METRIC

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15 July 1998
SUPERSEDING
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PERFORMANCE SPECIFICATION

CLEANING COMPOUND, TURBINE ENGINE GAS PATH

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the requirements for three types of turbine engine gas path cleaning compounds, two are used for off-line (starter cranked) engine cleaning operations and one is used for on-line (fired) engine cleaning (See 6.1).

1.2 Classification. The cleaning compounds will be of the following types, as specified (see 6.3).

1.2.1 Types. The types of cleaning compounds are as follows:

Type I	-	Solvent emulsion cleaner concentrate containing aromatic hydrocarbon solvents for use in starter cranked engine cleaning operations only.
Type II	-	Aqueous cleaner concentrate containing no aromatic hydrocarbon solvents for starter cranked engine cleaning operations only.
Type II RTU	-	Ready-To-Use aqueous cleaner containing no hydrocarbon solvents for starter cranked engine cleaning operations only.
Type III	-	Aqueous cleaner concentrate containing no hydrocarbon solvents for use in on-line (fired) engine cleaning of specifically approved engines.
Type III RTU	-	Ready-To-Use aqueous cleaner containing no hydrocarbon solvents for use in on-line (fired) engine cleaning of specifically approved engines.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 414100B120-3, Highway 547, Lakehurst, NJ 08733-5100, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 6850

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.3).

SPECIFICATIONS

FEDERAL

QQ-P-416	-	Plating, Cadmium (Electrodeposited)
TT-L-32	-	Lacquer, Cellulose Nitrate, Gloss, For Aircraft Use
PPP-P-704	-	Pail, Metal (Shipping, Steel, 1 through 12 Gallons)

DEPARTMENT OF DEFENSE

MIL-M-3171	-	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-T-9046	-	Titanium and Titanium Alloy, Sheet, Strip and Plate
MIL-PRF-22750	-	Coating, Epoxy, High-Solids
MIL-PRF-23699	-	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156
MIL-PRF-85285	-	Coating: Polyurethane, High-Solids

STANDARDS

FEDERAL

FED-STD-595	-	Colors Used in Government Procurement

(Unless otherwise indicated, copies of the above specifications and standards are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation (see 6.3).

CODE OF FEDERAL REGULATIONS (CFR)

40 CFR Part 60 Appendix A, Method 24	-	Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings
40 CFR Part 136	-	Guidelines Establishing Test Procedures for the Analysis of Pollutants

(Application for copies of the CFR should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402.)

2.3 Non-government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.3).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM-B209	-	Aluminum and Aluminun-Alloy Sheet and Plate, Standard Specification for
ASTM-C1111	-	Determining Elements in Waste Streams by Inductively Coupled Plasma-Atomic Emission Spectroscopy, Standard Test Method for
ASTM-D93	-	Flash-Point by Pensky-Martens Closed Cup Tester, Standard Test Method for (DoD Adopted)
ASTM-D95	-	Water in Petroleum Products and Bituminous Materials by Distillation, Standard Test Method for (DoD Adopted)
ASTM-D445	-	Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity), Standard Test Method for (DoD Adopted)
ASTM-D1141	-	Substitute Ocean Water, Standard Specification for (DoD Adopted)
ASTM-D1976	-	Elements in Water by Inductively-Coupled Argon Plasma Atomic Emission Spectroscopy
ASTM-D2240	-	Rubber Property-Durometer Hardness, Standard Test Method for (DoD Adopted)

ASTM-D2834	-	Nonvolatile Matter (Total Solids) in Water-Emulsion Floor Polishes, Solvent-Based Floor Polishes, and Polymer-Emulsion Floor Polishes, Standard Test Method for
ASTM-D3919	-	Measuring Trace Elements in Water by Graphite Furnace Atomic Absorption Spectrophotometry, Standard Practice for
ASTM-D4057	-	Manual Sampling of Petroleum and Petroleum Products, Standard Practice for (DoD Adopted)
ASTM-D4177	-	Automatic Sampling of Petroleum and Petroleum Products, Standard Practice for (DoD Adopted)
ASTM-D4691	-	Measuring Elements in Water by Flame Atomic Absorption Spectrophotometry, Standard Practice for
ASTM-E70	-	pH of Aqueous Solutions With the Glass Electrode, Standard Test Method for (DoD Adopted)
ASTM-F483	-	Total Immersion Corrosion Test for Aircraft Maintenance Chemicals, Standard Test Method for (DoD Adopted)
ASTM-F484	-	Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds, Standard Test Method for (DoD Adopted)
ASTM-F502	-	Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces, Standard Test Method for (DoD Adopted)
ASTM-F945	-	Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials, Standard Test Method for
ASTM-F1110	-	Sandwich Corrosion Test, Standard Test Method for

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA. 19428-2959.)

AMERICAN PUBLIC HEALTH ASSOCIATION (APHA)

Standard Method 4500-Cl G	-	Chlorine, DPD Colorimetric Method, Water and Wastewater, Standard Method for the Examination of
Standard Method 5530	-	Phenols, Water and Wastewater, Standard Method for the Examination of

(Application of copies of these Standard Methods should be addressed to the American Public Health Association, 1015 Fifteenth Street, NW, Washington, DC 20005.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE-AMS2416	-	Plating, Nickel-Cadmium Diffused (DoD Adopted)
SAE-AMS4377	-	Sheet and Plate, Magnesium Alloy 3.0Al 1.0Zn 0.20Mn, Cold Rolled, Partially Annealed (DoD Adopted)
SAE-AMS5046	-	Sheet, Strip, and Plate, Carbon Steel (SAE 1020 and 1025) Annealed (DoD Adopted)
SAE-AMS5504	-	Steel Sheet, Strip, and Plate, Corrosion and Heat Resistant 12.5 Cr (SAE 51410) Annealed UNS S41000 (DoD Adopted)
SAE-AMS5510	-	Steel, Corrosion and Heat Resistant, Sheet, Strip and Plate 18Cr 10.5Ni 0.40Ti Solution Heat Treated (DoD Adopted)
SAE-AMS5536	-	Nickel Alloy, Corrosion and Heat Resistant, Sheet, Strip and Plate 47.5Ni 22Cr 1.5Co 9.0Mo 0.60W 18.5Fe, Solution Heat Treated (DoD Adopted)

(Applications for copies should be addressed to Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Cleaning compounds furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.4).

3.2 Toxicity. The cleaning compound shall have no adverse effect on the health of personnel when used for its intended purpose. Use of the cleaning solution shall conform to local regulations for industrial hygiene and air pollution. The cleaning compound shall not contain known or suspected human carcinogens, heavy metals, or Total Toxic Organic (TTO) compounds, (see 40 CFR, Part 136) (see 6.6).

3.3 Materials. Surface active agents used in the cleaning compound shall be not less than 90 percent biodegradable. Types II, II RTU, III, and III RTU cleaning compounds shall not contain hydrocarbon solvents.

3.4. Performance requirements. The cleaning compound shall conform to table I.

TABLE I. Performance requirements.

