SEED CONVEYING - PROBLEMS AND SOLUTIONS

Duane W. Tyler 1/

All who are in the seed processing business are aware of the problems in conveying seed. In one sense, conveying systems in a plant are only a means to an end. The processing and merchandising of quality seed is and should be the prime interest. Very often primary attention is given to the equipment used for processing and very little attention is paid to conveying systems.

When I refer to conveying, I mean anytime material is passed from one point to another. This applies to conveying horizontally, vertically, or inclined, as well as by gravity to or from bins or through spouting.

When conveying seed, as opposed to conveying feed, grain, plastics, or other bulk materials, two distinct problems must be recognized:

1. Seed mixture 2. Seed damage

The economics of which type of conveying is used is a factor, but the risk of allowing either mixture or damage to the product should be of prime consideration. Mixture of commodities is something we all understand. However, let us define which mixtures are more critical than others.

When conveying seed ahead of any cleaning system, some mixing of physically dissimilar commodities may be tolerated because the cleaning equipment can make the required separation. Examples would be; wheat in soybeans, clover or small legume seed with wheat or very light seed mixed with heavy seed. Whatever the mixture, if a separation can readily be made due to physical differences, then a plant can tolerate foreign contamination in uncleaned seed.

When handling cleaned seed, mixing cannot be tolerated. To avoid this, we should use either self cleaning conveying systems or a plant must provide for clean-out features in the equipment. Obviously, time for shut-down and clean-up operation is costly to production and manpower.

Damage to seed in conveying systems is detrimental regardless of where it occurs throughout the operation. Seed damage may show up in one or more ways, for example:

1. Destroy germination
2. Splitting or chipping
3. Loosening or skinning of seed coat
4. Dehulling

1/ Technical Service Manager, Ferrell-Ross Co., P. O. Drawer 26468, Oklahoma City, Oklahoma 73126.
Once the seed is damaged, nothing can be done but to try to remove as much as possible by sizing, which results in loss. Germination cannot be restored and may not be detected by inspection. An immediate germination test may show some of the damage, but often, only after weeks of storage will the full extent of damage become apparent. Regardless of how tenderly fragile seed is handled, a certain amount of damage is inevitable. The point is to recognize the susceptibility of each type of seed to injury and to take all precautions possible against it. Too often the most unexpected places within a plant can be causing seed injury. These may be offsetting joints of spouting, weld splatter on metal surfaces, rough surface bins, and unusual impact points.

Each type of conveyor when first designed probably had one chief purpose for its use. Therefore, each type of unit may have its distinct advantage for a given operation. One must recognize the job to be done, what precautions are to be considered, and how to select the type of conveying best adapted to a specific function.

Before discussing types of conveying, let me list additional factors which could assist you in making a selection. The equipment must be adaptable to the following:

1. Movement - vertical, horizontal, incline or combination
2. Product - heavy, light, trashy, or bulky
3. Multiple feed points, single discharge
4. Multiple feed points, multiple discharges
5. Single feed point, single outlet
6. Single feed point, multiple outlets
7. Dust or water tight
8. Accessible for maintenance
9. Prevention of plugging
10. Limits of mixing characteristics
11. Limits of damage characteristics
12. High or low capacity needs

These factors do not necessarily cover all that should be considered, but they do cover several that apply to seed handling.

With reference to conveying equipment available, there are basic characteristics to be considered. Mention should be made also of the need for using equipment not always best suited for the job, but which may be used under extenuating circumstances. To understand equipment capabilities is to recognize what modifications may be made to allow its best performance under whatever conditions it may be forced to operate. Let us briefly discuss types of equipment commonly available:

1. Bucket elevators - centrifugal type
2. Bucket elevators - continuous type
3. Screw conveyors
4. Belt conveyors
5. Vibrating conveyors
6. Drag flight conveyors
7. Pneumatic conveying –
   a. Positive
   b. Negative
8. Gravity spouting

BUCKET ELEVATORS

Bucket elevators are available in two basic types. Centrifugal discharge type is normally used for free flowing materials. Gravity discharge type which include positive discharge and internal discharge types, as used on poor flowing or fragile materials.

