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SCREW CONVEYORS

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SCREW CONVEYORS

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**Prepared By
The Screw Conveyor Engineering Committee
of the
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Conveyor Equipment Manufacturers
Association
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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 and which utilizes 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* 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 (CEMA) 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.

* Conveyor Equipment Manufacturers Association

Nomenclature

The following list covers the symbols used in this book.

A	Area, square inches
Ab	Gross cross-sectional area of conveyor screw, square inches
Ap	Projected area of pipe and bushing bolt hole, square inches
a	Coupling bolt hole diameter, inches
C	Capacity, cubic feet per hour
CF	Capacity factor
Cf	Screw feeder capacity, cubic feet per hour at one RPM
c	Coefficient of linear expansion, inches per inch per degree Fahr.
D	Diameter, inches
Dd	Coupling shaft diameter, inches
Dp	Pipe diameter, inches
Ds	Conveyor screw diameter, inches
E	Modulus of elasticity
e	Combined efficiency of drive motor and reduction gear
Fb	Hanger bearing factor
Fd	Conveyor diameter factor
Ff	Flight factor
Fm	Material factor
Fo	Overload factor
Fp	Paddle factor
Fv	Empirical Vertical Screw Conveyor Factor
Hp	Horsepower
HPa	Friction horsepower of empty feeder conveyor
HPb	Friction horsepower of material only, in feeder conveyor
HPf	Friction horsepower of empty screw conveyor
HPm	Friction horsepower of material only, in a screw conveyor
HPv	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
Lf	Equivalent length of feeder
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
T₁	Torsional shear rating of coupling bolts, inch pounds
T₂	Torsional bearing rating of coupling bolts, inch pounds
T₃	Torsional rating of pipe, inch pounds
T₄	Torsional rating of unhardened coupling, inch pounds
T₅	Torsional rating of hardened coupling, inch pounds
t₁	Higher of any two temperatures, degrees F
t₂	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

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Screw Conveyor History and General Application

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Chapter 1

Screw Conveyor History and General Application

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 true conveyor as such was designed by Archimedes (287 to 212 BC) - 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 today a similar machine is said to be used in the Netherlands - except for the substitution of electrical power for muscle power. In today's 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, is not now seen in use; 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 eliminate hazards to workmen and reduce maintenance work largely to a matter of periodic inspection. The screw conveyor engineer has a tremendous latitude in the selection of materials best to 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 confine the products conveyed - along with any dust, gas or fumes, - within the trough and out of contact with anyone in the area. Also, materials are protected from contamination by foreign matter.

The versatile screw conveyor is no longer limited to transporting materials on the horizontal. Standard designs with auxiliary equipment are available for operating up or down a slope or for the vertical elevating of some materials.

While screw conveyors are about the oldest form of conveyor known today, they are still among the most useful of mechanical handling devices, a fact attested to in the past twenty years by a seven-fold growth in the rate of annual manufacture.

In addition to the movement of bulk materials, screw conveyors are now forming an integral part of many production processes where mixing, blending, heating, cooling, dewatering, drying or similar operations must be performed in transit.

Thus, one of the oldest forms of conveyor on record has become an important factor in Space Age industrial technology.

APPLICATION OF SCREW CONVEYORS

Screw conveyors are bulk material transporting devices capable of handling a great variety of materials which have relatively good flowability. Flowability is defined in the CEMA Material Classification Standard and denotes the degree of freedom of individual material particles to move past each other. This characteristic is important in screw conveyor operation as the screw helix, mounted on a central pipe or shaft, rotates within a fixed trough or tube, pushes the material along the bottom and sides, shearing the material in the radial clearance between the helix and trough and causing the material to tumble upon itself as the moving face of the helical flight tends to lift the material.

The various applications of screw conveyors proceed naturally from two factors: the characteristics of the material to be conveyed and the operating advantages peculiar to this type of conveyor.

Among the many advantages of screw conveyors is the feasibility of numerous feed and discharge openings, each easily provided with a regulating gate. This facility lends itself to the use of screw conveyors to receive and distribute bulk materials for in-plant material storage in such a manner that different grades or different kinds of materials may be conveyed to or from the proper storage bins. Screw conveyors likewise may be used for unloading materials from cars, bins or piles, often to initiate a material process. Typical applications are grain storage plants, feed mills, cereal processing plants and chemical plants.

Screw conveyors are very adaptable to the volume control of materials from the bottoms of bins, hoppers, bag dumps, storage piles and the like. In this use they are termed screw feeders and as such fill a most important place in industry. Not only is the control of volume necessary for the proper operation of succeeding conveyors of any type, but also for the operation of processing units such as dryers, hammer mills, oil expellers and countless other pieces of processing machinery.

It is rather simple to arrange screw conveyors for the heating or cooling of material in transit. The conveyor trough is provided with a jacket through which the heating or cooling medium is circulated to obtain the required degree of heat transfer. Another use is the blending of several ingredients to make a finished product or to make a pre-mix for some product. This may involve the blending of different grades of the same material or the making of a blended mixture of different materials. The conveyor screw can be so fashioned that materials are well mixed or blended while in transit.

In the handling of toxic materials screw conveyors lend themselves very well because the enclosing trough can be made tight enough to contain toxic dusts or vapors, thus reducing personnel hazards. Conversely, materials that must be kept free from contaminants are nicely handled. In some processing operations, the fact that the material load in the conveyor acts as a "nut" on the helical screw permits screw conveyors, particularly the tubular types, to be used as air or vapor lock devices. The conveyed solids enter and leave but the gases or vapors cannot pass through.

Screw conveyors may be operated horizontally, on an incline or vertically. Frequently, inclined conveyors simplify a conveying system because they can do in one conveyor assembly what otherwise would require a more elaborate combination of horizontal and vertical units. Several types of vertical screw conveyors are available. These generally have tubular troughs in which the screws operate at appreciably higher speeds than in horizontal units.

CEMA has established dimensional standards for many screw conveyor components. These standards are detailed in *CEMA Standard Book No. 300 - 1971* and may be obtained from the Conveyor Equipment Manufacturers Association.



Tail Ends of Two Screw Conveyors Arranged Side by Side and Fed From Bifurcated Chutes With Flop Gates.

FIGURE 1.1

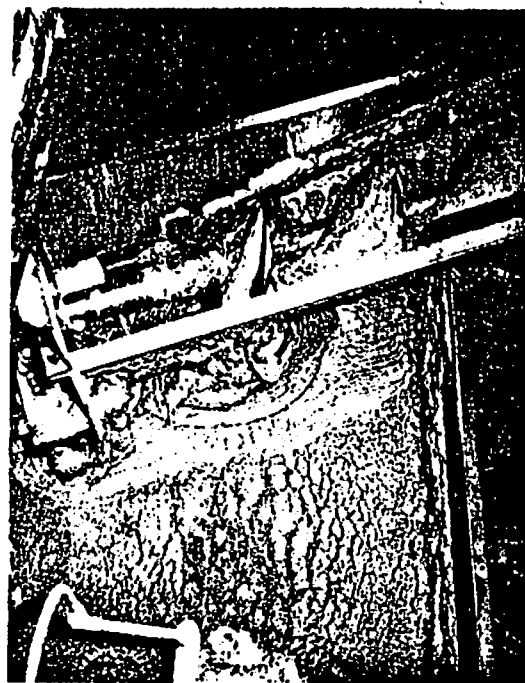


FIGURE 1.2

Stainless steel screw conveyor in a flared trough carrying a mixture of raw sugar and molasses.



FIGURE 1.3

A 9" diameter inclined screw conveyor moves creamed corn from silking to mixing operations.

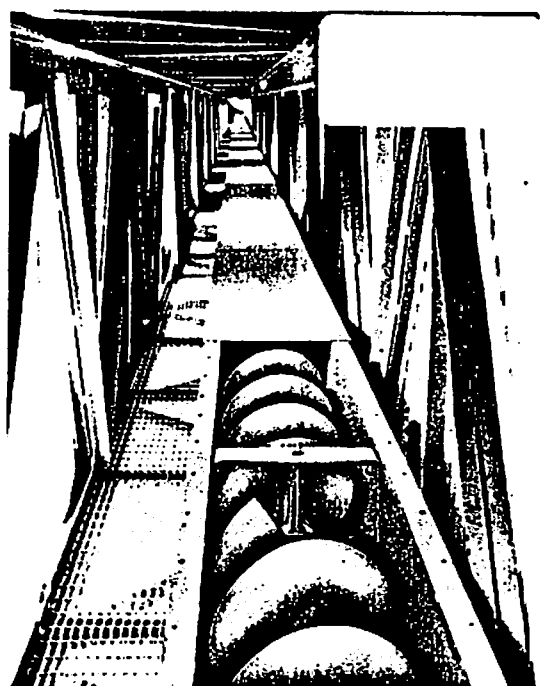


FIGURE 1.4

Large diameter screw conveyor installed in the malt house of a brewery

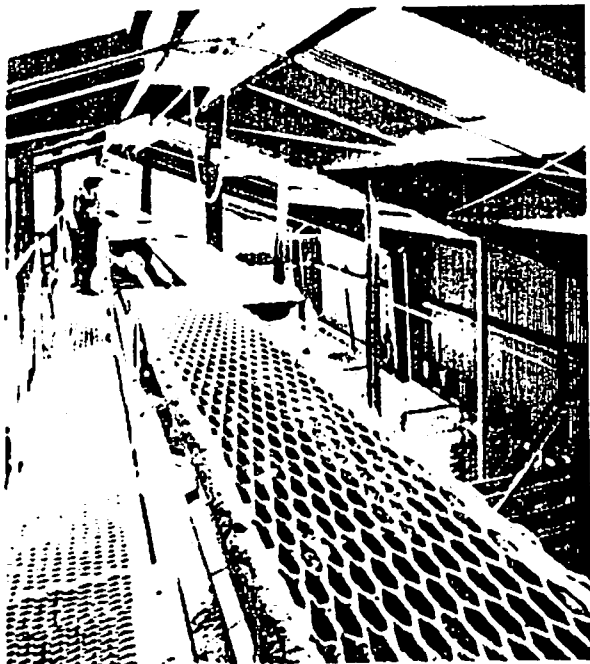


FIGURE 1.5

An offset type of screw conveyor construction that eliminates the need for intermediate hanger bearings.

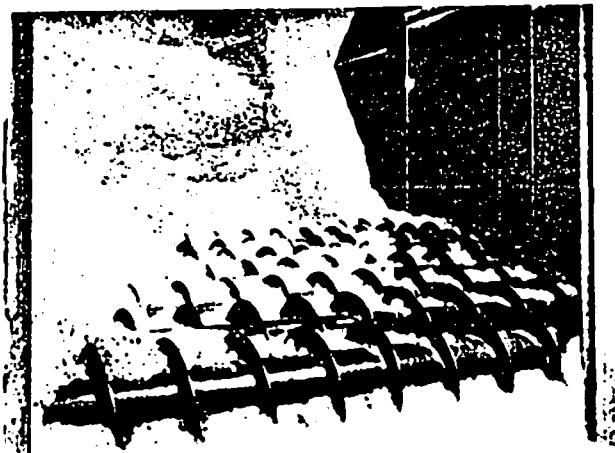


FIGURE 1.6

In a live bottom bin, 16 parallel screws overcome the tendency of wood shavings to bridge and arch. Wood is refuse, being carried to boiler.

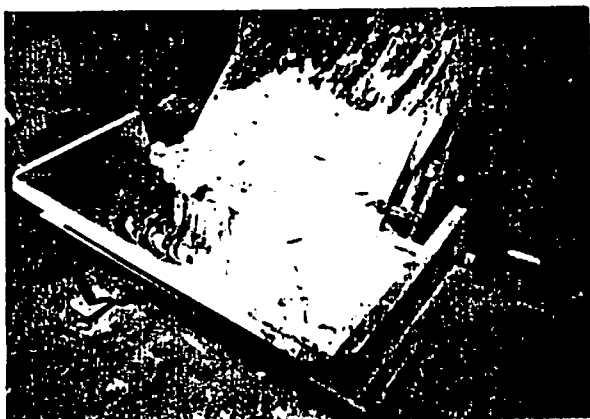


FIGURE 1.7

Cut flight screw in a feed hopper breaks up chunks of mash. Flared trough contributes to better flow.



FIGURE 1.8

Open bottom screw conveyors increased capacity of this storage bin 50 per cent. Clay forms its own carrying surface, enabling bin to fill almost to the ceiling.

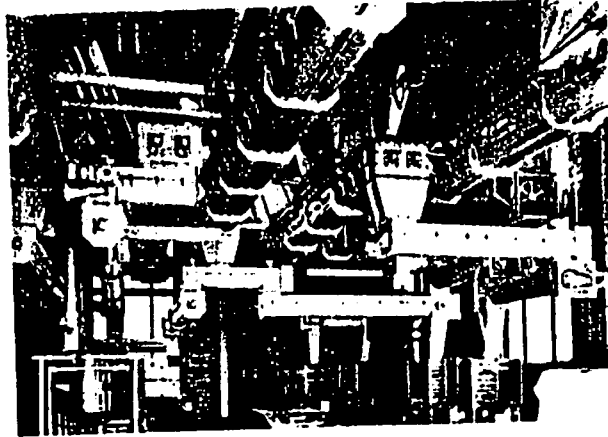


FIGURE 1.9

Large bakery uses screw feeders and conveyors to regulate handling of flour and sugar from storage to sifting and mixing rooms. Reversible screws in key locations permit feeding to more than one sifter without use of gates.

It is the purpose of this book to facilitate the engineering application of screw conveyors made up of these standardized components.

The data here presented applies to the handling of such bulk materials as are generally found in industrial conveying problems and does not relate to special applications such as snow blowers, grain harvesting machines or similar individual farm machinery units.

DESIGN PREPARATION

Experience shows that the key to successful screw conveyor design is a thorough knowledge of the characteristics of the material to be handled. Chapter 2 offers a coded classification of many bulk materials. The code is based on the physical characteristics of the listed materials and provides a basis for determining screw conveyor specifications.

It is important to understand that the action of a screw conveyor is such that it tends to tumble and shear the material as it is being conveyed. Therefore, it follows that materials which tumble or shear readily are more easily conveyed than others which do not.

Of paramount importance in the design of any conveyor is the knowledge and understanding of the way material will flow and the effect of variations in the flow. Capacity in most bulk material handling is often expressed in terms of pounds or tons per unit of time. Maximum capacity is very often greater than average daily or hourly output. Furthermore, the apparent density of the ma-

terial may vary. Conveyor size and speed is based on maximum volume. To obviate difficulties, the recommended practice is first to establish the maximum poundage per unit of time and then to determine the corresponding volumetric conveyor capacity by dividing the maximum poundage rate by the least apparent density expected in the material.

As an example, bulk Portland cement, packaged in barrels, weighs 94 lbs. per cubic foot. When this cement is conveyed in a screw conveyor, it will aerate and its apparent density will be less. As conveyed in a screw conveyor, cement may have an apparent density as low as 60 lbs. per cubic foot. Thus, to determine the volumetric capacity of the screw conveyor, it will be necessary to divide the required maximum poundage rate by 60 instead of 94.

Surge loads are frequent in many conveyor systems. The likelihood of surge loads depends upon the means of initiating the flow. This may be as simple - and likely as inconstant - as a slide gate in the bottom of a bin. Even with more sophisticated feed regulation than a simple gate, materials do not always flow uniformly from the bottom of a bin or storage pile, consequently there always is the hazard of varying flow. Care should be exercised to consider possible surge loads and to proportion the screw conveyor so that it has the capacity to handle the maximum surge volume.

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Chapter 2

Bulk Material Characteristics, Material Code, Conveyor Size and Speed, Component Groups

BULK MATERIAL CHARACTERISTICS

A study has been made to define the characteristics of bulk materials in terms which are readily recognized. These characteristics and terms are indicated in the Material Classification Code Chart. It can be seen that different materials having the same classification code number may be handled with screw conveyors having the same specifications. Also, should it be desired to handle a material not given in the Material Table, it is possible to make at least a preliminary selection of material code number by comparing the material with similar listed materials.

It should be borne in mind that because of the peculiar action of a conveyor screw in moving bulk materials, the condition of the material in transit may be quite different from the condition at rest.

Materials, first of all, are classified according to particle size. It is important to have a screen analysis made of the material, if at all possible. For example if a material is said to consist of $\frac{1}{2}$ inch and under, it may be similar to granules of plastic. Or it may have only 10% of $\frac{1}{2}$ " particle size, with 90% fines grading to micron sizes. Granular materials which have no fines such as granules of plastic or clean grain require no special gasketing of trough covers, nor any seals at the trough end. Other materials with the same maximum particle size but which do contain fines may involve gasketing of trough cover and the protection of the bearings at trough ends or intermediate locations.

Lumpy materials must be checked against the Lump Size Table. Very often larger screw conveyors must be used solely to accommodate the lumps, than otherwise would be required from a standpoint of normal capacity. See Table 2-3 on page 27.

Irregular, stringy and interlocking materials that mat or cling together require special consideration. Stringy materials, particularly if long enough, may wrap around the pipe shaft of the conveyor screw or around the intermediate hanger bearings, thus effectively clogging the conveyor. Materials that mat may also be those that pack under pressure. If the material does pack under pressure, it may jam the conveyor screw and seriously damage the conveyor. All materials with these characteristics must be carefully studied in detail with respect to their actions in a screw conveyor.

Materials are also classified as to their flowability. This, unfortunately, is a relative term and not easily measured. It has been claimed that flowability is related to the angle of repose such that the coefficient of friction of the material moving over the conveyor surfaces is the tangent of this angle. However, so far as the operation of screw conveyors is concerned, flowability is related to two factors, one the angle of slide and the other the angle of internal friction of the material. The angle of slide may be determined by tilting a plate carrying a quantity of the material. The angle of internal friction may be evaluated from shear cell test data. Changes in moisture content, temperature, particle size distribution and chemically corrosive action of the material all affect the flowability.

Experience with screw conveyors show that the more free flowing the material is, the less horsepower will be required to transport it. The converse also is true. Because flowability isn't easily reduced to numerical terms, actual experience has been the guide in codifying the flowability of the materials in Table 2-2.

Judging a material just from its angle of repose is misleading. Some materials which have a very high angle of repose when stored in a bin may have a very low angle of repose in the "as conveyed" condition in a screw conveyor. An example of this is wheat bran. Its particles vary widely in shape and size yet it appears to have a relatively low angle of "repose" or rather angle of slide, while moving thru a screw conveyor.

It is known that some materials which are uniform in particle shape and size are quite free-flowing when dry. Screened dry sand is quite free flowing. The addition of moisture, however, changes the flowability character. Likewise, dry granulated sugar is free-flowing, but this material is hygroscopic and will pick up moisture from the air. If this happens, its flowability is changed considerably. The flowability of most materials is affected by changes in their moisture content, with consequent changes in their ability to be conveyed.

The abrasiveness of materials is also a relative quantity, and isn't easily defined with accuracy. Some materials are more abrasive than others. It will be found that non-abrasive or very mildly abrasive materials can be handled with screw conveyors with standard gauge screws and troughs as specified in the Component Group 1A for Normal Service, table 2-7. Very abrasive materials require heavier than standard components. See Component Groups in tables 2-8 and 2-9. Most abrasive materials in the following Material Table, Table 2-2, are handled at lower cross-sectional loads than are the non abrasive materials. This is done to attain the maximum economical life of the conveyor and its parts.

The selection of components for handling abrasive materials should also be considered in view of the amount of service to which the conveyor will be subject. Continuous, 24 hour per day operation will cause more wear than if the conveyor were operating but a few hours per day.

All of the foregoing bulk material characteristics are described in more detail in C E M A publication book No. 550-1970 entitled Classification and Definition of Bulk Materials. Chapter II of that publication fully explains size classification and coding, flowability coding and abrasive coding. In addition there are certain other miscellaneous bulk material characteristics that are defined in chapter I as hazards affecting conveyability. The effect of some of these hazards as they affect screw conveyor design follows.

- K. Some bulk substances are sensitive to small changes in temperature or pressure. For example, materials containing vegetable oils or fats can become spoiled by the heat of friction in a hanger bearing.
- L. Dusty materials, especially those that are very dusty should be carefully considered. Previous experience with similar materials is the best guide. Flange gaskets and special trough end seals may be needed. See Chapter 5 for several classes of construction.
- M. Some materials such as dry Portland cement will aerate and develop fluid characteristics as a result of transport in a screw conveyor. The "as conveyed" apparent density is much lower than the normal apparent density. Many dusty and aerated materials can bypass an intermediate discharge spout. As the material becomes more fluidlike, the flowability increases markedly, and in some cases the aerated material will flood and run like water with the result that the cross-sectional load increases and control

- of the rate of flow is lost. Consult your conveyor manufacturer regarding materials which may aerate greatly.
- N. Dusts associated with certain bulk materials are flammable or even explosive when mixed with air in the proper concentration. It is therefore highly desirable to contain dust laden material at all times within the conveyor enclosure. Grain dust is an example. The very nature of a screw conveyor - being an enclosed conveying device - makes it satisfactory for handling materials with flammable or explosive dusts, although more sophisticated than standard enclosures may be required. Consult Chapter 5, Classes of Enclosures, page 75.
- P & Q. Contaminable and degradable materials must be recognized because their salability or use may be affected by improper conveying or ill-considered conveyor specifications. Suitable non-lubricated bearings should be used. Low conveyor speeds normally will prevent excessive degradation.
- R. Materials in this category are similar to those described under L and N, except that exposure of the dust or fumes may be hazardous to personnel. Tight enclosures and spouting connections - usually gasketed - are required. Elaboration of the enclosures depends upon the severity of the hazard.
- S&T. Corrosion protection requiring the use of special metals is a common problem. Here again "corrosion" is a relative term which isn't easily defined numerically. Consult Chapter 5, Materials of Construction, page 74. The choices of materials of construction, such as the types of stainless steel or other special metals, should be referred to the conveyor manufacturer.
- U. Certain bulk materials are hygroscopic. They absorb water from the moisture in the ambient atmosphere. The water they pick up changes their flowability, of course, and this has been taken into account for the usual behavior of such materials as listed in Table 2-2.
- V&X. Bulk materials which interlock and mat usually will require screws of heavier than standard construction and flight edges that can cut their way through the material. Intermediate hanger bearings may have to be eliminated. A similar condition exists for materials which pack under pressure.
- W. Oils or chemicals that may be contained in bulk materials require special consideration. Some of these constituents may make the materials sticky and cause adherence to the working parts of the conveyor. Ribbon type conveyor screws sometimes help. It is best to consult your conveyor manufacturer when attempting to handle such materials.
- Y. Light and fluffy materials require consideration similar to those which are dusty or which tend to aerate as they are conveyed. See paragraphs L and M.
- Z. Elevated temperatures are encountered in many phases of material processing. Screw conveyors should be fabricated of heavier than standard construction and design to withstand the inevitable expansion and contraction that takes place. Intermediate hanger bearings must be protected against heat or omitted. End bearings and drive equipment may be separated from the trough end to reduce their exposure to heat. Consult Chapter 5, Screw Conveyors for Hot Materials.

Table 2-1
Material Classification Code Chart

Major Class	Material Characteristics Included	Code Designation
Density	Bulk Density, Loose	Actual Lbs/CF
Size	Very Fine No. 200 Sieve (.0029") And Under No. 100 Sieve (.0059") And Under No. 40 Sieve (.016") And Under	A ₂₀₀ A ₁₀₀ A ₄₀
	Fine No. 6 Sieve (.132") And Under	B ₆
	Granular ½" And Under 3" And Under 7" And Under	C _½ D ₃ D ₇
	Lumpy 16" And Under Over 16" To Be Specified X=Actual Maximum Size	D ₁₆ D _x
	Irregular Stringy, Fibrous, Cylindrical, Slabs, Etc.	E
Flowability	Very Free Flowing - Flow Function > 10 Free Flowing - Flow Function > 4 But < 10 Average Flowability - Flow Function > 2 But < 4 Sluggish - Flow Function < 2	1 2 3 4
Abrasiveness	Mildly Abrasive - Index 1-17 Moderately Abrasive - Index 18-67 Extremely Abrasive - Index 68-416	5 6 7
Miscellaneous Properties Or Hazards	Builds Up and Hardens Generates Static Electricity Decomposes - Deteriorates in Storage Flammability Becomes Plastic or Tends to Soften Very Dusty Aerates and Becomes Fluid Explosiveness Stickiness-Adhesion Contaminable, Affecting Use Degradable, Affecting Use Gives Off Harmful or Toxic Gas or Fumes Highly Corrosive Mildly Corrosive Hygroscopic Interlocks, Mats or Agglomerates Oils Present Packs Under Pressure Very Light and Fluffy - May Be Windswept Elevated Temperature	F G H J K L M N O P Q R S T U V W X Y Z

PREFACE TO MATERIAL TABLE

The material table 2-2 lists a wide range of bulk materials that can be handled in screw conveyors. The table shows in the first column the range of density that can be experienced in handling that material. The "as conveyed" density is not specifically shown but is often assumed to be at or near the minimum.

The next column shows the material code number. This consists of the average density, the usual size designation, the flowability number, the abrasive number followed by those material characteristics which are termed conveyability hazards.

The component series column refers to selection of conveyor components as used in tables 2-7, 2-8 and 2-9 of this chapter.

A very fine 100 mesh material with an average density of 50 lbs. per cubic foot that has average flowability and is moderately abrasive would have a material code 50A10036. If this material was very dusty and mildly corrosive the number would then be 50A10036LT.

The Material Factor is used in the horsepower formula to determine the horsepower to operate a horizontal screw conveyor. The calculation of horsepower is described in Chapter 3, Page 36.

The indication of suitability for handling the material in a vertical screw conveyor is only a guide. See Chapter 7.

The information and data in the Material Table, Table 2-2, has been compiled by members of CEMA and represents many years of experience in the successful design and application of screw conveyors for handling the listed materials. The indicated physical characteristics of these materials are not the result of any particular laboratory tests but were learned from the actual industrial operation of countless screw conveyors.

The Material Table includes various grains, seeds, feeds, etc. that are commonly handled in many conveyor types. The published unit weights, the component series and material factors F_m are for average conditions. For instance wheat when dry or with a low moisture of less than 10% is very free flowing and the F_m factor of .4 can be used. When higher moistures are prevalent a material factor of .5 or .6 is suggested. This phenomena is common to all grains and some other substances.

It should also be noted that soybeans are shown as being very abrasive. Heavy conveyor construction is recommended. This is because soybeans, especially when dirty and harvested at a low moisture, are extremely abrasive. On the other hand, hard iron bearings which are commonly used with abrasive materials cannot be recommended either because of spark generation and consequent dust explosions. This phenomena is also true of rough rice and to a lesser degree on other grains.

The Material Table is a guide only. The material code, and the material factor F_m are based on experience of the several conveyor manufacturers. A specific material sample may have properties that vary from those shown in the table. The range of densities will also vary depending on moisture content as well as its source.

Table 2-2
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Adipic Acid	45	45A10035	2B	.5	x
Alfalfa Meal	14-22	18B645WY	2D	.6	x
Alfalfa Pellets	41-43	42C1/225	2D	.5	
Alfalfa Seed	10-15	13B615N	1A-1B-1C	.4	x
Almonds, Broken	27-30	29C1/235Q	2D	.9	
Almonds, Whole Shelled	28-30	29C1/235Q	2D	.9	
Alum, Fine	45-50	48B635U	1A-1B-1C	.6	
Alum, Lumpy	50-60	55B625	2A-2B	1.4	
Alumina	55-65	58B627MY	3D	1.8	
Alumina Fines	35	35A10027MY	3D	1.6	
Alumina Sized or Briquette	65	65D337	3D	2.0	
Aluminate Gel (Aluminate Hydroxide)	45	45B635	2D	1.7	x
Aluminum Chips, Dry	7-15	11E45V	2D	1.2	
Aluminum Chips, Oily	7-15	11E45V	2D	.8	
Aluminum Hydrate	13-20	17C1/235	1A-1B-1C	1.4	x
Aluminum Ore (See Bauxite)	—	—	—	—	—
Aluminum Oxide	60-120	90A10017M	3D	1.8	
Aluminum Silicate (Andalusite)	49	49C1/235S	3A-3B	.8	x
Aluminum Sulfate	45-58	52C1/225	1A-1B-1C	1.0	
Ammonium Chloride, Crystalline	45-52	49A10045FRS	3A-3B	.7	
Ammonium Nitrate	45-62	54A4035NTU	3D	1.3	
Ammonium Sulfate	45-58	52C1/235FOTU	1A-1B-1C	1.0	
Antimony Powder	—	A10035	2D	1.6	x
Apple Pomace, Dry	15	15C1/245Y	2D	1.0	x
Arsenate of Lead (See Lead Arsenate)	—	—	—	—	—
Arsenic Oxide (Arsenolite)*	100-120	110A10035R	—	—	—
Arsenic Pulverized	30	30A10025R	2D	.8	
Asbestos-Rock (Ore)	81	81D337R	3D	1.2	
Asbestos-Shredded	20-40	30E46XY	2D	1.0	
Ash, Black Ground	105	105B635	1A-1B-1C	2.0	
Ashes, Coal, dry-1/2"	35-45	40C1/246TY	3D	3.0	x
Ashes, Coal, dry-3"	35-40	38D346T	3D	2.5	
Ashes, Coal, Wet-1/2"	45-50	48C1/246T	3D	3.0	
Ashes, Coal, Wet-3"	45-50	48D346T	3D	4.0	
Ashes, Fly (See Fly Ash)	—	—	—	—	—
Asphalt, Crushed-1/2"	45	45C1/245	1A-1B-1C	2.0	x
Bagasse	7-10	9E45RVXY	2A-2B-2C	1.5	
Bakelite, Fine	30-45	38B625	1A-1B-1C	1.4	x
Baking Powder	40-55	48A10035	1B	.6	x
Baking Soda (Sodium Bicarbonate)	40-55	48A10025	1B	.6	x
Barite (Barium Sulfate) + 1/2"-3"	120-180	150D336	3D	2.6	
Barite, Powder	120-180	150A10035X	2D	2.0	x
Barium Carbonate	72	72A10045R	2D	1.6	
Bark, Wood, Refuse	10-20	15E45TVY	3D	2.0	
Barley, Fine, Ground	24-38	31B635	1A-1B-1C	.4	x
Barley, Malted	31	31C1/235	1A-1B-1C	.4	x
Barley, Meal	28	28C1/235	1A-1B-1C	.4	x
Barley, Whole	36-48	42B625N	1A-1B-1C	.5	x
Basalt	80-105	93B627	3D	1.8	
Bauxite, Dry, Ground	68	68B625	2D	1.8	
Bauxite, Crushed-3"	75-85	80D336	3D	2.5	
Beans, Castor, Meal	35-40	38B635W	1A-1B-1C	.8	x
Beans, Castor, Whole Shelled	36	36C1/215W	1A-1B-1C	.5	x
Beans, Navy, Dry	48	48C1/215	1A-1B-1C	.5	
Beans, Navy, Steeped	60	60C1/225	1A-1B-1C	.8	

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Bentonite, Crude	34-40	37D ₃ 45X	2D	1.2	
Bentonite, -- 100 Mesh	50-60	55A ₁₀₀ 25MXY	2D	.7	x
Benzene Hexachloride	56	56A ₁₀₀ 45R	1A-1B-1C	.6	
Bicarbonate of Soda (Baking Soda)	--	--	1B	.6	
Blood, Dried	35-45	40D ₃ 45U	2D	2.0	x
Blood, Ground, Dried	30	30A ₁₀₀ 35U	1A-1B	1.0	x
Bone Ash (Tricalcium Phosphate)	40-50	45A ₁₀₀ 45	1A-1B	1.6	
Boneblack	20-25	23A ₁₀₀ 25Y	1A-1B	1.5	x
Bonechar	27-40	34B ₆ 35	1A-1B	1.6	x
Bonemeal	50-60	55B ₆ 35	2D	1.7	x
Bones, Whole*	35-50	43E45V	2D	3.0	
Bones, Crushed	35-50	43D ₃ 45	2D	2.0	x
Bones, Ground	50	50B ₆ 35	2D	1.7	x
Borate of Lime	60	60A ₁₀₀ 35	1A-1B-1C	.6	
Borax, Fine	45-55	50B ₆ 25T	3D	.7	x
Borax Screening--½"	55-60	58C _½ 35	2D	1.5	
Borax, 1½-2" Lump	55-60	58D ₃ 35	2D	1.8	
Borax, 2"-3" Lump	60-70	65D ₃ 35	2D	2.0	
Boric Acid, Fine	55	55B ₆ 25T	3D	.8	x
Boron	75	75A ₁₀₀ 37	2D	1.0	
Bran, Rice-Rye-Wheat	16-20	18B ₆ 35NY	1A-1B-1C	.5	
Braunite (Manganese Oxide)	120	120A ₁₀₀ 36	2D	2.0	
Bread Crumbs	20-25	23B ₆ 35PQ	1A-1B-1C	.6	
Brewer's Grain, spent, dry	14-30	22C _½ 45	1A-1B-1C	.5	x
Brewer's Grain, spent, wet	55-60	58C _½ 45T	2A-2B	.8	
Brick, Ground--1/8"	100-120	110B ₆ 37	3D	2.2	
Bronze Chips	30-50	40B ₆ 45	2D	2.0	
Buckwheat	37-42	40B ₆ 25N	1A-1B-1C	.4	x
Calcine, Flour	75-85	80A ₁₀₀ 35	1A-1B-1C	.7	
Calcium Carbide	70-90	80D ₃ 25N	2D	2.0	
Calcium Carbonate (See Limestone)	--	--	--	--	
Calcium Fluoride (See Fluorspar)	--	--	--	--	
Calcium Hydrate (See Lime, Hydrated)	--	--	--	--	
Calcium Hydroxide (See Lime, Hydrated)	--	--	--	--	
Calcium Lactate	26-29	28D ₃ 45QTR	2A-2B	.6	
Calcium Oxide (See Lime, unslaked)	--	--	--	--	
Calcium Phosphate	40-50	45A ₁₀₀ 45	1A-1B-1C	1.6	
Calcium Sulfate (See Gypsum)	--	--	--	--	
Carbon, Activated, Dry, Fine*	--	--	--	--	
Carbon Black, Pelleted*	--	--	--	--	
Carbon Black, Powder *	--	--	--	--	x
Carborundum	100	100D ₃ 27	3D	3.0	
Casein	36	36B ₆ 35	2D	1.6	
Cashew Nuts	32-37	35C _½ 45	2D	.7	
Cast Iron, Chips	130-200	165C _½ 45	2D	4.0	
Caustic Soda	88	88B ₆ 35RSU	3D	1.8	
Caustic Soda, Flakes	47	47C _½ 45RSUX	3A-3B	1.5	
Celite (See Diatomaceous Earth)	--	--	--	--	
Cement, Clinker	75-95	85D ₃ 36	3D	1.8	
Cement, Mortar	133	133B ₆ 35Q	3D	3.0	
Cement, Portland	94	94A ₁₀₀ 26M	2D	1.4	x
Cement, Aerated (Portland)	60-75	68A ₁₀₀ 6M	2D	1.4	x

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Cerrusite (See Lead Carbonate)	—	—	—	—	—
Chalk, Crushed	75-95	85D ₃ 25	2D	1.9	x
Chalk, Pulverized	67-75	71A ₁₀₀ 25MX	2D	1.4	
Charcoal, Ground	18-28	23A ₁₀₀ 45	2D	1.2	
Charcoal, Lumps	18-28	23D ₃ 45Q	2D	1.4	
Chocolate, Cake Pressed	40-45	43D ₃ 25	2B	1.5	
Chrome Ore	125-140	133D ₃ 36	3D	2.5	
Cinders, Blast Furnace	57	57D ₃ 36T	3D	1.9	
Cinders, Coal	40	40D ₃ 36T	3D	1.8	
Clay (See Bentonite, Diatomaceous Earth, Fuller's Earth, Kaolin & Marl)	—	—	—	—	—
Clay, Ceramic, Dry, Fines	60-80	70A ₁₀₀ 35P	1A-1B-1C	1.5	x
Clay, Calcined	80-100	90B ₆ 36	3D	2.4	
Clay, Brick, Dry, Fines	100-120	110C _{1/2} 36	3D	2.0	
Clay, Dry, Lumpy	60-75	68D ₃ 35	2D	1.8	
Clinker, Cement (See Cement Clinker)	—	—	—	—	—
Clover Seed	45-48	47B ₆ 25N	1A-1B-1C	.4	x
Coal, Anthracite (River & Culm)	55-61	60B ₆ 35TY	2A-2B	1.0	
Coal, Anthracite, Sized—1/2"	49-61	55C _{1/2} 25	2A-2B	1.0	
Coal, Bituminous, Mined	40-60	50D ₃ 35LNXY	1A-1B	.9	
Coal, Bituminous, Mined, Sized	45-50	48D ₃ 35QV	1A-1B	1.0	
Coal, Bituminous, Mined, Slack	43-50	47C _{1/2} 45T	2A-2B	.9	
Coal, Lignite	37-45	41D ₃ 35T	2D	1.0	
Cocoa Beans	30-45	38C _{1/2} 25Q	1A-1B	.5	
Cocoa, Nibs	35	35C _{1/2} 25	2D	.5	
Cocoa, Powdered	30-35	33A ₁₀₀ 45XY	1B	.9	
Cocoanut, Shredded	20-22	21E45	2B	1.5	x
Coffee, Chaff	20	20B ₆ 25MY	1A-1B	1.0	x
Coffee, Green Bean	25-32	29C _{1/2} 25PQ	1A-1B	.5	
Coffee, Ground, Dry	25	25A ₄₀ 35P	1A-1B	.6	x
Coffee, Ground, Wet	35-45	40A ₄₀ 45X	1A-1B	.6	
Coffee, Roasted Bean	20-30	25C _{1/2} 25PQ	1B	.4	x
Coffee, Soluble	19	19A ₄₀ 35PUY	1B	.4	x
Coke, Breeze	25-35	30C _{1/2} 37	3D	1.2	
Coke, Loose	23-35	30D ₇ 37	3D	1.2	
Coke, Petrol, Calcined	35-45	40D ₇ 37	3D	1.3	
Compost	30-50	40D ₇ 45TV	3A-3B	1.0	
Concrete, Pre-Mix Dry	85-120	103C _{1/2} 36U	3D	3.0	
Copper Ore	120-150	135D _X 36	3D	4.0	
Copper Ore, Crushed	100-150	125D ₃ 36	3D	4.0	
Copper Sulphate, (Bluestone)	75-95	85C _{1/2} 35S	2A-2B-2C	1.0	
Copperas (See Ferrous Sulphate)	—	—	—	—	—
Copra, Cake Ground	40-45	43B ₆ 45HW	1A-1B-1C	.7	x
Copra, Cake, Lumpy	25-30	28D ₃ 35HW	2A-2B-2C	.8	
Copra, Lumpy	22	22E ₃ 35HW	2A-2B-2C	1.0	
Copra, Meal	40-45	42B ₆ 35HW	2D	.7	x
Cork, Fine Ground	5-15	10B ₆ 35JNY	1A-1B-1C	.5	x
Cork, Granulated	12-15	14C _{1/2} 35JY	1A-1B-1C	.5	x
Corn, Cracked	40-50	45B ₆ 25P	1A-1B-1C	.7	x
Corn Cobs, Ground	17	17C _{1/2} 25Y	1A-1B-1C	.6	
Corn Cobs, Whole*	12-15	14E35	2A-2B		
Corn Ear*	56	56E35	2A-2B		
Corn Germ	21	21B ₆ 35PY	1A-1B-1C	.4	x
Corn Grits	40-45	43B ₆ 35P	1A-1B-1C	.5	x
Cornmeal	32-40	36B ₆ 35P	1A-1B	.5	x
Corn Oil, Cake	25	25D ₇ 45HW	1A-1B	.6	x

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Corn Seed	45	45C $\frac{1}{2}$ 25PQ	1A-1B-1C	.4	
Corn Shelled	45	45C $\frac{1}{2}$ 25	1A-1B-1C	.4	x
Corn Sugar	30-35	33B $\frac{1}{6}$ 35PU	1B	1.0	x
Cottonseed, Cake, Crushed	40-45	43C $\frac{1}{2}$ 45HW	1A-1B	1.0	x
Cottonseed, Cake, Lumpy	40-45	43D $\frac{1}{2}$ 45HW	2A-2B	1.0	x
Cottonseed, Dry, Delinted	22-40	31C $\frac{1}{2}$ 25X	1A-1B	.6	x
Cottonseed, Dry, Not Delinted	18-25	22C $\frac{1}{2}$ 45XY	1A-1B	.9	x
Cottonseed, Flakes	20-25	23C $\frac{1}{2}$ 35HWY	1A-1B	.8	x
Cottonseed, Hulls	12	12B $\frac{1}{6}$ 35Y	1A-1B	.9	x
Cottonseed, Meal, Expeller	25-30	28B $\frac{1}{6}$ 45HW	3A-3B	.5	x
Cottonseed, Meal, Extracted	35-40	37B $\frac{1}{6}$ 45HW	1A-1B	.5	x
Cottonseed, Meats, Dry	40	40B $\frac{1}{6}$ 35HW	1A-1B	.6	x
Cottonseed, Meats, Rolled	35-40	38C $\frac{1}{2}$ 45HW	1A-1B	.6	x
Cracklings, Crushed	40-50	45D $\frac{1}{3}$ 45HW	2A-2B-2C	1.3	x
Cryolite, Dust	75-90	83A $\frac{1}{100}$ 36L	2D	2.0	x
Cryolite, Lumpy	90-110	100D $\frac{1}{16}$ 36	2D	2.1	x
Cullet, Fine	80-120	100C $\frac{1}{2}$ 37	3D	2.0	
Cullet, Lump	80-120	100D $\frac{1}{16}$ 37	3D	2.5	
Culm. (See Coal, Anthracite)	-	-	-	-	
Cupric Sulphate (Copper Sulfate)	-	-	-	-	
Detergent (See Soap Detergent)	-	-	-	-	
Diatomaceous Earth	11-17	14A $\frac{1}{40}$ 36Y	3D	1.6	
Dicalcium Phosphate	40-50	45A $\frac{1}{40}$ 35	1A-1B-1C	1.6	x
Disodium Phosphate	25-31	28A $\frac{1}{40}$ 35	3D	.5	
Distiller's Grain-Spent Dry	30	30B $\frac{1}{6}$ 35	2D	.5	
Distiller's Grain, Spent Wet	40-60	50C $\frac{1}{2}$ 45V	3A-3B	.8	
Dolomite, Crushed	80-100	90C $\frac{1}{2}$ 36	2D	2.0	
Dolomite, Lumpy	90-100	95D $\frac{1}{2}$ 36	2D	2.0	
Earth, Loam, Dry, Loose	76	76C $\frac{1}{2}$ 36	2D	1.2	
Ebonite, Crushed	63-70	67C $\frac{1}{2}$ 35	1A-1B-1C	.8	x
Egg Powder	16	16A $\frac{1}{40}$ 35MPY	1B	1.0	
Epsom Salts (Magnesium Sulfate)	40-50	45A $\frac{1}{40}$ 35U	1A-1B-1C	.8	x
Feldspar, Ground	65-80	73A $\frac{1}{100}$ 37	2D	2.0	
Feldspar, Lumps	90-100	95D $\frac{1}{2}$ 37	2D	2.0	
Feldspar, Powder	100	100A $\frac{1}{200}$ 36	2D	2.0	
Feldspar, Screenings	75-80	78C $\frac{1}{2}$ 37	2D	2.0	
Ferrous Sulfide- $\frac{1}{2}$ "	120-135	128C $\frac{1}{2}$ 26	1A-1B-1C	2.0	x
Ferrous Sulfide-100M	105-120	113A $\frac{1}{100}$ 36	1A-1B-1C	2.0	x
Ferrous Sulphate	50-75	63C $\frac{1}{2}$ 35U	2D	1.0	
Fish Meal	35-40	38C $\frac{1}{2}$ 45HP	1A-1B-1C	1.0	x
Fish Scrap	40-50	45D $\frac{1}{2}$ 45H	2A-2B-2C	1.5	
Flaxseed	43-45	44B $\frac{1}{6}$ 35X	1A-1B-1C	.4	x
Flaxseed Cake (Linseed Cake)	48-50	49D $\frac{1}{2}$ 45W	2A-2B	.7	
Flaxseed Meal (Linseed Meal)	25-45	35B $\frac{1}{6}$ 45W	1A-1B	.4	x
Flour Wheat	33-40	37A $\frac{1}{40}$ 45LP	1B	.6	x
Flue Dust, Basic Oxygen Furnace	45-60	53A $\frac{1}{40}$ 36LM	3D	3.5	
Flue Dust, Blast Furnace	110-125	118A $\frac{1}{40}$ 36	3D	3.5	
Flue Dust, Boiler H. Dry	30-45	38A $\frac{1}{40}$ 36LM	3D	2.0	
Fluorspar, Fine (Calcium Fluoride)	80-100	90B $\frac{1}{6}$ 36	2D	2.0	
Fluorspar, Lumps	90-110	100D $\frac{1}{2}$ 36	2D	2.0	
Flyash	30-45	38A $\frac{1}{40}$ 36M	3D	2.0	
Foundry Sand, Dry (See Sand)	-	-	-	-	
Fuller's Earth, Dry, Raw	30-40	35A $\frac{1}{40}$ 25	2D	2.0	
Fuller's Earth, Oily, Spent	60-65	63C $\frac{1}{2}$ 45OW	3D	2.0	
Fuller's Earth, Calcined	40	40A $\frac{1}{100}$ 25	3D	2.0	
Galena (See Lead Sulfide)	-	-	-	-	
Gelatine, Granulated	32	32B $\frac{1}{6}$ 35PU	1B	.8	x

