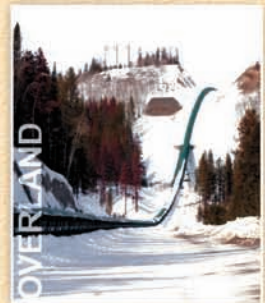
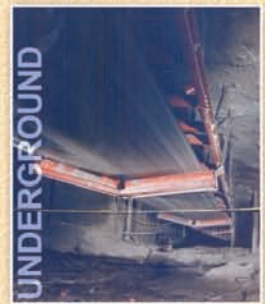




# BELT CONVEYORS for BULK MATERIALS

PREVIEW COPY

Prepared by the Engineering Conference of the  
CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION





*Printed by the Engineering Conference of the  
Conveyor Equipment Manufacturers Association*

# **BELT CONVEYORS for BULK MATERIALS**

---

SIXTH EDITION 2<sup>nd</sup> Printing

Published by the Conveyor Equipment Manufacturers Association  
6724 Lone Oak Boulevard, Naples, Florida, USA 34109 239-514-3441 [www.cemanet.org](http://www.cemanet.org)

Copyright © 2007 by the Conveyor Equipment Manufacturers Association  
All rights reserved. This book may not be reproduced in any form without written  
permission from the Conveyor Equipment Manufacturers Association.

Printed in the United States of America

Page layout and editing by K-Kom, Inc.

Printing (last digit): 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Conveyor Equipment Manufacturers Association.  
Engineering Conference  
Belt conveyors for bulk materials.

Includes index.

1. Belt conveyors. 2. Bulk solids handling.

ISBN 1-89117-59-3

# TABLE OF CONTENTS

| Chapter | Index Title  | Page |
|---------|--|------|
|         | <i>PREFACE</i> .....   | IX   |
|         | <i>ACKNOWLEDGEMENTS</i> .....  | X    |
|         | <i>INTRODUCTION</i> .....  | XI   |
| <hr/>   |  |      |
|         | <i>ONE - BELT CONVEYOR GENERAL APPLICATIONS AND ECONOMICS</i> .....      | 1    |
|         | Introduction .....   | 2    |
|         | Conveying of a Variety of Materials .....                                | 2    |
|         | Wide Range of Capacities .....   | 2    |
|         | Adaptability to Path of Travel .....                                     | 4    |
|         | Steep Angle Conveying .....  | 5    |
|         | Loading, Discharging, and Stockpiling Capabilities .....                 | 8    |
|         | Process Functions .....  | 9    |
|         | Reliability and Availability .....                                       | 10   |
|         | Environmental Advantages .....   | 11   |
|         | Safety .....   | 12   |
|         | Low Labor Costs .....  | 12   |
|         | Low Power Costs .....  | 12   |
|         | Low Maintenance Costs .....  | 12   |
|         | Long-Distance Transportation .....                                       | 13   |
|         | Conveyor Economics .....   | 13   |
|         | Feasibility Studies .....  | 14   |
|         | Reduce After Purchase Costs .....  | 15   |
|         | Summary .....  | 15   |
| <hr/>   |  |      |
|         | <i>TWO - DESIGN CONSIDERATIONS</i> .....                                 | 17   |
|         | Introduction .....   | 19   |
|         | Conveyor Arrangements .....  | 20   |
|         | Basic Flat and Troughed Belt Conveyor Paths .....                        | 20   |
|         | Belt Conveyor Loading and Discharge Arrangements .....                   | 23   |
|         | Conveyor Structures .....  | 24   |
|         | Types of Structures .....  | 25   |
|         | Connections .....  | 28   |
|         | Codes and Standards .....  | 29   |
|         | Design .....   | 30   |
|         | Loads .....  | 33   |
|         | Corrosion Protection .....   | 36   |
|         | Maintenance .....  | 38   |
|         | Cross-Overs and Cross-Unders .....                                       | 42   |
|         | Considering the Long Term Effects of Design Decisions .....              | 43   |
| <hr/>   |  |      |
|         | <i>THREE - CHARACTERISTICS AND CONVEYABILITY OF BULK MATERIALS</i> ..... | 45   |
|         | Introduction .....   | 46   |
|         | Material Characteristics .....   | 46   |
|         | Material Class Description .....   | 47   |
|         | Behavior of Materials on a Moving Belt .....                             | 49   |
|         | Effect of Inclines and Declines .....                                    | 50   |

| <b>Chapter</b>                                   | <b>Index Title</b>  | <b>Page</b> |
|--|---|-------------|
| <hr/>  |   |             |
| <i>FOUR - CAPACITIES, BELT WIDTHS AND SPEEDS</i> |   | 53          |
|  | Introduction  | 54          |
|  | Belt Widths   | 54          |
|  | Lump Size Considerations  | 54          |
|  | Belt Speeds   | 55          |
|  | Belt Conveyor Capacities  | 57          |
|  | Belt Conveyor Capacity Tables and Their Use                                 | 58          |
|  | Belt Load Cross Section Areas   | 60          |
| <hr/>  |   |             |
| <i>FIVE - BELT CONVEYOR IDLERS</i>               |   | 65          |
|  | Introduction  | 66          |
|  | Idler Requirements  | 66          |
|  | Idler Classifications   | 66          |
|  | General Types of Belt Conveyor Idlers                                       | 66          |
|  | Idler Spacing   | 73          |
|  | The Selection of Idlers   | 74          |
|  | Idler Selection Procedure   | 75          |
|  | Preface to Selection Procedure, Figures and Tables                          | 78          |
|  | Example Idler Selection   | 84          |
|  | Belt Alignment  | 89          |
| <hr/>  |   |             |
| <i>SIX - BELT TENSION AND POWER ENGINEERING</i>  |   | 91          |
|  | Scope   | 95          |
|  | Introduction  | 95          |
|  | Definition of the Three Conveyor Cases                                      | 100         |
|  | Belt Tension Calculations for Basic Conveyors: Basic Method                 | 102         |
|  | Belt Tension Calculations for Standard Conveyors: CEMA<br>Historical Method | 103         |
|  | Belt Tension Calculations for All Conveyors: Universal Method               | 104         |
|  | Tension Management  | 129         |
|  | Component Tension Characteristics   | 140         |
|  | Conveyor as a System  | 155         |
|  | System Interactions   | 157         |
|  | Transient Behaviors   | 164         |
|  | Design Tools  | 166         |
|  | Example Conveyor Analysis   | 168         |
| <hr/>  |   |             |
| <i>SEVEN - BELT SELECTION</i>                    |   | 185         |
|  | Introduction  | 187         |
|  | Determining Belt Specifications   | 187         |
|  | Factors in the Composition of Conveyor Belting                              | 187         |
|  | Conveyor Belt Cover Characteristics, Composition and Design                 | 188         |
|  | Loading Considerations  | 192         |
|  | The Belt Carcass  | 194         |
|  | Belt Splices  | 198         |
|  | Belt and System Considerations  | 201         |
|  | Belt Selection  | 206         |
|  | Belt Selection Tables   | 208         |
| <hr/>  |   |             |
| <i>EIGHT - PULLEYS AND SHAFTS</i>                |   | 211         |
|  | Introduction  | 212         |
|  | Conveyor Pulleys  | 212         |
|  | Pulley Lagging  | 221         |
|  | Shafting  | 223         |
|  | Terminology   | 228         |
|  | Special Pulleys   | 229         |

