jumper

Cylinder liner water jumper sectioned to show corrosion after approximately 5000 hours operation. Coolant consisted of hard water, 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.

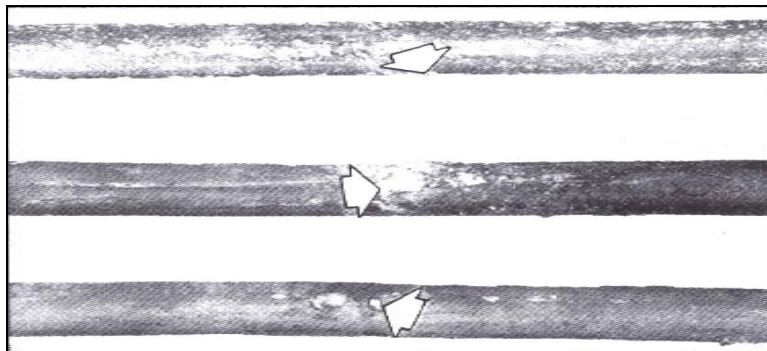


Fig 3 – Section Of Heat Exchange Tubes

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

With a quality corrosion inhibitor, water of the quality shown in Table 1 is considered suitable for use in the cooling system.

Table 1. Water Quality

Measurement	PPM (mg/L)	Grains/Gallon
Total Solids, Max.	340	20
Total Hardness (Salts, Max)	170	10
Chlorides, Max.	40	2.5
Sulfates, Max.	100	5.8

Water containing excessive amounts of the ingredients shown in Table 1 can cause scale and sludge deposits, corrosion, or a combination of these.

## 4.0 Cooling Water Treatment

The water used in the engine cooling system shall be treated with a corrosion inhibitor. The corrosion inhibitor is a blend of chemical compounds, which function by forming a corrosion-inhibiting film on exposed metal surfaces. The borate nitrite/nitrate corrosion inhibitor is the most common type inhibitor used in EMD engine cooling systems. Chromate based corrosion inhibitors are not commonly used. Two other types of inhibitors, soluble oil and an organic product, have seen very limited use in EMD cooling systems in field service.

This section describes various inhibitors that can be used to treat cooling water, as follows:

- Chromate Type Inhibitors
- Borate-Nitrite Type Inhibitors
- Soluble Oil (Emulsifiable Oils) Inhibitors
- Organic Type Inhibitors

The section also contains a summary that comments on these inhibitors.

### 4.1 Chromate Type Inhibitors

Chromate is an effective corrosion inhibitor for engine cooling water; however, because of federal, state, and local pollution restrictions in the discharge of chromates, their use is not recommended or endorsed. The use of chromate with ethylene-glycol may, under certain conditions, result in insoluble sludge forming in the cooling system.

## **4.2 Borate-Nitrite Type Inhibitors**

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 that is distinctive in color and stable at a temperature of 190 ° F (88 ° C). It is recommended that a pellet or powder inhibitor first be dissolved in water and then added to the cooling system.

The water treatment supplier shall recommend a dose amount of the qualified inhibitor product that shall provide a minimum level of 1200 to 1400 ppm nitrite as (NO<sub>2</sub>). Only products that have been qualified acceptable by the EMD laboratory glassware corrosion test shall be considered for use in the cooling system of EMD products.

This concentration of water treatment product shall also provide a level of silicate and yellow metal protectants, present in sufficient amounts to protect non-ferrous components of the cooling system from corrosion. Silicate shall not exceed the levels specified by ASTM D4985.

If aluminum has been introduced to the cooling system via a retrofit component, silicate should be at least 200 ppm. The pH of nitrite/ non-borate corrosion inhibitor products may be detrimental to aluminum. The corrosion inhibitor supplier should be consulted before considering the use of this type of formulation.

Some geographical areas have restrictions relative to the discharge of borates. In states where surface water is used to irrigate citrus crops, stricter limitations may be established. Federal, state, and local pollution restrictions should be investigated before discharging borate-containing inhibitors.