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Gilsonite	37	37C $\frac{1}{2}$ 35	3D	1.5	
Glass, Batch	80-100	90C $\frac{1}{2}$ 37	3D	2.5	
Glue, Ground	40	40B $\frac{1}{2}$ 45U	2D	1.7	
Glue, Pearl	40	40C $\frac{1}{2}$ 35U	1A-1B-1C	.5	
Glue, Veg. Powdered	40	40A $\frac{1}{2}$ 45U	1A-1B-1C	.6	
Gluten, Meal	40	40B $\frac{1}{2}$ 35P	1B	.6	
Granite, Fine	80-90	85C $\frac{1}{2}$ 27	3D	2.5	
Grape Pomace	15-20	18D $\frac{1}{2}$ 45U	2D	1.4	x
Graphite Flake	40	40B $\frac{1}{2}$ 251P	1A-1B-1C	.5	x
Graphite Flour	28	28A $\frac{1}{2}$ 10035LMP	1A-1B-1C	.5	x
Graphite Ore	65-75	70D $\frac{1}{2}$ 35L	2D	1.0	
Guano Dry*	70	70C $\frac{1}{2}$ 35	3A-3B	2.0	
Gypsum, Calcined	55-60	58B $\frac{1}{2}$ 35U	2D	1.6	
Gypsum, Calcined, Powdered	60-80	70A $\frac{1}{2}$ 10035U	2D	2.0	
Gypsum, Raw-1"	70-80	75D $\frac{1}{2}$ 35	2D	2.0	
Hay, Chopped*	8-12	10C $\frac{1}{2}$ 35JY	2A-2B	1.6	
Hexanedioic Acid (See Adipic Acid)	-	-	-	-	
Hominy, Dry	35-50	43C $\frac{1}{2}$ 25D	1A-1B-1C	.4	x
Hops, Spent, Dry	35	35D $\frac{1}{2}$ 35	2A-2B-2C	1.0	x
Hops, Spent, Wet	50-55	53D $\frac{1}{2}$ 45V	2A-2B	1.5	
Ice, Crushed	35-45	40D $\frac{1}{2}$ 35O	2A-2B	.4	x
Ice, Flaked*	40-45	43C $\frac{1}{2}$ 35O	1B	.6	x
Ice, Cubes	33-35	34D $\frac{1}{2}$ 35O	1B	.4	x
Ice, Shell	33-35	34D $\frac{1}{2}$ 45O	1B	.4	x
Ilmenite Ore	140-160	150D $\frac{1}{2}$ 37	3D	2.0	
Iron Ore Concentrate	120-180	150A $\frac{1}{2}$ 4037	3D	2.2	
Iron Oxide Pigment	25	25A $\frac{1}{2}$ 10036LMP	1A-1B-1C	1.0	
Iron Oxide, Millscale	75	75C $\frac{1}{2}$ 36	2D	1.6	
Iron Pyrites (See Ferrous Sulfide)	-	-	-	-	
Iron Sulphate (See Ferrous Sulfate)	-	-	-	-	
Iron Sulfide (See Ferrous Sulfide)	-	-	-	-	
Iron Vitriol (See Ferrous Sulfate)	-	-	-	-	
Kafir (Corn)	40-45	43C $\frac{1}{2}$ 25	3D	.5	x
Kaolin Clay	63	63D $\frac{1}{2}$ 35	2D	2.0	
Kaolin Clay-Talc	42-56	49A $\frac{1}{2}$ 4035LMP	2D	2.0	
Kryalith (See Cryolite)	-	-	-	-	
Lactose	32	32A $\frac{1}{2}$ 4035PU	1B	.6	
Lamp Black (See Carbon Black)	-	-	-	-	
Lead Arsenate	72	72A $\frac{1}{2}$ 4035R	1A-1B-1C	1.4	
Lead Arsenite	72	72A $\frac{1}{2}$ 4035R	1A-1B-1C	1.4	
Lead Carbonate	240-260	250A $\frac{1}{2}$ 4035R	2D	1.0	
Lead Ore-1/8"	200-270	235B $\frac{1}{2}$ 35	3D	1.4	
Lead Ore-1/2"	180-230	205C $\frac{1}{2}$ 36	3D	1.4	
Lead Oxide (Red Lead)-100 Mesh	30-150	90A $\frac{1}{2}$ 10035P	2D	1.2	
Lead Oxide (Red Lead)-200 Mesh	30-180	105A $\frac{1}{2}$ 20035LP	2D	1.2	
Lead Sulphide-100 Mesh	240-260	250A $\frac{1}{2}$ 10035R	2D	-	
Lignite (See Coal Lignite)	-	-	-	-	
Limante, Ore, Brown	120	120C $\frac{1}{2}$ 47	3D	1.7	
Lime, Ground, Unslaked	60-65	63B $\frac{1}{2}$ 35U	1A-1B-1C	.6	x
Lime Hydrated	40	40B $\frac{1}{2}$ 35LM	2D	.8	x
Lime, Hydrated, Pulverized	32-40	36A $\frac{1}{2}$ 4035LM	1A-1B	.6	
Lime, Pebble	53-56	55C $\frac{1}{2}$ 25HU	2A-2B	2.0	
Limestone, Agricultural	68	68B $\frac{1}{2}$ 35	2D	2.0	
Limestone, Crushed	85-90	88D $\frac{1}{2}$ 36	2D	2.0	
Limestone, Dust	55-95	75A $\frac{1}{2}$ 4046MY	2D	1.6-2.0	
Lindane (Benzene Hexachloride)	-	-	-	-	
Linseed (See Flaxseed)	-	-	-	-	

Table 2-2 (cont)
Material Characteristics

Mat'l.	Factor	Component	Material Code	Weight lbs. per cu. ft.	Material
			48A32535MR	45-50	Lithopone
			25B635NP	20-30	Malt, Dry, Ground
x		1A-1B-1C	38B625P	36-40	Malt, Meal
x		1A-1B-1C	25C1/235N	20-30	Malt, Dry Whole
x		1A-1B-1C	14C1/235P	13-15	Malt, Sprouts
x		1A-1B	33C1/245	33	Magnesium Chloride (Magnesite)
		2A-2B	78A10035NRT	70-85	Magnesium Dioxide*
			133D1/237	125-140	Manganese Ore
			120A10036	120	Manganese Oxide
			70C1/237	70	Manganese Sulfate
			88B637	80-95	Marble, Crushed
			80D1/236	80	Marl, (Clay)
		2A-2B	53E45HQTX	50-55	Meat, Ground
			40E4611	40	Meat, Scrap (W/bone)
			20B616 MY	17-22	Mica, Flakes
x			14B636	13-15	Mica, Ground
x			14A10036M	13-15	Mica, Pulverized
			6B635PUY	5-6	Milk, Dried, Flake
			29A4045PX	27-30	Milk, Malted
			33B625PM	20-45	Milk, Powdered
			32A10035PX	32	Milk Sugar
			28B635PUX	20-36	Milk, Whole, Powdered
			123E46T	120-125	Mill Scale (Steel)
		1A-1B-1C	34B625	32-36	Milo, Ground
x		1A-1B-1C	43B615N	40-45	Milo Maize (Kafir)
			107B626	107	Molybdenite Powder
			50B636	50	Monosodium Phosphate
			150E46T	150	Mustard Seed
		1A-1B-1C	45B615N	45	Naphthalene Flakes
			35A4035P	35	Niacin (Nicotinic Acid)
		1A-1B-1C	26C1/225MN	26	Oats
x		1A-1B-1C	23C1/235	19-26	Oats, Crimped
x		1A-1B-1C	22B645NY	22	Oats, Crushed
x		1A-1B-1C	35A10035	35	Oats, Flour
x		1A-1B-1C	10B635NY	8-12	Oat Hulls
x		1A-1B-1C	22C1/235NY	19-24	Oats, Rolled
		2A-2B	59E45HKPWX	59	Oleo Margarine (Margarine)
			15E45	15	Orange Peel, Dry
			60B635QS	60	Oxalic Acid Crystals—Ethane Diacid Crystals
		1A-1B	55C1/236T	50-60	Oyster Shells, Ground
			80D1/236TV	80	Oyster Shells, Whole
		2A-2B	62E45	62	Paper Pulp (4% or less)
			61E45	60-62	Paper Pulp (6% to 15%)
		1A-1B	45C1/245K	45	Paraffin Cake—1/2"
		2A-2B	18D1/235Q	15-20	Peanut Meal
			30B635P	30	Peanut Meal
x		1B	18D1/236Q	15-20	Peanuts, Raw, Uncleaned (unshelled)
		3D	40C1/235Q	35-45	Peanuts, Shelled
x		1B	48C1/215NQ	45-50	Peas, Dried
x		1A-1B-1C	10C1/236	8-12	Fertilizer-Expanded
		2D	60B625T	60	Phosphate Disodium
		2A-2B	1.4		Phosphate Acid Fertilizer

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Phosphate Rock, Broken	75-85	80D _x 36	2D	2.1	
Phosphate Rock, Pulverized	60	60B ₆ 36	2D	1.7	
Phosphate Sand	90-100	95B ₆ 37	3D	2.0	
Plaster of Paris (See Gypsum)	—	—	—	—	
Plumbago (See Graphite)	—	—	—	—	
Polystyrene Beads	40	40B ₆ 35PQ	1B	.4	
Polyvinyl, Chloride Powder	20-30	25A ₁₀₀ 45KT	2B	1.0	
Polyvinyl, Chloride Pellets	20-30	25E45KPQT	1B	.6	
Polyethelene, Resin Pellets	30-35	33C _{1/2} 45Q	1A-1B	.4	x
Potash (Muriate) Dry	70	70B ₆ 37	3D	2.0	
Potash (Muriate) Mine Run	75	75D _x 37	3D	2.2	
Potassium Carbonate	51	51B ₆ 36	2D	1.0	
Potassium Chloride Pellets	120-130	125C _{1/2} 25TU	3D	1.6	
Potassium Nitrate—1/2"	76	76C _{1/2} 16NT	3D	1.2	x
Potassium Nitrate—1/8"	80	80B ₆ 26NT	3D	1.2	x
Potassium Sulfate	42-48	45B ₆ 46X	2D	1.0	
Potato Flour	48	48A ₂₀₀ 35MNP	1A-1B	.5	x
Pumice—1/8"	42-48	45B ₆ 46	3D	1.6	
Pyrite, Pellets	120-130	125C _{1/2} 26	3D	2.0	
Quartz,—100 Mesh	70-80	75A ₁₀₀ 27	3D	1.7	
Quartz,—1/2"	80-90	85C _{1/2} 27	3D	2.0	
Rice, Bran	20	20B ₆ 35NY	1A-1B-1C	.4	x
Rice, Grits	42-45	44B ₆ 35P	1A-1B-1C	.4	x
Rice, Polished	30	30C _{1/2} 15P	1A-1B-1C	.4	x
Rice, Hulled	45-49	47C _{1/2} 25P	1A-1B-1C	.4	x
Rice, Hulls	20-21	21B ₆ 35NY	1A-1B-1C	.4	x
Rice, Rough	32-36	34C _{1/2} 35N	1A-1B-1C	.6	x
Rosin—1/2"	65-68	67C _{1/2} 45Q	1A-1B-1C	1.5	
Rubber, Reclaimed Ground	23-50	37C _{1/2} 45	1A-1B-1C	.8	x
Rubber, Pelleted	50-55	53D ₃ 45	2A-2B-2C	1.5	
Rye	42-48	45B ₆ 15N	1A-1B-1C	.4	x
Rye Bran	15-20	18B ₆ 35Y	1A-1B-1C	.4	x
Rye Feed	33	33B ₆ 35N	1A-1B-1C	.5	x
Rye Meal	35-40	38B ₆ 35	1A-1B-1C	.5	x
Rye Middlings	42	42B ₆ 35	1A-1B	.5	x
Rye, Shorts	32-33	33C _{1/2} 35	2A-2B	.5	x
Safflower, Cake	50	50D ₃ 26	2D	.6	
Safflower, Meal	50	50B ₆ 35	1A-1B-1C	.6	x
Safflower Seed	45	45B ₆ 15N	1A-1B-1C	.4	x
Saffron (See Safflower)	—	—	—	—	
Sal Ammoniac (Ammonium Chloride)	—	—	—	—	
Salt Cake, Dry Coarse	85	85B ₆ 36TU	3D	2.1	
Salt Cake, Dry Pulverized	65-85	75B ₆ 36TU	3D	1.7	
Salicylic Acid	29	29B ₆ 37U	3D	.6	
Salt, Dry Coarse	45-60	53C _{1/2} 36TU	3D	1.0	x
Salt, Dry Fine	70-80	75B ₆ 36TU	3D	1.7	x
Saltpeter—(See Potassium Nitrate)	—	—	—	—	
Sand Dry Bank (Damp)	110-130	120B ₆ 47	3D	2.8	
Sand Dry Bank (Dry)	90-110	100B ₆ 37	3D	1.7	
Sand Dry Silica	90-100	95B ₆ 27	3D	2.0	
Sand Foundry (Shake Out)	90-100	95D ₃ 37Z	3D	2.6	
Sand (Resin Coated) Silica	104	104B ₆ 27	3D	2.0	
Sand (Resin Coated) Zircon	115	115A ₁₀₀ 27	3D	2.3	
Sawdust, Dry	10-13	12B ₆ 45UX	1A-1B-1C	.7	
Sea-Coal	65	65B ₆ 36	2D	1.0	
Sesame Seed	27-41	34B ₆ 26	2D	.6	x

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Shale, Crushed	85-90	88C $\frac{1}{2}$ 36	2D	2.0	
Shellac, Powdered or Granulated	31	31B $\frac{1}{6}$ 35P	1B	.6	x
Silicon Dioxide (See Quartz)	—	—	—	—	
Silica, Flour	80	80A $\frac{40}{46}$	2D	1.5	
Silica Gel + $\frac{1}{2}$ "-3"	45	45D $\frac{3}{37}$ HKQU	3D	2.0	
Slag, Blast Furnace Crushed	130-180	155D $\frac{3}{37}$ Y	3D	2.4	
Slag, Furnace Granular, Dry	60-65	63C $\frac{1}{2}$ 37	3D	2.2	
Slate, Crushed, - $\frac{1}{2}$ "	80-90	85C $\frac{1}{2}$ 36	2D	2.0	
Slate, Ground, -1/8"	82-85	84B $\frac{1}{6}$ 36	2D	1.6	
Sludge, Sewage, Dried	40-50	45E47TW	3D	.8	
Sludge, Sewage, Dry Ground	45-55	50B46S	2D	.8	
Soap, Beads or Granules	15-35	25B $\frac{1}{6}$ 35Q	1A-1B-1C	.6	
Soap, Chips	15-25	20C $\frac{1}{2}$ 35Q	1A-1B-1C	.6	
Soap Detergent	15-50	33B $\frac{1}{6}$ 35FQ	1A-1B-1C	.8	
Soap, Flakes	5-15	10B $\frac{1}{6}$ 35QXY	1A-1B-1C	.6	
Soap, Powder	20-25	23B $\frac{1}{6}$ 25X	1A-1B-1C	.9	
Soapstone, Talc, Fine	40-50	45A $\frac{200}{45}$ XY	1A-1B-1C	2.0	
Soda Ash, Heavy	55-65	60B $\frac{1}{6}$ 36	2D	1.0	
Soda Ash, Light	20-35	28A $\frac{40}{36}$ Y	2D	.8	x
Sodium Aluminate, Ground	72	72B $\frac{1}{6}$ 36	2D	1.0	
Sodium Aluminum Fluoride (See Kryolite)	—	—	—	—	
Sodium Aluminum Sulphate*	75	75A $\frac{100}{36}$	2D	1.0	
Sodium Bentonite (See Bentonite)	—	—	—	—	
Sodium Bicarbonate (See Baking Soda)	—	—	—	—	
Sodium Chloride (See Salt)	—	—	—	—	
Sodium Carbonate (See Soda Ash)	—	—	—	—	
Sodium Hydrate (See Caustic Soda)	—	—	—	—	
Sodium Hydroxide (See Caustic Soda)	—	—	—	—	
Sodium Borate (See Borax)	—	—	—	—	
Sodium Nitrate	70-80	75D $\frac{3}{25}$ NS	2A-2B	1.2	
Sodium Phosphate	50-60	55A35	1A-1B	.9	
Sodium Sulfate (See Salt Cake)	—	—	—	—	
Sodium Sulfite	96	96B $\frac{1}{6}$ 46X	2D	1.5	
Sorghum, Seed (See Kafir or Milo)	—	—	—	—	
Soybean, Cake	40-43	42D $\frac{3}{35}$ W	2A-1B-1C	1.0	x
Soybean, Cracked	30-40	35C $\frac{1}{2}$ 36NW	2D	.5	x
Soybean, Flake, Raw	18-25	22C $\frac{1}{2}$ 35Y	1A-1B-1C	.8	x
Soybean, Flour	27-30	29A $\frac{40}{35}$ MN	1A-1B-1C	.8	x
Soybean Meal, Cold	40	40B $\frac{1}{6}$ 35	1A-1B-1C	.5	x
Soybean Meal Hot	40	40B $\frac{1}{6}$ 35T	2A-2B	.5	
Soybeans, Whole	45-50	48C $\frac{1}{2}$ 26NW	—	1.0	
Starch	25-50	38A $\frac{40}{15}$ M	1A-1B-1C	1.0	x
Steel Turnings, Crushed	100-150	125D $\frac{3}{46}$ WV	3D	3.0	
Sugar Beet, Pulp, Dry	12-15	14C $\frac{1}{2}$ 26	2D	.9	
Sugar Beet, Pulp, Wet	25-45	35C $\frac{1}{2}$ 35X	1A-1B-1C	1.2	
Sugar, Refined, Granulated Dry	50-55	53B $\frac{1}{6}$ 35PU	1B	1.0; 1.2	x
Sugar, Refined, Granulated Wet	55-65	60C $\frac{1}{2}$ 35X	1B	1.4; 2.0	
Sugar, Powdered	50-60	55A $\frac{100}{35}$ PX	1B	.8	x
Sugar, Raw	55-65	60B $\frac{1}{6}$ 35PX	1B	1.5	
Sulphur, Crushed - $\frac{1}{2}$ "	50-60	55C $\frac{1}{2}$ 35N	1A-1B	.8	
Sulphur, Lumpy, -3"	80-85	83D $\frac{3}{35}$ N	2A-2B	.8	
Sulphur, Powdered	50-60	55A $\frac{40}{35}$ MN	1A-1B	.6	
Sunflower Seed	19-38	29C $\frac{1}{2}$ 15	1A-1B-1C	.5	x
Talcum, - $\frac{1}{2}$ "	80-90	85C $\frac{1}{2}$ 36	2D	.9	
Talcum Powder	50-60	55A $\frac{200}{36}$ M	2D	.8	x
Tanbark, Ground*	55	55B $\frac{1}{6}$ 45	1A-1B-1C	.7	

Table 2-2 (con't)
Material Characteristics

Material	Weight lbs. per cu. ft.	Material Code	Component Series	Mat'l. Factor Fm	V
Timothy Seed	36	36B ₆ 35NY	1A-1B-1C	.6	x
Titanium Dioxide (See Ilmenite Ore)					
Tobacco, Scraps	15-25	20D ₃ 45Y	2A-2B	.8	
Tobacco, Snuff	30	30B ₆ 45MQ	1A-1B-1C	.9	x
Tricalcium Phosphate	40-50	45A ₄₀ 45	1A-1B	1.6	
Triple Super Phosphate	50-55	53B ₆ 36RS	3D	2.0	
Trisodium Phosphate	60	60C _{1/2} 36	2D	1.7	
Trisodium Phosphate Granular	60	60B ₆ 36	2D	1.7	
Trisodium Phosphate, Pulverized	50	50A ₄₀ 36	2D	1.6	x
Tung Nut Meats, Crushed	28	28D ₃ 25W	2A-2B	.8	x
Tung Nuts	25-30	28D ₃ 15	2A-2B	.7	x
Urea Prills, Coated	43-46	45B ₆ 25	1A-1B-1C	1.2	
Vermiculite, Expanded	16	16C _{1/2} 35Y	1A-1B	.5	
Vermiculite, Ore	80	80D ₃ 36	2D	1.0	
Vetch	48	48B ₆ 16N	1A-1B-1C	.4	x
Walnut Shells, Crushed	35-45	40B ₆ 36	2D	1.0	x
Wheat	45-48	47C _{1/2} 25N	1A-1B-1C	.4	x
Wheat, Cracked	40-45	43B ₆ 25N	1A-1B-1C	.4	x
Wheat, Germ	18-28	23B ₆ 25	1A-1B-1C	.4	x
White Lead, Dry	75-100	88A ₄₀ 36MR	2D	1.0	x
Wood Chips, Screened	10-30	20D ₃ 45VY	2A-2B	.6	
Wood Flour	16-36	26B ₆ 35N	1A-1B	.4	x
Wood Shavings	8-16	12E45VY	2A-2B	1.5	
Zinc, Concentrate Residue	75-8	78B ₆ 37	3D	1.0	
Zinc Oxide, Heavy	30-35	33A ₁₀₀ 45X	1A-1B	1.0	
Zinc Oxide, Light	10-15	13A ₁₀₀ 45XY	1A-1B	1.0	x

* Consult Conveyor Manufacturer

V Those materials which show an X may be handled in vertical screw conveyors.

SELECTION OF CONVEYOR SIZE AND SPEED

In order to determine the size and speed of screw conveyor, it is necessary first to establish the material code number. It will be seen from what follows that this code number controls the cross-sectional loading that should be used.

The various cross-sectional loadings shown in the Capacity Table (Table 2-3) are for use with the standard screw conveyor components indicated in the Component Group Selection Guide on page 30, and are for the usual screw conveyor applications. The usual screw conveyor applications may be defined as those in industrial use where the conveying operation is controlled with volumetric feeders and where the material is uniformly fed into the conveyor housing and discharged from it.

Check lump size limitations before choosing conveyor diameter. See Table 2-5.

Capacity Table

The capacity table, (Table 2-3), page 27, gives the capacities in cubic feet per hour at one revolution per minute for various sized screw conveyors for four cross-sectional loadings and for various classes of materials as delineated by code numbers. Also shown are capacities in cubic feet per hour at the maximum recommended revolutions per minute.

The capacity values have been rounded off to the nearest three digits. In the case of 12 inch screw conveyors, there are three standard specifications for the screw, consisting of flights mounted on 2½ inch, 3 inch and 3½ inch Schedule 40 pipe. The net cross-sectional area of the load, of course, is not the same in these three cases, due to the varying pipe diameter, but the difference is small. So the capacities for 12 inch screw conveyors are based on the average of the three cross-sectional areas. A similar situation holds true for several other sizes where more than one pipe diameter is customary.

The basis for the Capacity Table, Table 2-3, is as follows:

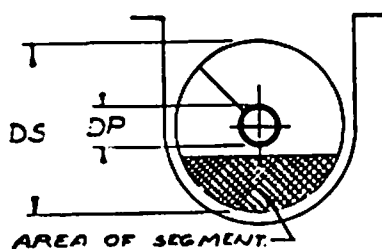


Fig. 2.1

The capacity, cubic feet per hour per revolution per minute:

$$\frac{C}{\text{rpm}} = \frac{0.7854 (D_s^2 - D_p^2) PK 60}{1728}$$

where

C = cubic feet per hour

rpm = revolutions of screw per minute

D_s = Diameter of screw, inches

D_p = diameter of pipe, inches

P = pitch of screw, inches

K = per cent trough loading

The formula thus gives the capacity in cubic feet per hour for 1 revolution per minute.

The capacity values have been computed by the formula without consideration for flight thickness, flight diameter tolerance, pitch tolerance or further for the fact that the material may or may not move in the clearance between the screw and trough. Some materials will adhere to the trough and form a cake in which case the capacity will be very close to the formula figure. Other materials—cotton seed for example—will not pack in the clearance and all the material within the trough will move forward. In this case the actual capacity may exceed the formula figure. The capacity values given in the table will be found satisfactory for most all applications. Where the capacity of a screw conveyor is very critical, especially when handling a material which isn't listed in Table 2-2, it is best to consult the conveyor manufacturer.

The maximum capacity of any size screw conveyor for a wide range of materials, and various conditions of loading may be obtained from Table 2-3, by noting the values of cubic feet per hour at maximum recommended speed.

Conveyor Speed

For screw conveyors with screws having regular helical flights all of standard pitch, the conveyor speed may be calculated by the formula:

$$N = \frac{\text{Required capacity, cubic feet per hour}}{\text{Cubic feet per hour at 1 revolution per minute}}$$

where

N = revolutions per minute of screw,
but not greater than the maximum
recommended speed.

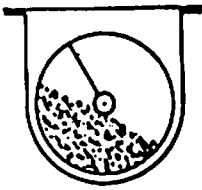
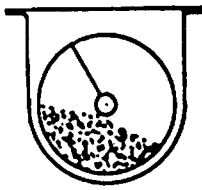
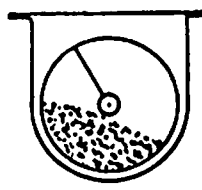
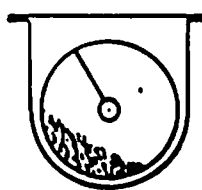
For the calculation of conveyor speeds where special types of screws are used, such as short pitch screws, cut flights, cut and folded flights and ribbon flights, an equivalent required capacity must be used, based on factors in the table 2-4.

Factor CF_1 relates to the pitch of the screw. Factor CF_2 relates to the type of the flight. Factor CF_3 relates to the use of mixing paddles within the flight pitches.

The equivalent capacity then is found by multiplying the required capacity by one or more of the capacity factors that are involved. See Table 2-4 for capacity factors.

$$\begin{array}{lcl} \text{Equiv. Capacity} & = & (\text{Required Capacity}) (CF_1) (CF_2) (CF_3) \\ \text{cubic feet per hour} & & \text{cubic feet per hour} \end{array}$$

Table 2-3
Screw Conveyor Capacities

Material Class Code		Degree of Trough Loading	Screw Dia. Inch	Maximum RPM *	Capacity, Cubic Feet Per Hour	
					At Max. RPM	At One RPM
A-15 A-25 B-15 B-25 C-15 C-25		45% 	6 9 12 14 16 18 20 24	165 155 145 140 130 120 110 100	368 1270 2820 4370 6060 8120 10300 16400	2.23 8.2 19.4 31.2 46.7 67.6 93.7 164.0
A-35 A-45 B-35 B-45 C-35 C-45 D-15 D-25 D-35 D-45 E-15 E-25	E-35 E-45	Non-Abrasive Materials 30% A 	6 9 12 14 16 18 20 24	120 100 90 85 80 75 70 65	180 545 1160 1770 2500 3380 4370 7100	1.49 5.45 12.9 20.8 31.2 45.0 62.5 109.0
A-16 A-26 A-36 A-46 B-16 B-26 B-36 B-46 C-16 C-26 C-36 C-46	D-16 D-26 D-36 D-46 E-16 E-26 E-36 E-46	Abrasive Materials 30% B 	6 9 12 14 16 18 20 24	60 55 50 50 45 45 40 40	90 300 645 1040 1400 2025 2500 4360	1.49 5.45 12.9 20.8 31.2 45.0 62.8 109.0
A-17 A-27 A-37 A-47 B-17 B-27 B-37 B-47 C-17 C-27 C-37 C-47	D-17 D-27 D-37 D-47 E-17 E-27 E-37 E-47	15% 	6 9 12 14 16 18 20 24	60 55 50 50 45 45 40 40	45 150 325 520 700 1010 1250 2180	0.75 2.72 6.46 10.4 15.6 22.5 31.2 54.6

* Maximum recommended R.P.M.

Table 2-4

Capacity Factors

Special Conveyor Pitch Capacity Factor CF ₁			CF ₁
Pitch	Description		
Standard	Pitch = Diameter of screw		1.00
Short	Pitch = 2/3 Diameter of screw		1.50
Half	Pitch = 1/2 Diameter of screw		2.00
Long	Pitch = 1 1/2 Diameters of screw		0.67

Special Conveyor Flight Capacity Factor CF₂

Conveyor Loading				
Type of Flight	15%	30%	45%	
Cut Flight	1.95	1.57	1.43	
Cut & Folded Flight	N.R.*	3.75	2.54	
Ribbon Flight	1.04	1.37	1.62	

*Not Recommended

Special Conveyor Mixing Paddle Capacity Factor CF₃

		Paddles per pitch			
Standard Paddles at 45° reverse pitch Factor CF ₃	None	1	2	3	4
	1.00	1.08	1.16	1.24	1.32

A standard pitch screw conveyor is to transport 36,000 lbs. per hour of a material weighing 60 lbs. per cubic feet in a 30% A type of cross-sectional loading. A further requirement is that the conveyor is to mix the material in transit by means of a cut flight with one 45° reverse pitch mixing paddle per pitch, for a mixing time of 40 seconds minimum.

The required capacity is $\frac{36,000}{60} = 600$ cubic feet per hour.

Due to the conveying inefficiency of a conveyor screw with cut flights and mixing paddles, an equivalent capacity will have to be calculated from the appropriate capacity factors.

Equivalent capacity = $600 \times 1.57 \times 1.08 = 1020$ cubic feet per hour

Now referring to the Capacity Table 2-3, for a 30%A loading a 12 inch screw at maximum RPM will have slightly more than the equivalent capacity, and will also have a capacity of 12.9 cubic feet per hour at 1 RPM.

Therefore the speed should be:

$$N = \frac{1020}{12.9} = 79 \text{ RPM}$$

The length of the screw to retain the material for the specified mixing time, 40 seconds or $\frac{2}{3}$ minute is calculated as follows:

$$L = \frac{(N) (\text{Length one pitch, inches}) (\text{Minutes time})}{12}$$

or:

$$L = \frac{(79) (12) (.666)}{12} = 53 \text{ feet}$$

This is the actual mixing length of screw. The overall screw and trough length will be a bit more, to provide space to bring the material into the trough and to discharge it from the trough without reducing the mixing time specified.

Lump Size Limitations

The size of a screw conveyor not only depends on the capacity required, but also on the size and proportion of lumps in the material to be handled. The size of a lump is the maximum dimension it has. A closer definition of the lump size would be the diameter of a ring thru which the lump would pass. However, if a lump has one dimension much longer than its transverse cross-section, the long dimension or length would determine the lump size.

The character of the lump also is involved. Some materials have hard lumps that won't break up in transit through a screw conveyor. In that case provision must be made to handle these lumps. Other materials may have lumps that are fairly hard, but degradable in transit through the screw conveyor, thus really reducing the lump size to be handled. Still other materials have lumps that are easily broken in a screw conveyor and lumps of these materials impose no limitations.

Three classes of lump sizes apply as follows:

Class 1

A mixture of lumps and fines in which not more than 10% are lumps ranging from maximum size to one half of the maximum; and 90% are lumps smaller than one half of the maximum size.

Class 2

A mixture of lumps and fines in which not more than 25% are lumps ranging from the maximum size to one half of the maximum; and 75% are lumps smaller than one half of the maximum size.

Class 3

A mixture of lumps only in which 95% or more are lumps ranging from maximum size to one half of the maximum size; and 5% or less are lumps less than one tenth of the maximum size.

Table 2-5 shows the recommended maximum lump size for each customary screw diameter and the three lump classes. The ratio, R , is included to show the average factor used for the normal screw diameters which then may be used as a guide for special screw sizes and constructions. For example;

$$\text{Ratio, } R = \frac{\text{Radial Clearance, Inches}}{\text{Lump Size, inches}}$$

This ratio applies to such unusual cases as screws 16 inches diameter mounted on 2 inch solid shafts; or 12 inch diameter screws mounted on 6 inch diameter pipes (the large pipe serving to reduce deflection of the screw).

The allowable size of a lump in a screw conveyor is a function of the radial clearance between the outside diameter of the central pipe and the radius of the inside of the screw trough, as well as the proportion of lumps in the mix. The following illustration illustrates this relationship.

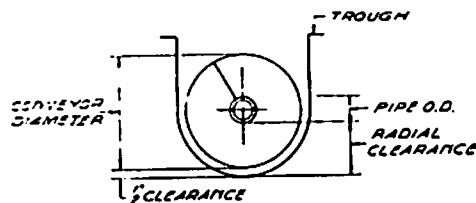


Fig. 2.3

Example

To illustrate the choice of screw size from Table 2-5, say the material is ice with Material Characteristic code number D15, 35 to 45 lbs. per cubic foot and with size distribution as follows: 4"×2", 9%; 2"×1", 41%; 1"×¾", 22%; minus ¾", 28%.

This lump size distribution falls under Class 1, From Table 2-5, the ratio R is 1.75 and the radial clearance (4) (1.75) or 7 inches. This calls for an 18 inch diameter screw.

Table 2-5
Screw Conveyor Maximum Lump Size

Screw Diameter Inches	Pipe O.D. Inches	Radial Clearance Inches	Class I 10% lumps Ratio, R , = 1.75 Max. lump, inch	Class II 25% lumps Ratio, R , = 2.5 Max. lump, inch	Class III 95% lumps Ratio, R , = 4.5 Max. lump, inch
6	2 3/8	2 5/16	1 1/4	3/4	1/2
9	2 3/8	3 13/16	2 1/4	1 1/2	3/4
9	2 7/8	3 9/16	2 1/4	1 1/2	3/4
12	2 7/8	5 1/16	2 3/4	2	1
12	3 1/2	4 3/4	2 3/4	2	1
12	4	4 1/2	2 3/4	2	1
14	3 1/2	5 3/4	3 1/4	2 1/2	1 1/4
14	4	5 1/2	3 1/4	2 1/2	1 1/4
16	4	6 1/2	3 3/4	2 3/4	1 1/2
16	4 1/2	6 1/4	3 3/4	2 3/4	1 1/2
18	4	7 1/2	4 1/4	3	1 3/4
18	4 1/2	7 1/4	4 1/4	3	1 3/4
20	4	8 1/2	4 3/4	3 1/2	2
20	4 1/2	8 1/4	4 3/4	3 1/2	2
24	4 1/2	10 1/4	6	3 3/4	2 1/2

COMPONENT GROUPS

To facilitate the selection of proper specifications for a screw conveyor for a particular duty, screw conveyors are broken down into three Component Groups. These groups relate both to the Material Classification Code and also to screw, pipe size, type of bearings and trough thickness.

If the material to be conveyed is not listed in Table 2-2, then its Classification code may be determined from Table 2-1.

Table 2-6 is a guide to the proper selection of the appropriate Component Group. It will be observed that in addition to the flow characteristics of a material, consideration must be given to the material size, its abrasiveness and its corrosiveness as these determine construction details.

For example, if the material has suitable flow characteristics, is of a classification Code Size B, has an abrasive number of 5 and is non-corrosive, the Component Group Number is 1. If babbitted or bronze bearings, 1A; or for ball bearings, 1C. It will be noted that if the material is at all corrosive, ball bearings are not recommended.

Having made the Component Group selection, refer to Table 2-7, 2-8 and 2-9 which give the specifications of the various sizes of conveyor screws. The tabulated screw numbers in this table refer to CEMA Standard No. 300 - 1971 on Screw Conveyors. This standard gives complete data on the screws such as the length of standard sections, minimum edge thickness of screw flight, bushing data, bolt size, bolt spacing, etc.

Table 2-6
Component Group Selection Guide

Material Classification			Component Group Letter Designation					
Code			Type of Intermediate Hanger Bearing					
Material Size Classification		Abrasiveness Number	Corrosiveness Letter	Group Number Designation				
				Babbitted or Bronze	Self Lubricating	Ball Bearing	Hard Iron	
A200 A100 A40	B6	S	Non-Corr. T S	1	A	B	C	-
	C½			2 3	A A A	B B B	- - -	
D3 D7 D16 Dx	or E	S	Non-Corr. T S	2 2 3	A A A	B B B	C - -	- - -
A200 A100 A40	B6	6	Non-Corr. T S	2	-	-	-	D
	C½			3 3*	- -	- -	- -	D D D
D3 D7 D16 Dx	or E	6	Non-Corr. T S	2	-	-	-	D
				3 3*	- -	- -	- -	D D D
A200 A100 A40	B6	7	Non-Corr. T S	3	-	-	-	D
	C½			3 3*	- -	- -	- -	D D D
D3 D7 D16 Dx	or E	7	Non-Corr. T S	3	-	-	-	D
				3 3*	- -	- -	- -	D D D

* For very corrosive conditions (codes 6S or 7S) lighter gauge special anti-corrosion materials may be used. See Chapter 4.
 ^ Ball bearings are not usually recommended for conveyors Handling materials partly or wholly finely ground. (Code A)
 + Any abrasive material which is flammable, or which may contain explosive dust, consult manufacturer for bearing recommendations.

Bearing Recommendations

Selection of bearing material for an intermediate hanger is based on experience together with a consideration of the characteristics of the material to be conveyed. Normally, the bearing selection will be made from one of the following four bearing types:

A. Babbitted or Bronze Bearings

Lubricated babbitted bearings are very frequently used, but have a maximum operating temperature of 130°F; lubricated bronze bearings may be operated at temperatures up to 225°F. This temperature figure for bronze bearings may be exceeded by the use of special high temperature alloys and/or by using appropriate high temperature lubricants. Care must be exercised in the use of babbitted or bronze bearings when the conveyed material must not be contaminated by the products of bearing wear or the lubricants used.

B. Self Lubricated Bearings

Self lubricated bearings are available in several types.

1. Oil impregnated hard maple wood has a maximum operating temperature of 160°F.
2. Oil impregnated sintered bronze has a maximum operating temperature of 200°F.
3. Plastic and reinforced fibre compounds are available in a wide variety of compositions and constructions, and can be obtained from many sources. They require no grease or oil lubrication and usually are run dry. They are best suited for use in conveyors handling a material wetted with water. Maximum operating temperatures vary with the composition and construction of the bearing. When appropriately used, the wear rate is usually low and contamination of the material conveyed is not a very great hazard.
4. Graphited bronze bearings have a maximum operating temperature of 500°F.
5. Commercial carbon bearings may be used for operating temperatures up to 700°F.

C. Ball Bearings

Ball bearings are preferably used when handling granular or pelletized materials not containing any fine powder. Maximum operating temperature is 225°F with petroleum base lubricants, or 270°F with high temperature synthetic lubricants. When appropriately used and sealed against loss of lubricant, ball bearings usually involve no contamination of the material conveyed.

D. Hard Iron Bearings

Hard white iron or chilled iron bearings are used with hardened coupling shafts, for handling abrasive materials. Depending on circumstances, manganese steel, stellite or hardened nickel iron may be used in place of hard iron bearings. Hard iron bearings are not normally lubricated. The maximum operating temperature is 500°F.

Conveyors screw speeds must be considered when using hard iron bearings on hardened coupling shafts in order to minimize wear and to reduce the squealing noise of dry metal on metal. The following formula gives maximum recommended operating speed:

$$N = \frac{120}{\text{Shaft diameter in inches}}$$

where N = Maximum operating RPM of screw

Coupling Shafts

For bearing types A, B and C listed above, the shafting used for the couplings is AISI C1018 standard cold rolled steel or equal.

For hard iron bearings, the shafting for the couplings is usually low carbon steel and surface hardened. Suitably hardened alloy shafting also may be used.

Table 2-7
Component Groups

Normal Service		Component Groups 1A, 1B and 1C Regular screw flights and troughs		Thickness, U.S. Std. Gauge or Inches	
Screw Dia. Inches	Coupling Dia. Inches	Helicoid Flights	Sectional Flights	Trough	Cover
6	1 1/2	6H304	6S307	16 ga.	16 ga.
9	1 1/2	9H306	9S307	14 ga.	14 ga.
9	2	9H406	9S409	14 ga.	14 ga.
12	2	12H408	12S409	12 ga.	14 ga.
12	2 7/16	12H508	12S509	12 ga.	14 ga.
14	2 7/16	14H508	14S509	12 ga.	14 ga.
16	3	16H610	16S612	12 ga.	14 ga.
18	3	—	18S612	10 ga.	12 ga.
20	3	—	20S612	10 ga.	12 ga.
24	3 7/16	—	24S712	10 ga.	12 ga.

Note: Screw numbers refer to CEMA Standard No. 300-1971 on Screw Conveyors.

