

AEROSPACE RECOMMENDED PRACTICE

ARP5921

Issued 2014-04

Evaluation of Coking Propensity of Aviation Lubricants
in an Air-Oil Mist Environment using the Vapor Phase Coker

RATIONALE

The Vapor Phase Coker apparatus bubbles a stream of dry air through a heated oil sump. The oil mist and vapor generated by the airflow travels through a furnace tube, where it is heated, and then travels through a stainless steel tube, where the deposition occurs. In general, vapor phase coking is a form of deposition which can be formed by a gas turbine lubricant when it is exposed to high temperatures in a non-oil wetted engine area. After engine shutdown, the airflow through the bearing vent tubes and seals ceases. This mist, vapor mixture is carried in the airflow condenses in the engine and is subjected to high soak back temperatures. The neopentyl polyol ester molecules typically experience thermal and oxidative degradation which form carbonaceous deposits. Over a period of time coke build up can cause back pressure in bearing compartments and lead to seal malfunction. Vent lines need to be clear for the pressure balance within vented bearing compartments to be maintained, allowing proper sealing of oil within these compartments.

1. SCOPE

This method is designed to evaluate the coking propensity of synthetic ester-based aviation lubricants under two phase air-oil mist conditions as found in certain parts of a gas turbine engine, for instance, bearing chamber vent lines. Based on the results from round robin data in 2008-2009 from four laboratories, this method is currently intended to provide a comparison between lubricants as a research tool; it is not currently a satisfactory pass/fail test. At this juncture a reference oil may improve reproducibility (precision between laboratories); a formal precision statement will be given when there is satisfactory data and an agreed on, suitable reference oil if applicable.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

ARP5088	Test Method for the Determination of Total Acidity in Polyol Ester and Diester Gas Turbine Lubricants by Automatic Potentiometric Titration
AMS5560	Steel, Corrosion Resistant, Seamless Tubing, 19Cr - 10Ni (SAE 30304) Solution Heat Treated
AMS5567	Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing, 19Cr - 10Ni (SAE 30304) Solution Heat Treated

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2014 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

Full document details: SAE ARP5921

SAE values your input. To provide feedback
on this Technical Report, please visit
<http://www.sae.org/technical/standards/ARP5921>

Documents

Document Sharing Hub

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D445 Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).

2.3 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, <http://quicksearch.dla.mil/>.

MIL-T-8504B Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded

3. WARNING

This document may involve hazardous materials, operations, and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

4. APPARATUS

NOTE: The Vapor Phase Coker is fundamentally comprised of a Three Neck Flask Section, Test Furnace Section, Insulated Test Tube Section, and a Control Cabinet. Currently the only known manufacturer is Vector House, Inc. of Wheaton, Illinois. The end user provides a data acquisition system of their choice. Items listed below are for replacement purposes. The original design specifications of the test furnace are drawn in blueprint number E-625, issued by the Operations and Plant Engineering Department of the Naval Air Propulsion Center, Trenton, NJ.

4.1 Three Neck Flask Section

4.1.1 Air Inlet Tube

Ground glass inlet tube, Joint 24/40, interchangeable, hose connection #2, approximate bottom tube length = 200 mm, approximate overall height = 290 mm, such as Kontes PN 179000-2440 or Lab Glass PN LG-1970-102.

NOTE: The air inlet tube will need to be trimmed to a length of approximately 175 mm so it able to sit flush in the angled flask neck and is centered in flask.

4.1.2 Adapter, Thermocouple

(1) Ground glass adapter, Joint 24/40 to #7 THD with ferrule and bushing, such as Ace Glass PN 5028-31 or (2) PTFE thermocouple adapter 24/25 joint, such as Lab Glass PN LG-10477-306.

4.1.3 Flask, Three-Neck

Distilling, three-neck, angled type, Joint 24/40 interchangeable, round bottom, 2000 mL capacity, such as Ace Glass PN 6948-232 or Lab Glass PN LG-7331-202.

4.1.4 Mantle, Heating

Spherical Mantel, Glass Fabric Construction, holds 2000 mL three neck flasks, 700 W, such as Glass-Col PN 01103.

4.1.5 Thermocouple, Control

High Temperature Quick Disconnect, Type J thermocouple, Type 304 Stainless steel sheath, sheath diameter = 0.125 inch, length = 12 inch, ungrounded, dual connector, such as Omega PN SICSS-125U-12-DUAL.