## **4.3 Soluble Oil (Emulsifiable Oils) Inhibitors**

Soluble oils are not considered suitable for use in EMD engine cooling systems for the following reasons:

1. It is difficult to run quick tests to determine the concentration.
2. The emulsifiers tend to break down, causing an oily film to float on the water.
3. In some instances, the oil layer may interfere with heat transfer or cause sludge accumulation in the system.
4. They may be harmful to the elastomers in the cooling system thereby causing coolant leaks.
5. They do not contain a tracer element, which can be used as a tracer to detect the presence of coolant leaks into the lubricating oil.

## **4.4 Organic Type Inhibitors**

Organic type inhibitors are generally in the form of liquids. The pH of this type inhibitor when mixed with water is approximately 7.5. They also contain a distinctive color dye, which is stable at a temperature of 190 ° F (88 ° C). The recommended inhibitor dosage, for an initial fill, is 1.2 fluid ounces per gallon. Thereafter, the inhibitor concentration should be maintained



above 0.6 fluid ounces per gallon. When coolant is lost from the system, the makeup coolant should contain inhibitor in the recommended dosage.

Organic type inhibitors do not contain an element that can be used as a tracer to detect the presence of coolant leaks into the lubricating oil.

Most states restrict the discharge of this type of inhibitor, which is similar to petroleum base materials.

## 4.5 Summary

1. 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.
2. The above inhibitor usage concentrations have been found suitable for most corrosion inhibitors. However, customers should always contact the inhibitor supplier for recommendations as to the proper concentration level for their application.
3. To be satisfactory for use in EMD cooling systems, inhibitors should contain a strong tracer element. Most inhibitor suppliers have test kits to determine the concentration of their respective inhibitors. It is important that the concentration of a specific inhibitor be determined with the proper test kit as recommended by the supplier.
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 operation, 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 a poor practice, which can cause corrosion.
6. The reuse of inhibited coolant that has been drained from an engine is not recommended. If a customer does reuse the coolant, particular attention should be given to piping and holding tanks to ensure they are free of dirt and oil.
7. Most manufacturers advise against mixing of different brands of corrosion inhibitors. This restriction recognizes the fact that some corrosion inhibitor brands may not be compatible with other brands. This incompatibility may lead to foaming, precipitations, or accelerated corrosion. EMD concurs with the manufacturer's advice in this matter.

## 5.0 Antifreeze Coolant

This section describes the following antifreeze coolants and provides recommendations for their use:

- Alcohol Type Antifreeze
- Ethylene-Glycol Type Antifreeze Coolant

- Ethylene-Glycol Type Antifreeze Coolant Containing Deionized Water
- Propylene-Glycol Type Antifreeze Coolant

## **5.1 Alcohol Type Antifreeze**

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

## **5.2 Ethylene-Glycol Type Antifreeze Coolant**

Where EMD engine cooling systems must be protected from freezing, an antifreeze coolant meeting ASTM D4985 specification is recommended. The antifreeze shall be fully formulated, containing a balanced blend of corrosion inhibitors, anti-foam, and a distinctive color dye. Further, the antifreeze shall not contain more than 0.10% of sodium silicate.

**NOTE:** See comments under Silicate Dropout

Ethylene-glycol type antifreeze should be used at concentrations between 33% and 68% by volume, as required to prevent freezing. Generally a 50/50 mix is recommended: this provides freezing protection to -32° F (-36° C). Antifreeze concentrations below 33% do not provide a sufficient amount of inhibitors to adequately protect the cooling system from corrosion. Antifreeze concentrations above 68% may not provide adequate heat transfer and will raise the freezing point. For example, the freezing point of 100% ethylene glycol is -8° F (-22° C).

## **5.3 Ethylene-Glycol Type Antifreeze Coolant Containing Deionized Water**

The hardness, total solids, and corrosivity of water varies throughout the United States. It is recommended that antifreeze containing inhibitors and deionized water be used in areas where the water does not meet the standards listed in Table 1. This type of antifreeze contains the proper amount of ethylene glycol to protect the cooling system from freezing to -40 ° F (-40 ° C).

These products are generally identified as full-fill antifreeze coolant. These products shall not be diluted with water.

## **5.4 Propylene-Glycol Type Antifreeze Coolant**

Propylene-glycol type antifreeze coolants are analogues to ethylene-glycol type antifreeze. The corrosion inhibitor package added to ethylene-glycol is also soluble in a propylene-glycol product. The reported advantage in using propylene-glycol is that it is less toxic.

