

Baur / Osswald / Rudolph
Plastics Handbook

Erwin Baur
Tim A. Osswald
Natalie Rudolph

Plastics Handbook

The Resource for Plastics Engineers

5th Edition

Hanser Publishers, Munich

HANSER

Hanser Publications, Cincinnati

The Authors:

Dr.-Ing. Erwin Baur, M-Base GmbH, Aachen, Germany

Prof. Dr. Tim A. Osswald, Department of Mechanical Engineering, University of Wisconsin-Madison, WI

Dr.-Ing. Natalie Rudolph, Arevo Inc., Santa Clara, CA

Distributed in the Americas by:

Hanser Publications

6915 Valley Avenue, Cincinnati, Ohio 45244-3029, USA

Fax: (513) 527-8801

Phone: (513) 527-8977

www.hanserpublications.com

Distributed in all other countries by:

Carl Hanser Verlag

Postfach 86 04 20, 81631 Munich, Germany

Fax: +49 (89) 98 48 09

www.hanser-fachbuch.de

The use of general descriptive names, trademarks, etc., in this publication, even if the former are not especially identified, is not to be taken as a sign that such names, as understood by the Trade Marks and Merchandise Marks Act, may accordingly be used freely by anyone. While the advice and information in this book are believed to be true and accurate at the date of going to press, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

The final determination of the suitability of any information for the use contemplated for a given application remains the sole responsibility of the user.

Cataloging-in-Publication Data is on file with the Library of Congress

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying or by any information storage and retrieval system, without permission in writing from the publisher.

© Carl Hanser Verlag, Munich 2019

Editor: Dr. Mark Smith

Translation: Dr. Christine Strohm, Engineering and Science Editors

Production Management: Jörg Strohbach

Coverconcept: Marc Müller-Bremer, www.rebranding.de, Munich

Coverdesign: Stephan Rönigk

Typesetting: Kösel Media GmbH, Krugzell

Printed and bound by Druckerei Hubert & Co GmbH und Co KG BuchPartner, Göttingen

Printed in Germany

ISBN: 978-1-56990-559-3

E-Book ISBN: 978-1-56990-560-9

Preface

This new and completely reworked edition of the *Plastics Handbook* finds its roots in the German Plastics Handbook (*Saechtling Kunststoff Taschenbuch*), first published in 1936, and now in its 31st edition. After years of working back and forth between the German and English language editions, updating the processing and materials chapters as well as upgrading the figures into color, we have finally achieved two synchronized handbooks, each designed for their specific geographical market. We realize that the plastics field is constantly in flux, with changes driven by major factors such as energy conservation, new materials, and new manufacturing techniques, such as additive manufacturing. Therefore, we know that this handbook is a never-ending project that will organically change over time. We look forward to the developments our industry will bring in the years to come, and to the work we will do together to bring you the next version of this handbook. It would have been impossible to produce this new edition without the irreplaceable contributions from Dr. Christine Strohm who helped with the translations, as well as those from Tobias Mattner who reworked all the figures. We thank both for their steadfast dedication. We are also thankful to Dr. Mark Smith for his meticulous work while combing through the whole manuscript and to Jörg Strohbach for his production work to generate a version that is so pleasing to the eye. We are grateful to our families for their unconditional love and support.

Winter 2018

Erwin Baur, Tim A. Osswald, and Natalie Rudolph

Contents

Preface	V
1 Common Acronyms in Plastics Technology	1
1.1 Table I: Alphabetical List of Plastics Acronyms, Chemical Notation ..	2
1.2 Table II: Common Units, ISO- and US-Units	9
2 Introduction	13
2.1 Economic Significance of Plastics	13
2.2 Classification of Plastics	15
2.3 Composition of Plastics	18
2.3.1 Chemical Structure (Constitution and Configuration of Macromolecules)	18
2.3.1.1 Conformation	19
2.3.1.2 Configuration	19
2.3.1.3 Constitution	21
2.3.1.4 Major Plastic Material Groups	25
2.3.2 Morphological Structure (Conformation and Aggregation of Macromolecules)	27
2.3.2.1 Different Classes of Plastic Materials	33
2.4 Effects of Processing on Material Properties	35
2.4.1 Residual Stress	36
2.4.2 Molecular Orientation	37
2.4.3 Crystallization Behavior	38
2.5 Modifications of Plastic Materials	40
2.5.1 Copolymers and Polymer Blends	40
2.5.2 Plastic Composites	41
3 Material Properties and Testing Methods	45
3.1 Significance of Characteristic Values	46

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.