Table 2-8

Heavy Service		Component Groups 2A, 2B, 2C and 2D Heavy flights and heavy trough		Thickness, U.S. Std. Gauge or Inches	
Screw Dia. Inches	Coupling Dia. Inches	Helicoid Flights	Sectional Flights	Trough	Cover
6	1 1/2	6H308	6S309	14 ga.	16 ga.
9	1 1/2	9H312	9S309	10 ga.	14 ga.
9	2	9H412	9S412	10 ga.	14 ga.
12	2	12H412	12S412	3/16 in.	14 ga.
12	2 7/16	12H512	12S512	3/16 in.	14 ga.
12	3	12H614	12S616	3/16 in.	14 ga.
14	2 7/16	—	14S512	3/16 in.	14 ga.
14	3	14H614	14S616	3/16 in.	14 ga.
16	3	16H614	16S616	3/16 in.	14 ga.
18	3	—	18S616	3/16 in.	12 ga.
20	3	—	20S616	3/16 in.	12 ga.
24	3 7/16	—	24S716	3/16 in.	12 ga.

Note: Screw numbers refer to CEMA Standard No. 300-1971 on Screw Conveyors.

Table 2-9

Extra Heavy Service		Component Groups 3A, 3B and 3D Extra heavy flights and extra heavy trough		Thickness, U.S. Std. Gauge or Inches	
Screw Dia. Inches	Coupling Dia. Inches	Helicoid Flights	Sectional Flights	Trough	Cover
6	1 1/2	6H312	6S312	10 ga.	16 ga.
9	1 1/2	9H312	9S312	3/16 in.	14 ga.
9	2	9H414	9S416	3/16 in.	14 ga.
12	2	12H412	12S412	1/4 in.	14 ga.
12	2 7/16	12H512	12S512	1/4 in.	14 ga.
12	3	12H614	12S616	1/4 in.	14 ga.
14	3	—	14S624	1/4 in.	14 ga.
16	3	—	16S624	1/4 in.	12 ga.
18	3	—	18S624	1/4 in.	12 ga.
20	3	—	20S624	1/4 in.	12 ga.
24	3 7/16	—	24S724	1/4 in.	12 ga.

Note: Screw numbers refer to CEMA Standard No. 300-1971 on Screw Conveyors.

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Chapter 3

Horsepower Requirements, Torsional Ratings for Conveyor Screws, End Thrust Typical Horizontal Screw Conveyor Problem

HORSEPOWER REQUIREMENTS, HORIZONTAL SCREW CONVEYORS

The horsepower required to operate a horizontal screw conveyor is based on proper installation, uniform and regular feed rate to the conveyor and other design criteria as determined in this book.

The following factors determine the horsepower requirement of a screw conveyor operating under the foregoing conditions.

C = Capacity in cubic feet per hour. See Chapter 2.

e = Drive efficiency. See Chapter 8, Table 8-1.

F_b = Hanger bearing factor. See Table 3-1.

F_d = Conveyor diameter factor. See Table 3-2.

F_f = Flight factor. See Table 3-3.

F_m = Material factor. See Chapter 2, Table 2-2.

F_o = Overload factor. See Figure 3.1.

F_p = Paddle factor. See Table 3-4.

L = Total length of conveyor, feet.

N = Operating speed, RPM (revolutions per minute).

W = Apparent density of the material AS CONVEYED, lbs. per cubic foot.

See Chapter 2, Table 2-2.

The horsepower requirement is the total of the horsepower to overcome conveyor friction (HP_f) and the horsepower to transport the material at the specified rate (HP_m) multiplied by the overload factor F_o and divided by the total drive efficiency e , or:

$$HP_f = \frac{LN F_d F_b}{1,000,000}$$

$$HP_m = \frac{CLW F_f F_m F_p}{1,000,000}$$

$$\text{Total } HP = \frac{(HP_f + HP_m) F_o}{e}$$

The derivation of these formulas is given in the Appendix.

It is apparent that with capacity, conveyor size and speed plus conveyor length all known that factors F_m , F_d and F_b are quite important. Small changes in these factors cause significant changes in the required horsepower. A discussion of these factors follows.

The factor F_b is related to the friction in the hanger bearings, due to rubbing of the journals in the bearing metal and including, for sleeve type hanger bearings, an allowance for the entry into the bearing of some foreign material. This factor is empirically derived.

Factor F_d has been computed proportional to the average weight per foot of the heaviest rotating parts and to the coupling shaft diameter.

The factor F_m depends upon the characteristics of the material. It is an entirely empirical factor determined by long experience in designing and operating screw conveyors. It has no measurable relation to any physical property of the material transported.

The overload factor F_o is a correction for calculated horsepowers of less than five horsepower. This factor is necessary because screw conveyors often require a greater torque range than small motors are able to provide. In other words, small overloads or minor choke conditions could easily stall a drive and create an intolerable nuisance in a continuous process. Increasing the horsepower of these small motors has been found a satisfactory means of correcting such undesirable conditions, and the factor F_o does just that.

Factors F_f and F_p are provided as correction factors for the various conveyor screw flight forms. They are empirically derived but have relation to the net effective area of the screw flight.

While it is good procedure in the conveying of bulk materials to run the conveyor until it is empty, prior to a work stoppage, frequently conveyors must of necessity be stopped while fully loaded. In that event, starting the conveyor again may possibly cause serious overloading of the driving motor. The characteristics of the material have much to do with the re-starting of a fully loaded screw conveyor. Some materials will settle and pack or otherwise change their "as conveyed" characteristics. For example, Portland cement may take on the characteristics of a solid. Granulated sugar may pick up moisture from the atmosphere and form a crust or cake. These situations will require a larger than normal driving motor.

It is quite important that a conveyor system operate as demanded by its controls. Start-up conditions or temporary overloads should not cause interruptions in service so all components of the drive, as well as the motor, should be chosen accordingly.

It is generally accepted practice that all power transmitting elements of a screw conveyor be sized and selected to handle safely the full load motor torque. If, for example, a screw conveyor requires 3.5 horsepower as determined by the horsepower formula, a 5 H.P. motor must be used and all power transmitting elements must be capable of safely handling the full 5 horsepower. However, on a screw conveyor made up of several lengths of conveyor screw, only the drive shaft has to handle the full motor load. The succeeding screw lengths and couplings only have to handle loads proportionate to the distance these parts are from the drive shaft. For economy, ease of design and maintenance, it is usual to select conveyor couplings, coupling bolts and other rotating parts such that all are of the same size and interchangeable, even if they are a bit larger than necessary.

The foregoing load carrying requirements really constitute a minimum. Shock loading, metal fatigue from 24 hour per day continuous service, etc., must be considered in addition.

Table 3-1
Hanger Bearing Factor, F_b .

Bearings, Component Groups	Bearing Type	Hanger Bearing Factor F_b
Group A Group B	Ball	1.0
	Babbitt	
	Bronze	
Group C	*Graphite bronze	1.7
	*Canvas base phenolic	
	*Oil Impreg. bronze	
	*Oil Impreg. wood	
	*Plastic, graphite impreg	
	*Nylon	
Group D	*Teflon	2.0
	*Chilled hard iron	
	*Hard surfaced	

* Non lubricated bearings, or bearings not additionally lubricated.

Table 3-2
Conveyor Diameter Factor, F_d

Screw Diameter Inches	Factor F_d	Screw Diameter Inches	Factor F_d
4	12.0	14	78
6	18.0	16	106
9	31.0	18	135
10	37.0	20	165
12	55.0	24	235

Table 3-3
Flight Factor, F_f

Flight Type	F_f Factor for Per Cent Conveyor Loading			95%
	15%	30%	45%	
Standard	1.0	1.0	1.0	1.0
Cut Flight	1.10	1.15	1.20	1.20
Cut & Folded Flight	N.R.*	1.50	1.70	2.20
Ribbon Flight	1.05	1.14	1.20	1.20

* Not Recommended

Table 3-4
Paddle Factor, F_p

Standard paddles per pitch, paddles set at 45° reverse pitch.

Number of Paddles per Pitch	0	1	2	3
Paddle Factor - F_p	1.0	1.29	1.58	1.87

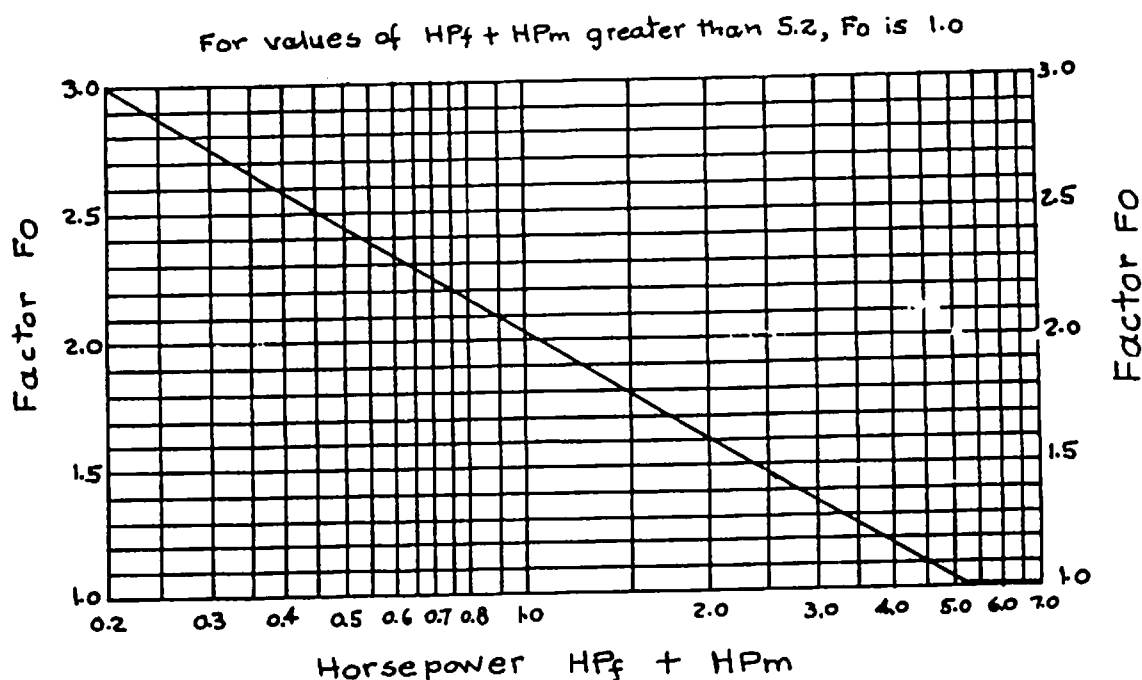


Chart For Values of Factor F_o .

FIGURE 3.1

TORSIONAL RATINGS OF CONVEYOR SCREW PARTS

Screw conveyors are limited in overall length by the amount of torque that can be safely transmitted through the pipes and couplings.

Table 3-5 combines the various torsional ratings of bolts, couplings and pipes so that it is easy to compare the torsional ratings of all the stressed parts of standard conveyor screws. The table conforms to the CEMA Screw Conveyor Standard No. 300-1971. The torsional values are confined to the sizes listed in that standard. However, by referring to the detailed data in the Appendix, under TORSIONAL RATINGS OF CONVEYOR SCREW PARTS, the screw conveyor designer can evaluate sizes of bolts, pipes and couplings for special applications.

The lowest torsional rating figure for any given size of coupling will be the one that governs how much horsepower may be safely transmitted. For example, using standard unhardened two bolt coupling shafts, the limiting torsional strength of each part is indicated by the underlined figures in Table 3-5.

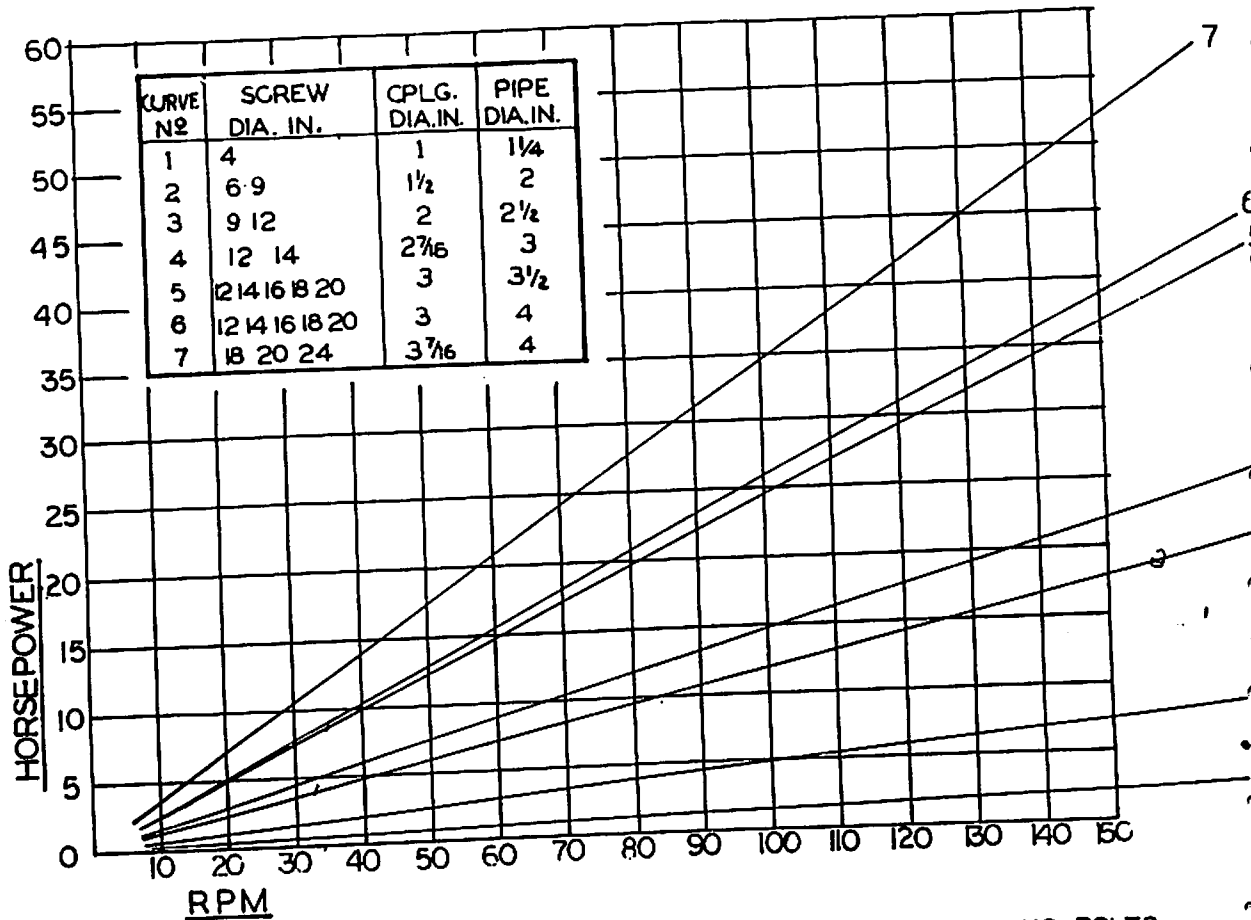
Thus it can be seen that the shaft itself is the limiting factor on 1", 1½" and 2" couplings. The bolts in shear are the limiting factors on the 2 7/16" coupling and on the 3" coupling used in conjunction with 4" pipe. The bolts in bearing are the limiting factors for the 3" coupling used in conjunction with 3½" pipe, and for the 3 7/16" coupling.

Horsepower For Couplings at Various Speeds

The curve on charts Figures 3.2, 3.3, 3.4 and 3.5 give the horsepowers at various speeds for all sizes of screw conveyors using standard shaft two-bolt couplings, hard shaft two-bolt couplings, standard shaft three-bolt couplings and hard shaft three-bolt couplings.

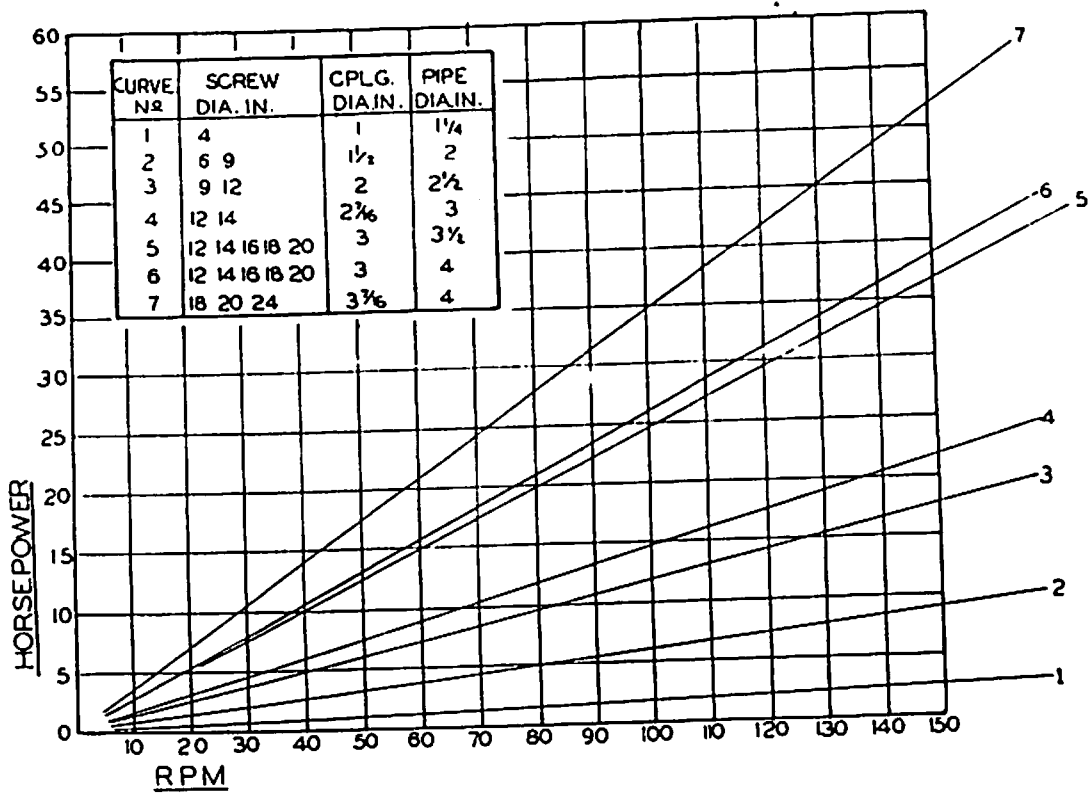
Table 3-5
Torsional Ratings of Bolts, Pipe and Coupling in. Lbs.

Coupling		Pipe	Couplings			Bolts					
Shaft Dia. in.	Size in.	Torque in. Lbs.	Torque in. Lbs.		Dia. in.	Bolts in Shear T ₁ in. Lbs.			Bolts in Bearing T ₂ in. Lbs.		
			Std.	Hard		No. of Bolts Used	No. of Bolts Used				
							1	2	3		
		T ₃	T ₄	T ₅		1	2	3	1	2	3
1	1 1/4	3,140	820	1,025	3/8	690	1,380	2,070	985	1,970	2,955
1 1/2	2	7,500	3,070	3,850	1/2	1,830	3,660	5,490	2,500	5,000	7,500
2	2 1/2	14,250	7,600	9,500	5/8	3,800	7,600	11,400	3,930	7,860	11,790
2 7/16	3	23,100	15,090	18,900	5/8	4,635	9,270	13,900	5,820	11,640	17,460
3	3 1/2	32,100	28,370	35,400	3/4	8,200	16,400	24,600	7,770	15,540	23,310
3	4	43,000	28,370	35,400	3/4	8,200	16,400	24,600	12,500	25,000	37,500
3 7/16	4	43,000	42,550	53,000	7/8	12,800	25,600	38,400	10,900	21,800	32,700



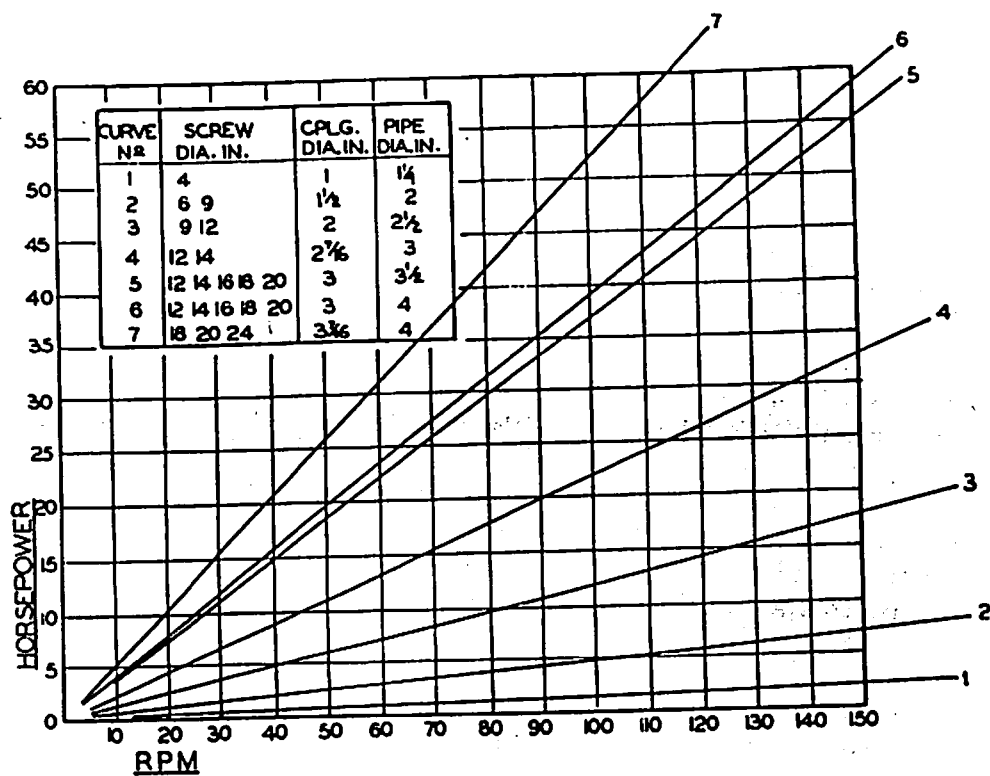
HORSEPOWER LIMITATIONS FOR COUPLINGS USING STD. SHAFT AND TWO BOLTS

FIGURE 3.2



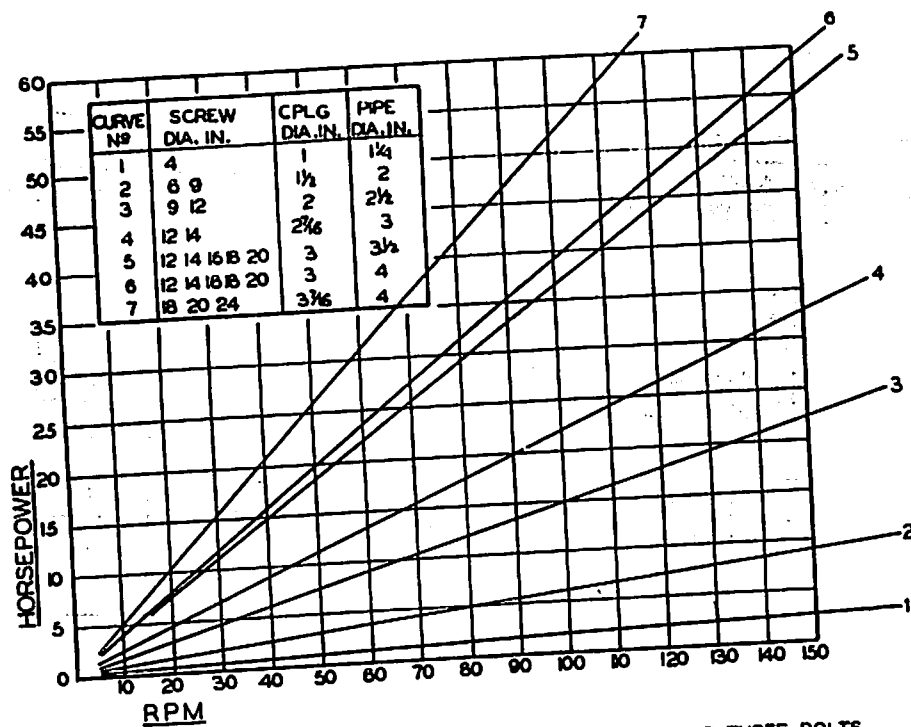
HORSEPOWER LIMITATIONS FOR COUPLINGS USING HARD SHAFT AND TWO BOLTS

FIGURE 3.3



HORSEPOWER LIMITATIONS FOR COUPLINGS USING STD. SHAFT AND THREE BOLTS

FIGURE 3.4



HORSEPOWER LIMITATIONS FOR COUPLINGS USING HARD SHAFT AND THREE BOLTS

FIGURE 3.5

SCREW CONVEYOR END THRUST

End thrust in a Screw Conveyor is created as a reaction to the forces required to move the material along the axis of the conveyor trough. Such a force is opposite in direction to the flow of material. A thrust bearing and sometimes reinforcement of the conveyor trough is required to resist thrust forces. Best performance can be expected, if the conveyor end thrust bearing is placed so that the rotating members are in tension, therefore, an end thrust bearing should be placed at the discharge end of a conveyor. Placing an end thrust bearing assembly at the starting or feed end of a conveyor places rotating members in compression which may have undesirable effects, but this is sometimes necessary in locating equipment.

The simplest end thrust bearing assembly consists of steel, bronze and steel washers assembled as shown in figures 4.13G and 4.13H.

The thrust bearing assembly shown in figures 4.13C and 4.13D is a typical bearing for moderate thrust loads. This bearing is commonly a double row ball bearing or tapered roller bearing assembly in a flange block.

A heavy duty thrust bearing assembly is shown in figure 4.13E and 4.13F and incorporates heavy tapered roller bearings in a special flange block.

Past experience has established that component selection to withstand end thrust is rarely a critical factor and thrust is not normally calculated for design purposes. Standard conveyor thrust components will absorb thrust without resorting to special designs in most applications.

There are, however, cases where components should be sized to take heavy thrust loads. For those cases, the following thrust formula may be used as a conservative calculation of conveyor end thrust:

$$\text{THRUST, lbs.} = \frac{(252,000) (HP) (K)}{(N) (D_s)}$$

where

$K = 1.0$ for standard pitch, pitch = diameter

$K = 1.5$ for $\frac{2}{3}$ pitch

$K = 2.0$ for $\frac{1}{2}$ pitch

$K = 3.0$ for $\frac{1}{3}$ pitch

$K = 4.0$ for $\frac{1}{4}$ pitch

N = Revolutions per minute

D_s = Conveyor screw diameter, inches.

As an example, a 16 inch standard pitch screw conveyor driven by a 10 horsepower motor and operating at 60 revolutions per minute will have a calculated thrust of:

$$\frac{(252,000) (10) (1.0)}{(60) (16)} = 2630 \text{ lbs.}$$

Tests have established that this formula tends to give thrust values several times larger than the measured thrust and past experience will often permit selection of lighter thrust components than indicated by this formula.

CONVEYOR SCREW DEFLECTION

Deflections of conveyor screws of standard length is seldom a problem. However, if longer than standard sections of screw are to be used, without intermediate hanger bearings, care should be taken to prevent the screw flights from contacting the trough because of excessive deflection. The nomograph in Figure 3.10 indicates the deflection of standard helicoid conveyor screw sections on schedule 40 and schedule 80 pipe, for various lengths of screw sections. The schedule 80 pipe may be needed for large torques.

Applications of screw conveyors in which the deflection of the screw exceeds 0.25 inches should be referred to the screw conveyor manufacturer for recommendations. Very often the problem can be solved by using a conveyor screw section with a larger diameter pipe. It will be noted from the nomograph that the use of a schedule 80 pipe reduces the deflection very little, hence it isn't practical to reduce deflections by using heavier pipe. Larger diameter pipe should be used.

Example No. 1

Determine the deflection of a 12H512 conveyor screw section mounted on a schedule 40 pipe, with an overall unsupported length of 18 feet. From the nomographic chart, Figure 3-6, the deflection is greater than 0.25 inch, and therefore indicates that the problem should be referred to the screw conveyor manufacturer for solution.

When the flights of the screw are mounted on something other than Schedule 40 or Schedule 80 steel pipe, such as mechanically drawn tubing or solid shafting of steel or of other metals, the deflection at mid span may be calculated from the following formula:

$$\Delta = \frac{5 W L^3}{384 E I}$$

where: Δ = deflection at mid span, inches

W = total weight of screw, lbs.

L = Length of screw between bearings, inches

E = modulus of elasticity for steel

I = moment of inertia of hollow or solid shaft section.

Example No. 2

Determine the deflection of a 12H512 conveyor screw section mounted on a 3-15/16 inch diameter solid steel shaft, the overall section length being 18 ft. 0 in.

$$W = 8.2 \text{ lbs/ft.} \times 18 = 270 \text{ lbs. wt of 3-15/16" dia. shaft plus 745 lbs. for flights} = 892 \text{ lbs. total.}$$

$$L = 18 \times 12 = 216 \text{ inches; } L^3 = 216^3 = 10.08 \times 10^6$$

$$E = 30.0 \times 10^6$$

$$I = 11.8$$

$$= \frac{(5)(892)(10.08)(10)^6}{(384)(30)(10)^6(11.8)} = 0.342 \text{ inch}$$

The 0.342 inch deflection is greater than the 0.25 inch normally allowable deflection. Therefore, either a larger diameter of solid shaft may be tried, or other section having a higher moment of inertia.

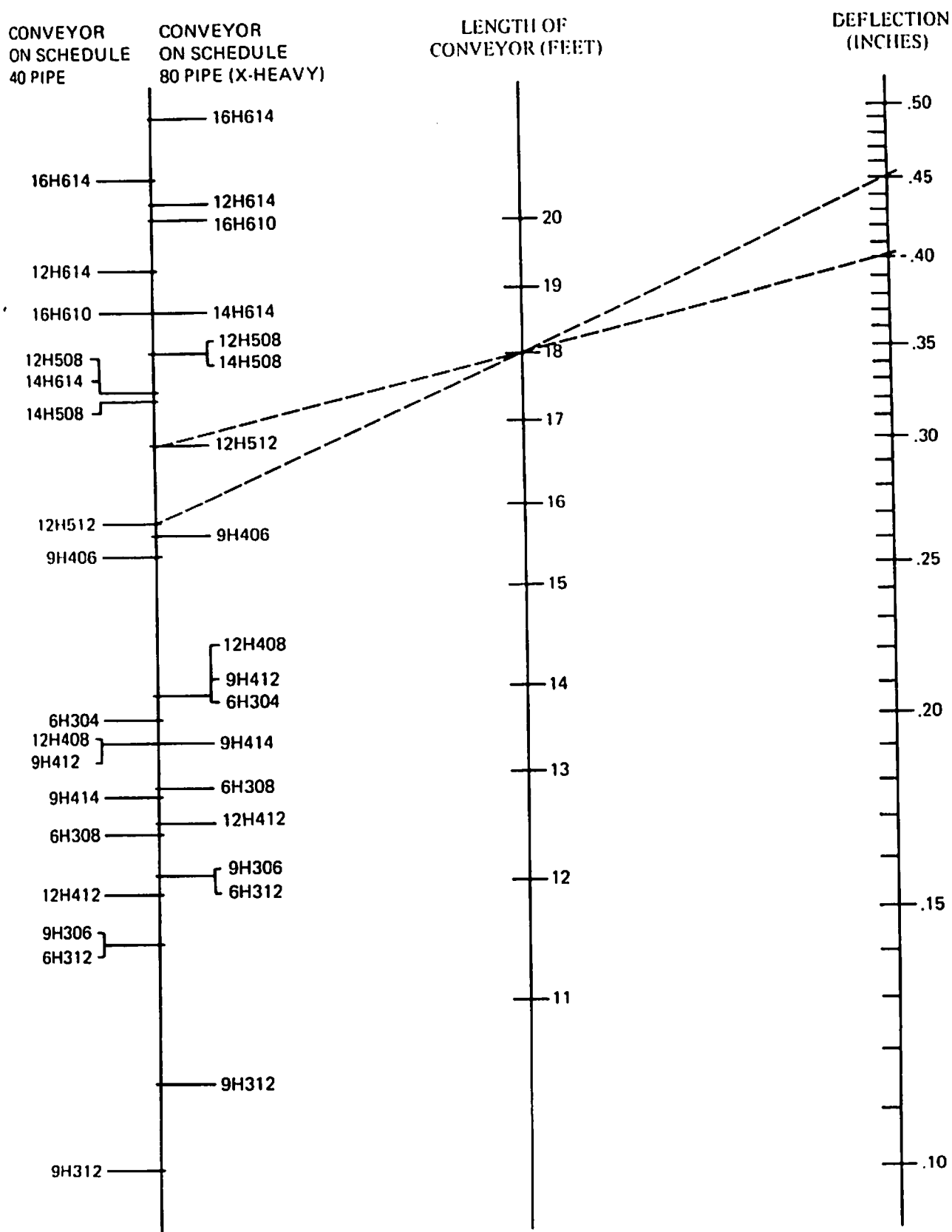


FIGURE 3.6

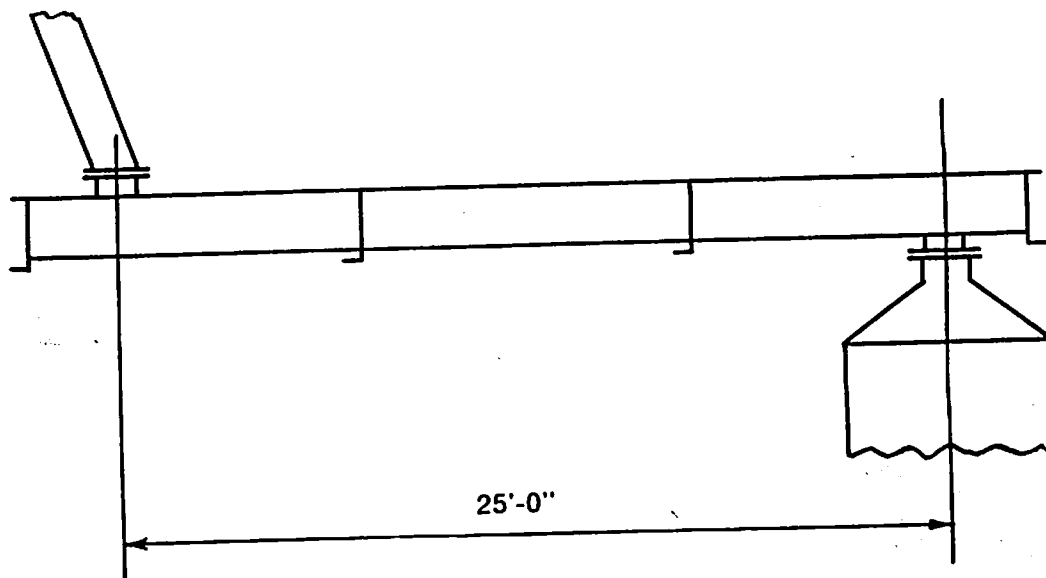
TYPICAL HORIZONTAL SCREW CONVEYOR PROBLEM

The following is a typical screw conveyor problem and its solution. The conveyor specifications and the horsepower to operate the conveyor are determined, stepwise.

A free hand sketch first should be made to indicate the loading and discharge points and to establish general layout dimensions. See Chapter 4 for layout guidance.

Problem.

Convey bulk Portland cement horizontally from a chute to a bin at the rate of 1000 cubic feet per hour. The distance from the center of the chute to the center of the bin is 30 ft. 0 in. Prior feeding apparatus, upstream of the chute, assures a steady stream of the cement from the chute. It is presumed that there are no surge loads and that the rate of flow is constant.



Problem Screw Conveyor Outline
Fig. 3.7

Steps to Solve Problem

Consult the information given under Design Preparation on page 8 of Chapter 1.

Step (a)

✓ Consult material Table 2-2 in Chapter 2. Portland cement is listed as Cement, Portland and Cement, Portland, aerated. Because the action of a screw conveyor will aerate the cement, use the "aerated" data and code.

W = weight of material, lbs./cu. ft. = 60 to 75

94A₁₀₀26M is the material code

2 D is the Component Series

1.4 is the Material Factor, F_m

Step (b)

Because bulk Portland cement is purchased and sold at its highest apparent density and "as conveyed" is at its lowest apparent density, it is necessary to find the equivalent aerated volume.

The total lbs. of cement to be delivered to the conveyor are (95) times (1000) = 95,000 lbs. per hr., using the highest apparent density: Then the volumetric capacity of the screw conveyor must be

$$C = \frac{95,000}{60} = 1580 \text{ cu. ft. per hr., using the lowest aerated apparent density.}$$

Step (c)

From Table 2-3 on page 27, for a Material Class Code of A16, the corresponding trough loading is 30% for Abrasive Material. From the same table, at Maximum RPM, it is obvious that at least an 18 inch diameter must be employed. The volume at maximum speed for an 18 inch screw is 2025 cu. ft. per hr., so to handle the required 1580 cu. ft. per hr., the speed can be:

$$N = \frac{(1580)}{(2025)}(45) = 35 \text{ R.P.M. actual operating speed}$$

Step (d)

Because the cement is a fine powder, there is no "lump size" to consider and make an allowance for.

Step (e)

The conveyor is simply a transport device, devoid of any feeding requirement. There are no other peculiarities that would require a reduced pitch, so the screw will be made full pitch. In fact full pitch was already envisaged when the operating speed was calculated.

The Flight Factor, F_f , from Table 3-3 for standard full pitch at 30% loading is 1.0. There is no mixing requirement and no paddles needed; hence the Paddle Factor, F_p , is 1.0.

Step (f)

By using Component Series 2D and the diameter of the screw, D_s , as 18, from Table 2-6, Heavy Service with heavy flights and heavy trough, it is found that:

Coupling Size 3 inch
Screw Number 18 S 616, Pipe size $3\frac{1}{2}$ Schedule 40, Section length, 11 ft. 9 in., Flight thickness $\frac{1}{4}$ inch from CEMA Std. No. 300-1971 for Screw Conveyors. The trough is $\frac{3}{16}$ inch and the cover 12 gauge. Trough sections 12 ft. long.

Step (g)

Using Material Code size "A", the Abrasive Code number 6, and the Component Series 2D, select from Table 2-5 hard iron bearings for the hangers. These hard iron bearings require hardened coupling shafts.

Checking the maximum recommended operating RPM from paragraph D, page 32 Chapter 2, for Hard Iron bearings.

$$N = \frac{120}{3} = 40 \text{ R.P.M. Maximum recommended}$$

The chosen operating speed of 35 RPM is less, so it is all right.

Step (h)

The Hanger Bearing Factor, F_b from Table 3-1, Chapter, 3, page 38, for Hard Iron Bearings is 4.4.

The Conveyor Diameter Factor, F_d , for 18 inch diameter is 135.0.

The overall length of screw must be greater than the 20 ft. 0 inch distance between the centers of the feed chute and bin. Use three standard screw conveyor trough sections, each 12 ft. long, making the total length of screw conveyor $(3)(12) = 36 \text{ ft.} = L$.

Step (i)

There is now sufficient information to make a tentative horsepower calculation to determine the Overload Factor F_o .

From the horsepower formulas on page 36,

$$HP_f = \frac{L N F_d F_b}{1,000,000} = \frac{(36)(35)(135)(4.4)}{1,000,000} = 0.75 \text{ HP}$$

$$HP_m = \frac{CLW F_f F_m F_p}{1,000,000} = \frac{(1580)(36)(75)(1)(1.4)(1)}{1,000,000} = 6.0 \text{ HP}$$

The sum of HP_f plus HP_m is $0.75 + 6.0 = 6.75$. Referring now to Figure 3.1 on page 39, for the sum of HP_f and HP_m as 6.75, Overload Factor F_o is 1.0. Therefore, the calculated total horsepower of 6.75 is no longer tentative but final.

In order to select a motor horsepower, it is necessary to know the drive efficiency. Assume the drive will be a double reduction helical gear box shaft mounted on the screw drive shaft and driven from a motor by a vee belt. From Table 8-1, in Chapter 8, the efficiency of the gear box is 0.94 and the vee belt drive 0.94. Hence the overall efficiency is $(.94)(.94) = 0.885$. The motor horsepower, therefore, may not be less than

$$HP = \frac{5.55}{0.885} = 6.27$$

The nearest larger motor size is $7\frac{1}{2}$ HP and this is the motor to use.

Step (j)

Check the conveyor coupling and pipe to ascertain whether their horsepower ratings are adequate to handle the full motor horsepower.

From Figure 3.2, Curve 5, for an 18 inch screw at 35 RPM, it is seen that the $3\frac{1}{2}$ inch pipe and the 3 inch hardened coupling are rated at 8 HP, safely above the $7\frac{1}{2}$ HP motor.

Step (k)

Calculate the conveyor end thrust from the thrust formula on page 42.

$$\text{Thrust, lbs.} = \frac{(252,000)(HP)(K)}{(N)(D_s)}, \text{ where } K = 1.0 \text{ for Standard pitch}$$

$$= \frac{(252,000)(7.5)(1)}{(35)(18)} = 3,000 \text{ lbs.}$$

Because this thrust load is heavy an appropriate thrust bearing is required at one end of the conveyor. Thrust bearings may not be used at both ends because the screw must be free to expand and contract with temperature changes. The thrust bearing should be applied at the conveyor end that will put the screw in tension and thus avoid buckling.

Various kinds of thrust bearings are shown in Chapter 4, page 63. The thrust bearing must be protected against entry of the abrasive cement dust.

Step (l)

As the sections of the conveyor screw are standard length, it will not be necessary to check the screw for deflection. Were any of the sections longer than standard, a check would be necessary.

Step (m)

Because bulk Portland cement is a dusty material, particularly when aerated by the action of the conveyor screw, it is necessary to use Class IIE or better covers on the trough, and to use seals between the inside of the trough end and the end bearings, including the thrust bearing. See Chapter 4, page 64 for the various types of trough end seals. See also class of enclosures page 75.

The hardened couplings journaled in the hard iron hanger bearings are recommended for handling cement.

Step (n)

The various components required to make up a screw conveyor are shown in Chapter 4. Dimensional data on these components are contained in CEMA Standard No. 300-1971 for Screw Conveyors, and also in manufacturer's catalogs.

The sections of a conveyor screw must be supported in hanger bearings, at the points where the sections are joined by couplings. There will be two such hanger bearings required for the screw conveyor in the subject problem.

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Chapter 4

Screw Conveyor Layout, Screw Conveyor Components

SCREW CONVEYOR LAYOUT ARRANGEMENTS

There are three general layout arrangements for horizontal screw conveyors, as described below.

Arrangement A

This is the usual arrangement of a horizontal screw conveyor. The simplest arrangement involves one or more standard lengths of screw and trough with hangers located at the trough joints producing a conveyor that is a multiple of standard conveyor trough lengths. Intermediate conveyor lengths can be provided by locating an odd length of screw and trough at one end with hangers remaining at the trough joints. If the layout dictates, the odd length of screw may be placed at one end of the conveyor and the odd length of trough at the other end. The hangers then will not be located at the trough joints.

See Figure 4.1 for illustration of this arrangement.

