

**Journal of ASTM International**  
Selected Technical Papers



**STP 1536**

---

# **In-Service Lubricant and Machine Analysis, Diagnostics, and Prognostics**

---

*JAI Guest Editor:*

**Allison M. Toms  
Amy Fentress**

**Journal of ASTM International  
Selected Technical Papers STP1536  
In-Service Lubricant and Machine  
Analysis, Diagnostics, and Prognostics**

---

*JAI Guest Editors:*

Allison M. Toms

Amy Fentress



ASTM International  
100 Barr Harbor Drive  
PO Box C700  
West Conshohocken, PA 19428-2959

Printed in the U.S.A.

ASTM Stock #: STP1536

## **Library of Congress Cataloging-in-Publication Data**

**ISBN:** 978-0-8031-7522-8

Copyright © 2011 ASTM INTERNATIONAL, West Conshohocken, PA. All rights reserved. This material may not be reproduced or copied, in whole or in part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of the publisher.

### ***Journal of ASTM International (JAI) Scope***

The JAI is a multi-disciplinary forum to serve the international scientific and engineering community through the timely publication of the results of original research and critical review articles in the physical and life sciences and engineering technologies. These peer-reviewed papers cover diverse topics relevant to the science and research that establish the foundation for standards development within ASTM International.

### **Photocopy Rights**

Authorization to photocopy items for internal, personal, or educational classroom use, or the internal, personal, or educational classroom use of specific clients, is granted by ASTM International provided that the appropriate fee is paid to ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9634; online: <http://www.astm.org/copyright>.

The Society is not responsible, as a body, for the statements and opinions expressed in this publication. ASTM International does not endorse any products represented in this publication.

### **Peer Review Policy**

Each paper published in this volume was evaluated by two peer reviewers and at least one editor. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM International 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 the peer reviewers. In keeping with long-standing publication practices, ASTM International maintains the anonymity of the peer reviewers. The ASTM International Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM International.

### **Citation of Papers**

When citing papers from this publication, the appropriate citation includes the paper authors, "paper title", J. ASTM Intl., volume and number, Paper doi, ASTM International, West Conshohocken, PA, Paper, year listed in the footnote of the paper. A citation is provided as a footnote on page one of each paper.

# Foreword

---

THIS COMPILATION OF THE *JOURNAL OF ASTM INTERNATIONAL (JAI)*, STP1536, *In-Service Lubricant and Machine Analysis, Diagnostics, and Prognostics*, contains only the papers published in JAI that were presented at a symposium on In-Service Lubricant and Machine Analysis, Diagnostics, and Prognostics held during December 8, 2010 in Jacksonville, FL. The symposium was sponsored by ASTM Committee D02 on Petroleum Products and Lubricants and Subcommittee D02.96 on In-Service Lubricant Testing and Condition Monitoring Services.

The Symposium Co-Chairs and JAI Guest Editors are Allison M. Toms, GasTOPS Inc., Pensacola, FL and Amy Fentress, Lubrication Engineers, Wichita, KS.



# Contents

---

Overview .....	vii
<b>Outstanding Return on Investment When Industrial Plant Lubrication Programs are Supported by International Standards</b>	
R. Garvey.....	1
<b>Guidelines for Alarm Limits and Trend Analysis</b>	
A. Toms and D. Wooton .....	9
<b>Optimizing a Wind Turbine Oil Condition Monitoring Program</b>	
G. J. Livingstone, J. Ameye, and D. Wooton.....	22
<b>The Use of Linear Sweep Voltammetry in Condition Monitoring of Diesel Engine Oil</b>	
A. Fentress, J. Sander, and J. Ameye.....	40
<b>An Overview of Progress and New Developments in FTIR Lubricant Condition Monitoring Methodology</b>	
F. R. van de Voort, J. Sedman, and D. Pinchuk .....	55
<b>Particle Characterization and Sizing: SEM Utilizing Automated Electron Beam and AFA Software for Particle Counting and Particle Characterization</b>	
W. R. Herguth and G. W. Nadeau.....	74
<b>Recent Developments in Online Oil Condition Monitoring Sensors and Alignment with ASTM Methods and Practices</b>	
S. Lunt.....	86
<b>In-Line Monitoring of Particulate, Color, and Water Content in Lubricating Oils to Facilitate Predictive Maintenance, Reduce Wear, and Provide Real Time Alarming</b>	
T. M. Canty .....	107
<b>Analysis of In-Service Lubricating Grease</b>	
D. Turner .....	120
<b>Lubricating Oils Evaluation of Dispersancy Capacity of Lubricating Oils and the Impact of Biofuels on Lubricant Dispersancy</b>	
G. Abellaneda and D. Pigeon.....	126
<b>Experiences with ASTM D02 Practices D4378 and D6224 for Turbine Oils and Auxiliary Power Plant Equipment Condition Monitoring Programs</b>	
A. Wardlow and J. Ameye.....	142



## Overview

---

This publication contains the presentations delivered at the “Symposium on In-Service Lubricant and Machine Analysis, Diagnostics, and Prognostics,” on December 8, 2010 in Jacksonville, Florida, sponsored by D02.CS96. In 1999, D02.CS96, In-Service Lubricant Testing and Condition Monitoring Services Industry Support, was formed to address the needs of monitoring in-service oils. This symposium showcases the progress made in the past decade and highlights the future direction of the CS96 subcommittee.

The standards developed and being developed by this subcommittee provide equipment users with a known basis for the quality of the data they are receiving which Garvey highlights by demonstrating the return-on-investments that can be achieved through proper oil condition monitoring. Toms and Wooton stress the necessity of alarm limits to properly interpret raw lubricant test data and demonstrate how remaining useful life diagnostics of machinery and fluid relies on trending.

With expanding use of alternative energy, comes new oil condition-monitoring demands. Livingstone, Ameye and Wooton address optimizing an oil condition-monitoring program specifically for wind turbines. Pigeon and Abellaneda present the impact of biofuels on lubricant dispersancy and health.

The latest laboratory and field techniques for in-service lubricant and grease analysis were presented. These papers included an alternative use of linear sweep voltammetry for diesel engine oil by Fentress, Sander and Ameye, to monitoring particles, color and water by Canty, and the latest in Fourier transfer infrared lubricant condition monitoring by Pinchuk and van de Voort. The importance of in-service grease analysis was covered by Turner.

Walsh, Barraclough, and Henning offered a historical overview of the role of wear particles in oil condition monitoring, followed by a presentation demonstrating the application of scanning electron microscopy for particle counting and classification by Herguth.

Recent developments in online oil condition monitoring sensors and their alignment with ASTM methods and practices were highlighted by Lunt.

The experiences with ASTM D02 Practices D4378 and D6224 for Turbine oils and Auxiliary Power Plant Equipment Condition Monitoring Programs by Wardlow and Ameye concluded the program.

We wish to acknowledge the prompt response and cooperation received from the authors, reviewers, and the ASTM staff to make for a successful



symposium and subsequent efficient publication of this volume. The success of the Symposium and this publication are possible because of the efforts and commitments of the authors, reviewers and their companies. Thank you.

Allison M. Toms  
Symposium Co-Chair  
GasTOPS Inc.  
Pensacola, FL

Amy Fentress  
Symposium Co-Chair  
Lubrication Engineers  
Wichita, KS



[www.astm.org](http://www.astm.org)

ISBN: 978-0-8031-7522-8  
Stock #: STP1536