1. Centrifugal Discharge

Centrifugal type as illustrated in Figure #1 without question is the most widely used method of vertically elevating bulk seed and grain. Based on its universal use, in my opinion, it is one of the most misunderstood pieces of equipment. There are more styles of elevators offered to the seed industry than any other one piece of equipment. In a properly designed elevator there are basic mechanical fundamentals to be adhered to. To select the best equipment the following steps should be taken:

1. Determine capacity required
2. Height of discharge
3. Select size and type of bucket and spacing
4. Select head pulley size consistent with power applied and f.p.m. travel most adaptable to product handled.
5. Figure horse power required
7. Head shaft and bearings determined for heavy duty moment (torque).
8. Determine area of head discharge and clearance for good flow of material.
9. Determine inside leg clearances for safe operation.
10. Determine reduction drive to meet safety, insurance, and trouble-free service.
11. Calculate total weight to be supported and built into boot, legging, head and motor support.

All of these calculations are designed into a high quality elevator. Light duty economy elevators are built with short cuts to proper design and unfortunately it is the user who must live with the deficiencies.
(A) Unit with head & boot pulley same size. This often done on elevators of smaller size or where height is not excessive.

(B) Unit with larger head pulley than boot. Preferred for permitting use of lower boot inlets, better cup filling & less material left in boot cavity. Head pulley size determined by required lift load and proper pulley and belt contact for horsepower employed.
Of course, there are variations of design, and because these exist, this may account for the many types built. Almost every basic design of mechanical equipment can be modified and called new, but whenever basic fundamentals are varied too far, you end up with a compromise. Compromise, as defined in the dictionary is "to come to agreement by concession". To concede basics in favor of variables in elevator design can lead to problems.

Basically, bucket elevators of centrifugal design involve head and boot pulleys over which belting travels and onto which buckets are attached. Material picked up by buckets in the boot is carried upward and centrifugally discharged as buckets pass over the head pulley. The material is directed to the elevator throat discharge chute. The capacity of the system is solely related to the quantity of the material, usually referred to as cubic feet or bushels per running foot of belt. Running feet refers to speed at which belt travels over surface of head pulley.

We refer to two very different designs. Both are rated at about the same capacity, yet bring to focus some rather interesting evaluations. The illustrations on Figure #2 shows how a slower speed, large head pulley, and a high speed, small head pulley elevator may be rated at about the same capacity. There are other factors to be considered. The high centrifugal force caused by buckets passing over a small head pulley will account for high impact force. Additional negative effects occur in the boot because buckets will not fill properly until the mass of material builds up several feet in the up leg. High speed boots cause great impact between the cup lip and the product.

We all understand the ability to drive an auto around a long sweep curve at a rather high speed. However, if the curve is very tight, we must reduce speed to a crawl. The same force applies to using large or small head pulleys in elevators. Remember, the larger the head pulley used, the faster the belt speed (f.p.m.) permissible and necessary for correct centrifugal force. Do not confuse belt speed (f.p.m.) with shaft speed (r.p.m.). A comparison table may give you a better understanding.

<table>
<thead>
<tr>
<th>Head Pulley Dia</th>
<th>Head Shaft r.p.m.</th>
<th>Belt Speed f.p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;</td>
<td>60</td>
<td>188</td>
</tr>
<tr>
<td>16&quot;</td>
<td>52</td>
<td>218</td>
</tr>
<tr>
<td>24&quot;</td>
<td>45</td>
<td>283</td>
</tr>
<tr>
<td>30&quot;</td>
<td>39</td>
<td>306</td>
</tr>
<tr>
<td>36&quot;</td>
<td>37</td>
<td>349</td>
</tr>
<tr>
<td>42&quot;</td>
<td>34</td>
<td>375</td>
</tr>
<tr>
<td>48&quot;</td>
<td>32</td>
<td>402</td>
</tr>
<tr>
<td>60&quot;</td>
<td>28.5</td>
<td>448</td>
</tr>
</tbody>
</table>
EFFECT OF PULLEY DIAMETER ON TIP SPEED OF BUCKETS
The larger the head pulley, the better the friction contact on the belt, avoiding head pulley slippage. If the head pulley slips, it allows leg plugging and the belting burns in two.

The action that takes place in the elevator head by slow, optimum, and fast speeds is shown in Figure #3.

By using the correct speed elevator, buckets will discharge with proper trajectory so as to avoid product damage, excessive wear on metal surfaces, and will eliminate turbulence at point of discharge. Turbulence will cause back-logging and poor flow of product into spouting.