| <b>Chapter</b>                                | <b>Index Title</b>                                  | <b>Page</b> |
|---|---|-------------|
| <hr/>   |   |             |
| <i>NINE - CURVES</i>                          |   | 233         |
|   | Introduction  | 234         |
|   | Vertical Curves                                     | 234         |
|   | Horizontal Curves                                   | 243         |
| <hr/>   |   |             |
| <i>TEN - STEEP ANGLE CONVEYING</i>            |   | 251         |
|   | Introduction  | 252         |
|   | Incline Limitations with Conventional Conveyors     | 252         |
|   | Molded Cleat Belts                                  | 253         |
|   | Pocket Belts  | 260         |
|   | Totally Enclosed Belts                              | 267         |
|   | Pipe/Tube Conveyors                                 | 272         |
|   | Fold Belts  | 281         |
|   | Suspended Belts                                     | 187         |
|   | Sandwich Belt Conveyors                             | 293         |
| <hr/>   |   |             |
| <i>ELEVEN - BELT CLEANERS AND ACCESSORIES</i> |   | 307         |
|   | Introduction  | 308         |
|   | Conveyor Belt Cleaning Equipment                    | 308         |
|   | Access Doors  | 321         |
|   | Stops   | 322         |
|   | Impact Beds   | 325         |
|   | Slider Beds   | 326         |
|   | Combination Impact, Slider and Roller Beds          | 327         |
|   | Belt Training Devices                               | 328         |
|   | Belt Turnovers                                      | 329         |
|   | Pulley Cleaners                                     | 330         |
|   | Wing-type Pulleys                                   | 331         |
|   | Deck Plates   | 332         |
|   | Drip Pans   | 332         |
|   | Weather Protection                                  | 333         |
|   | Magnetic Separators                                 | 334         |
|   | Metal Detectors                                     | 336         |
|   | Conveyor Belt Scales                                | 336         |
|   | Sampling Devices                                    | 337         |
|   | Rip Detection Systems                               | 339         |
|   | Electrical Conveyor Accessories                     | 339         |
|   | Accessory Horsepower Requirements                   | 342         |
|   | The Importance of Maintenance                       | 342         |
| <hr/>   |   |             |
| <i>TWELVE - TRANSFER POINTS</i>               |   | 343         |
|   | Introduction  | 345         |
|   | System Design                                       | 347         |
|   | Addressing Impact                                   | 350         |
|   | Control of Fugitive Material                        | 353         |
|   | Skirtboards   | 371         |
|   | Wear Liners   | 375         |
|   | Other Discharge Chutes (into stockpiles, ships etc) | 378         |
|   | Feeders   | 381         |
|   | Trippers  | 392         |
|   | Discharge Plows                                     | 394         |
|   | Discharge Trajectories                              | 395         |

| Chapter  | Index Title   | Page |
|--|---|------|
| <i>THIRTEEN - CONVEYOR MOTOR DRIVES AND CONTROLS</i> ..... 419 |   |      |
|  | Introduction .....  | 422  |
|  | Conveyor Drive Evaluation Criteria .....  | 422  |
|  | Belt Drive Attributes .....   | 427  |
|  | Conveyor Drive Systems Overview .....   | 429  |
|  | Other Conveyor Drives .....   | 446  |
|  | Speed Reducers .....  | 446  |
|  | Belt Conveyor Drive Arrangement .....   | 449  |
|  | Backstops .....   | 452  |
|  | Brakes .....  | 455  |
|  | Brakes and Backstops in Combination .....   | 456  |
|  | Devices for Acceleration, Deceleration, and Torque Control .....                    | 457  |
|  | Brake Heat Absorption Capacity .....  | 460  |
|  | Conveyor Belt Controls .....  | 461  |
|  | Belt Protection Controls .....  | 462  |
|  | Belt Control Apparatus .....  | 465  |
|  | Conclusion .....  | 466  |
| <i>FOURTEEN - OPERATION, MAINTENANCE AND SAFETY</i> ..... 467  |   |      |
|  | Introduction .....  | 468  |
|  | Operation .....   | 468  |
|  | Maintenance .....   | 469  |
|  | Lubrication .....   | 470  |
|  | Safety .....  | 472  |
|  | Guidelines for Safe Operation and Maintenance .....                                 | 473  |
|  | Trouble Shooting Conveyor Problems .....  | 475  |
| <i>FIFTEEN - BELT TAKEUPS</i> ..... 479                        |   |      |
|  | Introduction .....  | 480  |
|  | Belt Takeups .....  | 480  |
|  | Belt Stretch or Elongation .....  | 480  |
|  | Takeup Movement .....   | 480  |
|  | Manual Takeups .....  | 481  |
|  | Automatic Takeups .....   | 483  |
| <i>SIXTEEN - EMERGING TECHNOLOGIES</i> ..... 491               |   |      |
|  | Introduction .....  | 492  |
|  | Advanced Conveyor Design Methods .....  | 492  |
|  | Component Properties .....  | 496  |
|  | Belt Construction .....   | 497  |
|  | Transient System Analysis .....   | 498  |
|  | Numerical Simulation of Transfer Chutes using Discrete<br>Element Analysis .....    | 505  |
|  | Air Supported Conveyors .....   | 507  |
|  | Example of Dynamic Analysis .....   | 513  |
| <i>LIST OF EQUATIONS, FIGURES AND TABLES</i> ..... 517         |   |      |
| <i>APPENDIX A</i>  | SI Units .....  | 531  |
| <i>APPENDIX B</i>  | Nomenclature .....  | 535  |
| <i>APPENDIX C</i>  | $K_x$ and $K_y$ .....   | 548  |
| <i>APPENDIX D</i>  | Conveyor Installation Standards For Belt Conveyors<br>Handling Bulk Materials ..... | 557  |
| <i>APPENDIX E</i>  | Belt Conveyor Idler Roll $A_i$ ' Test Procedure .....                               | 570  |
| <i>APPENDIX F</i>  | Belt Conveyor Idler Roll $K_{is}$ ' Test Procedure .....                            | 576  |
| <i>INDEX</i>   | .....   | 583  |

# PREFACE

---

The goal of this book is to be the definitive resource to experienced conveyor engineers on the design, installation, operation, and maintenance of belt conveyors for bulk materials. An experienced conveyor engineer, by following the methods in this book, can be greatly assisted in the design a bulk material conveyor that will be efficient and reliable at a level of quality that reflects a systems approach to design and operation and meets the user's expectations.

Experienced conveyor engineers can use the information and engineering principals put forth to design virtually any width, length, configuration and capacity of bulk materials handling belt conveyor and predict its performance within an acceptable range. Interested parties can also gain a basic understanding of the engineering, selection of components, related equipment and accessories and applications for belt conveyors.

The information presented in this book is intended to cover the basic principles of belt conveyor design and to include such formulas, tables, charts and recommendations as are required to design most belt conveyors. The material is arranged in the order most convenient for the use of an experienced conveyor engineer. As always, the responsibility for the ultimate safety, reliability, and functionality of any conveyor system rests with those who design and build it.

**While the formulas, recommendations and data are based on industry practice and are believed to be reliable, CEMA does not, and can not, assume any role in, or responsibility for, the safety, reliability or functionality of any conveyor system or component which it did not design. The formulas and principles in this book are guidelines only and are applicable to the design of a high percentage of conveyors that are required to operate under reasonably normal conditions. However, conveyor design is as much art as it is science and some conveyors will operate under conditions that are beyond the scope of this book. These design challenges require broad experience for a satisfactory solution. A qualified designer or engineer from a CEMA member company should be consulted in such cases, as well as in the design of conveyors critical to a process, very wide or fast conveyors and complex conveyor systems.**

# ACKNOWLEDGEMENTS

---

The Conveyor Equipment Manufacturers Association is indebted to the members of The Engineering Conference, The General Bulk Material Handling Section, The Unit Handling Conveying Section, and the many other individuals who contributed their time, effort and resources to the planning and compilation of this book; to the member companies who made available the time and talent of their engineers, draftspersons and marketing specialists; to the non-member companies, technical associations and professional societies for their assistance in making this book a reality.

CEMA and all of its members would like to express our appreciation to R. Todd Swinderman for his work in organizing, writing and producing this 6th Edition of the Belt Book. We are most grateful for his extraordinary effort and dedication without which this book would never have been completed.

# INTRODUCTION

---

The development of belt conveyors, capable of transporting virtually any bulk material at thousands of tons per hour in a continuous and uniform stream, has been one of the most important innovations for modern industry. Its history dates back to 1830 when sawmills applied flat belts sliding in steel troughs to move sawmill refuse and other materials away from milling operations. In the 1850's, the grain industry evolved the first conveyors designed to reduce the friction of rubber sliding in a steel trough by replacing the trough with a series of pulleys, with end discs separated by bent bars, to form a cup for troughing a leather belt. These leather troughed belt conveyors were successfully applied in many grain elevators during the 1860's through 1880 as refinements in the bent bar pulley design led to spooled wooden drums with shafts supported in bearings.

