SIZING, FILLING, AND HANDLING FLEXIBLE INTERMEDIATE BULK CONTAINERS

As more materials are supplied in flexible intermediate bulk containers (FIBCs) to facilities in the powder and bulk solids industry, such as food and beverage, chemical, and mineral manufacturers, the number of people who interact with FIBCs grows. Therefore, it’s important that everyone’s aware of all aspects of the bulk bag packaging system. This article addresses those aspects, which include FIBC sizing, filling, and handling.

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Flexible intermediate bulk containers (FIBCs) are used throughout the powder and bulk solids industry to store and transport materials, such as food ingredients, chemical additives, pigments, and plastic resin compounding fillers. A variety of companies in this industry use FIBCs as packaging units, and the companies usually fall into one of the following categories:

- suppliers or manufacturers of materials going into FIBCs,
- end users or buyers of materials supplied in FIBCs,
- companies using FIBCs as handling units within their own plants,
- custom packers receiving materials in bulk for packing into FIBCs, and
- transportation, shipping, or storage companies handling FIBCs.

Each of these parties is interested in the safe and easy handling, reduced costs, and minimum risk of damage or loss in relation to FIBCs. In order to achieve these goals, it’s necessary for those who use FIBCs to take into consideration the many factors for efficient and safe use, including the bags’ design, the filling principles, and handling filled FIBCs.

Designing your FIBC

FIBCs, also known as bulk bags, are industrial containers made of woven polypropylene, but not all FIBCs are created equal. When preparing to integrate FIBCs into your process, the following criteria must be taken into account:

- the internal dimensions of the shipping container or road vehicle where the filled FIBC will be placed for transportation,
- the net filled height of the FIBC, and
- the weight of the material going into the FIBC and the filled FIBC’s tamped bulk density.

Bag size. First, you want to make sure you have the right size FIBC for the material you’re moving and the vehicle transporting the FIBCs. Most FIBCs with a square or rectangular base will round out in their midsection during filling, similar to a bloated cube, as shown in Figure 1. Certain bag types don’t round out as much, like bags with internal corner baffles that have fabric panels sewn across the FIBC’s four corners and four-panel bags that are constructed with four individual side pieces sewn together with four vertical seams. To arrive at the correct base size, the internal dimen-
sions of the container or road trailer carrying the FIBCs should be looked at closely to ensure that when they’re loaded, the bags’ sides touch the sides of the container or trailer and each other. Close communication with the FIBC manufacturer is required to ensure that they’re able to supply the correct base size needed to fit the selected transporting method.

**Bag height.** You’ll also need to consider bag height, which depends on the requirements for fill density, bag weight, and any height restrictions placed on the FIBC by the user. Filling and handling methods both have a bearing on the bag height required. The material height in the FIBC after filling can vary considerably depending on the type of filling equipment used and the material characteristics. Therefore, it’s important to test the material by filling a bag using the selected filling equipment before ordering additional FIBCs. Filling machines that densify the material during the filling process save on FIBC height and make the bag safer and more stable for stacking and handling. We’ll discuss more on FIBC filling and handling later.

**Bag weight.** The allowable weight of material contained in an FIBC depends on transport method, pallet size, the customer’s needs, and storage.

**Transport method.** You’ll need to figure out the maximum payload trailer or container weight and how much weight can be in each FIBC to load out and weigh out the container.

**Pallet size.** Consider if there’s a restriction on the pallet size used with the FIBC. The FIBC’s base seam dimensions should be sized to slightly exceed the pallet dimensions when the FIBC is filled and rounded out so that the bags and not the pallets touch when stored.

**Customer needs.** The customer who receives the filled bulk bags should be able to handle them with the forklifts or pallet trucks on hand and with enough headroom available to move freely. The bag’s resulting height will determine its payload weight.

**Storage method.** If the bags are going to be stored in racks, take into account the rack dimensions so the FIBC can fit into the rack.

**FIBC components**

Just like other powder and bulk solids processing equipment, FIBCs can be furnished with design features that are there to make working with the FIBCs easier. To help with filling, discharging, and handling tasks, bulk bags have lifting loops, filling spouts, and discharge spouts among other accessories.