One must recognize the same centrifugal forces are in effect in the boot as in the head, although not as readily apparent.

Another key factor to consider in elevators is the manner in which a product is fed into the boot. Feeding on up leg is considered more standard because of feeding directly into the bucket, thus filling it to its best capacity. This might be true if all material fed alike and intake chutes were properly positioned. Generally speaking, however, non-fragile free flowing commodities are fed into the up leg. Easily damaged commodities such as very dry soybeans and edible beans should be fed on the down leg. Trashy or light products like bluegrass should always be fed on the down leg side.

Centrifugal elevators are not self-cleaning, but there are features that can aid in clean up. Pulleys can be equipped with solid ends and spacers can be inserted behind buckets. Boots can be equipped with full slide clean-outs, drop bottoms or with air suction adaptations.

Maintenance of these elevators is normally very low unless basic principles of design are ignored.

2. Gravity Discharge Elevators - (Figure #4)

The two types of gravity discharge elevators are the external and internal design. Normally, we will not find the external gravity type in seed and grain plants, but we do find the internal discharge type.

The buckets are mounted on chain in a continuous manner and this is why it is often called "continuous bucket elevator". These elevators are ideally suited to handle fragile products such as edible beans. Loading is internal, by gravity or metering feeder. Buckets are close together with overlapping lips to prevent spillage. At discharge, buckets are inverted for internal dumping into a chute spouted to either side. Because buckets are attached between two chains riding on sprockets, various configurations at head or boot can be adapted to fit requirements. Buckets with up to four separate compartments
Clipper ELEVATOR HEAD SPEEDS

Clipper heads, boots and legging are products of intensive study involving thorough engineering and precise construction. A bucket elevator, properly designed, driven at correct speed, will make a clean discharge directly into the throat assuring no appreciable damage on vulnerable commodities and little or no backlegging or downlegging.

Note: A slight deviation such as 5 r.p.m above or below optimum speed causes the cups to spill or throw.

Sketches below illustrate commodity discharge patterns of a 24 inch diameter pulley at:
TOO SLOW — 35 r.p.m., OPTIMUM — 45 r.p.m. and TOO FAST — 65 r.p.m.

TOO SLOW — spillage

Cups spill the product into the upleg and downleg. Breakage occurs when the kernels strike the cups ahead, when tumbled within the pulley and when re-elevated.

OPTIMUM — recommended speed

Cups fill and carry perfectly, then discharge directly into the throat — no spillage — no breakage.

TOO FAST — critical when commodities are damageable by rough or fast handling.

Cups lose all holding and discharge control, resulting in gross inefficiency, excessive breakage and undue head wear of the head liner.

OPTIMUM SPEED CHART

<table>
<thead>
<tr>
<th>Pulley Dia.</th>
<th>12</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>26</th>
<th>30</th>
<th>32</th>
<th>36</th>
<th>42</th>
<th>48</th>
<th>60</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.M.</td>
<td>60</td>
<td>55</td>
<td>52</td>
<td>49</td>
<td>47</td>
<td>45</td>
<td>43</td>
<td>40</td>
<td>38</td>
<td>37</td>
<td>34</td>
<td>32</td>
<td>28</td>
<td>26</td>
</tr>
</tbody>
</table>

The chart on the reverse page indicates greater Clipper elevator capacities achieved by increasing head pulley speeds. Practical when handling feeds or other non-damageable commodities.
FIGURE #4

INTERNAL DISCHARGE ELEVATOR
can be used to handle four different products simultaneously without mixing. Using single compartments buckets, capacities range from 420 bushels to 2,000 bushels per hour.

Due to design and slowly moving overlapping buckets, the product is carefully handled without mixing. This is probably the most gentle way to handle seed. Units can be housed or unhoused depending on the installation. Damage or spillage of seed is held to an absolute minimum.

These units when driven through fluid or shot type coupling drives, reduces shock start-up and lengthens chain life.

The chief opposition to greater use of internal gravity discharge elevators is the initial cost and greater space required. Nevertheless, if the operation demands gentle handling, minimum clean-up, no mixing and quick changeover of product or variety, then these units will answer your need.