Characteristic	Requirement	Test method
Volatile organic compound (VOC) content (in the ready to use state), maximum (max.)	10 percent by weight	40 CFR 60, Appendix A, Method 24 (EPA Test Method 24)
Water content, minimum (min.) Types II and III Types II RTU and III RTU	 50 percent content 1/ 90 percent content 1/	ASTM-D95
Non-volatile content	1/	2/ ASTM-D2834
Infrared spectrum of non-volatile matter	1/	3/
Phenol content	None Detected	APHA Method 5530
Flash point, min.	60°C (140°F)	ASTM-D93
Elemental content, max. Types I, II, and III Sulfur (S) Chlorine (Cl) Sodium (Na) Potasium (K) Phosphorous (P) Other metallic elements Types II RTU, IIII RTU Sulfur (S) Chlorine (Cl) Sodium (Na) Potasium (K) Phosphorous (P) Other metallic elements	 500 parts per million (ppm) 100 ppm 50 ppm 50 ppm 50 ppm 10 ppm 100 ppm 20 ppm 10 ppm 10 ppm 10 ppm 2 ppm	4.4.1
pH (in the ready to use state)	7.0 - 9.0	ASTM-E70
Viscosity @ 27 °C (80 °F), cSt. Type I: min. - max. Type II, II RTU, III, III RTU: max.	 15 - 25 25	ASTM-D445
Insoluble matter, max. Type I Types II and III Types II RTU and III RTU	 0.1 percent by weight 0.025 percent by weight 0.01 percent by weight	4.4.2

TABLE I. Performance requirements - Continued.

Characteristic	Requirement	Test method
Cleaning efficiency Type I, min. Types II, II RTU, III, III RTU	 85 percent 1/ 99 percent 1/	4.4.4
Ash content, max. Types I, II, and III Types II RTU and III RTU	 0.05 percent by weight 0.01 percent by weight	4.4.3
Titanium stress corrosion (microscopic cracking) at 500X magnification	None detected	4/ ASTM-F945
Total immersion corrosion Weight change per area per day Aluminum (ASTM-B209, Alloy 6061, 0 temper) Type I Type II, II RTU, III, and III RTU Aluminum (ASTM-B209, Alloy 2024, T3 temper) Type I Type II, II RTU, III, and III RTU Magnesium, chrome pickled (SAE-AMS4377) Type I Type II, II RTU, III, and III RTU Titanium (MIL-T-9046, type III, composition C) Type I Type II, II RTU, III, and III RTU Nickel alloy (SAE-AMS5536) Type I Type II, II RTU, III, and III RTU Steel (SAE- AMS5046) Type I Type II, II RTU, III, and III RTU Stainless steel, martensitic (SAE-AMS5504)	 1.0 mg/cm^2/24 hours, max. 0.5 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max. 0.5 mg/cm^2/24 hours, max. 5.0 mg/cm^2/24 hours, max. 2.5 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max. 0.5 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max. 0.5 mg/cm^2/24 hours, max. 2.0 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max.	4.4.5

TABLE I. Performance requirements - Continued.

Characteristic	Requirement	Test method
Type I Type II, II RTU, III, and III RTU Cadmium plated steel (SAE-AMS5046, plated and treated in accordance with QQ-P-416, type I) Type I Type II, II RTU, III, and III RTU Nickel cadmium plated steel (SAE-AMS5046; plated and treated in accordance with SAE-AMS2416) Type I Type II, II RTU, III, and III RTU Ceramic coated steel (AMS 5046 coated with Sermetel W, or equal) Type I Type II, II RTU, III, and III RTU	2.0 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max. 5.0 mg/cm^2/24 hours, max. 2.5 mg/cm^2/24 hours, max. 5.0 mg/cm^2/24 hours, max. 2.5 mg/cm^2/24 hours, max. 2.0 mg/cm^2/24 hours, max. 1.0 mg/cm^2/24 hours, max.	
Hot corrosion Visible corrosion (all metals) Microscopic corrosion (maximum depth of scar), at a magnification of 250X, for the following metals: Aluminum alloy (ASTM-B209, Alloy 6061, 0 temper) at 454 °C (850 °F) Aluminum alloy (Alloy 2024, T3 temper) at 454 °C (850 °F) Titanium (MIL-T-9046, type II, composition F) at 482 °C (900 °F) Titanium (MIL-T-9046, type III, composition C) at 482 °C (900 °F) Nickel alloy (SAE-AMS5536) at 1,093 °C (2,000 °F) Steel (SAE-AMS5046) at 454°C (850 °F) Stainless steel, martensitic (SAE-AMS5504) at 482°C (900 °F) Stainless steel (SAE-AMS5510) at 871 °C (1,600 °F)	 None visible 0.0076mm (0.0003 in.) for all	4.4.6

TABLE I. Performance requirements - Continued.

Characteristic	Requirement	Test method
Nickel-cadmium plated steel (SAE-AMS5046, plated and treated in accordance with SAE-AMS2416) at 454 °C (850 °F) Ceramic coated steel (SAE-AMS5046 coated with a ceramic coating such as Sermetel W or equal) at 454 °C (850 °F)		
Sandwich corrosion (corrosion rating) Types I, II, II RTU, III, and III RTU, undiluted, for the following metals: Aluminum, non-anodized, (ASTM-B209, Alloy 2024, T3 temper) Aluminum alloy, Alclad (ASTM-B209, Alloy 2024, T3 temper) Aluminum alloy, non-anodized, (Alloy 7075) Aluminum alloy (ASTM-B209, Alclad Alloy 7075, T6 temper) Types I, II, and III (dilute and ready-to-use state) for the following: Aluminum alloy, non-anodized, (ASTM-B209, Alloy 2024, T3 temper) Aluminum alloy, alclad (ASTM-B209, Alloy 2024, T3 temper) Aluminum alloy, non-anodized, (ASTM-B209, Alloy 7075) Alclad aluminum alloy (ASTM-B209, Alloy 7075, T6 temper)	1 max. 1 max.	ASTM-F1110
Effect on painted surfaces; decrease in pencil hardness value for FED-STD-595, color number 17875, of TT-L-32, MIL-PRF-22750, and MIL-PRF-85285	2 max.	4.4.7
Effect on silicone elastomers; change in durometer hardness: Dow Corning Silastic J Dow Corning 93-118 General Electric RTV 159	 5 points, max. 7 points, max. 5 points, max.	4.4.8

TABLE I. Performance requirements - Continued.

