

FOOD



BATCH POWDER HANDLING IN FOOD AND OTHER INDUSTRIES

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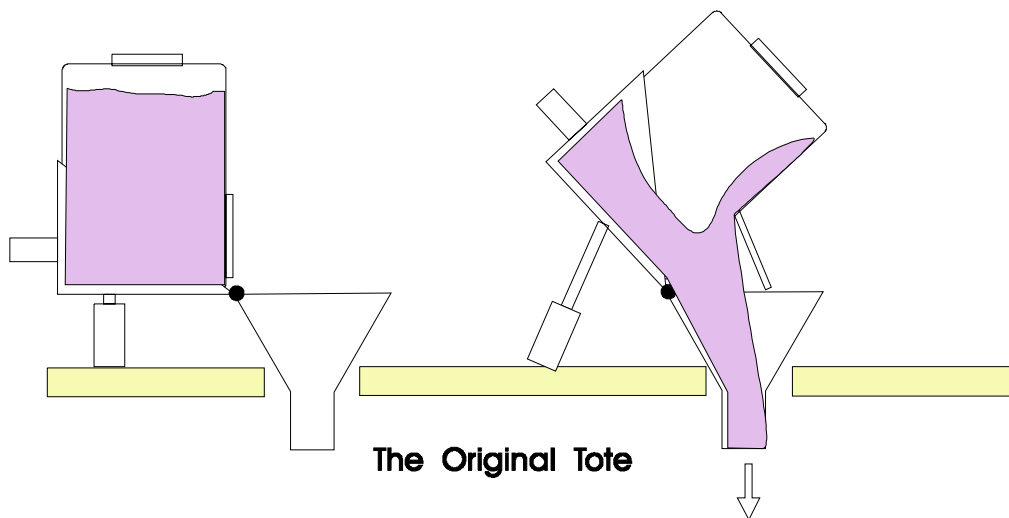
Batch Powder Handling in Food and Other Industries

1.0 Introduction

MATCON is the world leading supplier of batch orientated powder handling systems based on the Intermediate Bulk Container concept. This paper analyses the history of this concept and some of its possible areas of use within the food industry; also being relevant to many other process industries. We will also describe the Principal of Operation of the Matcon IBC system and highlight different flow patterns when discharging from IBC's and pro's and con's thereof. We also describe a number of application examples and their benefits.

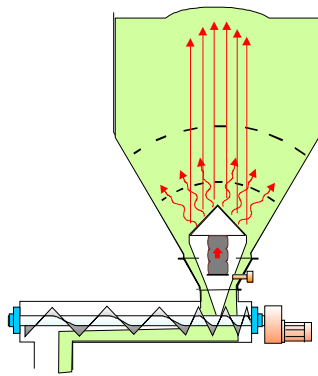
2.0 History of Batch Powder Processing

In the 60's process industries such as food and pharmaceutical, began using IBC's which were simple, often home produced boxes to transfer bulk materials between different processes. This approach allowed flexibility of production, but had severe limitations because the filling and discharging systems available were dusty, could not discharge some materials and could not control the flow of product to the process below.

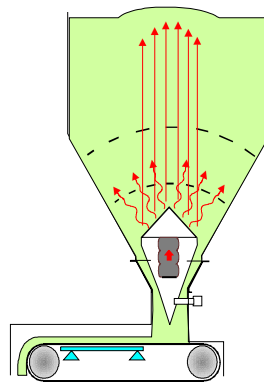


These limitations together with a trend in the 70's and 80's towards larger and longer production runs, ("big is beautiful"), caused the industry to move towards fixed hopper and pneumatic conveying systems as a means of transferring bulk materials.

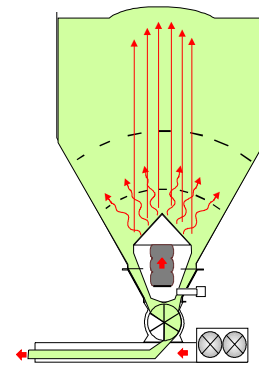
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Controlled feed to screw conveyor and other mechanical conveying equipment.



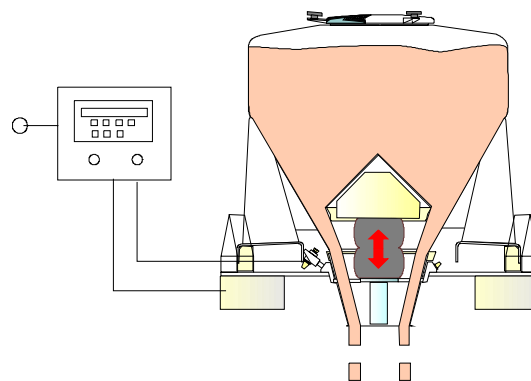
Controlled feed to weigh feeder/belt feeder



Controlled feed to rotary valve and pneumatic conveying system.

The advantages of this approach were that no make and break connections were necessary during processing and it offered a degree of automation. However suitable this concept is in continuously operating chemical plants, it has limitations in batch processing systems. It limits the flexibility of production' cross contamination is inevitable; segregation of mixed products is likely during conveying; and frequent cleaning is required, leading to significant downtime and escape of dust.

In the 90's the trend has turned again both regarding production equipment and philosophy. The "buzz words" of today are "just in time" and "custom fit products" justifying higher prices and improving profitability. The IBC cone valve technology invented and perfected by MATCON, overcomes the problems experienced using earlier IBC systems as well as overcoming the limitations of continuous systems. Not only has IBC technology improved dramatically, but the use of bar codes and improved transportation systems now allows batch traceability and automation which previously wasn't feasible.



Cone Valve IBC System.

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3.0 Discharge from IBC's/Silos, Core (Funnel) Flow – Mass Flow

Any hopper, silo or container achieves a "pattern" of flow when discharging solids.

These flow patterns can sometimes be influenced by design of the storage vessel or by a discharge device which controls the flow from the vessel.

Most flow patterns from storage vessels fall into the category of Core (or Funnel) Flow. This is when flow occurs in a narrow vertical flow channel from the outlet to the top surface of the material. The material on the top surface will always prefer to flow towards the centre with the central downward flow applying pressure to hold the material being stored along the sides of the vessel.

Although there is nothing wrong in vessels storing unblended, individual solids (flour, grain, etc) discharging on a Core (or Funnel) Flow basis there is an inherent problem with this type of flow when discharging blended solids.

This is because the flow pattern induces separation of fine and coarse particles as they free fall through the core at different rates, as well as a tendency for the fine particles to discharge first.

The discharge of any blended product from a vessel or blender where segregation must be avoided, should achieve a Mass Flow pattern.

This is when the material discharges evenly across the vessel without any preferential flow taking place. This ensures that the material "lowers" in the vessel at a consistent rate avoiding any rush or free fall of solids from occurring.

A mass flow design of vessel will usually use steep angles in the hopper section of the vessel so that the material will prefer to flow down the hopper walls than to core through the centre of the vessel.

Although practical for some applications, for IBC's it results in very tall IBC's which are out of proportion and top heavy. These "tall" IBC's are then not of the ideal shape for blending when using the "in bin" blending principle.

Cone Valve IBC technology prevents any form of core or funnel flow from occurring by preventing any flow through the centre of the IBC and directing flow through an annular gap around the cone valve and towards the sides of the IBC. Flow can be induced and controlled by raising/lowering the cone valve during discharge.

The risk of bridging or blocking of material in the IBC is also overcome as the cone valve raises and vibrates into the bridge, undermining its compressive strength and causing it to collapse.

Having solved the potential segregation problem discharging from a silo or an IBC, it is imperative to avoid the problem occurring on the way to the packing machine. Ideally the packing machine should be positioned directly below the silo/IBC and high speed pneumatic conveying (vacuum or pressure) should be avoided as it inevitably will deteriorate the quality of the finished product (i.e. by segregation and/or degradation).