**SCREW CONVEYORS**

These units are one of the oldest means of conveying horizontally, on incline, and even vertically. They are available in a wide range of capacities and in either "U" trough or tube housings. They are not considered to be self-cleaning or to be gentle with friable products. They are adaptable for multiple inlets and outlets with chance of a small carry over past intermediate discharges. Caution should be taken to prevent over feeding.

Units work satisfactorily on incline or vertically when built in tube housings. For inclining "U" trough units, figure a decrease in capacity approximately as follows:

- 15° Inclined, decrease capacity by 25%
- 25° Inclined, decrease capacity by 50%

For inclined units using "U" trough, consider using double flighting to appreciably increase capacity as opposed to single standard flighting. Manufacturers should be informed of the intended use and circumstances involved.

For inaccessible areas, screw conveyors are considered favorable if large foreign objects are prevented from plugging units.

Power requirements are greater than most other types of horizontally conveying. Maintenance on non-abrasive material handling is ordinary but generally more than other conveyors. Screw conveyors have applications in seed plants but not normally on any clean seed operation. They are difficult to clean and are considered abrasive on most seeds.
BELT CONVEYORS

Belt conveyors are identified as slider or idler troughing types. The slider type is a unit having a drive pulley and take-up pulley, and a metal or wood slider bed. The carrying surface for the belt can be flat or formed troughing. The slider type is often selected for capacities up to 6,000 bushels per hour and for lengths up to 100 feet.

Idler troughing type consists of head and tail pulley assemblies and usually ball bearing trougher rolls to form the contour of belt and carry the bed load. These units are found in large volume operations handling many thousands of bushels per hour.

Belt conveyors are considered non-choking and adapted for multiple feed points and single discharge or multiple discharges if equipped with a tripper system. A plow-off or side discharge is not desirable in seed plants. Almost any product or commodity can be handled. Conveying is gentle and self-cleaning if loaded within safe limits of belt carrying ability. On flat slide type, since the entire bottom surface is live, the load can be carried up the vertical side of the trough. However, this type is not entirely self-cleaning.

On all troughed units, the feed should be controlled and directed to the center of the belt. Speed (f.p.m.), width, and shape of formed trough determine capacity. Generally, the heavier the material conveyed, the higher the belt speed, up to 700 f.p.m. The opposite is true on light, fluffy material which may handle best at speeds as low as 200 f.p.m. All units operate with low power and maintenance, deliver uniform volumes, and are quiet.

When using on incline, depending on material, a safe limit is 12° on slider type and 20° on idler roll type. Waffled or rough top belting will improve carrying ability on steeper inclines.

Belt conveyors have many applications in seed operations but certain precautions will improve their performance.

VIBRATING CONVEYORS

Vibrating conveyors, available in balanced or unbalanced construction, are ideally suited for conveying any relatively free flowing material. Carrying trough can be "U" or "V" shaped, square or round. Material is conveyed very gently and uniformly, and units are 100% self-cleaning.

The balanced units should be used for longer distances of up to 100 feet, or where vibration is critical, or when conveyor is hung from overhead bins, etc.
The unbalanced units, very familiar in seed plants, are driven by eccentric bearings with the trough mounted on inclined hangers. The stroke action is upward and forward resulting in a pitching action. Eccentric driven units may vary in stroke from 1/8" to 1/1". The longer the stroke, the slower eccentric shaft speed required. The slower the speed, the more gentle the motion and the slower the flow rate of travel. Flow rate is governed by length of stroke and r.p.m.

Various vibrating feeders are employed, some electromagnet units with speed controlled through potentiometer. Such units are high frequency and have very short movement.

All units are considered non-choking and have low power and maintenance. Units are suited for multiple feed inlets and usually single discharge. Multiple outlets are available, but there may be a trace of carry-over from outlet to outlet.

They are most desirable for short distance conveying, moderate capacities, accurate cleanout, low power, and simple installation. (Figure #5).

**DRAG FLIGHT CONVEYORS**

A drag flight conveyor is not to be confused with "drag or cleat type". Drag flight units are built to operate in a screw conveyor "U" type trough assembly. A terminal or drive-end and a tail or take-up assembly consists of a cross shaft on which a single sprocket is centered. Flights of assorted materials shaped to fit the contour of the "U" trough are secured to a special chain with attachment links. The material conveyed is carried along the bottom of the trough to the point of discharge. The return empty flights pass along the top of the trough housing held in place by a return support rail. The non-metallic surface flights prevent abrasive wear on trough metal and prevent damage to fragile commodities. A very small amount of the product comes in direct contact with the chain itself. (Figure #6).