Characteristic	Requirement	Test method
Effect on epoxy adhesives; decrease in pencil hardness value: 3M Company AF 163 Dexter-Hysol EA 9689	 3 points, max. 1 point, max.	4.4.9
Effect on acrylic materials	No crazing or cracking	5/ ASTM-F484
Emulsibility (types I, II, III only) Homogeneity at 5 °C (41 °F) after 60 seconds Phase separation at 5 °C (41 °F) after 48 hours	 No clotting, coagulation, or gel formation None observed	4.4.10
Rinsibility; FED-STD-595,color number 17875 of MIL-PRF-85285	No visible, non-rinsible film	4.4.11
Hard water stability at 25 °C (77 °F) for 16 hours	No separation	4.4.12
Salt water stability after 1 hour	No separation	4.4.13
Acid stability after 1 hour	No separation	4.4.14
Accelerated storage stability Cleaning compound Steel (SAE-AMS5046) Type I cleaners; 60 °C (140 °F) to room temperature cycling for five days Types II, II RTU, III, and III RTU; 49 °C (120 °F) to room temperature cycling for five days	 No color change or separation No corrosion or staining No corrosion or staining	4.4.15
Low temperature stability Type I: Low temperature, at -12 °C (10 °F) after 16 hours Room temperature inspection, after soak at -26 °C (-15 °F) for 24 hours Types II, II RTU, III, III RTU: Room temperature inspection, after soak at -26 °C (-15 °F) for 24 hours	 No solidifying or crystallization Homogenous (No separation) Homogenous (No separation)	4.4.16

TABLE I. Performance requirements - Continued.

Characteristic	Requirement	Test method
Engine cleaning performance Types I, II, and II RTU (types I and II diluted and ready-to-use) Crank wash performance test Types III and III RTU Running wash performance test	 see paragraph 3.6 see paragraph 3.6	 4.4.18.1 4.4.18.2
Workmanship	Free of turbidity and foreign matter	Visual observation

1/ Conformance inspection results shall not differ from values recorded on the qualification sample by more than ±1.5 percentage points. IR Spectra shall have no new or missing peaks.
2/ Non-volatile content shall be determined using 2 to 3 gram sample weights, 100 mm diameter glass Petri dishes, and a forced-draft oven maintained at 105 °C ±2°C (221 °F ± 4 °F) for 16 hours.
3/ An infrared spectrum of the non-volatile matter smeared on a potassium bromide plate shall be recorded using an infrared spectrometer with a minimum resolution of 4 wavenumbers. Results should be expressed as percentage transmittance in the range of 4,000 to 400 wavenumbers. There shall be no difference in spectra when run by the qualifying laboratory.
4/ Use Method A and both alloys for testing the concentrate.
5/ Type A and Type C specimens shall be stressed to 2,000 and 3,000 psi, respectively.

3.5 Long Term Storage Stability. After a 6 month period, samples stored under both conditions described in 4.4.17 shall meet the table I requirements for pH, cleaning efficiency, rinsibility, salt water stability, and acid stability.

3.6 Engine cleaning performance. Each candidate formulation shall be tested in a T63-A-700 turboshaft engine to assess its cleaning performance and to ensure that engine components are not adversely affected. Upon successful completion of all laboratory tests, types I, II, and II RTU compounds shall be evaluated in a crank wash cleaning performance test (see 4.4.18.1), while types III and III RTU compounds shall be evaluated in a running wash cleaning performance test (see 4.4.18.2). Types I, II, and II RTU cleaning compounds shall demonstrate statistical equivalence to the average cleaning ability of the entire type I class of products that have already been tested under the same severity of engine test conditions. The lowest equivalent satisfactory value has been determined to be an average 7.46 percent less than full engine horsepower output after three consecutive crankwash cleanings. Full engine horsepower output is measured prior to inducing an approximate 25 percent horsepower power loss. Types III and III RTU shall demonstrate statistical improvement over the average cleaning ability of the entire type III class of products that have already been tested under the same severity of engine test conditions. The lowest equivalent satisfactory value has been determined to be an average 8.35 percent less than full engine horsepower output after one running wash cleaning. Full

engine horsepower output is measured prior to inducing an approximate 25 percent horsepower power loss.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 Qualification inspection. The qualification inspection shall consist of all requirements specified in section 3. Qualification test samples for types I, II, and III cleaning compound consist of one twenty liter (or five gallon) container of the cleaning compound; qualification test samples for types II RTU and III RTU cleaning compound consist of three twenty liter (or five gallon) containers.

4.3 Conformance inspection. Each lot shall be inspected to verify conformance to the following requirements: volatile organic compounds; water content; non-volatile content; IR spectrum of non volatile matter; ash content; pH; flash point; viscosity; total immersion corrosion; emulsibility; salt water stability; acid stability; accelerated storage stability (examine for conformance after one 24-hour cycle and discontinue test); workmanship. Each lot (See 6.7.1) of material shall be sampled at random in accordance with ASTM-D4057 or ASTM-D4177 for the conformance inspection.

4.4 Test methods. The tests of this specification shall be conducted in accordance with table I and 4.4.1 through 4.4.18.

4.4.1 Elemental content. Elemental content shall be determined in accordance with table II. For type I cleaning compounds, a 10 weight percent solution (or emulsion) in distilled water shall be prepared for analyses in table II. For types II and III cleaning compounds, a 10 weight percent solution in distilled water shall be prepared for all elemental analyses. For types II RTU and III RTU cleaning compounds, no dilution shall be used. Results shall be calculated in parts per million of undiluted cleaning compound.

TABLE II. Elemental content determination methods.

Element	Method
Sulfur, Phosphorus	ASTM-C1111 or ASTM-D1976
Chlorine	APHA Standard Method 4500-Cl G
Sodium, Potassium	ASTM-C1111, ASTM-D1976, ASTM-D3919, or ASTM-D4691
Other Metals	ASTM-C1111, ASTM-D1976, ASTM-D3919, or ASTM-D4691

4.4.2 Insoluble matter. Undiluted cleaning compound, after having been stored undisturbed for at least one week, shall be thoroughly agitated and two 100 gram samples withdrawn and weighed to the nearest gram. The insoluble matter shall be collected with the aid of a vacuum filtering apparatus to produce 200 to 250 mm of vacuum (water tap filter pump), a 250 ml filtering flask, a 42.5 mm Buchner funnel and three pieces of filter paper (Whatman no. 1 or equivalent). Two filter papers for each determination shall be dried at 60 °C ±2 °C (140 °F ±4 °F) for 30 minutes and cooled in a desiccator and then weighed to the nearest mg. The filter papers shall be stacked in the Buchner funnel (the unweighed paper on the bottom), the vacuum started and the test sample filtered. The sides of the sample container shall be rinsed with 25 ml of the filtrate and the rinse mixture transferred to the funnel. The sides of the funnel shall be rinsed with an additional 25 ml of the filtrate and this liquid filtered. The vacuum shall be maintained for an additional five minutes. The filter papers shall then be dried for 10 minutes at 105 °C ±2 °C (221 °F ±4 °F) and cooled in a desiccator and weighed to the nearest 1 mg. The percent insoluble shall be calculated as follows:

$$\text{Percent insoluble} = \left[\left[A_2 - \left(B_2 \div B_1\right) \times A_1\right] \div \text{Weight of sample}\right] \times 100$$

where:

A_1 = initial weight of top filter paper.
B_1 = initial weight of middle filter paper.
A_2 = final weight of top filter paper.
B_2 = final weight of middle filter paper.

