The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control

Designed to help educate and guide field service technicians, engineers, operations staff, and maintenance personnel, Foundations™, Fourth Edition, provides a comprehensive review of best practices in conveyor safety, best practices in fugitive material control and prevention, and advances in conveyor design.
FOUNDATIONS™

The Practical Resource
for Cleaner, Safer, More Productive
Dust & Material Control

Fourth Edition

by

R. Todd Swinderman, P.E.
Andrew D. Marti
Larry J. Goldbeck
Daniel Marshall
&
Mark G. Strebel

Martin Engineering Company
Neposnet, Illinois
U.S.A.
Application of the information and principles in this book should be carefully evaluated to determine their suitability for a specific project. For assistance in the application of the information and principles presented here on specific conveyors, consult Martin Engineering or other knowledgeable engineers.

**Disclaimer**

1. Martin Engineering publishes this book as a service to the bulk-material handling industry. The book is provided for general information purposes only and is not intended to provide comprehensive knowledge pertaining to the control of fugitive materials in bulk-material handling operations. The opinions expressed herein are those of the authors and represent a consensus of the authors regarding the topics discussed.

2. Pictures, graphics, tables, and charts contained in this book are used to convey specific points and therefore may not be technically correct or complete in every detail. Fictitious names and data provided in this book are intended to convey concepts and any similarity thereof to actual entity names or data is purely coincidental and unintentional.

3. This book is provided without any representations or warranties as to the accuracy or completeness of the content of the book. Without limiting the generality of the foregoing, the “Safety Concerns” sections of this book are intended to highlight specific safety issues and should not be considered as inclusive of all safety concerns related to bulk-material handling operations.

4. To the maximum extent permitted by applicable law, IN NO EVENT SHALL MARTIN ENGINEERING OR THE AUTHORS BE LIABLE FOR PERSONAL INJURY OR FOR ANY INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES WHATSOEVER ARISING OUT OF OR IN ANY WAY CONNECTED TO THIS BOOK, INCLUDING WITHOUT LIMITATION ANY DAMAGES ARISING OUT OF THE APPLICATION OF THE INFORMATION, PRINCIPLES, OR OTHER CONTENTS IN THIS BOOK. In all events, to the maximum extent allowed by law, Martin Engineering’s and the authors’ aggregate liability for claims relating to the book shall be limited to the cost of replacing this book.

5. Information presented in this volume is subject to modification without notice. Martin Engineering reserves the right to make corrections, deletions, or additions to the book without prior notice or obligation to replace previously published versions. If an error is found or you wish to provide input to future editions, please contact Marketing Manager, Martin Engineering at info@martin-eng.com, by phone: 309-852-2384, or by fax: 309-594-2432.

**Metric / Imperial Measurements**

Metric measurements, with their common Imperial conversions, are used throughout the book except where the original source information is specified in Imperial units. In that case, the actual Imperial units are used with approximate metric conversions.

The comma has been used throughout this book as the decimal marker in metric measurements, which is the current practice in standards published by the International Organization for Standardization (ISO).

**FOUNDATIONS™**


Library of Congress Control Number: 2007942747

Copyright © 2009 Martin Engineering

Second Printing: February 2011

Third Printing: February 2012

Part Number L3271-4

Cover Photo © Lester Lefkowitz/Corbis Corporation

All rights reserved. This publication may not be reproduced in any form without permission from Martin Engineering, Neponset, Illinois. Some of the content of this book has been reproduced from other copyrighted sources with permission.

Printed in the United States of America.

