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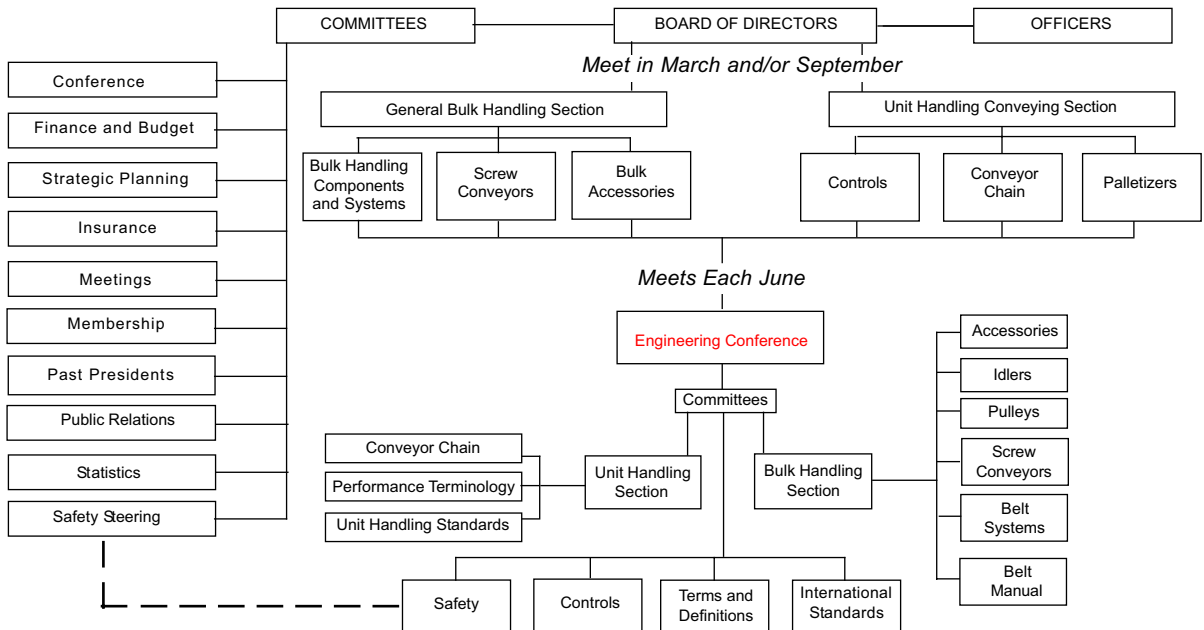
SCREW CONVEYORS for Bulk Materials



CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION

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The labels are available for sale to member companies and non-member companies.

A full description of the labels, their purpose, and guidelines on where to place the labels on typical equipment, has been published in CEMA's Safety Label Brochure No. 201. The Brochure is available for purchase by members and non-members of the Association. Safety Labels and Safety Label Placement Guidelines, originally published in the Brochure, are also available free on the CEMA Web Site at <http://www.cemanet.org/Safety/>

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Prepared by the Screw Conveyor Engineering Committee of the
Engineering Conference

Conveyor Equipment Manufacturers Association

Screw Conveyors for Bulk Materials

CEMA Book No. 350

Third Edition

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A VHS safety instruction tape, entitled ***Screw Conveyor, Drag Conveyor, and Bucket Elevator Safety Video***, has also been developed by the CEMA Screw Conveyor Section. It describes key safety practices people should adhere to when working with and around these different conveyors. It is available for purchase from CEMA.

NOTE: *Some pictures and diagrams of screw conveyors in this book are without covers or have exposed screws or shafting and are for illustration purposes only. Conveyors should never be used without covers, guards, or protective equipment.*

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Foreword

While the screw conveyor as we know it today is the descendant of the oldest form of conveyor in recorded history, utilizing the oldest mechanical device employed by mankind, the inclined plane (wrapped around a core to form a helix), this book is the first attempt to bring together the collective knowledge and experience of leading manufacturers to codify what has come to be acceptable engineering practice for the benefit of user and manufacturer alike.