Arrangement B

This arrangement of a horizontal screw conveyor consists of right and left hand screw sections, feeding material from two or more oppositely spaced points toward a single more or less central discharge point. See Figure 4.2.

The screw sections at the discharge point have the flights stopped off so as to dump the material into the discharge opening without compressing it. The right and left hand screws may each consist of an odd length, or one or more standard lengths plus an odd length as required.

Still another variation is possible. If the drive is made reversible, the screws may be all of one hand, and the material travel obtained in the desired direction simply by reversing the rotation of the screw.

Arrangement C

This arrangement of horizontal screw conveyor is called a leveling screw conveyor and is similar to Figure 1.8 in Chapter 1. Its purpose is to make possible the level filling of bins and compartments, or the leveling of the top of a storage pile. It is preferable in this arrangement to use a sort of bottomless trough, consisting of a pair of formed or rolled channels, to support the hangers. The channel trough is usually boxed in at the feed point to support the drive shaft - and perhaps the drive itself. For convenience in construction, the thrust bearing in this case is placed at the feed end, which puts the screw in compression.

The channel trough may be eliminated if the hangers can be supported from overhead building steel, but in that event the thrust is no longer self-contained within the conveyor assembly and must be taken by the building steel.

Arrangement C is shown typically in Figure 4.3.

GUIDE FOR LAYING OUT A STANDARD CONVEYOR

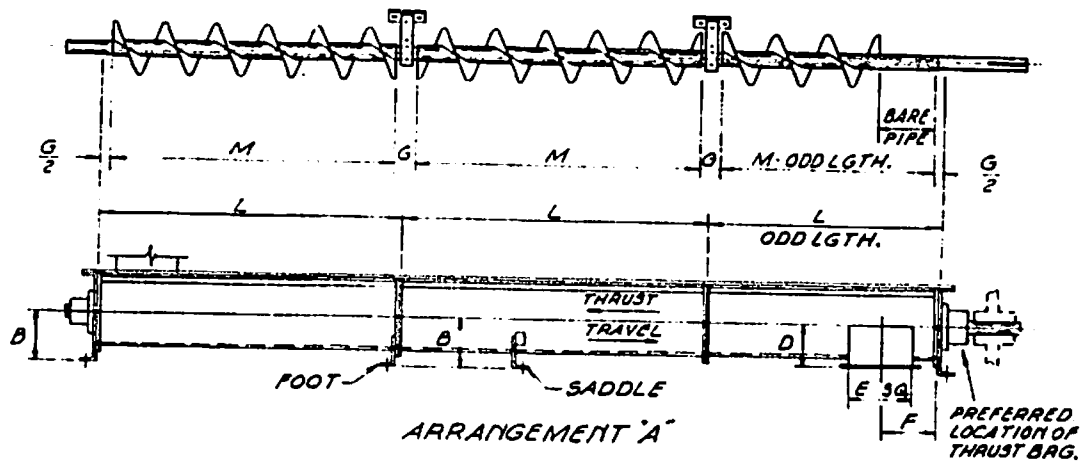


FIGURE 4.1

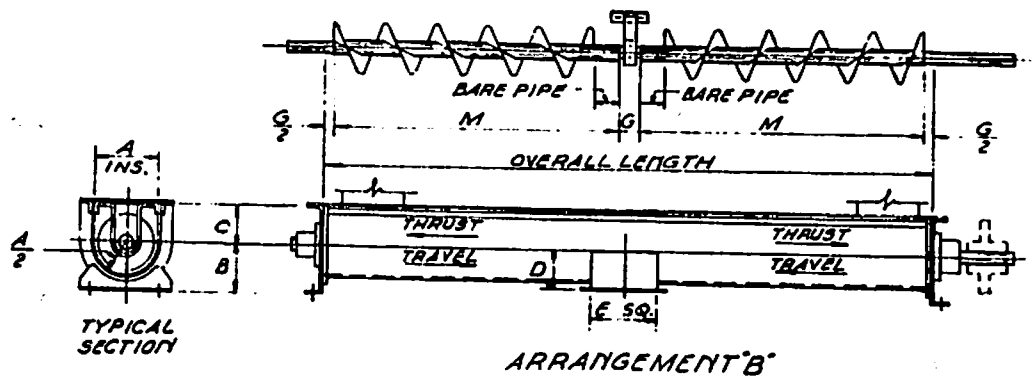


FIGURE 4.2

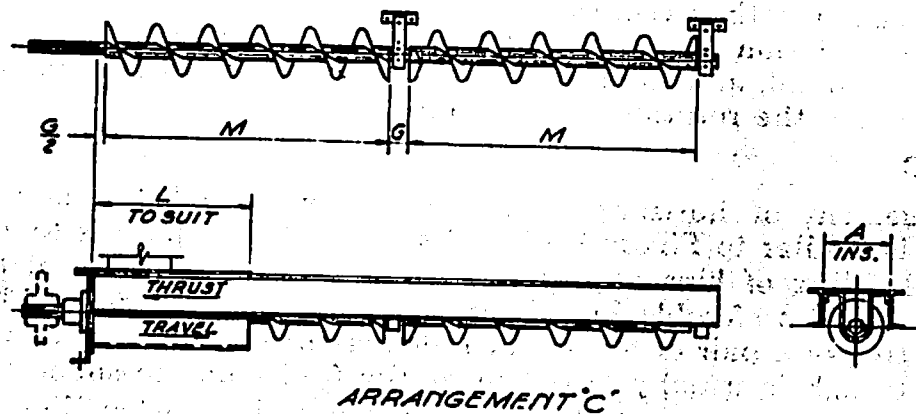


Figure 4.3

Table 4-1
Dimensional Data For Screw Conveyor

Layout Arrangements Dimensions, Inches For Figs. 4.1, 4.2 and 4.3									Standard Section Length Feet and Inches	
Nom. Conveyor Dia. Inch	Coupling Dia. Inch	A	B	C	D	E	F	G	Trough Length L	Screw Length M
6	1 1/2	7	5 5/8	4 1/2	5	7	6	2	10'-0"	9'-10"
9	1 1/2	10	7 7/8	6 1/8	7 1/8	10	8	2	10'-0"	9'-10"
9	2	10	7 7/8	6 1/8	7 1/8	10	8	2	10'-0"	9'-10"
12	2	13	9 5/8	7 3/4	8 7/8	13	10 1/2	2	12'-0"	11'-10"
12	2 7/16	13	9 5/8	7 3/4	8 7/8	13	10 1/2	3	12'-0"	11'-9"
12	3	13	9 5/8	7 3/4	8 7/8	13	10 1/2	3	12'-0"	11'-9"
14	2 7/16	15	10 7/8	9 1/4	10 1/8	15	11 1/2	3	12'-0"	11'-9"
14	3	15	10 7/8	9 1/4	10 1/8	15	11 1/2	3	12'-0"	11'-9"
16	3	17	12	10 5/8	11 1/8	17	13 1/2	3	12'-0"	11'-9"
18	3	19	13 3/8	12 1/8	12 3/8	19	14 1/2	3	12'-0"	11'-9"
18	3 7/16	19	13 3/8	12 1/8	12 3/8	19	14 1/2	4	12'-0"	11'-8"
20	3	21	15	13 1/2	13 3/8	21	15 1/2	3	12'-0"	11'-9"
20	3 7/16	21	15	13 1/2	13 3/8	21	15 1/2	4	12'-0"	11'-8"
24	3 7/16	25	18 1/8	16 1/2	15 3/8	25	17 1/2	4	12'-0"	11'-8"

L is trough length and intermediate cover length. At the ends of the conveyor, the cover length is the trough length plus the width of the top flange of the trough end.

Dimensional Data

Figures 4.1, 4.2 and 4.3 are dimensioned with letters, the values for which are given in Table 4-1 for screw conveyors of 6 to 24 inch diameter. This table also gives additional data helpful in laying out the three arrangements. Additional dimensions of the parts of the screw conveyor are given in the CEMA Standard No. 300-1971 for Screw Conveyors.

General Conditions

Descriptions of component parts of the screw conveyors such as screws, flighting, troughs, trough ends, trough covers, inlets, discharge spouts and gates, saddles and feet, hangers, drive and tail shafts, thrust bearings and seals are given on the following pages of this chapter. Screw conveyor drives are covered in Chapter 8.

Most safety codes prescribe that screw conveyors always be equipped with a cover. Depending on circumstances, the cover may be solid metal or some variety of heavy metal screening.

Fabricated openings in the cover provide means for connecting inlet spouts. Whether there are one or more such inlets, consideration must be given to the design arrangement so that surge or other overloads do not occur to the extent that the allowable cross-section load capacity of the conveyor is exceeded. This is true only of screw conveyors with intermediate hanger bearings; short, single-flight-length screw conveyors may be designed to run full and act as feeders.

Discharge arrangements are shown in Figures 4.17A, B, C, D and E; 4.18A, B, C, D, E, F and G.

Right angle bevel gear or miter gear boxes (or counter shaft trough ends) may be used in place of standard trough ends where it is desired to drive one conveyor from another and the conveyors are at a right angle to each other. These boxes or countershaft trough ends will absorb conveyor thrust in either direction.

SCREW CONVEYOR COMPONENTS

The following descriptions and uses of components of screw conveyors facilitate the appropriate selection of each of them to solve a particular screw conveyor problem, and reveals to the reader the extensive flexibility of screw conveyor.

Conveyor Screw Flighting

Screw conveyor flighting is made in either of two ways, as "helicoid" or "sectional" flights. Helicoid flights are formed from a flat bar or strip into a continuous helix. This flighting is thinner on the outer edge than on the inner edge. Sectional flights are formed from a flat disc and the thickness of the flight is uniform. The lead of a sectional flight is slightly greater than one pitch. A continuous helix is made by joining a number of sectional flights together on a piece of pipe and butt welding them together. Standard conveyor specifications are illustrated in CEMA standard 300-1971.

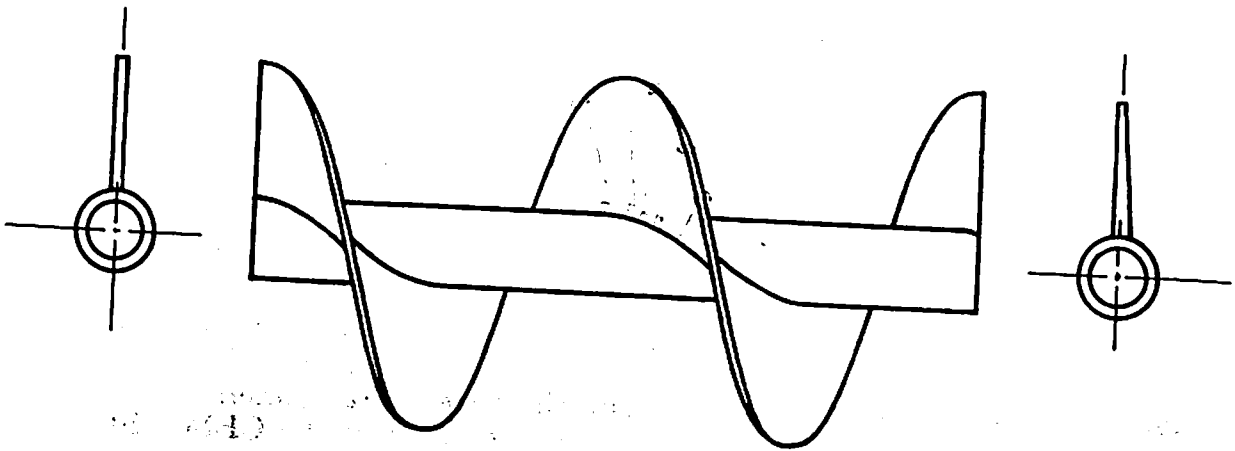


FIGURE 4.4

Figure 4.5
Conveyor Screw Flight Modifications

FIGURE 4.5A

Cut Screw flight

Used for conveying, cooling and moderately mixing materials, simultaneously.



FIGURE 4.5B

Cut and folded screw flight

The folded flight lifts a portion of the material then releases it at the top of the regular flow. This improves aeration and agitation of the material, promotes mixing.

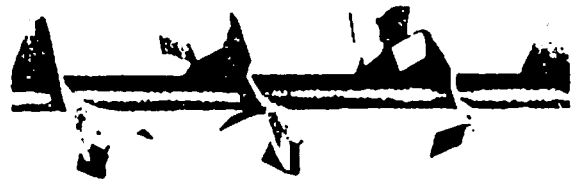


FIGURE 4.5C

Regular screw flighting with mixing paddles

Used to mix materials where the conveyor length provides time for proper mixing.

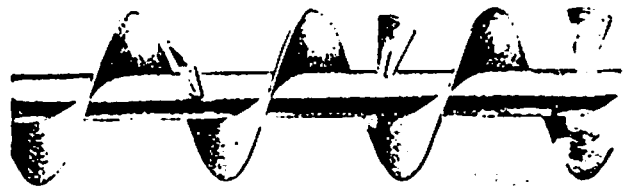


FIGURE 4.5D

Paddle conveyor screw

Paddle conveyor screws have formed steel blades mounted on rod shanks inserted through the pipe. Conveying action can be controlled by adjusting the angle of the paddles. They are used for mixing, blending or stirring dry or fluid materials.

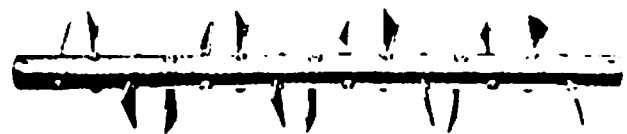
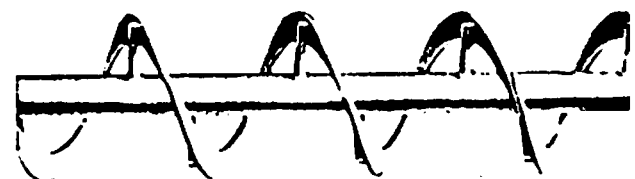
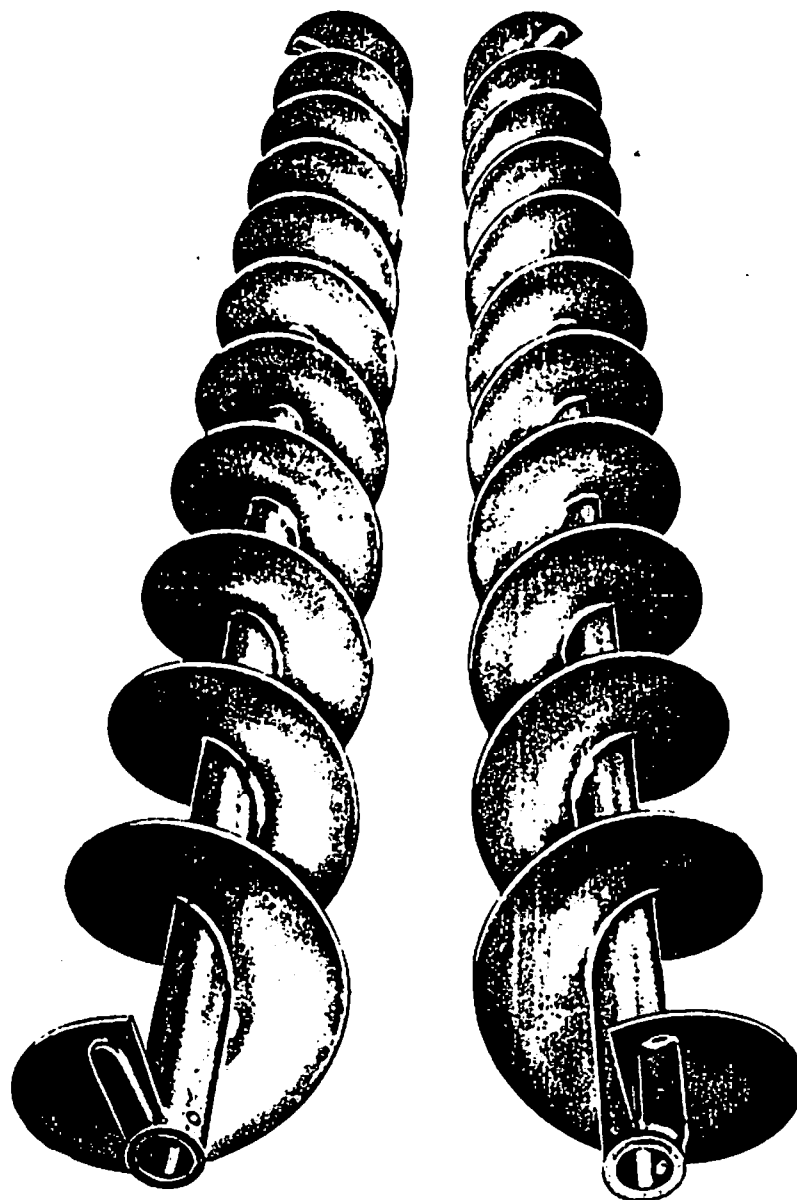


FIGURE 4.5E

Ribbon flight conveyor screw

Ribbon flight conveyor screws consist of continuous helical flighting formed from steel bar and secured to the pipe by supporting lugs. They are used for conveying sticky, gummy or viscous substances, or where the material tends to adhere to the flighting in the corner where the flight meets the pipe.





Left hand

Right hand

Hand of Screw Flights

Fig. 4.6

Right and Left Hand Screws

A conveyor is either right hand or left hand as determined by how the helical flighting is formed. The hand of the screw may be clearly and easily ascertained by looking at the end of the screw, as shown in Figure 4.6.

The screw pictured to the left has the helical flighting wrapped around the pipe in a counter-clockwise direction. This is arbitrarily termed a **LEFT** hand screw.

The screw pictured to the right has the helical flighting wrapped around the pipe in a clockwise direction. This is termed a **RIGHT** hand screw.

A conveyor screw viewed from either end will show the same configuration.

If the end of the conveyor screw is not readily visible, then by merely imagining that the flighting has been cut and the cut end exposed, the hand of the screw readily may be determined.

The arrows in Figure 4.7 indicate which way the material will move if right or left hand screws are rotated as indicated.

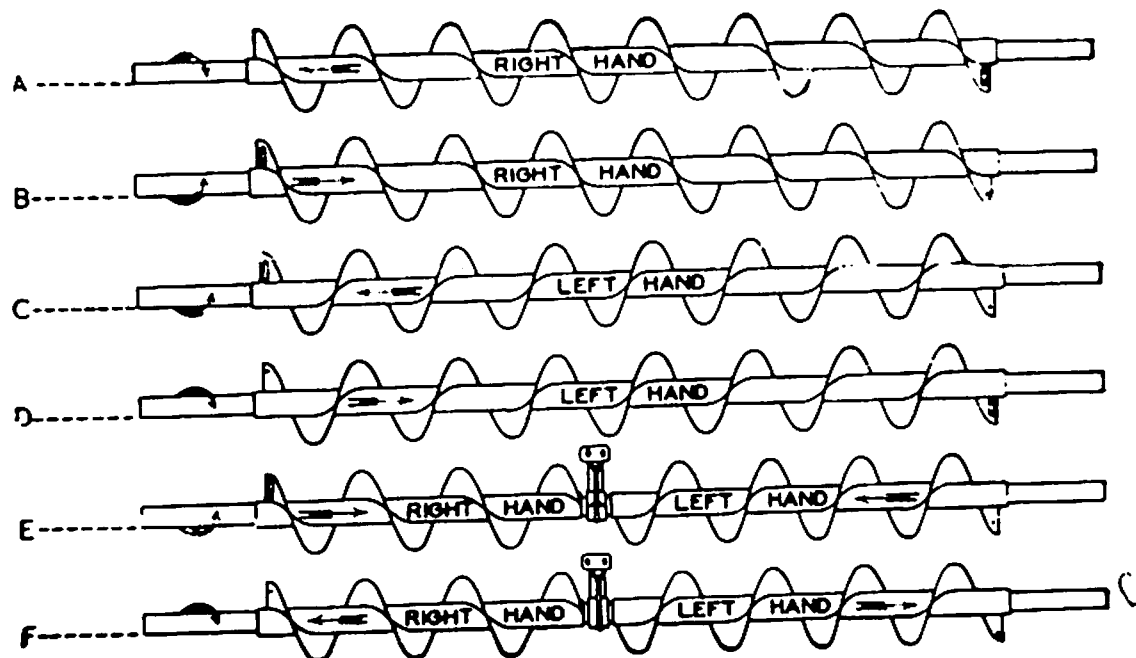


Figure 4.7

Material travel in RIGHT and LEFT HAND screw conveyors

It will be obvious to the attentive observer that the HAND of a conveyor screw is a most important consideration in the design, application and ordering of a conveyor screw. Once a screw conveyor is built and installed with a certain hand, the direction of rotation is fixed for the desired direction of material transport. Any replacements must be of the same HAND to avoid disastrous results.

If the HAND of the screw isn't specified, the screw manufacturer will normally supply a RIGHT HAND screw.

Screw Flight Mounting

The metal helix of the screw, or the paddles used in lieu of a continuous helix, is mounted on either a hollow tube or a solid shaft. The hollow tube is normally Schedule 40 black steel pipe, but Schedule 80 pipe and mechanically drawn steel tubing sometimes are used. Occasionally a solid steel shaft is used for special conditions.

The pipe sections are bushed at the ends, and holes are drilled for the coupling bolts.

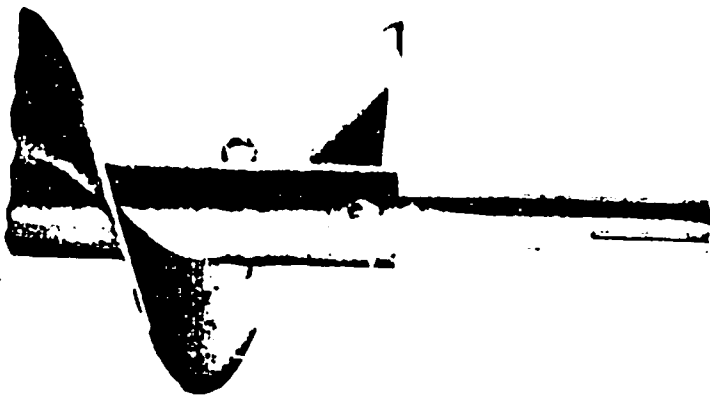
Shafting

In a screw conveyor, the drive, coupling and tail shafts usually are of the same diameter. They are drilled to match the drilled holes in the ends of the pipe shafts of the conveyor screw. All screw pipe shaft ends are bushed so that the shafts are a slip fit in them.

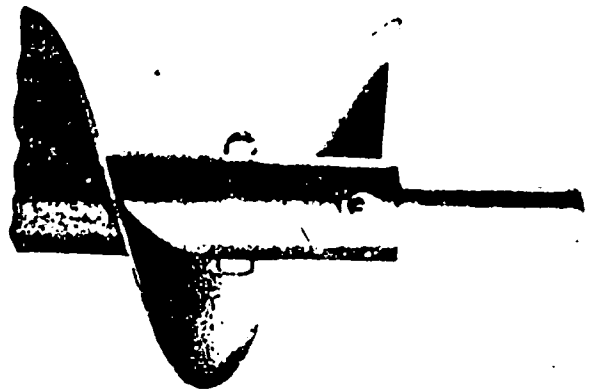
For conveying abrasive material, the coupling shafts are hardened.

CEMA Standard 300-1971 governs the dimensions of ordinary steel and hardened steel coupling shafts.

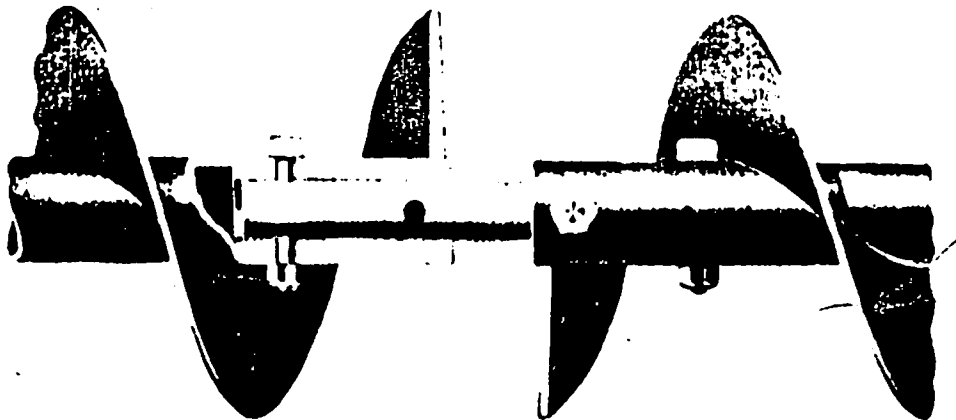
See accompanying illustrations for these shafts in Figures 4.8A, 4.8B and 4.8C.



Conveyor Drive Shaft
Fig. 4.8A



Conveyor Tail Shaft
Fig. 4.8B



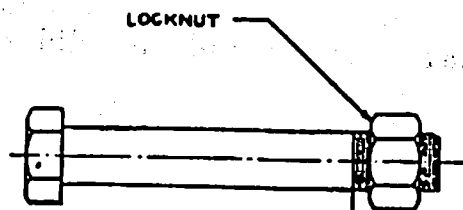
Conveyor Coupling Shaft
Fig. 4.8C

Coupling Bolts

Coupling bolts are special hexagon head bolts with a short length of threads, so that the threaded portion does not come into the load area where the screw pipe shaft contacts the bolt.

CEMA Standard 300-1971 specifies the dimensions for coupling bolts.

A typical coupling bolt, with hexagon nut, is shown in Fig. 4.9,



Coupling Bolt, With Nut
Fig. 4.9

Hangers And Hanger Bearings

Hangers and hanger bearings support and position the conveyor screw within the trough where more than one section of screw conveyor is used, or at the point where the trough discharges directly out of its open end.

Typical hangers are shown in Figures 4.10A, B, C, D, E, F, G, & H. The commonly used hanger bearings are illustrated in Figures 4.11A, 4.11B and 4.11C.

The dimensions for Nos. 216 and 226 hangers and hanger bearings are given in the CEMA Screw Conveyor Standard No. 300, 1971.

No. 216 hangers have formed steel frames of superior strength and rigidity and are excellent for heavy service. They are mounted inside of the conveyor trough. Mounting holes are slotted parallel with the conveyor to facilitate assembly and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings.

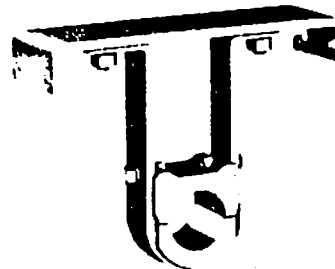


FIGURE 4.10A

No. 230 hangers are similar in construction to No. 216, except that they are mounted on top of the trough angles or flanges. Mounting holes are slotted parallel with the conveyor to facilitate assembly and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings but can also be furnished with special bearings. Stainless steel frames can be furnished.



FIGURE 4.10B

No. 226 hangers have a rigid, formed steel frame with clearance for passage of material in large volume. They are mounted inside of the conveyor trough. Mounting holes are slotted parallel with the conveyor to facilitate assembly and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings but can also be furnished with special bearings. Stainless steel frames can be furnished.

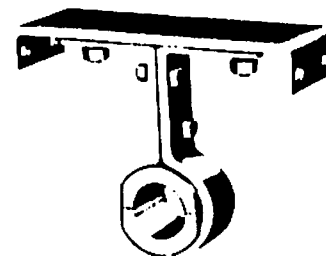


FIGURE 4.10C

No. 220 hangers are similar in construction to No. 226, except that they are mounted on top of the trough angles or flanges. Mounting holes are slotted parallel with the conveyor to facilitate assembly and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings but can also be furnished with special bearings. Stainless steel frames can be furnished.

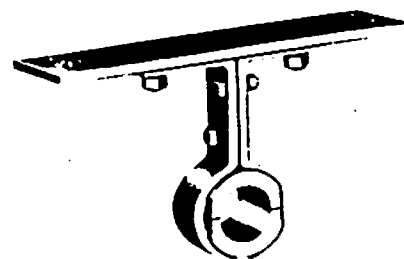


FIGURE 4.10D

Hanger No. 260 features a self-aligning ball bearing for lower power consumption and quieter operation. Sealed to minimize contamination from the bearing lubricant, the 260 is furnished with Alemite fittings. The top bar, with widely spaced bolt holes, mounts to the top of the trough and provides rigid support for maintaining proper conveyor alignment. This feature is particularly essential when using ball bearing hangers. It also allows mounting the hanger at trough joints.

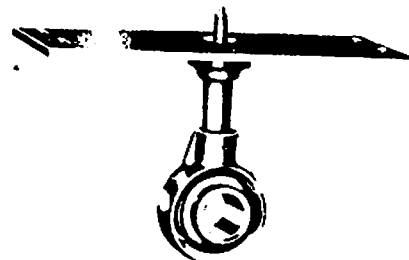


FIGURE 4.10E

Hanger No. 270 is similar to the No. 260 in that it features a self-aligning ball bearing. This results in lower power requirements and quieter operation. The bearing is sealed to prevent contamination from the bearing lubricant and is furnished with Alemite fittings. The No. 270 is designed to be mounted inside the trough which simplifies cover fabrication and assembly, and makes it suitable for use with a dust-tight or weather-proof cover. The widely spaced bolt holes on the top bar provides for stable support and helps maintain proper conveyor alignment. This is particularly important when using ball bearing hangers. The extra width of the top bar also allows mounting the hangers at trough joints.

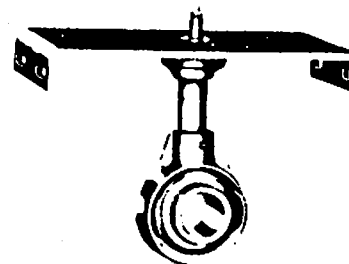


FIGURE 4.10F

Hangers for use in flared troughs may be furnished in any of the fabricated hanger styles shown on pages 59 and 60. Hanger is normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings. Assembly bolts for mounting hangers to trough are included.

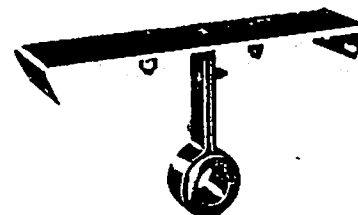


FIGURE 4.10G

No. 326 hangers are similar in construction to No. 226 hangers, except that they are self-adjusting. The top bars are arranged to slide on angle guides fastened to the troughs. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings. Assembly bolts for mounting hanger to trough are included.

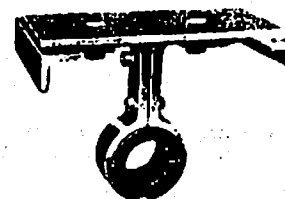


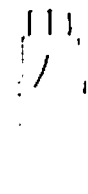
FIGURE 4.10H



Numbers 220, 226 and 326
Hanger Bearings
Fig. 4.11A



Numbers 216 and 230
Hanger Bearings
Fig. 4.11B



Ball Bearing for Hangers
Fig. 4.11C

The numbers 216, 220, 226, 230 and 326 bearings are made from cast iron, cast bronze, molded plastic or machined from wood. The cast bearings can be cored for babbitt or may be machined for sleeve bushings.

Trough Ends

Fabricated plate trough ends serve to close the ends of the trough. They give the trough rigidity and proper contour. A flange at the top of the trough end corresponds with the trough flanges, thus providing a uniform surface for the trough cover.

Trough ends commonly are designed to support the end bearings for the drive and tail shafts and provide a place to fasten the seal arrangements. They usually have a foot for supporting the end of the conveyor from a structure or a foundation.

Trough ends may be modified to omit the foot or even to omit that portion of the end plate below the bearing if end discharge or an overflow safety provision is desired. In the latter case specially shaped plain or anti-friction flanged bearing mounts are necessary. If a pillow block bearing is desired, a shelf type trough end is used.

CEMA Standard 300-1971 indicates the dimensions of the ordinary fabricated trough ends, with or without feet.

Typical trough ends are shown in Figures 4.12A, 4.12B, 4.12C, 4.12D, 4.12E, 4.12F, and 4.12G.

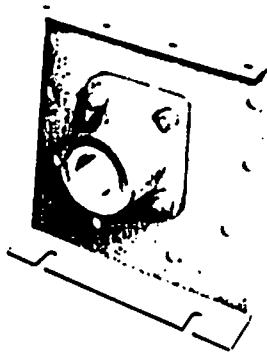


FIGURE 4.12A
For babbitted or bronze bushed end bearings. Shown without dust seal between bearing and plate.

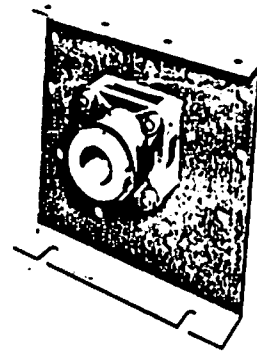


FIGURE 4.12B
For flange type ball or roller bearings. Shown with dust seal.

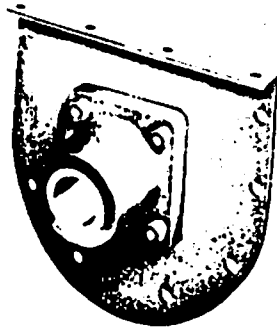


FIGURE 4.12C
For babbitted or bronze bushed end bearings, with or without dust seal.

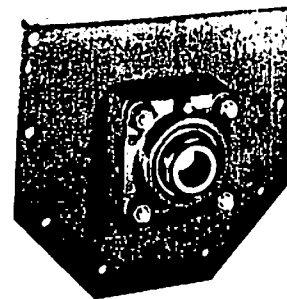


FIGURE 4.12D
For flange type ball or roller bearings, with or without dust seal.

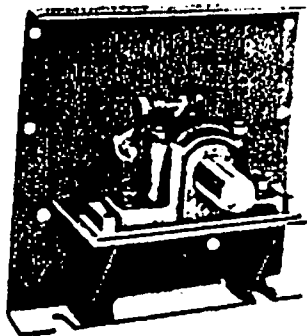


FIGURE 4.12E
Trough end has integral bracket for pillow block bearing, plain or anti-friction. With or without dust seal.

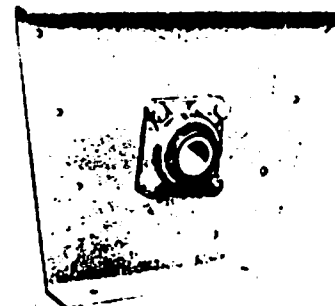


FIGURE 4.12F
Flared trough end for flared troughs. Bearing may be plain or anti-friction. With or without dust seal.

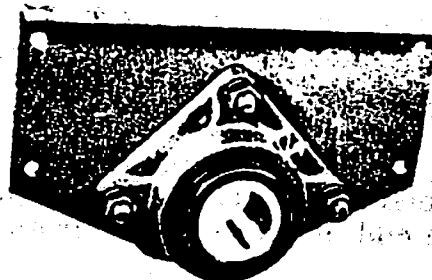


FIGURE 4.12G
The lower part of this trough end is omitted, to permit material to discharge under bearing. Bearings babbitted, bronze bushed or anti-friction.

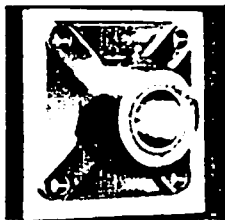
Trough End Bearings, Thrust Bearings And Pillow Blocks

Trough end bearings may be of babbitt, bronze, ball or roller type or of special bushing materials.

Flange bearings are used with plate type and pillow blocks with shelf type box ends.

Ball and roller bearings have thrust capabilities and some bearing assemblies are designed specifically to carry heavy thrust loads. Sleeve bearings, on the contrary, are not adapted to carry thrust loads and have to be augmented by a thrust bearing, usually composed of alternate steel and bronze thrust washers.

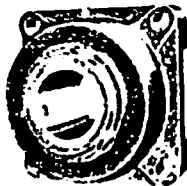
The various types of trough end and thrust bearings are shown in Figures 4.13A, 4.13B, 4.13C, 4.13D, 4.13E, 4.13F, 4.13G, 4.13H and 4.13I.



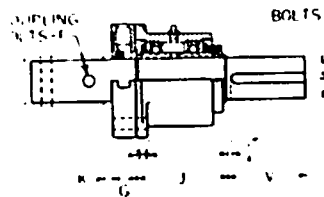
Sleeve Bearing
(Babbitt or bronze)
FIGURE 4.13A



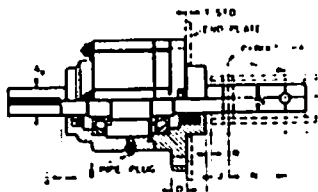
Ball Bearing
FIGURE 4.13B



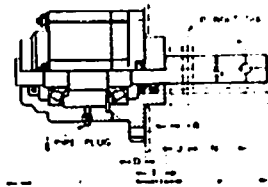
Roller Bearing
(For moderate thrust)
FIGURE 4.13C



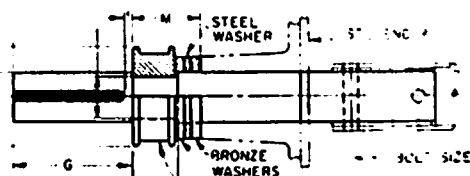
Double Ball Bearing
(For moderate thrust)
FIGURE 4.13D



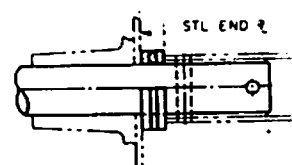
Roller Bearing, Drive End
(For extra heavy thrust)
FIGURE 4.13E



Roller Bearing, Tail End
(For extra heavy thrust)
FIGURE 4.13F



Bronze Thrust Bearing
(Conveyor screw in tension)
FIGURE 4.13G



Bronze Thrust Bearing
(Conveyor Screw in compression)
FIGURE 4.13H

Trough End Seals

Trough end seals are used to prevent the material being handled in the conveyor from leaking around the tail or drive shaft openings in the trough end. They are used to protect the end bearings from damage by entrance of abrasive or corrosive materials, and also to prevent foreign materials from entering the trough and contaminating the materials being handled. See Figures 4.14A, 4.14B, 4.14C, 4.14D, and 4.14E.

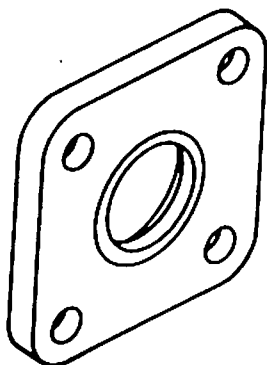
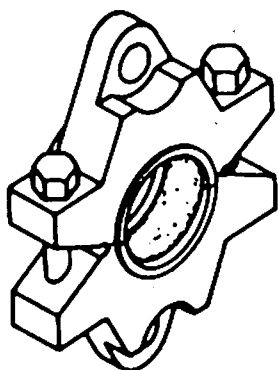


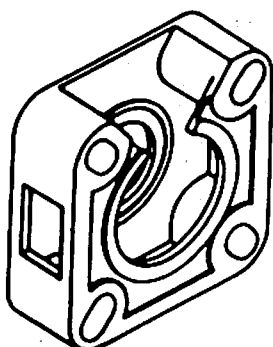
Plate Seal
Fig. 4.14A

The plate seal is an economical, effective sealing device designed, for exterior mounting between the end bearing and the trough end. Standard units employ lip type seals to contact the shaft but other types of commercial seal cartridges also may be used. The seal plate and the end bearing are bolted to the trough end by one set of bolts.



Split Gland Seal
Fig. 4.14B

Split gland seals are designed for interior or exterior mounting. They provide an effective seal by compression of the packing which is contained in a housing split to facilitate assembly and replacement of the packing material.

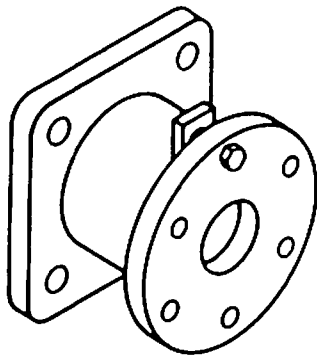


Waste Packing Seal
Fig. 4.14C

This universal type seal is arranged for use with waste packing or with cartridge type lip or felt seals. An opening at the top of the seal housing facilitates waste repacking, and exposes the waste for oiling.

The packing seal housing is mounted outside the trough end between it and the end bearing.

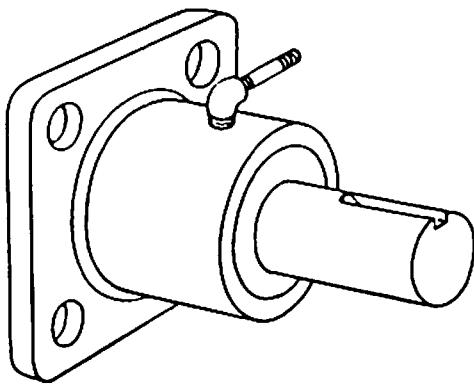
Special Trough End Seals



Packed Gland Seal
Fig. 4.14D

Packed gland seals are highly effective means for sealing the conveyor both internally and externally. This seal also is sometimes suitable for pressure or vacuum service.

The packing pressure is adjusted by the gland bolts.

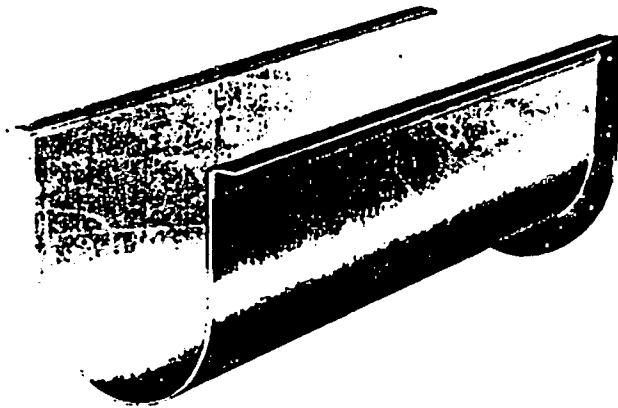


Air Purge Shaft Seal
Fig. 4.14E

Air purge shaft seals are arranged for attaching to standard or special trough ends. A constant air pressure is maintained to prevent material from escaping from the trough along the shaft. The air purge seal is desirable for sealing highly abrasive materials.

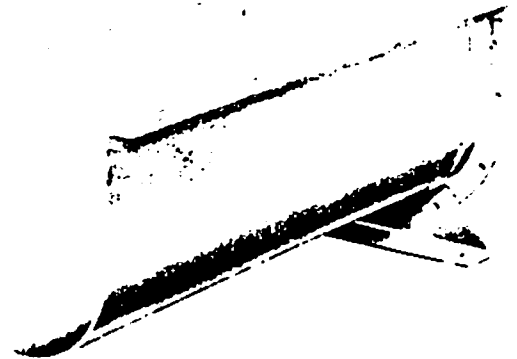
Conveyor Troughs

The normal screw conveyor trough is "U" shaped. The radius of the lower part, the trough height and length have been arranged to make a convenient and rigid enclosure for the conveyor parts as well as to provide economy of construction. Four trough types are illustrated.