Printer: Worzalla Publishing Company, Stevens Point, WI

Martin Engineering Company
One Martin Place
Neponset, Illinois 61345-9766 USA
800-544-2947 or 309-852-2384
Fax: 309-594-2432
info@martin-eng.com
www.martin-eng.com
Table of Contents

Research, Personnel Development, Services, and Products
Center for Bulk Materials Handling Innovation .516
Foundations™ Educational Programs .518
Services .520
Products .521

Appendices
Appendix A: References .526
Appendix B: Glossary .532
Measurement Abbreviations .542
Appendix C: Safety Labels .544
Appendix D: Equation Index .552
Table Index .553
Topic Index .554
Appendix E: Authors & Acknowledgments .560

Section One
FOUNDATIONS OF SAFE BULK-MATERIALS HANDLING
1 Total Material Control .2
2 Safety .14
3 Conveyors 101–Conveyor Components .28
4 Conveyors 101–The Belt .36
5 Conveyors 101–Splicing the Belt .60

Section Two
LOADING THE BELT
6 Before the Loading Zone .76
7 Air Control .90
8 Conventional Transfer Chutes .100
9 Flow Aids .116
10 Belt Support .130
11 Skirtboards .152
12 Wear Liners .170
13 Edge-Sealing Systems .180

Section Three
RETURN RUN OF THE BELT
14 Belt Cleaning .196
15 Pulley-Protection Plows .244
16 Belt Alignment .252

Section Four
DUST MANAGEMENT
17 Dust Management Overview .280
18 Passive Dust Control .296
19 Dust Suppression .304
20 Dust Collection .322

Section Five
LEADING-EDGE CONCEPTS
21 Clean, Safe, and Productive Conveyors by Design .340
22 Engineered Flow Chutes .348
23 Air-Supported Conveyors .364
24 Belt-Washing Systems .376
25 Material Science .398

Section Six
CONVEYOR MAINTENANCE
26 Conveyor Accessibility .414
27 Conveyor System Survey .424
28 Maintenance .434
29 The Human Factor .444

Section Seven
THE BIG PICTURE OF BULK-MATERIALS HANDLING
30 Total Project Management .454
31 Performance Measurements .464
32 Considerations for Specific Industries .484
33 Considerations for Specialty Conveyors .504
Working in our basement workshop in 1944, my father, Edwin F. Peterson, invented an answer to problems in bulk-materials handling: the ball-type industrial vibrator. Trademarked Vibrolator®, his invention provided the foundation for the success of Martin Engineering. Since then, we have expanded around the world: We own and operate business units in Michigan, Brazil, China, Germany, India, Indonesia, Mexico, and South Africa, with licensees in Australia, Canada, and Chile. In Europe, we also have branch offices in France, Turkey, and the United Kingdom. We have over 800 employees around the world; our dedicated people made it possible to achieve sales exceeding $135M USD in 2011.

Following my father’s example, Martin remains steadfastly innovative in solving problems in bulk-materials handling. Intrinsic to Martin’s values is our quest to make the industrial-material handling environment cleaner, safer, and more productive. For nearly 65 years, we have worked to improve our global environment by controlling dust and spillage in bulk-materials handling, “going green” long before it became popular. The control of dust and spillage is not only a science but also an art; Martin has mastered both.

Martin, the pioneer and world leader in the development of engineered belt-cleaning and belt-sealing systems, continues to be an innovator with capabilities to meet industry needs around the world. Our Center for Bulk Materials Handling Innovation—opened in June 2008—demonstrates our commitment to improving the industry. Located at our world headquarters in Neponset, Illinois, USA, the Center for Innovation (CFI) is part pure-science research laboratory and part industrial-product development center. It is focused on helping our customers understand and solve their bulk-materials handling problems. Controlling dust and spillage is a goal that comes true everyday for our customers with our Absolutely No Excuses Guarantee.

It is with great pleasure that I offer the fourth edition of Foundations™: The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control to those involved with bulk-materials handling.