The Screw Conveyor Engineering Committee of the CEMA (Conveyor Equipment Manufacturers Association) Engineering Conference was assigned the task of bringing together under one cover the accumulated experience of many individuals and their companies in an effort to provide a common basis for the selection and installation of screw conveyors of sizes and capacities to handle the most commonly encountered bulk materials of commerce and industry.

This book is not intended as the final word on all screw conveyor engineering, but rather to serve as an engineering guide. Those who have contributed so generously of time and effort to its compilation strongly recommend that help from conveyor manufacturers be enlisted to check selection of sizes, capacities and types of conveyors where there is the least element of doubt, and always when materials of unknown, unusual or changeable character are involved. Today's rapidly changing technology and the continuous introduction of new materials—or old materials with new characteristics—emphasizes this recommendation as a means to the satisfactory performance of a conveyor or conveyor system.

The Conveyor Equipment Manufacturers Association believes that this publication represents a milestone in the long historical development of the screw conveyor as a vital machine for the transport of a wide variety of materials.

***NOTE:** Environmental as well as many other conditions vary with each installation. As a result, this engineering manual is intended merely as a guide to conveyor selection. Neither the Conveyor Equipment Manufacturers Association nor its member companies warrant that adherence to the guidelines set forth in this brochure will necessarily result in proper selection, manufacture, installation or maintenance of conveyor equipment and/or a conveyor system. Unless there are specific written specifications or recommendations pursuant to a written contractual commitment, the Conveyor Equipment Manufacturers Association and its member companies hereby disclaim all responsibility for any equipment and/or system malfunction, any violations of law, property damage, personal injury or any other damages resulting from equipment and/or system selection, design, installation, maintenance, or operation carried out by the contractor or user.*

Nomenclature

The following list covers the symbols used in this book:

| | |
|--------|---|
| A | Area, square inches |
| A_b | Cross-sectional area of coupling bolt, square inches |
| A_p | Projected area of pipe and bushing bolt hole, square inches |
| a | Coupling bolt hole diameter, inches |
| C | Capacity, cubic feet per hour |
| C_F | Capacity factor |
| C_f | Screw feeder capacity, cubic feet per hour at one RPM |
| c | Coefficient of linear expansion, inches per inch per degree F |
| D | Diameter, inches |
| D_d | Coupling shaft diameter, inches |
| D_p | Pipe diameter, inches |
| D_s | Conveyor screw diameter, inches |
| E | Modulus of elasticity |
| e | Combined efficiency of drive motor and reduction gear |
| F_b | Hanger bearing factor |
| F_d | Conveyor diameter factor |
| F_f | Flight factor |
| F_m | Material factor |
| F_o | Overload factor |
| F_p | Paddle factor |
| F_v | Empirical Vertical Screw Conveyor Factor |
| HP | Horsepower |
| HP_a | Friction horsepower of empty feeder conveyor |
| HP_b | Friction horsepower of material only, in feeder conveyor |
| HP_f | Friction horsepower of empty screw conveyor |
| HP_m | Friction horsepower of material only, in a screw conveyor |
| HP_v | Horsepower to convey material vertically |
| I | Moment of inertia |
| J | Polar moment of inertia |
| K | Percent of trough loading, expressed decimally |
| L | Length, feet |