It wasn't until 1891 that rubber belt conveyors were applied to handling heavy bulk materials previously considered transportable only by mobile equipment and gravity. Prior to this, ore processing plants were always built into the side of a hill, eliminating the need for horizontal transport by belt conveyor. In 1891, Thomas Edison experimented with flat belt conveyors similar to those used in the grain handling industry to move heavy, abrasive ore at his iron mine and processing complex in Ogdensburg, New Jersey. The belts were simply a cotton duck material. It soon became apparent that the cotton belts and wooden idlers were no match for the heavy and abrasive ore. Replacement of the belt and idlers became necessary on a one to two month cycle.

In that same year, Thomas Robins Sr. approached Mr. Edison and convinced him to try a cotton duck belt with a 1/8" rubber cover. Edison agreed and the new belt proved to be the wear solution. A working relationship began between the two inventors and Robins persuaded Edison to try a troughed belt configuration using spool shaped idlers to form the trough. This proved to be a failure because the upper edge of the spool moved at a higher speed than the base of the trough, causing damage to the underside of the belt from frictional resistance. The solution recommended by Robins was to break the spool into three independent cylindrical pulleys, each supported by a bearing at the ends of its shaft. These two innovations, the rubber belt covers and three roll idler, became the foundation for modern belt conveyor design and the origin of the Hewitt-Robins Company, a founding member of CEMA, in 1933.

In the ensuing years, the demand for higher capacities, longer runs, steeper conveying angles, and energy efficiency has led to new innovations and technologies. Belt conveyors with capacities reaching 20,000 tons per hour, lengths exceeding 30 miles, horizontal curves, and inclinations to vertical are covered in this Sixth Edition. In addition, the costs per ton-mile to transport various materials are illustrated, based on proven experience at different operating sites. The technical information contained in this book is generally conservative in nature. Variations in specific application requirements or extreme service requirements should always be addressed by member company engineering personnel whose depth of experience exceeds that covered in this text.

In the first edition of this book, the Conveyor Equipment Manufacturers Association (CEMA) stated its objectives to make available the experience and technical knowledge of its members as a contribution toward the design and construction of conveyors of superior performance, and also to provide basic data and fundamentals of design for application to ordinary belt conveyor problems in order to achieve successful performance. Adhering to these same objectives, CEMA is pleased to offer this Sixth Edition of *Belt Conveyors for Bulk Materials*.

# INDEX

|          | Index Title   | Page   |
|----------|---|--------|
| <b>A</b> | Abrasive Environments .....   | 216    |
|          | Abrasiveness .....  | 48     |
|          | AC Induction Motor and Mechanical Transmission with Integral Hydroviscous Coupling .....    | 443    |
|          | AC Induction Motor with Direct Coupling .....   | 430    |
|          | AC Induction Motor with Full Voltage Starting and Fixed Fill Fluid Coupling .....           | 440    |
|          | AC Induction Motor with Full Voltage Starting and Variable Fill Hydrokinetic Coupling ..... | 443    |
|          | AC Induction Motor with Reduced Voltage Starting and Direct Coupling .....                  | 431    |
|          | AC Induction Motor with Variable Frequency Control and Direct Coupling .....                | 438    |
|          | Access Doors .....  | 322    |
|          | Access Requirements .....   | 38     |
|          | Accessories .....   | 155    |
|          | Accessory Horsepower Requirements .....   | 341    |
|          | Active Dust Collection Systems .....  | 367    |
|          | Active Powered Takeups .....  | 490    |
|          | Active Pulley Locations .....   | 156    |
|          | Active Pulleys .....  | 157    |
|          | Active Speed Change Acceleration/Deceleration .....   | 138    |
|          | Active Takeup Sensitivity .....   | 487    |
|          | Active Tension Contributions .....  | 128    |
|          | Adaptability to Path of Travel .....  | 3      |
|          | Addressing Impact .....   | 350    |
|          | Advanced Conveyor Design Methods .....  | 492    |
|          | Advantages of Air Supported Conveyors .....   | 508    |
|          | Advantages of Fold Belts .....  | 286    |
|          | Advantages of Molded Cleat Belts .....  | 255    |
|          | Advantages of Pipe/Tube Conveyors .....   | 281    |
|          | Advantages of Pocket Belts .....  | 267    |
|          | Advantages of Sandwich Belt Conveyors .....   | 306    |
|          | Advantages of Suspended Belts .....   | 292    |
|          | Advantages of Using CEMA Standards .....  | 214    |
|          | Air Flow .....  | 510    |
|          | Air Supported Conveyors .....   | 507    |
|          | Alignment .....   | 144    |
|          | Allowable Stress Design .....   | 30     |
|          | Alternate Materials and Methods .....   | 37     |
|          | Alumina Tiles .....   | 375    |
|          | Analysis Process .....  | 129    |
|          | Analyzing Carryback .....   | 310    |
|          | Anchor Bolts and Base Plates .....  | 27     |
|          | Angle of Repose .....   | 48, 52 |
|          | Angular Tangent Direction .....   | 400    |
|          | Application Considerations .....  | 248    |

| <b>Index Title</b>  | <b>Page</b> |
|---|-------------|
| <b>A</b> Application Range .....                            | 383         |
| Applications for Sandwich Belt Conveyors .....              | 303         |
| Apron Feeders .....   | 382         |
| AR plate .....  | 375         |
| Automatic Takeup Force Requirements .....                   | 484         |
| Automatic Takeup Location .....                             | 484         |
| Automatic Takeup Response .....                             | 162         |
| Automatic Takeup Sensitivity .....                          | 485         |
| Automatic Takeups .....                                     | 483         |
| Availability .....  | 13          |
| <b>B</b> Backstops .....                                    | 150, 452    |
| Basic Components of a Pipe Conveyor .....                   | 269         |
| Basic Construction .....                                    | 282, 287    |
| Basic Conveyor .....  | 100         |
| Basic Flat and Troughed Belt Conveyor Paths .....           | 20          |
| Basic Power Requirements .....                              | 391         |
| Bearing Temperature .....                                   | 426         |
| Bearings .....  | 424, 447    |
| Behavior of Materials on a Moving Belt .....                | 49          |
| Belt .....  | 140         |
| Belt Alignment .....  | 89, 462     |
| Belt Alignment in Pipe/Tube Conveyors .....                 | 279         |
| Belt and System Considerations .....                        | 200         |
| Belt Carcass .....  | 193         |
| Belt Cleaner Locations .....                                | 40          |
| Belt Cleaner Tensioner Requirements .....                   | 314, 316    |
| Belt Cleaners .....   | 127         |
| Belt Cleaners and Conveyors .....                           | 311         |
| Belt Cleaners and Horsepower Requirements .....             | 316         |
| Belt Cleaners and Top Cover Wear .....                      | 316         |
| Belt Cleaners for Belts with Patterns, Cleats or Ribs ..... | 317         |
| Belt Cleaning and Sealing .....                             | 385         |
| Belt Cleaning Pocket Belts .....                            | 262         |
| Belt Construction .....                                     | 497         |
| Belt Control .....  | 464         |
| Belt Control Apparatus .....                                | 465         |
| Belt Control System .....                                   | 429         |
| Belt Conveyor Accessory Equipment .....                     | 309         |
| Belt Conveyor as a Basic Machine .....                      | 95          |
| Belt Conveyor as an Electro/Mechanical System .....         | 500         |
| Belt Conveyor Capacities .....                              | 57          |
| Belt Conveyor Capacity Tables and Their Use .....           | 58          |
| Belt Conveyor Drive Arrangement .....                       | 448         |
| Belt Conveyor Idler Roll Ai' Test Procedure .....           | 588         |
| Belt Conveyor Idler Roll Kis' Test Procedure .....          | 594         |
| Belt Conveyor Loading and Discharge Arrangements .....      | 23          |
| Belt Cover Thickness .....                                  | 191         |

