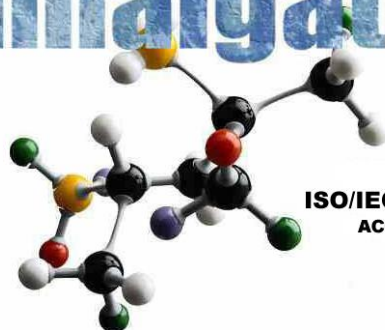


**amalgatech**



**ISO/IEC 17025-2005  
ACCREDITED**

**REPORT OF LABORATORY TESTING  
ASTM STANDARD TESTING PROTOCOL**

COOLANT STANDARDS:

ASTM D 3306<sup>1</sup>  
(ASTM D-4985<sup>1</sup>)

August 21, 2014

PERFORMED FOR  
**DOBER INNOVATION & TECHNOLOGY CENTER  
D-16L-604 EG 50% Aqueous Premix**

Laboratory ID: 1406192

**AMALGAMATED LABORATORIES, INC.**  
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**Introduction:**

This specification covers the requirements for ethylene glycol or propylene glycol base engine coolants used in automobiles or other light duty service cooling systems. When concentrates are used at 40 to 70 % concentration by volume in water, or when prediluted glycol base engine coolants (50 volume % minimum) are used without further dilution, they will function effectively to provide protection against freezing, boiling, and corrosion.

This specification is intended to cover the requirements for engine coolants prepared from virgin or recycled ethylene or propylene glycol. The coolants governed by this specification are categorized as follows:

- I-FF Ethylene glycol base concentrate
- II-FF Propylene glycol base concentrate
- III-FF Ethylene glycol predilute (50 vol %)
- IV-FF Propylene glycol predilute (50 vol %)

The D3306 specification publishes the following requirements for the physical and chemical tests:

Property	EG Concentrate	PG Concentrate	EG Predilute	PG Predilute	Test Method used at Amalgatech
Relative Density, 15.5/15.5°C (60 /60 °F)	1.110 –1.145	1.030-1.065	1.065 min.	1.025 min.	D1122 <sup>1</sup>
Freezing Point, °C (°F) 50% in DI water Undiluted	-37 (-34) max.	-32 (-26) max.	-37 (-34) max.	-32 (-26) max.	D1177 <sup>1</sup>
Boiling Point °C (°F) <sup>A</sup> 50% in DI water, Undiluted	108 (226) min 163 (325) min	104 (219) min 152 (305) min	108 (226) min	104 (219) min	D1120 <sup>1</sup>
Ash content, mass%	5 max.	5 max.	5 max.	5 max.	D1119 <sup>1</sup>
pH 50 vol% in DI water Undiluted	7.5 –11.0	7.5 –11.0	7.5 –11.0	7.5 –11.0	D1287 <sup>1</sup>
Chloride, µg/g	25 max	25 max	25 max	25 max	D5827 <sup>1</sup>
Sulfate, µg/g	50 max	50 max	50 max	50 max	D5827 <sup>1</sup>
Water, mass%	5 max.	5 max.	5 max.	5 max.	D1123 <sup>1</sup>
Reserve Alkalinity, ml <sup>B</sup>	report	report	report	report	D1121 <sup>1</sup>
Effect on Automotive Finish <sup>C</sup>	no effect	no effect	no effect	no effect	D1882 <sup>1</sup>
Foaming Tendencies (ml / break time sec)	150 / 5 max	150 / 5 max	150 / 5 max	150 / 5 max	D1881 <sup>1</sup>

<sup>A</sup> Some precipitate may be observed at the end of the test. This is not a cause for rejection.

<sup>B</sup> Value as agreed between customer and supplier.

<sup>C</sup> Procedure and acceptance criteria should be agreed between customer and supplier

**D3306 Table 2: Physical & Chemical Tests**

Test Number & Description	Test Result
D-5961* <sup>1</sup> Relative Density (aka Specific Gravity)	1.0727
D-1177 <sup>1</sup> Freeze Point °C (°F) 50% with 50% DI Water v/v	-37.3°C (-35.2°F)
D-1120 <sup>1</sup> Boiling Point °C (°F) As received	108.0°C (226.4°F)
D-1120 <sup>1</sup> Boiling Point °C (°F) 50% with 50% DI Water v/v	n/a
D-1882 <sup>1</sup> Auto Finish Effect	No effect
D-1119 <sup>1</sup> Ash Content, mass%	0.4
D-1287 <sup>1</sup> pH: 50% vol. in distilled water	8.20
D-5827 <sup>1</sup> Chloride µg/g	2
D-1123 <sup>1</sup> Water mass percent	49.4
D-1121 <sup>1</sup> Reserve Alkalinity ml	1.2
D-1881 <sup>1</sup> Foaming Tendencies	50 ml volume 1.2 seconds break time

**ASTM D2809<sup>1</sup>: Cavitation Corrosion and Erosion-Corrosion Characteristics of Aluminum Pumps With Engine Coolants**

This test method consists of pumping an aqueous coolant solution at 113°C (235°F) through a pressurized 103-kPa (15-psig) simulated automotive coolant system. An aluminum automotive water pump, driven at 4600 r/min by an electric motor, is used to pump the solution and to serve as the object specimen in evaluating the cavitation erosioncorrosion effect of the coolant under test. The pump is examined to determine the extent of cavitation erosioncorrosion damage and is rated according to the system given in Table 3.