Edwin H. Peterson  
Chairman, Board of Directors  
Martin Engineering

“The control of dust and spillage is not only a science but also an art; Martin has mastered both.”
From its beginning in the 1940s, Martin Engineering has been committed to safety, excellence, and innovation in bulk-materials handling. From our earliest vibrators to today’s leading-edge conveyor concepts, our strategic focus on continuous improvement represents the growth and evolution of practices for the control of material movement and the improvement of belt conveyor operations. Many of our improvements are based on our fundamental belief that in order to have clean, safe, and productive bulk-materials handling, companies must ensure total control of material on their belt conveyors.

With the opening of the Center for Bulk Materials Handling Innovation at our world headquarters in Neponset, Illinois, USA, Martin has made a significant commitment and a substantial statement for continued improvement to the bulk-materials handling industry. It is our intent to share the knowledge gained from this basic science and applied practical research facility with universities, associations, and customers. With these resources and commitment, Martin will continue to be the leader in providing information and developing technologies to control dust, spillage, and fugitive materials.

Based upon our experience and research, we intend to provide an extensive educational program that will include interactive online training, workshops, seminars, certification programs, university-accredited courses, and technical presentations at association conferences. We will work closely with participating universities to bring the bulk-materials handling industry the most current research, the most reliable technical data, and the best practices. Martin will continue to present information around the world through our books and workshops, all focused on helping the industries handling bulk materials to “Think Clean” while improving efficiency, productivity, and safety.

As we all know, we work in a dangerous global industry, and we cannot yell loud enough to voice our concern. There are too many injuries and fatalities in our business that could be prevented. We must bring safe conveyor operations to the forefront. Early in the revision of *Foundations 3* for this, the fourth edition, the authors made a conscious decision to move our emphasis on safety to the beginning section of the book. In addition to the material in the Safety chapter, the reader will find additional information and callouts on safety dispersed throughout the book. Most chapters include a separate section entitled “Safety Concerns” for the reader to consider. Quite simply, we must do a better job protecting the lives of those who work in our industry.

By reading this edition of *Foundations™, The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control*, you will learn more about Martin’s expertise and philosophy. We hope you find it useful in making your conveyor operations cleaner, safer, and more productive.

Scott E. Hutter  
President and CEO  
Martin Engineering
The question most often asked by engineers I meet in my world travels is, “What are the changes you have seen in the bulk-materials handling industry over these past 50 years?”

What has changed?

A. Computers: First and foremost is the computer: It tracks, records, and protects everything we do. Fifty years ago, design priorities for conveyors were contained in books; today, they are in computer databases. As a result, mechanical engineers are graduating who can make drawings and calculations only with the assistance of the computer.

Advanced computer programming permits engineers to see “virtual imagery” and designers to see visual representations of the flow characteristics of a material. These programs allow multiple design possibilities so engineers can obtain the most desirable results at each transfer point in the conveyor.

However, it is important to remember that the computer-generated model is valid only when an engineer or technician who has hands-on experience with the bulk material in question has reviewed it. In addition, the experienced engineer or technician must approve the conveyor components, keeping in mind that they will eventually need to be serviced, so they need to be designed to be accessible and serviced safely.

B. Hands-on Experience: Today, most plants operate 7 days a week, 24 hours a day. Management may expect a plant to double production with a crew that is reduced by half. These plants will need to fix conveyor problems as they occur, but operators cannot stop production because of the need to meet quotas.

Back when new engineers were placed with experienced colleagues in apprentice programs, they were exposed to real-world situations. They acquired experience in rapidly analyzing and fixing breakdowns to allow the plant to resume production.

As a result of modern engineering techniques, bulk-materials handling systems are being designed by detailers with little or no hands-on experience. While plants and mines are trying to keep the mechanical equipment working and producing, operators are forced to accept a design that has few provisions for servicing the system. As I look at modern plants with the same engineering designs that were used 30 years ago, I wonder who will be able to maintain, on a daily basis, the components that are prone to fail or wear out, especially when the design has no provision to allow those necessary repairs to be made easily and quickly.