The specific heat and thermal conductivity of aqueous solutions of ethylene and propylene glycols are similar. Lower freeze points may be obtained with propylene glycol. The propylene-glycol products may be obtained as a concentrate or pre-diluted with deionized water.

The freezing point of aqueous solutions may be determined by hydrometer or refractometer field testers, which are specifically calibrated for propylene glycol. Ethylene glycol field testers may be used; however, it will be necessary to obtain a conversion table from the supplier to convert the reading to propylene glycol. Certain models of refractometer field testers have both ethylene and propylene glycol freeze point protection scales.

## 5.5 Freezing Point

When liquids are cooled, they eventually either crystallize like ice or become increasingly viscous until they fail to flow and set up like glass. The first behavior is true freezing; the second is called supercooling.

The glycols do not have sharp freezing points. Under normal conditions, ethylene glycol and the other members of the ethylene series supercool rather than freeze; however, freezing points can be obtained if seeding and agitation are properly employed. Propylene glycol and its homologs likewise set to glass-like solids, rather than freezing.

The addition of water to a glycol yields a solution with a freezing point below that of water. This has led to the extensive use of glycol-water solutions as cooling media at temperatures appreciably below the freezing point of water. Instead of having sharp freezing points, glycol-water solutions become slushy during freezing. As the temperature is lowered, the slush becomes more and more viscous and finally fails to flow.

Freezing points of glycol-water solutions are shown in Figure 4. The freezing points are the temperatures at which the first crystals form; below these temperatures, a slushy solution exists, which will still flow.

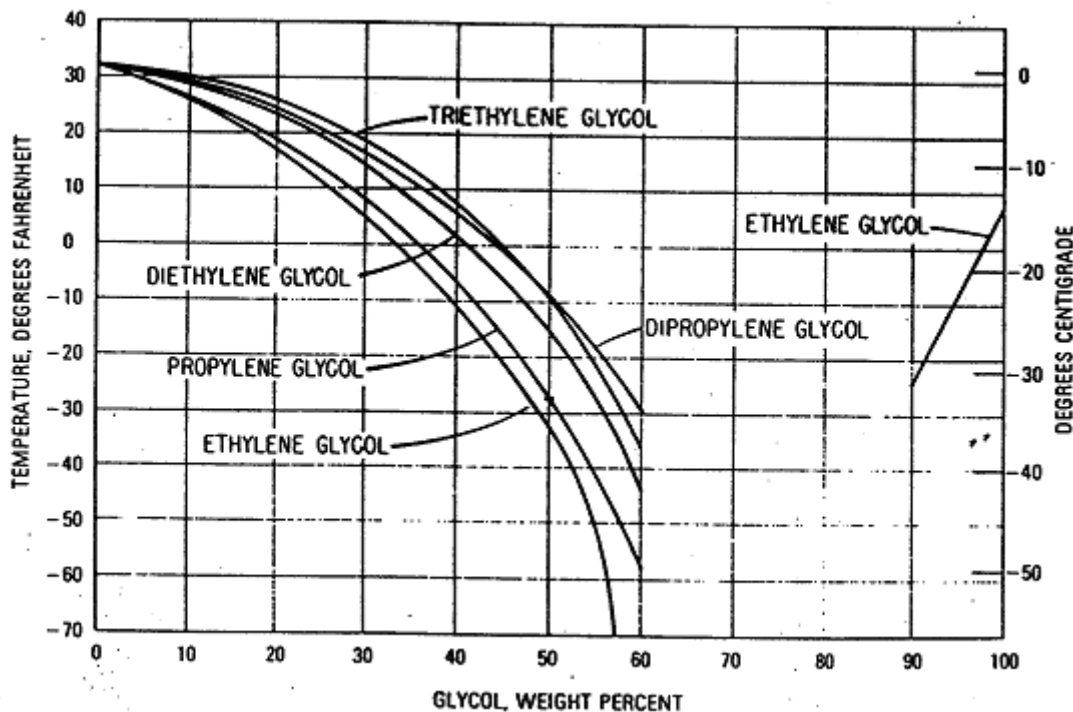


Fig 4 – Freezing Point of Aqueous Glycol Solutions

## **5.6 Addition of Supplemental Inhibitors or Mixing of Antifreeze Coolant Brands**

Most antifreeze coolant 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 coolant brands. These restrictions recognize the fact that some supplemental inhibitors, additives, and antifreeze coolant brands contain materials that may not be compatible with the corrosion inhibitors initially incorporated in the antifreeze coolant. The addition of these compounds could increase corrosion in the cooling system. EMD concurs with the antifreeze coolant manufacturer's advice.