This test method can be used to distinguish between coolants that contribute to cavitation corrosion and erosioncorrosion of aluminum automotive water pumps and those that do not. It is not intended that a particular rating number, as determined from this test, will be equivalent to a certain number of miles in a vehicle test; however, limited correlation between bench and field service tests has been observed with single-phase coolants. Field tests under severe operating conditions should be conducted as the final test if the actual effect of the coolant on cavitation corrosion and erosion-corrosion is to be appraised. It is also possible, with proper control of the test variables, to determine the effect of pump design, materials of construction, and pump operating conditions on cavitation

**TABLE 3: Rating System**

<b>10</b>	No corrosion or erosion present; no metal loss. No change from original casting configuration. Staining permitted.
<b>9</b>	Minimal corrosion or erosion. Some rounding of sharp corners or light smoothing or both, or polishing of working surfaces.
<b>8</b>	Light corrosion or erosion may be generalized on working surfaces. Dimensional change not to exceed 0.4 mm (164 in.).
<b>7</b>	Corrosion or erosion with dimensional change not to exceed 0.8 mm (132 in.). Random pitting to 0.8 mm permitted.
<b>6</b>	Corrosion or erosion with dimensional change not to exceed 0.8 mm. Depressions, grooves, clusters of pits, or scalloping, or both, within 0.8 mm dimensional change limit permitted.
<b>5</b>	Corrosion or erosion with dimensional change not to exceed 1.6 mm (116 in.). Small localized areas of metal removal in high-impingement regions or random pits to 1.6 mm permitted.
<b>4</b>	Corrosion or erosion with dimensional change not to exceed 1.6 mm. Small localized areas of metal removal in high-impingement regions, clusters of pits within 1.6 mm dimensional change. Random pits to 2.4 mm (332in.) permitted.
<b>3</b>	Corrosion or erosion with dimensional change not to exceed 2.4 mm. Depressions, grooves, clusters of pits or scalloping, or both, permitted.
<b>2</b>	Corrosion or erosion with any dimensional change over 2.4 mm, and short of pump case failure
<b>1</b>	Pump case leaking due to corrosion or erosion.

**ASTM D 2809<sup>1</sup> Test Results:**

Pump Rating	Solution pH
<b>9*</b>	Start 8.53 End 7.32
Minimal corrosion or erosion. Some rounding of sharp corners or light smoothing or both, or polishing of working surfaces. Light corrosion or erosion may be generalized on working surfaces. Dimensional change does not to exceed 0.4 mm (164 in.).	

