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Date: 02-May-2006

SMI/REF: 0603-468

Product: ARCTICA DG RTU (received 14-Mar-2006)
Dilution: Ready to Use

**AMS 1424G**

Deicing/Anti-icing, Fluid, Aircraft SAE Type I
(Fluid is ready to use)

| | |
|---|---|
| 3.1.4 Environmental Information | |
| Biochemical Oxygen Demand (BOD) | Informational |
| Chemical Oxygen Demand (COD) | Informational |
| Biodegradability | Informational |
| Aquatic Toxicity | Informational |
| 3.1.5 Trace Contaminants | Informational |
| 3.2 Properties | |
| Flash Point | Conforms |
| Specific Gravity | Informational |
| pH | Informational |
| Refractive Index | Informational |
| Freezing Point | Informational |
| Surface Tension | Informational |
| Viscosity | Informational |
| 3.3 Fluid Stability | |
| Storage Stability | Not performed |
| Thermal Stability *(WSET testing not performed)* | Conforms |
| Hard Water Stability *(WSET testing not performed)* | Not applicable |
| Shear Stability | Not performed |
| 3.4 Effect on Aircraft Materials | |
| Sandwich Corrosion | Conforms |
| Total Immersion Corrosion | Conforms |
| Low Embrittling Cadmium Plate | Conforms |
| Stress Corrosion Resistance | |
| AMS 4911 | Conforms |
| AMS 4916 | Informational |
| Hydrogen Embrittlement | Conforms |
| Effect on Transparent Plastics | Conforms |
| Effect on Painted Surfaces | Conforms |
| Effect on Unpainted Surfaces | Conforms |
| Runway Concrete Scaling Resistance | Conforms |
| 3.5.1 Freezing point (concentrate) | Not applicable |
| 3.5.1.1 Freezing point (ready to use) | Conforms |
| 3.5.2 Anti-Icing Performance | Not performed |
| 3.5.3 Aerodynamic Acceptance Test | Not performed |

Respecfully submitted,

Patricia D. Viani, SMI, Inc.

3.1.4 Environmental Information: Formulated fluid shall be tested in accordance with APHA "Standard Methods for the Examination of Water and Waste Water" unless otherwise specified in Annex A. The manufacturer shall supply not less than the following:

3.1.4.1 Biological Oxygen Demand (BOD) of fluid shall be determined at both 5°C (41°F) and 20°C (68°F). The test solutions shall be incubated at the designated temperatures for 5 and 28 days. The results shall be reported in terms of kilograms of oxygen per kilogram of concentrate and kilograms of oxygen per kilogram of mixture of fluid and water to formulate a freezing point of -26°C (-15°F).

| | |
|---|---|
| **5 day BOD at 5°C:** | **< 0.01 kg $O_2$/kg concentrate*** |
| **5 day BOD at 20°C:** | **0.003 kg $O_2$/kg concentrate*** |
| **28 day BOD at 5°C:** | **< 0.01 kg $O_2$/kg concentrate*** |
| **28 day BOD at 20°C:** | **0.004 kg $O_2$/kg concentrate*** |

** Information regarding the dilution required to formulate a -26°C freezing point was not supplied by manufacturer; therefore, results reflect testing of fluid as received (neat).*

Result: Informational

3.1.4.2 Chemical Oxygen Demand (COD) of the fluid, expressed in kilograms of oxygen per kilogram of fluid and kilograms of oxygen per kilogram of mixture of fluid and water to formulate a freezing point of -26°C (-15°F).