Some antifreeze coolant manufacturers market a solution specifically designed for reinhibiting their antifreeze product (SCA). These solutions are designed only for their product and should be added only on their advice.

## **5.7 Antifreeze Coolants with Antileak Additives**

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

## **5.8 Draining of Cooling Systems Containing Antifreeze Coolant**

If it is necessary to drain the cooling system, it is suggested that the antifreeze be placed into a clean retention tank such as a rubber bag. Reusing antifreeze solution from one engine in another engine is a poor practice that can cause corrosion. If it becomes necessary to discard the antifreeze remember that the antifreeze or inhibitor ingredients may be considered pollutants. Federal, state and local pollution restrictions should be investigated before discarding the antifreeze solution.

## **5.9 Silicate Dropout**

With the increased use of aluminum in automobile engines, many of the antifreeze coolant manufacturers have introduced high silicate antifreeze formulations. The primary purpose of the new formulations is to prevent corrosion of the aluminum heat rejection surfaces and other aluminum parts.

The combination of a high silicate antifreeze, supplemental corrosion inhibitors, and hard water results in silicate dropout (gelation). The resultant silica creates deposits, which plugs radiators and heater cores.

To reduce silicate dropout in EMD engine cooling systems, the following is recommended:

1. Use a low-silicate, (no more than 0.10%) sodium silicate antifreeze coolant meeting ASTM D4985 standard. Generally, the recommended antifreeze concentration shall never exceed 68% by volume.
2. Do not add supplemental inhibitors or additives to either fresh or used antifreeze. Further, do not mix different brands of antifreeze coolant.

## 5.10 Summary

1. The thermal conductivity of an antifreeze solution is lower than that of an inhibited water coolant. Thus, antifreeze should not be used without prior consultation with an EMD Service Representative regarding the specific installation and possible engine derating requirements.
2. The corrosion inhibitors incorporated in antifreeze coolants are slowly depleted in service. How long these inhibitors will remain effective depends on such factors as the cooling system condition, hours of operation, coolant and metal temperatures, aeration, and rate of contamination of solution. Usually, the antifreeze coolant manufacturers guarantee their products for only one year. In special applications involving large capacity systems, such as EMD engines, the antifreeze solutions may be guaranteed for a longer period of time. In these special applications, the customer should contact the manufacturer for instructions, which may include periodic tests of the antifreeze solution by the antifreeze manufacturer.
3. Chromate type inhibitors shall not be used in cooling systems containing ethylene or propylene glycol type antifreeze. The use of chromate with ethylene or propylene glycol, under certain conditions, may result in insoluble sludge forming in the cooling system.
4. The freezing point of antifreeze coolants may be determined by hydrometer-thermometer field tester (ASTM method D 1124) or refractometer (ASTM method D 3321).

## 6.0 Qualification Tests for Coolant Corrosion Inhibitors and Antifreeze Coolants

Before a corrosion inhibitor or antifreeze coolant is placed into a cooling system and subjected to field service, laboratory and field qualification tests shall be conducted on the product.

A corrosion inhibitor or antifreeze coolant is not considered suitable for use in EMD engine cooling systems until the product passes the qualification test. Placing an untested product in general field service may result in widespread cooling system damage and expensive repair. Unfortunately, damage to the cooling system may not appear early and may take as long as a year before the damage is visible.

All corrosion inhibitors and antifreeze coolants contain a blend of chemical compounds that prevents corrosion of the metals common to the cooling system. These compounds also maintain a suitable pH range, alkalinity, and reduce foam and scale formation.

To ensure adequate protection, the chemical compounds must be present in the proper proportions. Precipitation of these compounds in the corrosion inhibitor or antifreeze coolant indicates improper blending sequence by the manufacturer. Improper blending sequences or inadequate reaction time will result in excessive precipitation of the chemical compounds. This condition will reduce the effectiveness of the corrosion inhibitor. Precipitation of the corrosion inhibitor compounds is considered unacceptable and the product is considered unsuitable for use in EMD engine cooling systems.