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4.0 Principles of Operation for Cone Valve IBC Systems

The IBC System comprises mainly of three parts:-

- The IBC itself;
- The Filling system;
- The Discharge System;

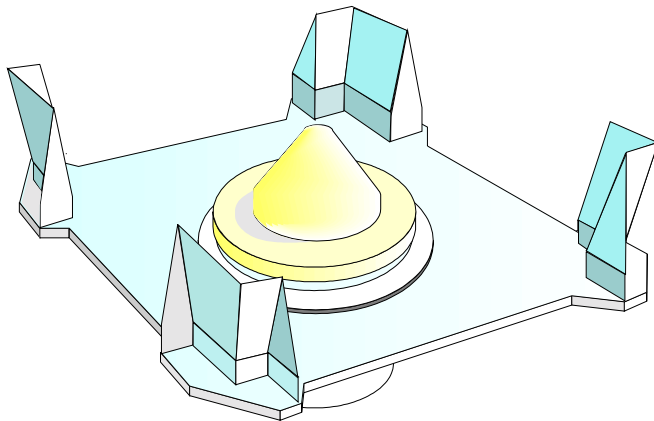
The three items and its' principle of operation will be described below.

4.1 Intermediate Bulk Container

The typical Intermediate Bulk Container is square in cross section with a square to round transition hopper ending in a circular outlet, in which is located an inverted cone with an integral edge seal. This becomes the “cone” valve and gives a dust tight seal under all conditions of full or empty container and during any form of transportation of the container.



Typical container sizes range from 500 litres up to 2500 litres. They are manufactured completely in stainless steel and plastic or plastic bottle inserted into a robust steel cage. For distribution IBC's there is also an option with a flexible top on a plastic base to minimise the return shipment cost.



4.2 The IBC Discharge Station

The typical IBC Discharge Station consists of square frame with corner guides to ensure that the Container is automatically positioned centrally on the Discharge Station. There is also a central hopper with an integrated lifting/lowering probe.

The cone valve remains closed during loading and the container hopper section engages a lip seal on the discharge hopper to give an automatic dust tight seal between the two units each and every time.

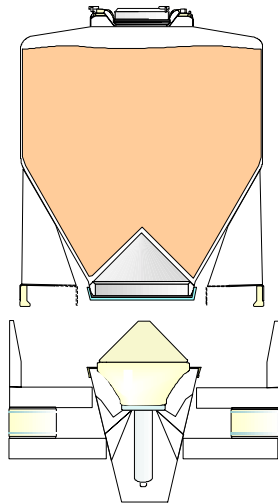
There is a large variety of options available for this basic unit, including weighing systems, internal and external vibration, extra lift force and height and extreme containment using air washing. The basic principle of operation is however always as described below giving the following main advantages:-

- A controlled feed to the following process preventing compaction;
- Mass flow discharge preventing segregation;
- No risk of flushing as the cone valve always stops the flow when in the seated position;
- Dust free operation both during and after discharge;
- Possibility to perform dosing direct from the IBC;
- Capability to handle virtually any powder materials;

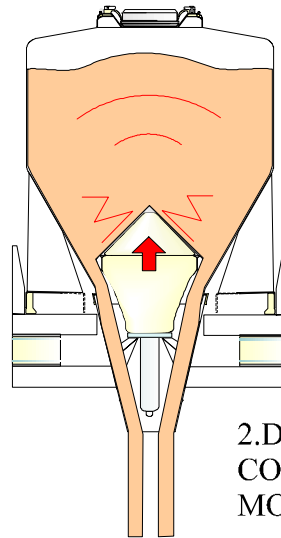
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4.3 Principle of Operation

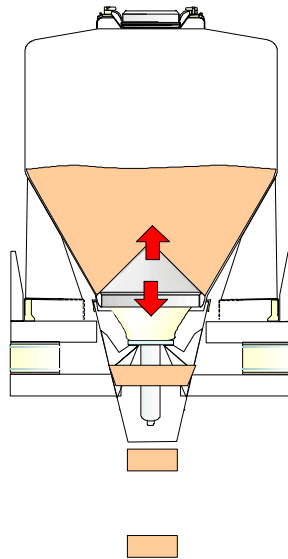
1. FULL IBC LOADED BY FORK TRUCK ONTO DISCHARGE STATION



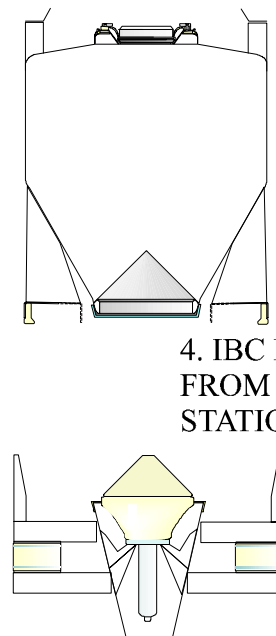
2. DISCHARGE BY CONTINUOUS MODE TO PROCESS



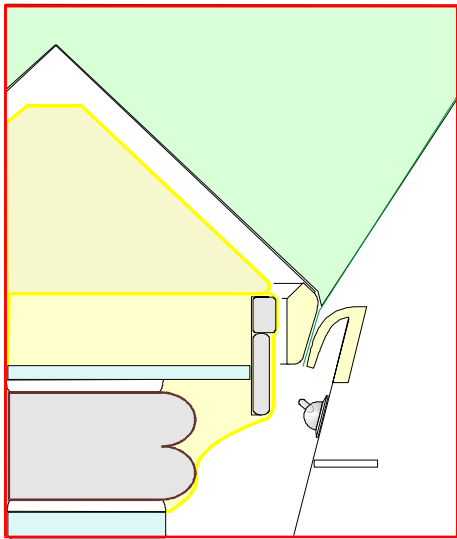
3. DISCHARGE IN PULSE MODE TO PROCESS. BATCH DOSING CAPABILITY WHEN USING LOAD CELLS.



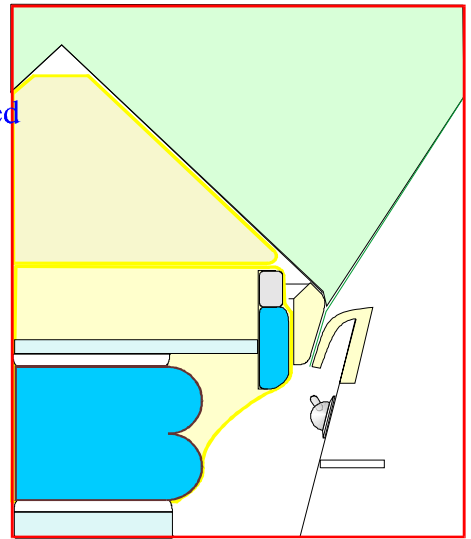
4. IBC REMOVED FROM DISCHARGE STATION



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← 1
IBC Positively Docked
with Discharge
Station Lip Seal.

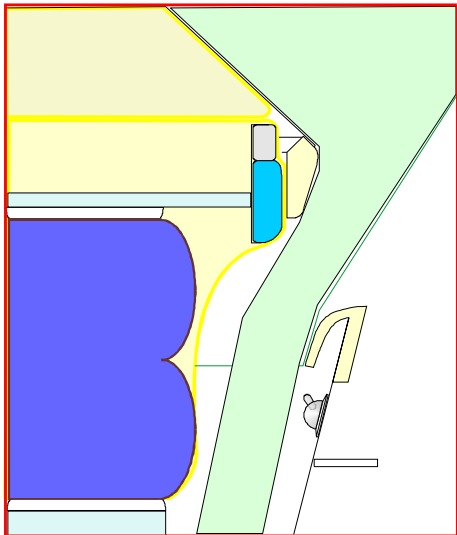


2 ↑
Discharge Station
probe raised and
pneumatically locked
to the IBC Cone Valve
sealing the under-
side of the Cone

Cone Valve lifted and
vibrated to discharge
product in a controlled
manner as required.

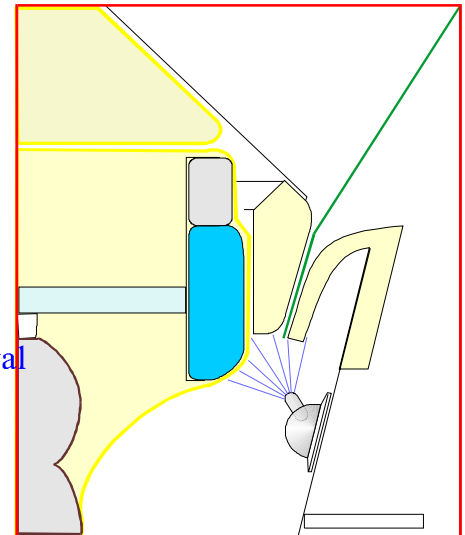


3 ↓



Cone Valve re-seated
Air wash system on,
cleaning the exposed
areas before cone
release and IBC removal
from the Discharge
Station.

