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Third Edition

SCREW CONVEYORS
for Bulk Materials

PREVIEW COPY

CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION

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CEMA SCREW CONVEYOR PRODUCT SECTION

It is provided as a service to the Bulk Handling Industry

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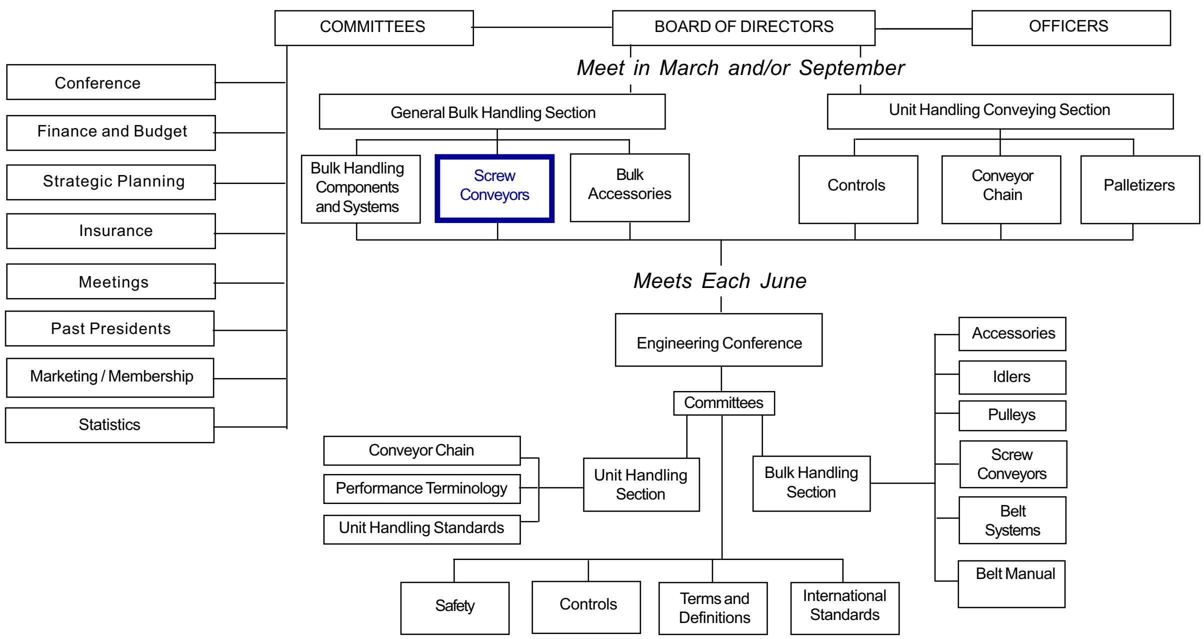

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Prepared by the Screw Conveyor Engineering Committee of the Engineering Conference
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Screw Conveyors for Bulk Materials

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Safety Notice

The Conveyor Equipment Manufacturers Association (CEMA) has developed industry ***Standard Safety Labels*** for use on the conveying equipment of its member companies. The purpose of the labels is to identify common and uncommon hazards, conditions, and unsafe practices that can injure, or cause the death of, the unwary or inattentive person who is working at or around conveying equipment. The labels are available for sale to member companies and nonmember 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 nonmembers of the Association.

PLEASE NOTE: Should any of the safety labels supplied by the equipment manufacturer become unreadable for any reason, the equipment USER is then responsible for replacement and location of these safety labels.

Replacement labels and placement guidelines can be obtained by contacting your equipment supplier or CEMA.

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.*

Contents

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

CHAPTER 1

Screw Conveyor History and General Application

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 argument) by one Isaac Pierce and his son, Abner. The mill is in running order and has all of the types of conveyors that Evans used, including screw conveyors with wooden flights on wooden cores on which wrought iron journals were pressed.

During this period the country grain elevator evolved of necessity to handle what then was thought to be vast volumes of grain needed by the growing and hungry population. Conveyors of the types Evans used in his "automatic" flour mills were ready made for grain elevator service. The technology of mechanization was keeping pace with the demands of the spreading population.

The metal screw conveyor flights were originally of the sectional flight variety, formed from flat sheets cut in circular form with a hole in the center then split on one side and the two edges pulled apart to form one flight section of a screw. Successive flights were then joined by riveting, shingle fashion, to make a continuous helix of whatever length was called for. At some unknown date, the wooden core was replaced by an iron pipe when the proper sizes of such pipes became available.

The next technological advancement of importance in screw conveyor design was patented March 29, 1898, by Frank C. Caldwell under patent number 601429. This was a continuous, one piece screw flight formed by rolling a continuous strip of steel into a helix. This construction is now known as the "helicoid" flight, and simplified manufacture and assembly by eliminating the joints in the sectional flight screws. Both types of screws are still produced.

Early screw conveyors used wooden bearings and there are still applications where such bearings are specified. Cast iron support hangers for the bearings and cast iron trough ends came along with the all-metal screws. The first use of metal in a trough probably was a sheet metal box liner curved to follow the periphery of the screw, and fastened in the wooden "box" or trough.

Since the screw conveyor came into general use a little over a century ago for moving grains, fine coal and other bulk material of the times, it has come to occupy a unique place in a growing area in the general field of materials handling and processing. Many refinements in design, materials and methods have come into general use. Welding has supplanted rivets to provide smooth conveying surfaces along with greater strength and rigidity in screws and troughs. Ball bearings for hangers have become less bulky so they now occupy little more space than did the older plain sleeve bearings. Such bearings in the box or trough ends provide improved thrust capacity. Improved methods of sealing to keep out foreign materials and to retain lubricants have greatly expanded the use of anti-friction bearings in screw conveyors.

Enclosed drive speed reduction units in place of open gearing greatly reduces hazards to workmen and reduces maintenance work largely to a matter of periodic inspection. The screw conveyor engineer has a tremendous latitude in the selection of materials to best meet the operating conditions of a particular conveying job, when it falls outside the broad capabilities of standard screws made of ordinary steel.

Whole new families of bulk products are being handled as a matter of course today that were not even thought of just a few years ago, and the advance of technology is such that additional new products are being discovered and developed almost daily for industrial and agricultural use. Many such products are toxic to human beings, or are toxic at certain stages of their processing. Others are merely irritating or unpleasant to work around. Screw conveyors often are the answer to handling these products. Highly developed seals and methods of using them help to confine the products conveyed—along with any dust, gas or fumes—within the trough and out of contact with anyone in the area. They also help to protect materials from contamination by foreign matter.