Improvements in design can best be accomplished by those with hands-on conveyor experience. Experienced operators have the knowledge to guide a design team to anticipate hardware failures and provide the means to fix problems with the least possible downtime. They must be allowed and encouraged to contribute to the design.

C. Environmental and Safety Regulations: Other differences are increased environmental and safety rules and regulations that must now be incorporated into design priorities. These regulations have become as important as the conveyor’s production requirements. It has been obvious to me, since the 1950s, that “Durt” and dust were a safety / health / profit-loss issue that needed to be addressed during the initial design, instead of waiting until regulators threatened fines or shut down operations to eliminate the “Durt” hazard.

What is in the Future?

A. Clean Conveyors: I see lots of blue sky; I see clean material handling from
conveyor belts that are washed and dried. These super clean systems will be designed by today’s fraternity of dedicated engineers who will work with safety, environmental, and process technicians to develop designs that are kind not only to the people who work on them, but also to the environment. The goal is to design systems that meet all governmental regulations for a safe, clean operation.

**B. Conveyor Serviceability:** Conveyor design will be based on quick, easy, safe, and intuitive service. Emerging safety regulations in the future may permit certified conveyor technicians (CCTs) to service conveyor belts during operation. Similar to current safety regulations that allow certified electricians to inspect an electrical control box without terminating power, CCTs may be able to service operating conveyors, resulting in fewer accidents, greater production, and higher profit. Furthermore, with improved serviceability better controlling “Durt” problems (the real cause of the majority of conveyor-related accidents), CCTs will significantly increase conveyor production availability.

**C. Cleanliness, Safety, and the Environment:** There will be an increasing demand by individuals, communities, and governmental agencies for conveyor operations to be clean, safe, and environmentally sound. I see those operators who choose to ignore these demands being either shut down or subject to heavy governmental fines.

---

**Past 50–Future 50**

There have been many changes over the past 50 years that have made bulk-materials handling cleaner, safer, and more productive: use of computers to make ideal designs for each transfer point, design teams utilizing the knowledge-base of operators to optimize the design, and regulations to make bulk-materials handling cleaner and safer for both the workers and the environment.

There is still a lot of room for positive changes during the next 50 years to make the industry even cleaner, more serviceable, more productive, and safer. Improvements will continue to be made that will revolutionize bulk-materials handling. Hopefully, the next edition of *Foundations™* will describe even more of these advancements.

“Think Clean!”

Dick Stahura
Product Application Consultant
DEDICATION

It is an honor for us to dedicate the fourth edition of Foundations™: The Practical Resource for Cleaner, Safer, More Productive Dust & Material Control to the following:

**Employees in Industries Handling Bulk Materials:** Much thought was given to the safety chapter and the safety section of each chapter. Therefore, we dedicate this book to the employees around the world who were, unfortunately, injured while working around conveyor belts. We especially dedicate this book to the employees who lost their lives and to their families. Although tragic, these misfortunes broaden awareness about the dangers associated with conveyor belts and the importance of safety.

**R. Todd Swinderman, P.E.:** Todd is a driving force behind many of the current innovations in our industry. He has been instrumental in developing consistent standards for the industry through the Conveyor Equipment Manufacturers Association (CEMA). Serving as one of the association’s officers and as former President and CEO of Martin Engineering, Todd’s guidance, influence, and professional engineering experience have touched every facet of conveyor operations throughout the world.

**The Peterson Family and the Employees of Martin Engineering (Past, Present, and Future):** For more than 65 years, members of the Peterson Family have devoted their lives to the improvement of those industries handling bulk materials by making the work environment cleaner, safer, and more productive. Martin employees have always had the best interest of the customers, the industry, and the company in mind. They worked countless hours to achieve the vision of the company’s founding father. Through their dedication and tenacity, the employees helped continue the Martin tradition of leading the world in conveyor research and innovation.

Andrew D. Marti
Larry J. Goldbeck
Daniel Marshall
Mark G. Strebel