4 →



IBC - Containment Discharge System
Principles of Operation.

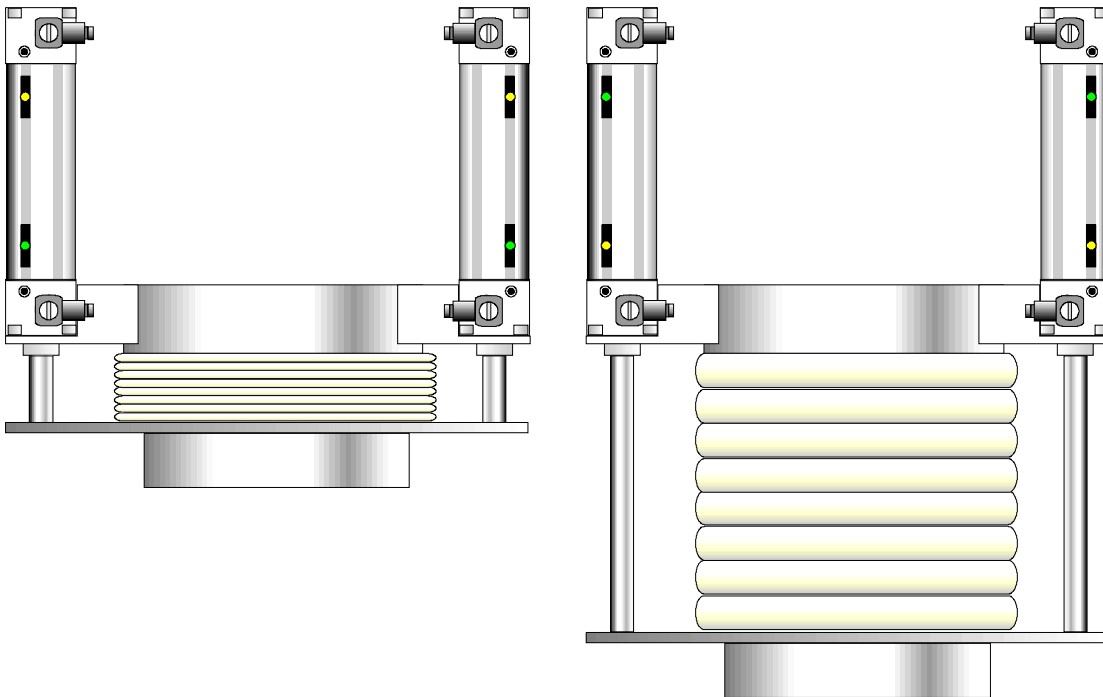
4.4 IBC Filling Systems

The IBC Filling Systems come in an even larger variety than the discharge systems, again all depending on the requirements for different process needs. The choices between the different alternatives can mainly be defined by two things:-

1. The level of automation required/wanted;
2. The level of containment required/risk of cross contamination perceived;

4.4.1 Manual / Semi-automatic filling systems

In a conventional IBC filling system the operator removes the lid and then connects the filling head to the IBC inlet manually or by pressing a button.



The level of containment during filling for the system is normally excellent as it is a sealed system. The critical exposure happens when the filling head is disengaged and the product in the IBC is exposed, thereby risking cross contamination. General practice is to introduce dust extraction at this point which, if designed correctly, overcomes the dust problem in most applications. After the transfer the operator then replaces the lid manually.

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4.4.2 Containment Transfer System (fully automatic)

Where full automation and/or microgram levels of dust containment is required the above described system is not adequate. Matcon has, to our knowledge, the only economically sound solution to meet this requirement.

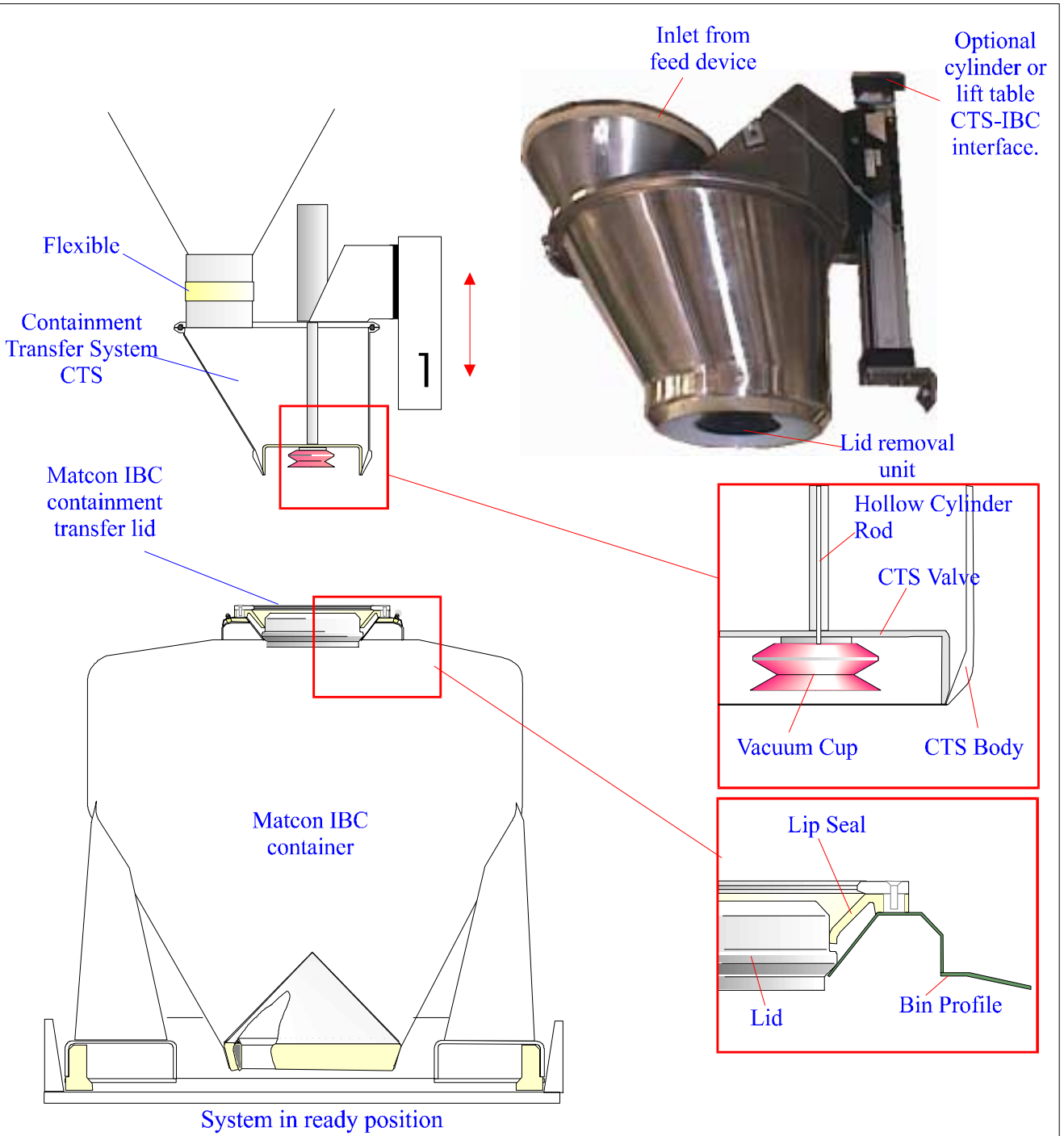
The Containment Transfer System enables transfer of powders from a process to an IBC while maintaining containment of the material from the outside environment. There is not even a momentary exposure of the inside of the IBC to the outside, either before, during or after the transfer. The system is totally automatic with no manual intervention whatsoever. The operator does not have to remove or replace a lid or operate a valve.

The system consists of:-

- A containment unit to bolt or flexibly connect to the bulk store or process vessel outlets;
- A loose lid inserted in a lip seal arrangement in each IBC;
- A separate control cabinet;

The principle of operation is clearly described on the following page, the engagement between the Containment Transfer System and the IBC can be performed either by lifting the IBC or indeed lowering the Containment Transfer System which Matcon supply with a cylinder mechanism as a standard option. When following the sequence of operation it is particularly important to notice how the IBC lid and the underside of the cone valve in the C.T.S. are engaged for as long as transfer takes place and are only separated once the transfer process is finished. Thereby extreme containment levels of down to less than 10 micro grams per cubic meter can be achieved, even without secondary dust extraction.