| <b>Index Title</b>  | <b>Page</b> |
|---|-------------|
| <b>B</b> Belt Deformation .....                                     | 112         |
| Belt Discharge Plow.....  | 127, 322    |
| Belt Drive Attributes .....   | 427         |
| Belt Drive System .....   | 422         |
| Belt Feeder Design .....  | 386         |
| Belt Feeders .....  | 383         |
| Belt Flap .....   | 165         |
| Belt Load Cross Section Areas .....                                 | 60          |
| Belt Modulus .....  | 237         |
| Belt on Idler Alignment Friction .....                              | 115         |
| Belt Overload .....   | 462         |
| Belt Protection Controls .....                                      | 462         |
| Belt Ratings .....  | 208         |
| Belt Repair Area .....  | 38          |
| Belt Sag between Idlers .....                                       | 133         |
| Belt Scale Idlers .....   | 73          |
| Belt Selection Tables .....   | 207         |
| Belt Slip .....   | 462, 477    |
| Belt Speed .....  | 55, 76      |
| Belt Speed, Maximum .....   | 51, 55      |
| Belt Splices .....  | 197         |
| Belt Stop .....   | 324         |
| Belt Strength .....   | 140         |
| Belt Stretch .....  | 480         |
| Belt Stretch Influences .....                                       | 161         |
| Belt Stretch Potential Energy .....                                 | 165         |
| Belt Takeups .....  | 480         |
| Belt Tension Calculations for All Conveyors: Universal Method ..... | 104         |
| Belt Tension Calculations for Basic Conveyors .....                 | 102         |
| Belt Tension Calculations for Standard Conveyors .....              | 103         |
| Belt Tension Loads .....  | 34          |
| Belt Tracking .....   | 477         |
| Belt Training Devices .....   | 327         |
| Belt Training Idlers, Carrying .....                                | 69          |
| Belt Trajectories .....   | 400         |
| Belt Turnovers .....  | 328         |
| Belt Washing Stations .....   | 318         |
| Belt Wear .....   | 477         |
| Belt Weights (lbf/ft) .....   | 79          |
| Belt Width, Trough Angle and Loading Direction .....                | 386         |
| Belt Widths .....   | 54          |
| Belting and Resistance to Belt Motion .....                         | 500         |
| Belting Fabrics by Fiber Content .....                              | 196         |
| Benefits of Horizontally Curved Belt Conveyors .....                | 243         |
| Bin Level .....   | 463         |
| Bin Lowering Chutes .....   | 380         |
| Blade Materials .....   | 316         |

| <b>Index Title</b>   | <b>Page</b>  |
|--|--------------|
| <b>B</b> Blade Width .....   | 312          |
| Blocked Chute Detectors .....  | 339          |
| Bolts .....  | 28           |
| Booster Drive Path .....   | 21           |
| Booster Drives .....   | 159          |
| Brake and Backstop Recommendations .....                                 | 457          |
| Brake Heat Absorption Capacity .....                                     | 460          |
| Brakes .....   | 150, 455     |
| Brakes and Backstops in Combination .....                                | 456          |
| Braking the Belt .....   | 129          |
| Breakers .....   | 192          |
| Buckling .....   | 31           |
| Buildup on Components .....  | 477          |
| Bulk Material Acceleration .....   | 107          |
| Bulk Material Characteristics and Belt Cleaning Considerations .....     | 312          |
| Bulk Material Losses .....   | 495          |
| By Impact Idlers and Grizzlies .....                                     | 351          |
| By Material Flow Control .....   | 350          |
| By Rock Boxes .....  | 353          |
| By Short Impact Conveyors .....  | 352          |
| <b>C</b> Calculated Average Acceleration /Deceleration Forces .....      | 135          |
| Calculating and Plotting Normal Material Trajectories .....              | 396          |
| Calculation of Edge Distance with a Maximum Material Depth on Belt ..... | 62           |
| Calculation of $T_c$ Tension .....                                       | 237          |
| Calculation of the Total Cross Sectional Area .....                      | 62           |
| Capacities .....   | 253, 291     |
| Capacities of Fold Belts .....   | 283          |
| Capacities of Pipe/Tube Conveyors .....                                  | 272          |
| Capacities of Sandwich Belt Conveyors .....                              | 299          |
| Capacity .....   | 58, 386, 446 |
| Capacity Considerations .....  | 348          |
| Capacity of Suspended Belts .....  | 292          |
| Capital Vs Operating Costs .....   | 43           |
| Carbon Steel .....   | 375          |
| Carcass Types .....  | 193          |
| Carrying and Return Run Structure .....                                  | 24           |
| Carrying Idler Spacing at Loading Points .....                           | 74           |
| Carrying Idlers .....  | 66           |
| Case 1 .....   | 103          |
| Case 2 .....   | 106          |
| CEMA Classification Code .....   | 48           |
| CEMA Conveyor Design Evolution .....                                     | 95           |
| CEMA Standard 550 .....  | 5            |
| CEMA Standard 550 Characteristics of Bulk Materials .....                | 33           |
| CEMA Standard Historical Method .....                                    | 104          |
| Center of Mass .....   | 396          |
| Centrifugal Clutch Couplings .....                                       | 459          |

| <b>Index Title</b>   | <b>Page</b> |
|--|-------------|
| <b>C</b> Ceramic Lagging .....   | 222         |
| Characteristics of Bulk Materials .....  | 48          |
| Chemical Exposure .....  | 189         |
| Chute Level Switches .....   | 339         |
| Clad Plate .....   | 376         |
| Cleaners for Special Applications .....  | 319         |
| Clearances, Minimum Recommended .....  | 38          |
| Cleat Designs .....  | 253, 263    |
| Clustered Drives .....   | 158         |
| Codes & Standards .....  | 29, 476     |
| Coefficient of Friction for Accessories .....                                    | 340         |
| Combination Impact, Slider and Roller Beds .....                                 | 326         |
| Complete Conveyor Model .....  | 501         |
| Complexity .....   | 428         |
| Component Implications .....   | 155         |
| Component Location .....   | 157         |
| Component Properties .....   | 496         |
| Component Tension Characteristics .....  | 140         |
| Computer Based Control .....   | 465         |
| Concave Vertical Curves .....  | 234         |
| Configuration .....  | 446         |
| Configurations of Sandwich Belt Conveyors .....                                  | 300         |
| Connections .....  | 28          |
| Considering the Long Term Effects of Design Decisions .....                      | 43          |
| Constant Belt Length Fixed Takeup .....  | 154         |
| Constant Tension from Automatic Takeups .....                                    | 153         |
| Construction .....   | 384         |
| Constructional Stretch .....   | 480         |
| Control Flow Chutes .....  | 370         |
| Control of Air Movement .....  | 359         |
| Control of Fugitive Material .....   | 353         |
| Controlled Acceleration .....  | 457         |
| Convex Vertical Curves .....   | 240         |
| Conveyability of Materials .....   | 510         |
| Conveying of a Variety Of Materials .....  | 2           |
| Conveyor Arrangements .....  | 19          |
| Conveyor as a System .....   | 155         |
| Conveyor Belt Cleaning Equipment .....   | 309         |
| Conveyor Belt Controls .....   | 461         |
| Conveyor Belt Cover Characteristics, Composition, and Design .....               | 187         |
| Conveyor Belt Scales .....   | 335         |
| Conveyor Belt Selection .....  | 205         |
| Conveyor Drive Evaluation Criteria .....   | 422         |
| Conveyor Drive Systems Overview .....  | 429         |
| Conveyor Economics .....   | 13          |
| Conveyor Installation Standards For Belt Conveyors Handling Bulk Materials ..... | 575         |
| Conveyor Jam .....   | 429         |