**Lifting loops.** These are usually located at the top four corners of the FIBC, as shown in Figure 2. There are various loop types, depending on the application. One popular lifting loop is the cross-corner type where each end of the loop is connected to each side of the FIBC’s corner walls. The length of a lifting loop is generally 10 inches but may increase to 12 inches if the FIBC is to be picked up and moved by forklift tines. Pop-up loops, which are fabric loops that have plastic strips sewn into them so that they’re stiff and stand upright, enable a forklift to engage the loops without additional labor, but they do incur additional bag costs.

**Filling spouts.** The spout on a bag is tailored to fit the filling equipment head. The most common filling spout size is 14 inches in diameter. When FIBC liners are used, some machines clamp onto only the liner, in which case the filling spout diameter can be increased to 20 to 24 inches to allow the material to reach the FIBC’s top four corners and not bridge at the inlet spout. This is most important with powders.

**Outlet spouts.** The diameter of the outlet spout should be sufficient to ensure easy material discharge. Easily discharging material is also achieved by having the discharge machine correctly designed. Most discharge units can handle poor-flowing material, depending on the unit’s design and choice of flow-promotion method, such as paddle massages, vibrations, and the bulk bag discharger dish angle. Outlet spout diameters tend to vary from 10 to 24 inches and, same as with the filling spouts, a 14-inch diameter is the most common size. Outlet spout length should be sufficient to ensure that the outlet can be tied off and, in most cases, goosenecked. Goosenecking is a method of securing the bag’s outlet spout by folding the tied outlet spout over itself and then attaching a wire tie around the folded spout to provide a second level of security. Spout length can vary from 16 to 36 inches but depends on the diameter size.

**Other FIBC outlet extras.** In addition to the traditional round outlet spout, there are various outlet systems and features for FIBCs. All are designed to accommodate a particular material type that can’t be dealt with using a standard outlet spout.

Flat-bottom bags are for one-time use only, as there’s no outlet on the bottom. Instead, a slit is cut in the bag’s bottom and the material flows out. These bags are used with a wide range of materials, such as fly ash and

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**FIGURE 2**

Typical FIBC with lifting loops and sealable filling and discharge spouts with ties
to ensure frayed material (from the bag being cut) isn’t created in order to prevent contamination. Outlet spouts should be hemmed, and tie cords should have flamed ends to prevent splitting.

**FIBC filling**

To successfully fill an FIBC, it’s necessary to fully understand untamped and tamped bulk densities and their effects on FIBC sizing and stability. Untamped bulk density is the density of a material collected from its free fall through the fill head. This density measurement includes all the entrained air in the bag. Tamped bulk density is the density achieved when a material has been densified and as much of the entrained air as possible has been removed. Methods of densification include vibration (high-frequency, low-amplitude energy transfer) and lift-and-drop (low-frequency, high-amplitude energy transfer). Table I shows the ratio of untamped bulk density to tamped bulk density.

The greater the ratio, the more difficult it is to remove entrained air while filling an FIBC. In looking at Table I, we can see that it’s harder to remove entrained air from talc, which has a ratio of 83 percent, than it is aluminum oxide, which has a ratio of 50 percent. Aluminum chips with a ratio of 47 percent, however, are easier to get a tamped bulk density with than aluminum oxide. Ultimately, the goal is to achieve the tamped bulk density during bag filling to give more room for material in the FIBC.

Particle shape and size play an important part in the amount of time required to remove entrained air. Plate-shaped particles, like the ones that make up clays for instance, take three to four times the amount of vibration to remove entrained air than a similar-sized round particle. Granular particles, as another example, will lose entrained air quickly under their own weight.

<table>
<thead>
<tr>
<th>Material</th>
<th>Untamped Bulk Density lb/ft³</th>
<th>Tamped Bulk Density lb/ft³</th>
<th>Ratio %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum chips</td>
<td>7</td>
<td>15</td>
<td>47</td>
</tr>
<tr>
<td>Aluminum oxide</td>
<td>60</td>
<td>120</td>
<td>50</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>45</td>
<td>62</td>
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<td>Baking soda</td>
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<td>Barium soda</td>
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<td>Portland cement</td>
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</tr>
<tr>
<td>Talc</td>
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<td>83</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>33</td>
<td>40</td>
<td>83</td>
</tr>
</tbody>
</table>