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The Containment Transfer System is lowered to dock with the IBC's transfer lid. The lid is automatically lifted to enable product transfer to the IBC. After filling the lid is replaced and the transfer unit lifted clear for IBC removal.



CTS Containment Transfer System. IBC Filling Principle Parts.

5.0 Typical Process Steps

We would like to outline a number of areas in the food and other industries where the Matcon IBC concept is increasingly being used. In each individual process step we will also discuss the interface to other pieces of equipment and how various technologies can be integrated into one common system solution.

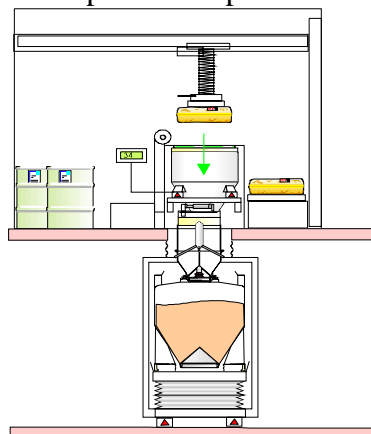
5.1 Raw Material Transfer/Formulation

25kg bags are by far the dominant means of distributing powder materials. For large quantities, mainly where hygiene is not an issue, bulk lorries have been available for many years and a more recent intermediate alternative has big bags.

The 25kg bags offers a tremendous flexibility in that they can be manually handled and emptied as and when required at any location in the factory. They do however cause a dust and ergonomical hazard to the operator and there is a risk of contamination by the bag material entering into the process.

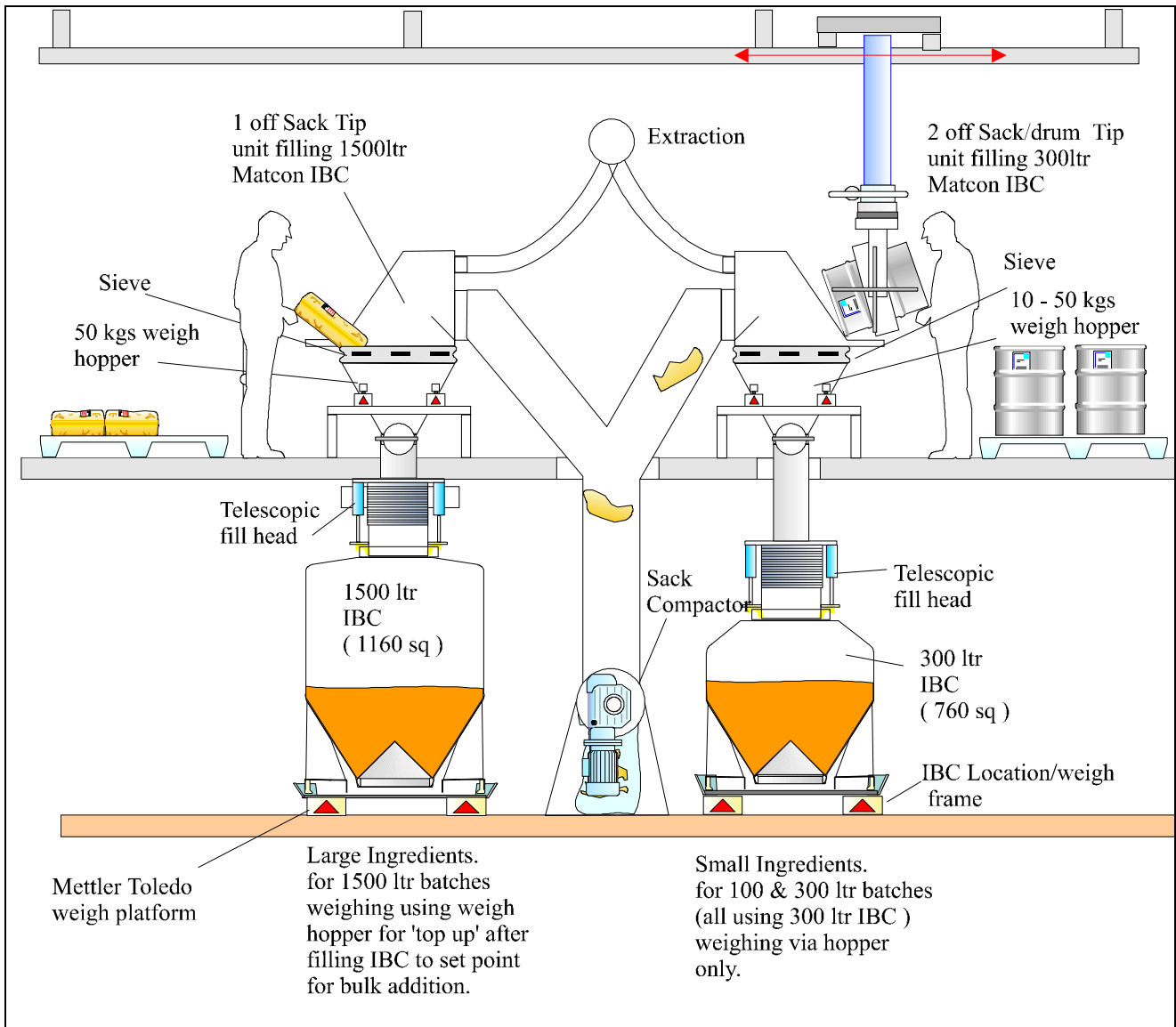
The bulk and silo combination overcomes these problems but has no flexibility and is far too expensive for most ingredients in a food factory. The big bag offers a sound intermediate alternative but has lost much of the flexibility as very rarely can the full content of the big bag be used at once in the process. To divide a big bag into sub-batches has proven extremely difficult if not impossible without tying up the pneumatic conveying line or discharge point for the whole duration of the big bag and thereby the flexibility again has gone missing.

Modern IBC systems are available to solve these problems and are being implemented in more or less all new installations and are also ex-changing existing systems. In these systems the 25kg bag are transferred at one central point into raw material IBC's on a campaign basis. By centralising elegant ergonomic work stations can be provided for the operators – sometimes even with automatic bag slitting. Dust extraction can be provided without risk of jeopardising the recipe as in-house formulation will take place as a second process step.