| <b>Index Title</b>   | <b>Page</b> |
|--|-------------|
| <b>C</b> Conveyor Power Loss Prediction and Terminology .....          | 493         |
| Conveyor Pulleys .....   | 212         |
| Conveyor Structures .....  | 24          |
| Conveyor Take-up Discussion .....                                      | 216         |
| Corrosion Protection .....   | 36          |
| Corrosion Resistant Stainless Steel (12% chromium) .....               | 376         |
| Corrosion Resistant Steels .....                                       | 37          |
| Cost .....   | 428         |
| Cost per Ton of Material Conveyed .....                                | 13          |
| Counterweight .....  | 477         |
| Cover and Ply Adhesion .....   | 188         |
| Cover Considerations .....   | 189         |
| Cover Wear .....   | 192         |
| Creeper Drives .....   | 452         |
| Cross Belt Sweep Sampler .....   | 337         |
| Cross Cut Sampler .....  | 337         |
| Cross Section Properties .....   | 142         |
| Cross Sectional Areas .....  | 58          |
| Cross-Overs & Cross-Unders .....                                       | 42          |
| Crossovers CEMA R SBP-001 .....  | 473         |
| Curve Crown .....  | 218         |
| Curves .....   | 131         |
| Cut/Slit Belt Edge .....   | 193         |
| <b>D</b> DC Motor and Direct Coupling .....                            | 435         |
| Dead Loads .....   | 33          |
| Dead Shaft Pulleys .....   | 229         |
| Deck Plates .....  | 331         |
| Declined Belt Conveyor Trajectories .....                              | 404         |
| Definition of a Horizontal Curve .....                                 | 243         |
| Definition of the Three Conveyor Cases .....                           | 100         |
| Deflection .....   | 31          |
| Design .....   | 30          |
| Design Criteria .....  | 510         |
| Design of Concave Vertical Curves .....                                | 235         |
| Design of Convex Vertical Curves .....                                 | 240         |
| Design of Horizontal Curved Belt Conveyors .....                       | 244         |
| Design of Sandwich Belt Curves .....                                   | 298         |
| Design Tools .....   | 166         |
| Deteriorating Conditions .....   | 190         |
| Determining Belt Specifications .....                                  | 186         |
| Determining the Need and Capacity of Backstop, Inclined Conveyor ..... | 454         |
| Devices for Acceleration, Deceleration, and Torque Control .....       | 457         |
| DIN f .....  | 157         |
| Disadvantages of Belt Feeders .....                                    | 385         |
| Disadvantages of Fold Belts .....                                      | 286         |
| Disadvantages of Horizontally Curved Belt Conveyors .....              | 244         |
| Disadvantages of Molded Cleat Belts .....                              | 255         |

| <b>Index Title</b>                                  | <b>Page</b> |
|---|-------------|
| <b>D</b> Disadvantages of Pipe/Tube Conveyors ..... | 281         |
| Disadvantages of Pocket Belts .....                 | 267         |
| Disadvantages of Sandwich Belt Conveyors .....      | 306         |
| Disadvantages of Suspended Belts .....              | 293         |
| Discharge Over the End Pulleys .....                | 379         |
| Discharge Plows .....                               | 394         |
| Discharge Trajectories .....                        | 395         |
| Discrete Element Method (DEM) .....                 | 505         |
| Displaced Air .....                                 | 359         |
| Distance of Material Fall from Tangent Line .....   | 405         |
| Drag .....  | 143         |
| Drag Scraper Feeders (Bar Drag Feeders) .....       | 382         |
| Dribble Chutes .....                                | 378         |
| Drip Pans .....                                     | 331         |
| Drive Components .....                              | 147         |
| Drive Efficiencies .....                            | 451         |
| Drive Inertia Considerations .....                  | 148         |
| Drive or Brake Slip .....                           | 165         |
| Drive System and Control .....                      | 151         |
| Drive Type Controller .....                         | 461         |
| Drives .....  | 148         |
| Driving the Belt .....                              | 128         |
| Dry-Fluid Couplings .....                           | 459         |
| Dust .....  | 11          |
| Dust Collection .....                               | 366         |
| Dust Control .....                                  | 360         |
| Dust Plates .....                                   | 32          |
| Dust Sprays .....                                   | 463         |
| Dust Suppression .....                              | 361         |
| Dynamic Braking .....                               | 456         |
| Dynamic Loads .....                                 | 35          |
| Dynamic Modeling .....                              | 498         |
| <b>E</b> Eddy Current Brakes .....                  | 455         |
| Eddy-Current Couplings .....                        | 458         |
| Edge Distance, Standard .....                       | 57          |
| Effect of Inclines and Declines .....               | 50          |
| Effect of Load on Predicted Bearing Life .....      | 76          |
| Effect on Material Carried .....                    | 164         |
| Effective $f$ .....                                 | 157         |
| Efficiency .....                                    | 424         |
| Elastic Stretch or Elongation .....                 | 480         |
| Electric Motor Attributes .....                     | 422         |
| Electrical Conveyor Accessories .....               | 338         |
| Elevator Belt Tension Recommendation .....          | 206         |
| Elongation .....                                    | 200         |
| Enclosures .....                                    | 423         |
| End Disc/Hub Configurations .....                   | 228         |

| <b>Index Title</b>                                      | <b>Page</b> |
|---|-------------|
| <b>E</b> Energy Loss or Resistance .....                | 140         |
| Engineered Pulleys .....                                | 214         |
| Environmental Advantages .....                          | 11          |
| Environmental Seal Contamination .....                  | 144         |
| Environmental, Maintenance and Other Conditions .....   | 77          |
| Example Conveyor Analysis .....                         | 167         |
| Example Idler Selection .....                           | 84          |
| Example of Dynamic Analysis .....                       | 513         |
| Examples of Trajectories .....                          | 407         |
| Expansion Joints .....                                  | 29          |
| Expansion Loads .....                                   | 35          |
| Explosion Protection .....                              | 369         |
| Extended Understanding of Energy Loss Mechanisms .....  | 493         |
| Extending Understanding of Energy Loss Categories ..... | 493         |
| Factors in the Composition of Conveyor Belting .....    | 186         |
| <b>F</b> Fastener Wear .....                            | 478         |
| Feasibility Studies .....                               | 14          |
| Feeder Loads .....                                      | 388         |
| Feeder Outlet Dimensions .....                          | 386         |
| Feeders .....   | 381         |
| Festooning from Low Tensions .....                      | 164         |
| Fire Detection .....                                    | 463         |
| Fire/Flame Resistance .....                             | 189         |
| Fixed Takeup or Constant Length Belt .....              | 161         |
| Flanged Systems .....                                   | 219         |
| Flanged Systems with a Shallow Taper Angle .....        | 219         |
| Flangeless Systems .....                                | 219         |
| Flat Return Idlers .....                                | 71          |
| Flight "n" .....  | 98          |
| Flow Aid Devices .....                                  | 385         |
| Flowability .....                                       | 47          |
| Fluid Couplings .....                                   | 458         |
| Flywheel .....  | 459         |
| Foam Dust Suppression .....                             | 365         |
| Fog Systems .....                                       | 362         |
| Fold Belts .....  | 281         |
| Food Processing .....                                   | 189         |
| Foundations .....                                       | 27          |
| Frames and Bases .....                                  | 27          |
| Frequency Factor .....                                  | 191         |
| Full Covers .....                                       | 333         |
| Fundamental Force-Velocity Relationships .....          | 400         |
| Future Allowable Loads .....                            | 36          |
| <b>G</b> Galvanizing .....                              | 37          |
| Garland Idler .....                                     | 117         |
| Garland, Catenary or Suspended Idlers .....             | 70          |
| General Purpose Rubber Covered Belting .....            | 187         |

