

# How to choose a dry materials feeder

Richard Wahl      Vibra Screw Inc.

Many processors of dry bulk materials—and occasionally some equipment manufacturers as well—assume that the proper selection of feeding equipment is more an art than a science. Quite the opposite is true. The requirements of any feeding application can be analyzed and quantified according to several relevant criteria. The purpose of this article is to set out the criteria and to offer guidelines for their use.

The following are the most important criteria to consider in making a feeder selection: (1) accuracy of feed required; (2) process control specified; (3) type of material to be fed; (4) feed rates required; (5) construction materials required; (6) budget limitations; and (7) upstream and downstream equipment used.

Each point deserves analysis before selecting a specific feeder, and each should be analyzed first in terms of its relationship to the application and then in terms of its relationships with the other criteria.

## Accuracy

The most important single criterion in selecting a feeder is accuracy, as measured by the percentage of allowable deviation from the selected feed rate. The industry generally recognizes three ranges of feeder accuracy: from  $\pm 3$  to 5 percent, from  $\pm 1$  to 3 percent, and better than  $\pm 1$  percent. Calculating the degree of accuracy required is the first step in determining the most appropriate feeder for any given application.

**Feeder accuracies of  $\pm 3$  to 5 percent.** Accuracies of 3 to 5 percent can generally be obtained with any of several volumetric de-

vices—vibrating feeders, rotary feeders, nonagitated belts, or screw feeders.

Of these, the vibrating feeder (Fig. 1) is the simplest and usually least expensive, and it will handle most materials. The motive force, generally an electromagnetic or electromechanical drive, is external to the feeder, which can be either trough or tube.