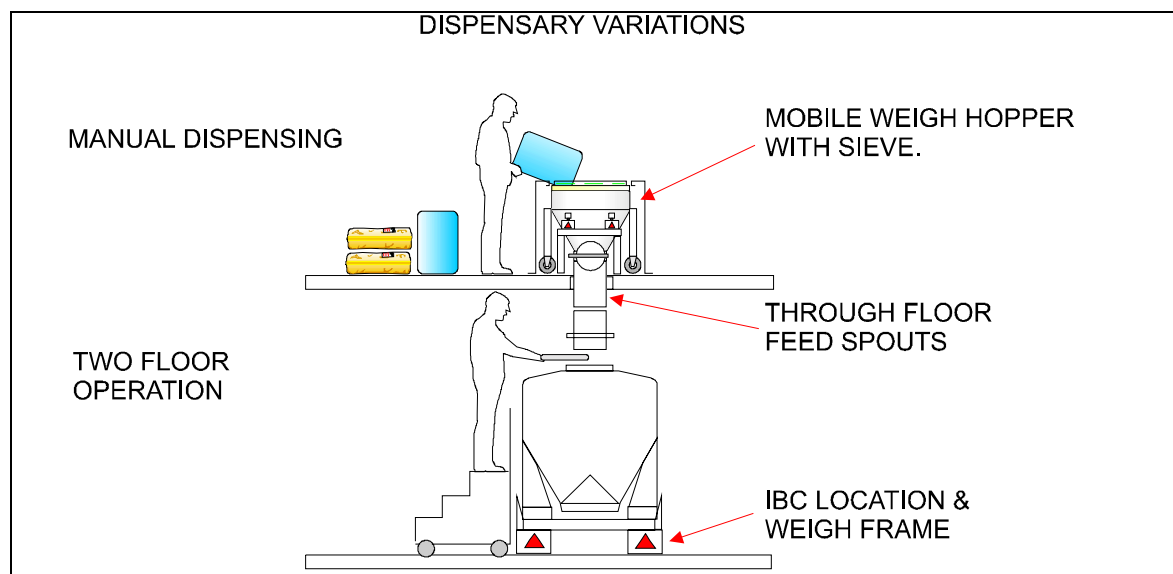


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Formulation

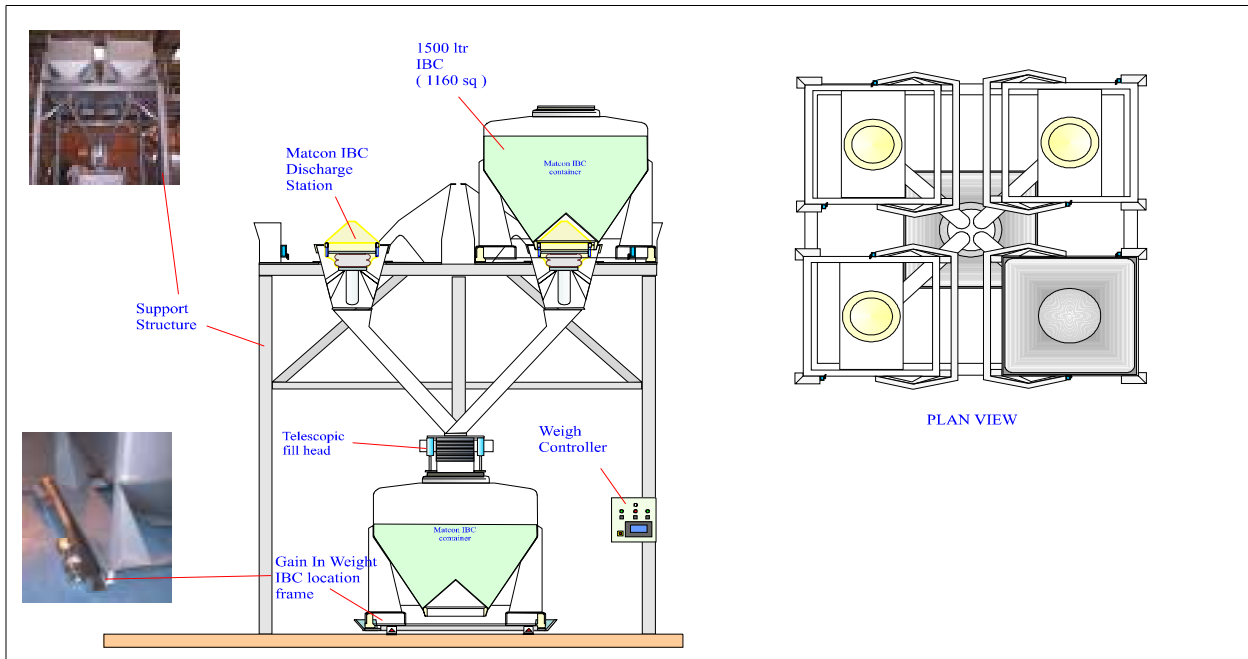
Once the product has been transferred into a Matcon IBC there is a whole range of various solutions available, all depending on the needs and production capacity for the specific plant. The key to success and flexibility of this system is the dosing performance of the cone valve discharger. The cone valve discharges material by lifting and vibrating and the extreme degree of flow control is achieved by pulsing the unit up and down in a sequence. This sequencing is typically controlled by a self-learning PLC. This has been pre-programmed to accommodate any types of materials and is typically capable of dosing batches from 20kg and upwards

The PLC controller has an inbuilt material memory for hundreds of materials. This allows rapid changeovers from extreme materials i.e. salt to cohesive fine starch with full dosing repeatability.

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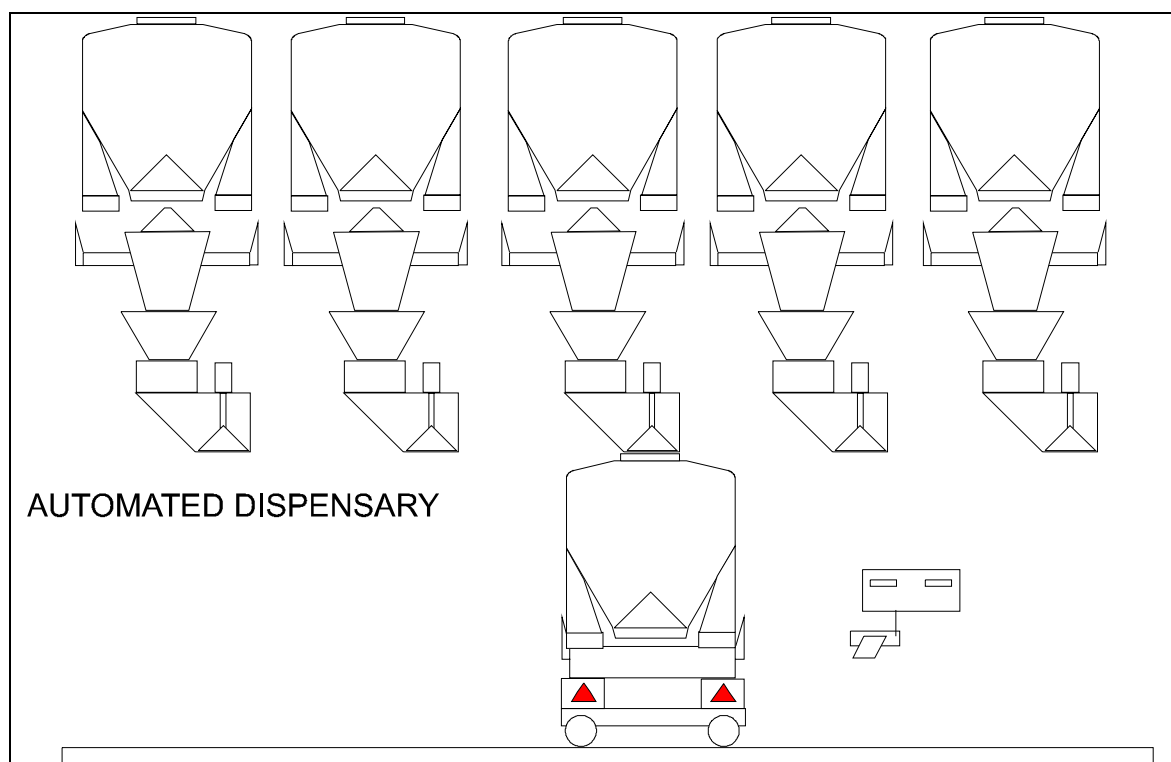
System layout

Generally speaking anything from two up to twenty materials are to be dosed in these systems. Depending on the number of blenders or other processes afterwards there may be a time constraint, but normally time is available to dose one component at a time. If so, a gain-in-weight system is normally chosen as being extremely cost effective. In smaller systems of up to four components there is normally a fixed weigh platform for the batch container and up to four dosing positions.



A major benefit of this system is that the weigh system is kept still, thereby more accurate and less liable to mechanical damage. A much higher degree of containment can also be achieved at a reasonable cost as only one filling position for the batch container is required. Typically a Matcon CTS can be supported from the weigh platform which allows containment levels down to micro grammes per cubic meter.

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This type of formulation system typically includes one or two bigger silos for large ingredients where a Matcon discharger performs the same dosing duty as the discharge stations.

As the dosing is performed direct from the IBC, and no secondary feeder is integrated, there is no residue or product when a changeover is required. Typically no cleaning or a quick dry cleaning is all that is needed to change between different products. This gives the possibility to minimise the number of dosing positions and thereby the investment cost but still with the full flexibility in the system.

Big Bags/Matcontainer

Matcon have developed a specially designed IBC in which a single or multi trip big bag can be inserted in a dust free manner. This special IBC can then be handled in exactly the same way as all the other raw material IBC's so that formulation from the big bag can be performed and the half empty unit can be lifted off the discharge station and removed for further storage.

A further development in this area is the range of plastic and flexible Matcontainers launched in 1995 which offers another economical alternative to distribution. A free video describing this alternative is available upon request.