4.4.3 Ash content. Approximately 10 grams of cleaning compound shall be weighed to the nearest 0.1 mg in a tared porcelain crucible. The crucible shall be heated at 105 °C ±1 °C (221 °F ±2 °F) for 24 hours, then heated at 240 °C ± 2 °C (464° ± 4°F) for the next 24 hours. Following this, the crucible and its contents shall be carefully ignited over a bunsen type gas burner. The crucible shall then be placed in a muffle furnace at 1,040 °C (1,900 °F) for 2 hours. The crucible shall be weighed and the ash content calculated as the percentage of the initial weight of cleaning compound.

4.4.4 Cleaning efficiency.

4.4.4.1 Type I. Cleaning compound solution shall be prepared by diluting the cleaning compound to 20 volume percent with distilled water.

4.4.4.1.1 Test panels and apparatus. Test panels shall be 150 mm (6 inch) diameter by 0.51 mm (0.020 inch) thick bare aluminum alloy 2024, T3 temper conforming to ASTM-B209, Alloy 2024 disks, scribed with a 95 mm (3.75 inch) circle centered on the panel. The cleaning apparatus shall rotate these panels vertically at 220 rpm in front of a nozzle perpendicular to the panel which travels back and forth across the scribed area nine times per minute. The nozzle tip shall remain 83.8 ±2.5 mm (3.3 ±0.1 inches) from the test panel through the cleaning and rinsing cycles (see figure 1).

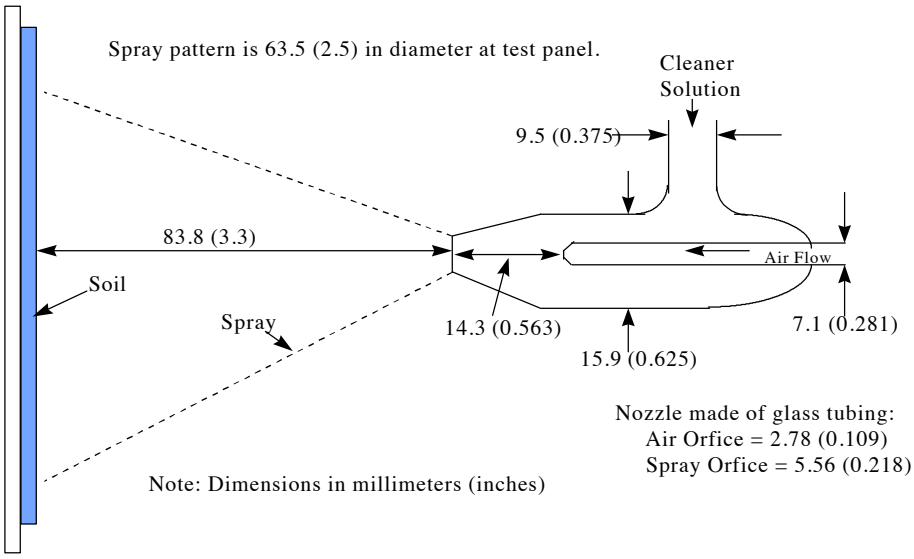

Figure 1. Laboratory cleaning efficiency test.

4.4.4.1.2 Soil. 500 grams of lubricating oil conforming to MIL-PRF-23699 shall be mixed with 50 grams of Raven 1040 carbon black (Columbia Carbon Company or equal) in a one liter (quart), wide-mouth jar. The jar shall be placed in an oven at 240 °C ±5 °C (464 °F ±10 °F). A 6.35 mm (0.25 inch) I.D. glass tube connected to a metered air supply shall be inserted into the mixture with an air flow of 8.5 ±0.5 cubic centimeters per second. The mixture, shall be heated at 240 °C ±5 °C (464 °F ±10 °F), with aeration for 120 hours, then cooled to room temperature and mixed until homogeneous.

4.4.4.1.3 Panel preparation. The test panels shall be abraded with a Scotchbrite fine abrasive mat (3M Company or equivalent), wiped with clean tissue soaked in reagent grade toluene followed with isopropanol, then dried to constant weight. Record the weight to the nearest 0.1 mg. Apply approximately 240 mg of soil by brush to cover the scribed area uniformly and bake at 232 °C ±3 °C (455 °F ±7 °F) for 20 ±0.2 minutes. Cool the panels and weigh to the nearest 0.1 mg. Use only panels with more than 135 mg and less than 165 mg of soil.

4.4.4.1.4 Test procedure. Prepare 1,000 ml of a 20 volume percent cleaning solution and aspirate it through the nozzle (with an air pressure of 10.0 ± 0.3 psig) onto the rotating soiled panel. Adjust the flow of cleaning solution to 100 ±10 ml per minute. Rinse the test panel with 100 ml of distilled water applied in the same manner. The rinsed panel shall be heated to 105 °C ±5 °C (221 °F ±10 °F) for 10 minutes, cooled to room temperature, then weighed to the nearest 0.1 mg. Calculate the percent cleaning efficiency as follows:

$$\text{Percent cleaning efficiency} = \left[(A - B) \div (A - C)\right] \times 100$$

where:

A = weight of the soiled panel before cleaning
B = weight of the soiled panel after cleaning
C = weight of the unsoiled panel

Record the cleaning efficiency as the average of four tests.

4.4.4.2 Type II, II RTU, III, and III RTU. Type II and III cleaning compounds shall be diluted to 20 volume percent with distilled water for testing; types II RTU and III RTU cleaning compounds shall be tested as received. Use the same test panels, apparatus, soil, and panel preparation as specified in 4.4.4.1.4, except that soiled test panels shall not be baked but shall be placed in a horizontal position with the soiled surface facing up for at least 30 minutes at room temperature. Modify the test apparatus by connecting the air pressure inlet of the nozzle to an 8 to 10 psig steam line. Aspirate the cleaning compound solution through the nozzle at a rate of 100 ±10 ml per minute. Rinse the test panel by pouring 100 ml of distilled water over the test panel. Dry and weigh the test panel and calculate the percent cleaning efficiency of the cleaning compound (see 4.4.4.1.4).

4.4.5 Total immersion corrosion. Types I, II, and III cleaning compounds shall be diluted to 20 volume percent with distilled water for testing; types II RTU and type III RTU cleaning compounds shall be tested as received. Corrosion specimens shall be fabricated from the following substrates, with dimensions as specified by ASTM-F483: aluminum alloy conforming to ASTM-B209, Alloy 6061, 0 temper; aluminum alloy conforming to, ASTM-B209, Alloy 2024, T3 temper; steel conforming to SAE-AMS5046; martensitic stainless steel conforming to SAE-AMS5504; magnesium conforming to SAE-AMS4377 which has been chrome pickled in

acordance with MIL-M-3171, type I; and titanium conforming to MIL-T-9046, type III, composition C. Cadmium plated steel specimens shall be prepared in accordance with QQ-P-416, type I and nickel-cadmium plated steel specimens shall be prepared in accordance with SAE-AMS2416. Immediately prior to testing, untreated specimens (not plated or coated) shall be abrasive blasted using U.S. sieve size 100 to 170 glass beads . Specimens shall be exposed as required by ASTM-F483, except that the cleaning compound solution shall be conditioned at 57 °C (135 °F) for one and one-half hours prior to immersion and the immersion shall be carried out at 57 °C (135 °F) for one-half hour. Weight changes shall be calculated in units of $mg/cm^2/24$ hrs.