Fig. 1 Vibrating feeder

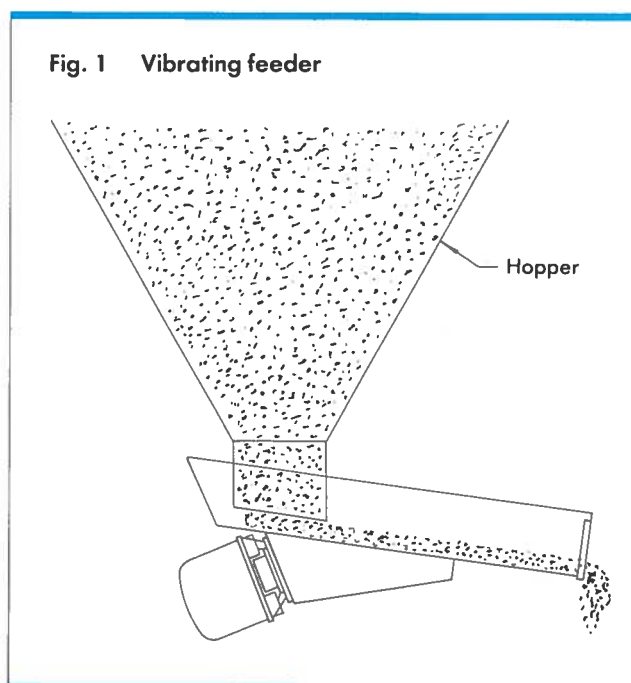
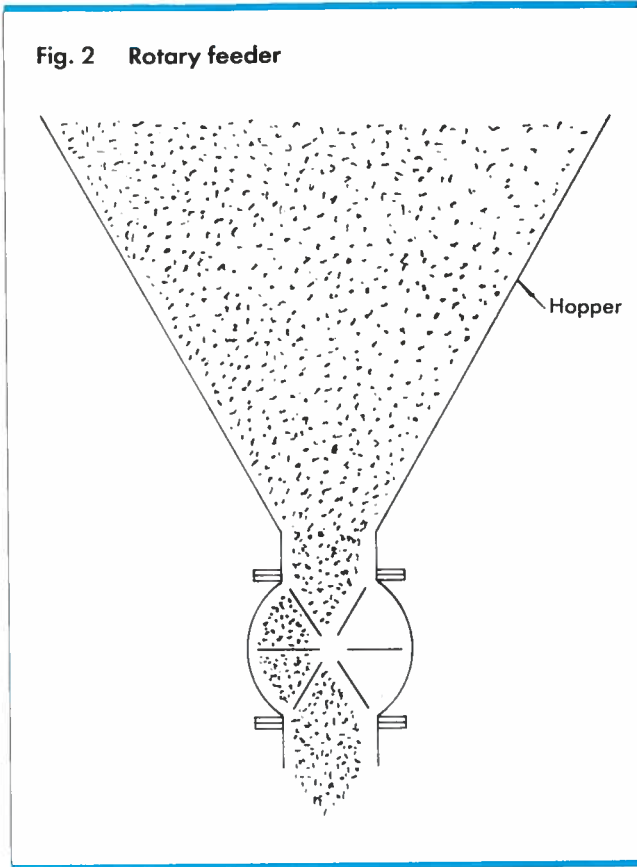
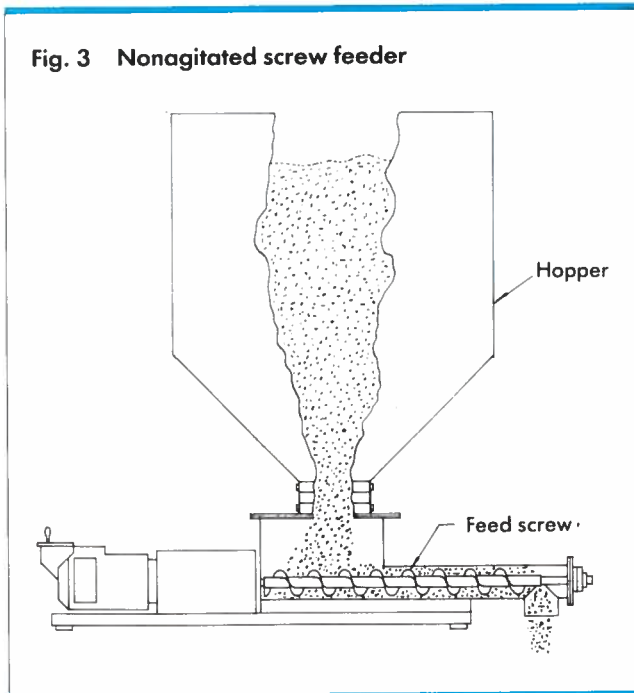


Fig. 2 Rotary feeder



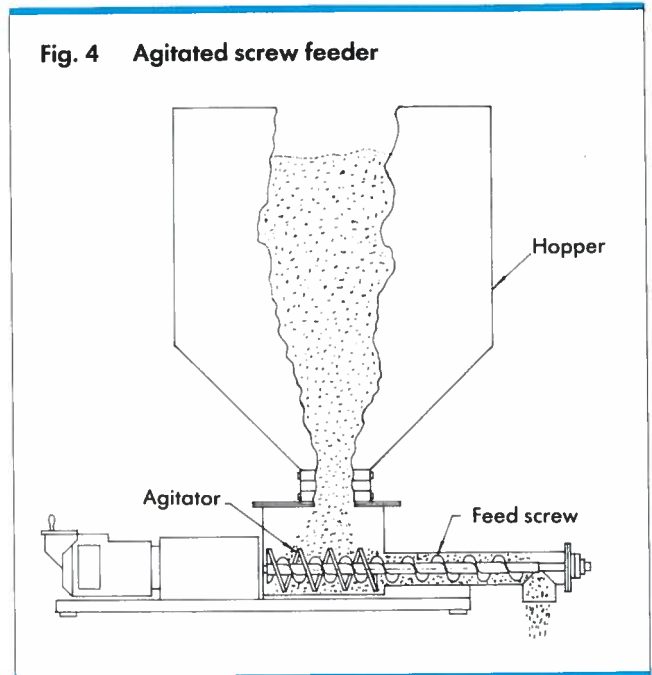
The rotary feeder (Fig. 2), with its ability to form a tight seal, is nearly always used to feed pneumatic conveyors. It is also used to prefeed floodable materials to belts.