## 6.1 Laboratory Tests

The purpose of the laboratory tests is to ensure complete solubility of the corrosion inhibitor in soft and hard water. Further, the pH of the corrosion inhibitor, at a concentration of two times the recommended dosage, should range between 7.5 and 10.5. A pH of 11 or above will result in erosion-corrosion of the non-ferrous metals in the cooling system. Any engine coolant with a pH in excess of 10.5 is generally considered unsuitable for use in EMD engine cooling systems.

### 6.1.1 Glassware Corrosion Test

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

- Red brass (85% copper-15% zinc) shall be included in the coupon bundle since this metal is used in the cooling system.
- Some inhibitors react differently in soft and hard waters. It is suggested that the glassware test be conducted in both waters. The glassware test, as specified in D1384, is considered soft water since the corrosive sodium salts are added to distilled water. The hardness of the hard water should range between 85 to 170 ppm. The corrosive salts, as specified in D1384, shall be added to the hard water.

**NOTE:** Before conducting glassware corrosion tests on unknown products, conduct tests on known quality products. Conducting glassware test on a quality product will familiarize laboratory personnel with the test procedure and the variations that may be encountered.

#### 6.1.1.1 Materials

The following materials are required:

- Brass 85/15 - UNS C23000 - size 50.8 by 25.4 by 1.59 mm (2 by 1 by 1/16 inch)
- Copper - UNS C11000 - size 50.8 by 25.4 by 1.59 mm (2 by 1 by 1/16 inch) cut from cold rolled stock.
- Solder - UNS L54915 - size 50.8 by 25.4 by 1.59 mm (2 by 1 by 1/16 inch)
- Brass 70/30 - UNS C26000 - size 50.8 by 25.4 by 1.59 mm (2 by 1 by 1/16 inch) cut from half-hard, sheet stock.
- Steel - UNS G10200 - size 50.8 by 25.4 by 1.59 mm (2 by 1 by 1/16 inch) cut from cold rolled stock.
- Cast iron - UNS F12801 (F10007) - size 50.8 by 25.4 by 3.18 mm (2 by 1 by 1/8 inch)
- Cast Aluminum - UNS A03190 - size 50.8 by 25.4 by 3.18 mm (2 by 1 by 1/8 inch)
- Set up the material as shown in Figure 5.

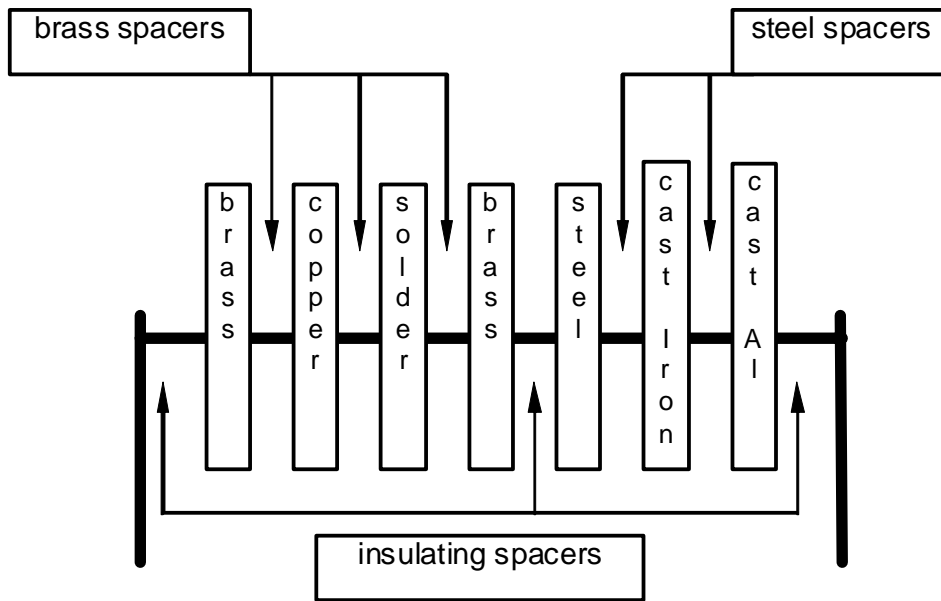


Fig 5 – Glassware Corrosion Test Setup

### 6.1.1.2 Weight Loss

Maximum weight loss allowances for both ASTM 1384 - D-3306 and EMD standards are shown in Table 2. These allowances are defined in mg per coupon at 336 hours.