4.4.6 Hot corrosion. Types I, II, and III cleaning compounds shall be tested as received; types II RTU and III RTU cleaning compounds shall be prepared for testing by boiling to 20 percent of its original volume in a pyrex glass beaker. Corrosion specimens with dimensions 25 by 50 by 1.5 mm (1.0 by 2.0 by 0.060 inches), shall be cut from the following alloys: titanium conforming to MIL-T-9046, type II, composition F and MIL-T-9046, type III, composition C; aluminum alloy conforming to ASTM-B209, Alloy 6061, 0 temper, and ASTM-B209, Alloy 2024, T3 temper; steel conforming to SAE-AMS5046; martensitic stainless steel conforming to SAE-AMS5504 and SAE-AMS5510; and nickel alloy conforming to SAE-AMS 5536. Nickel-cadmium plated steel specimens shall be prepared in accordance with SAE-AMS 2416. Untreated specimens (unplated or uncoated) shall be degreased by wiping with absorbent paper tissue wet with methyl ethyl ketone (reagent grade) followed by wiping with isopropanol. After drying at ambient conditions for one hour, corrosion specimens of each alloy shall be immersed in cleaning compound for 15 seconds, then withdrawn, air dried, and baked at the specified temperatures in table I for 8 hours. A control specimen of each alloy and surface treatment, degreased but not exposed to the cleaning solution, shall be baked for purposes of comparison. All specimens shall be cross-sectioned, mounted, and examined at 250X magnification in accordance with standard metallographic practice.

4.4.7 Effect on painted surfaces. Types I, II, and III cleaning compounds shall be diluted to 20 volume percent with distilled water for testing; types II RTU and III RTU cleaning compound shall be tested as received. The effect shall be determined in accordance with ASTM-F502 using finishes listed in table III, except the exposure shall be for 15 minutes at room temperature, and the panels shall be allowed to dry at room temperature for 24 hours.

Table III. Test panel finishes.

Coating	Number of coats	Thickness per coat	Drying time between coats. All specimens shall be baked for 1 week at 66 °C ±1 °C (150 °F ±2 °F) following final coat.
TT-L-32, FED-STD-595, color number 17875	2	0.7 to 1.0 mils (18 to 25 microns)	1 hour at room temperature, minimum
MIL-PRF-22750, FED-STD-595, color number 17875	1	mist coat 1.2 to 1.4 mils (30 to 36 microns)	½ hour at room temperature, minimum
MIL-PRF-85285, FED-STD-595, color number 17875	1	mist coat 1.7 to 2.3 mils (43 to 58 microns)	½ hour at room temperature, minimum

4.4.8 Effect on silicone elastomers.

4.4.8.1 Preparation of test specimens. Dow Corning elastomers Silastic J and 93-118 and General Electric elastomer RTV 159 (or equivalent molecular structure) shall be mixed as specified by the manufacturer and pressed in a 1/8-inch thick sheet mold until cured. Silastic J and RTV 159 shall be cured at room temperature for one week, while 93-118 sealant shall be cured at 150 °C (302 °F) for 2.25 hours. Specimens shall be cut from the sheet stock into 25 by 50 mm (1.0 by 2.0 inch) coupons.

4.4.8.2 Test procedure. Types I, II, and III cleaning compounds shall be diluted to 20 volume percent with distilled water for testing; types II RTU and III RTU cleaning compounds shall be tested as received. Immerse two specimens of each elastomer in the cleaning solution at 66 °C ±1 °C (150 °F ±2 °F) for 30 minutes. Remove from the solution, rinse with cool tap water, and test within 30 minutes for Shore A hardness in accordance with ASTM-D2240.

4.4.9 Effect on epoxy adhesives.

4.4.9.1 Preparation of test specimens. Using unprimed bare aluminum alloy sheet 2024, conforming to ASTM-B209, with a thickness of 0.51 mm (0.020 in), prepare panels coated with 0.13 to 0.25 mm (5 to 10 mils) of 3M Company AF163 adhesive (or equivalent molecular structure) cured for one hour at 121 °C ±1 °C (250 °F ±2 °F) at 40 psi. Panels coated with 0.13 to 0.25 mm (5 to 10 mils) of Dexter-Hysol EA 9689 adhesive (or equivalent molecular structure) shall be cured for 1 hour at 177 °C ±1 °C (350 °F ±2 °F) at 55 psi. Panels shall be cured in a press using a sheet of polyvinyl fluoride to release the adhesive coated panel from the top plate.

4.4.9.2 Test procedure. Types I, II, and III cleaning compounds shall be diluted to 20 volume percent with distilled water for testing; types II RTU and III RTU cleaning compounds shall be tested as received. Immerse a two-inch square test specimen in the cleaning solution at 66 °C ±1 °C (150 °F ±2 °F) for 30 minutes. Remove from the solution, rinse with cool tap water, and test for pencil hardness in accordance with ASTM-F502 after 24 hours at room temperature.

4.4.10 Emulsibility (types I, II, and III only). Add 10 ml of undiluted cleaning compound to a clean 50 ml glass-stoppered graduated cylinder and place in a chamber refrigerated to 5 °C ±1 °C (41 °F ±2 °F). Maintain the graduate at this temperature throughout the test. Cool distilled water to the same temperature, add 40 ml to the graduate, and replace the stopper. After 60 seconds, slowly invert the graduate once and return it upright, taking two full seconds for this procedure. After 60 seconds, pour the contents of the graduate onto a horizontal black glass plate and examine for homogeneity. The presence of any clotting, coagulation, or gelation constitutes a failure. If a homogeneous mixture forms, shake the graduate for 15 seconds and allow to stand undisturbed for 48 hours. The presence of any phase separation constitutes a failure.

4.4.11 Rinsibility.

4.4.11.1 Test panels. MIL-PRF-85285, FED-STD-595, color number 17875 (see table III), shall be used in this test.

4.4.11.2 Synthetic sea water. Synthetic sea water shall be prepared in accordance with ASTM-D1141, formula A.

4.4.11.3 Procedure. Types I, II, and III shall be diluted to 20 volume percent with distilled water for testing. Types II RTU and III RTU cleaning compounds shall be tested as received. The panels shall be placed in a horizontal position, lacquered surface up, and sprayed with the synthetic sea water. An atomizer, paint spray gun, or equivalent, shall be used for this operation. When the panels are thoroughly covered by sea water droplets, the panels shall be dried under an infrared lamp. The salt-coated panels shall be partially immersed in a glass tray, approximately 125 by 200 mm (5 by 8 inches), containing 150 ml of cleaning solution. The panels shall be tilted from the horizontal in such a manner that only half of the panel is beneath the surface of the solution. The panels shall be soaked in this manner for one minute without agitation, then removed and allowed to drain in an upright position for one minute. They shall then be dried under the infrared lamp. The panels shall then be rinsed in a moderate stream of distilled water until the salt on the portion of the panel that has not been submerged in the cleaning solution, appears to have been dissolved. The panel shall then be dried under the infrared lamp. The presence of a residue shall then be determined by visual comparison of the immersed and nonimmersed halves of the panel.