Fig. 3 Nonagitated screw feeder



The properties of the material being fed primarily determine whether a screw feeder (Fig. 3) or belt feeder is selected. A screw is used for floodable and noncompressible materials, a belt for pressure-sensitive materials and those with large particle size.

Fig. 4 Agitated screw feeder

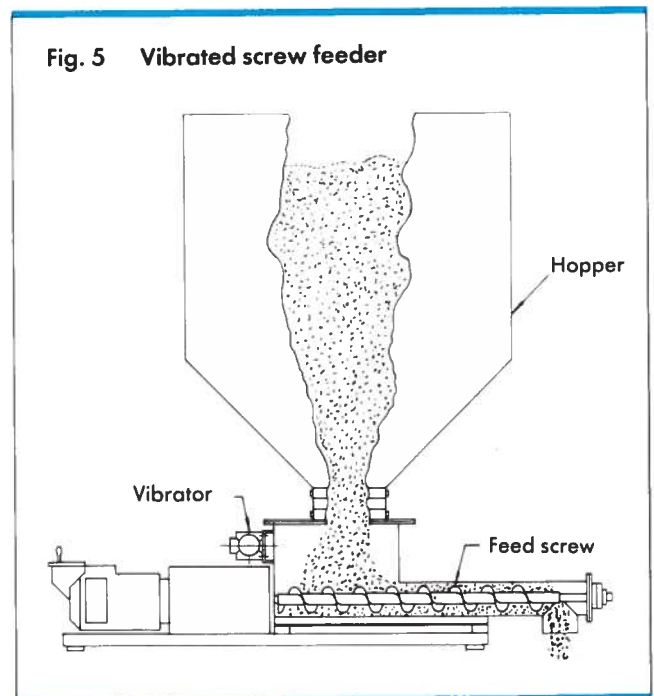


**Feeder accuracies of  $\pm 1$  to 3 percent.** Accuracies of 1 to 3 percent can be obtained by relatively simple (and thus, relatively inexpensive) volumetric screw and belt feeders. The increased accuracy is achieved through mechanical agitation—by equipping the feeder with a vibrator or some other means of conditioning the material to a constant density.

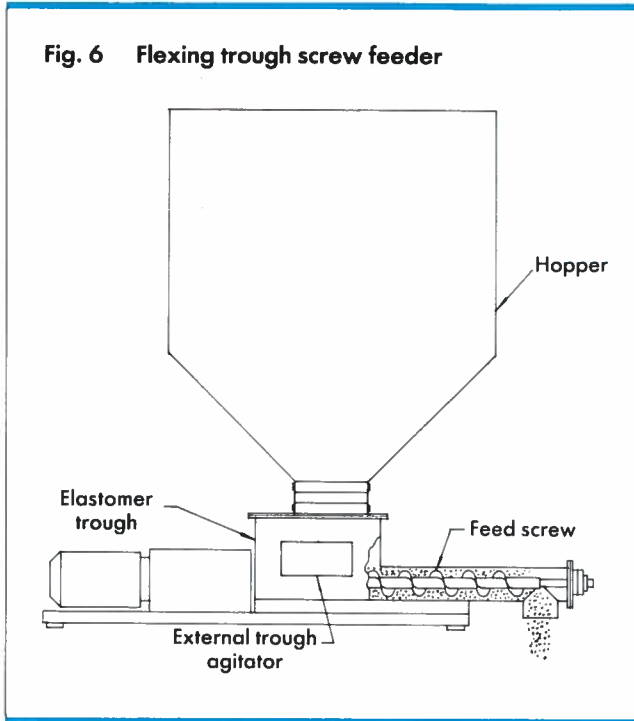
A screw feeder is accurate to the extent that each screw flight contains the same amount of material; in practice, this means that each flight must be filled to capacity with material of uniform density.