***COD = 0.90 kg $O_2$/kg fluid***

**Information regarding the dilution required to formulate a -26°C freezing point was not supplied by manufacturer; therefore, results reflect testing of fluid as received (neat).*

Result: Informational

3.1.4.3 Biodegradability: This characteristic can be approximated by determining the ratio of the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The percent of fluid biodegraded can be calculated by dividing BOD by COD and shall be reported for all incubation time periods.

| | |
|---|---|
| **5 day BOD/COD at 5°C:** | **< 0.01/0.90 = <0.01** |
| **5 day BOD/COD at 20°C:** | **0.003/0.90 = 0.003** |
| **28 day BOD/COD at 5°C:** | **< 0.01/0.90 = < 0.01** |
| **28 day BOD/COD at 20°C:** | **0.004/0.90 = 0.004** |

Result: Informational

3.1.4.4 Aquatic Toxicity: Formulated fluid shall be tested in accordance with EPA (40CFR 797.1300 and 797.1400, revised July 1,1989 and 40 CFR 136.3) or OECD (Organization for Economic Cooperation and Development Guidelines for Testing of Chemicals, Methods 202 and 203) procedures using test species required by regulatory agencies for permitted discharges. Examples include: fathead minnows (96-hour $LC_{50}$), *Ceriodaphnia dubia* (48-hour $EC_{50}$), *Daphnia magna* (48-hour $EC_{50}$) and rainbow trout (96-hour $LC_{50}$). The $LC_{50}$ (for fish) or $EC_{50}$ (for invertebrates) concentration (the highest concentration at which 50% of the organisms do not survive the test period) shall be given in milligrams per liter.

EPA 40 CFR 797.1300 DAPHNIA ACUTE TOXICITY TEST
*Daphnia magna,* static system
**48 hour $LC_{50}$: 4,125 mg/L**

EPA 40 CFR 797.1400 FISH ACUTE TOXICITY TEST
*Pimephales promelas,* static system
**96 hour $LC_{50}$: 2,575 mg/L**

Result: Informational

3.1.5 Trace Contaminants: Report the presence, in percentages by weight or ppm by weight, of sulfur, halogens, total phosphorus, nitrate, total kjeldahl nitrogen and metals (lead, chromium, cadmium, and mercury). Report the test method used and detection limits.

*Methods:*
*Metals & Heavy Metals: ICP Inductive-Coupled Plasma Spectrometry (Detection Limit: 1 ppm)*
*Halogens: Potentiometric Method per Standard Methods for Examination of Water and Wastewater, method 4500-Cl D. Digital Electronic Cloridimeter (Detection Limit: 1 ppm)*
*Phosphates: ICP (calculated as $P_2O_5$ from total phosphorus) (Detection Limit: 1 ppm)*
*Nitrates: Cadmium Reduction Method per Standard Methods for Examination of Water and Wastewater, method 4500-$NO_3$ E. (Detection Limit: 1 ppm)*
*Total kjeldahl nitrogen: Micro-Kjeldahl Method per Standard Methods for Examination of Water and Wastewater, method 4500-$N_{org}$ C. (Detection Limit: 1 ppm)*

| | | | |
|---|---|---|---|
| ***Sulfur:*** | ***10*** | ***ppm*** | ***(0.0010%)*** |
| ***Halogens:*** | ***58*** | ***ppm*** | ***(< 0.0058 %)*** |
| ***total phosphorus:*** | ***360*** | ***ppm*** | ***(0.0360 %)*** |
| ***Nitrate (as $NO_3$):*** | ***< 2*** | ***ppm*** | ***(< 0.0002 %)*** |
| ***Total kjeldahl nitrogen:*** | ***30*** | ***ppm*** | ***(0.0030%)*** |
| ***Heavy Metals:*** | | | |
| ***Lead (Pb):*** | ***<1*** | ***ppm*** | ***(< 0.0001%)*** |
| ***Chromium (Cr):*** | ***<1*** | ***ppm*** | ***(< 0.0001 %)*** |
| ***Cadmium (Cd):*** | ***<1*** | ***ppm*** | ***(< 0.0001 %)*** |
| ***Mercury (Hg):*** | ***<1*** | ***ppm*** | ***(< 0.0001 %)*** |

Result: Informational

3.2 Physical Properties: The fluid as supplied by the vendor shall conform to the following requirements:

3.2.1 Flash Point: Shall be not lower than 100°C (212°F), determined in accordance with ASTM D 93 or ASTM D 3278. In case of dispute, the flash point in accordance with ASTM D 93 shall apply.

***No flash to 100°C.***

Result: Conforms

3.2.2 Specific Gravity: Shall be within ±0.015 units of the preproduction value, determined in accordance with ASTM D 891.