4.4.12. Hard water stability.

4.4.12.1 Preparation of stock solution. A 10-grain hard water stock solution shall be prepared by dissolving 0.20 ± 0.005 gram of analytical reagent grade calcium acetate, $Ca(C_2H_3O_2)_2\ H_2O$, and 0.14 ± 0.005 gram of analytical reagent grade magnesium sulfate, $MgSO_4\ 7H_2O$, in one liter of boiled distilled water.

4.4.12.2 Procedure. For types I, II, II RTU, III, or III RTU, pour 10 ml of undiluted cleaner into a 50-ml graduated cylinder. Add 40 ml of the synthetic hard water to the graduated cylinder and shake the contents vigorously for 15 seconds. Allow the solution to stand undisturbed for 16 hours at a temperature of 25 °C ±5 °C (77 °F ±10 °F). At the end of the 16 hours examine the solution for separation.

4.4.13 Salt water stability. Types I, II, and III shall be diluted to 20 volume percent with distilled water for testing. Types II RTU and III RTU shall be tested as received. To 50 ml of cleaning solution, add 5 ml of synthetic salt water prepared in accordance with ASTM-D1141, and shake vigorously for 15 seconds. Examine after 1 hour for separation.

4.4.14 Acid stability. Types I, II, and III shall be diluted to 20 volume percent with distilled water for testing; types II RTU and III RTU shall be tested as received. To 50 ml of cleaning solution add 5 ml of a 1 percent acetic acid solution, and shake vigorously for 15 seconds. Examine after 1 hour for separation.

4.4.15 Accelerated storage stability.

4.4.15.1 Preparation of test sample. A 150 ml portion of a well shaken undiluted cleaning compound shall be poured into each of two chemically clean 250 ml pressure resistant clear glass bottles which shall be approximately 240 mm (9.5 inch) in height and 64 mm (2.5 inches) in outside diameter. One bottle shall be capped and stored in the dark for at least six days at room temperature. A strip of steel 150 by 125 by 0.5 mm, (6 by 5 by 0.02 inches) conforming to SAE-AMS5046 shall be polished with 280-grit silicon carbide paper to remove surface contamination and then cleaned by boiling for one minute in chemically pure isopropyl alcohol and one minute in mineral spirits. The steel strip shall be placed in the other test bottle and the bottle shall be capped. The capped bottle containing the steel strip shall be thoroughly shaken for one minute.

4.4.15.2 Procedure. The capped bottle containing the steel strip shall be placed in a water bath and heated to 60 ±2 °C (140 ±4 °F) for type I and 49 ±2 °C (120 °F ±4 °F) for types II, II RTU, III, and III RTU and held at that temperature for a period of eight hours. The bath shall then be allowed to cool to room temperature over the next 16 hours. The above heating procedure shall be repeated each day for five days (see 6.8). On the morning of the sixth day, the bottle shall be removed from the bath, uncapped, examined for separation, and the steel strip

carefully withdrawn from the cleaning compound. Separation into layers shall be cause for rejection. The portion of the steel strip which had been immersed in the compound shall be examined for evidence of pitting, corrosion, and uneven darkening. The open bottle shall be capped and the two bottles shall be thoroughly shaken for one minute, then allowed to remain undisturbed for one hour at room temperature and then examined. Any marked change in the color and uniformity of the aged sample shall be considered as showing unsatisfactory stability properties.

4.4.16 Low temperature stability.

4.4.16.1 Type I. Approximately 50 ml of undiluted cleaning compound shall be poured into a test tube and capped. The sample shall be subjected to a temperature of -12.2 °C (10 °F) for 16 hours and examined for cystallization or gellation. The sample shall then be refrigerated at -26 °C (-15 °F) for 24 hours, then removed from the cold box to room temperature for 8 hours, after which it shall be examined for homogeneity.

4.4.16.2 Types II, II RTU, III, and III RTU. Approximately 50 ml of undiluted cleaning compound shall be poured into a test tube and capped. The sample shall be subjected to a temperature of -26 °C (-15 °F) for 24 hours then removed from the cold box to room temperature for 8 hours, after which it shall be examined for homogeneity.

4.4.17 Storage stability. A 4 liter (one gallon) metal pail conforming to PPP-P-704, type I, class 1, filled with the cleaner shall be stored for 6 months at 21 °C ±3 °C (70 °F ±5 °F). In addition, 4 liters of the cleaning compound shall be poured into a glass container to which has been added a cleaned and polished metal strip conforming to SAE-AMS5046. The total surface area of both sides of the steel strip shall be 38.7 ± 3 cm^2 (6 ± 0.5 in^2) . The second sample shall be stored under the same conditions of time and temperature. After the 6 month storage period, specimens from both samples shall be tested for pH, cleaning efficiency, rinsibility, salt water stability, and acid stability (see 3.5).

4.4.18 Turboshaft engine cleaning tests.

4.4.18.1 Crank wash performance test. Types I, II, and II RTU shall be tested in accordance with Appendix A. Types I and II shall be diluted one part cleaner to four parts deionized water.

4.4.18.2 Running wash performance test. Types III and III RTU shall be tested in accordance Appendix B. Type III compounds shall be diluted one part cleaner to four parts deionized water.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.3). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cleaning compounds covered by this specification are used in the maintenance of military aircraft exposed for prolonged periods to extreme seagoing operating environments not encountered by commercial aircraft. Operating requirements and conditions result in the need to clean military engines on a significantly more frequent basis than commercial engines. A product's cleaning efficiency is critical to the military's use of these materials and it can only be determined via expensive and time consuming engine testing. Types I, II, and II RTU cleaning compounds are intended for cleaning the compressor section of gas turbine aircraft engines with the engine off-line (with the starter motoring the engine). Types III and III RTU are intended for on-line cleaning of the compressor section of a gas turbine engine in accordance with specific engine maintenance instructions. The cleaning compound will remove accumulated salt, dirt, and oily residues from the gas path.

6.2 Dilution of Types I, II and III cleaning compound. Types I, II, and III concentrated cleaning compounds are diluted prior to use at a ratio of one part cleaner to four parts water. Type II RTU, and type III RTU are ready to use and are not diluted prior to use. Potable water may be used to dilute type I and type II concentrates. Water for dilution of type III should conform to the following characteristics:

Conductivity:	10 micro-Siemens per centimeter (μS/cm, also known as micro-mho per centimeter), maximum
pH:	5.0 to 8.0 (pH units)

These limits can be achieved using reverse osmosis water purifiers in combination with mixed bed deionizers. Water quality can be monitored with digital conductivity and pH meters. It is essential that very high purity water (as defined by the conductivity and pH parameters shown

above) be used for on-line (fired) engine cleaning since contaminants can cause severe and costly damage to engines.

