



AVIATION FUEL

*Thermal Stability
Requirements*

Kirklin/David



STP 1138

STP 1138

Aviation Fuel: Thermal Stability Requirements

Perry W. Kirklin and Peter David, editors

ASTM Publication Code Number (PCN)
04-011380-12



ASTM
1916 Race Street
Philadelphia, PA 19103

Library of Congress Cataloging-in-Publication Data

Aviation fuel : thermal stability requirements / Perry W. Kirklin and Peter David, editors.

(STP : 1138)

"ASTM publication code number (PCN) 04-011380-12."

Includes bibliographical references and index.

ISBN 0-8031-1431-1

1. Airplanes--Fuel--Specifications. 2. Airplanes--Fuel--Thermal properties. 3. Airplanes--Fuel--Stability. I. Kirklin, Perry W. II. David, Peter, 1953-. III. Series: ASTM special technical publication ; 1138.

TL704.7.A94 1992

629.134'351--dc20

92-12285

CIP

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Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

Printed in Baltimore, MD

May 1992

Foreword

This publication, *Aviation Fuel: Thermal Stability Requirements*, contains papers presented at the symposium of the same name, held in Toronto, Ontario, Canada on 26 June 1991. The symposium was sponsored by ASTM Committee D-2 on Petroleum Products and Lubricants and Subcommittee J on Aviation Fuels. Perry W. Kirklin of Mobil Research and Development in Paulsboro, NJ and Peter David of BP Research Centre in Middlesex, United Kingdom, presided as symposium co-chairmen and are editors of the resulting publication.

Contents

Symposium Overview—P. W. KIRKLIN AND P. DAVID	vii
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SESSION I: OVERVIEW

Jet Fuel Thermal Stability—A Specification Writer's Viewpoint—G. L. BATCHELOR	3
Thermal Stability Testing of Aviation Turbine Fuel—A History—K. H. STRAUSS	8
Physicochemical Aspects of Aviation Fuel Thermal Stability—R. N. HAZLETT	18
Air Frame Considerations in Fuel Thermal Stability for Commercial Supersonic Flight—J. E. SCHMIDT	34

SESSION II: AVIATION ENGINE CONSIDERATIONS

High Temperature Fuel Requirements and Payoffs—B. M. CROSWELL AND T. B. BIDDLE	57
Fuel Thermal Stability Outlook for GE Aircraft Engines in 1991—T. F. LYON	73

SESSION III: MANUFACTURING AND DISTRIBUTION CONSIDERATIONS

The Effect of Manufacturing Processes on Aviation Turbine Fuel Thermal Stability—W. F. TAYLOR	81
The Effect of Manufacturing Processes on Aviation Turbine Fuel Thermal Stability—Handling—R. FLETCHER	90

SESSION IV, PANEL 1: ASTM D 3241, THE JFTOT TEST

Critical Review of the JFTOT—G. DATSCHEFSKI	97
Simulation, Precision and Decision in JFTOT Testing—G. R. WILSON, III	109

SESSION V, PANEL 2: NONSPECIFICATION TESTS FOR
AVIATION FUEL THERMAL STABILITY

Measures of Fuel Thermal Stability—Which Answer is Correct— R. H. CLARK AND G. J. BISHOP	117
Development of a Jet Fuel Thermal Stability Flow Device Which Employs Direct Gravimetric Analysis of Both Surface and Fuel Insoluble Deposits— D. R. HARDY, E. J. BEAL, AND J. C. BURNETT	138
An Automated Device to Quantitatively Measure Thermal Deposits from JFTOT Heater Tubes by Interferometry— R. E. MORRIS	151

Symposium Overview

ASTM Committee D-2, Subcommittee J, held an international Symposium on Aviation Fuel Thermal Stability Requirements on 26 June 1991 at the Royal York Hotel in Toronto, Ontario, Canada. The purpose of the symposium was to establish a foundation for future ASTM specifications on aviation fuel thermal stability. ASTM Specification for Aviation Turbine Fuels, D 1655 and ASTM Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels, D 3241, have served for many years to ensure against aviation fuel thermal stability problems. However, during that time period, there have been changes in engine designs, proposals for commercial supersonic transports, changes in fuel manufacturing processes, and changes in the fuel distribution systems that could have impact on both specifications and test methods. To ensure that the thermal stability specification continues to be satisfactory, the current diverse interests of users and suppliers of aviation fuel must be documented. ASTM Special Technical Publication (STP) 1138 is a record of papers presented at the symposium and addresses the following issues:

1. The philosophical and technical dilemma of the aviation fuel thermal stability specification from a specification writers perspective.
2. The history of aviation fuel thermal stability specifications, the status of our current knowledge of aviation fuel thermal stability, and fuel stability concerns for future commercial supersonic transports.
3. Fuel thermal stability considerations of aviation engine developers.
4. Thermal stability considerations in the manufacture and distribution of aviation fuels.
5. A critical review of ASTM D 3241, the Jet Fuel Thermal Oxidation Tester, or JFTOT test.
6. Current research on aviation fuel thermal stability including test methods that may form a basis for future ASTM thermal stability methods.

Session I: Overview

The STP opens with a technical essay by G. L. Batchelor (United Kingdom Ministry of Defense) on the specification writers dilemma of writing an aviation fuel thermal stability specification to satisfy all the realities of performance, manufacturing, and testing. (Mr. Batchelor's paper was actually presented in symposium Session IV but inserted here as the opening paper for the STP). K. H. Strauss (consultant) provides a historical background of aviation fuel thermal stability requirements and the JFTOT thermal stability test. Recent user problems are documented. R. N. Hazlett (consultant) summarizes current data on the chemical and physical nature of the aviation fuel thermal degradation process and fuel deposits. J. E. Schmidt (Boeing Commercial Airplane Group) describes fuel stability concerns for commercial supersonic transports.