***Specific gravity = 1.101 @ 60/60°F***

Result: Informational

3.2.3 pH: Shall be within ±0.5 units of the preproduction value, determined in accordance with ASTM E 70.

***pH = 9.2***

Result: Informational

3.2.4 Refractive Index: Shall be within ±0.0015 units of the preproduction value, determined in accordance with ASTM D 1747.

***Refractive Index: 1.4105@ 25°C***

Result: Informational

3.2.5 Freezing Point: Shall be within ±3°C (±5°F) of the preproduction value, determined in accordance with ASTM D 1177.

***Freezing point (of fluid, as received): -36°C***

Result: Informational

3.2.6 Surface Tension: Shall be within ±10% of the preproduction value.

***38.5 dynes/cm @ 24°C***

Result: Informational

3.2.7 Viscosity: Shall be within ±5% of the preproduction value at +20, 0, -10, and -20°C (68, 32, 14, and -4°F), determined in accordance with ASTM D 445.
*Note: Test was performed using Brookfield Model DV-II+ Viscometer, fitted with the LV1, LV2, or LV3 spindle in a sample of 500 mL contained in a 600 mL beaker.*

| Spindle | Speed (RPM) | Temp (°C) | Viscosity (cps) |
|---|---|---|---|
| LV1 | 6.0 | +20 | 6 |
| | 12.0 | | 7 |
| | 30.0 | | 11 |
| LV1 | 6.0 | 0 | 12 |
| | 12.0 | | 14 |
| | 30.0 | | 30 |
| LV1 | 6.0 | -10 | 64 |
| | 12.0 | | 52 |
| | 30.0 | | 45 |
| LV1 | 6.0 | -20 | 87 |
| | 12.0 | | 77 |
| LV2 | 30.0 | | 83 |

Result: Informational

3.3 Fluid Stability: The fluid, as supplied by the vendor, shall conform to the following requirements:

3.3.1 Storage Stability: Prior to the start of this test, determine the viscosity at 20°C (68°F) in accordance with ASTM D 445. The fluid shall then be subject to one complete cycle as outlined in ASTM F 1105. On completion of the cycle, the fluid shall be retested for viscosity as before and the result compared to the original values. These results shall not vary by more than +10% or -20%. pH of the aged fluid, determined as in 3.2.3, shall be within + 0.5 units of the unaged sample. A portion of the fluid shall then be diluted 1:1 with ASTM D 1193, Type IV, water. There shall be no evidence of separation, precipitation or evidence of insoluble deposits in the fluid or in the 1:1 dilution.

Result: Not performed

3.3.2 Thermal Stability - Accelerated Aging: Accelerated Aging for Concentrates and Ready-to-Use Fluids: Age sample as in 3.3.2.1 and examine as in 3.3.2.2.

3.3.2.1 Transfer 800 mL of fluid to a 1 liter Pyrex bottle fitted with a tight, heat-resistant plastic seal and tightly close. For the reference sample, also keep 800 mL ±10 mL of the fluid in an identical container and store at room temperature until the completion of 3.3.2.2. Transfer the other closed bottle containing the fluid to a circulating-air oven or heated oil or water bath. Elevate the temperature to 80°C (178°F) and maintain the sample in this environment for 30 days.

3.3.2.2 After 30 days, remove the fluid from the heated environment, allow the sample to cool to 20°C±1 (68°F±2), and compare to the initial unheated reference fluid. Invert the container through four complete cycles, then examine for evidence of a significant difference in the amount of separation or deposits of the heat-aged test fluid versus the unheated reference fluid. Report the findings. Determine the refractive index of the test and reference fluids in accordance with ASTM D 1747, If, the test and reference fluids have a refractive index difference of greater than 0.0020, the test is invalid. If the refractive index is within limits and the fluid tested is a concentrate intended to be diluted, dilute both the test and reference fluids 50/50 by volume with ASTM D1193, Type IV water and determine the pH in accordance with ASTM D70. If the test fluid is a ready-to-use fluid, no further dilution is necessary and the pH should be determined in accordance with ASTM D70. Report the difference in pH between the heat-aged test fluid and the unheated reference fluid. The pH dif-

ference between the heat-aged test fluid and the unheated reference fluid shall not be greater than 1.0 unit. The heat-aged test fluid shall be tested according to the water spray endurance test (WSET) as in AS5901 using one set of three plates, and the results reported.