Loss in weight dosing

The same principle of dosing described as 'gain in weight' above can be used for 'loss in weight' dosing. When several components need to be dosed at an extremely high throughput, this is a more suitable solution. In the ideal situation the process layout should be such that the loss in weight stations could be placed above the mixer and all the ingredients being fed simultaneously to the correct weighments. Alternatively, an elevator or screw feeder can direct material to the mixer inlet. This concept has, for example, been adopted by Farleys Health Care who intend to maximise the throughput in their plant. Another interesting aspect in this project is that they have implemented the use of an IBC mixer to pre-mix minor ingredients on a campaign basis. This is seen as a much more practical and cost-effective solution than to have multiple dosing positions also for the smaller ingredients.

5.2 Mixing

One of the most significant functions and consequently one of the most important aspects in a process system is blending. In most food applications it is the major source of increasing value to the products that go into the process. The quality of the mix performed within the mixer as well as when transferred to the next process, typically packing, is the single most important consideration for project managers and quality assurance personnel.

Blending Process methods

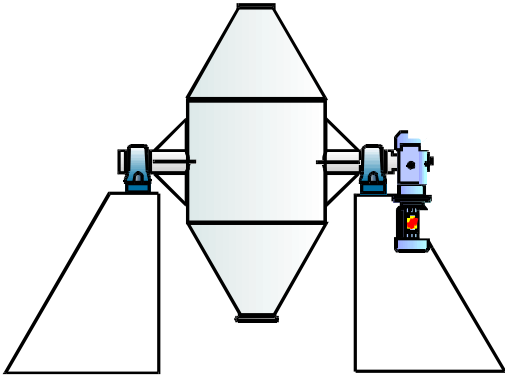
Regardless of blender type there are two primary process characteristics recognised in powder blending theory, namely '**Flow**' and '**Shear**'. Both of these are present, in different proportions, in every blender type. It is the application and control of the appropriate combination of Flow and Shear that leads to efficient blending.

Flow refers to the relative movement of particles within a material. The ability to randomly create that movement of particles encourages intermeshing and blending. High flow and a good blend will be achieved with materials that do not stick together. Flow is maximised and typically induced via tumbling or to a lesser extent via an internal conveying type device such as spiral blades, paddles and ploughs/plows.

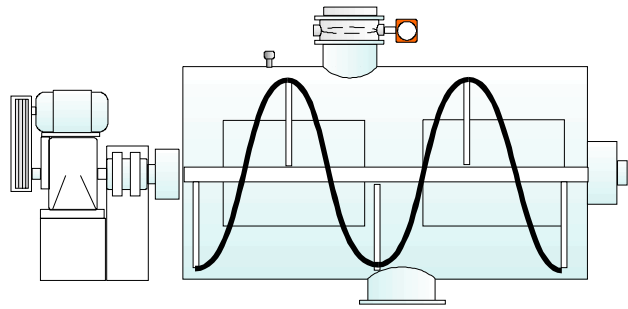
Shear is the amount of work applied to the material forcing the product particles to move. Applying the correct level of shear to particle forces intermeshing and blending. Shear is a necessary component when blending materials that tend to stick together and agglomerate, and is especially important when blending with liquids. However if mismanaged, particle degradation and heat build-up may occur.

Shear is typically induced via a high speed, high impact internal blade mechanism, such as chopper blades or impellers.

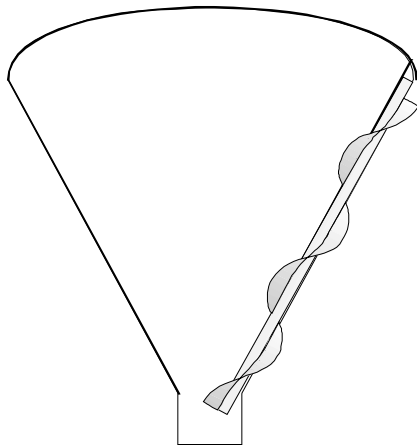
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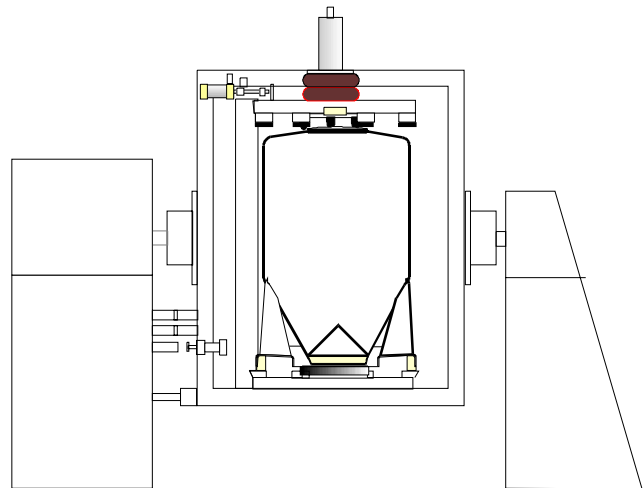
Cone Blender
(Flow)



Horizontal Ribbon
Blender (Shear)



Cone Blender
(Flow and Shear)



Containerised Batch
Tumble Blender (Flow)

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After mix considerations

Ensuring efficient blending requires many qualities in a Blender, not only the ability to blend effectively, thoroughly and quickly but also aspects such as the cleanability, dust tight operation, ease of filling and discharging and handling of the material.

Each aspect is as important, for although a Blender may blend thoroughly and efficiently, if the method of discharge is prone to segregation or the blend is handled frequently, also causing segregation, the blend quality is affected. Discharging the product correctly with minimum handling is therefore as important as blending efficiency.

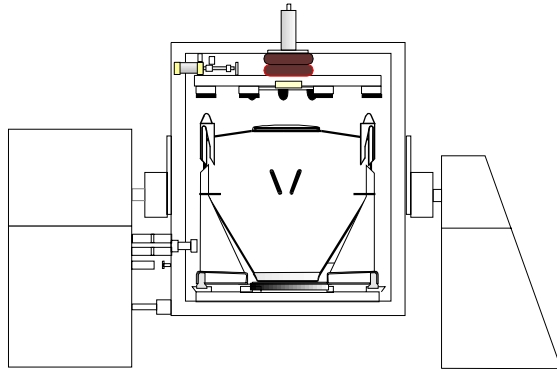
In small to medium sized operations it has been common practice to perform the packing into 25 Kg bags direct from the static mixer outlet. This is very inefficient as it occupies the mixer during the complete packing and there is also risk of overworking the material causing degradation. Therefore there is a requirement to discharge the mixed batch from the blender down to a storage hopper or a IBC. During the dropping of the mix batch from the blender to the storage hopper, there is a definite risk of segregation of the blend. This is especially true in the case of dry loose particulate solids requiring high flow, low shear type mixing.

Containerised Batch Tumble Blender

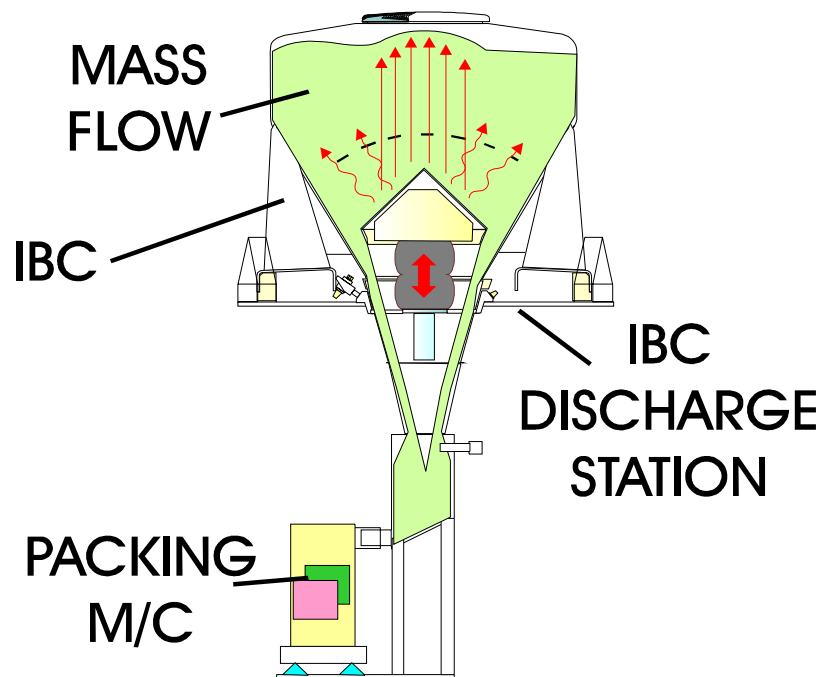
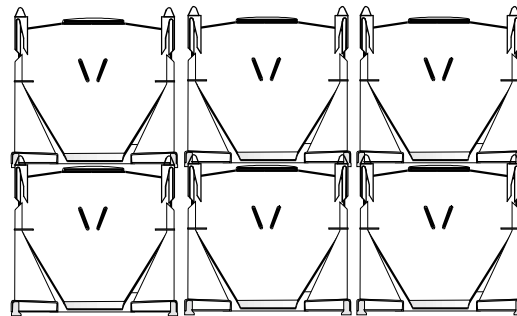
The containerised batch blender does not have the problem mentioned above because the mix batch is not dropped. Instead it remains in the intermediate bulk container while it is removed from the blending cage, transported direct to the packing line and discharged or stored until required. Other significant advantages of the IBC mixer is:-