Flight conveyors have wide application and capacities run from 800 to 14,000 bushels per hour in trough sizes from 6" to 24" wide. They are known for easy handling of products, practically self-cleaning, and can be readily inspected. They are suited for multiple inlets and outlets. Units with several outlets may permit a slight carry over from one outlet to another. To prevent mixing in bins, place a small collecting bin off the last opening.

Flight conveyors operate either horizontal or at nominal incline or a combination thereof in one unit. Inclined units will decrease capacity due to the fall back over top of flights. For incline of standard units handling products like shelled corn, figure capacity approximately as follows:
"FLANGED" DUST TIGHT COVER WITH "BARRON" CLAMPS

DUST-TIGHT GASKETING

DOUBLE FLANGED CONVEYOR TROUGH

ANTI-TILT BARS

STURDY GUIDE SUPPORT

ALUMINUM ALLOY STEEL FACED CHAIN RETURN BAR

"SCREWCO" FLIGHTS

COMBINATION OR STEEL SIDE BAR CHAIN WITH FLIGHTS ATTACHED

ALUMINUM ALLOY HOLD DOWN BAR

DIAGRAM OF DRAG FLIGHT CONVEYOR
10° incline capacity----------88%
15° incline capacity----------75%
20° incline capacity----------62%
25° incline capacity----------42%

To compensate for some loss of capacity when inclined use closer spacing of flighting. Closely spaced flights will substantially increase capacity of inclined units. All units should be equipped with by-pass, non-choking type inlets.

Power requirements are quite low, maintenance is most reasonable, and installation features are good.

PNEUMATIC CONVEYING

Pneumatic or air conveying has developed rapidly since the 1950's. It is employed to convey dry products from flour to products in all granular forms, including wood chips in lumber and pulp plants. Under development now is a unit to convey live chickens in broiler houses. One chief advantage is to convey assorted products for long distances through a combination of vertical, horizontal, and inclined pipes. They fit into compact areas and conveying runs are tightly sealed and self-cleaning. The few moving parts are located at the feed and discharge points only. Systems used in complicated flour mills, corn and soybean oil plants, and plastic operations add appreciably to cleanliness and beauty of plants.

While these systems are highly successful, they are not as common in seed or grain operations due partly to the higher power requirements and because they are used only during seasonal operation. Each system must be engineered for established requirements. Also, seed plants handling fragile seeds may not be able to use pneumatic systems. However, they are in use on toasted flake products.

Three basic systems are available:

(1) Suction system in which the pressure in the system is less than atmospheric pressure.

(2) Negative pressure (suction) systems employing high velocity, low density air and using centrifugal fans.

(3) Positive pressure systems, which employ low velocity, high pressure air.

Primarily, only systems (2) and (3) are used for product conveying.
NEGATIVE PRESSURE SYSTEMS

To date, this system is more common in seed plants primarily for grass and small legume seed, particularly out West.

These systems may fall in a range of 4 to 6 cubic feet of air to a pound of stock. Systems are sized for the total number of pick-up points needed and the volume material at each. Pipes are sized for sufficient air volume at velocities of 4000 + f.p.m. For multiple feed points, the maximum volume of material must be figured in the system. Therefore, at each feed point, the material must be controlled to not exceed capacity limits. Lesser amount of feed will not affect the system. Usually, to balance the entire system, air valve or blast gates are located in each branch line. Mechanical feeders are not normally required on negative systems. However, at the discharge of the collector-receiver, a rotary air lock is required allowing the product to discharge by gravity and allowing the free air to pass out the top and into the fan and be discharged.

These systems are very practical for handling a non-fragile product from one or more pick-ups to one position discharge. While power is relatively high per bushel, the elimination of multiple cross conveyors and the advantage of a compact system can save a great deal. We do not recommend negative systems for products which are easily split or skinned.

POSITIVE PRESSURE SYSTEMS

Positive systems have developed rapidly in many industries. They employ much less air, operating in the range of 1/2 to 1 cubic feet of air to one pound of stock conveyed, or about one-sixth the air required for negative air systems. The velocity is about the same - 4000 + f.p.m.