| | Unaged (As received) | Aged (As received) |
|---|---|---|
| Refractive index | 1.4105 | 1.4103 |
| Separation / insoluble deposits | none | None |

***Test is valid since values for refractive index are within 0.0020.***

Unaged and aged samples are then tested for pH:

| | Unaged (As received) | Aged (As received) |
|---|---|---|
| pH | 9.2 | 9.1 |

***pH values are within 1.0 unit***

Result: Conforms

Water Spray Endurance Test

Result: Not performed

3.3.3 Hard Water Stability: Fluid supplied as concentrate and intended to be diluted with water before use shall be diluted 1:1 by volume with standard hard water made up as in 3.3.3.1. Determine the refractive index of the diluted fluid in accordance with ASTM D 1747 and the pH in accordance with ASTM D70. Age the diluted fluid as in 3.3.2.1 but at a storage temperature of 95°C. After 30 days, remove the bottle from the heated environment and examine the contents for evidence of separation or insoluble deposits. Report any evidence of these factors. Allow the sample to cool to 20°C±1 (68°F±2). Invert the container through four complete cycles, re-examine and report any evidence of separation or insoluble deposits. Retest for refractive index as before and record the result. If the refractive index of the aged fluid has increased by more than 0.0020 the test is invalid as water has been allowed to evaporate. If the refractive index is within limits, the pH of the aged fluid shall be determined as before and shall not vary by more than 0.5 units from the unaged value. The aged sample(s) shall be tested according to the water spray endurance test (WSET) as in AS5901 using one set of three plates, and the results reported.

3.3.3.1 Composition of Hard Water: Dissolve 400 mg ± calcium acetate dihydrate [$Ca(C_2H_3O_2)_2 2H_2O$] or 363 mg ± 5 calcium acetate monohydrate [$Ca(C_2H_3O_2)_2H_2O$], and 280 mg ± 5 magnesium sulfate heptahydrate ($MgSO_4 7H_2O$), both of analytical reagent quality, in 1 liter of ASTM D 1193 Type IV water.

| | Unheated (undiluted) | Heat-Aged (undiluted) |
|---|---|---|
| PH | – | – |
| Refractive index | – | – |
| Separation/ insoluble deposits | – | – |

***Product is ready-to-use; not intended for dilution, therefore this test is not applicable.***

Result: Not applicable

Water Spray Endurance Test

Result: Not performed

3.3.4 Shear Stability: The anti-icing performance tests shall be performed after the product has been sheared using the laboratory method as in 3.3.4.1

Result: Not performed

3.4 Effect on Aircraft Materials: The fluid shall conform to the following requirements in the form supplied by vendor and, if a concentrate intended to be diluted prior to use, diluted 1:1 by volume with ASTM D 1193, Type IV, water, except as noted.

3.4.1 Sandwich Corrosion: Specimens after testing in accordance with ASTM F 1110, shall not show corrosion worse than control panels run using ASTM D 1193, Type IV, water.

| | 2024-T3 Bare Anodized | 2024-T3 Alclad | 7075-T6 Bare Anodized | 7075-T6 Alclad |
|---|---|---|---|---|
| As received | 1 | 1 | 1 | 1 |
| CONTROL | 1 | 1 | 1 | 1 |

Result: Conforms

3.4.2 Total Immersion Corrosion Test: The fluid, tested in accordance with ASTM F 483, shall neither show evidence of corrosion of panels nor cause a weight change of any test panel greater than as shown in Table I.