Table 2. Maximum Allowance (mg/Coupon at 336 Hours)

Material	ASTM 1384 - D-3306 Standard	EMD Standard
Cast Iron/Steel	10	5
Solder	30	10
Brass and Copper	10	10
Cast Aluminum	30	10

Brass leg dimensions, spacer composition and dimensions per ASTM D1384 specification. The conditions and duration of test are defined by ASTM D 1384 Glassware Corrosion Test.

### 6.1.1.3 Interpretation of Test Results

In general, an inhibitor or antifreeze coolant is considered unsuitable for use in EMD engine cooling systems when the weight loss of the metal test coupons exceeds the recommended limits shown in Table 3.

Table 3. Weight Loss

Material	Weight Loss
Cast Iron and Steel	5 milligrams per coupon
Solder and Aluminum.	10 milligrams per coupon
Brass and Copper	10 milligrams per coupon

If the weight losses of the metal test coupons do not exceed the limits shown in Table 3 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 considered undesirable because it may cause fouling or erosion in the engine cooling systems.

## **6.1.2 Elastomer Immersion Tests**

The elastomer immersion tests determine whether exposure to a corrosion inhibitor or antifreeze coolant 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 B), and D471.

### **6.1.2.1 Apparatus**

The following apparatus is required:

- Container - D1384
- Condenser - D1384
- Oil Bath - D1384
- Aerator Tube - D1384
- Air Supply - D1384
- Three compression set fixtures each consisting of
  - Two 2 1/4-inch (57 mm) diameter steel discs with 3/8-inch (10 mm) diameter holes drilled into the center of each disc. Drill three 1/4-inch (6 mm) equally spaced holes, 3/4-inch (19 mm) from the bolt hole center.
  - A 5/16-inch (8 mm) threaded bolt for insertion through drilled discs.
  - A 5/16-inch (8 mm) nut to fit the bolt for compression discs together upon tightening.
  - Several 1/2-inch (13 mm) square spacers of a thickness necessary to produce a 30% deflection of elastomers as specified in the following sections.

### **6.1.2.2 Test Specimens**

Test specimens shall have been qualified to specification in air before testing in coolant.

1. Silicone Rubber Seals (Part No.8305815)
2. Silicone Rubber Seals (Part No. 8384772)
3. Fluoroelastomer Seals (Part No. 9317972)



### **6.1.2.3 Test Solutions**

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

1. Corrosion Inhibitor - The 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 Coolant - The antifreeze coolant shall be mixed with distilled water in the ratio of 50% by volume (1-1).

### **6.1.2.4 Procedure**

1. Cut a 1 ¼-inch (32 mm) length from each of five 8305815 and 9317972 seals. Use three of each seal type for the compression set test. The remaining seals shall be used for volume and durometer hardness change determinations.
2. Three 8384772 seals shall be subjected to the compression set test. The seals shall be tested in their entirety. Two seals shall be used for the volume and durometer hardness change determinations.

### **6.1.2.5 Compression Set Determination**

These determinations are according to ASTM D395, Method B, except as follows:

1. Measure initial thickness of each of the three 8305815 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.
2. Place the 8305815 seals on the disc allowing sufficient space between samples. Do not cover the 1/4-inch (6 mm) holes with the seals. 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.
3. Repeat procedure outlined above for the 9317972 seals using the second compression set fixture.
4. Repeat procedure outlined above for the 8384772 seals except that each sample is centered over each of the three 1/4-inch (6 mm) holes. Place three sets of spacers between each seal.