High pressure air is developed through a pump giving positive displacement of air. Air is pumped into the conveying line and a rotary feeder (air lock) introduces material into the down-stream air line. The material in the line is fed in a near solid mass and is pushed by the high pressure air more on the order of laminations: i.e., mass, air cell, mass, air cell. This explains why the material to air ratio is far greater than free air negative systems. Some systems offered use 2” to 6” air lines to handle 2 1/2 to 45 tons per hour at distances to 350 feet. Systems beyond this capacity and length runs may also be available.

Due to labor, plant safety, cleanliness, and air pollution requirements, positive pressure systems have many attractive advantages. Power requirements are high, but for the difficult conveying installations, the assets are many.

One of the unfavorable features is the risk of line plug-up if power failure occurred. Also, unlike other conveying systems, including negative air units,
each feed point must be equipped with motor driven rotary air lock. These are rather expensive. Pipe joints must be very smooth. Most dry granular products can be conveyed with less damage than in negative systems.

**GRAVITY SPOUTING**

Gravity flow is used for conveying wherever possible, yet spouting can be a source of product damage, wear, poor flow, or choke-up. To select proper spouting, one must know something about the product flow, angle of repose, and the area of spout required for the volume.

On the chart below is shown the normal minimums I use in a plant layout.

**Spout Angles Generally Applied**

<table>
<thead>
<tr>
<th>Product</th>
<th>Degree Slope</th>
<th>Carpenters Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>30°</td>
<td>7/12</td>
</tr>
<tr>
<td>Barley</td>
<td>33°</td>
<td>8/12</td>
</tr>
<tr>
<td>Oats</td>
<td>37°</td>
<td>9/12</td>
</tr>
<tr>
<td>Corn, dry (uncleaned)</td>
<td>37°</td>
<td>9/12</td>
</tr>
<tr>
<td>Corn, damp</td>
<td>45°</td>
<td>12/12</td>
</tr>
<tr>
<td>Soybeans</td>
<td>40°</td>
<td>10/12</td>
</tr>
<tr>
<td>Grasses (general)</td>
<td>45° (unless trashy)</td>
<td>12/12</td>
</tr>
<tr>
<td>Grasses, trashy</td>
<td>60°</td>
<td>20/12</td>
</tr>
<tr>
<td>Feed, ground</td>
<td>53°</td>
<td>16/12</td>
</tr>
</tbody>
</table>

The above chart is based on normal conditions, dry clean smooth piping and normal product. The slope should be increased above minimums if extreme contingencies demand.

The volume a spout is capable of handling is directly related to flow characteristics. Flow is determined by type and variety of commodity as well as moisture content. In general, the chart shows a formula for estimating volume of free flowing products in the area of round spouting.

**VOLUME HANDLED IN GRAVITY SPOUTING**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>12.57</td>
<td>40-70</td>
<td>500 to 750</td>
</tr>
<tr>
<td>5&quot;</td>
<td>19.63</td>
<td>50-75</td>
<td>980 to 1,470</td>
</tr>
<tr>
<td>6&quot;</td>
<td>28.27</td>
<td>50-75</td>
<td>1,410 to 2,120</td>
</tr>
<tr>
<td>8&quot;</td>
<td>50.27</td>
<td>50-75</td>
<td>2,510 to 3,770</td>
</tr>
<tr>
<td>10&quot;</td>
<td>78.54</td>
<td>50-75</td>
<td>3,925 to 5,890</td>
</tr>
<tr>
<td>12&quot;</td>
<td>113.1</td>
<td>50-75</td>
<td>5,655 to 8,480</td>
</tr>
<tr>
<td>14&quot;</td>
<td>153.9</td>
<td>50-75</td>
<td>7,695 to 11,540</td>
</tr>
<tr>
<td>16&quot;</td>
<td>201.0</td>
<td>50-75</td>
<td>10,050 to 15,075</td>
</tr>
</tbody>
</table>
NOTE:

(1) Volume is based on choke feed of free flowing product at the top end of the spout provided there is not unusual disturbance or boiling action at that point. Entrances from gates or square-to-round fitting should be smooth and with sufficient taper to allow good flow.

(2) Any back pressure of air, from bins without air relief, can cause severe reduction of capacities, particularly on light, fluffy or ground materials.

(3) Low to high rate of capacities is determined by natural flow of product and its moisture content.