| <b>Index Title</b>  | <b>Page</b> |
|---|-------------|
| <b>G</b> General Types of Belt Conveyor Idlers .....                | 66          |
| Generated Air .....   | 360         |
| Gravity .....   | 106         |
| Guarding Automatic Takeups .....                                    | 483         |
| Guidelines for Safe Operation and Maintenance .....                 | 473         |
| <b>H</b> Half Covers .....  | 332         |
| Handling the Removed Material .....                                 | 319         |
| Height of Skirtboards .....   | 372         |
| High Angle Conveying .....  | 252         |
| High Chromium Cast Iron Tiles/Ni-Cr Tiles .....                     | 376         |
| High Dynamic Tensions .....   | 164         |
| High Lift Pocket Belts .....  | 264         |
| High Tension Applications .....                                     | 222         |
| Higher Belt Speeds .....  | 56          |
| History of the Air Supported Conveyor .....                         | 507         |
| Horizontal Belt Conveyor Trajectories .....                         | 400         |
| Horizontal Curve Path .....   | 21          |
| Horizontal Curves .....   | 131, 243    |
| Horizontal Gravity Takeups .....                                    | 489         |
| Horizontal Motivating Force .....                                   | 245         |
| Horizontal Takeups .....  | 489         |
| Horizontal V-Plow .....   | 394         |
| Horizontal, Inclined, and Declined Conveyor Belt Trajectories ..... | 400         |
| Hot Materials Handling .....  | 188         |
| Housekeeping .....  | 476         |
| Human-Machine Interface .....                                       | 465         |
| Hysteresis .....  | 153         |
| <b>I</b> Idler .....  | 142, 496    |
| Idler Bearing Losses .....  | 112         |
| Idler Center Roller Length .....                                    | 61          |
| Idler Classifications .....   | 66          |
| Idler Load .....  | 76          |
| Idler Load Ratings .....  | 82          |
| Idler Lubrication Viscous Loss .....                                | 497         |
| Idler Requirements .....  | 66          |
| Idler Rotating Part Weights .....                                   | 86          |
| Idler Seal Drag .....   | 110         |
| Idler Selection Procedure .....                                     | 75          |
| Idler Series B, C, D, E, F .....                                    | 66          |
| Idler Spacing .....   | 73          |
| Idler Spacing in a Convex Curve .....                               | 241         |
| Idler Testing .....   | 496         |
| Impact Beds .....   | 324         |
| Impact Forces .....   | 76          |
| Impact Idlers .....   | 68          |
| Impact Resistance .....   | 203         |
| Importance of Maintenance .....                                     | 341         |

| <b>Index Title</b>   | <b>Page</b> |
|--|-------------|
| <b>I</b> Incline Limitations with Conventional Conveyors ..... | 252         |
| Inclined Belt Conveyor Trajectories .....                      | 402         |
| Individually Spring-Loaded Roller and Ramp Design .....        | 454         |
| Induced Air .....  | 359         |
| Inertia .....  | 108, 145    |
| Inspection .....   | 473         |
| Interlock .....  | 464         |
| Iterative Process .....  | 166         |
| <b>K</b> $K_x$ and $K_y$ .....                                 | 566         |
| <b>L</b> $L_{10}$ Bearing Life .....                           | 74          |
| Labels, Safety .....   | 474         |
| Lagging .....  | 146         |
| Lagging Grooving .....   | 221         |
| Length of Skirtboards .....                                    | 371         |
| Lifetime Affects .....   | 143         |
| Liftoff Loss .....   | 123         |
| Limitations of Air Supported Conveyors .....                   | 509         |
| Limiting Conditions .....                                      | 391         |
| Limits of the Trajectory Path .....                            | 406         |
| Load and Resistance Factor Design .....                        | 31          |
| Load and Tension Dependant Friction .....                      | 121         |
| Load Combinations .....  | 35          |
| Load Dependent Friction .....                                  | 112         |
| Load Independent Friction .....                                | 108         |
| Load Shape .....   | 396         |
| Loading .....  | 139         |
| Loading Conditions Resulting in Maximum Cover Wear .....       | 192         |
| Loading Conditions Resulting in Minimum Cover Wear .....       | 192         |
| Loading Conditions Resulting in Normal Cover Wear .....        | 191         |
| Loading Considerations .....                                   | 191         |
| Loading Point .....  | 154         |
| Loading the Belt .....   | 348         |
| Loading, Discharging, and Stockpiling Capabilities .....       | 8           |
| Loads .....  | 33          |
| Local Belt Stretch .....                                       | 161         |
| Lock Out Tag Out .....   | 472         |
| Lockout .....  | 464         |
| Long-Distance Transportation .....                             | 13          |
| Longitudinal Stretch .....                                     | 141         |
| Low Labor Costs .....  | 12          |
| Low Maintenance Costs .....                                    | 12          |
| Low Power Costs .....  | 12          |
| Low Temperature Environments .....                             | 189         |
| Lower Belt Speeds .....  | 56          |
| Lowering Chutes .....  | 379         |
| Lubrication .....  | 447, 470    |
| Lump Size Consideration .....                                  | 54, 75      |

| <b>Index Title</b>   | <b>Page</b>  |
|--|--------------|
| <b>L</b> Lump Size Pipe/Tube Conveyors .....                 | 267          |
| <b>M</b> Magnetic Pulleys .....                              | 230          |
| Magnetic Separators .....                                    | 333          |
| Main Pulley and Drive Components Structure .....             | 24           |
| Main Resistances .....                                       | 108          |
| Maintenance .....  | 38, 385, 469 |
| Maintenance and Supporting System .....                      | 428          |
| Maintenance Cost .....                                       | 13           |
| Manual Takeup Location .....                                 | 482          |
| Manual Takeups .....   | 481          |
| Manufacturer's Belt Brand .....                              | 188          |
| Mass and Energy .....  | 106          |
| Material Characteristics .....                               | 46           |
| Material Class Description .....                             | 47           |
| Material Cross Section Area Between Skirtboards .....        | 63           |
| Material Entry Geometry .....                                | 154          |
| Material Live Loads .....                                    | 33           |
| Material Trampling Loss .....                                | 121          |
| Materials .....  | 31           |
| Materials Handled Resulting in Deterioration of Covers ..... | 191          |
| Mathematical Modeling .....                                  | 499          |
| Maximum Belt Tension .....                                   | 130, 156     |
| Maximum Conveying Angle .....                                | 5            |
| Maximum Conveying Angle of Molded Cleat Belts .....          | 256          |
| Maximum Material Depth .....                                 | 63           |
| Measurement of the Time Interval .....                       | 406          |
| Mechanical Clutches .....                                    | 459          |
| Mechanical Fastener Splice .....                             | 206          |
| Mechanical Friction Brakes .....                             | 455          |
| Mechanical Variable Speed Devices .....                      | 452          |
| Mechanically Fastened Splice Advantages .....                | 199          |
| Mechanically Fastened Splice Disadvantages .....             | 200          |
| Mechanics of Sandwich Belt Conveyors .....                   | 294          |
| Metal Detectors .....  | 335          |
| Methods to Control Dust and Spillage .....                   | 357          |
| Mild Steel .....   | 376          |
| Mine Duty Pulleys .....                                      | 214          |
| Minimize T at Takeup .....                                   | 156          |
| Minimum Design Tensions .....                                | 131          |
| Minimum Radius for Concave Curves .....                      | 235          |
| Minimum Radius for Convex Curves .....                       | 240          |
| Minimum Radius for Horizontal Curves .....                   | 245          |
| Minimum T <sub>2</sub> for Active Pulleys .....              | 131          |
| Misalignment .....   | 89           |
| Misalignment Switches .....                                  | 340          |
| Miscellaneous Fluid Couplings .....                          | 459          |
| Modulus/ Stiffness .....                                     | 141          |