Various kinds of agitation devices will achieve this result. One kind is a large agitator screw or rotating arm, located around or above the feed screw, that keeps material moving freely (Fig. 4).

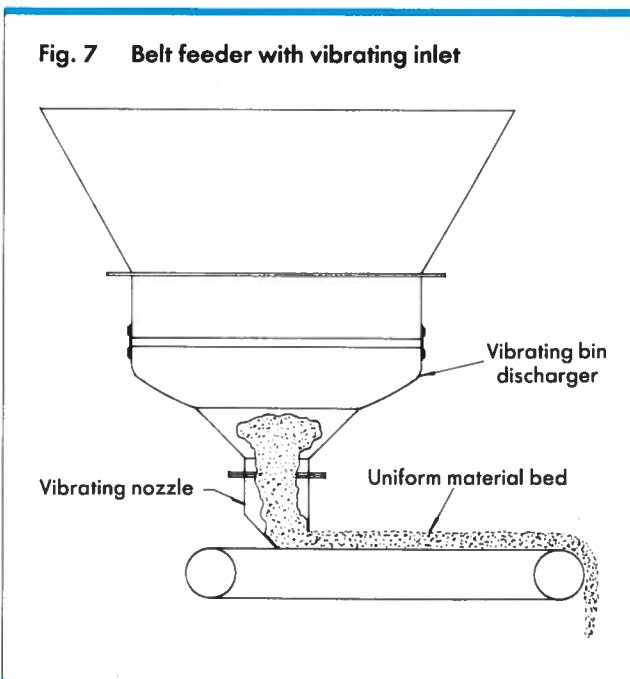
Fig. 5 Vibrated screw feeder



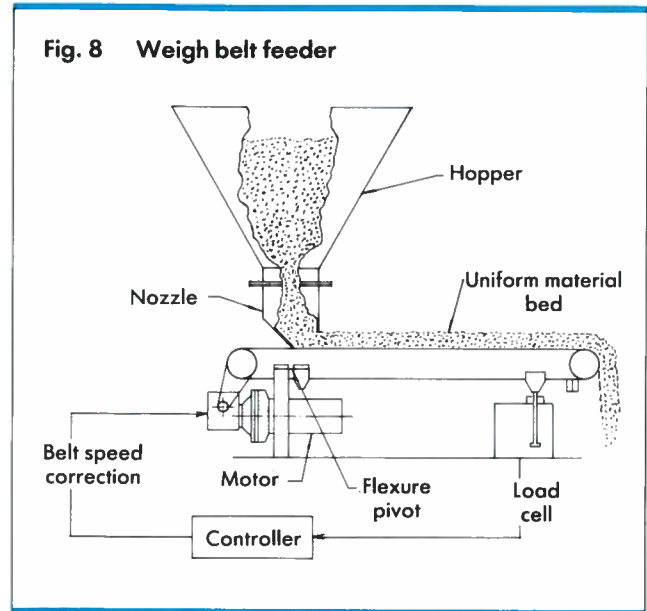
Another is a vibrator that rapidly pulsates the feeder trough and screw, achieving the same result (Fig. 5). An advantage of the vibrated feeder is that it also ensures complete emptying of each screw flight at discharge. Still another uses an elastomer feed trough which is externally flexed to keep material mobile (Fig. 6). In certain circumstances, as with high-rate large-diameter screws with large pitches that fill easily, a 1 to 3 percent accuracy may be obtained with nonagitated screw feeders, avoiding the additional expense of agitation devices.



A belt feeder (Fig. 7) is accurate to the extent that the volume of material continuously laid on the belt is uniform in width, height, and density. Typically, material is placed on the belt through a nozzle, the outlet of which defines the width and height of the ma-



terial bed. For free-flowing materials, a static nozzle may suffice to provide a bed of uniform material; for difficult-to-handle materials, the nozzle must be vibrated to ensure uniformity.