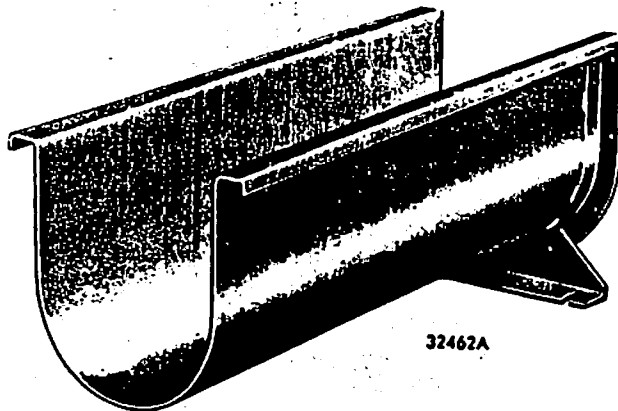
Angle Type Trough
Fig. 4.15A

The angle type trough here illustrated is typical. Dimensional data is published in C.E.M.A. Screw Conveyor Standard 300-1971.



Single Flanged Trough
FIGURE 4.15B

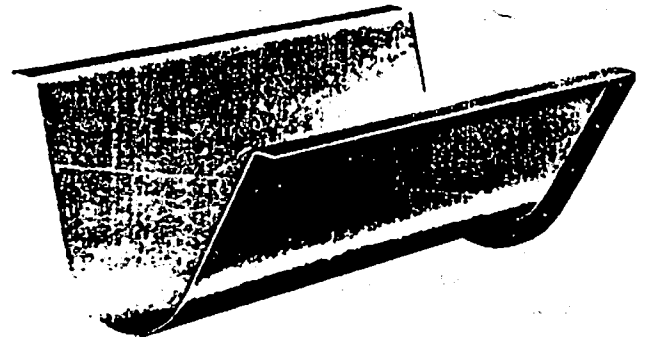
The single flanged trough is generally an alternate construction when the heavier gauges of steel are required.



32462A

Double Flanged Trough
FIGURE 4.15C

The double flanged trough conforms to the same general dimensions as the angle type and single flanged type. It is an alternate construction when the lighter gauges of trough are required.



Flared Trough
Fig. 4.15D

Trough Covers

Troughs customarily are covered to keep materials - and dust from it - inside the trough and to keep out foreign substances. Trough covers also protect personnel from injury. The degree to which the cover fits the trough depends upon circumstances attending the particular conveying problem, and so does the means of securing the cover. See Classes of Enclosure in Chapter 5.

Standard covers are simply a light gauge metal plate attached to the trough in various ways. Trough covers are available in several styles, and thicknesses depending upon requirements and are usually made the same length as trough sections.

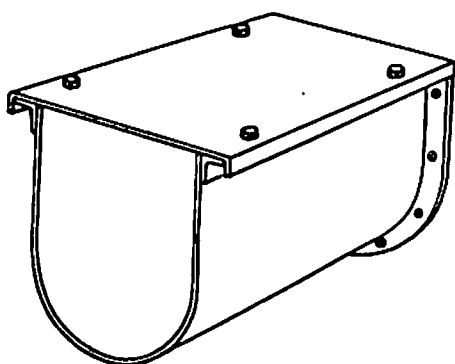
Provision should be made in covers for the attachment of inlet spouts through which material to be conveyed is introduced into the conveyor.

The manner of shaping and attaching covers to troughs depends upon the degree of dust-tightness that is required. Covers may be gasketed and bolted or attached in various ways with spring clamps, "C" type screw clamps or by special connections. Covers may be hinged at one edge for easy cleaning of the interior of the trough. Covers may be flat or may be formed or flanged in various ways to stiffen their edges. Sections of the cover may be simply butted together or provided with flanged and bolted joints.

Typical covers and fasteners are shown in Figures 4.16A, 4.16B, 4.16C, 4.16D, 4.16E and 4.16F.

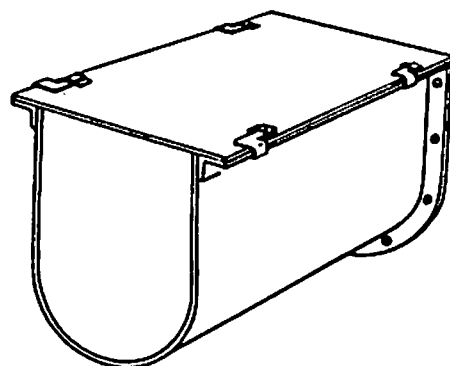
In Fig. 4.16D, due to their stiffness, the flanged covers are more convenient to handle and require fewer bolts or clamps. Spring cover clamps are not adapted to fully flanged covers but are suitable for semi-flanged covers as in Fig. 4.16D, or flat covers as in Fig. 4.16B.

Spring cover clamps are secured below the trough flange, by rivets driven just snug. The rivet heads are the flat, counter-sunk type so the heads lie flush with the top of the trough flange.



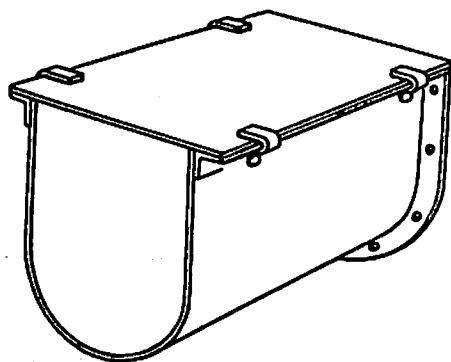
Angle Flanged Type Trough With Flanged and Bolted Cover

FIGURE 4.16A



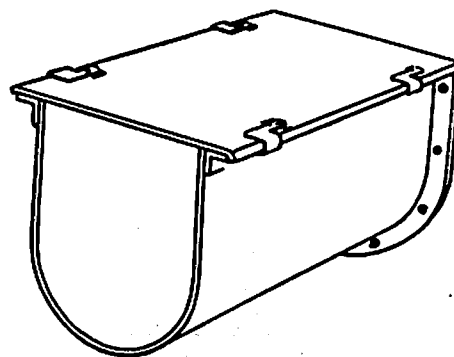
Angle Flanged Type Trough With Plain Flat Cover Fastened With Spring Cover Clamps

FIGURE 4.16B



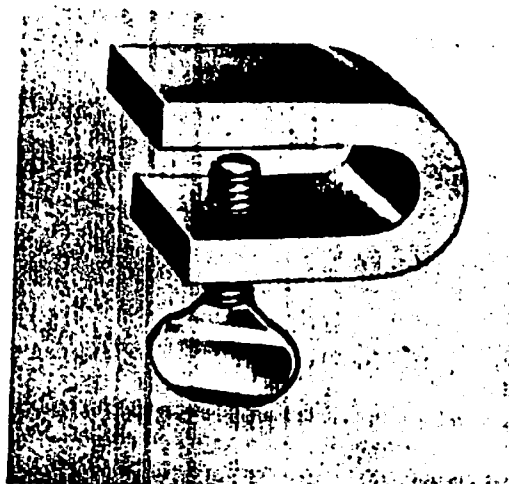
Angle Flanged Type Trough With Plain Flat Cover Fastened With Screw "C" Clamps

FIGURE 4.16C



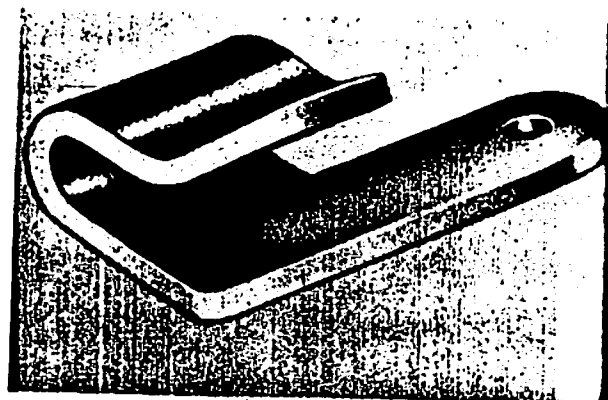
Angle Flanged Type Trough With Semi-Flanged Cover Spring Clamped

FIGURE 4.16D



Screw Cover Clamp

FIGURE 4.16E



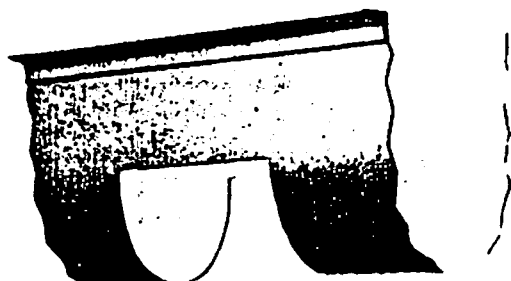
Spring Cover Clamp

FIGURE 4.16F

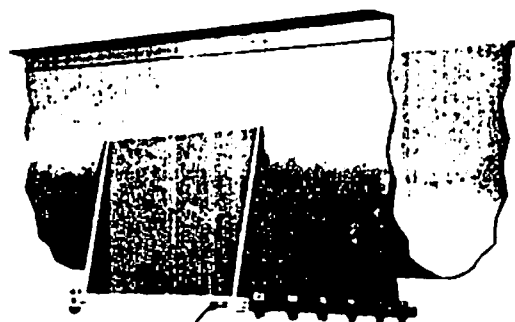
Discharge Openings, Spouts and Gates

Because most screw conveyors discharge through the bottom of the trough, discharge spouts and gates are provided to direct and control the flow of the material, as shown in Figures 4.17A, 4.17B, 4.17C, 4.17D and 4.17E.

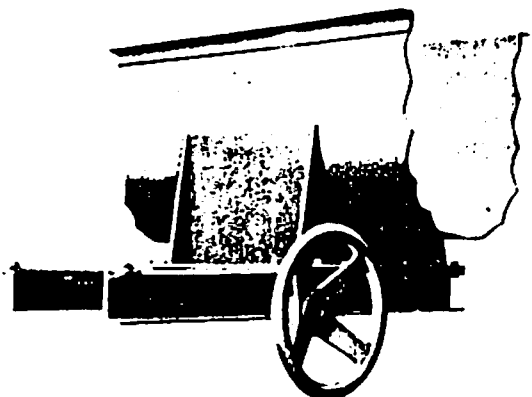
CEMA Screw Conveyor Standard 300-1971 give the dimensions for discharge spouts and for discharge spouts with manually operated slide gates.



Plain Discharge Opening
FIGURE 4.17A

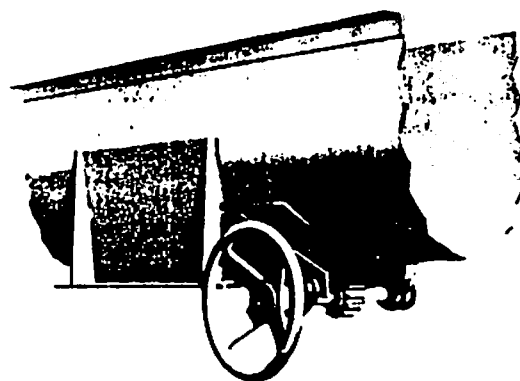


Discharge Spout (with Flat Slide Gate)
FIGURE 4.17B



Discharge Spout With Rack And Pinion Flat Slide
Gate Plate

FIGURE 4.17C



Discharge Spout With Rack And Pinion Curved Slide
Gate Plate

FIGURE 4.17D



Plain Discharge Spout
FIGURE 4.17E



Standard Discharge Spout

FIGURE 4.18A

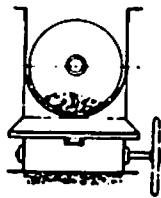
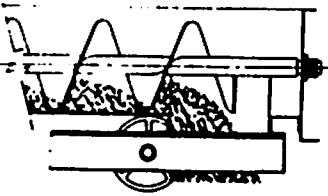
This discharge spout is one of the most widely used discharge arrangements. It provides means of direct attachment to inter-connecting spouts, processing machinery, other conveyors or storage bins. It may be provided with cut-off gates, manually operated as in Fig. 4.18C or operated by power.



Flush End Discharge Spout

FIGURE 4.18B

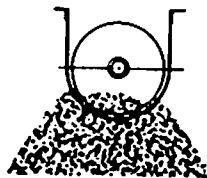
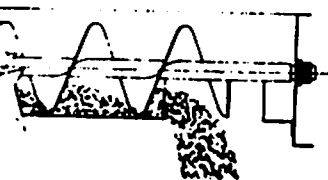
This discharge spout is similar to the standard discharge spout shown above, except it is located at the extreme end of the trough, integral with the fabricated trough end.



Mechanically Operated Gates

FIGURE 4.18C

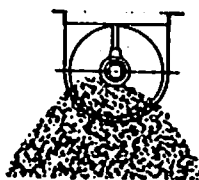
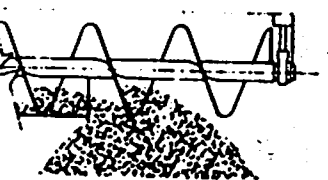
Mechanically operated gates, actuated manually or by power, control the discharge of material from the conveyor. These gates can be operated by remote control if desired.



Plain Trough Opening

FIGURE 4.18D

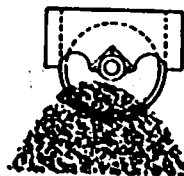
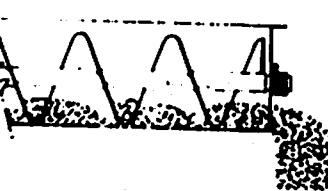
This simple opening in the bottom of trough lets the material drop directly through it. It is a useful arrangement where it is not necessary to stop or control the discharge of material from the conveyor, such as discharge to open storage piles.



Open Bottom Discharge

FIGURE 4.18E

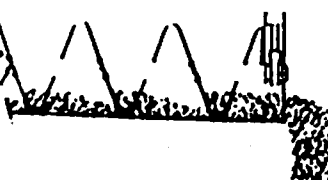
This type of discharge is especially useful for distributing material to long storage piles. As the pile rises to the bottom of the conveyor screw, the top of the pile forms the "natural" trough and the material continuously is carried over to the forward edge of the pile.



Trough End Discharge

FIGURE 4.18F

Here the lower portion of the trough end is cut away (See Fig. 4.12G page 62) to permit the material to discharge. This type of discharge should not be used for screw conveyors more than 30% full.



Open Discharge End

FIGURE 4.18G

This method of discharge is widely used. The end of the conveyor screw is supported in a hanger bearing. The bottom of the trough often is cut back a bit to allow more free passage of the discharging material.

Saddles and Feet

Intermediate supports for a conveyor trough are called "saddles and feet". Saddles are used when the support is between the trough joints. Feet are used when the support is at the trough joint, usually attached to the angle flanges at the joint. See Figures 4.19.



FIGURE 4.19A

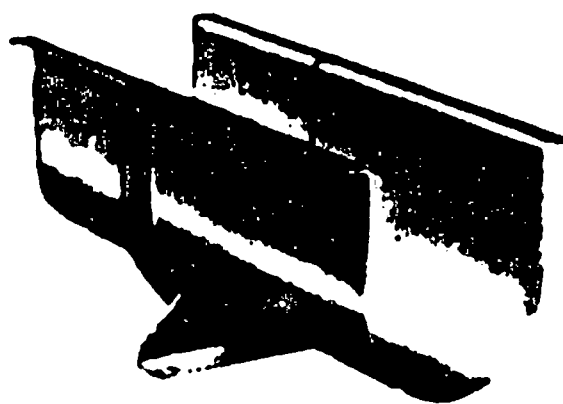


FIGURE 4.19B



FIGURE 4.19C

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Maintenance	95
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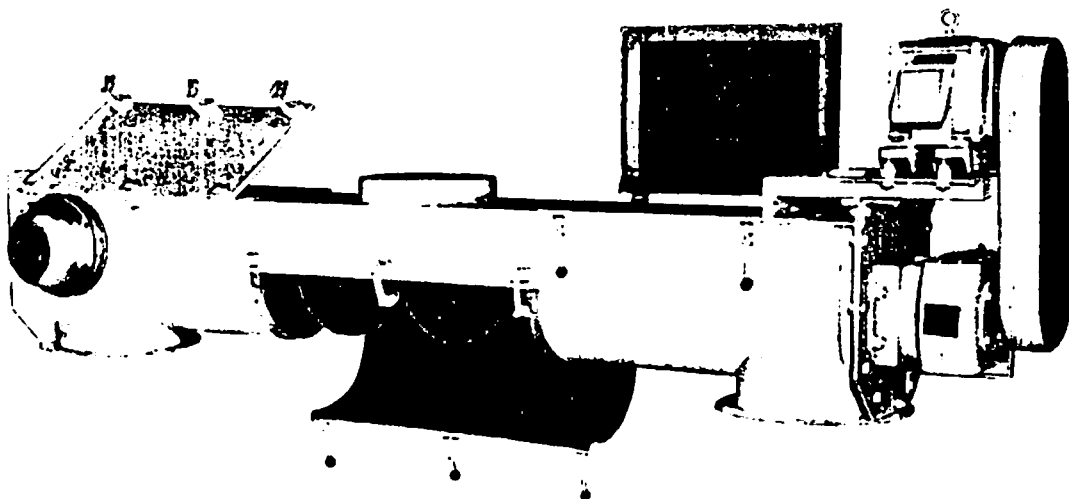
Chapter 5

Materials of Construction, Classes of Enclosure, Weld Finish, Special Features and Modifications, Installation, Operation, Maintenance, Expansion

In this chapter many special features are shown that may be incorporated in screw conveyors to attain certain objectives. The following pages list and illustrate these special features.

This chapter also covers the materials of construction of standard components, the various classes of enclosure of screw conveyor troughs and the calculation of the expansion of a screw conveyor handling hot materials.

The illustration in Figure 5.1 shows an assembled 12 inch diameter screw conveyor equipped with many of the special features described in this chapter. This conveyor, which is used in a food handling operation, has a central round inlet and two round discharge spouts. The drive is reversible so that by reversing the direction of rotation of the screw, material may be carried from the inlet to either discharge spout. Two hinged, quick opening trough cover sections and one section of hinged, drop bottom trough are used for ease of inspection and cleaning. A pressure sensitive limit switch device is located over one of the discharges to cut off the power to the drive motor if the conveyor is overloaded. A continuously welded conveyor screw, outboard shaft seals and a neoprene gasket for the cover are other special features used in this conveyor.



MATERIALS OF CONSTRUCTION **FIGURE 5.1**

For Standard Components

Standard screw flighting, pipe, shafts, troughs, trough ends, covers, hanger straps, feed spouts, discharge spouts, and gates are ordinarily made of low carbon, hot rolled steel in the form of sheets, plates, bars, strip, angles, channels and pipe.

Standard shafting normally is made of cold finished mild steel. However, coupling shafts may be hardened, depending on the materials conveyed.

Flanged sleeve type end bearing housings and the housings for ball and roller bearing mounts are usually made of cast iron.

The hanger bearing materials vary with the service conditions to which they are exposed. Sometimes they are of ordinary cast iron, lined with babbitt, bronze, oil-impregnated hard wood or plastic such as nylon; sometimes they are made of extremely hard white cast iron; and sometimes ball bearing cartridges are employed.

While the materials of construction of standard components, as outlined above, are satisfactory for many screw conveyor applications, there are a number of not uncommon service conditions that require different materials. Table 5-1 indicates the changes in the construction materials for certain components for nine specified service conditions. Before proceeding with component selections, the intended service conditions should be checked with those enumerated in Table 5-1.

Table 5-1

Service Conditions	Troughs	Covers	Helical Flighting	Sectional Flighting	Screw Pipes	Shafting	Gates & Spouts
1. Material packs and builds on trough	CO SS						
2. Material is slightly corrosive	CO CR	CR CO	CO	CO CR	CO		CO CR
3. Material is mildly corrosive	CO SS	CO SS	CO SS	CO SS	CO SS	SS	CO SS
4. Material is highly corrosive	CO SS	CO SS	CO SS	CO SS	CO SS	SS	CO SS
5. Material must not be contaminated	SS CO	SS CO	SS CO	SS CO	SS CO	SS	SS CO
6. Material must not be discolored	CO SS	CO SS	CO SS	CO SS	CO SS	SS	CO SS
7. Material is very hot	SS SS	SS	SS	SS	SS	SS	SS
8. Material is very abrasive	CO AR		CO AR HC	CO	CO	HS	CO AR
9. Material is very wet (with water)	CO SS	CO SS	CO SS	CO SS	CO SS	SS	CO SS

Where the abbreviations used signify:

Abbreviation	Construction Material
HC	Mild steel over which a hard coating has been applied by welding
SS	Stainless steel of a suitable grade
CR	Corrosion resisting steel
HS	Carburized and hardened mild steel shaft
AR	Abrasion resisting steel
CO	Mild steel coated with epoxy resin, plastic, rubber, ceramic fused on, galvanizing, whichever is most suitable for the required conveying application

In addition to the above, other coatings such as various paints and platings may be used to secure the desired results; or the parts may be wholly made of brass, various bronzes, monel, inconel or aluminum as the occasion requires.

CLASSES OF ENCLOSURES

GENERAL

The terms "dust tight", "semi dust tight", "commercially dust tight", "weatherproof", are used in specifications relating to conveyor enclosure. These are extremely broad terms and subject to many interpretations depending on individual conception and experience. It is difficult, if not impractical to attempt to define these terms by their degree of effectiveness. Enclosure of conveyors beyond that which is necessary for the conveying function can be designed to protect the material being handled from a hazardous surrounding or to protect the surroundings from a hazardous material being conveyed. Thus there is in the following the term, "protection for or against the material being conveyed or handled."

Recognizing the above facts, this section establishes CEMA recommended classes of construction for conveyor enclosures—without regard to their end use or application. These several classes call for specific things to be done to a standard conveyor housing to provide several degrees of enclosure protection and will eliminate the general terms listed above.

It is recognized that other types of enclosures are sometimes practical and that additional design features can be incorporated as dictated by specific job requirements. They are too numerous and too special to be included here.

CEMA ENCLOSURE CLASSIFICATIONS

Class IE— Class IE enclosure are those provided primarily for the protection of operating personnel or equipment, or where the enclosure forms an integral or functional part of the conveyor or structure. They are generally used where dust control is not a factor or where protection for, or against, the material being handled is not necessary—although as conveyor enclosures a certain amount of protection is afforded.

Class IIE— Class IIE enclosures employ constructions which provide some measure of protection against dust or for, or against, the material being handled.

Class IIIE— Class IIIE enclosures employ constructions which provide a higher degree of protection in these classes against dust, and for or against the material being handled.

Class IVE— Class IVE enclosures are for outdoor applications and under normal circumstances provide for the exclusion of water from the inside of the casing. They are not to be construed as being water-tight, as this may not always be the case.

When more than one method of fabrication is shown, either is acceptable.

Table S-2
Enclosure Construction

	ENCLOSURE CLASSIFICATIONS			
	I E	II E	III E	IV E
A. TROUGH CONSTRUCTION				
Formed & Angle Flanged				
1. Plate type end flange				
a. Continuous arc weld	X	X	X	X
b. Continuous arc weld on top of end flange and trough flange			X	X
2. Angle type end flange				
a. Intermittent arc weld	X			
b. Intermittent arc weld to trough if mastic is used between leg of angle flange and trough		X	X	X
c. Continuous arc weld of top of end flange and trough flange			X	X
d. Continuous arc weld to trough			X	X
3. Trough angle flange (Angle flange trough only)				
a. Staggered intermittent arc or spot weld	X			
b. Continuous arc weld on top leg of angle on inside of trough and intermittent arc weld on lower leg of angle to outside of trough		X	X	X
c. Staggered intermittent arc weld on top leg of angle on inside of trough and intermittent arc weld on lower leg of angle to outside of trough, or spot weld when mastic is used between leg of angle and trough sheet		X	X	X
B. COVER CONSTRUCTION				
1. Plain flat				
a. Only butted when hanger is at trough joint	X			
b. Only butted when hanger is not at trough joint	X			
2. Semi-Flanged				
a. Only butted when hanger is at trough joint	X	X	X	X
b. Only butted when hanger is not at trough joint	X			
c. One end crimped when hanger is not at trough joint		X	X	X
3. Flanged				
a. Only butted when hanger is at trough joint		X	X	X
b. Ends flanged and bolted, or use a butt strap when hanger is not at trough joint		X	X	X
4. Hip Roof				
a. Ends flanged and bolted, or a butt strap connection				X
C. COVER FASTENERS FOR STANDARD GA. COVERS				
1. Spring, screw or toggle clamp fasteners or bolted construction*				
a. Max. spacing plain flat covers	60"			
b. Max. spacing semi-flanged covers	60"	30"	18"	18"
c. Max. spacing flanged and hip-roof covers		40"	24"	24"
*For bolted construction use:-				
1/4" bolts - 4"-10" dia. screws - (min. dia.)				
5/16" bolts - larger dia. screws - (min. dia.)				
D. GASKETS				
1. Covers				
a. Felt type gaskets up to 230° F.		X	X	
b. Neoprene rubber, Neoprene coated fabric when contamination is a problem		X	X	
c. Closed cell foam type elastic material to suit temperature rating of gasket		X	X	
2. Trough and flanges				
a. Mastic type compounds		X	X	X
b. Felt type gaskets up to 230° F.		X	X	X
c. Neoprene rubber, Neoprene coated fabric when contamination is a problem		X	X	
d. Closed cell foam type elastic material to suit temperature rating of gasket		X	X	X

Table S-2 Continued

	ENCLOSURE CLASSIFICATIONS			
	I E	II E	III E	IV E
E. TROUGH END SHAFT SEALS*				
1. When handling non-abrasive materials			X	X
2. When handling abrasive materials	X	X	X	X
*Lip type seals for non-abrasive materials Felt type for mildly abrasive materials Waste type for highly abrasive materials				
F. DUST COLLECTING SYSTEMS				
1. Provisions should be made for connecting to external dust collecting systems				X

SPECIAL SCREW CONVEYOR CONTINUOUS WELD FINISHES†

Specifications on screw conveyor occasionally include the term "grind smooth" when referring to the finish on continuous welds. This specification is usually used for stainless steel, but occasionally it will appear in carbon steel specifications as well.

"Grind smooth" is a general term and subject to various interpretations. This section establishes C.E.M.A. recommended classes of finishes, which should be used to help you find the class required for an application.

Operation	Class of Finish				
	I	II	III	IV	V
Weld spatter and slag removed	X	X	X	X	X
Rough grind welds to remove heavy weld ripple or unusual roughness (Equivalent to a 40-50 grit finish)		X			
Medium grind welds - leaving some pits and crevices (Equivalent to a 80-100 grit finish)			X		
Fine grind welds - no pits or crevices permissible (Equivalent to a 140-150 grit finish)				X	X
Polish to a bright uniform finish					X

Class I finish has the weld spatter and slag removed, but no grinding of the welds.

Class II finish is a refinement of the "as welded condition" with the welds rough ground to remove heavy weld ripple or unusual roughness.

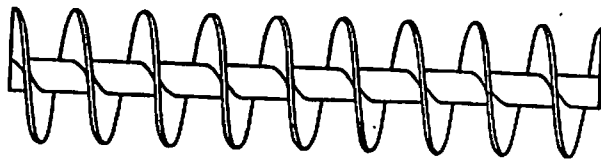
Class III finish has the welds medium ground with some pits and crevices permitted. This finish is recommended for materials which do not tend to contaminate or hang up in pits or crevices.

Class IV & V finishes have the welds ground fine with no pits or crevices. The only difference between the two finishes is the degree of polish. These finishes are recommended where sanitary regulations dictate total exclusion of the materials being handled from the welded surface. The type of finish is dependent on the application and/or industry.

†Special weld finishes do not apply to standard stock conveyor screws.

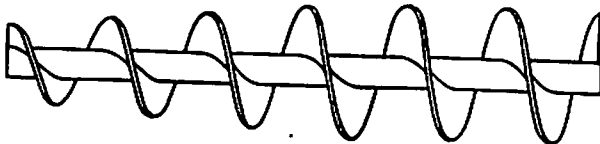
SPECIAL FEATURES AND MODIFICATIONS

The following descriptions cover the most commonly used special features available for equipping screw conveyors to perform various functions in conveying systems. When added to the many available standard constructions, these special features greatly broaden the range of usefulness of screw conveyors. While standard components are more desirable and practical in the design of a screw conveyor system, the inclusion of one or more of the following special features may result in a more compact or efficient overall arrangement.



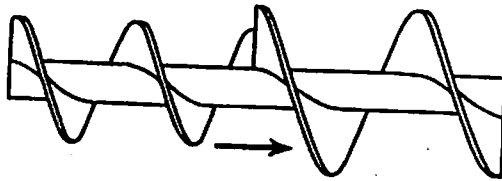
Short Pitch Conveyor Screw
FIGURE 5.2A

Short pitch conveyor screws are of regular construction except that the pitch of the flights is made less than the outside diameter of the screw. These short pitch screws are recommended for use in inclined screw conveyors of slopes 20° and over. They also are used extensively as feeder screws, especially as the feeder portion of a uniform diameter conveyor screw consisting of a section of short pitch flights and the balance regular pitch. The cross-sectional loading of the regular pitch portion of the screw thus is controlled.



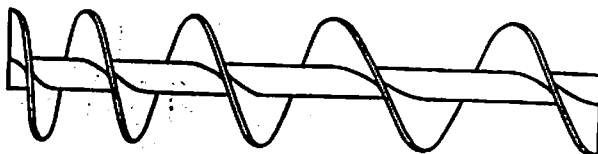
Tapering Flight Conveyor Screw
FIGURE 5.2B

Tapering flight conveyor screws are frequently used as feeder screws for handling friable, lumpy materials from bins or hoppers. Tapered screws draw feed materials uniformly from the entire length of the feed opening. The trough tapers to suit.



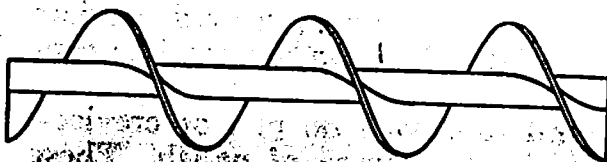
Stepped Diameter Conveyor Screw
FIGURE 5.2C

Stepped diameter conveyor screws consist of flights of different diameters, each with regular pitch, mounted in tandem on one pipe or solid shaft. They are frequently used as feeder screws, with the portion having the smaller diameter being under the feed opening of a bin or hopper, to regulate the flow of material. The screw portion with the smaller diameter usually operates in a correspondingly small trough.



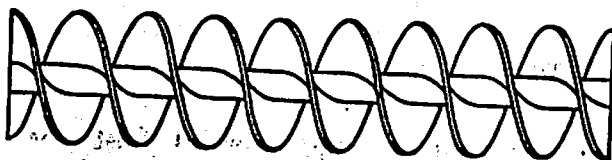
Stepped Pitch Conveyor Screw
FIGURE 5.2D

Stepped pitch conveyor screws have succeeding single or groups of flights progressively increasing in pitch. They are used to draw free flowing materials uniformly from the entire length of the feed opening.



Long Pitch Conveyor Screws
FIGURE 5.2E

Long pitch conveyor screws occasionally are used for rapid conveying of very free flowing materials or as agitators for liquids.



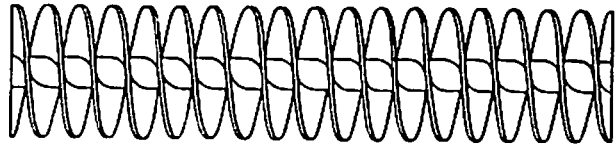
Double Flight Conveyor Screws
FIGURE 5.2F

Double flight conveyor screws of regular pitch promote a smooth gentle flow and discharge of certain materials. Very short portions of double flight screws may be used either side of a hanger point, for smooth flow past the hanger.

Double Flight Short Pitch Conveyor Screw

FIGURE 5.2G

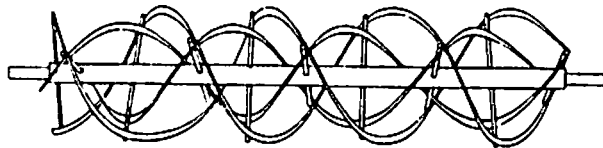
Double flight short pitch conveyor screws assure more accurate regulation of feed and flow in screw feeders and effectively deter the flushing action of materials that have become fluidized.



Multiple Ribbon Flight Conveyor Screws

FIGURE 5.2H

This type of screw consists of two or more ribbon flights of different diameters and hand, mounted one within the other on the same pipe or solid shaft by rigid supporting lugs. Material is moved forward by one flight and backward by the other, thereby inducing positive and thorough mixing.



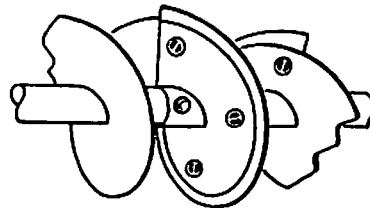
CONVEYOR SCREW MODIFICATIONS

Regular conveyor screws and many with special features, may be modified in arrangement or construction. The common modifications are described in the following text.

Bearing Shoes

FIGURE 5.3A

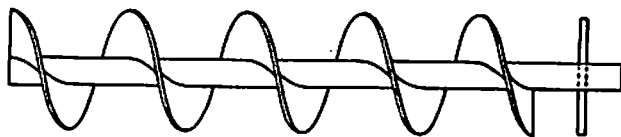
Bearing shoes of nylon, teflon, brass and other materials are used in place of intermediate hanger bearings. The shoes are bolted to the periphery of the screw, and project radially beyond the flight edge thus preventing the metal flight from wearing the trough. These bearing shoes extend along the screw helix slightly more than one pitch and are located along the screw at the same distance as normal hangers.



Breaker Pins

FIGURE 5.3B

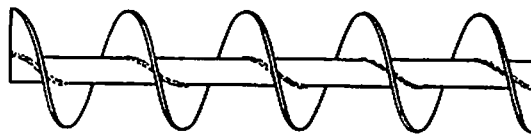
A breaker pin is a rod of a length approximately equal to the screw diameter, inserted through and secured to the pipe shaft at the screw discharge point. These breaker pins aid the discharge by breaking up relatively soft lumpy materials.



Continuous Welding of Screw Flights

FIGURE 5.3C

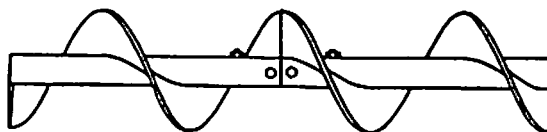
To prevent ripping the flights from a conveyor screw under extremely heavy loads, the flights may be continuously welded to the pipe shaft on one or both flight sides. Continuously welded flights are also used to eliminate the small aperture between the flights and pipe, for sanitary purposes.



Close Coupled Conveyor Screw

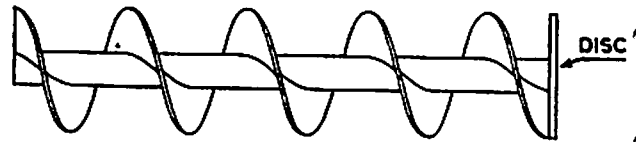
FIGURE 5.3D

Close coupled conveyor screws form a continuous helix. The space for the hanger bearing is omitted, and a short coupling shaft is used.



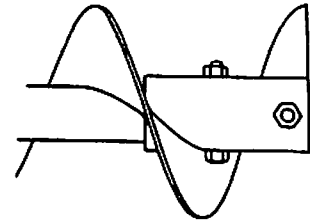
**End Disc On
Conveyor Screw
FIGURE 5.3E**

An end disc is the same diameter as the screw and is welded flush with the end of the pipe shaft at its discharge end and, of course, rotates with the screw. The end disc helps to keep discharging material away from the trough end seal.



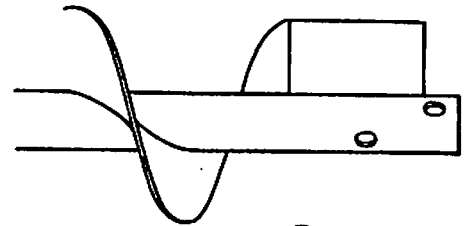
**External Sleeves
FIGURE 5.3F**

External sleeves are welded to the outside of the conveyor screw pipe shafts at the ends where couplings are bolted, to reinforce the pipe at the bolt area.



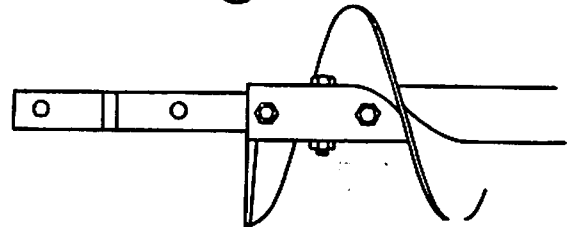
**Kicker Bars
FIGURE 5.3G**

Kicker bars are flat bars projecting from the conveyor screw pipe shaft and extending to the outside of the screw. They are located over discharge spouts and assist in cleanly discharging the material.



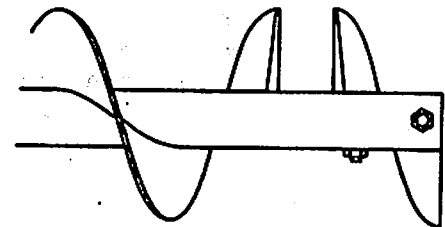
**Multiple Hole Drilling
FIGURE 5.3H**

Multiple hole drilling of the screw conveyor pipe shaft and couplings or drive shafts increases the torque rating of the bolted screw sections.



**Opposite Hand Flights
FIGURE 5.3I**

Opposite hand flights are short sections—approximately one half a pitch long—of flight added to the conveyor screw beyond the discharge point, these short flights being the opposite hand to the rest of the screw. These flights oppose the flow of material that tends to carry past the discharge spout and pack at the trough end plate, and forces the material back to the spout for discharge.



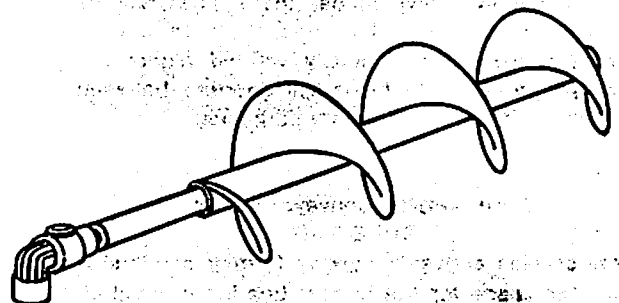
**Odd Diameter Conveyor Screw
FIGURE 5.3J**

Odd diameter conveyor screws are of conventional construction except they may be over or under standard size. Such screws can provide close or wide clearance between the outside of the screw and the trough, making possible the use of standard size troughs, trough ends and hanger bearings.



**Rotary Joint For
Conveyor Screw Pipe Shaft
FIGURE 5.3K**

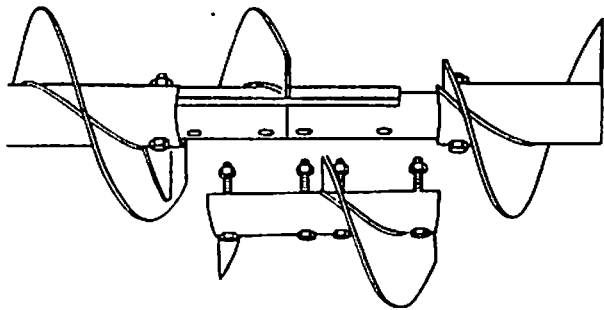
When the hollow screw conveyor pipe shaft is used as a heat exchanger for heating or cooling, rotary joints are necessary to admit and discharge the steam or liquid.



Split Flight Couplings

FIGURE 5.3L

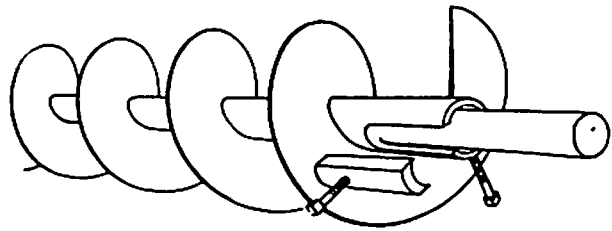
Split flight couplings permit installation or removal of individual sections of conveyor screw without disturbing adjoining sections. When they are installed on both sides of each hanger, sections of the screw can be removed without disturbing the hanger.



Removable Key Conveyor Screw

FIGURE 5.3M

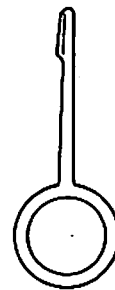
Removable key conveyor screws are designed for easy removal of screw sections from the conveyor trough. Each section of screw is provided with a removable key located at one end of its pipe shaft. By removing this key a screw conveyor section with coupling and hanger can be quickly removed from the trough without disturbing other components.



Hard Surfaced Screw Conveyor Flights

FIGURE 5.3N

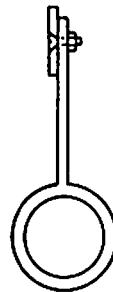
Hard surfaced flighting, sometimes called abrasive resistant conveyor screw flighting, is constructed by applying to the flight edge and working surfaces, by any of a number of commercial processes, a hard metallic coating. The hard surfaced area is normally just the outer portion of the working area, on the material carrying side only. Such hard surfacing reduces the wear on the screw when handling abrasive materials.



Wear Flights or Shoes

FIGURE 5.3O

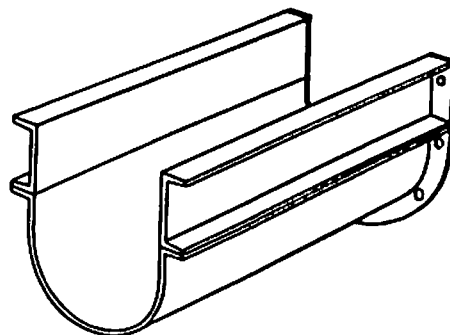
Wear flights or wearing shoes consist of metal plates attached with countersunk head bolts to the carrying side of the conveyor screw flights. They are used for handling highly abrasive material and are easily replaced.



Channel Side Trough

FIGURE 5.4A

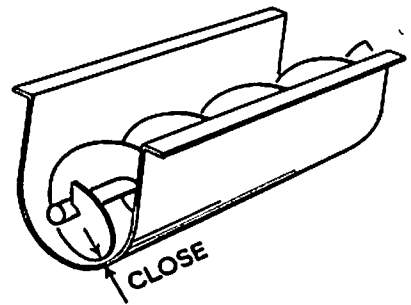
The channel side trough is made with separate detachable trough bottoms, bolted or clamped to formed or rolled side channels. The channels may be of any reasonable length to span widely spaced supports. This type of trough is occasionally used for easy replacement of trough bottoms and to facilitate repairs when the conveyor screw and hangers are not accessible from the top. The channel side trough can also be used without a bottom, for filling bins or hoppers.



Close Clearance Trough

FIGURE 5.4B

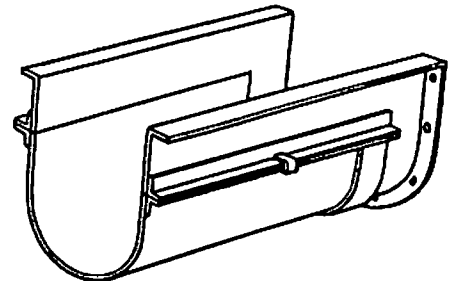
The close clearance trough is of conventional construction except that a closer clearance is provided between the outside of the conveyor screw and the inside of the trough. This type of trough leaves less material in the trough when the conveyor is emptied and is often used when a greater clean-out of conveyed material is required. This type trough also minimizes the fall-back of certain materials in an inclined conveyor.