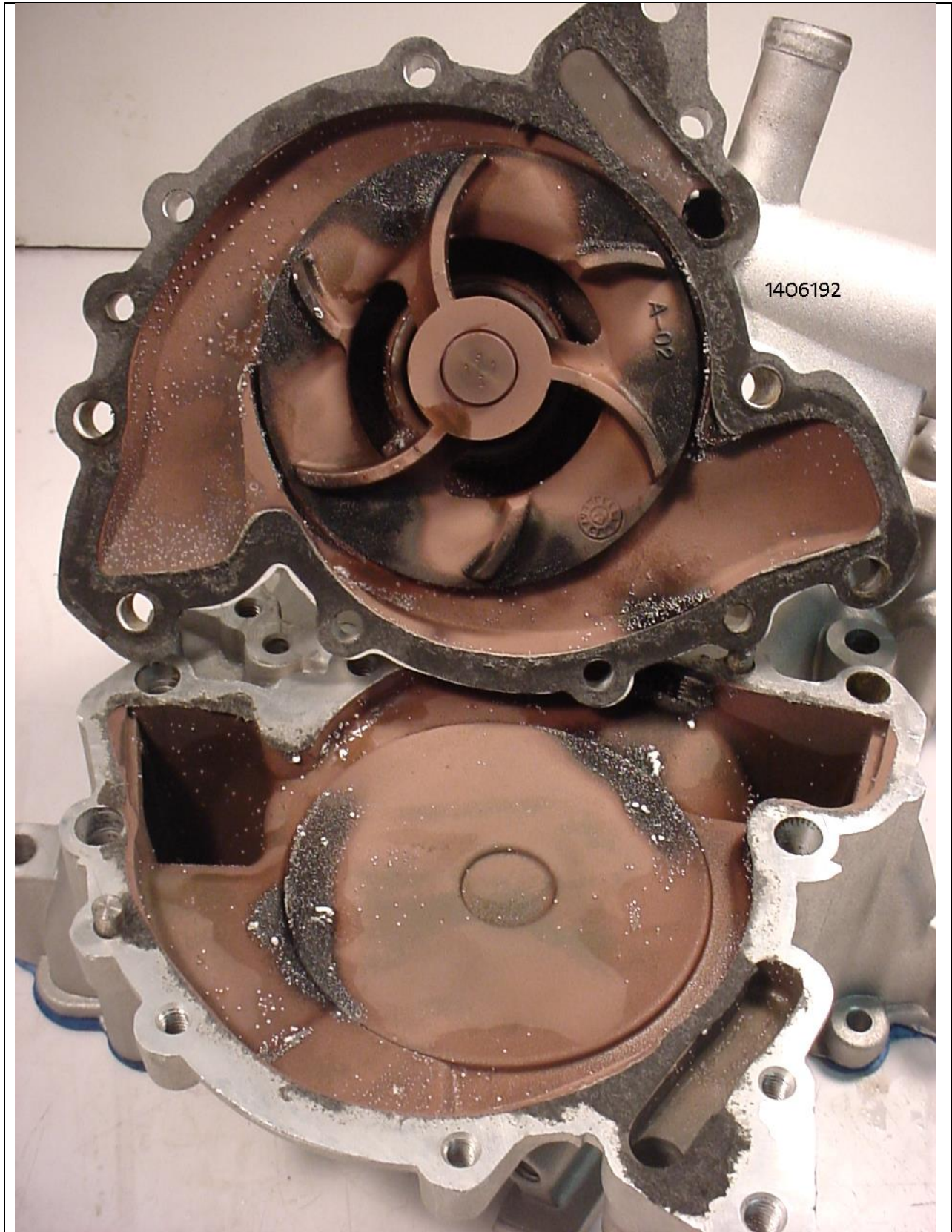
Note: ASTM D-3306 requires a pump rating of 8 or higher on a scale of 10.

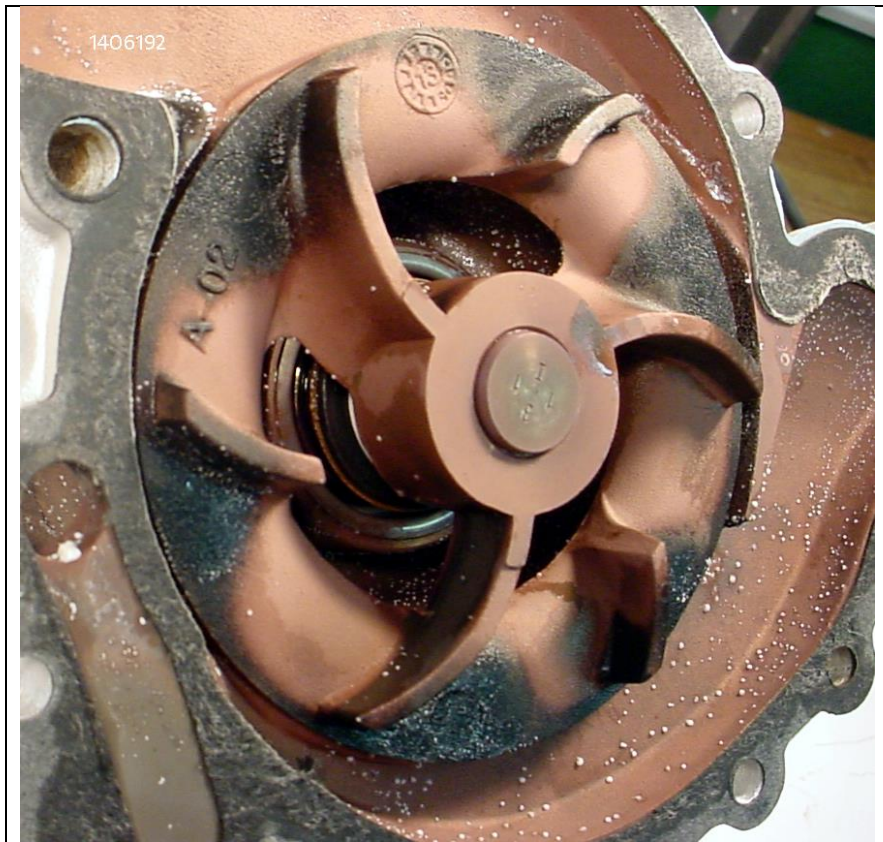
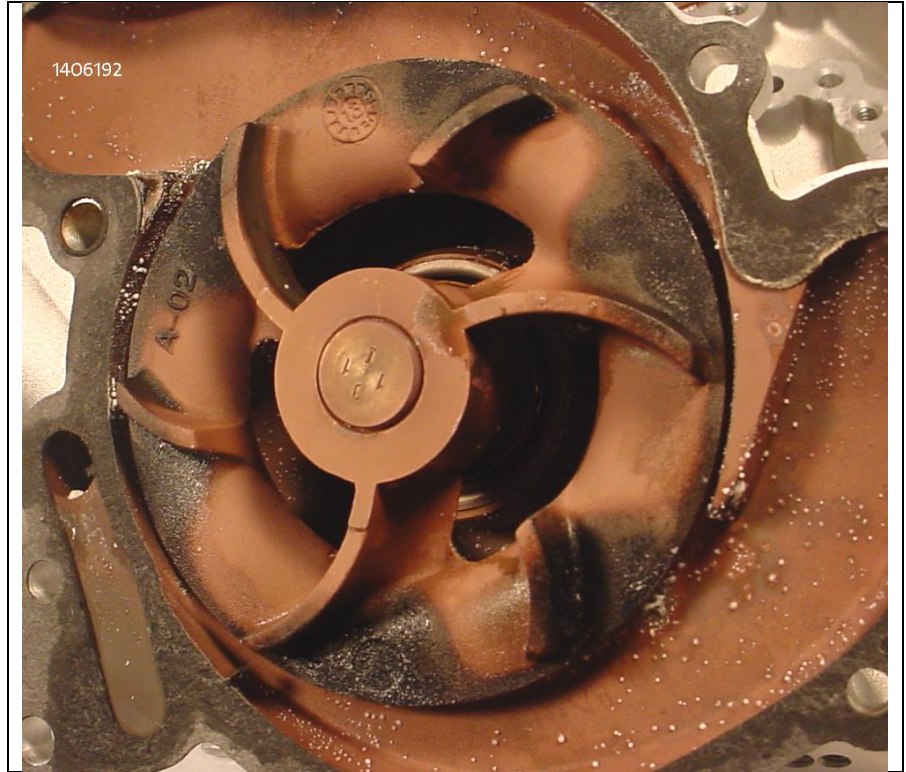
\*If placement in a rating group is uncertain or border-line, elevate the rating to the higher of the two groups in question.