**Feeder accuracies of less than  $\pm 1$  percent.** Consistent accuracies of better than  $\pm 1$  percent can be achieved only with a gravimetric (weigh) feeder. There are three such types—weigh-belt feeder, loss-in-weight screw feeder, and en masse gravimetric feeder.

A weigh-belt (Fig. 8) is similar to the volumetric belt, with the addition of gravimetric control. The control senses the rate of material feed and deviation (if any) from a preset rate and sends a signal, which adjusts belt velocity to achieve continuous accuracy of  $\pm \frac{1}{2}$  percent, in most cases. The care with which material is deposited on the belt is as important as it is with volumetric devices. Most gravimetric belts are weighed only at a single point and therefore require tensioning and tracking devices to ensure proper loading of the weigh cell. Another type, which weighs the entire belt assembly, has a simpler design and feeds slightly more accurately.

Loss-in-weight devices (Fig. 9) most commonly incorporate a screw as the method of feed; they are used when a belt is inappropriate for the material (for example, if the material is floodable, dusty, or hot). The design of loss-in-weight feeders is necessarily complex. The entire assembly—including supply hopper, feeder, and material—must be weighed. Control is complicated because it must provide for periodic refill of the supply hopper; valving is extensive. In the final analysis, loss-in-weight feeders deliver accuracies similar to weigh belts, but they are more expensive: their extensive design elements are reflected in initial costs and maintenance.

The en masse gravimetric feeder (Fig. 10) was designed to overcome the practical problems associated with the precision feeding of floodable and other hard-to-handle materials. It incorporates a well-known device—the enmasse conveyor—in a feeder design. The unit drags or pushes material through a sealed trough to discharge. It accepts continuous flow from a bulk bin, unlike the loss-in-weight feeder. The feed rate is recorded and corrected in the same way it is with a weigh belt. Accuracy is  $\pm \frac{1}{2}$  percent.

### Control specifications

It is almost always best to select a feeder that is only as accurate as needed. Simpler is better. If a volumetric feeder provides the required accuracy, then, all else being equal, a volumetric installation is preferable in terms of design simplicity, initial costs, and potential maintenance problems. In the context of control requirements, it should be noted that a volumetric feeder can be equipped with controls yielding signals proportional to rate, which are approximately equal to the accuracy of the specific feeder. At times, however, accuracy takes second place to the demands of process control. A weigh feeder is necessary when the process requires weight data or for system control that requires a signal truly proportional to the flow rate.

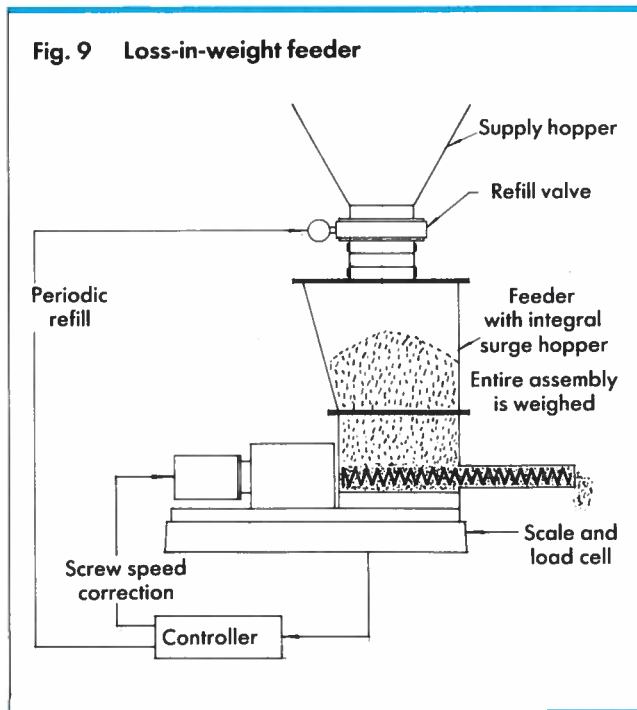
To a limited extent, this need to "over spend" can be mitigated with one of the less accurate weigh feeders on the market. These will deliver accuracy of  $\pm 1$  percent.