**FIBC liners**

FIBC liners, the majority of which are made from polyethylene, are usually used for fine powders, food, and pharmaceutical materials to prevent the ingress of contaminants into or the egress of hazardous materials from the FIBC. Polyethylene allows the ingress of moisture over a period of time, so typical liners are only rated as moistureproof and not waterproof; although, there are specialized designs that are vaporproof. Liners are normally manufactured from linear-blend polyethylene as it’s stronger than low-density polyethylene and reduces the risk of shredding when it’s cut open. Typically, liners are generally between 1 and 6 mil in thickness, depending on the material and the protection level required for certain materials. Typical liners are only suitable for holding material at temperatures less than 176°F; above this temperature, the liner starts to plasticize. When dealing with material at temperatures at or above 176°F, special liners should be used, such as those made from resins with greater temperature limits or metallized liners. Loose liners are normally extruded from a tube and are then cut to the appropriate length to fit the FIBC in use. The circumference of the extruded liner should be equal to the base perimeter of the FIBC plus 2 percent greater to eliminate overstrecthing.

**FIBC construction and quality**

FIBCs are designed to be lifted by their loops when filled. Strength is built into the FIBC to give a safety factor ratio of 5-to-1 for single-trip bags and 6-to-1 for multitrip bags, meaning they’re used more than once. This safety factor means that a bag with a 5-to-1 capacity can securely hold 5 times the weight of the bag’s expected contents. FIBCs designed to hold food or pharmaceutical materials should be manufactured
The larger the granule, the less time necessary to get to a tamped bulk density because the spaces between the particles are larger, making it easier to expel the air between the particles. Additionally, vibration ensures that added stability is achieved. Vibrational energy must be injected into and absorbed by the material; therefore, vibration shouldn’t be commenced until a minimum weight of 450 pounds of material is in the FIBC. Vibrating with less weight in the bag usually doesn’t provide much benefit as the material can be completely dispersed by the vibration energy, resulting in more air being entrained rather than less.

### Principles of filling

When it comes to filling FIBCs, certain basic filling parameters have been identified as necessary and mustn’t be overlooked. These parameters were allowed for when FIBC filling equipment was developed and built, and they include:

- **FIBC positioning.** The correct empty FIBC must be positioned in relation to the machine’s base. When hung by the loops, all woven polypropylene bags, which is what most FIBCs are made out of, will stretch to some extent during filling. The FIBC should be positioned so that the FIBC seams can stretch downward during the filling cycle and the bag’s actual corners only touch the filler’s base when the fill cycle is complete, as shown in Figure 3.

- **FIBC densifying.** For thorough densification, vibration must be applied to the FIBC’s base. The material’s bulk density in the filled bag should be as near as possible to its tamped bulk density. This should be achieved while the FIBC is in the bulk bag filler.

- **Filling and air displacement.** Fill-rate control and displaced air exhaust are important to successfully fill an FIBC. Complete control of the material passing through the fill head must be maintained for a steady filling rate, which makes establishing a consistent bag-filling cycle easier. The fill head must also allow for the displaced air to exhaust, which prevents dust and FIBC pressurization during filling.

- **Liner usage.** For FIBCs with loose liners, inflating the empty FIBC and liner with air is particularly necessary prior to filling to eliminate folds in the liner. Failing to do this will usually lead to the material filling over the folds in the liner, resulting in a limited amount of material that can be filled and an unstable package. The liner also needs to be properly sealed to the fill head to ensure there’s no dust release. During inflation and filling, however, the liner must also be free to move inside the FIBC and take up the shape of the bulk bag without stretching.

### Quality FIBC construction

Robust bulk bag construction using durable materials is crucial to ensure a long FIBC working life and protection from potential damage by forklifts.

### Operator access

Operators need easy access to the FIBC and filling equipment, which will keep production flowing smoothly and decrease downtime. Operators should be able to easily attach the loops to the FIBC support arms, which hold the FIBC in place while filling happens. The operators should also be able to easily connect the filling spout and liner to the fill head, disengage the filling spout and liner from the fill head, and tie off the filling spout. The operators must be able to complete these three functions at shoulder height without the need to climb on or in the machine. Lastly, the electrical controls should be easily accessible to operators. All bag-filling functions need to be able to be performed manually (as required by the operator) and automatically (once the filling cycle is initiated).