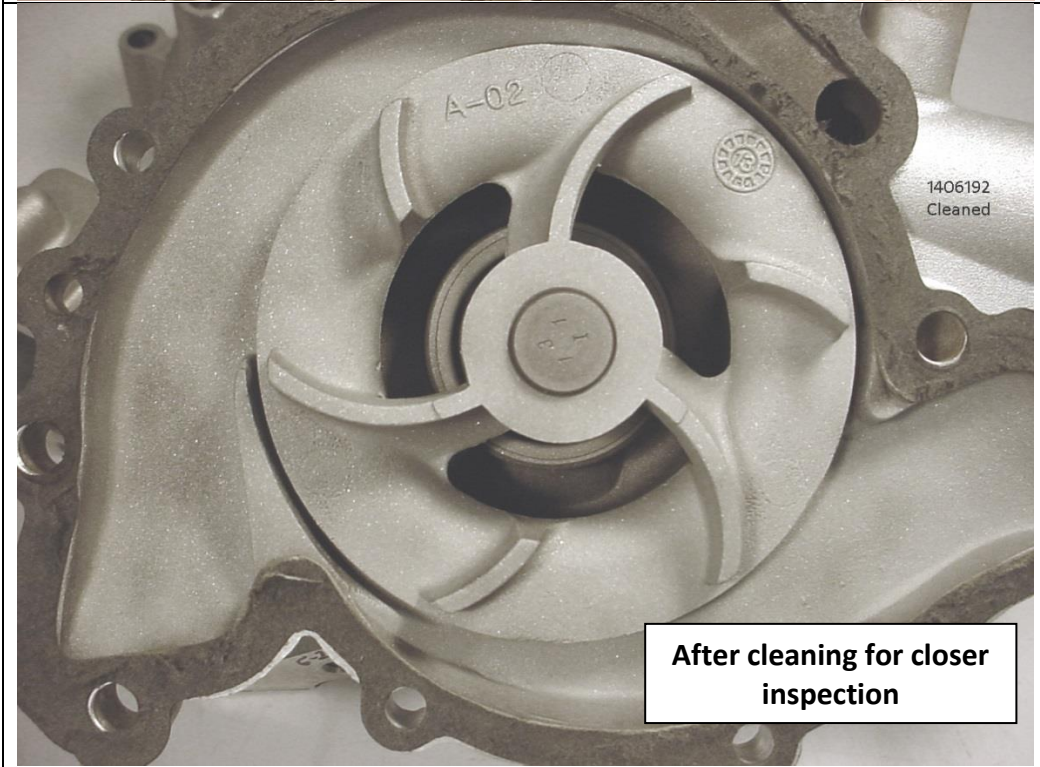
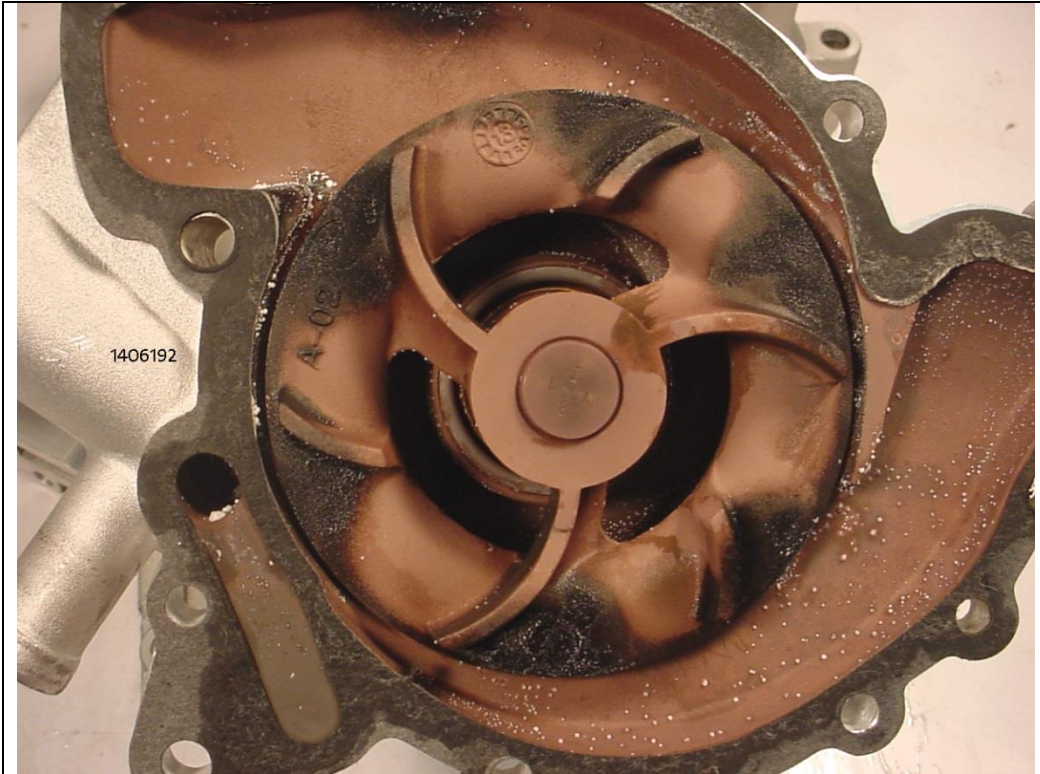
Measurements:

1406192	D-16L-604 EG 50% Premix					
	Area					
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
1	0.11	0.01	0.05	0.01	0.06	0.01
2	0.10	0.02	0.05	0.01	0.07	0.01
3	0.11	0.01	0.05	0.01	0.06	0.01
<b>average</b>	<b>0.11</b>	<b>0.01</b>	<b>0.05</b>	<b>0.01</b>	<b>0.06</b>	<b>0.01</b>

Photos of D2809 Pump







### ASTM D4340<sup>1</sup>: Corrosion of Cast Aluminum Alloys in Engine Coolants Under Heat-Rejecting Conditions

This test method covers a laboratory screening procedure for evaluating the effectiveness of engine coolants in combating corrosion of aluminum casting alloys under heat-transfer conditions that may be present in aluminum cylinder head engines.

In this test method, a heat flux is established through a cast aluminum alloy typical of that used for engine cylinder heads while exposed to an engine coolant under a pressure of 193 kPa (28 psi). The temperature of the aluminum specimen is maintained at 135°C (275°F) and the test is continued for 1 week (168 h). The effectiveness of the coolant for preventing corrosion of the aluminum under heat-transfer conditions (hereafter referred to as heat-transfer corrosion) is evaluated on the basis of the weight change of the test specimen.

#### ASTM D 4340<sup>1</sup> TEST RESULTS

	Run #1	Run #2	Average
Weight Loss (mg/cm <sup>2</sup> /wk)	0.06	0.21	<b>0.14</b>
pH After	7.88	7.86	<b>7.87</b>

Notes: ASTM places the maximum corrosion rate at **1.00** (mg/cm<sup>2</sup>/wk).