Control complexity depends on process needs and the type of feeder required. Volumetric feeders have simple mechanical or electrical speed controls. Weigh feeders employ microprocessors to perform complex control functions.

Recently, programmable controllers have been introduced to the process industries. They are less expensive than in the past, require less calibration and service, and now perform many more tasks, such as handling multiple feeders and interfacing with other process controls.

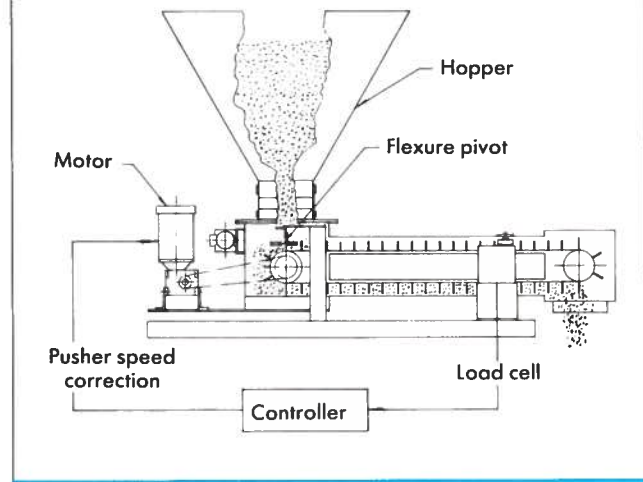
### Type of material

Next to determining accuracy requirements, calculating the phys-



ical properties of the material to be processed is the most important step in selecting the type of feeder most appropriate to the application. Relevant properties include bulk density, particle size and shape, compressibility, degradability, toxicity, abrasiveness,

**Fig. 10 En masse gravimetric feeder**



floodability, moisture content, temperature, stickiness, waxiness, dustiness, and explosiveness.

Once these properties have been determined, they can be related to the intrinsic characteristics of the several feeders. For example, a screw confines materials in a tight enclosure. Therefore, it is the feeder of choice for materials that are floodable, dusty, toxic, and of small particle size. A screw will also handle hot materials.

A belt's chief advantage is that it handles materials gently—it does not distort them. Therefore, a belt will logically be used with materials that are compressible, degradable, or abrasive or that tend to adhere to contact surfaces. It's also the choice for materials with particles that explode when jolted or compressed or that have large particle sizes.

A rotary design seals materials in an enclosed housing, making it possible for it to handle the same types of materials as a screw. Like a belt, it subjects material to low mechanical pressure; but like a screw, it cannot handle large particles.

A vibrating feeder, either pan or tube, is characterized by the general ability to handle nearly any material in applications where high accuracy is not needed. It conveys gently and easily handles materials ranging in size from powders to aggregates.

The en masse gravimetric feeder is designed to handle floodable, dusty materials—those, in short, that are best confined during processing and that require a high degree of accuracy.

Most materials, of course, contain several properties, and sometimes they conflict with one another in terms of the material's ability to be fed by a given feeder. An equipment manufacturer should be able to respond to any question or doubt about which property is the determining one and be able to conduct tests of material when required.

### Feed rates required

Feed rates are determined in two ways: by the size of the unit

(screw diameter, belt width, etc.) and by the adjustability of the speed at which it operates. The first step is to select a feeder of the size best suited to the application's rate range and which can be adjusted to the full range of the application's requirements.

All units function well at moderate-to-high rates of flow. It is at low rates that most problems occur, especially for applications that require high accuracy. At low rates, the pulse of a screw or rotary blade can result in disproportionate discharge, as can drop-off from a slow-moving belt. Techniques especially applicable to screw feeders have been devised to minimize the problem. Among the gravimetric feeders, the loss-in-weight feeder's design and control makes it better able to handle extremely low rates.