### Technology for filling

These basic filling principles have also been augmented by various options designed to further automate the filling operation and reduce operator involvement.

- **Pallet dispenser.** Several pallets can be placed on top of one another ready for the filling operation to
For safe FIBC stacking, it’s not advisable to stack bags 2 high if the bags are more than 5 feet tall or 3 high if they’re more than 4 feet tall. Note that this applies regardless of whether they’re on pallets or not. The general rule is that FIBCs shouldn’t be stacked higher than twice their base width, as shown in Figure 4.

As mentioned earlier, slip sheets are thick plastic or cardboard sheets that go under an FIBC to prevent contamination of the bag’s bottom. Slip sheets can be used with or in lieu of a pallet when dealing with FIBCs. There are some restrictions to using slip sheets though.

- Stability is reduced when stacking FIBCs that are placed on slip sheets. FIBCs with seam heights greater than 4 feet, 3 inches shouldn’t be stacked at all when using slip sheets, not even at 2 high. And bags that have seam heights greater than 3 feet, 3 inches shouldn’t be stacked more than 2 high when using skid sheets.
- The same restrictions that apply to centering FIBCs on pallets also apply to slip sheets.
- The general stacking rule applies for FIBCs on slip sheets as well.

FIBCs that have been correctly sized and properly filled are stable and safe to handle and stack, but stability must be maintained, not just after filling but during stacking, unstacking, transporting, and restacking. If FIBCs are to be stacked, unstacked, and restacked, the bottom FIBC, which has a more compressed base, must always be positioned on the bottom of the new stack. FIBCs that have become banana shaped, meaning they lean to one side, can’t be corrected once they have been filled nor can they be stacked. These banana-shaped FIBCs are dangerous and expensive to handle.

Choosing the right FIBC is critical, especially regarding its design and size, as the most expensive part of an FIBC filling system is the bulk bag itself. Over time, the FIBCs’ cumulative costs usually far outweigh the one-time capital cost of the filling equipment. The wrong choice isn’t only expensive in terms of wasted materials and high labor costs but could also lead to a loss of customers’ confidence in FIBCs, leading them to using drums, boxes, or 50-pound bags for material. Choosing a standard FIBC size at a reduced price that doesn’t suit the application’s exact needs and those of the end user can lead to disaster. Trials should always be conducted on the chosen filling equipment and discharger. And while filling an FIBC is relatively easy, discharging it may not be if incorrectly filled or the wrong type of bag is used. 

FIGURE 4
Filled and stacked FIBCs ready for shipment

commence. Then, a pallet dispenser selects the top pallet from the stack to be sent to the filling machine.

**Slip sheet dispenser.** A *slip sheet*, which we’ll discuss more in-depth later, is made of cardboard or plastic and goes underneath an FIBC to prevent contamination of the package’s bottom. A slip sheet is typically placed on the pallet automatically prior to filling.

**Automatic bag loop release.** Just as its name suggests, once the FIBC is filled, it’s automatically released from the filling machine and ready for automatic removal.

**Take-off or accumulation conveyor.** The filled bag is automatically conveyed away, allowing a new bag to be placed ready for filling.

**FIBC handling, stacking, and stability**

Most applications call for FIBCs to be on pallets. Pallets are typically used to move filled FIBCs and are subject to a few considerations.

- The correct pallet size will allow the FIBC’s rounded section to overlap the edges of the pallet so that when two palletized bags are placed side by side, the bags touch but not the pallets. This increases the bags’ stability when packed in containers and trailers.
- The FIBC should be placed as close to a central position on the pallet as possible, especially after filling, as bags that aren’t centered wouldn’t likely be able to fit side by side in a trailer or container.
- If the FIBCs are to be stacked with a pallet between the bags, close-slatted pallets (both top and bottom) should be used to prevent the FIBC’s top and bottom from protruding through the slats, which could result in the bags pinching and tearing as they’re handled and removed from the pallet. These types of pallets tend to be expensive and may only be financially justifiable for in-plant use if their return can be guaranteed.

- For safe FIBC stacking, it’s not advisable to stack bags 2 high if the bags are more than 5 feet tall or 3 high if they’re more than 4 feet tall. Note that this applies regardless of whether they’re on pallets or not. The general rule is that FIBCs shouldn’t be stacked higher than twice their base width, as shown in Figure 4.

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