### ASTM D1384<sup>1</sup>: Corrosion Test for Engine Coolants in Glassware

This test method covers a simple beaker-type procedure for evaluating the effects of engine coolants on metal specimens under controlled laboratory conditions. In this test method, specimens of metals typical of those present in engine cooling systems are totally immersed in aerated engine coolant solutions prepared with corrosive salts for 336 hours at 88°C (190°F). The corrosion inhibition properties of the test solution are evaluated on the basis of the weight changes incurred by the specimens. Each test is run in triplicate, and the average weight change is determined for each metal. This test method will generally distinguish between coolants that are definitely deleterious from the corrosion standpoint and those that are suitable for further evaluation. However, the results of this test method cannot stand alone as evidence of satisfactory corrosion inhibition. Only more comprehensive bench, dynamometer, and field tests can determine the actual service value of an engine coolant formulation.

Automobile manufacturers have accepted the specimens prescribed in this test method, but their composition may not be the same as that of alloys currently used for engine cooling system components. Therefore, specimens other than those designated in this test method may be used by mutual agreement of the parties involved. The following metal test specimens, 1 by 2 inches in size, representative of cooling system metals, were used:

1. **Steel**, UNS G10200 (SAE 1020), Chemical composition of the carbon steel is as follows: carbon, 0.17 to 0.23 %; manganese, 0.30 to 0.60 %; phosphorus, 0.040 % maximum; sulfur, 0.050 % maximum.
2. **Copper**, conforming to UNS C11000 (SAE CA110) or UNS C11300 (SAE CA113). Cold-rolled.
3. **Brass**, conforming to Alloy UNS C26000 (SAE CA 260).
4. **Solder**—A brass specimen as described in 6.1.3, coated with solder conforming to Alloy Grade 30A (SAE 3A)
5. **Cast Aluminum**, conforming to Alloy UNS A23190 (SAE 329).
6. **Cast Iron**, conforming to Alloy UNS F10007 (SAE G3500).

**ASTM D 1384<sup>1</sup> TEST RESULTS – Performed as a repeat analysis, but on the same sample submission**

ASTM D 1384	Specimen Corrosion Weight Loss (mg)				
	#1	#2	#3	Avg	Max**
Specimen					
Copper	0	1	1	1	10
Solder	1	0	2	1	30
Brass	0	0	0	0	10
Steel	1	1	0	1	10
Cast Iron	1	1	2	1	10
Cast Aluminum	26	27	25	26	30

\*\*Maximum corrosion weight loss as specified by ASTM D3306

**ASTM D 1384<sup>1</sup> TEST RESULTS as Corrosion Rates (Calculated per JIS K2234)**

ASTM D 1384	Specimen Corrosion Weight Loss (mg/cm <sup>2</sup> )			
	#1	#2	#3	Avg
Specimen				
Copper	0.02	0.04	0.03	0.03
Solder	0.02	0.00	0.07	0.03
Brass	0.01	0.01	0.01	0.02
Steel	0.02	0.02	0.01	0.02
Cast Iron	0.05	0.04	0.06	0.05
Cast Aluminum	0.82	0.83	0.80	0.82