6.3 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2 and 2.3).

c. Type required (see 1.2.1).

d. Packaging requirements (see 5.1), including the type and size of containers.

e. Quantity desired.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for the products which are, at the time of award of contract, qualified for inclusion in Qualified Products List, QPL-85704, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Naval Air Systems Command, AIR-4.4.5, Propulsion Systems Evaluation Facility, Building 2360, 22229 Elmer Road, Unit 4, Patuxent River MD 20670-1534.

6.5 Part or Identifying Number (PIN). The PIN to be used for cleaning compounds acquired to this specification are created as follows. (This number is intended for cataloging and ordering purposes.):

M85704	-	X	-	X
Specification identifier		Type designator I = Type I II = TypeII IIR = Type II RTU III = Type III IIIR = Type III RTU		Container size designator A = 18.9 liters (5 gal.) B = 56.8 liters (15 gal.) C = 208.2 liters (55 gal.)

6.6 Toxicity. Questions pertinent to the effect(s) of this cleaner shall be referred to the appropriate medical service who will act as advisor to the contracting agency. Contracting Officers will identify those activies requiring copies of completed Material safety Data Sheets

prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.7 Definitions.

6.7.1 Lot. A lot is a quantity of homogeneous mixture of material offered for acceptance and manufactured by a single plant run (not exceeding 24 hours) through the same processing equipment, with no change in ingredient material.

6.8 Accelerated storage stability test. The accelerated storage stability test need not necessarily be attended if an internal timer is used to regulate the temperature automatically. The test may be started on a Wednesday, Thursday, or Friday and still have the pressure bottle removed on a normal weekday.

6.9 Subject term (key word) listing.

Cleaner, aqueous
Cleaner, solvent emulsion

6.10 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

APPENDIX A

ENGINE CRANKWASH TEST PROCEDURE

A.1 SCOPE

A.1.1 Scope. This appendix describes the procedure for testing the crankwash cleaning efficiency of types I, II, and II RTU turbine engine gas path cleaning compounds. This appendix is a mandatory part of this specification.

A.2 APPLICABLE DOCUMENTS

(This section is not applicable to this appendix.)

A.3 PROCEDURE

A.3.1 Summary of procedure. The crankwash cleaning efficiency of a compound is determined by measuring the candidate's ability to restore the performance of a turboshaft engine after its performance has been reduced by the application of a synthesized contaminant to the compressor. This testing procedure is designed to examine the performance of one candidate type I or II cleaner per day. All candidate submittals are tested three separate times on three different days, per a random test matrix.

A.3.2 Apparatus. The tests are conducted using a T63-A-700 turboshaft engine. The contaminant used in this evaluation is a mixture of new turbine engine oil conforming to MIL-PRF-23699 and pelletized carbon black in the ratio of 50 ml oil to 25 grams carbon black, resulting in a material with a thin paste consistency. The significance of this ratio is its ability to thinly coat all active surfaces of the compressor, and its ability to contain itself within the compressor assembly (without exiting the bleed valve during operations), which allows for good repeatability. A modified T63-A-700 fuel nozzle is used as an atomizer to spray the prepared cleaner into the compressor inlet. The cleaner is delivered from a pressurized canister at a flowrate of 1 quart per 10 seconds, per the overhaul manual.

A.3.3 Engine preparation. The start of each evaluation begins with the collection of performance data on the clean engine, followed immediately by the introduction of the compressor contaminant. The procedure is performed as follows:

a. Warm-up engine for 5 minutes at ground idle.
b. After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):

TOT of 1,148°F, 75 percent of normal rated power
TOT of 1,280°F, 100 percent of normal rated power
TOT of 1,380°F, 104 percent of normal rated power

Record the following:
Barometric pressure
Turbine outlet temperature
Engine torque

Total pressure at the compressor inlet
Temperature at the compressor inlet
Standard temperatures and pressures to ensure satisfactory engine operation

c. Apply 10 grams of contaminant to first stage compressor rotor blades.
d. Motor engine for 20 seconds to disperse the contaminant throughout the compressor assembly.
e. Repeat steps (c) and (d) with a second application of 10 grams of the dirt mixture.
f. Operate engine at normal rated power (100 percent) for 15 minutes with the anti-ice valve ON. The anti-ice valve will supply compressor discharge air at 475°F.
g. Shut down engine and remove anti-ice valve. Start the engine and conduct performance run, recording the performance parameters listed below (fouled compressor assembly). After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):

TOT of 1,148°F, 75 percent of normal rated power
TOT of 1,280°F, 100 percent of normal rated power
TOT of 1,380°F, 104 percent of normal rated power

Record the following:
Barometric pressure
Turbine outlet temperature
Engine torque
Total Pressure at the compressor inlet
Temperature at the compressor inlet
Standard temperatures and pressures to ensure satisfactory engine operation

The engine should show an approximate 25 percent loss in horsepower.

h. Allow engine to cool-down for 45 minutes in accordance with overhaul manual.

A.3.4 Cleaning Test. Each candidate cleaner is given three successive chances to clean the contaminant from the compressor assembly. The procedure, developed in accordance with the T63-A-700 depot overhaul manual, is performed as follows:

a. Prepare four liters of the candidate cleaner (1 part cleaner to 4 parts distilled water for types I and II and no mixing for type II RTU) in the pressurizeable delivery canister.
b. Spray the prepared cleaner through the atomizer into the compressor inlet for 20 seconds while simultaneously motoring the engine at approximately 8,000 rpm on the output shaft. Flowrate shall be approximately 1 quart every 10 seconds.
c. Cool the engine's starter motor for 3 minutes.
d. Repeat steps (b) and (c) until the remainder of the 4 liters is depleted.
e. Allow engine to soak fifteen minutes.
f. Perform four rinse cycles using the same procedure as the wash cycle [steps (b) and (c) above] and potable water in place of the cleaner solution.

g. Start and run the engine at normal rated power for 5 minutes to dry it out.
h. Reduce power and begin post-wash performance run. After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):

TOT of 1,148°F, 75 percent of normal rated power
TOT of 1,280°F, 100 percent of normal rated power
TOT of 1,380°F, 104 percent of normal rated power

Record the following:
Barometric pressure
Turbine outlet temperature
Engine torque
Total Pressure at the compressor inlet
Temperature at the compressor inlet
Standard temperatures and pressures to ensure satisfactory engine operation

i. Cool-down the engine for 45 minutes in accordance with overhaul manual.
j. Conduct a second wash cycle by repeating steps (a) through (i) above.
k. Conduct a third wash cycle by repeating steps (a) through (i) above.

A.3.5 Engine inspection and clean-up. Following the third and final cleaning procedure of the day, the compressor is disassembled for inspection and prepared for the next day's clean engine performance run as follows:

a. Remove a stator case from the compressor assembly for inspection. Photograph the condition of the stator case liner and a reference row of stator blades (both front and rear). In addition photograph the compressor rotor.
b. Hand-clean the stator cases and the rotor using a laboratory-grade soap solution to remove all traces of the contaminant. Thoroughly hand-rinse the clean parts.
c. Reassemble the engine and conduct four rinse cycles using potable water. Deliver the water crank-wash style at a flow rate of one quart per 10 seconds while the engine is being starter cranked for 20 seconds. Allow the starter to cool down for three minutes before performing the next rinse cycle.
d. Start and run engine at 100 percent rated power for five minutes to dry compressor.