Drop Bottom Trough

FIGURE 5.4C

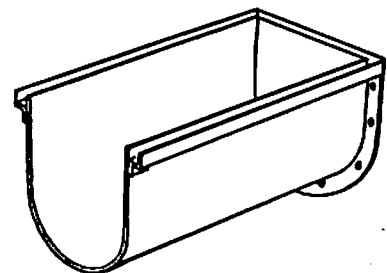
The drop bottom trough is equipped with either a bolted or clamped and completely removable drop bottom, or hinged on one side with bolts or clamps on the opposite side. This arrangement offers ease in cleaning of the trough and conveyor screw and is often used when handling food products where internal inspection and cleaning of the screw conveyor is necessary.



Dust Seal Trough

FIGURE 5.4D

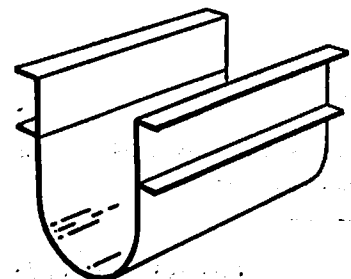
The dust seal trough (sometimes referred to as Sand Seal Trough) has Z bar top flanges and formed channel cross members at the trough ends, making a continuous channel pocket around the top of the trough, into which a special flanged cover is set. The channel pocket may be filled with dust from the material being conveyed or with sand. Thus an effective seal is created, confining dust within the conveyor trough.



High Side Trough

FIGURE 5.4E

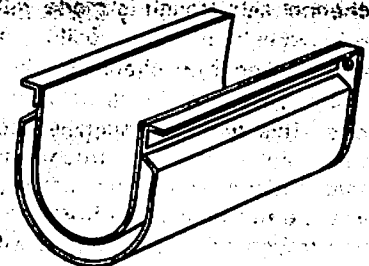
The high side trough is of conventional construction except that the trough sides are higher than standard, as shown. This type of trough frequently is used in conveying materials that tend to mat together and travel as a mass on top of the conveyor screw. High side troughs will confine such material within the trough, yet provide necessary room above the screw.



Jacketed Trough

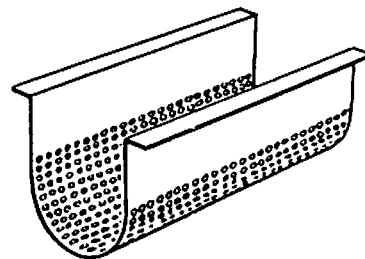
FIGURE 5.4F

In this type of trough a formed metal jacket is welded continuously to the exterior of the trough, for the use of steam or circulating hot or cold liquids for which pipe connections are provided. This type of trough is widely used for heating, drying or cooling of the materials in transit.



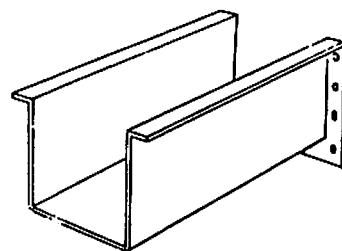
Perforated Bottom Trough
FIGURE 5.4G

The perforated bottom trough has holes or slots which extend around the bottom and some distance up the sides of the trough. It is used for screening, or draining liquids from materials in transit. The nature of the material conveyed determines the character and extent of the perforations.



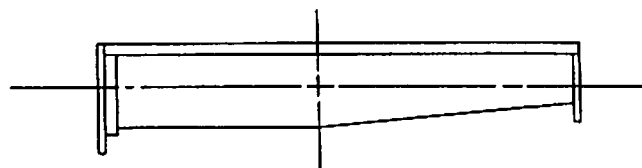
Rectangular Trough
FIGURE 5.4H

Rectangular troughs have flat bottoms. The trough can be formed with integral bottom and sides or with sides and bottom fastened together. It is frequently used in handling abrasive materials, which form a layer on the bottom and a bit up the side, thus forcing the material in transit to travel on itself. Also, in handling hot materials the material will form its own internal insulation with this type trough.



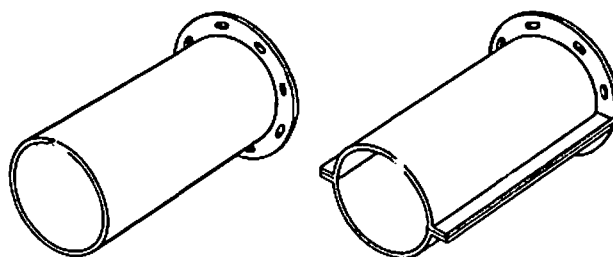
Tapered Bottom Trough
FIGURE 5.4I

Tapered bottom troughs are used to prevent a dead space in the trough at the small end of a tapered conveyor screw. With some materials the taper is necessary to prevent the material bridging in the trough, above the screw.



Tubular Trough
FIGURE 5.4J

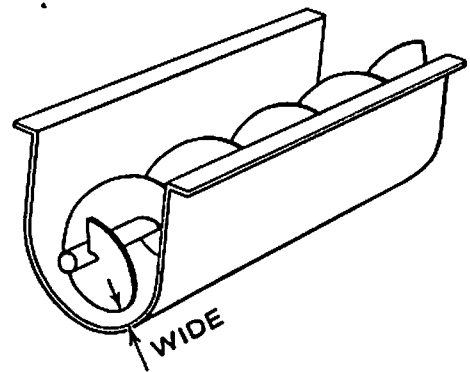
Tubular troughs may be of solid tubular form, or split and having flanges for holding the halves together by bolts or clamps. They are used for weather-tight applications, for loading full cross-sections, and for inclined or vertical applications where full loading is required to reduce fall-back of the material.



Wide Clearance Trough
FIGURE 5.4K

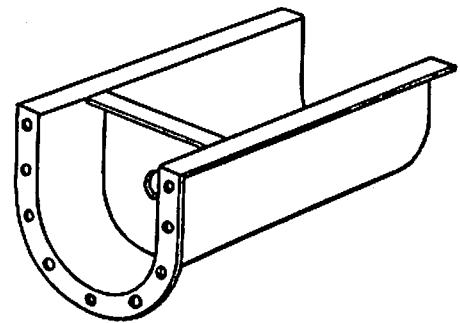
Wide clearance troughs are of conventional construction except with a greater clearance between the outside of the conveyor-screw and the inside of the trough. They are used when it is desirable to form in the bottom of the trough a layer of the conveyed material to reduce trough wear.

Also, by using a wide clearance or oversize trough and a standard size conveyor screw, a greater capacity can be obtained with certain materials which tend to travel as a mass. However, it is usually more economical to use the next size standard conveyor screw and trough than to use the wide clearance trough solely for this purpose.



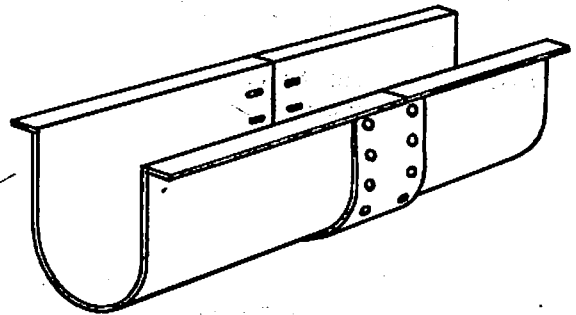
Trough Bulk Head
FIGURE 5.4L

A bulk head is the term given to a plate or baffle, shaped to the contour of the inside of the trough and bolted or welded six to twelve inches from the trough end. The bulk head protects the end bearing and drive unit from heat when handling hot materials, when the pocket between the bulk head and trough end is filled with insulation or packing. The bulk head may be employed in a similar manner to prevent damage to seals and bearings, when handling extremely abrasive materials.



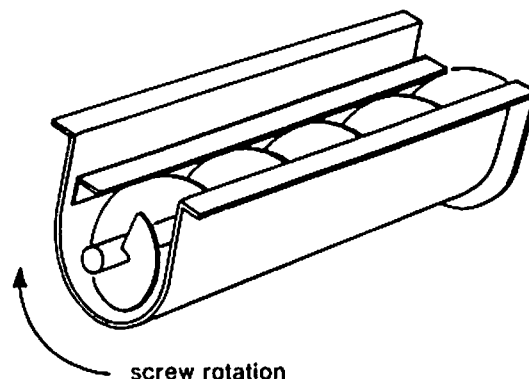
Trough Expansion Joint
FIGURE 5.4M

A trough expansion joint is an exterior connection within a standard section length of trough, applied to permit expansion caused by conveying hot materials. The expansion joint is made with slots so that countersunk head bolts in the trough will allow the required movement; or telescoping type slip joints may be employed. The number of such joints and the amount of expansion depend upon the particular application.



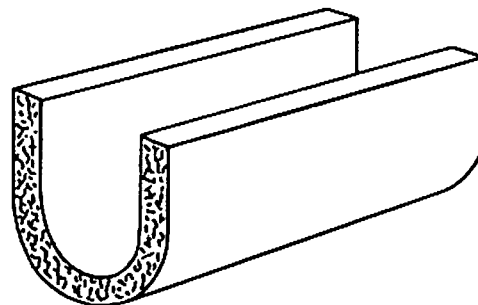
Trough Hold-Down Angles
FIGURE 5.4N

Trough hold-down angles are used to hold the conveyor screw from rising in the trough when the conveyor is not equipped with intermediate hanger bearings, or when chunks of material may tend to ride under the conveyor screw and force it up from its normal position. The hold down angle, usually a rolled section, is attached to one side of and along the full length of the trough, far enough above the conveyor screw to allow approximately one-half inch clearance between the bottom of the hold-down angle and the adjacent periphery of the screw.



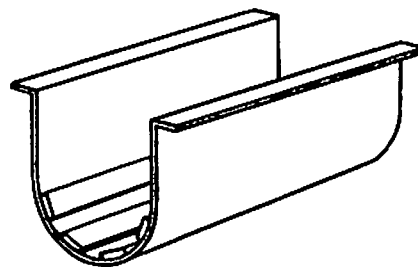
Insulated Trough
FIGURE 5.4O

Insulated conveyor troughs are used when handling hot or cold materials. There are many types of insulating materials and arrangements for applying them to the trough.



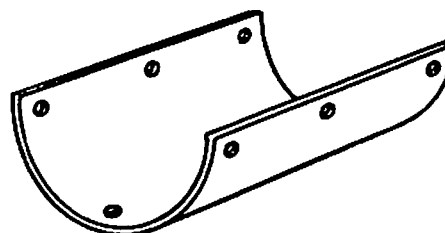
Trough Rider Bars
FIGURE 5.4P

Trough rider bars are flat bars one to one and one-half inches wide applied inside the curved portion of the trough and extending for the full trough length. Two to four bars are normally used, equally spaced. These bars support the conveyor screw when intermediate hanger bearings are not used, thus preventing wear on the trough. Rider bars are sometimes referred to as "rifling bars" when they are used to assist in conveying materials that tend to stick to the conveyor screw and rotate with it.



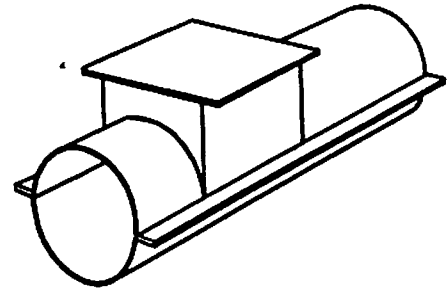
Trough Replaceable Liner
FIGURE 5.4Q

Saddle type wear plates are curved to the contour of the inside of the trough, and are thinner than the clearance between the trough and screw. These plates are made in lengths of approximately one and one-half times the pitch of the conveyor screw and are spaced longitudinally of the trough at intervals equal to trough section lengths. They are used to support the screw and prevent damage to the trough when intermediate hanger bearings are not used.



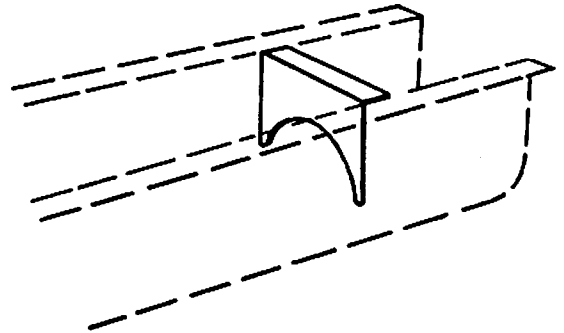
Trough Hanger Pockets
FIGURE 5.4R

Hanger pockets are used with tubular troughs and are mounted on the trough at hanger bearing points. The hanger pocket forms a "U" shaped section for a short distance, allowing the use of standard conveyor hanger bearings and providing easy access to them.



Strike Off Plate
FIGURE 5.4S

Strike off plate (shroud baffle) is a single metal plate bolted in a vertical position in the upper part of the trough. The lower edge of this plate is cut out to the contour of the screw. Strike off plates are used to regulate the flow of material from an inlet by preventing flooding along the screw in a U shaped trough.

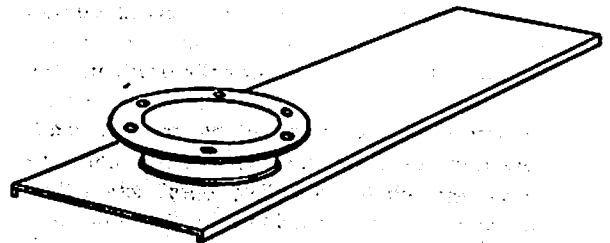


Material Inlet Special Features

Special inlet features include round inlet spouts, deflector plate inlets, cushion chamber inlets, side inlets and various types of inlet gates as shown in Figures 5.5A, 5.5B, 5.5C, 5.5D, 5.5E and 5.5F.

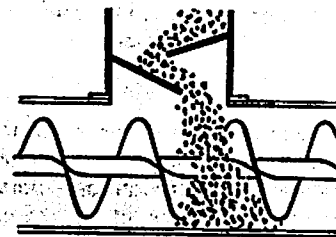
Round Inlet Spout
FIGURE 5.5A

Round inlet spouts are used for tubular inlet attachments or when connecting the discharge of one conveyor to the inlet of a succeeding conveyor where the two screw conveyors are not at right angles to each other.



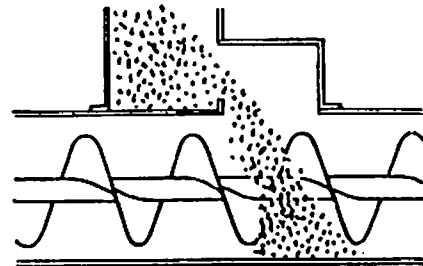
Deflector Plate Inlets
FIGURE 5.5B

Deflector plate inlets are used when material falls vertically into the inlet, subjecting the conveyor screw to the hazard of impact damage or abrasion. The rectangular inlet is equipped with deflector plates or baffles that reduce impact and gentle the flow of material to the conveyor.



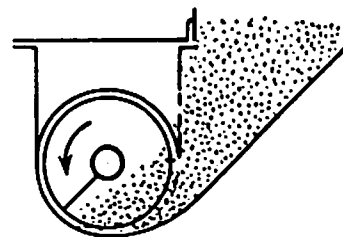
Cushion Chamber Inlets
(Dead bed inlets)
FIGURE 5.5C

Cushion chamber inlets (dead bed inlets) serve the same purpose as deflector plate inlets, but are constructed with a ledge on which a bed of material accumulates to form a cushion for the material flowing to the conveyor.



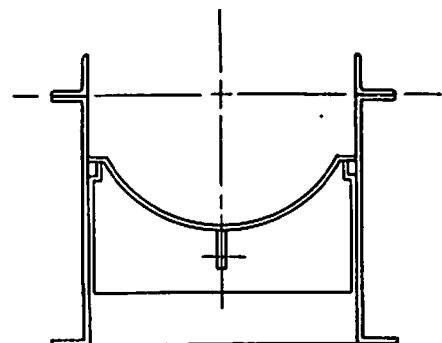
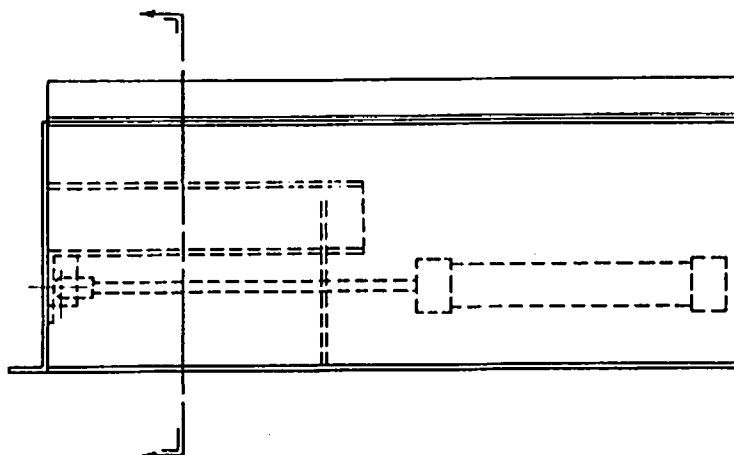
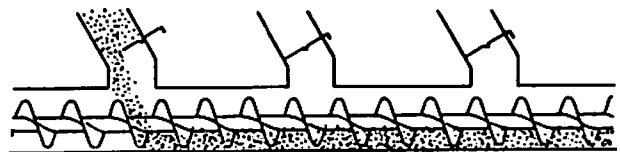
Side Inlet
FIGURE 5.5D

The side inlet acts to relieve the conveyor screw from excessive pressure of the material, and is of advantage for feeding materials that tend to pack and arch. When using the side inlet, the screw rotation should be toward the inlet opening to assure a constant flow rate. A slide gate usually is provided to control the flow of material.

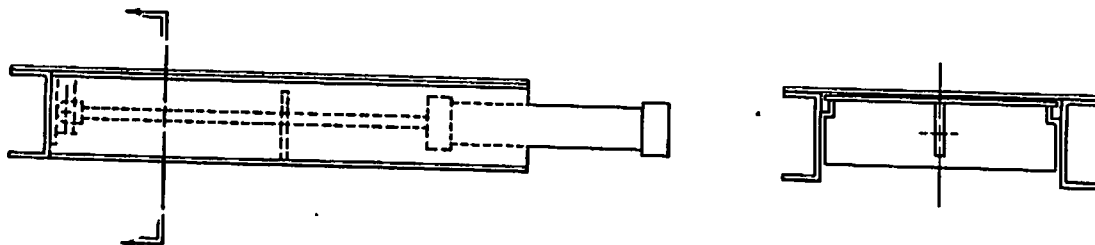


Hand Slide Inlet Gate
FIGURE 5.5E

Hand slide inlet gates are used to regulate or shut off the flow of material to a screw conveyor. They normally are used when multiple inlets are required. The gates are adjusted manually to control the amount of material flow from the desired source.

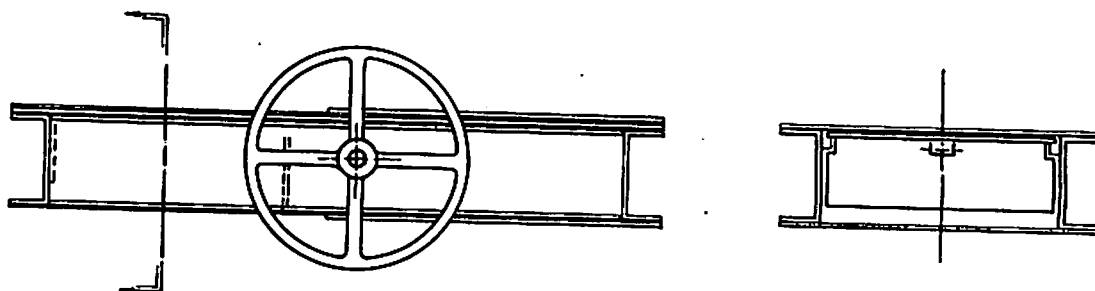


Air Operated Gate With Curved Slide
FIGURE 5.6A



Air Operated Gate With Flat Slide
FIGURE 5.6B

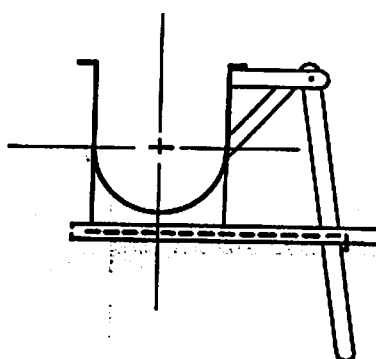
Air operated gates are similar in action and purpose to rack and pinion gates. The gate movement is accomplished by an air cylinder. These gates are usually employed when remote control and automatic operation is desired.



TOTALLY ENCLOSED RACK & PINION FLAT SLIDE GATE
FIGURE 5.6C

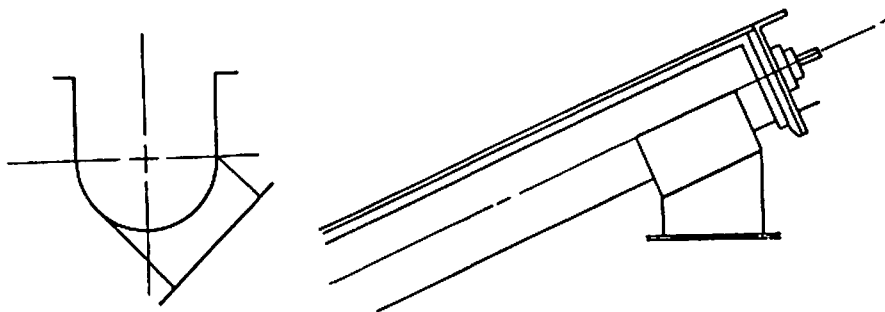
Enclosed rack and pinion gates are similar in construction to the standard rack and pinion gate illustrated in Figs. 4.17C and 4.17D. They may have flat or curved gate plates.

Rack and pinion gates can be operated by electric motors for remote control. The drive usually consists of a gear-motor and a chain drive to the pinion shaft. Limit switches are provided to stop the motor with the gate in the open or closed position. The gate plates may be curved or flat and the working parts - exclusive of the drive - may be enclosed.



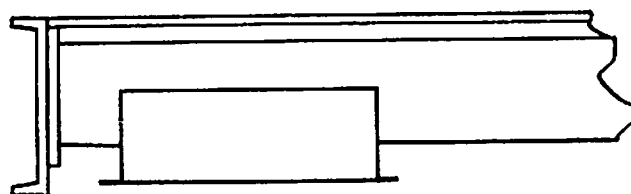
Lever Operated Gate
FIGURE 5.6D

Lever operated gates are a modification of standard slide discharge gates. A lever is provided for ease in operation and a convenient means for quick opening and closing.



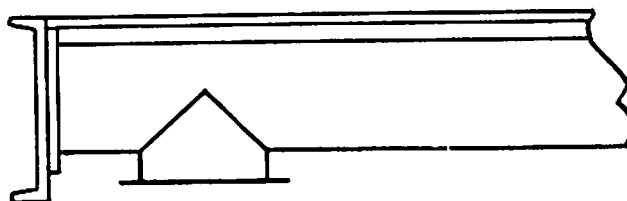
Angular Discharge
FIGURE 5.6E

Angular discharges can be supplied for certain applications. This type of discharge is normally used on inclined conveyors when it is required that the discharge spout bolting flange be horizontal.



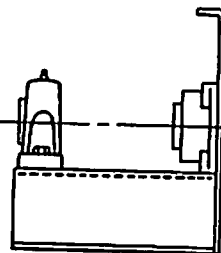
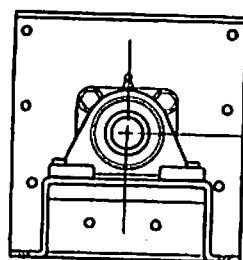
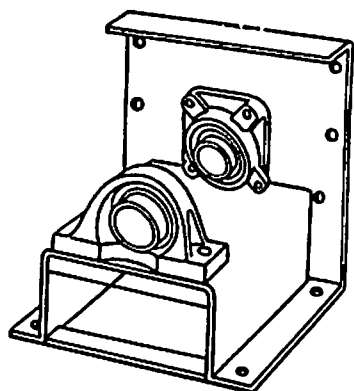
Extra Long Discharge Spout
FIGURE 5.6F

Longer and sometime wider than standard discharge spouts may be required when materials will not completely discharge through a regular standard spout. Other engineering considerations not covered here may also dictate special discharge openings.

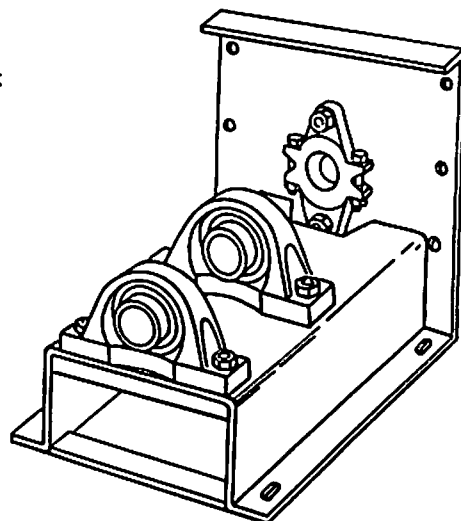
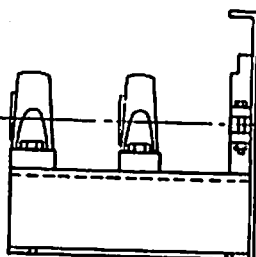
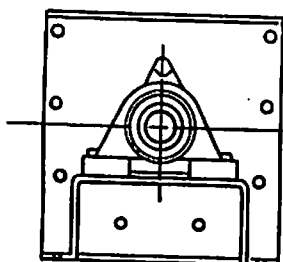


Round Discharge Spouts
FIGURE 5.6G

Round discharge spouts are used where tubular chutes or other circular connections are required such as when the discharge of one screw conveyor to a succeeding screw conveyor is not at a right angle.

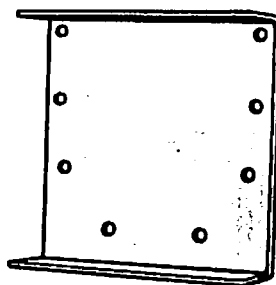
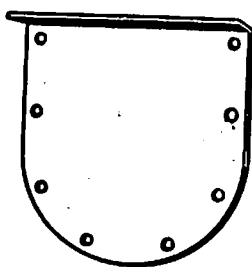


Special Shelf Type Trough End
Flange Bearing and Pillow Block
FIGURE 5.7A



Special Shelf Type Trough End
Two Pillow Blocks
FIGURE 5.7B

These special shelf type trough ends have two bearings to carry the shaft out to provide for greater shaft rigidity. In Fig. 5.7B the two pillow block bearings are mounted away from the trough end plate to protect the bearings when handling abrasive or hot materials. This also allows the use of most any type of shaft seal. Such shelf type trough ends also are used in short screw conveyor feeders where conditions preclude the use of a tail shaft bearing and the conveyor screw must be cantilevered from the inlet trough end.

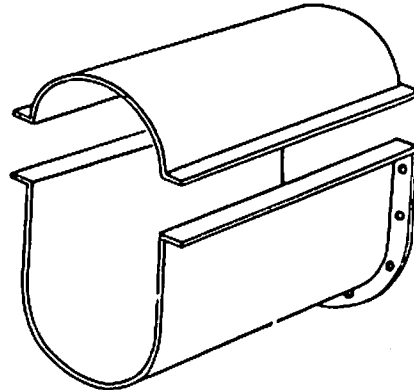


Blind Trough Ends
FIGURE 5.8

Blind trough ends are used on the tail end, normally the inlet end, of a screw conveyor when sealing of the tail end shaft is extremely difficult. A hanger is used inside the trough to support the tail shaft, and the shaft stops short of the trough end plate.

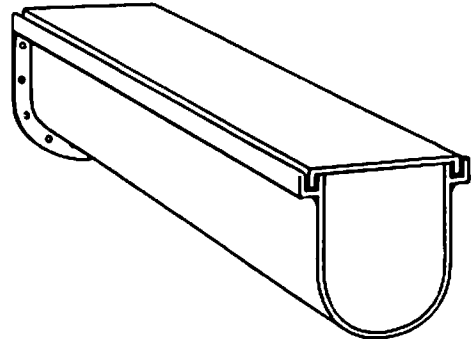
Dome Trough Cover
FIGURE 5.9A

Dome covers are of semi-circular shape, of the same diameter as the trough, and are flanged for fastening to the trough by bolts or clamps. End sections have a semi-circular flanged end plate, and intermediate joints are covered by a butt strap. Vent pipes or suction ducts may be attached to the cover. Such covers are used where venting of fumes or heat is required, from the conveyed material.



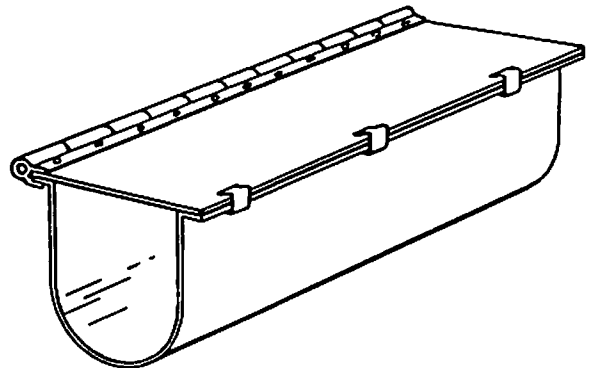
Dust Seal Covers
FIGURE 5.9B

Dust seal covers are flanged down on all four sides to match the open channel flanges of the trough. The length of the cover sections should not exceed one half the length of the trough section. See Fig. 5.4D, Dust Seal Trough.



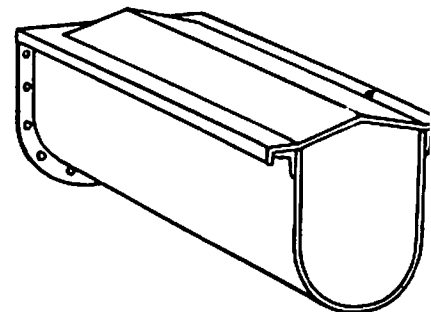
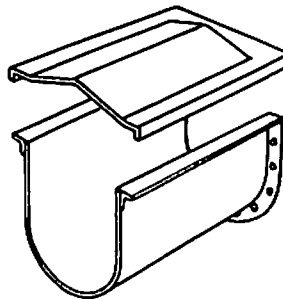
Hinged Covers
FIGURE 5.9C

Hinged covers may be constructed from conventional flat covers or other, special covers. They are equipped with a continuous (piano) type hinge along one edge. The other edge is bolted or clamped to the trough flange. Hinged covers are used in applications where it is not desirable to have a cover that must be completely removed such as high areas above walkways or work spaces where a detached cover might fall.



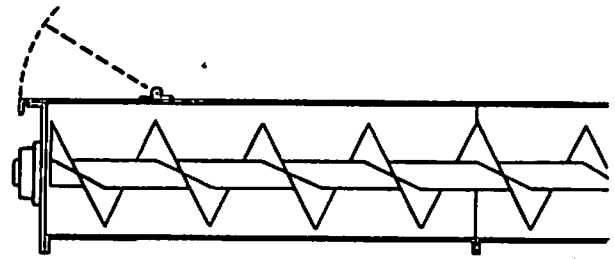
Hip Roof Covers
FIGURE 5.9D

Hip roof covers are similar to conventional flanged covers except they are peaked slightly to form a longitudinal ridge. The ends of the peaks are closed with welded plates; the intermediate joints are covered by a buttstrap. Hip roof covers usually are recommended for outdoor screw conveyor installations to shed water readily. They also are used in applications where a more rigid cover is required.



Overflow Cover
FIGURE 5.9E

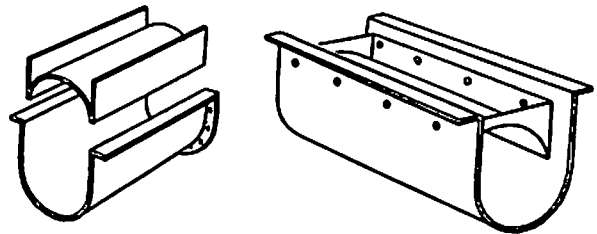
Overflow cover sections are used as a safety relief to permit any material passing by the last discharge opening to flow up out of the trough, should the normal discharge opening become plugged. The overflow portion of the cover is normally of the same construction as the balance of the cover section, is hinged across the full width of the cover, and is not attached to the trough.



Shroud Covers
FIGURE 5.9F

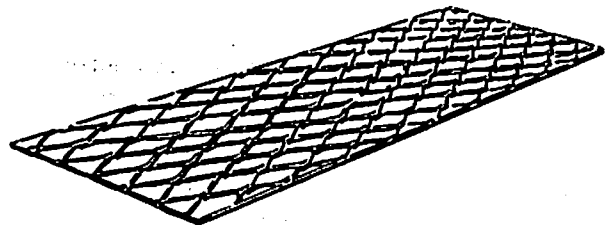
Shroud covers are fabricated of plate to alter the shape of a standard U trough to a cylindrical trough, and are generally bolted to the vertical trough sides.

They are used on inclined screw conveyors and screw feeders. The advantage of the shroud cover is that a tubular trough effect may be secured and still use standard trough and hanger components; in addition, to provide ease of access to the screw and trough bottom. An additional flat cover may be required over the shroud to prevent accumulation of dust or water in the recesses in the upper surface of the shroud.



Expanded Metal Covers
FIGURE 5.9G

Expanded metal covers provide a safe trough closure but still permit constant visual inspection of the operation of the conveyor.



INSTALLATION, OPERATION AND MAINTENANCE

General

All standard screw conveyor components are manufactured in conformity with CEMA standard tolerances. Special components are usually designed and manufactured to the particular job specifications.

Screw conveyors may be ordered either as complete units, or by individual components. Complete units are normally shop assembled and then match marked and disassembled for shipment and field re-assembly. When components only are ordered, shipment is made as ordered and these components must be sorted out and aligned in field assembly.

Because shop assembled screw conveyors are pre-aligned and match marked at the factory, they are easier to assemble in the field and require the minimum installation time. When individual components are ordered more careful alignment and assembly are required. More time is required for field installation. Assembly bolts are not included with parts orders but are included with pre-assembled units.

In field erection, the mounting surfaces for supporting the conveyor must be level and true so that there is no distortion in the conveyor. Shims and grout should be used as required. Anchor bolts that are out line should be moved. If these bolts are only a little out of line, the holes in the conveyor feet and saddles may be slotted.

Drawings normally are provided for engineered screw conveyors, and the conditions indicated thereon should be followed during installation. Any additional installation, operating or maintenance information supplied by the conveyor manufacturer should be carefully adhered to.

Individual components, ordered as such and not part of an engineered conveyor, must be installed in accordance with the following procedures:

1. Receiving

Check all parts and assemblies with shipping papers and inspect for shipping damage. Specifically, check for dented or bent troughs, bent flanges, bent flighting, bent pipe shafts or hangers or damaged bearings. If any components are found damaged in shipment, claims should be filed immediately with the carrier.

2. Erection

Place conveyor troughs in proper sequence with inlet and discharge spouts properly located. Connect trough end flanges loosely—do not tighten bolts. Align trough bottom center-lines perfectly, using piano wire technique (or equivalent), as indicated in Fig. 5.9H tighten flange bolts and anchor bolts.

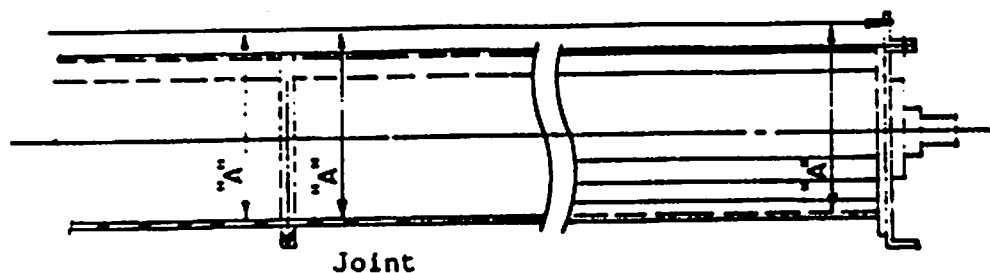


Figure 5.9H

Assembly of conveyor screws should always begin at the thrust end. If the conveyor does not require a thrust unit, assembly should begin at the discharge end. If the thrust end is designated, assemble trough end and thrust bearing and insert the drive shaft in the end bearing. Do not tighten set screws.

Place the first screw section in the trough, slipping the end shaft (or drive shaft) into the pipe end. Secure tightly with coupling bolts. If supporting lugs on ends of flighting are used, install these on the non-carrying side of the flighting.

Place a coupling shaft in the opposite end of the screw pipe. Install and tighten coupling bolts.

Insert coupling shaft in hanger bearing and clamp hanger to trough with "C" clamps.

Assemble alternately: conveyor screw sections, couplings and hangers until all screws are installed:

(a) With Hangers. Assemble screw sections so that flighting end is approximately 180° from end of flight end on adjacent screw section.

(b) Without Hangers. (Close Coupled) Assemble screw sections so that adjoining ends of flighting forms one continuous surface.

Remove any clamps holding hangers to trough and bolt, with hanger bearing centered between pipe ends.

Install trough covers in proper sequence. Properly locate inlet openings. Handle covers carefully to avoid bending or warping.

Attach covers to trough with fasteners provided. Do not tighten excessively; particularly when gaskets are used, as leaks may occur later from covers that are permanently kinked or dimpled at the fastener location.

Install drive at proper location and in accordance with any separate drive instructions that are provided.

Check screw rotation for desired material travel after electrical connections have been made, but **BEFORE** handling any material. Incorrect screw rotation can result in serious damage to the conveyor and to related conveying and drive equipment. If necessary re-connect motor wiring to change the direction of rotation and secure proper travel of material.

3. Operation

Before start-up of the conveyor, re-check correct rotation, electrical connections to drive and make sure that the conveyor is empty and free from obstructions. Lubricate all bearings and drives per service instructions. Make sure that all covers and guards, as installed, comply with the A.S.M.E. B-20 Safety Code, before the conveyor is started.

In start-up of the conveyor, operate it empty for several hours as a break-in period. Observe for bearing heat-up, unusual noises or any apparent misalignment. Should any of these things occur, take the following steps:

(a). When anti-friction bearings are used, check for proper lubrication. Insufficient or excess lubricant will cause high operating temperatures.

(b). Misalignment of trough ends, screws, hangers and troughs should be re-checked. Do not force alignment of components, but check and correct the causes of misalignment.

(c). Check assembly and mounting bolts. Tighten these if necessary.

Do not overload the conveyor. Do not exceed the proper conveyor speed, capacity, rate of flow of material for which the conveyor and drive were designed. Do not use the conveyor for materials of densities other than those for which the conveyor was originally intended.

If the conveyor is to be inoperative for a prolonged period of time, operate the conveyor until it is cleared of all material. This is particularly important when the material conveyed tends to harden or become more viscous or sticky if allowed to stand for a period of time. This is also true of materials which may absorb moisture from the air and corrode the conveyor components.

After operating the conveyor with material in it, it may be necessary to re-center the hanger bearings.

4. Maintenance

Practice good housekeeping. Keep the area around the conveyor and drive clean and free of obstacles, so as to provide easy access. Nothing should be placed or stored so close to the conveyor that it would interfere with the proper function of the conveyor or its drive machinery.

Establish routine, periodic inspections of the entire conveyor to insure continuous maximum operating performance.

In case of wear or damage, to replace screw sections, proceed as follows:

- (a). Removal of a screw section—or sections—usually must proceed from the end opposite the drive. Make sure that the drive is positively disconnected from all electrical power before starting to disassemble.
- (b). Remove the trough end, sections of the screw, coupling shafts and hangers until the damaged or worn section is reached and removed, or if necessary, until all screw sections have been removed.
- (c). To re-assemble, follow the above steps in reverse order.

EXPANSION OF SCREW CONVEYORS HANDLING HOT MATERIALS

Screw conveyors often are employed to convey hot materials. It is therefore necessary, to recognize that the conveyor will increase in length as the temperature of the trough and screw increases when the hot material begins to be conveyed.

The recommended general practice is to provide supports for the trough which will allow movement of the trough end feet during the trough expansion, and during the subsequent contraction when handling of the hot material ceases. The drive end of the conveyor usually is fixed, allowing the remainder of the trough to expand or contract. In the event there are intermediate inlets or discharge spouts that cannot move, then expansion type troughs are required.

Furthermore, the conveyor screw may expand or contract in length at different rates than the trough. Therefore, expansion hangers are generally recommended. The trough end opposite the drive should incorporate an expansion type ball or roller bearing or sleeve bearing which will safely provide sufficient movement.

The change in screw conveyor length may be determined from the following formula:

$$\Delta L = L (t_1 - t_2) C$$

where: ΔL = increment of change in length, inch

L = overall conveyor length in inches

t_1 = upper limit of temperature, degrees Fahrenheit

t_2 = lower limit of temperature, degrees Fahrenheit,
(or the lowest ambient temperature expected)

C = coefficient of linear expansion, inches per inch
per degree Fahrenheit. This coefficient has the
following values for various metals:

(a) Hot rolled carbon steel, 6.5×10^{-6} , (.0000065)

(b) Stainless steel 9.9×10^{-6} (.0000099)

(c) Aluminum, 12.8×10^{-6} , (.0000128)

Example:

A carbon steel screw conveyor 30 feet overall length is subject to a rise in temperature of 200° F, reaching a hot metal temperature of 260° F from an original metal temperature of 60° F.

$$t_1 = 260 \quad t_1 - t_2 = 200$$

$$t_2 = 60$$

$$L = (30)(12) = 360$$

$$\Delta L = (360)(200)(6.5 \times 10^{-6})$$

$$= 0.468 \text{ inches, or about } 15/32 \text{ inches.}$$

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Chapter 6

Screw Feeders, Single and Multiple

DESIGN PREPARATION

This chapter relates to screw feeders that are used to control the rate of flow of a bulk material from a bin or hopper. This is limited to the handling of bulk free flowing materials less than $\frac{1}{8}$ " in size and which are classified as abrasive 5 or 6 as shown in Table 2-1.

In screw feeders, the inlet portion of the trough is made to be flooded with the material and by means of a shroud in the trough, or by the use of a tubular trough, only a controlled amount is carried to the discharge.

The screws in the feeder are arranged in several different ways, depending upon circumstances. For relatively small inlet openings, the screw often has a standard diameter and pitch. Frequently, however the screw is tapered in diameter with its smallest diameter at the extreme feed end. Screws also may be made with a constant standard diameter and a variable pitch, the pitch growing larger from the extreme feed end. The purpose of the tapered diameter or variable pitch screw is to obtain an even flow from all areas of the feed opening. The capacity of tapered screws or variable pitch screws is determined by the diameter and pitch at the downstream end of the inlet opening.