| <b>Index Title</b>  | <b>Page</b> |
|---|-------------|
| <b>M</b> Molded Cleat Belts .....   | 253         |
| Molded Covers .....   | 191         |
| Molded Edge Belting .....   | 192         |
| Motor Protection .....  | 425         |
| Motor Space Heater .....  | 426         |
| Motor Tachometer .....  | 426         |
| Motorized Conveyor Pulleys .....  | 440         |
| Motorized Pulleys .....   | 230         |
| Moving Mass .....   | 135         |
| Multiple Drives .....   | 429         |
| Multiple Pulley Drives .....  | 158         |
| <b>N</b> Nomenclature .....   | 553         |
| Non-woven fabric .....  | 194         |
| Normal Forces .....   | 246         |
| Numerical Simulation of Transfer Chutes using Discrete Element Analysis ..... | 505         |
| <b>O</b> Oil Resistant Belting .....  | 189         |
| Operating Maximum Belt Tension .....  | 130         |
| Operation .....   | 468         |
| Optimization .....  | 155         |
| Other Considerations for Structure Spacing .....                              | 24          |
| <b>O</b> Other Conveyor Drives .....  | 446         |
| Other Discharge Chutes (into stockpiles, ships etc) .....                     | 378         |
| Overall Efficiency .....  | 156         |
| <b>P</b> Paint .....  | 36          |
| Parallel Forces .....   | 246         |
| Passive Dust Collection .....   | 369         |
| Passive Speed Change .....  | 137         |
| Performance Based Belt Cleaning .....   | 311         |
| Permanent Length Change .....   | 480         |
| Pins .....  | 29          |
| Pipe/Tube Conveyor Applications .....   | 276         |
| Pipe/Tube Conveyor Belt Construction .....                                    | 270         |
| Pipe/Tube Conveyor Curves .....   | 276         |
| Pipe/Tube Conveyor Transitions .....  | 274         |
| Pipe/Tube Conveyors .....   | 268         |
| Piping and Conduit .....  | 33          |
| Plenum Design .....   | 510         |
| Plotting the Trajectory .....   | 404         |
| Plows Discharging to One Side .....   | 394         |
| Plugged Chute Loads .....   | 34          |
| Plugged Chutes .....  | 478         |
| Plugging the Motor .....  | 456         |
| Pneumatic (Air Knife) Cleaners .....  | 318         |
| Pocket Belt Speed .....   | 273         |
| Pocket Belts .....  | 260         |
| Point Sources of Tension .....  | 90          |
| Polyurethane .....  | 376         |

| <b>Index Title</b>                                       | <b>Page</b>   |
|--|---------------|
| <b>P</b> Portals .....                                   | 26            |
| Power Generating Plants .....                            | 55            |
| Power Requirements for Curves .....                      | 234           |
| Power Requirements of Pipe/Tube Conveyors .....          | 280           |
| Precautions for Design of Concave Curves .....           | 238           |
| Preface to Selection Procedure, Figures and Tables ..... | 78            |
| Pre-start Alarms .....                                   | 338           |
| Primary Location Belt Cleaners .....                     | 314           |
| Process Functions .....                                  | 9             |
| Pull Cord Switches .....                                 | 339, 463      |
| Pulley .....   | 145           |
| Pulley Cleaners .....                                    | 329           |
| Pulley Components .....                                  | 228           |
| Pulley Crown .....                                       | 218           |
| Pulley Diameter .....                                    | 145, 210, 217 |
| Pulley Face .....  | 205           |
| Pulley Face Widths .....                                 | 218           |
| Pulley Hub and Bushing Systems .....                     | 218           |
| Pulley Inertia .....                                     | 146           |
| Pulley Lagging .....                                     | 221           |
| Pulley Overloads .....                                   | 216           |
| Pulley Terminology .....                                 | 228           |
| Pulley Tolerances .....                                  | 217           |
| Pulley Types .....                                       | 212           |
| Pulley Wear .....  | 478           |
| Pulley Weights .....                                     | 218           |
| Pulleys as Passive Point Losses .....                    | 125           |
| PVC Belt .....   | 210           |
| <b>Q</b> Quarry Tiles .....                              | 377           |
| <b>R</b> Rating and Idler Life .....                     | 74            |
| Reaction Time .....                                      | 487           |
| Receiving Belt Equipment .....                           | 155           |
| Reciprocating Plate Feeders .....                        | 382           |
| Recommended Takeup Movements .....                       | 483           |
| Reduce After Purchase Costs .....                        | 15            |
| Redundancy .....   | 43            |
| Regeneration or Overhauling Load .....                   | 428           |
| Regenerative Braking .....                               | 456           |
| Regulatory Limits and the Environment .....              | 356           |
| Reliability and Availability .....                       | 10            |
| Restraint of Declined Conveyors .....                    | 456           |
| Resultant Loads .....                                    | 223           |
| Return Belt Training Idlers .....                        | 72            |
| Return Idler Spacing .....                               | 74            |
| Return Idlers .....                                      | 67, 71        |
| Return-Run Belt Cleaning .....                           | 320           |
| Reversing Conveyor .....                                 | 162           |

| <b>Index Title</b>   | <b>Page</b> |
|--|-------------|
| <b>R</b> Reversing Conveyor Dual Drive .....                       | 163         |
| Reversing Conveyor Fixed Takeup .....                              | 162         |
| Reversing Conveyor Single Automatic Takeup .....                   | 162         |
| Rip Detection Systems .....  | 338         |
| Rip Detectors .....  | 463         |
| RMA Grade I .....  | 188         |
| RMA Grade II .....   | 188         |
| Rock Ladders .....   | 380         |
| Roll Diameter .....  | 77          |
| Roll Run Out .....   | 145         |
| Roller Cage and Ramp Design .....                                  | 454         |
| Rotary Cleaners .....  | 317         |
| Rotary-Drum Feeders .....  | 382         |
| Rotary-Table Feeders (Disc Feeders) .....                          | 383         |
| Rotary-Vane Feeders .....  | 382         |
| $R_r$ .....  | 108         |
| Rubber Disk Idlers .....   | 71          |
| Rubber Lagging Hardness .....                                      | 221         |
| Rubber Viscoelastic Losses .....                                   | 494         |
| Rubber/Synthetic Rubber .....                                      | 377         |
| <b>S</b> Safety .....  | 12, 472     |
| Safety Practices, CEMA Recommendation 001-2004 .....               | 42          |
| Safety Publications .....  | 476         |
| Safety Standard for Conveyors & Related Equipment ASME B20.1 ..... | 473         |
| Safety Labels .....  | 474         |
| Sampling Devices .....   | 336         |
| Sandwich Belt Conveyors .....                                      | 293         |
| Screw Feeders .....  | 381         |
| Secondary Location Belt Cleaners .....                             | 315         |
| Seismic Loads .....  | 35          |
| Selection of Idlers .....  | 74          |
| Self Cleaning Return Idlers .....                                  | 71          |
| Service Conditions .....   | 206         |
| Service Factor .....   | 424         |
| Shaft Materials .....  | 223         |
| Shaft Mounted Back Stop .....                                      | 323         |
| Shaft Sizing .....   | 225         |
| Shaft Sizing by Deflection Limit .....                             | 226         |
| Shaft Sizing by Stress Limit .....                                 | 225         |
| Shafting .....   | 223         |
| Shear Cell Tests .....   | 46          |
| SI Units .....   | 549         |
| Sidewall Designs .....   | 262         |
| Single Horizontal Swing Plow .....                                 | 394         |
| Single Lift Plow .....   | 394         |
| Single Ramp and Multiple Roller Design .....                       | 453         |
| Size .....   | 427         |

| <b>Index Title</b>                                       | <b>Page</b> |
|--|-------------|
| <b>S</b> Skirtboard Clearance over the Belt .....        | 373         |
| Skirtboard Covers .....                                  | 373         |
| Skirtboard Friction .....                                | 118, 374    |
| Skirtboard Resistance .....                              | 391         |
| Skirtboard Seal Friction .....                           | 109         |
| Skirtboard Sealing Strips .....                          | 374         |
| Skirtboards .....  | 371         |
| Skirtboards for Intermediate Loading Points .....        | 373         |
| Slider Bed .....   | 118, 325    |
| Snow and Ice Loads .....                                 | 35          |
| Software Attributes .....                                | 167         |
| Spacing .....  | 144         |
| Spacing of Skirtboards .....                             | 371         |
| Span to Depth Ratio .....                                | 31          |
| Special Conditions .....                                 | 77          |
| Special Pulleys .....                                    | 229         |
| Special Purpose Belting .....                            | 188         |
| Specialized Cleaning Systems .....                       | 316         |
| Speed .....  | 423         |
| Speed of Tension Change .....                            | 141         |
| Speed Reducers .....                                     | 446         |
| Speed-Reduction Mechanisms .....                         | 448         |
| Spillage .....   | 51, 478     |
| Spillage Loads .....                                     | 34          |
| Spiral Drum Pulleys .....                                | 231         |
| Spiral Lowering Chutes .....                             | 380         |
| Spiral Pulleys .....                                     | 230         |
| Spiral Wing Pulleys .....                                | 230         |
| Splice .....   | 141         |
| Sprag Design .....                                       | 453         |
| Squirrel-Cage Induction Motor with Autotransformer ..... | 457         |
| Stabilizing Forces .....                                 | 247         |
| Stainless Steel .....                                    | 377         |
| Standard Conveyor .....                                  | 101         |
| Standard Steel Drum Pulleys .....                        | 212         |
| Standard Steel Wing Pulleys .....                        | 213         |
| Start of Trajectory .....                                | 396         |
| Start Warning .....                                      | 464         |
| Starting and Stopping Control Algorithms .....           | 461         |
| Starting and Stopping Maximum Tension .....              | 130         |
| Starting Simulation .....                                | 503         |
| Starting the Conveyor .....                              | 457         |
| Startup and Shutdown .....                               | 139         |
| Steady State Running Analysis .....                      | 130         |
| Steel Cable Reinforcements .....                         | 197         |
| Steel Cord Belt Covers .....                             | 193         |
| Steel Cord Carcass .....                                 | 197         |