**Specimen Photographs**

**D1384 Metal Specimens (post test)**

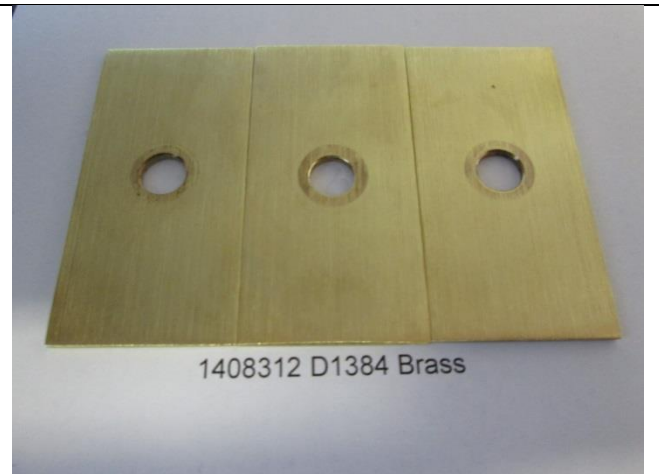
**Copper**



**Solder**



**Brass**



**Steel**



**Cast Iron**



**Cast Aluminum**



**ASTM D2570<sup>1</sup>: Simulated Service Corrosion Testing of Engine Coolants**

This test method evaluates the effect of a circulating engine coolant on metal test specimens and automotive cooling system components under controlled, essentially isothermal laboratory conditions. This test method specifies test material, cooling system components, type of coolant, and coolant flow conditions that are considered typical of current automotive use. An engine coolant is circulated for 1064 h at 190°F (88°C) in a flow loop consisting of a metal reservoir, an automotive coolant pump, an automotive radiator, and connecting rubber hoses. Test specimens representative of engine cooling system metals are mounted inside the reservoir, which simulates an engine cylinder block. At the end of the test period, the corrosion-inhibiting properties of the coolant are determined by measuring the mass losses of the test specimens and by visual examination of the interior surfaces of the components. This test method, by a closer approach to engine cooling system conditions, provides better evaluation and selective screening of engine coolants than is possible from glassware testing (Test Method D 1384). The improvement is achieved by controlled circulation of the coolant, by the use of automotive cooling system components, and by a greater ratio of metal surface area to coolant volume. Although this test method provides improved discrimination, it cannot conclusively predict satisfactory corrosion inhibition and service life. If greater assurance of satisfactory performance is desired, it should be obtained from full-scale engine tests and from field-testing in actual service. The same coupons used in D1384 are also used in this test.

**ASTM D 2570 TEST RESULTS as Weight Loss (mg)**

Specimen	#1	#2	#3	Avg.	Max
Copper	1	1	0	0	20
30a Solder	13	15	14	14	60
Brass	2	2	2	2	20
Steel	5	5	5	5	20
Cast Iron	3	4	4	3	20
Cast Aluminum	7	8	9	8	60

**ASTM D 2570 TEST RESULTS as Corrosion Rates (Calculated per JIS K2234)**

Specimen	#1	#2	#3	Avg
Copper	0.02	0.02	0.01	0.02
Solder	0.47	0.53	0.51	0.50
Brass	0.06	0.06	0.06	0.06
Steel	0.17	0.19	0.16	0.17
Cast Iron	0.09	0.12	0.12	0.11
Cast Aluminum	0.21	0.26	0.30	0.26

pH	Pre Test	8.24	Post Test	6.73
RA	Pre Test	1.2	Post Test	0.6

**Photos follow:**

- **Metal Corrosion coupons, front and reverse.**
- **Water pump from test rig (post test)**
- **Hose specimens**
- **Radiator sections**

