
Liquid Detergent for Compressor Cleaning for GE Aircraft Derivative Gas Turbines

This specification establishes the requirements for liquid detergent products used to prepare cleaning solutions for cleaning the compressors of gas turbine engines, where the intent is to restore performance by removing the build-up of deposits on compressor components. Such deposits include salt, soils or oils that may be ingested from the atmosphere.

The cleaning process shall be carried out by spraying the cleaning solution into the bellmouth of the engine while the engine is running at power (on-line cleaning) or while the engine is being cranked (crank soak cleaning).

For the purposes of this specification, the following definitions shall apply:

Liquid Detergent - A concentrated solution of water soluble surface active agents and emulsifiable solvents.

Cleaning Solution - A solution or emulsion of liquid detergent in water or a water and antifreeze mixture for direct engine application. The recommended dilution of liquid detergent and water shall be determined by the liquid detergent manufacturer.

1. Applicable Documents

The following documents shall form a part of this specification to the extent specified herein. Unless a specific issue is specified, the latest revision shall apply.

ASTM D88 Standard Test Method For Saybolt Viscosity

ARP 1795 Stress-Corrosion of Titanium Alloys, Effect of Cleaning Agents on Aircraft Engine Materials

AMS 1424 Deicing/Anti-icing Fluid, Aircraft (Newtonian-SAE Type 1)

2. Detergent Properties

2.1 Composition

The chemical composition of the detergent is not limited, other than as specified herein.

2.2 Biodegradability

Use of the liquid detergent/cleaning solution shall conform to local regulations for water pollution. Use of biodegradable ingredients is recommended.

2.3 Toxicity

Use of the liquid detergent/cleaning solution shall conform to local regulations for industrial hygiene and air pollution. Use of nontoxic ingredients is recommended.

2.4 Health and Safety Information

The liquid detergent manufacturer shall make available health and safety information for the liquid detergent as required by applicable local, state and federal regulations.

2.5 Solids

The liquid detergent shall contain no particles larger than 20 micron.

2.6 Physical and Chemical Properties

The liquid detergent shall meet the test requirements.

3. Test Requirements

3.1 Liquid Detergent

3.1.1 Residue or Ash Content

Residue or ash content shall not exceed 0.01 percent when tested in accordance with paragraph 4.1.

3.1.2 Low Temperature Stability

The liquid detergent shall show no evidence of separation of component parts when maintained at $40^{\circ}\text{F} \pm 3$ ($5^{\circ}\text{C} \pm 2$). It is highly desirable although not mandatory that the fluid shall remain liquid below 32°F (0°C).

3.1.3 Cold Weather Solution Compatibility

The liquid detergent shall show no separation, layering or precipitation when mixed to the liquid detergent manufacturer's recommended dilution in one or more of the following antifreeze solutions after 2 hours at $10^{\circ}\text{F} \pm 3$ ($-12^{\circ}\text{C} \pm 2$):

- Isopropyl Alcohol
- Monopropylene glycol (PG)
- Acetone

See paragraph 6.1 for more information regarding liquid detergent and antifreeze mixtures.

3.1.4 Hard Water Compatibility

The liquid detergent shall show no separation or layering when mixed with synthetic hard water prepared in accordance with paragraph 4.2.

3.1.5 Acid and Alkali Acceptance

The liquid detergent shall show no separation, layering or precipitation when tested in acidic or alkali media in accordance with paragraph 4.3.

3.1.6 Salt Water Tolerance

The liquid detergent shall show no separation or gelling when mixed with 3.5 percent salt water in accordance with paragraph 4.4.

3.1.7 Viscosity

The liquid detergent shall have a viscosity of 50 to 200 SUS at 77°F (25°C) when tested in accordance with ASTM D88.

3.1.8 pH

The pH of the liquid detergent as received shall be from 6.5 to 8.5 when measured with a suitable pH meter employing a glass electrode.

3.2 Cleaning Solution

3.2.1 Corrosive Elements

Maximum levels of elements in the cleaning solution which may promote various types of corrosion, shall be no greater than as shown in Table 1, when analyzed by methods in paragraph 4.5.

Table 1. Maximum Corrosives Limit

Total alkali metals (sodium + potassium + lithium, etc.)	25 ppm max.
Magnesium + calcium	5 ppm max.
Vanadium	0.1 ppm max.
Lead	0.1 ppm max.
Tin + Copper	10 ppm max.
Sulfur	50 ppm max.
Chlorine	40 ppm max.

3.2.2 pH

The pH of the cleaning solution shall be from 6.5 to 8.5 when measured with a suitable pH meter employing a glass electrode.

4. Test Methods**4.1 Residue or Ash Content**

Weigh 10 ± 0.1 gram sample of liquid detergent in a weighed 30 ml porcelain crucible. Heat gently to volatilize any water or solvents. (Crucible may be placed in air oven at $105^{\circ}\text{C} \pm 2$ for 24 hours, followed by $240^{\circ}\text{C} \pm 2$ for 24 hours to insure all volatile matter is evaporated.) Finally, ignite contents over Bunsen Burner, first at low temperature under good oxidizing conditions until all ignitable material is consumed, then place a crucible in a muffle furnace at 1040 to 1100°C for 2 hours. Cool in desiccator, and weigh.