### Construction materials

The application determines the type of material used in fabricating a feeder. Most food and sanitary applications require that all contact parts be fabricated of polished stainless steel. More stringent conditions, perhaps where daily washdown is called for, require contact and noncontact parts to be stainless steel.

Feeders for other applications normally are constructed of carbon steel with a durable paint to resist corrosion. Carbon steel, when properly sandblasted, primed, and carefully finish-coated, will last many years—even in the most difficult environments. Several of the newer epoxy paints have food-grade approval and are sometimes durable enough to be substituted for stainless steel. Cost savings are considerable.

Quick disassembly for cleanup and maintenance is typically a concern, and no-tool fasteners are now commonly available. Special construction is also generally available for high-temperature, high-pressure, and explosion-proof applications.

### Budget limitations

Of necessity sometimes, price influences and perhaps even controls the selection of a feeder. Such situations need not be cause for regret; some equipment manufacturers will go out of their way to help create solutions.

As a rule of thumb, cost generally goes up as accuracy improves, as sophisticated controls are added, and as fabrication becomes more specialized. At \$1,500 and up, the vibrating feeder is generally the least expensive; the loss-in-weight feeder at \$15,000 and up is generally the most expensive.

### Upstream and downstream equipment

The success of a feeder installation is closely linked to the performance of its peripheral equipment. Many feeder problems can be traced to poor flow, either upstream or down. Table I discusses flow characteristics of several classes of material.

If a material is slow to flow or will not flow out of the upstream storage bin at all, the feeder will be erratic or completely starved. Similarly, material that backs up downstream will affect feeder performance.

As shown in Table I, most materials will not flow by gravity alone. Even previously free-flowing materials can be affected after a feeder is installed because the feeder becomes a flow restriction.

**Table I Hoppering — Material classification**

Material class	Description
I	Material is granular and free flowing. Would normally flow out of storage unassisted, but temperature and moisture changes can cause it to bridge occasionally. <i>Examples:</i> granular salt, sugar, plastic pellets — 1/4 inch to 50 mesh.
II	Material is a sluggish powder. Would not normally flow by gravity alone. <i>Examples:</i> flour, limestone — 100 to 300 mesh.
III	Material is a powder that tends to be readily adhesive or becomes easily fluidized. <i>Examples:</i> adhesive materials such as foundry sand, pigments; fluidizing materials such as hydrated lime, cement, talcum powder, fly ash, confectionary sugar — -325 mesh.
IV	Material is fibrous or flaky with a relatively low bulk density of 3 to 20 lb/ft <sup>3</sup> . Particle sizes are from 1/8 inch strands to 1 inch or larger chips. Has a tendency to interlock and absorb vibration. <i>Examples:</i> wood chips, slivers, shavings, plastic scrap, flaked grain.

Downstream, poor flow can result in backed-up chutes or other impediments to discharge.

Before a feeder is installed, equipment manufacturers should be asked to comment on methods to ensure proper flow. Recommendations can include agitation or vibration of the supply hopper and discharge chutes, venting of all heat and moisture that finds its way into the feeder, and slaving of downstream process equipment with the feeder to ensure that all devices operate only together.

### Conclusion

Guesswork plays no role in the selection of a feeder. The most appropriate feeder for any given task is determined by the various requirements of the application—accuracy, controls, material, rates, and fabrication. Inevitably, extrinsic considerations—for example, price and peripherals—play a role in the selection process, but this need not be entirely negative. At all times, the equipment manufacturer should be an ally, offering insights and recommendations, responding to questions and requests for information, conducting all necessary tests, and most important, guaranteeing the end result. **PBE**

*Richard C. Wahl is vice president and technical manager of Vibra Screw Inc. in Totowa, N. J. He holds several patents for bulk materials handling equipment and is author of numerous articles on bulk materials storage, feeding, and blending. He earned a BS in mechanical engineering from the University of Virginia.*