Several factors should be established before selecting a screw feeder, these being:

- A. Kind and character of material being handled
- B. Density of material as conveyed, lbs. per cu. ft.
- C. Maximum rate at which material is to be handled, cu. ft. per hour
- D. Size consist or screen size analysis
- E. Overall length of feeder, or feeder with extended conveyor, feet
- F. Width and length of inlet opening

Single screw feeders are most commonly used. However, if the inlet opening is very wide, multiple screw feeders are more practical.

SINGLE SCREW FEEDERS

The single screw feeder may be a separate unit, or it may be extended by sections of normal screw conveyor to any practical length. The procedure by which to choose a single screw feeder is as follows:

Refer to Chapter 2, Material Classification Code, Table 2-1 and the Material Table 2-2. Determine the material code class and density from Table 2-2.

Capacity and Speed

From Table 6-1, under the column captioned capacity at maximum RPM, find the capacity which equals or exceeds the desired feeder capacity. Then find from that the feeder diameter and capacity at one RPM or C_f . Divide the required feeder capacity by C_f to obtain the required speed in RPM.

$$N = \frac{C}{C_f}$$

where: N = Speed of feeder in RPM.

C = Required capacity of feeder, cu. ft. per hr.

C_f = Capacity at One RPM, cu. ft. per hr.

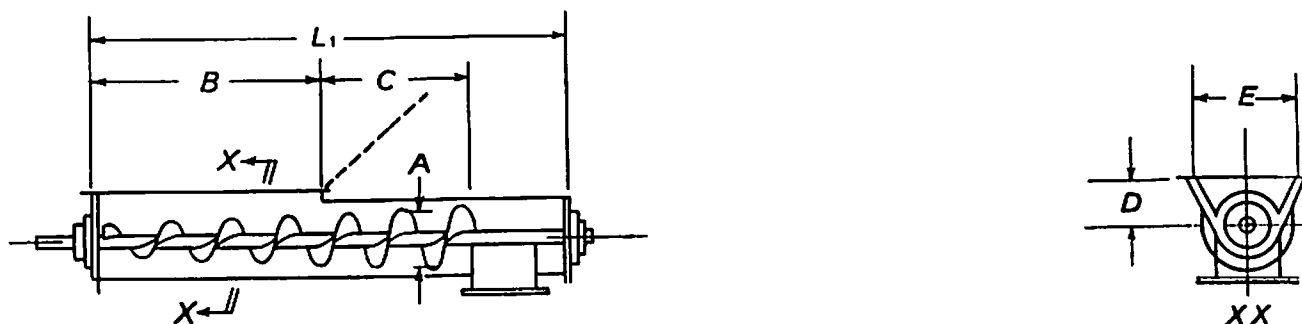
This maximum RPM is not absolute but has been selected as general recommended practice. Experience with a particular set of conditions, or application, may establish slightly different design limitations. Many factors including bin or hopper design, a subject not covered here, will significantly affect screw feeder performance.

Single Screw Feeder Arrangement

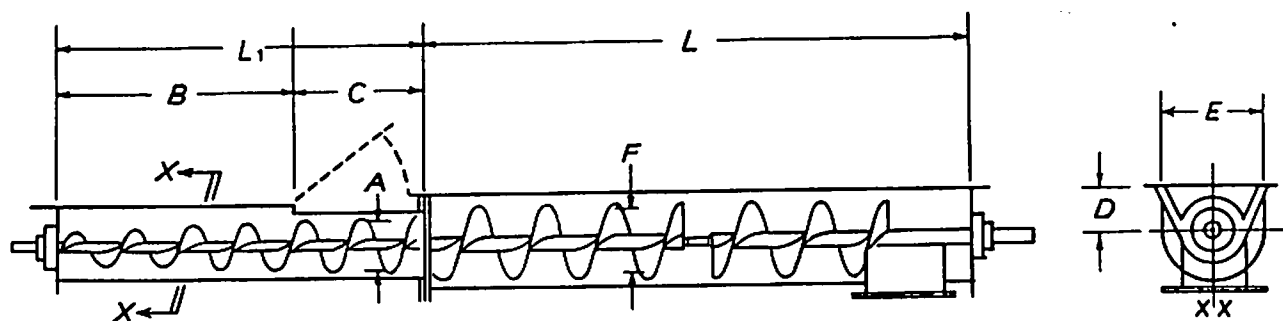
The arrangement and dimensional data for single screw feeders are shown in Fig. 6.1 and Table 6-1.

Extension Conveyor

The arrangement of an extension conveyor, directly connected to a single screw feeder, is shown in Fig. 6.2. Obviously the extension conveyor must operate at the same RPM as the feeder. The size of the extension conveyor may be obtained by referring to Table 2-3. For the code class of the material to be handled find a screw diameter which will give an equal or greater capacity in cubic feet per hour at ONE RPM than the C_f capacity of the screw feeder used in the formula to determine the feeder speed. The degree of trough loading corresponding to the code class of material to be handled and its abrasiveness, must not be exceeded.



Single Screw Feeder
Fig. 6.1



Single Screw Feeder With Extension Conveyor
Fig. 6.2

Table 6-1

Screw Feeder Capacities, Speeds and Typical Dimensions*

A Screw Diameter	Maximum Speed RPM	Capacity Cubic Feet Per Hour **		B † Inch	C †† Inch	D Inch	E	
		At one RPM C _f	At Max. RPM				Flared Trough Inch	U Trough Inch
6	70	4.98	348	36	12	7	14	7
9	65	18.50	1202	42	18	9	18	10
12	60	44.40	2664	48	24	10	22	13
14	55	70.0	3850	54	28	11	24	15
16	50	104.7	5235	56	32	11 1/2	28	17
18	45	151	6795	58	36	12 1/8	31	19
20	40	209	8360	60	40	13 1/2	34	21
24	30	363	10,890	64	48	16 1/2	40	25

* Dimensions are all in inches, but are typical and approximate. Actual dimensions should be certified for installation purposes.

** Based on 100% of theoretical capacity with standard pitch and screw pipe. For non-standard pitch or pipe size consult screw conveyor manufacturer.

† Maximum in regular construction. Larger inlet openings require engineering consideration not covered here.

†† The length C is equal to TWO standard pitches.

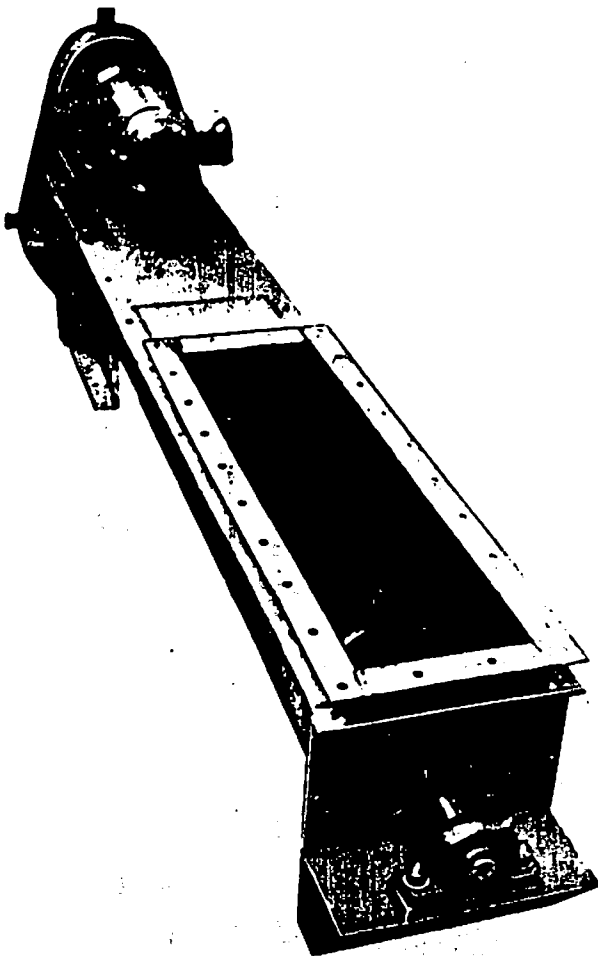


FIGURE 6.3

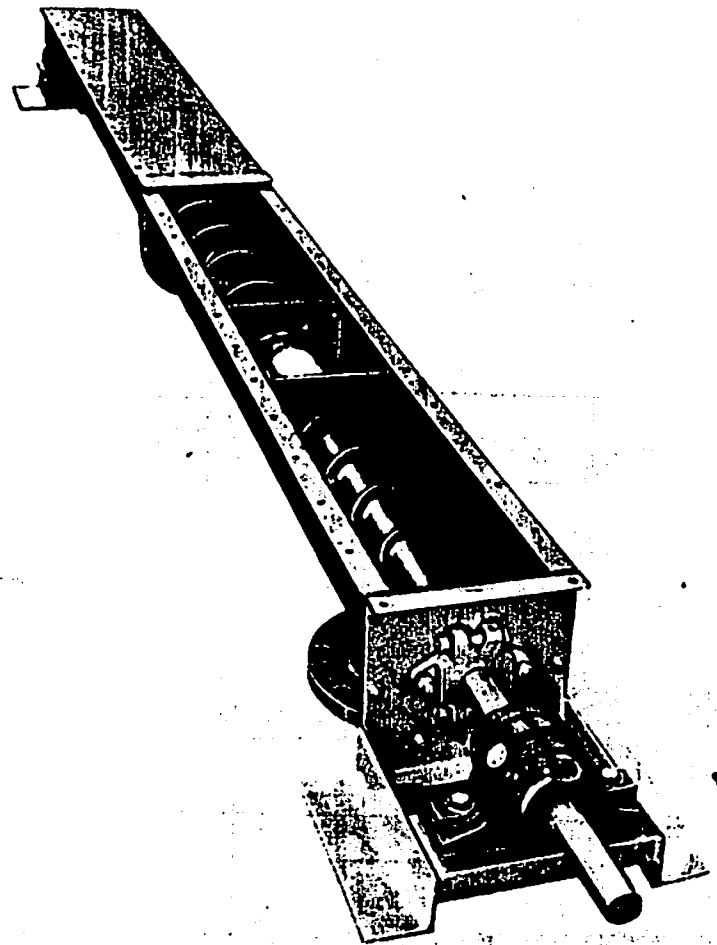


FIGURE 6.4

Power Required

The calculation of the required horsepower to operate screw feeders is very similar to that involved for standard screw conveyors. Essentially, the calculation involves the addition of two horsepowers, one for empty feeder friction, and the other the material friction.

Horsepower for Single Screw Feeder:

$$HP = \frac{(HP_a + HP_b) F_o}{e}$$

Horsepower for Single Screw Feeder with Extension Conveyor:

$$HP = \frac{(HP_a + HP_b + HP_f + HP_m) F_o}{e}$$

where: Empty Feeder Friction Power

$$HP_a = \frac{L_1 N F_d F_b}{1,000,000}$$

Feeder Material Friction Power

$$HP_b = \frac{C W L_f F_m}{1,000,000}$$

and Empty Extension Conveyor Friction Power

$$HP_f = \frac{L N F_d F_b}{1,000,000}$$

Extension Conveyor Material Friction Power

$$HP_m = \frac{C W L F_f F_m F_p}{1,000,000}$$

and the nomenclature used is defined:

C = capacity in cu. ft. per hr.

W = apparent density of material as conveyed, lbs. per cu. ft.

L = Length of extension conveyor, feet.

L_f = equivalent length of feeder, feet. See Table 6.2 for method of arriving at values of L_f for various types of screw flighting.

L_1 = length of feeder, feet, as shown in Figures 6.1 and 6.2.

N = speed of screw rotation, RPM (rev. per min.)

F_b = hanger bearing factor, Chapter 3, Table 3.1

F_d = conveyor diameter factor, Chapter 3, Table 3.2

F_m = material factor, Chapter 2, Table 2-2

F_o = overload factor, Chapter 3, Fig. 3.2

e = efficiency of the drive selected. See Chapter 8 and Table 8-1

Table 6-2

Equivalent Length of Feeder, L_f

Material Code Class	Particle Size Inches	Flight Type Under Inlet	Values of L_f , Feet For Dimensions See Figs. 6.1 & 6.2
A15, A16, A17, A25, A26, A27, A35, A36, A37, also	1/8	Standard Pitch Uniform dia.	$\frac{B}{L_1} + \frac{C}{12}$
		Short Pitch Uniform dia.	B & C from Table 6-1
B15, B16, B17, B25, B26, B27, B35, B36, B37.	Maximum	Standard Pitch *Tapered dia.	$\frac{B}{L_1} + \frac{C}{12}$
		Short Pitch *Tapered dia.	B & C from Table 6-1

*Variable pitch of constant diameter may be used in place of tapered diameter and constant pitch lighting.

Example of Single Screw Feeder Selection

Problem: select a single screw feeder without extension conveyor for the following conditions

Material to be handled Salt cake, dry, pulverized
 Weight per cubic foot 65-85 lbs. per cu. ft.
 Capacity 26 tons (2000 lb) per hour = 800 cubic feet per hour
 Length of feeder, L_1 10 feet
 Inlet opening 60 inches long, 10 inches wide
 Required is an even rate of flow along the whole inlet opening.

Solution:

- From Table 2-2, Chapter 2, salt cake is code classified at 75 B₆₃₆ TU, has a component group designation of 3-D and a material factor (F_m) of 1.7
- From Table 3-1, for a Component Group D, the hanger bearing factor, $F_b = 4.4$
- To be prudent, for capacity calculations use the lowest apparent density, 65 lbs. per cu. ft. Then the volume for 26 tons per hour is $\frac{(26)(2000)}{65} = 800$ cu. ft. per hr. required feed rate.
- Referring to Table 6-1, a 9 inch diameter single screw feeder will handle 1202 cu. ft. per hr. at a maximum of 65 RPM. and $C_f = 18.5$ at one RPM
 Using the formula for speed,

$$N = \frac{C}{C_f} = \frac{800}{18.5} = 43.2 \text{ RPM}$$

- From table 6.2, the equivalent length of the feeder is $L_1 + \frac{B}{6} + \frac{C}{12}$, in which

$$L_1 = 10, \frac{B}{6} = \frac{60}{6} = 10, \text{ and } \frac{C}{12} = \frac{(2)(9)}{12} = 1.5$$

$$L_f = 10 + 10 + 1.5 = 21.5 \text{ feet}$$

(f) From Table 3-2, the conveyor diameter factor $F_d = 31$

(g) Again to be prudent, for power calculations it is well to use the largest apparent density for W , so $W = 85$ lbs per cu. ft.

$$(h) HP_a = \frac{L_1 N F_d F_b}{1,000,000} = \frac{(10)(43.2)(31)(4.4)}{1,000,000} = .059 \text{ HP}$$

$$(i) HP_b = \frac{C W L_f F_m}{1,000,000} = \frac{(800)(85)(21.5)(67)}{1,000,000} = 2.48 \text{ HP}$$

(j) Referring to Fig. 3.1, Chapter 3, the factor F_o depends upon the SUM of the horsepower for friction of the empty conveyor (feeder in this case) and the horsepower of material friction. In this case this sum is $.059 + 2.48 = 2.539$ HP. and $F_o = 1.45$

(k) Then assuming a drive efficiency (expressed decimally) of 0.88, (see note below)

$$HP = \frac{(HP_a + HP_b) F_o}{e} = \frac{(.059 + 2.48)(1.45)}{0.88} = 4.18 \text{ HP}$$

(e) Use a 5 HP Electric motor with speed reduction to 43.2 RPM

Note:

Checking drive efficiency assumption, say the motor is 1800 RPM nominal speed, 1750 full load speed and is connected by vee belt drive having a ratio of 1.5 to 1 to a double reduction shaft mounted speed reducer with ratio of 27 to 1. From Table 8-1, Chapter 8, the vee belt drive has an efficiency of 0.94 and the double reduction speed reducer an efficiency of 0.94. Hence the overall efficiency of the drive is $(.94)(.94) = 0.88$.

The theoretical estimated power requirements calculated in the foregoing example conceivably could be exceeded to the extent that the full 5 horsepower of the motor would be used. Therefore, all components of the power train, the feeder drive shaft, the screw pipe shaft and the screw itself should be capable of withstanding—at the speeds involved for each—the torsion force or torque of full 5 horsepower. See Chapter 3 for torsional capacities of screw conveyor components.

Effect of Material Loads on Screw

In many cases, where screw feeders are mounted at the bottoms of bins or hoppers, the screw has to perform its function under heavy loads of material above the bin opening or feeder inlet. Under certain conditions and with certain materials the start-up torque can be very high, resulting in bigger drives and heavier feeder components.

MULTIPLE SCREW FEEDERS

Multiple screw feeders may consist of twin, triple or quadruple screws, side by side, to feed materials from very wide inlet openings. A twin screw feeder is shown in Fig. 6.5.

Multiple screw feeders should be designed as groups of single screw feeders, each screw of the group being designed as an individual feeder. Each screw should have its own shroud at the end of the inlet opening to assure the fully controlled loading of each screw.

Adjacent screws in a multiple feeder may rotate in opposite directions, using right and left hand flights respectively, to draw material from the entire width of the inlet opening, and also to facilitate drive gearing as indicated in Fig. 6.5. The troughs can be individual tubular housings with a common inlet opening or a wide U shaped trough with individual shrouds and curved dividers (half round bottoms) between each screw.

Capacities, required, operating power, etc., can be calculated by the same methods shown for a single screw feeder, making the calculations for one screw and then multiplying by the number of screws used. However, due to certain factors affecting the operation of multiple screw feeders—such as the load imposed on the screws by the weight of the material in the bin above them—any multiple feeder having an inlet area of more than 15 square feet should be referred to a screw conveyor manufacturer.

Bin Bottom Type of Multiple Screw Feeder

Fig. 6.7 shows a multiple screw feeder used as the entire bottom of a rectangular bin.

The bin bottom type of multiple screw feeders usually is installed in flat bottom bins for discharging materials which have a tendency to pack or bridge under pressure. The multiple screws feed the material to a collecting screw conveyor.

Because of the many factors involved in designing multiple feeders of this type, such as material characteristics, height of bin or weight stored vertically above the screws, the design of bin bottom type multiple screw feeders should be referred to a screw conveyor manufacturer.

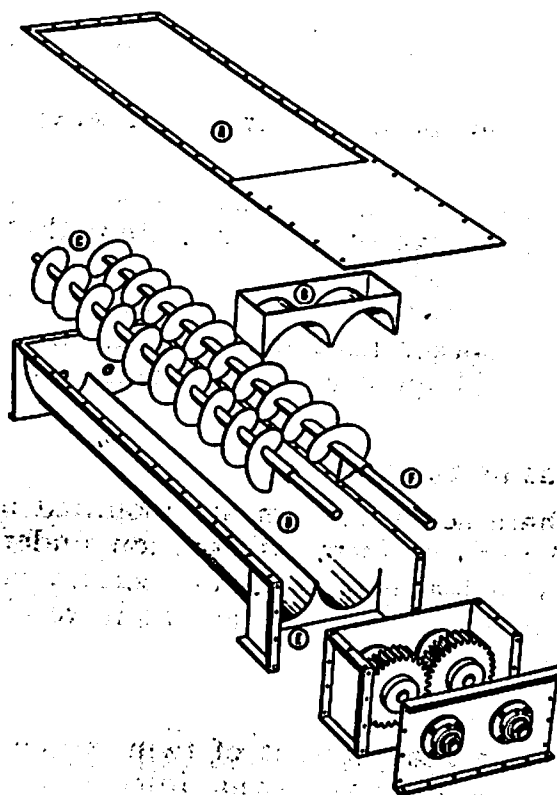


FIGURE 6.5

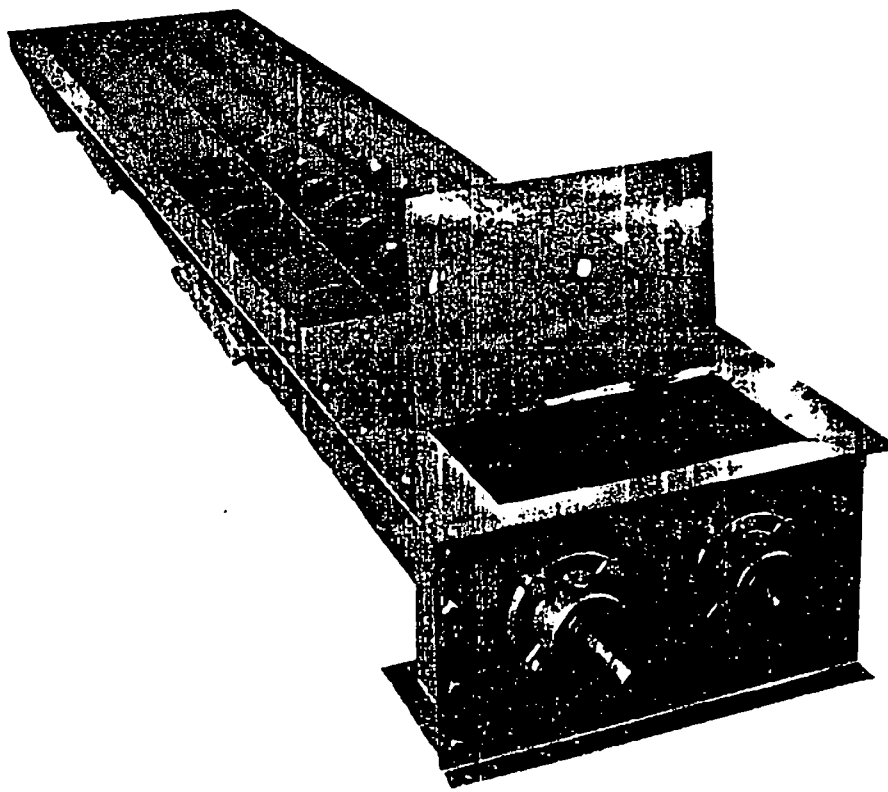


FIGURE 6.6

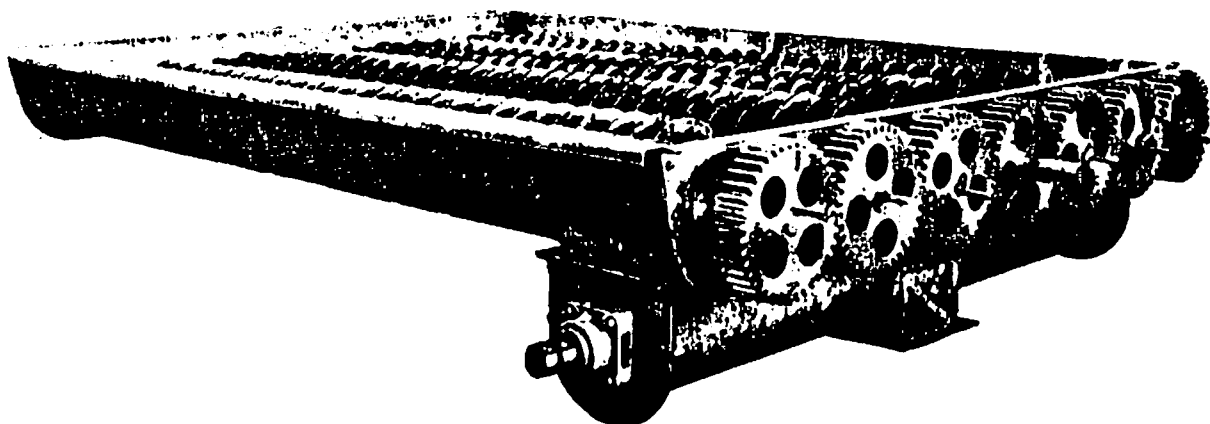


FIGURE 6.7

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Chapter 7

Inclined and Vertical Screw Conveyors

INCLINED SCREW CONVEYORS

A screw conveyor arranged to convey bulk material up an inclined path is often very desirable as it will solve a conveying problem with a minimum of equipment and occupy a minimum of space. The only alternate is to convey the material horizontally and then vertically or vice versa, in which case two conveyors are needed to do the job. However, aside from the obvious advantages, there are a number of problems that must be recognized in designing an inclined screw conveyor.

As the angle of incline of the screw conveyor is increased there is a serious loss of efficiency. Primarily two things happen to bring this about:

1. The capacity, or the maximum available capacity of a given screw conveyor decreases with increase of incline.
2. The horsepower per unit of capacity increases.

There are a number of reasons for these effects. As the angle of incline is increased, there is a reduction of the effective angle of the flight as it pushes against the material. At certain angles of incline—and depending on the pitch—a portion of the helical flight is virtually on a horizontal plane and this flight portion does not urge the material to slide forward at all. The reduction in the ability of the flighting to urge the material forward causes material turbulence and tumbling.

These causes lead to an increase in the cross-sectional loading so that intermediate hangers offer a much greater obstruction to material flow past them. Also, the turbulence and tumbling of the material requires more power, power that really is not useful in conveying the material.

Finally, the shape of a standard conveyor U shaped trough is such that the material is allowed to fall backwards over the top of the rotating screw, contributing both to turbulence and increased cross-sectional loading and to wasted power.

Figure 7.1 shows in a qualitative manner the percent capacities of screw conveyors at various angles of incline for standard designs, modified designs and for vertical designs. See figure 7.3 for illustrations of these designs.

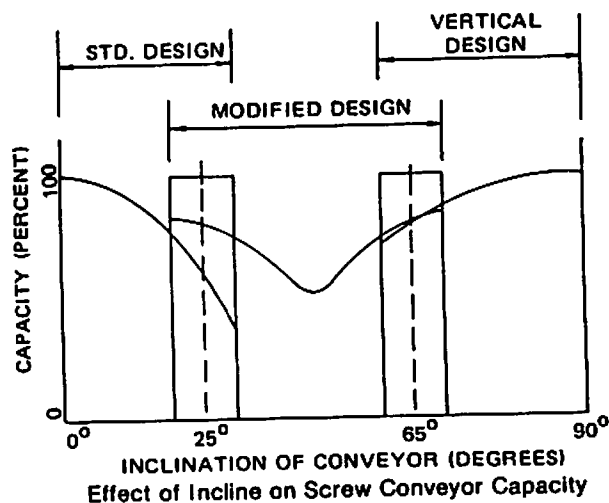


Fig. 7.1

The capacity curve in Fig. 7.1 for even the best modified designs shows that there is an angle of incline somewhere between 25° and 65° where the capacity is at a minimum. This angle of minimum capacity is not specific for it depends on many things such as material characteristics, flight pitch, speed, housing (trough) design, etc.

Several things can be done to overcome many of the problems associated with inclined screw conveyors, and obtain a workable inclined screw conveyor installation. These are:

- A. Limit the use of standard screw conveyor components to inclines of less than 25° , preferably not over 15° .
- B. Use close clearance between trough and screw.
- C. Increase the speed over that applicable for a horizontal screw conveyor of the same size.
- D. Use short pitch screws, $\frac{2}{3}$ or $\frac{1}{2}$ pitch as the material to be handled will permit.
- E. Use special extra long screw sections to eliminate intermediate hangers as far as possible.
- F. Use tubular troughs with minimum clearance between trough and screw.

The increase in speed of screw rotation imparts a greater forward material velocity which is an aid in pushing the material past an intermediate hanger. Even though there is an increase in the agitation and tumbling of the material, the net result probably will be an increased capacity, depending of course on the characteristics of the material being handled.

The reduction in flight pitch improves the angle of the flight on which the material must slide. While reduced pitch travels the material forward less per revolution of the screw, the rotational speed may be increased to effect a satisfactory forward speed of the material.

Elimination of intermediate hanger bearings is possible in some cases, by making the conveyor screw sections longer than standard. It must be recognized however, that long lengths may cause excessive deflections of the screw such that the screw might rub on the trough. This may not be altogether objectionable in some cases, depending on the application. With some materials the material being conveyed may itself support the screw and prevent undue rubbing of the screw on the trough.

Tubular housings are of advantage on many inclined screw conveyors because they tend to contain the material in the screw and prevent the fall-back of material over the top of the screw which takes place in U shaped troughs. This is especially true when using higher than usual rotational speeds.

The vertical screw conveyor design is often used at angles less than 90° and will be capable of capacity performance equal to that of a standard horizontal screw, but the use of vertical design screw conveyors is limited to those materials which can be handled in such units.

In general, the capacities and horsepower requirements of inclined screw conveyors are dependent on the characteristics of the material handled and cannot accurately be predicted. Before going forward with the design, construction and installation of a screw conveyor to operate at more than small incline angles, consult a screw conveyor manufacturer.

Horsepower of Inclined Screw Conveyors

The horsepower required by inclined screw conveyors may be approximated by using the following method:

- (a). Calculate the horsepower of the screw conveyor just as though it were a horizontal screw conveyor, using the horsepower formulas in Chapter 3.
- (b). Calculate the actual horsepower to lift the material the total height of the incline. This may be done as follows:

$$\frac{(\text{Lbs. per min}) (\text{actual height of lift, feet})}{33,000} = \text{HP of lift}$$

If the rate of conveyance of the material to be handled is in cubic feet per hour, C , and the apparent density of the material is W lbs. per cubic foot, then:

$$\text{Lbs. per minute} = \frac{CW}{60}$$

- (c). Estimate the horsepower required to overcome the decrease in efficiency due to the extra agitation and tumbling of the material. Obviously, this factor will vary with each application. It is wise to consult a screw conveyor manufacturer for the benefit of his experience.
- (d). Add the horsepower calculated in (a), (b) and (c). This will be the approximate total horsepower to operate the loaded inclined screw conveyor, not considering the efficiency of the drive.
- (e). Divide by the drive efficiency to judge the motor HP.

In any case the drive should be placed at the top or discharge end of the screw conveyor. Note that if the speed reduction unit is tilted at the angle of the conveyor, care should be taken to see that the oil level is not just jeopardized, that the shaft seals will be satisfactory to retain the lubricant, that the oil level gauge will indicate the necessary level and that the oil filling and drain plugs are accessible and operative at the tilted position of the reducer. An enclosed right angle countershaft box or trough end may be necessary to obviate direct connected speed reducer difficulties.

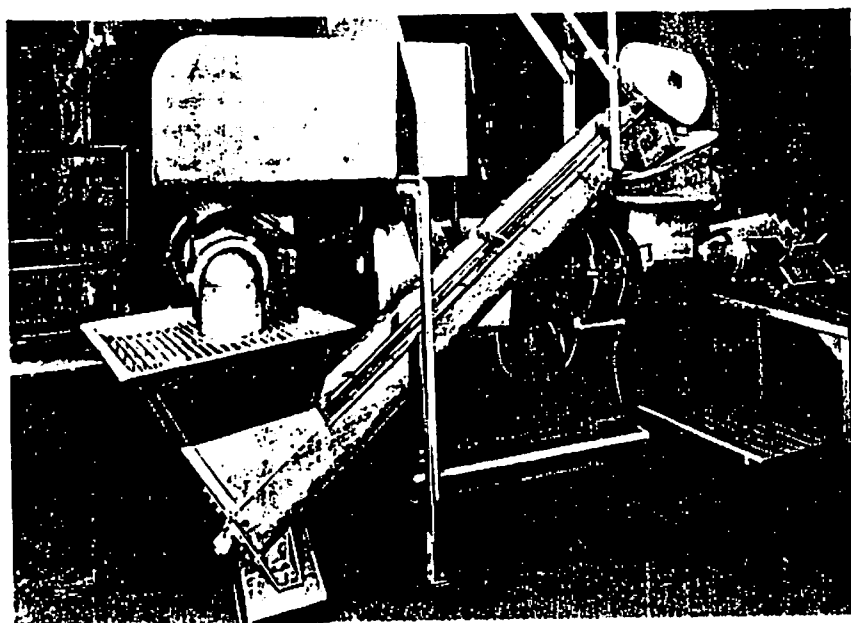


FIGURE 7.2

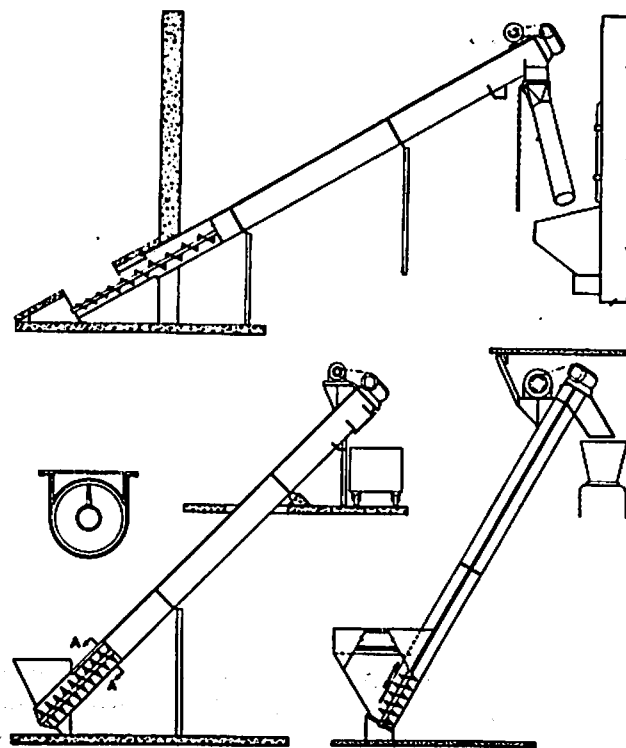


FIGURE 7.3

VERTICAL SCREW CONVEYORS

A vertical screw conveyor is one that conveys material upward in a vertical path. Vertical screw conveyors are sometimes called "lifts" or "elevators" but such names are ambiguous. In any event they can satisfy many conveying problems and they have the further advantage of being compact. They require less space than some other forms of elevating conveyors.

Vertical screw conveyors can handle many of the bulk materials shown in the material table Chapter II, column V. Generally this includes all materials listed except those containing large lumps, or which are very dense or are extremely abrasive.

The vertical screw conveyor consists of a conveyor screw rotating in a vertical casing or housing with a suitable inlet at the lower end and an outlet at the upper end. The drive may be located at the top or the bottom. The top bearing for the screw shaft must be adequate to handle both the radial and thrust loads.

The method of feeding the vertical conveyor is most important because some materials lend themselves to one method of feeding better than another. Very light materials for instance cannot be handled in a gravity inlet hopper because the rotating screw acts somewhat like a fan and blows the material back out. This is often overcome by leaning the vertical screw off with the inlet hopper on top of the inclined unit.

Most materials are fed to the vertical by a straight or offset intake horizontal feeder conveyor. The straight intake unit is simple and effective for those materials which will not become damaged by jamming or forcing.

The offset intake is very often used especially for the more fragile materials. See figures 7.4, 7.5, and 7.6. Standard practices and design will vary somewhat between manufacturers and it is important to consult them for recommendations and complete specification.

The ideal operation of a vertical screw conveyor is to have a controlled and uniform volume of material fed to the unit. Uneven or surge loads and start, stop operations can affect specifications of speed, capacity and horsepower. Some granular or pelletized materials will roll to the bottom of the vertical section after stopping and will then create a starting problem unless recognized.

If a horizontal feeder screw conveyor is employed to feed the vertical screw, the speed of the vertical screw may be constant and any change in the material flow rate made only in the horizontal feeder. In this way specific flow rates of material may be obtained.

One of the features of vertical screw conveyors is that if the rotation of the vertical screw be stopped, the conveyor will be full of material. It is also true that if the vertical screw be left turning but the feed of material cease, the vertical screw conveyor will not empty itself; some material will be left in it, in an amount depending on the material characteristics. It is important to realize, however, that material left over from a previous operation will be the first to discharge when the vertical screw conveyor is started again.

Vertical Screw Speeds

Vertical conveyor screw speeds must be adequate not only to convey but to overcome the fall back of the material in the annular clearance between the housing or casing and the screw. It also must be realized that the speed of the vertical screw imparts a lineal velocity to the material, against the pull of gravity, and this velocity is very important in propelling the material past the gaps between the screw sections at intermediate hanger bearings.

Capacities of Vertical Screw Conveyors

Table 7-1 indicates typical average capacities for various sizes of vertical screw conveyors. These capacities can be exceeded when handling some materials which have particularly favorable characteristics.

A range of vertical screw speeds is shown and although the screw speed is constant for any given application, the speed will have to be chosen to suit the material characteristics.

Table 7-1
Vertical Screw Conveyor Capacities

Inch Size of Conveyor Screw	Capacity in Cubic Feet per Hour	RPM Speed of Vertical Screw
6	400	170 to 420
9	1300	170 to 340
12	3000	170 to 270
16	6000	135 to 230

Vertical Conveyor Screws

Vertical conveyor screws normally have standard diameters and standard pitches. Usually, helicoid flighting is employed, welded to the pipe shaft.

Often longer than standard screw sections are used, to reduce the number of intermediate hanger bearings. Because of the high speed, screw sections may deflect if made too long and tend to whip, particularly when extended heights of lift are required.

The customary drive shafts, tail shafts and couplings are employed, bolted to the pipe shafts of the screws.

For special conveyor screw finishes, see Table 5-3, Chapter 5.

Vertical Screw Conveyor Housings or Casings

The tubular housings or casings have flanged ends for bolted assembly, and are made in lengths to suit the length of the screw sections. Often the tubular housings are split vertically and the halves either bolted together or hinged and clamped, depending on the ease of access desired. Access doors may be installed at the lower end of the unit for inspection and clean out.

The housing or casing joints may be gasketed for tightness, may have special painting and have other features that are consistent with good sheet metal work, conforming with a number of provisions of Table 5-2 in Chapter 5, (tho this table was not set up for vertical screw conveyor enclosures.)

When any part of the vertical screw conveyor housing is open for inspection or cleaning, some type of safety control must be provided to prevent accidental operation until all parts are re-assembled in proper operating condition.

Gravity Inlet Hopper

The gravity inlet hopper usually is arranged as shown in Figure 7.4. It funnels the material by gravity to the lower end of the vertical screw. The top of the hopper ordinarily is provided with a grating or screen to keep out foreign objects.

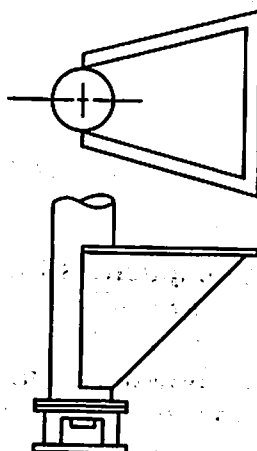


FIGURE 7.4

While the gravity inlet hopper usually is employed to receive material manually dumped from sacks or other containers, it also can receive material discharged by other conveyors or through spouting from bins, etc. However, the successful use of this type of inlet depends upon the characteristics of the material handled. Consult a screw conveyor manufacturer before choosing a gravity inlet hopper.

Force Feed Inlet Arrangements

There are two commonly used inlet arrangements for connection to horizontal force feed screw conveyors. One is the straight intake and the other the offset intake.

Straight Intake

This inlet connects to the vertical casing or housing at a 90° angle, similar to a tee in a pipe. It has an adapter flange for connection to the flanged end of the horizontal screw conveyor used to force feed the material to the vertical screw. A hanger normally is necessary at the end of the horizontal conveyor, to support the end of the screw.

This type of intake is most frequently used with a free flowing material, one which will not cause problems at the end hanger of the horizontal screw conveyor.

When a straight intake is used the horizontal screw conveyor can only be driven from its inlet end.

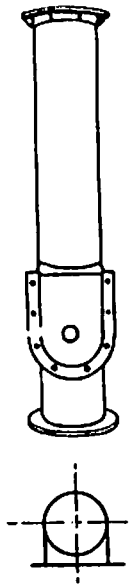


Figure 7.5

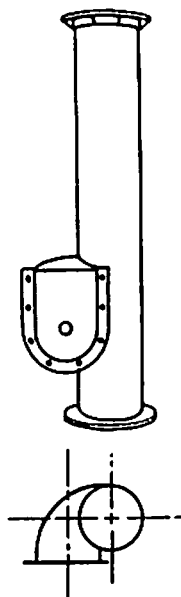


Figure 7.6A

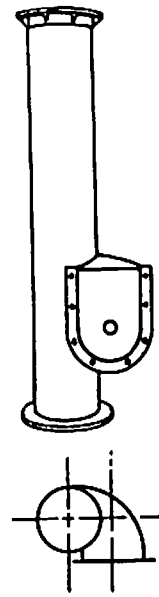


Figure 7.6B

Offset Intakes

This type of intake connects to the vertical casing or housing at 90° angle, but is offset from the center of the vertical screw conveyor as illustrated in Figures 7.6A and 7.6B.

The advantage of the offset intake is that the shaft of the horizontal force feed screw conveyor can extend past the casing of the vertical screw conveyor and be supported in an external bearing on the far side. This eliminates the need for any internal hanger to support the inner end of the horizontal screw. The external bearing on the horizontal screw may carry the thrust load as well as the radial load of this screw.

Also, the horizontal screw conveyor may be driven from either its inlet or discharge end.

Discharge Arrangements

Discharge of material at the top of a vertical conveyor is through an opening similar to the plain discharge spout of a horizontal screw conveyor, as in Figure 4.17E. The discharge spout may be connected to an elbow spout or other inclined or vertical spouting to direct the flow of material into subsequent conveyors or process machinery.

To insure a positive discharge through the spout, the vertical screw may carry discharge paddles, and sometimes reverse flights above the discharge opening. Even so, there are times when it is advisable to provide a safety overflow. This usually is an opening diametrically opposite and above the discharge spout, arranged to spill the material if the discharge spout becomes clogged and unable to handle the normal material flow.

Figure 8.7 in Chapter 8 illustrates the usual discharge arrangement.

Hanger or Stabilizer Bearings

Intermediate hanger or stabilizer bearings usually are necessary in vertical screw conveyors when extended heights of lift are required, to eliminate excessive screw deflection and "whip". These hanger or stabilizer bearings are positioned between the sections of the screw and are supported between the housing flanges. The particular kind of hanger or stabilizer bearing to use is determined by the characteristics of the material being handled.

However, some materials tend to travel upward in a mass and would not readily pass a hanger bearing. One such material is cottonseed. With it, hanger bearings are not used. Certain other materials tend to center the screw within the housing, thus eliminating the need for hanger or stabilizer bearings.

Construction Metals

Vertical screw conveyors can be manufactured of stainless steel, aluminum or other special metals. Or if made of carbon steel, the parts may be hot dip galvanized after fabrication, to increase their corrosion resistance. A great variety of constructions are available, as in the case of standard horizontal conveyor screws.

Drives

Drives for vertical screw conveyors are described and illustrated in Chapter 8.

Horsepower for Vertical Screw Conveyors

The following horsepower formula is to be used only for approximating the horsepower required for a vertical screw conveyor. Because of the many variables that may affect the horsepower of a vertical screw conveyor installation, it is recommended that the supplier of the vertical conveyor be consulted to determine the horsepower that actually may be needed.

Because of the difficulty in determining theoretically the power losses in a vertical screw conveyor, most manufacturers of these units have done extensive testing and through such experience have developed empirical factors that can be used to set up realistic horsepower requirements. These factors may be combined here in a single factor, F_v , which of course will vary for different applications and for different manufacturers' designs of vertical screw conveyors.