Table I – TOTAL IMMERSION CORROSION

| Test Panel | Wgt change allowed, mg/cm$^2$ per 24 hrs | Results "as received" |
|---|---|---|
| AMS 4037 Aluminum Alloy, Anodized as in AMS 2470 | 0.3 | 0.02 |
| AMS 4041 Aluminum Alloy | 0.3 | 0.01 |
| AMS 4049 Aluminum Alloy | 0.3 | 0.01 |
| AMS 4376 Magnesium Alloy, dichromate treated as in AMS 2475 | 0.2 | 0.02 |
| AMS 4911 Titanium Alloy | 0.1 | 0.01 |
| AMS 5045 Carbon Steel | 0.8 | 0.01 |

Result: Conforms

3.4.3 Low Embrittling Cadmium Plate: Test panels, coated with low-embrittling cadmium plate, shall not show a weight change greater than 0.3 mg/cm$^2$ per 24 hours, determined in accordance with ASTM F1111.

***As received:*** ***0.01 mg/cm$^2$/24hrs***

Result: Conforms

3.4.4 Stress Corrosion Resistance: The fluid shall not cause cracks in AMS 4911 or MAM 4911, titanium alloy specimens determined in accordance with ASTM F 945, Method A.

***As received:***
***AMS 4911:*** ***No surface reaction or cracking.***

Result: Conforms

3.4.4.1 Stress Corrosion Resistance: The fluid shall be tested in accordance with ASTM F 945, Method A using AMS 4916 specimens. Report shall detail the effect of the fluid and the effect on control solution.

***As received:***
***AMS 4916:*** ***No surface reaction or cracking.***
*100 ppm salt control showed appropriate cracking*

Result: Informational

3.4.5 Hydrogen Embrittlement: The fluid shall be non-embrittling, determined in accordance with ASTM F 519, Type 1a, 1c, or 2a. In case of dispute, the 1c bar shall be used. Galvanic reactions must not be allowed to occur; this may be accomplished by confining the test specimen using a chemically inert cup.
*Specimens: Type 1C, cadmium plated per Treatment B of ASTM F519.*

***As received:*** ***No failures occurred within 150 hours***

Result: Conforms

3.4.6 Effect on Transparent Plastics:

3.4.6.1 Fluid shall be diluted with ASTM D 1193, Type IV, water to the maximum intended fluid/water concentration recommended for use by the manufacturer. The diluted fluid, heated to and applied at 65°C±1 (149°F±2), and then allowed to cool naturally to test temperature specified in ASTM F 484, shall not craze, stain, or discolor MIL-PRF-25690 stretched acrylic plastic determined in accordance with ASTM F 484.
*Note: Fluid is ready to use; not intended for dilution.*

***MIL-PRF-25690 (Type C) 4500 psi/8 hours: No crazing, stains, or discoloration.***

Result: Conforms

3.4.6.2 Fluid, supplied as concentrate and intended to be diluted with water before use shall be diluted to the maximum intended fluid/water concentration with standard hard water made up as in 3.3.3.1. The diluted fluid or the ready-to-use fluid, heated to and applied at 65°C±1 (149°F±2), and then allowed to cool naturally to test temperature specified in ASTM F 484, shall not craze, stain, or discolor MIL-P-83310 polycarbonate plastic, determined in accordance with ASTM F 484, except that the specimens shall be stressed for 30 minutes ± 2 to an outer fiber stress level of 13.8 Mpa (2000 psi).
*Note: Fluid is ready-to-use; not intended for dilution.*

***MIL-P-83310 (2000 psi/30 minutes): No crazing, stains, or discoloration.***

Result: Conforms

3.4.7 Effect on Painted Surfaces: Fluid, heated to 65°C±2 (149°F±4), and applied to a painted surface having an initial surface temperature of 22°C±1 (72°F±2), shall not produce any streaking, discoloration, or blistering of the paint film, and shall not decrease paint film hardness by more than two pencil hardness numbers, determined in accordance with ASTM F 502.

***As received: No streaks, discoloration or blistering, no hardness change***

Result: Conforms

3.4.8 Effect on Unpainted Surfaces: Fluid, tested in accordance with ASTM F 485, shall neither produce streaking nor leave stains which require polishing to remove.