- Once an IBC has been removed from the mixing cage, the mixer is free to mix the next batch without cleaning;
- The removable containers eases/simplifies the quality assurance, by avoiding cross contamination as separate containers are ensuring batch integrity. The mixed product can be retained in a container during quality assurance always ensuring a repeatable process without the cost of going through the packing process;
- The mixer does not need to be cleaned between different batches. Each container can be taken away from the mixing/process site and be washed down allowing continued production in the mixer;
- No filling or discharge of the mixer is required as this is performed elsewhere into the IBC's. Besides the actual time saving it gives a complete dust free operation;
- The mixed product can be moved within the container to an ideal position above the packing machine avoiding the pneumatic transfer that may cause both segregation and degradation of the product during the transfer;

CONTAINERISED BATCH TUMBLE BLENDER



IBC STORAGE (Q.A.)



Principle of Operation

IBC mixers are available from laboratory scale up to 2500 litre gross volume, even as multi-size if required. Both steel and plastic containers can be mixed. The IBC is simply inserted on an angle into a cage and then vertically rotated on an eccentric axis creating an irregular flow pattern, moving all particles within the IBC. The angle has been defined through excessive testing and should not be changed whilst the rotation speed varies depending on the size of container and product to be mixed. To achieve the highest possible mixing throughput, the IBC should be filled to approximately $\frac{2}{3}$.

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Mixing systems with high shear

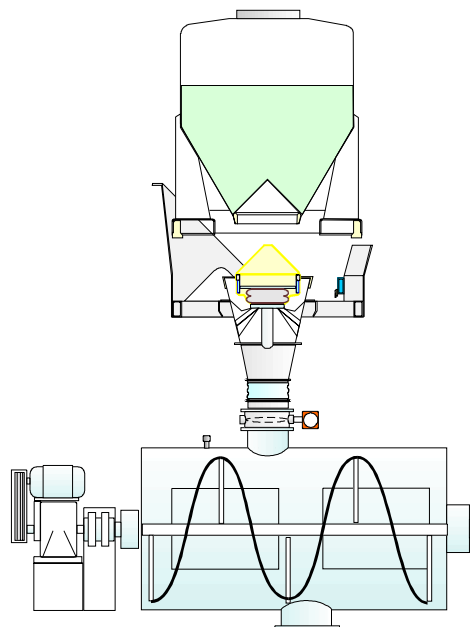
The ideal system using the IBC mixer described above is not possible to use when handling poor flowing product or mixes with liquid additions. In these situations various types of cone blenders and ribbon blenders are normally considered. We have highlighted problems and solutions for the system integration with these type of mixers.

Filling of the Mixer

The chosen way to perform the formulation of a batch will decide in which way the mixer is being filled. In the past it has meant a lot of manual hand tipping of bags causing problems mentioned earlier, and sometimes complimented with pneumatic conveying lines feeding the bulk ingredients direct to the mixers. This type of conveying is limited to one product per conveying line and when a number of mixers are in operation it becomes a complex net of pipes to which it is virtually impossible to do changes if required.

The IBC concept for the formulation gives the ideal situation where one batch is contained in one IBC. A Matcon discharge station is placed above the mixer allowing a sealed docking, discharge and undocking of the empty IBC which can then be re-used for receiving the material after mix. The filling of a mixer is more or less instantaneous which greatly improved production efficiency rather than waiting for slower conveying lines filling it up.

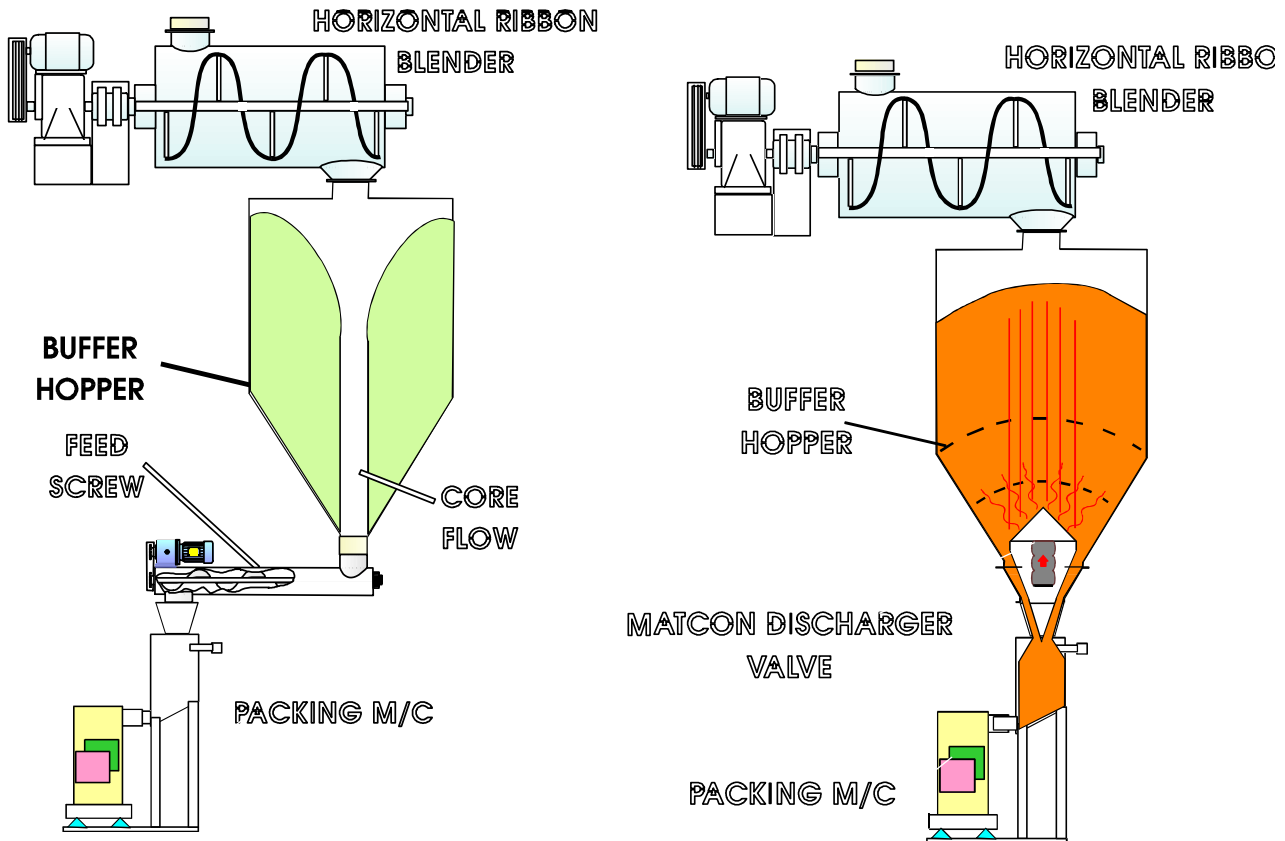
Another significant advantage of using the Matcon discharge station for in-feed to the mixer is that major ingredients can be dosed directly, a concept which for example Bush Boake Allen has adopted for their salt (see “Bush Boake Allen case study” for further details).



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Conventional methods of powder transfer from mixer to packing machine

Where building layout allows, the use of gravity to discharge to a storage hopper positioned below, is employed.