The basic horsepower formula has been empirically determined as:

$$HP = \frac{(HP_f + HP_v)}{.90}$$

where: HP_f is the horsepower to drive the empty conveyor
 HP_v is the horsepower to convey the material vertically.

and where: $HP_f = \frac{L_1 N F_d F_b}{1,000,000}$

L_1 = Total length of the vertical screw conveyor, feet

N = Speed of vertical conveyor screw, RPM

F_d = Conveyor diameter factor from Table 3-2, Chapter 3

F_b = Hanger bearing factor from Table 3-1, Chapter 3.

and where: $HP_v = \frac{C L W F_v}{1,000,000}$

L = Total lift height in feet, measured from the centerline of the opening to the bottom of the discharge opening.

C = Capacity in cubic feet per hour

W = Apparent density of the conveyed material, pounds per cubic foot

F_v is Manufacturers' empirical factor.



FIGURE 7.7

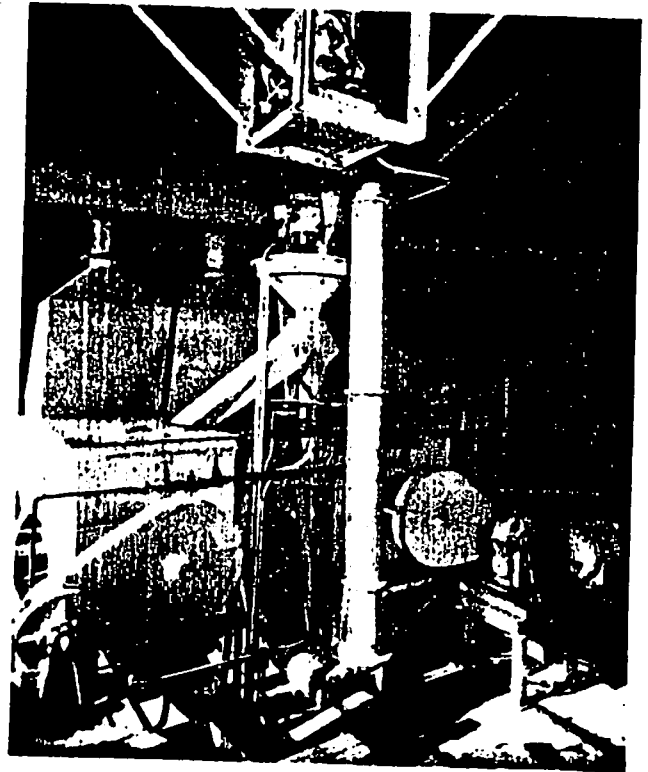


FIGURE 7.8

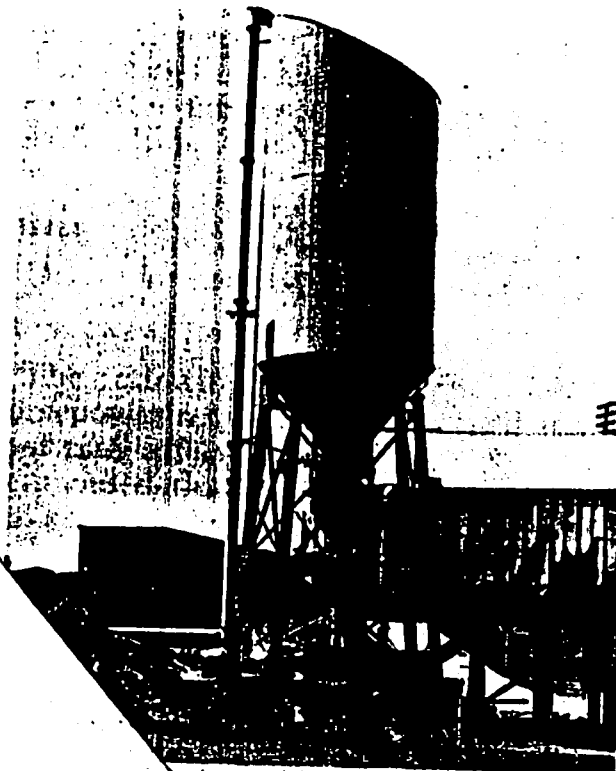


FIGURE 7.9

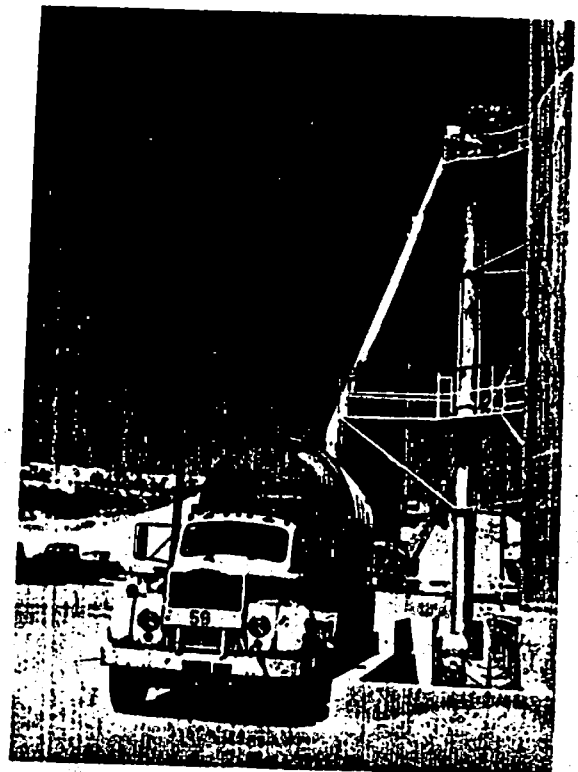


FIGURE 7.10

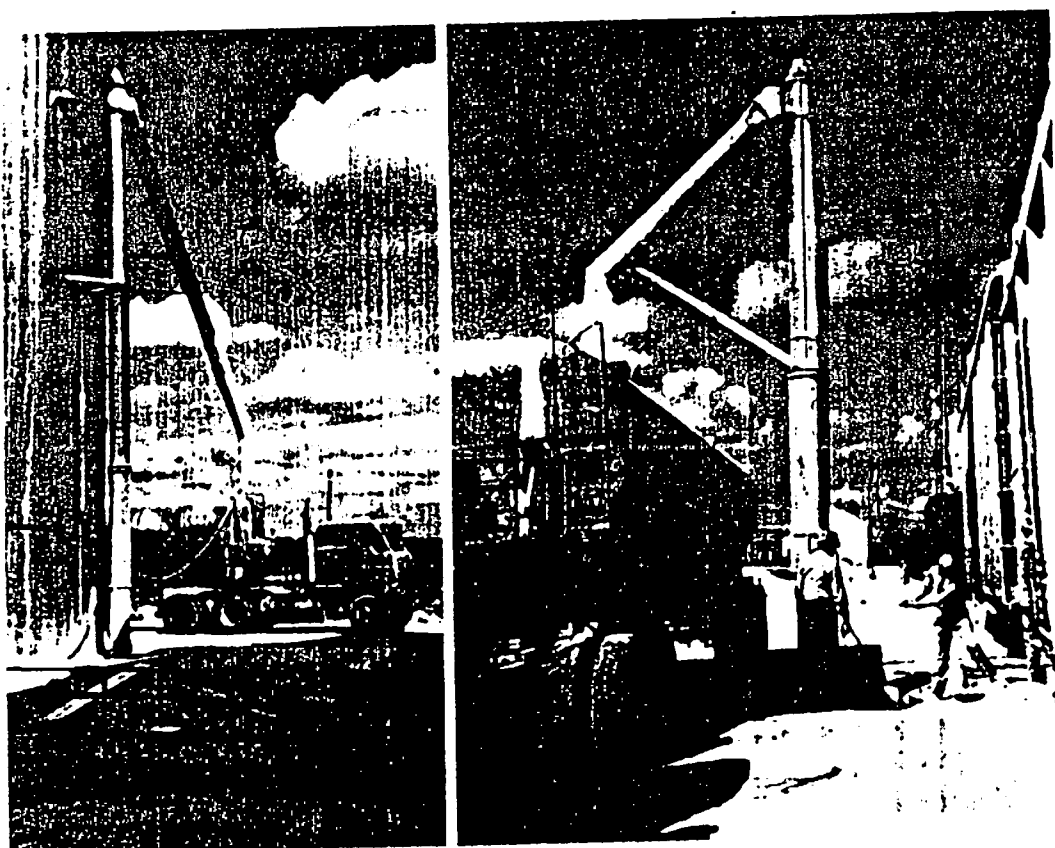


FIGURE 7.11

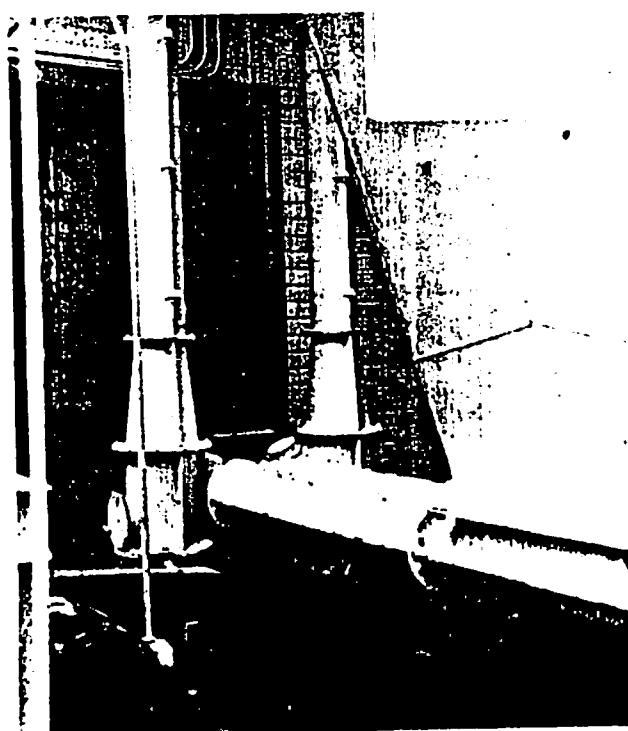


FIGURE 7.12



FIGURE 7.13

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Chapter 8

Screw Conveyor Drives, Drive Efficiencies and Drive Service Factors

SCREW CONVEYOR DRIVES

Screw conveyor drive equipment normally consists of an electric motor, speed reduction machinery and drive shaft, together with the necessary means to transmit power from one unit to the next. The simplest drive, using the minimum number of units, usually is the best. However, physical limitations or special reasons may dictate more complex drive arrangements.

Horizontal Screw Conveyors

Figures 8.1 through 8.5 show most of the drive arrangements currently in common use for driving horizontal screw conveyors. Selection of the specific drive arrangement may be determined by cost, power limitations, available space, desirable drive location or individual preference.

Within its capacity range, the special self-contained screw conveyor drive is the one most commonly used today. It is shown in Figs. 8.1 and 8.2. It consists of a fully enclosed single or double reduction speed reducer with a special low speed shaft, a special mounting trough end adapter, a V-belt drive and usually a motor support bracket. The special slow speed shaft of the speed reducer is of the proper length to extend through the adapter and trough end plate to make a standard connection to the conveyor screw. This shaft transmits all radial and thrust loads directly to the speed reducer which is built to receive these loads.

The adapter usually incorporates the necessary baffles and seals to prevent leakage of the material that is being conveyed or the entrance of contaminants into the conveyor trough. Seals retain the lubricant in the speed reducer and prevent the entry of foreign material.

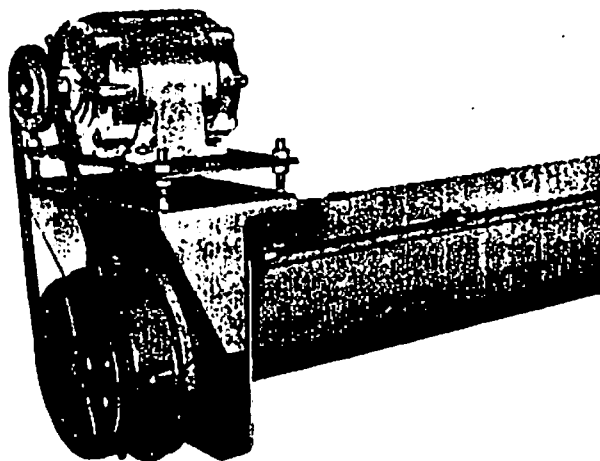


FIGURE 8.1

Typical Screw
Conveyor Drive

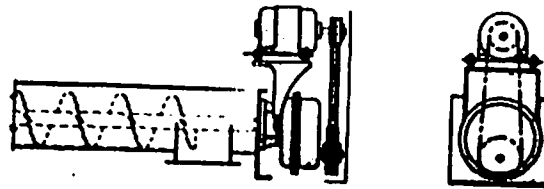


Figure 8.2
Speed Reducer and V-Belt Drive

Because the speed reducer is bolted directly to the adapter and the adapter is bolted the trough endplate, no supplementary means are needed to control torque reactions. The motor is connected to the input shaft of the speed reducer by a V-belt drive. The proper tension in the V-belt is easily maintained by a simple adjustment incorporated in the motor support bracket, as shown in Fig. 8.1.

A wide range of conveyor screw speeds can be obtained through the use of standard speed reducer ratios supplemented by available standard V-belt drive ratios. In fact the conveyor speed may be somewhat altered at any time simply by substituting appropriate V-belt sheaves and V-belts.



Figure 8.3
Shaft Mounted Reducer and V-Belt Drive

Another simple drive combination is shown in Fig. 8.3 and consists of a standard shaft mounted speed reducer mounted directly on the extended drive shaft. The motor is connected to the speed reducer input shaft by a V-belt drive and may be mounted above, below or to the side of the speed reducer. An adjustable tie-rod or torque arm prevents rotation of the speed reducer and also affords a simple means of putting the proper tension in the V-belt.

A gear motor (or moto-reducer) also can be connected to the screw conveyor drive shaft by a precision roller chain drive. This provides very great flexibility in motor location. If desired, a change in the speed of the screw conveyor is easily made by the selection of appropriate sprockets. The chain drive may be provided with an oil tight casing to retain the chain lubricant, exclude foreign matter and insure the safety of operating personnel. These in-line gear motors generally provide a wider range of power capacity than shaft mounted speed reducers. This gear motor drive arrangement is shown in Fig. 8.4.

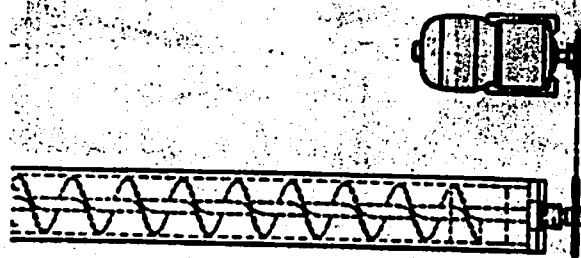


Figure 8.4
Gear Motor and Chain Drive

Other drive arrangements include parallel shaft speed reducers and worm gear speed reducers. These reduction units are useful when large horsepowers are involved or when very large reductions in speed are necessary.

Where two screw conveyors are connected at right angles to one another, enclosed bevel or miter gear trough end drive provide a compact means of powering both conveyors from a single power source, as is shown in Fig. 8.5.

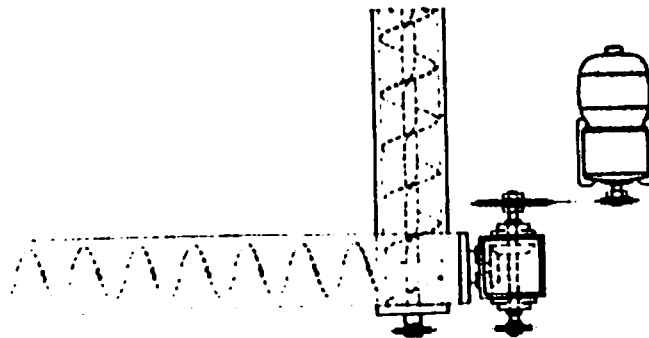


Figure 8.5
Bevel Geared Trough End Drive

Normally speed reducers should not be directly connected to a screw conveyor drive shaft unless adequate provision has been made for carrying the conveyor thrust load independently of the speed reducer. Flexible couplings must be provided to connect the screw conveyor drive shaft to the speed reducer output shaft. The alignment of these shafts must be carefully made and maintained as the speed reducer usually is independently supported.

On certain installations it may be desirable to provide means for a cushioned start of the screw conveyor or series of conveyors, or to provide a torque limiting device. Dry shot type, viscous shear type or hydraulic type couplings or centrifugal clutch couplings offer cushioned starts. Torque-arm shaft mounted speed reducers may be had with over-load release mechanisms. Torque limiting sprockets may be used where chain drives are employed. Shear pins are a very common means of preventing damage due to overloads.

Occasionally variable speed drives are required for process control. Screw Conveyors have constant torque, variable horsepower speed characteristics. For simple, economical change from one fixed speed to another, substitution of V-belt sheaves or chain sprockets may be used. Where continuously adjustable variable speeds are required, there is available a wide variety of mechanical speed changing mechanisms, the most common ones being the variable pitch motor sheave for V-belt drives, self-contained continuously adjustable ratio belt drives, special chain drives and various designs of friction roller drives. Speed adjustment also can be made electrically, by adjustable voltage direct current and alternating current motors and eddy current couplings. Hydraulic motors may be employed not only for speed control but torque control as well. The hydraulic power generating unit may be remotely located, to conserve space.

Inclined Screw Conveyors

In general, the drives outlined for horizontal screw conveyors may also be used for inclined screw conveyors, provided the incline is moderate.

Care should be exercised that when speed reduction units are inclined because of direct connection to or on the screw conveyor drive shaft, that the oil seals on the speed reducer will retain the lubricant properly, that the tilted oil supply still

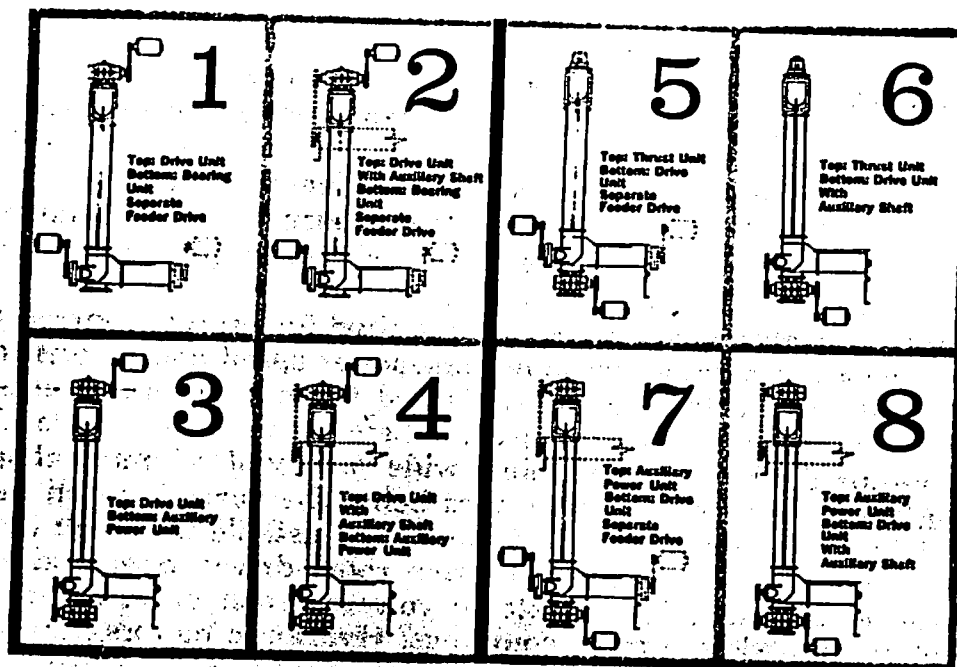
will properly lubricate the gearing, that the oil level gauge will not be rendered inoperative and that the oil filler and drain openings are not made too inconvenient for servicing. If motors must be tilted too, their lubrication must be checked for the required inclined position.

One simple way to avoid tilting of motors and speed reducers is to provide a countershaft box end at the drive end of the inclined Screw Conveyor, and connect the speed reducer output shaft to the countershaft by means of a chain drive. This method of drive is particularly advantageous when gear motors are employed.

On inclined conveyors, the drive preferably should be located at the upper or discharge end.

For the more steeply inclined screw conveyors, the design of the components ordinarily follows that of vertical screw conveyors, so the vertical screw conveyor type of drive is generally employed. Again, seals and lubrication must be checked for the incline required.

Drive At Top		Drive At Bottom	
To Drive	Select	To Drive	Select
vertical screw only	Arrangement 1	vertical screw only	Arrangement 5
vertical screw & discharge conveyor	Arrangement 2	vertical screw & feeder	Arrangement 6
vertical screw & feeder	Arrangement 3	vertical screw & discharge conveyor	Arrangement 7
vertical screw, feeder & discharge conveyor	Arrangement 4	vertical screw, feeder & discharge conveyor	Arrangement 8



Vertical Screw Conveyor
Drive Arrangements
FIGURE 8.6

Vertical Screw Conveyors

A wide variety of drive and power take-offs are available for vertical screw conveyors. For the most part these involve one or the other—or both—of the two basic drives: the top drive and the bottom drive. Figure 8.6 illustrates eight common drive arrangements, employing these basic units.

An additional choice of drive is available, in which the vertical screw is directly driven by V-belt from a motor, as shown in Figure 8.7.

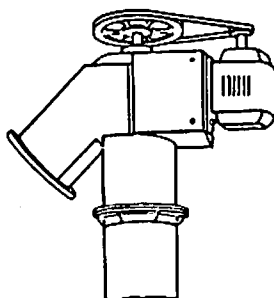


Figure 8.7
Direct V-Belt Drive

Top Drive Unit

The top drive unit shown in Figure 8.8 incorporates a set of cut tooth bevel gears—usually of 2 to 1 ratio—mounted on shafts journaled in anti-friction bearings and enclosed in an oil tight housing so arranged that it mounts directly on the top of the screw conveyor housing flange.

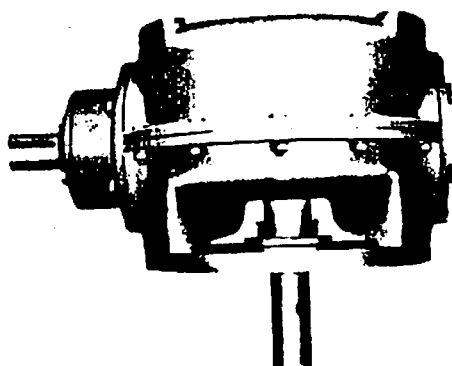


Figure 8.8
Vertical Screw Conveyor Top Drive

The drive incorporates a thrust bearing to carry in suspension the entire weight of the screw and load. There are seals or packing glands around the vertical shaft at the bottom of the housing, and a vertical shaft extension with conventional coupling bolt holes for the end of the pipe shaft of the vertical screw.

The input shaft of the gear box is usually connected by a V-belt drive to an electric motor. The motor normally is supported on a bracket secured to the upper end of the casing. Sometimes the input shaft of the top drive is extended through the housing so that it projects out the opposite side, to act as a power take-off shaft by which a horizontal discharge conveyor may be driven through a precision roller chain drive.

Bottom Drive Unit

The bottom drive unit is used where overhead power transmission facilities are not possible, or the height of the vertical screw conveyor is such that a drive unit at that elevation cannot be serviced conveniently. Fig. 8.9 shows a typical bottom drive unit.

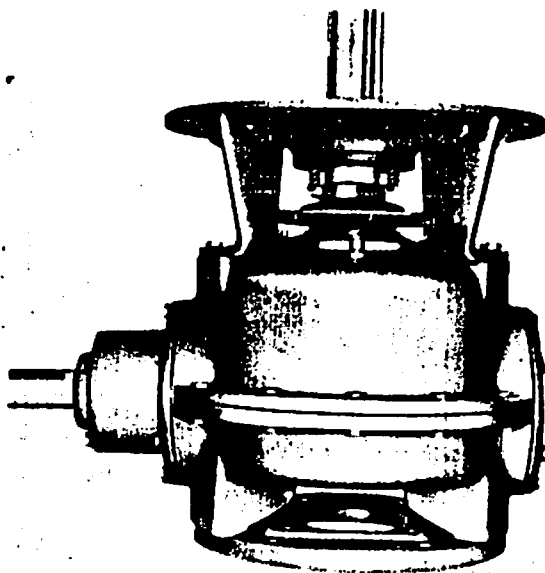


Figure 8.9
Vertical Screw Conveyor Bottom Drive

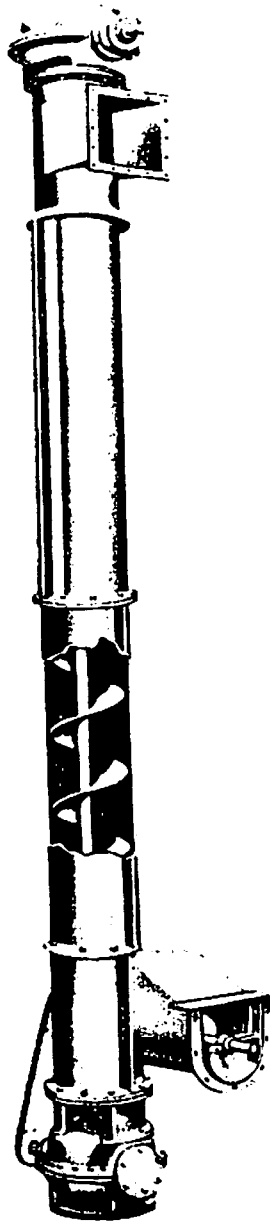
The construction of the bottom drive unit is the same as the top drive, except that a flange is provided to bolt the unit to the bottom of the casing. The bottom drive housing may be arranged to rest on the floor or foundations. The vertical shaft extends upward to engage the pipe shaft of the screw and has holes for the conventional coupling bolts. Seals are provided for both input and output shafts.

The input shaft is usually V-belt driven from an electric motor, and may extend through the housing to act as a power take-off shaft by which a horizontal feed conveyor may be driven through a precision roller chain drive.

When the vertical screw conveyor is driven at the top, a bottom drive unit may also be used, but acting solely as a power take-off for driving a horizontal feed conveyor.

Other Drive Units

In addition to the top and bottom drives per Figs. 8.8 and 8.9, other types of speed reduction units have been modified for use on vertical screw conveyors, such as special vertical shaft worm gear speed reducers.



Vertical Screw Conveyor arranged for drive at the top through a Top Drive Unit, but also provided with a Bottom Drive Unit from which to drive a horizontal Feed Screw by means of a chain drive.

FIGURE 8.10

DRIVE EFFICIENCIES

To determine the minimum horsepower of the motor, it is necessary to divide the calculated horsepower at the screw conveyor drive shaft by the overall efficiency of the speed reduction machinery. The overall efficiency is the product of multiplying the efficiencies of each unit of the drive train.

The efficiencies of various speed reduction mechanisms are listed in Table 8-1. These efficiencies represent conservative figures for the components of the drive train, taking into account possible slight misalignments, uncertain maintenance and the effects of temperature change. While there are variations in the efficiency of different manufacturer's products, the data given in Table 8-1 will cover any such discrepancies.

SERVICE FACTORS

Appropriate service factors for individual power transmission components should be determined from the manufacturer's catalogs, taking into account the intended service, hours of operation and the type of operating conditions.

Because the American Gear Manufacturers Association (AGMA) designates different service factors for different types of speed reducers, no single system of service factors is available for geared speed reduction mechanisms.

The Mechanical Power Transmission Association's "Standard Specifications for Drives Using Narrow V-Belts" (3V, 5V and 8V cross sections) dated July 1964, and "Engineering Standard Specifications for Drives Using Multiple V-Belts" (A, B, C, D and E cross sections) dated January 1964, tabulate recommended service factors for V-belt drives.

Table 8-1
Mechanical Efficiencies of Speed Reduction Mechanisms

Type of Speed Reduction Mechanism	Approximate Mechanical Efficiencies
V-belts and Sheaves	0.94
Precision Roller Chain on Cut Tooth Sprockets, Open Guard	0.93
Precision Roller Chain on Cut Tooth Sprockets, Oil Tight Casing	0.94
Single Reduction Helical or Herringbone Enclosed Gear Reducer or Gear Motor	0.95
Double Reduction Helical or Herringbone Enclosed Gear Reducer or Gear Motor	0.94
Triple Reduction Helical or Herringbone Enclosed Gear Reducer or Gear Motor	0.93
Single Reduction Helical Gear, Enclosed Shaft Mounted Speed Reducers	0.95
Double Reduction Helical Gear, Enclosed Shaft Mounted Speed Reducers	0.94
Low Ratio (up to 20:1 range) Enclosed Worm Gear Speed Reducers	0.90
Medium Ratio (20:1 to 60:1 range) Enclosed Worm Gear Speed Reducers	0.70
High Ratio (over 60:1 to 100:1 range) Enclosed Worm Gear Speed Reducers	0.50
Cut Tooth, Miter or Bevel Gear, Enclosed Countershaft Box Ends	0.93
Cut Tooth Spur Gears, Enclosed, For Each Reduction	0.93
Cut Tooth Miter or Bevel Gear Open Type Countershaft Box Ends	0.90
Cut Tooth Spur Gears, Open For Each Reduction	0.90
Cast Tooth Spur Gears, Open, For Each Reduction	0.85

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Appendix

HORSEPOWER FORMULA FOR HORIZONTAL SCREW CONVEYORS

The derivation of the basic formula for the horsepower of horizontal screw conveyors is as follows:

C = Capacity, cubic feet per hour

W = Apparent density, lbs. per cubic foot

L = Length of conveyor, feet

F_m = Empirical factor based on material characteristics and friction of material against screw and trough

Then

CW = lbs. per hour transported

$CWLF_m$ = foot lbs. per hour of power required

(60) (33,000) = foot lbs per hour for 1 horsepower

so:

$$HP = \frac{CWLF_m}{1,980,000}$$

For convenience, divide numerator and denominator by 1.98, yielding:

$$HP = \frac{CWL F_m}{1,000,000}$$

Similarly, the mechanical friction horsepower has been formulated. $L F_b F_d N$ is the foot lbs. per hour of purely mechanical friction that must be overcome, so the frictional horsepower

$$HP = \frac{L F_b F_d N}{1,980,000}$$

and for convenience, dividing numerator and denominator by 1.98, gives:

$$HP = \frac{L F_b F_d N}{1,000,000}$$

In both cases above the factors F_m , F_b and F_d have been adjusted numerically to reflect the division.

Also other factors, F_f , F_o , and F_p have been introduced to provide for the effect of conveyor screw flight configurations, overload correction for small motors and of the power required by mixing paddles.

TORSIONAL RATINGS OF CONVEYOR SCREW PARTS

The following text covers the calculation of the individual torsional rating of:

Bolts in Shear
Bolts And Pipe in Bearing
Pipe
Coupling Shaft

which are presented in composite in Table 3-5. By following the methods used in these calculations, the screw conveyor designer will be able to determine the torsional values of any size of bolt, pipe or coupling shaft.

The four factors above named govern the amount of torque the coupling safely will transmit, and for any given case of bolt size, pipe size and coupling size, the lowest torsional rating will be the limiting value of torque that may be transmitted.

Torsional Rating of Bolts in Shear

The bolts used are "Finished Hexagon Head Bolts" made to ANSI Standard B-18.6.2-1956. The threaded length is short to keep the threads out of the shear area and also as far as practical, out of the area in bearing. The bolts are of low carbon steel of ASTM-A 307-64 specifications.

Approximate physical properties are:

Ultimate tensile stress, psi	55,000
Yield point stress, psi	35,000
Elongation in 2", min. %	18
Ultimate shear stress, psi	44,000

To get additional shear capacity on coupling bolts, it is possible to use high strength bolts made to ASTM-A325-64 specifications. However, when using high strength bolts, shearing ceases to be a limiting factor, since the soft pipe and coupling would hardly shear the tougher bolt. Deformation of the coupling or bending of the bolt is more likely to occur.

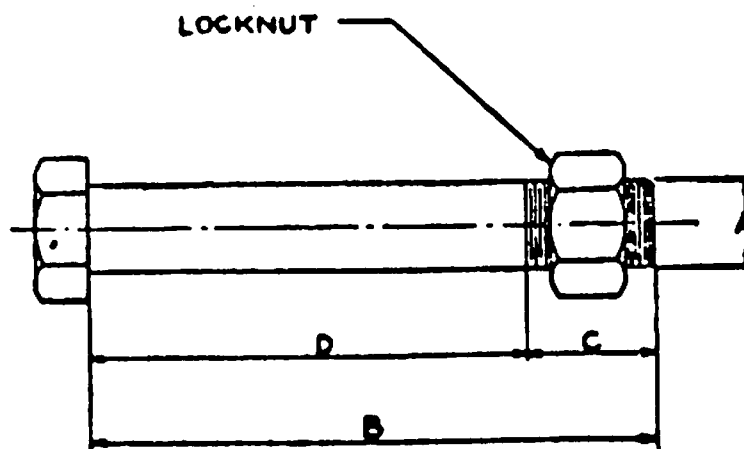


Figure A.1
Coupling Bolt

Coupling Bolt Dimensions

Table A-1

Coupling Diameter Inches	Pipe Nom. Size	O.D. Inches	Inches			
			A	B	C	D
1	1 1/4	1 5/8	3/8	2 1/8	5/8	1 1/2
1 1/2	2	2 3/8	1/2	3	3/4	2 1/4
2	2 1/2	2 7/8	5/8	3 5/8	7/8	2 3/4
2 7/16	3	3 1/2	5/8	4 3/8	1	3 3/8
3	3 1/2	4	3/4	5	1 1/8	3 7/8
3	4	4 1/2	3/4	5 1/2	1 1/8	4 3/8
3 7/16	4	4 1/2	7/8	5 1/2	1 1/8	4 3/8

Bolt Loading

When the conveyor is under load, the coupling shaft tends to turn within the bushing in the pipe end. This turning force is resisted by the bolts, which are in double shear. It is the usual practice to assume that the shearing force is resisted equally by all areas in shear.

The allowable torque rating is determined by the following formula:

$$T_1 = (n) (2) (A_b) (S_1) \left(\frac{D_d}{2} \right)$$

where

T_1 = Torque rating in inch pounds

n = number of bolts

A_b = cross sectional area of the bolt, square inches

D_d = coupling shaft diameter, inches

S_1 = 6200 psi, allowable shear stress in bolt

From this formula the allowable torque ratings of coupling bolts in shear have been calculated and are indicated in Table A.2.

Table A-2

Allowable Torque Rating of Coupling Bolts in Shear

Coupling Diameter D Inches	Bolt Diameter Inches	Cross Sect. A_b Sq. Inch	T_1 = Torque rating, inch lbs.		
			$n = 1$	$n = 2$	$n = 3$
1	3/8	0.1105	690	1380	2070
1 1/2	1/2	0.1964	1830	3660	5490
2	5/8	0.3068	3800	7600	11,400
2 7/16	5/8	0.3068	4635	9270	13,900
3	3/4	0.4418	8200	16,400	24,600
3 7/16	7/8	0.6013	12,800	25,600	38,400

Torsional Rating of Bolts and Pipe in Bearing

The quality of the bolts has been stated on page 39. The pipes are Schedule 40 black pipe with dimensions as shown in Table A.3.

The pipe is made of low carbon steel per ASTM-A53-64 Grade A specifications. The approximate physical properties are as follows:

Tensile strength, min. psi	48,000
Yield point, min. psi	30,000
Elongation in 2", min. %	35

Table A-3
Conveyor Screw Pipes

Nominal Pipe Size Inches	Nominal O.D. Inches	Nominal I.D. Inches	Nominal Wall Thick. Inches	Weight of Pipe lbs./foot
1 1/4	1.660	1.380	0.140	2.27
2	2.375	2.067	0.154	3.65
2 1/2	2.875	2.469	0.203	5.79
3	3.500	3.068	0.216	7.58
3 1/2	4.000	3.548	0.226	9.11
4	4.500	4.026	0.237	10.79

Bushings

Bushings in the pipe ends are made of cold drawn seamless steel tubing in sizes and with wall thicknesses as shown in Table A-4. Wall thickness will vary with the conveyor manufacturers mounting practice. Some press the bushing into the pipe end and weld it in place; others shrink the bushing in place. Bushings are generally held so firmly in the pipe end that they will not turn within the pipe and so will be able to support their share of the torsional load. The bushing inside diameter is taken from the CEMA standard for Screw Conveyors 300-1971.

Bushing material is AISI-C-1010 cold drawn steel tubing made per ASTM-A519-64 specifications. The approximate physical properties are as follows:

Tensile strength, min. psi	70,000
Yield point, psi	60,000
Elongation in 2", min. %	5

Table A-4
Dimensions of Bushings For Pipe Ends

Coupling Size Inches	Nominal Pipe Size Inches	Bushing I.D. Inches	Approximate Wall Thickness Inches
1	1 1/4	1.005-1.016	3/16
1 1/2	2	1.505-1.516	9/32
2	2 1/2	2.005-2.016	15/64
2 7/16	3	2.443-2.458	5/16
3	3 1/2	3.005-3.025	17/64
3	4	3.005-3.025	33/64
3 7/16	4	3.443-3.467	19/64

Bearing Value of Bolts, Pipe and Bushing

The bolts bear against the pipe and bushing as shown in Figure A.2.

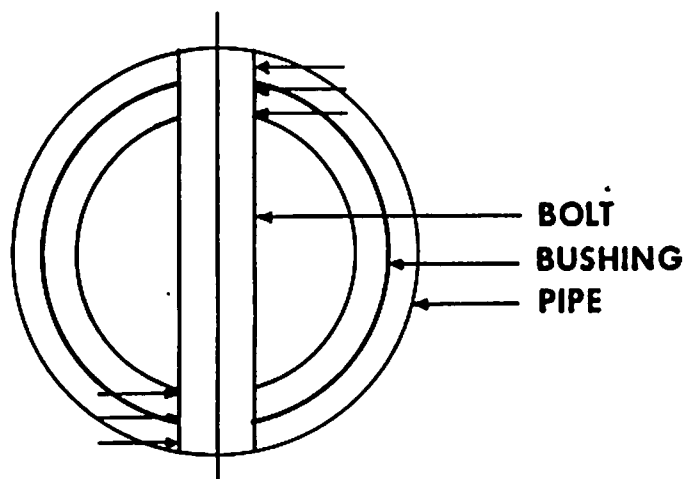


Figure A.2
Bearing of Bolts, Pipe and Bushing

The projected bearing area, for all practical purposes, is rectangular in shape, as wide as the diameter of the bolt and as high as the combined thickness of the pipe and bushing walls. Table A-5 lists these projected areas; the values are for one bolt only.

Table A-5
Projected Areas in Bearing

Coupling Size Inches	Pipe Size Inches	Bushing I.D. Max Inches	Nominal Pipe O.D. Inches	Bolt Diameter Inches	Projected Area in Bearing, A_p , Square Inches
1	1 1/4	1.015	1.660	0.375	0.242
1 1/2	2	1.515	2.375	0.500	0.430
2	2 1/2	2.015	2.875	0.625	0.537
2 7/16	3	2.458	3.500	0.625	0.650
3	3 1/2	3.025	4.000	0.750	0.730
3	4	3.025	4.500	0.750	1.112
3 7/16	4	3.467	4.500	0.875	0.915

The torque rating for each size of coupling is determined by the following formula:

$$T_2 = (n) (A_p) (S_2) (r)$$

where

T_2 = torque rating in inch pounds

n = number of bolts

A_p = projected bearing area per bolt

S_2 = allowable bearing stress = 6000 psi

r = load radius which is:

$$r = \frac{D_d}{2} + \frac{(\text{Pipe O.D.} - \text{coupling diameter})}{4}$$

D_d = coupling shaft diameter, inches

Pipe O.D. and coupling diameter are in inches

Table A-6, with values calculated by the above formula, lists the allowable torque ratings of the coupling bolts based on safe bearing loads between the bolt, pipe and bushing.

Table A-6
Allowable Torque Rating Coupling Bolts in Bearing

Coupling Dia. Inch	Pipe Size Inch	Bolt Dia. Inch	Ap Sq. Inch	r Inch	T2= Torque Rating, Inch, lbs.		
					n = 1	n = 2	n = 3
1	1 1/4	3/8	0.242	0.68	985	1970	2955
1 1/2	2	1/2	0.430	0.97	2500	5000	7500
2	2 1/2	5/8	0.537	1.22	3930	7860	11,790
2 7/16	3	5/8	0.650	1.48	5820	11,640	17,460
3	3 1/2	3/4	0.730	1.75	7770	15,540	23,310
3	4	3/4	1.112	1.87	12,500	25,000	37,500
3 7/16	4	7/8	0.915	1.98	10,900	21,800	32,700

Torsional Rating of the Pipe

The pipe description and metal have been given on page 40. Dimensional data are found in Table A-3.

The torque rating of the pipe is found by use of the following formula:

$$T_3 = (S_3)(Z_p)$$

where

T_3 = torque rating, inch pounds

S_3 = allowable shear stress, psi, = 6700

Z_p = polar section modulus of pipe

Table A-7 shows the allowable torque rating of the pipe.

Table A-7
Allowable Torque Rating of Pipe

Pipe Size Inch	Z_p	T_3 , Torsional Rating, Inch lbs.
1 1/4	0.470	3140
2	1.122	7500
2 1/2	2.128	14,250
3	3.448	23,100
3 1/2	4.788	32,100
4	6.428	43,000

Torsional Rating of the Coupling Shaft

The coupling shafts are of cold drawn steel or equivalent, unhardened as standard. These standard couplings may also be surface hardened for use with hard bearings.

The minimum coupling material is AISI-C1018 steel made to ASTM-A108-61T specifications. Approximate physical properties, in the as cold drawn condition, are as follows:

Tensile strength, min. psi,	69,000
Yield point, min. psi.	58,000
Elongation in 2", min. %	15

The torsional capacity of the coupling shaft is found by the following formula:

$T_4 = (S_4)(Z_p)$ torque rating, inch lbs., for unhardened shaft

$T_5 = (S_5)(Z_p)$ torque rating, inch lbs., for hardened shaft

where

T_4 = torque rating, inch lbs.

T_5 = torque rating, inch lbs.

S_4 = allowable shear stress for unhardened shaft, psi, 7000 min.

S_5 = allowable shear stress for hardened shaft, psi, 8750 min.

and if

D_d = shaft diameter, inches

a = bolt hole diameter, inches

then the polar section modulus of the shaft, Z_p is

$$Z_p = \left[\pi \frac{D_d^3}{16} - \left(\frac{a D_d^2}{6} + \frac{a^3}{6} \right) \right]$$

Calculated from the above formula, Table A-8 gives the torsional rating of unhardened and hardened coupling shafts.

Table A-8
Torsional Rating of Coupling Shafts

Coupling Shaft Dia. = D_d Inches	Hole Dia. = a Inches	Z_p	Torsional Rating in Inch lbs.	
			Unhardened T_4	Hardened T_5
1	13/32	0.1172	820	1025
1 1/2	17/32	0.4386	3070	3850
2	21/32	1.0868	7600	9500
2 7/16	21/32	2.1554	15,090	18,900
3	25/32	4.0530	28,370	35,400
3 7/16	25/32	6.0790	42,550	53,200

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