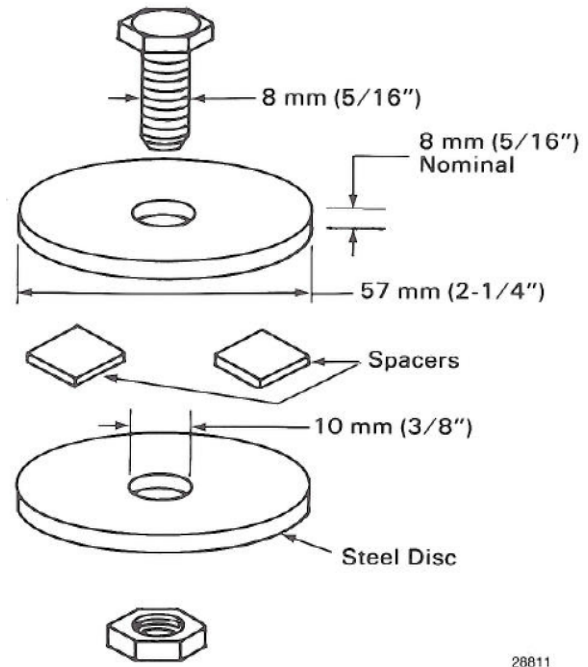


Fig 6 – Usage Reference For Test Sample Seals Fig 7 – Compression Set Fixture And Spacer

### 6.1.2.6 Volume Change and Duro Hardness Change

1. Measure the initial durometer hardness and initial weight in air and water of the silicone and fluoroelastomer seals per ASTM-D471.
2. Fill the glassware container with 600 cc of the test solution. Place the three compression set fixtures and all the measured volume and hardness change samples into the test solution. Insert the rubber stopper, containing the aerating and condenser tubes, into the container as outlined in D1384. Place the container into an oil bath heated to 190 ° F (88 ° C). Adjust the air supply rate at 100 mm/min.
3. At the end of 70 hours, remove the container from the bath. Immediately remove the compression fixtures and disassembly. Carefully remove the seals from the fixture. Allow the seals to cool for 30 minutes on a thermally non-conductive surface, such as wood. Determine the compression set per ASTM D395.
4. Allow the volume change samples to remain in the container (do not drain any coolant). Place container in a water bath and cool to 77 ° F (25 °C). 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.

### 6.1.2.7 Interpretation of Test Results

If the changes in the elastomeric properties after the immersion tests exceed the limits in Table 4, the inhibitor or antifreeze coolant is considered unsuitable for use in EMD cooling systems.

**Table 4. Limits**

<b>Property</b>	<b>Limit</b>
Volume change for Fluoroelastomer Silicone Rubber	-0 to +10%
Duro hardness change for Fluoroelastomer Silicone Rubber	10 Points Max.
Compression set for - Fluoroelastomer Silicone Rubber	20% Max.

## **6.2 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 that appears satisfactory in glassware corrosion tests may fail in the field. The glassware corrosion test is conducted statically; the final evaluation of a coolant shall be made in the field where the inhibitor or antifreeze will be subjected to the cooling system turbulence, heat, and flow rates.

Whenever possible, the inhibitor or antifreeze coolant shall be tested in five new and five old engine cooling systems. The engines used in the qualification tests shall be the highest horsepower available and operated in heavy duty service. Install new water jumper lines and inlet deflectors on the right bank front and rear. The new parts will establish a valid base line. 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:

- Coolant Sample
- Visual Inspection of Jumper Lines and Inlet Deflectors
- Visual Inspection of the Oil Cooler
- Visual Inspection of the Water Pump

### **6.2.1 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 the 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 coolant) The inhibitor or antifreeze coolant manufacturer should be contacted to analyze the coolant to determine whether there has been excessive depletion of the inhibitor ingredients.

### **6.2.2 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 1/32-inch (1 mm) or more in thickness. The removal of the solid corrosion products by pickling or abrasion may reveal pitting.

Inspect both sides of the deflectors for signs of pitting that 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.

### **6.2.3 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).

### **6.2.4 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.

### **6.2.5 Interpretation of Field Qualification Test Results**

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

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

## **7.0 Cleaning EMD Engine Cooling Systems**

Cooling systems on new EMD engines are protected from corrosion during testing and storage periods. Thus, it is unnecessary, and it is not recommended, that the cooling system be cleaned prior to use. Cooling systems that have been maintained with a quality inhibitor and water

should not require cleaning. Field history has shown that EMD cooling systems are rarely cleaned.