| | |
|-------|--|
| L_1 | Feeder conveyor length, feet |
| l | Length, inches |
| L_f | Equivalent length of feeder, feet |
| N | Speed of conveyor, RPM |
| n | Number of coupling bolts at each end of screw section |
| P | Pitch of screw flight, inches |
| psi | Pounds per square inch |
| R | Ratio of lump sizes |
| RPM | Revolutions per minute |
| r | Load radius, inches |
| S | Allowable working stress, psi |
| S_1 | Allowable shear stress in coupling bolts, psi |
| S_2 | Allowable bearing stress for coupling bolts, pipe and bushing, psi |
| S_3 | Allowable shear stress in pipe, psi |
| S_4 | Allowable shear stress of unhardened coupling, psi |
| S_5 | Allowable shear stress of hardened coupling, psi |
| T | Torque, inch pounds |
| T_1 | Torsional shear rating of coupling bolts, inch pounds |
| T_2 | Torsional bearing rating of coupling bolts, inch pounds |
| T_3 | Torsional rating of pipe, inch pounds |
| T_4 | Torsional rating of unhardened coupling, inch pounds |
| T_5 | Torsional rating of hardened coupling, inch pounds |
| t_1 | Higher of any two temperatures, degrees F |
| t_2 | Lower of any two temperatures, degrees F |
| W | Weight or apparent density of material, pounds per cubic foot |
| w | Weight of a section, part or piece, pounds |
| Z_p | Polar section modulus of pipe or coupling shaft |

Screw Conveyor History and General Application

**Screw Conveyor History
Application of Screw Conveyors
Design Preparation
Illustrations**

Screw Conveyor History

If we overlook the possibility that some caveman used some round tree branches under a rock to replace sliding friction by rolling friction, thereby inventing the roller conveyor, undoubtedly the first conveyor as such was designed by Archimedes (287 to 212 B.C.)—Greek mathematician, physicist and inventor—for removing water from the hold of a ship built for King Hiero of Syracuse. Apparently the idea was a success, for this same device was next used to raise water from a river to irrigate farm land.

The Archimedean conveyor was of the internal helical screw type. It was mounted at an angle with its lower end in the water and the upper end arranged to discharge the water to a flume or irrigation ditch. The device was powered by a slave who turned a crank fixed to its upper end. Even in contemporary times a similar machine is said to have been used in the Netherlands—except for the substitution of electrical power for muscle power. In modern industry, the Archimedean screw exists in the form of a tubular conveyor, to the inner surface of which is fastened a helical ribbon. The exterior of the tube is supported on rolls, and the tube is revolved by a pinion meshing with an externally mounted ring gear.

It is said that Archimedes may have been the originator of two other forms of screw conveyors. One, a tube formed into a helix around a central shaft or core; the other, a helix rotating within a stationary casing, is the forerunner of the modern screw conveyor in its most common form.

A little before 1790, an American inventor, John Fitch, designed a steam boat to be propelled by a section of screw conveyor flighting that appears in the drawings of that day to be almost identical to flighting used in present day screw conveyors. It appears, though, that this method of ship propulsion was at once a victim of technological obsolescence brought on by the success of paddle wheels. The term, "screw," still lives on as the usual terminology for a ship's propeller.

During the many centuries of individual or small group self-sufficiency following the days of Archimedes, there was little need for continuous mechanical handling devices because there was little need for volume production, and even if there had been, there was no satisfactory source of power available.

It was about 1900 years later that screw conveyors again were proposed, when it became imperative that some means be found to handle mechanically the grain harvests made necessary to serve the needs of the rapidly growing American population. In 1783, the man who might be called the patron saint of mechanized materials handling, Oliver Evans, laid out on paper his first mechanized flour mill which incorporated not only screw conveyors but bucket elevators and belt conveyors as well. All these devices were tied together by a system of wooden toothed gears, wooden pulley and leather belts, and all were driven from a single water wheel.

The first mill built by Evans in 1785 actually was a reconstruction of a 1742 mill thought by some to have been built by his grandfather. The screw conveyor as first designed by Evans consisted of a round wooden core on which were mounted in helical form a series of wooden plows or flattened wooden pegs. The whole screw assembly revolved in a wooden trough or "box" as it was called then. Appropriate sliding gates in the trough bottom could be opened to deliver grain to the mills as needed. Soon, though, Evans improved on his design by making the screws of helically formed sheet metal sections mounted on a wooden core that might be anywhere from five to twenty feet long. He still maintained his trough of "close fitting" boards.

In Rock Creek Park, Washington, D.C., visitors may inspect a restored mill of the Oliver Evans era. The Pierce Mill was built around 1820 (the exact year is open to