Cohesive, high fat content blends will almost always require a discharge aid to assist flow, i.e. Matcon Discharger Valve, Bin Activator etc.

The Matcon Discharge Valve is able not only to promote flow but also control the discharge to provide direct refilling of the packing line in feed hopper whilst retaining a consistent bulk density.

The drawback of the solution is now that the packing and the mixing is bound together reducing flexibility and causing downtime for both processes when only one is down for maintenance or cleaning.

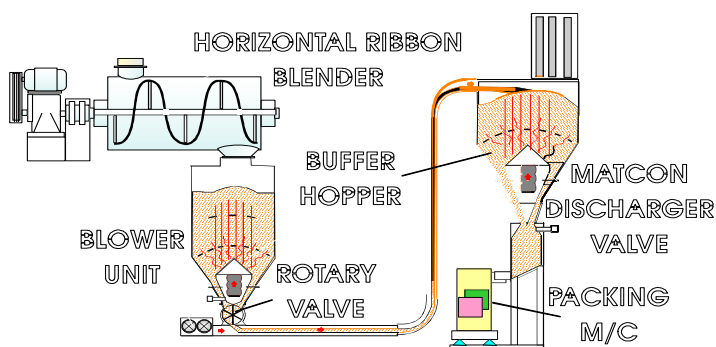
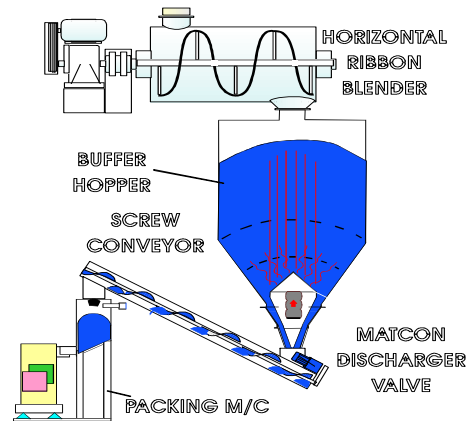
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Various fixed conveying methods from mixer to packing machine.

The problems for above described system is multiplied where a secondary conveyor is required for building layout reasons or when multiple packing positions are in operation.

Mechanical Conveying

Mechanical conveying systems (usually screw conveyors) are sometimes used for short horizontal or inclines transfers. High risks of segregation and degradation of finished blends exists with cross contamination between batches and difficult clean down.

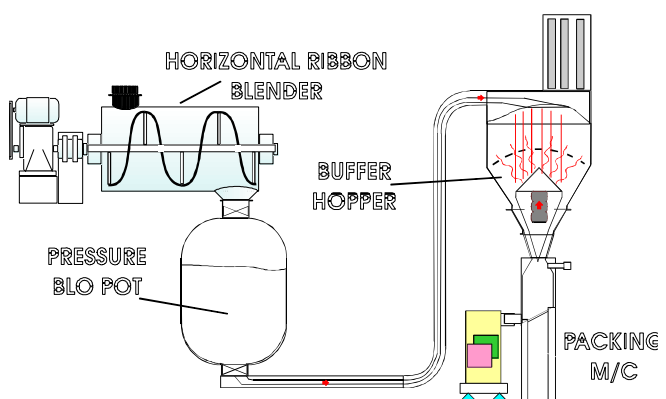


Pneumatic Conveying

Lean Phase pneumatical conveying (low pressure/high velocity) is usually considered totally unsuitable for pneumatic transfer of finished blends due to high segregation and degradation with cross contamination and difficult clean down.

Dense Phase pneumatic conveying (high pressure/low velocity) is more suitable for pneumatic transfer with reduced risk of segregation, degradation. However, cross contamination and difficult clean down are still major problems.

In both forms of pneumatic conveying, the material is fed to a “buffer” hopper complete with filter. Therefore, all the risks of segregation due to flow patterns introduced when discharging to packing machines exists.

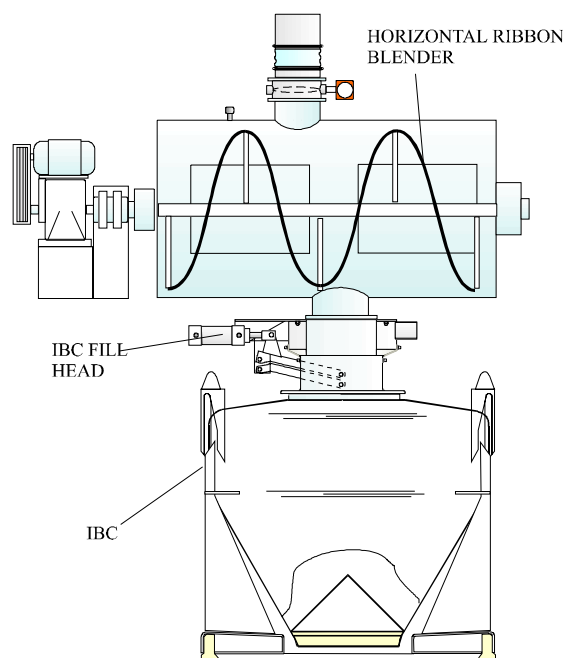


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Additionally the filters introduce a major risk for cross contamination or else filter change would be required between every single batch of product being transferred.

Interprocess Matcon IBC system

The use of the Matcon IBC system to transfer finished blends from the batch mixer to the packing machine is now regularly employed in the industry. The detachable container makes the mixer itself a lot more flexible, the batches can be campaign mixed, unloaded from the mixer and stored in the mixing container, retaining its mix until required. The mixer is then ready for mixing the next batch or to be cleaned. All/none of the problems created by the conveying systems mentioned above are not applicable for this conveying method and there are no limitations for the number of packing machines that can be fed from the one mixer.



The potential risk of dust and cross contamination when making and breaking connection between a mixer and the IBC inlet can be overcome using the Matcon Containment Transfer System. Lucas ingredients applied this concept from 12 mixers all charging 2.5 cubic metre Matcon IBC's. Containment levels of less than 2mg per cubic meter has been achieved using this principle.

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Filling and discharging is often under-rated in its importance when thinking of a mixer. Yet as briefly mentioned earlier, discharging especially, can detrimentally affect the quality of mix. With a detachable mixing container, filling can be carried out in a separate area at floor level, the mixing container can then be taken and easily loaded into the mixer, reducing any dust contamination. Equally so, discharging can be carried out in a separate area directly above the packaging machine hopper. The container with material can either be stored until required or discharged direct to packaging. Either way, the product is not handled excessively and the mix is thus not prone to segregation or degradation – the mix quality is maintained.

5.3 Packing

As already mentioned and described in mixing, the Matcon IBC system is the ideal transfer system from mixing to packing. Not only that, it also helps the packing machine by providing a controlled flow. Its' normal working mode is to employ level sensors controlling the refill making the cone valve raising and lowering as and when required.

An interesting aspect when using the cone valve IBC as the refill device, is that the horizontal screw feeder can in most cases be removed from the system. The refill from the IBC is controllable to such a degree that the packing machines accuracy can be withheld without this screw. (See case study from IFF using this principle).

The same applies for filling systems using horizontal screw or vibratory feeders as dosing devices. Matcon have integrated many of these systems to complete packages for small throughput packing.

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In multi-purpose plants where both free-flowing and extremely difficult flowing cohesive powders are being handled, the volumetric refill operation described above may not be adequate. In these instances the same PLC controller as mentioned earlier under formulation can be employed performing a continuous dosing as a refill. Instead of requesting a batch, a certain throughput rate to match that of the packing line is keyed in by the operator. The two systems will then operate in conjunction with the high level sensor as a secondary security to shut off the Matcon in emergencies. Lucas ingredients, for example, handles approx. 2,000 different mixes and have commissioned the Matcon loss in weight system for each of these products, which it handles extremely successfully.



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6.0 Conclusion

Food and other industries are moving towards batch orientated production. Sales and Marketing for the food companies have favoured this approach as they can justify higher prices for their product. It has however been a great headache for the production managers, as most of today's factories have been built for single, large production runs.

The IBC technology is now available to overcome all these problems giving an efficient, flexible and dust free factory, with the same throughput as previously for single product production. Matcon are willing to assist with feasibility studies, pre-engineering and complete system designs to accommodate these types of projects.

Please feel free to contact your nearest Matcon office for initial discussions.