| <b>Index Title</b>                                   | <b>Page</b> |
|--|-------------|
| <b>S</b> Steep Angle Conveying .....                 | 5, 252      |
| Stockpile Loads .....                                | 36          |
| Stop/Start .....                                     | 464         |
| Stopping Simulation .....                            | 501         |
| Stops .....  | 323         |
| Straight Face Crown .....                            | 218         |
| Stringers .....                                      | 25          |
| Structural Considerations .....                      | 24          |
| Structural Shapes and Plates .....                   | 32          |
| Structure Widths .....                               | 24          |
| Stub Shaft Pulleys .....                             | 231         |
| Summary of the CEMA Standard Historical Method ..... | 104         |
| Surcharge Angle .....                                | 48, 52      |
| Surcharge Load .....                                 | 60          |
| Surface Friction .....                               | 144         |
| Surfactant Systems .....                             | 363         |
| Suspended Belts .....                                | 287         |
| System Design .....                                  | 347         |
| System Interactions .....                            | 157         |
| Systems Approach to Belt Cleaning .....              | 314         |
| <b>T</b> Tail Drive .....                            | 160         |
| Tail Protection Plows .....                          | 321         |
| Takeup .....   | 152         |
| Takeup Location .....                                | 160         |
| Takeup Movement .....                                | 480         |
| Take-up Over-travel .....                            | 463         |
| Takeup Reaction Time .....                           | 154         |
| Takeup Tension Deadband .....                        | 153         |
| Takeup Tension Deadband .....                        | 485         |
| Takeup Travel .....                                  | 201         |
| Taper Crown .....                                    | 218         |
| $T_e, T_1, T_2$ .....                                | 98          |
| Telemetry .....                                      | 464         |
| Telescopic chutes .....                              | 381         |
| Temperature .....                                    | 422         |
| Temporary Operating Maximum Belt Tension .....       | 130         |
| Tension and Friction Terminology .....               | 98          |
| Tension Management .....                             | 129         |
| Tension Oriented Design .....                        | 96          |
| Tension Ratings .....                                | 205         |
| Tension Vs Energy Cost .....                         | 156         |
| Tertiary location Belt Cleaners .....                | 316         |
| Textile Reinforcements .....                         | 194         |
| Thermal Rating .....                                 | 427         |
| Thickness and Attachment .....                       | 221         |
| Three Quarter Covers .....                           | 332         |
| $\Delta T_n$ .....                                   | 99          |

| <b>Index Title</b>   | <b>Page</b> |
|--|-------------|
| <b>T</b> Torque and Power .....                            | 147         |
| Torque Control .....                                       | 427         |
| Torque Transferal .....                                    | 145         |
| Torque Type .....  | 425         |
| Totally Enclosed Belts .....                               | 267         |
| Towers and Bents .....                                     | 26          |
| Tracking .....   | 144         |
| Transfer Chute Plug .....                                  | 463         |
| Transient Behaviors .....                                  | 164         |
| Transient Load Safety Factor .....                         | 141         |
| Transient System Analysis .....                            | 498         |
| Transient Tension Simplified Approach .....                | 134         |
| Transition Distance .....                                  | 201-202     |
| Transitions with Fold Belts .....                          | 284         |
| Transport Efficiency $f_e$ .....                           | 157         |
| Trapezoidal Crown .....                                    | 218         |
| Traveling Rotary Plow Feeders .....                        | 383         |
| Traveling V-Plow .....                                     | 395         |
| Tripper with Batwing Chutes .....                          | 393         |
| Tripper with Reversible Cross Belt .....                   | 393         |
| Tripper with Reversible Shuttle Belt .....                 | 393         |
| Tripper with Two Transverse Stacker Belts .....            | 393         |
| Trippers .....   | 392         |
| Trouble Shooting Conveyor Problems .....                   | 476         |
| Troughability and Load Support .....                       | 200         |
| Troughed Belt Load Areas .....                             | 60          |
| Troughing Carrying Idlers .....                            | 67          |
| Troughing Idler Spacing Adjacent to Terminal Pulleys ..... | 74          |
| Trusses .....  | 25          |
| Tubular Galleries .....                                    | 26          |
| Two Fluid Atomization .....                                | 364         |
| Two-Roll "Vee" Return Idlers .....                         | 72          |
| Type .....   | 422         |
| Type of Material Handled .....                             | 75          |
| Types of Pocket Belts .....                                | 260         |
| Types of Screw Takeups .....                               | 482         |
| Types of Structures .....                                  | 25          |
| Typical Applications .....                                 | 244         |
| <b>U</b> UHMW .....  | 377         |
| Unexpected Failures .....                                  | 165         |
| Universal Conveyors .....                                  | 101         |
| Upgrading .....  | 43          |
| Use of Bend Pulleys for Convex Curves .....                | 242         |
| <b>V</b> Valley Angles .....                               | 349         |
| Variable Speed .....                                       | 427         |
| Variable-Speed Hydraulic couplings .....                   | 459         |
| Velocities .....   | 396         |

| <b>Index Title</b>                                      | <b>Page</b> |
|---|-------------|
| <b>V</b> Vertical Curves .....                          | 131, 234    |
| Vertical Distance between Belts (Belt Separation) ..... | 349         |
| Vertical Gravity Takeups .....                          | 487         |
| Vertical Load and Material Shearing Resistance .....    | 389         |
| Vertical V-Plow .....                                   | 395         |
| Vibrating Feeders .....                                 | 382         |
| Vibration .....   | 31, 426     |
| Vitrified Tiles .....                                   | 378         |
| Voltage .....   | 424         |
| Vulcanized Splice .....                                 | 206         |
| Vulcanized Splice Advantages .....                      | 199         |
| Vulcanized Splice Disadvantages .....                   | 199         |
| <b>W</b> Walkway and Ladder Live Loads .....            | 34          |
| Wear Liners .....                                       | 375         |
| Weather Protection .....                                | 332         |
| Weight .....  | 142         |
| Weld Configurations .....                               | 229         |
| Welds .....   | 28          |
| What Happens in DEM .....                               | 507         |
| When is Dynamic Analysis Required? .....                | 504         |
| Why do Numerical Simulations? .....                     | 507         |
| Wide Range of Capacities .....                          | 2           |
| Width of Lower Chute (Spoon) .....                      | 350         |
| Wind hoops .....  | 333         |
| Wind Loads .....  | 35          |
| Windbreak .....   | 333         |
| Winding Temperature .....                               | 425         |
| Wing Pulley Lagging .....                               | 222         |
| Wing-type Pulleys .....                                 | 330         |
| Wire Rope Friction .....                                | 485         |
| WK <sup>2</sup> .....                                   | 135         |
| WK <sup>2</sup> , Idlers .....                          | 90          |
| W <sub>m</sub> .....                                    | 99          |
| Wound Rotor AC Motor and Direct Coupling Drive .....    | 433         |
| Wound-Rotor Motors with Step Starting .....             | 457         |
| Woven Fabrics .....                                     | 194         |
| <b>Z</b> Zero Speed Switches .....                      | 340         |