Percent residue or ash = $(100 \times A)/W$

Where: A = grams of residue

W = grams of sample

4.2 Hard Water Compatibility**4.2.1 Preparation of Synthetic Hard Water**

A hard water solution is prepared by dissolving the following in one liter of just boiled and cooled distilled water:

- 0.20 ± 0.005 gram Calcium Acetate, reagent grade $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$
- 0.15 ± 0.005 gram Magnesium Sulfate, reagent grade $\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$

4.2.2 Hard Water Test

5 ml of liquid detergent shall be added to a clean 50 ml cylinder. 45 ml of synthetic hard water shall be added and mixed well. The solution shall be examined for compatibility after 16 hours at $77^{\circ}\text{F} \pm 5$ ($25^{\circ}\text{C} \pm 3$).

4.3 Acid and Alkali Acceptance

The liquid detergent shall be mixed with distilled water in accordance with the liquid detergent manufacturer's recommended dilution. To 50 ml of the solution, add 1 ml of 75 percent phosphoric acid. To another 50 ml of the solution, add 5 ml of 75 percent phosphoric acid. To another 50 ml of the solution, add 1 ml of 50 percent potassium hydroxide. Let all three mixtures stand for one hour at $77^{\circ}\text{F} \pm 5$ ($25^{\circ}\text{C} \pm 3$), and then examine for acid or alkali acceptance.

4.4 Salt Water Tolerance

Prepare a 3.5 percent by weight solution of sodium chloride in distilled water. Add 15 ml of salt solution to 35 ml of liquid detergent and let stand for 1 hour at 77°F ± 5 (25°C ± 3). Examine for salt water tolerance.

4.5 Elemental Content

Elemental content shall be determined using the following methods:

Element	Method
Sulfur, Phosphorous	Inductivity Coupled Plasma Spectroscopy - Atomic Emission Spectroscopy (ICP-AES)
Chlorine	Microcoulometric filtration
Sodium, Potassium	Atomic Absorption (AA)
Other metals	ICP-AES or AA

5. Material Compatibility

5.1 Compatibility with Engine Materials

Use of the detergent gas turbine cleaner shall not have adverse effects on engine system materials such as titanium stress corrosion, hot corrosion of turbine components or damage to lubrication system components.

5.2 Titanium Stress Corrosion

A titanium stress corrosion test in accordance with ARP 1795 or equivalent may be run on the liquid detergent at the discretion of GE.

6.1 Cold Weather Usage

In cold weather, liquid detergent must be added to antifreeze mixture rather than to water alone. At present, the only acceptable antifreeze solutions are:

- Isopropyl Alcohol
- Monopropylene glycol (PG)
- Acetone

Monopropylene glycol (PG) must be per AMS 1424 and may be used down to 20°F (-7°C)

Antifreeze mixtures are shown in Table 2. The liquid detergent manufacturer must specify which, if any, of the antifreezes specified above is not compatible with the liquid detergent.

The use of non-isopropyl alcohol, ethylene glycol or additives containing chlorine, sodium or potassium are not permitted since they may attack the titanium and other metals in the gas turbine.

It is extremely important that the liquid detergent and antifreeze solution be a homogeneous mixture when sprayed into the bellmouth of the gas turbine. If after 2 hours the liquid detergent and antifreeze solution separates, (see paragraph 3.1.3) agitation of the mixture in the wash water tank is permissible. However, the liquid detergent manufacturer shall specify that agitation is required.

Table 2. Water Wash Antifreeze Mixtures.

Compressor Washing Antifreeze Mixtures						
Outside Air Temp, °F (°C)	Monopropylene glycol (PG) % Vol	H2O % Vol	Acetone % Vol	H2O % Vol	Isopropyl Alcohol % Vol	H2O % Vol
+20 to +50 (-7 to 10)	21	79	25	75	22	78
+10 to +20 (-12 to -7)	N/A	N/A	40	60	34	66
0 to +10 (-18 to -12)	N/A	N/A	53	47	47	53
-10 to 0 (-23 to -18)	N/A	N/A	63	37	72	28
-20 to -10 (-29 to -23)	N/A	N/A	69	31	88	12
-30 to -20 (-34 to -29)	N/A	N/A	75	25	97	3
Compressor Rinsing Antifreeze Mixtures						
Outside Air Temp, °F (°C)	Monopropylene glycol (PG) % Vol	H2O % Vol	Acetone % Vol	H2O % Vol	Isopropyl Alcohol % Vol	H2O % Vol
+20 to +50 (-7 to 10)	14	86	20	80	18	82
+10 to +20 (-12 to -7)	N/A	N/A	33	67	27	73
0 to +10 (-18 to -12)	N/A	N/A	43	57	39	61
-10 to 0 (-23 to -18)	N/A	N/A	50	50	58	42
-20 to -10 (-29 to -23)	N/A	N/A	55	45	70	30
-30 to -20 (-34 to -29)	N/A	N/A	60	40	77	23