(4) Spouting on angles up to 50 to 60 degrees will carry more material at higher velocity than spouting near vertical in fall. Even a slight angle is better than vertical.

Square or rectangular spouting may be advisable if degree of fall is less than desired. Also, square spouting can be formed of heavy material with abrasion resistant, or other type liner material inserted to prevent wear. The top side of square spouting can be bolted in place for easy access to liner replacement.

Joints of all spouting should be as flush and smooth as possible to avoid both product damage and turbulence which will rapidly dish-out metal surfaces.

Dead boxes are desirable on longer spout runs to decrease speed of flow and absorb impact of points of directional flow change. Many types are built but the self-cleaning types are preferred.

"E-Z Down" vertical ladders are used successfully to reduce cracking of soybeans, edible beans, and other fragile products. These consist of rubber lined baffles, each in counter flow to the other, giving the material a walk down action. These are available in closed units for spouting or open units for inside bin let-downs. (Figure #7). For best results, a starter box or trap is used to properly introduce the stream to the ladder. (Figure #8).

It helps, but is not essential, to be a seed technician to categorize seed and to establish basic conveying characteristics. From a behavioral viewpoint, the following classifications can be established:

(1) Flow Characteristics

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Wheat)</td>
<td>(Barley)</td>
<td>(Soybeans)</td>
<td>(Grass)</td>
</tr>
</tbody>
</table>

(2) Density

<table>
<thead>
<tr>
<th>Light</th>
<th>Average</th>
<th>Heavy</th>
</tr>
</thead>
</table>
"BEAN LADDER"
(3) **Susceptibility to damage** - (Under ordinary plant conveying conditions)

- Slight
- Ordinary
- Most

(4) **Moisture Conditions**

- Damp
- Average
- Quite Dry
- Very Dry

(5) **Damage Most Feared**

- Germination
- Skinning
- Cracking
- Shock

(6) **Storability Precautions**

- Mixing
- Breakage
- Final Moisture

With the aforementioned in mind, let us take various types of seed and apply these characteristics.

**Grass Seed - Conveying Characteristics**

1. Not all but a very high percentage of grasses are rather poor to very poor in flowing and have quite a high angle of repose.

2. Usually lightweight.

3. Difficult to damage.

4. Normally dry at time of processing.

5. Germination - is characteristic of seed, not normally of handling system.

6. Storability quite good if product properly cleaned.

**Wheat - On the other hand**

1. Very free flowing

2. Heavy density.

3. Unlikely to damage

4. Usually dry at time of processing.

5. Germination mostly affected by immature kernels not removed.

Soybeans and perhaps Rice - By contrast

1. Average to fair flow depending on contamination and splits present.

2. Heavy density.

3. Highly susceptible to damage.

4. Moisture - everything from very dry to above best storage conditions.

5. Damage by cracking and germination affected by shock or impact.

6. Store thoroughly cleaned and with very easy handling after processing.

Let us further evaluate these basics and behavioral characteristics.

1. **Flow** - This governs the ability to bin, feed through cleaner feed mechanisms, flow across cleaning screens, and slope of gravity spouts.

2. **Density** - Applies more generally to weight in bins or against feed hoppers but also governs that light grass seed is not conveyed well on average speed belt conveyors.

3. **Susceptibility to damage** - Will usually clearly indicate what type of conveying equipment should or should not be used.

4. **Moisture condition** - This is of particular concern when handling such commodities as edible beans, soybeans and seed corn when moisture is low and susceptibility to cracking is high. Certainly, when designing a conveying system, the extreme or poorest conditions should be the governing decision in your selection.

5. **Damage most feared** - Equipment should be selected considering the products susceptibility to damage.

6. **Storability precautions** - When thinking of seed stock, of course, no mixing can be allowed and breakage of certain commodities must be closely guarded. However, when handling market corn, for instance, some mixing can be tolerated, but breakage can be costly and a factor to proper aeration in storage. If final moisture of bulk commodities is on the higher side, breakage or improper cleaning causes a concentration of "fines" and is very risky.

I say again, you do not have to be an expert seed analyst to apply common sense in your selection of equipment. The difference in original cost of
equipment and methods of spouting will be small compared to the mistakes you may be forced to live with or money you will spend to do it over properly. Like we often hear, "If we don't have the money to do it right the first time, when will we have either the time or the money to do it over?"