APPENDIX B

ENGINE RUNNING WASH TEST PROCEDURE

B.1 SCOPE

B.1.1 Scope. This appendix describes the procedure for testing the running wash cleaning efficiency of types III and III RTU turbine engine gas path cleaning compounds. This appendix is a mandatory part of this procedure.

B.2 APPLICABLE DOCUMENTS

(This section is not applicable to this appendix.)

B.3 PROCEDURE

B.3.1 Summary of procedure. The running wash cleaning efficiency of a compound is determined by measuring the candidate's ability to restore the performance of a turboshaft engine after its performance has been reduced by the application of a synthesized contaminant to the compressor. This testing procedure is designed to examine the performance of one candidate type III or III RTU cleaner per day. All candidate submittals are tested three separate times on three different days, per a random test matrix.

B.3.2 Apparatus**.** The tests are conducted using a T63-A-700 turboshaft engine. The contaminant used in this evaluation is a mixture of new turbine engine lubricating oil conforming to MIL-PRF-23699 and pelletized carbon black in the ratio of 50 ml oil to 25 grams carbon black, resulting in a material with a thin paste consistency. The significance of this ratio is its ability to thinly coat all active surfaces of the compressor, and its ability to contain itself within the compressor assembly (without exiting the bleed valve during operations), which allows for good repeatability. Two modified T63-A-700 fuel nozzles are used to atomize the prepared cleaner into the compressor inlet. These spray nozzles are mounted at the 3 and 9 o'clock positions and aimed at he bullet nose of the engine's compressor in order to obtain full spray coverage into the compressor. The cleaner is delivered from a pressurized canister at a flowrate of 500 ml/minute.

B.3.3 Engine preparation. The start of each evaluation begins with the collection of performance data on the clean engine, followed immediately by the introduction of the compressor contaminant. The procedure is performed as follows:

a. Warm-up engine for 5 minutes at ground idle.
b. After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):
    TOT of 1,148°F, 75 percent of normal rated power
    TOT of 1,280°F, 100 percent of normal rated power
    TOT of 1,380°F, 104 percent of normal rated power
    Record the following:
        Barometric Pressure
        Turbine Outlet Temperature
        Engine Torque

Total Pressure at the Compressor Inlet
Temperature at the Compressor Inlet
Standard temperatures and pressures to ensure satisfactory engine operation

c. Apply 10 grams of contaminant to first stage compressor rotor blades.
d. Motor engine for 20 seconds to disperse the contaminant throughout the compressor assembly.
e. Repeat steps (c) and (d) with a second application of 10 grams of the dirt mixture.
f. Operate engine at 100 percent rated power for 15 minutes with the anti-ice valve ON. The anti-ice valve will supply compressor discharge air at 475°F.
g. Shut down engine and remove anti-ice valve. Start the engine and conduct performance run, recording the performance parameters listed below (fouled compressor assembly). After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):

TOT of 1,148°F, 75 percent of normal rated power
TOT of 1,280°F, 100 percent of normal rated power
TOT of 1,380°F, 104 percent of normal rated power

Record the following:
Barometric Pressure
Turbine Outlet Temperature
Engine Torque
Total Pressure at the Compressor Inlet
Temperature at the Compressor Inlet
Standard temperatures and pressures to ensure satisfactory engine operation

The engine shall show an approximate 25 percent loss in horsepower.

B.3.4 Cleaning test. Each candidate cleaner is given three successive chances to clean the contaminant from the compressor assembly. The procedure is performed as follows:

a. Prepare 2.5 liters of the candidate cleaner (1 part cleaner to 4 parts distilled water for type III, no mixing for type III RTU's) in the pressurizeable delivery canister.
b. With the engine running at ground idle, spray the prepared cleaner into the compressor inlet until exhausted. The cleaner is delivered from a pressurized canister at a pressure of 75 psi achieving a flow rate of approximately 500 ml/min.
c. Dry out the engine for five minutes by running at 100 percent rated power.
d. Reduce power and begin post-wash performance run. After running five minutes at each setting, record baseline performance (compressor is clean) at three specified Turbine Outlet Temperatures (TOT):

TOT of 1,148°F, 75 percent of normal rated power
TOT of 1,280°F, 100 percent of normal rated power
TOT of 1,380°F, 104 percent of normal rated power

Record the following:

APPENDIX B

ENGINE RUNNING WASH TEST PROCEDURE

Barometric Pressure
Turbine Outlet Temperature
Engine Torque
Total Pressure at the Compressor Inlet
Temperature at the Compressor Inlet
Standard temperatures and pressures to ensure satisfactory engine operation

e. Conduct a second wash cycle by repeating steps (a) through (e) above.
f. Conduct a third wash cycle by repeating steps (a) through (e) above.

B.3.5 Engine inspection and clean-up. Following the third and final cleaning procedure of the day, the compressor is disassembled for inspection and preparation for the next day's "clean" engine performance run. The procedure is as follows:

a. Remove a stator case from the compressor assembly for inspection. Photograph the condition of the stator case liner and a reference row of stator blades (both front and rear). In addition photograph the compressor rotor.
b. Reinstall case half and perform a single crankwash with a qualified type II or II RTU product using the standard procedure contained in Appendix A to maintain engine horsepower.
c. Remove and hand-clean the stator cases and the rotor using a laboratory-grade soap solution to remove all traces of the contaminant. Thoroughly hand-rinse the clean parts.
d. Reassemble the engine and conduct four rinse cycles using potable water. Deliver the water crank-wash style at a flow rate of one quart per 10 seconds while the engine is being starter cranked for 20 seconds. Allow the starter to cool down for three minutes before performing the next rinse cycle.
e. Start and run engine at 100 percent rated power for five minutes to dry compressor.

CONCLUDING MATERIAL

Custodians:
Army - AV
Navy - AS
Air Force - 68

Review activities:
Army - MD, MR
DLA – GS

Preparing activity:
Navy - AS
(Project 6850-1232)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.
   NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-PRF-85704C	2. DOCUMENT DATE (*YYMMDD*) 98 JUL 15

3. DOCUMENT TITLE
   CLEANING COMPOUND, TURBINE ENGINE GAS PATH

4. NATURE OF CHANGE (*Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.*)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (*Last, First, Middle Initial*)	b. ORGANIZATION	
c. ADDRESS (*Include Zip Code*)	d. TELEPHONE (*Include Area Code*) (1) Commercial: (2) DSN: (*If Applicable*)	7. DATE SUBMITTED (*YYMMDD*)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE NUMBER (*Include Area Code*)
COMMANDER NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION	(1) Commercial: (732) 323-2947 (2) DSN: 624-2947
c. ADDRESS (*Include Zip Code*) CODE 414100B120-3 HIGHWAY 547 LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Logistics Agency, DLSC-LM Attn: Carla Jenkins/John Tascher 8725 John J Kingman Rd, Suite 2533, Fort Belvoir, VA 22060-6221 (703) 767-6874