4.2 Test Furnace Section

4.2.1 Furnace Section Heater

Spare heater coils are 120 V and 1200 W. The only known current source is HCS (Heaters, Controls, and Sensors) Limited, London, Ontario: PN AZ 71.

4.2.2 PTFE Adapter

50.8 mm (2 inches) tall stopper for 24/40 ground glass joint with an inner diameter through-hole of approximately 14.7 mm (0.578 inch).

4.2.3 Thermocouple, Test Furnace

High Temperature Quick Disconnect, Type J thermocouple, Type 304 Stainless steel sheath, sheath diameter = 0.125 inch, length = 6 inch, ungrounded, dual connector, such as Omega PN: SICSS-125U-6-DUAL or Omega PN ICSS-18U-6-DUAL.

NOTE: Appendix A.1 depicts the Flask and Furnace Sections along with the test tube.

4.3 Insulated Test Tube Section

4.3.1 Test Tube

Tubing Type 304, conforming to AMS5567E/AMS5560M, Annealed (bright), Seamless, Outer Diameter = 0.5 inch

NOTE: The original USN VPC method referred to MIL-T-8504B type tubing, which has been cancelled, but can still be referenced for ordering purposes.

4.3.2 Thermocouples, Test Tube

High Temperature Quick Disconnect, Type J thermocouple, Type 304 Stainless steel sheath, sheath diameter = 0.125 inch, length = 12 inches, ungrounded, at the tip of the thermocouple a 0.5 inch O.D. hose clamp is silver soldered to the outside of the thermocouple.

4.4 Control Cabinet and Data Acquisition

4.4.1 The design and layout of the instrument control of the Vapor Phase Coker design can be tailored to each laboratory's specifications and requirements. Appendix A.2 depicts an example of a control cabinet. The Vector House, Inc manufactured unit comes with a control cabinet, but the user provides their own data acquisition system. The important parameters that must be adhered to are listed below:

4.4.1.1 Recording and Temperature Control

- Data Acquisition - Capable of reading Type J thermocouples, sensitivity within 1 °C, acquire data for greater than 20 hours.
- Controller, Flask - Time Variable programmable, Ramp/Soak capability, single loop, input Type J thermocouple, output relay or contact, capable of maintaining control points within 1 °C accuracy.
- Controller, Furnace - Time Variable programmable, Ramp/Soak capability, single loop, input Type J thermocouple, output relay or contact, capable of maintaining control points within 1 °C accuracy.

- Power Control, Flask - Silicon Controller Rectifier (SCR), accept Flask Controller input
- Power Control, Furnace - SCR, accept Furnace Controller input

4.4.1.2 Air Flow

Controlled to 765 mL/min $\pm$ 5 mL/min by a rotometer or a controller such as Brooks Mass Flow Controller model 5850 Series E. To ensure dry, clean air the use of a gas purifier is recommended, such as Matheson Gas Purifier model 450B. Appendix A.3 depicts an example of the air flow path.

4.5 Additional Apparatus Requirements

4.5.1 Ultrasonic Cleaner

Minimum 2 L capacity

4.5.2 Oven

Non circulatory air, capable of maintaining a temperature of 100 °C.

4.5.3 Balance, Analytical

Sensitivity greater than or equal to 0.1 mg.

4.5.4 Balance, Analytical

Sensitivity greater than or equal to 0.1 g.

4.5.5 Band Saw

5. REAGENTS AND/OR MATERIALS

5.1 Suitable solvents, technical grade or better, which are used for cleaning. Examples are heptane, acetone, and toluene. If a particular solvent is referred to in this method, that particular solvent shall be used.

5.2 Air - house air, dry

5.3 Laboratory glassware soap such as Microsoap or Mallinckrodt Chem-Solve

5.4 Caustic cleaner such as Oakite LRS (optional)

6. PREPARATION AND ASSEMBLY

6.1 Preparation of Three-Neck Flask

6.1.1 Rinse flask with suitable solvent(s) to remove oily residue from the previous test. Remove any deposits by any conventional laboratory glassware cleaning method.

6.1.2 Rinse the flask three times with water and then rinse well with acetone. Allow the flask to completely dry.

6.1.3 Weigh the empty flask to the nearest 0.1 of a gram; record this weight as the initial weight of the flask.

6.1.4 Weigh 900 g of the test fluid into the clean 2000 mL flask to the nearest 0.1 of a gram; record this as the oil net weight.