**D2570 Metal Specimens (post test)**

**Copper**



**Solder**



**Brass**



**Steel**



**Cast Iron**

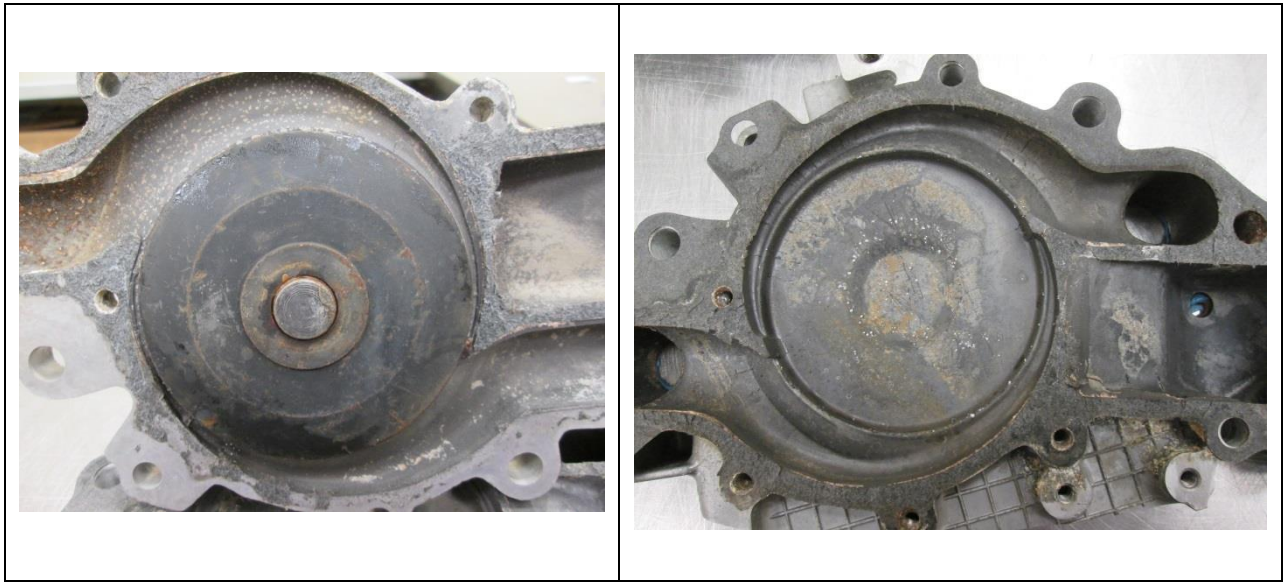


**Cast Aluminum**



**Water Pump (Post Test)**

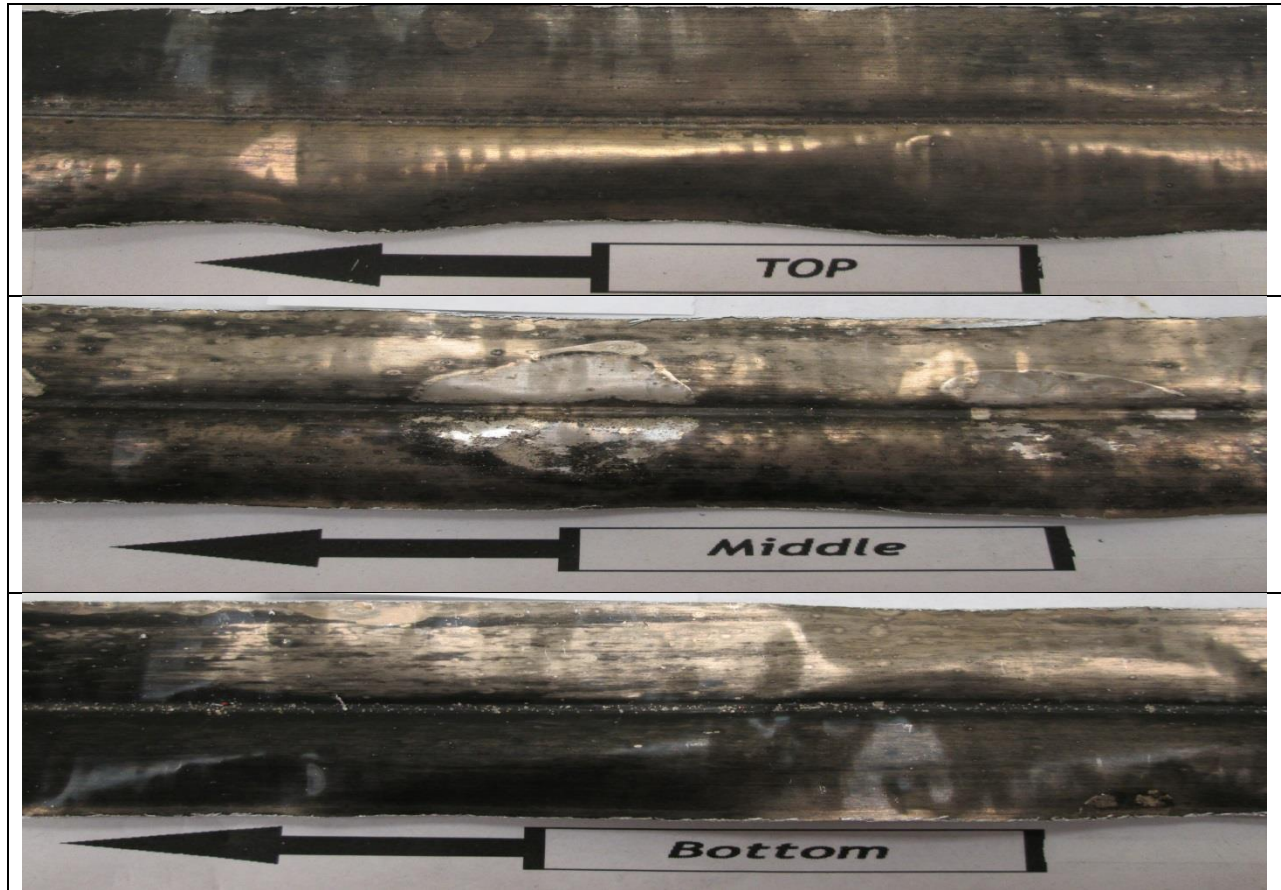
**Water Pump Cover**



**Hose Section (Post Test)**



## Radiator Sections



**Important note:** [Amalgatech is accredited by A2LA to ISO/IEC 17025:2005](#) (CHEMICAL TESTING, Cert 2168.01). Amalgatech receives samples that are identified by the customer/sender and takes these identifications in good faith, reporting data to the customer using the customer's identification. Our laboratory services are not intended for marketing and are not product certifications. We are accredited to perform most ASTM coolant tests. Any test performed for which Amalgatech is not accredited is identified with an asterisk (\*). This report is © Amalgatech division, Amalgamated Laboratories, Inc. 2014. It may not be reproduced, altered, copied or disseminated except in whole. Use of the report is permitted, including copying, as long as the entire report, including this information section, is always provided in its entirety.

NOTE <sup>1</sup> Amalgatech has performed the test in accordance with the revision of the standard in place at the time the test was performed. Amalgatech uses only active ASTM standards available at [www.astm.org](http://www.astm.org).

Respectfully submitted,

AMALGATECH DIVISION  
AMALGAMATED LABORATORIES, INC.

Ed Eaton  
Chief Engineer