***As received:*** ***AMS 4049 - No streaks nor stains***
***AMS 4911 - No streaks nor stains***

Result: Conforms

3.4.9 Runway Concrete Scaling Resistance: The condition of the runway concrete surface shall have a rating not greater than 1 for fifty freeze-thaw cycles determined in accordance with ASTM C 672, except that the concrete shall be air-entrained with an air content as specified in ASTM C 672, have a minimum cement content of 302 kg/$m^3$ ± 6 (510 lb/$yd^3$ ± 10) and a slump of 38 mm ± 13 (1.5 inches ± 0.5). A25% ± 1 volume solution of the fluid prepared using tap water shall be substituted for the specified calcium chloride solution. Performing more than one freeze-thaw cycle per day is acceptable.

***Rating after 50 cycles: 1.***

Result: Conforms

3.5. Performance Properties: The fluid shall conform to the following requirements:

3.5.1 Freezing Point: Fluid supplied as concentrate shall, after dilution 1:1 by volume with ASTM D 1193, Type IV water, have a freezing point not higher than -20°C (-4°F), determined in accor-

dance with ASTM D1177. Freezing point shall be expressed as a function of volume dilution with water and shall be reported from 100:0 to 0:100, with each increment of 10% expressed.

Result: Not applicable

3.5.1.1 For fluid supplied in a ready-to-use form, the freezing point shall be determined on the fluid in the as supplied, undiluted form, and have a freezing point not higher than -20°C (-4°F), determined in accordance with ASTM D1177.

***As received: Freezing point = -36°C***

Result: Conforms

3.5.2 Anti-Icing Performance: The (ready to use) fluid shall be tested in the form supplied by the vendor if intended for use undiluted. The fluid (concentrate), if intended for use diluted, shall be tested in two diluted forms. The diluted forms shall be made with hard water as defined in 3.3.3.1. The two diluted forms shall be (1) a 50/50 by volume ratio of fluid concentrate and hard water (50 parts fluid concentrate/50 parts hard water) and (2) a volume ratio of the highest concentration of fluid concentrate recommended for use by the manufacturer and the balance being hard water to make up 100 parts (e.g. 75 parts fluid concentrate/25 parts hard water). The fluid or fluids as tested shall protect against formation of frozen deposits within the failure zone depicted in Figure 1 of AS5901 for not less than three minutes in the water spray endurance test procedure (WSET) and for not less than 20 minutes in the high humidity endurance test (HHET) procedure. The confirmation shall be obtained from six panels, three panels from each of two successive test runs for each type of test. Testing shall be done in a facility meeting the requirements set forth in Section 4.2 of AS5901. Prior to the anti-icing performance test, the fluid, or the diluted fluid, shall first be sheared in accordance with 3.3.4.1

Result: Not performed

3.5.3 Aerodynamic Acceptance Test: The fluid shall demonstrate acceptable aerodynamic performance when tested in accordance With AS5900. AS5900 details the approved aerodynamic test for fluids used on both large transport type jet aircraft and on the lower take-off rotation speed commuter aircraft. A fluid is acceptable for use on large transport type jet aircraft or on lower takeoff rotation speed commuter aircraft if it meets the criteria defined in 8.3 of AS5900. Also see 1.2.1.

3.5.3.1 Tests will be performed depending on the forms in which the fluid is supplied by the vendor:

Case 1: The fluid is supplied only in concentrated form (intended for use diluted). The fluid concentrate shall be tested in two diluted forms in accordance with AS5900 and AS5901. The diluted forms shall be made with ASTM 1193, Type IV water. The two diluted forms shall be (1) a 50/50 by volume ratio of fluid concentrate and water (50 parts fluid concentrate/50 parts water) and (2) a volume ratio of the highest concentration of fluid concentrate recommended for use by the manufacturer and the balance being water to make up 100 parts (e.g. 75 parts fluid concentrate/25 parts water).

Case 2: The fluid is only supplied ready-to-use. The fluid shall be tested in accordance with AS5900 and AS5901.

Case 3: The fluid is supplied in both forms, concentrate and ready-to-use. The concentrate shall be tested according to Case 1 (above) requirements. Ready to use dilutions falling outside of the tested dilution range (e.g. a volume ratio less than 50/50 or greater than the highest concentration tested in Case 1) shall be tested according to Case 2 (above) requirements.

Result: Not performed