Before considering cleaning a cooling system, symptoms of the cooling system problem should be identified, as follows:

- Excessive Coolant or Oil Temperatures
- Excessive Rust or Sediment in the Coolant
- Oil Contamination of the Coolant

## **7.1 Excessive Coolant or Oil Temperatures**

Excessive coolant and/or oil temperatures may be due to dirty radiator fins, fouled radiator coolant screens or plugged radiator tubes. Radiator fins and coolant screens should be cleaned as recommended in the EMD Maintenance Instructions. Plugged radiator tubes are difficult to clean by chemical treatment: chemical solutions that are capable of dissolving the debris may also, to some degree, attack the radiator metal. The only practical method of cleaning the radiator is to rod out the tubes. The radiator should be pressure-tested to insure that the rodding operation did not damage the tubes.

Excessive oil temperature may be due to the oil cooler having dirty fins or tubes coated with water hardness salts. To remove carbonaceous deposits from the fin side, the cooler may be cleaned in a vapor degreaser or a water soluble cleaner. Do not use a strong alkaline cleaner to clean the aluminum fins. Strong alkaline cleaners will attack and/or dissolve aluminum. The deposits in the tubes should be cleaned by mechanical rodding.

Excessive temperatures may also be due to hard water salts. The hardness salts of magnesium and calcium will coat the hot surfaces of the fire face side of the cylinder head. To a lesser extent, the hardness salts will coat the oil cooler tubes.

## **7.2 Excessive Rust or Sediment in the Coolant**

Generally, the only indication of excessive scale on the coolant side of the fire face is failure (cracking) of the cylinder head. To determine the severity of the scale coating, the failed cylinder head may be sectioned (cut) approximately one inch from the fire face (valve) seat side. Scale thickness greater than 1/64 inch (0.0156 inch) is considered detrimental to efficient heat transfer. If the other cylinder heads have been in the engine for a similar period of time as the failed head, it can be assumed that the scale thickness is also similar. The most efficient method, with the least damage to the engine, is to remove the cylinder head for cleaning. Cleaners based on inhibited sulfuric acid are recommended for removing water hardness scale. It is suggested that the acid be flushed through the cylinder head. Flushing the head with acid will effect faster dissolution of the hardness scale.

Rust is an obvious sign of active corrosion in the cooling system. Generally, the area most susceptible to corrosive attack is the coolant jumper lines. The coolant jumper lines should be inspected for pitting corrosion. Evidence of pitting corrosion indicates the jumper line has been weakened to some degree. Rather than cleaning the jumper lines, it is recommended that they be replaced. Rust may also plug the cylinder liner coolant ports. Past experience has

shown that acid cleaners are not effective in dissolving rust in a blocked port. Further, the acid may damage the base metal. The only effective way of opening a blocked port is rodding.

A mild descaling compound can be added to the coolant to break up light scale and rust deposits in the cooling system, although this may not be effective against heavy deposits or scale in the engine or radiators. This compound cannot contain muriatic or hydrochloric acid, as noted in section 7.3.

Caterpillar's cooling system cleaners, 4C-4609, 4C-4610, 4C-4611, 4C-4612, or 4C-4613, can be used for this purpose. Users must follow the instructions provided with the cleaner.

If a customer wishes to use another descaling compound, the customer should contact the EMD Service Department to see if the alternative compound is acceptable for use in EMD engines or locomotives.

### 7.3 Oil Contamination of the Coolant

**H** Oil contamination of the coolant will adversely affect the heat transfer. Oil may be removed by flushing the cooling system with a mild automatic dishwashing detergent. Before flushing the cooling system with dishwashing detergent, the whole system should be flushed thoroughly with plain water to physically remove as much residual oil as possible before introducing a detergent or chemical cleaning. The cleaner concentrations must be decided on an individual basis. Generally, the customer should contact the cleaner representative with information as to the type of scale to be removed. Cleaner concentration, time, and temperature should be decided by the representative.

The detergent cleaning procedure is intended to remove oil residues in these circumstances, but not for removal of bulk amounts of lube oil. If bulk amounts of oil are present, multiple flushings and drainings, using plain water and small amounts of detergent or chemical, should be performed. Use of large amounts of detergent in a single flushing operation can leave detergent residues in the engine, radiator and oil cooler and is not recommended.

**NOTE:** Cleaning solutions containing hydrochloric acid (muriatic acid) shall not be used in EMD engine cooling systems.

Questions concerning cleaning engine cooling systems should be directed to the EMD Service Department.

When using any corrosion inhibitor, verify the new material has not passed the shelf life noted on the product specifications.

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