Session II: Aviation Engine Considerations

As interest in more fuel efficient engines increases, new aviation turbine engines will have to operate under more severe thermal conditions. These engine designs will place additional thermal stresses on aviation turbine fuel. T. Biddle (United Technologies-Pratt & Whitney, Florida) indicates some engine design restrictions due to fuel thermal stability limits. Benefits of reduced engine size and weight could be realized if heat sink capability of fuel was not limiting. T. F. Lyon (General Electric Co.) identifies engine and fuel design factors considered in advanced engine designs. Mr. Lyon also presents data on Eastern Europe fuels and notes the need for more information concerning these fuels and the specified test methods to insure that international operators use ASTM quality fuels.

An oral only presentation by T. Fiorentino for R. Lohmann (Pratt & Whitney, Connecticut), described engine components that currently operate at maximum allowable temperatures due to fuel stability limitations.

In an oral only presentation, B. Rayner (Rolls-Royce, Derby, UK) described trends in engine design and power over the past two decades and highlighted the upward trend in compressor exit temperatures. As a consequence, burner feed arms and nozzles experience higher temperatures with increased tendency for fuel degradation and deposit formation. Deposit tendency was related to ASTM D 3241 JFTOT breakpoint temperatures. Mr. Rayner indicated that improvements in fuel thermal stability allowance would enable greater developments in engine technology.

Session III: Manufacturing and Distribution Considerations

W. F. Taylor (Exxon Research and Engineering) describes the influence of refinery process technology on aviation fuel quality. Thermal stability is generally not a control factor in aviation fuel manufacturing. However, crude sources and refinery processes may interact to affect fuel thermal stability. Dr. Taylor reviews trends in refinery processing that may influence future aviation fuel thermal stability. R. Fletcher (BP International, London) describes fuel thermal stability problems that can arise through poor handling in the fuel distribution system. Refinery processes may also affect the fuel's sensitivity to contaminants in the fuel distribution system.

In an oral only presentation, J. Pearce (Wright-Patterson AFB, presented for S. Anderson) described on going United States Air Force exploratory work to increase jet fuel thermal stability using additives. Preliminary research suggests that some additives improve fuel thermal stability, but additional data are required to confirm the benefits. The U.S. Air Force work will consider degradation of other fuel properties to determine if improving thermal stability with additives will require compromises in other fuel properties.

Session IV, Panel 1: ASTM D 3241, The JFTOT Test

G. Datschewski (Esso Research Centre, Oxfordshire, England) presents results of a comprehensive review of ASTM D 3241, the JFTOT test, carried out by the UK-MOD Thermal Stability Working Group. This paper examines fuel flowrate, heater tube surface finish, heater tube metallurgy, and heater tube deposit rating techniques. Recommendations are presented for improving the test precision. G. Wilson (Alcor, Inc.) indicates that the JFTOT was developed to simulate the process of heat exchange and not as an aircraft fuel system simulator. Since its introduction, the JFTOT has successfully identified fuels of poor thermal stability. Mr. Wilson indicates recent developments in JFTOT design that should improve test precision.

Session V, Panel 2: Nonspecification Tests for Aviation Fuel Thermal Stability

R. H. Clark (Shell Research, Thornton, United Kingdom oral presentation by G. Bishop) describes some large-scale aircraft simulators and small-scale test devices that Shell Research uses to study aviation fuel thermal stability. Differences in thermal stability of hydrofined fuels and chemically sweetened fuels are shown. The paper suggests that different tests or combination of tests may be necessary to adequately characterize fuel thermal stability. However, for routine quality assurance, ASTM D 3241, the JFTOT test, was still satisfactory.

R. Morris (United States Naval Research Laboratory) presents data on measuring ASTM D 3241 heater tube deposits using fiber optic interferometry. The technique is reliable for heavy deposits, but additional work is required to assess Code 3 deposits as required by ASTM D 1655. D. R. Hardy (United States Naval Research Laboratory) presents a new aviation fuel thermal stability test device to measure deposits gravimetrically. This device can be constructed from off-the-shelf components and offers better precision than ASTM D 3241.

In an oral only presentation, J. Pearce (Wright-Patterson AFB, presented for W. Harrison) presented objectives of a United States Air Force program to increase the thermal stability of jet fuel by 100°F (37.8°C). This increase in aviation fuel thermal stability will require revolutionary developments in thermal stability test methods. In another oral only presentation, B. Nowack (United States Navy Aviation Propulsion Center) presented on-going United States Navy studies to examine fuel thermal stability at high temperatures using fiber optics in a modified JFTOT apparatus (fiber optics techniques are as described earlier by R. Morris). Dr. Nowack also described a fuel system simulator designed to evaluate effects of additives and contaminants on aviation fuel thermal stability. The simulator is under construction and results of these studies should be available in 1993.

Conclusion

In the true spirit of consensus, the symposium and resulting STP 1138 bring together diverse aviation fuel interests to comprehensively document the aviation fuel thermal stability concerns that must be considered in future ASTM specifications and test methods. Many concerns, notably fuel thermal stability restrictions on aviation engine designs and isolated reports on fuel thermal stability related aircraft operation problems, have not been previously documented. The critical review of ASTM D 3241, the JFTOT test, the mathematical treatment of the JFTOT and thermal stability results from nonstandard tests, significantly increase the understanding of the process of heat exchange and heat exchange test methods. This STP will not only be useful for future ASTM aviation fuel thermal stability considerations but will be a valuable resource for anyone wishing a comprehensive overview of aviation fuel thermal stability.

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ISBN 0-8031-1431-1