

DESIGN CONSIDERATIONS FOR REFILLING AND VENTING CONTINUOUS LOSS-IN-WEIGHT FEEDERS

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Refilling and venting continuous loss-in-weight feeders occur simultaneously with feeding. They affect feeder performance. They require careful consideration when designing a loss-in-weight feeding system.

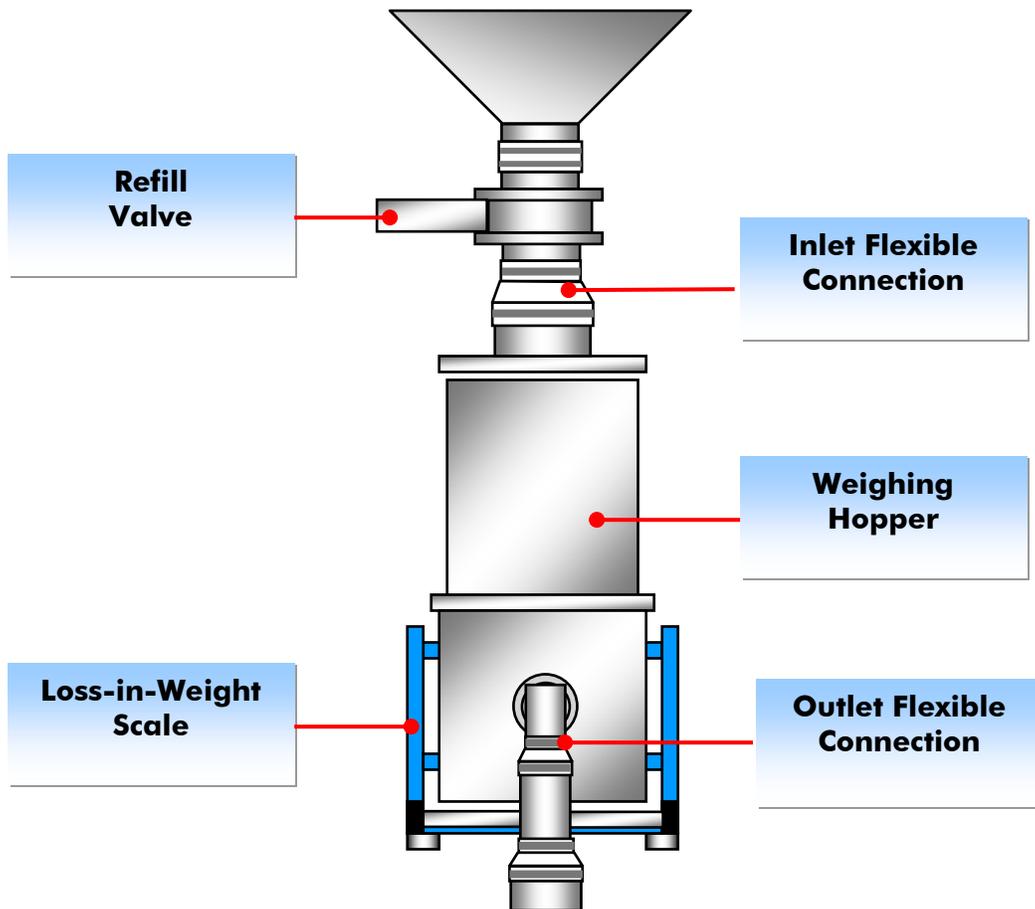
This paper will cover the following:

1. Refill frequency determination.
2. Refill volume and total feeder volume calculation.
3. Refill rate calculation.
4. Manual refill versus automated refill.
5. Venting during gravimetric feeding cycle.

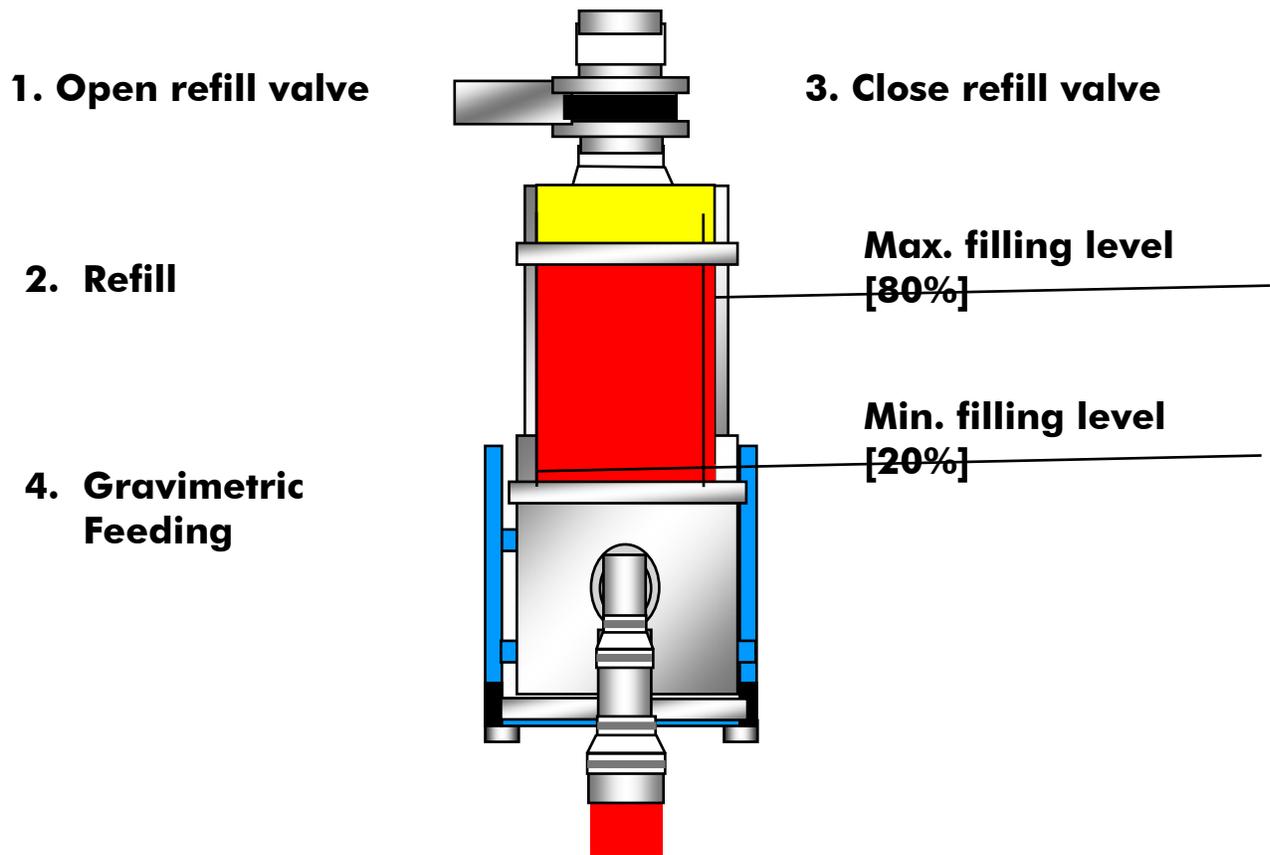
To begin, we will review the operation of the continuous loss-in-weight feeder using the following schematics:

Loss in Weight Feeder System

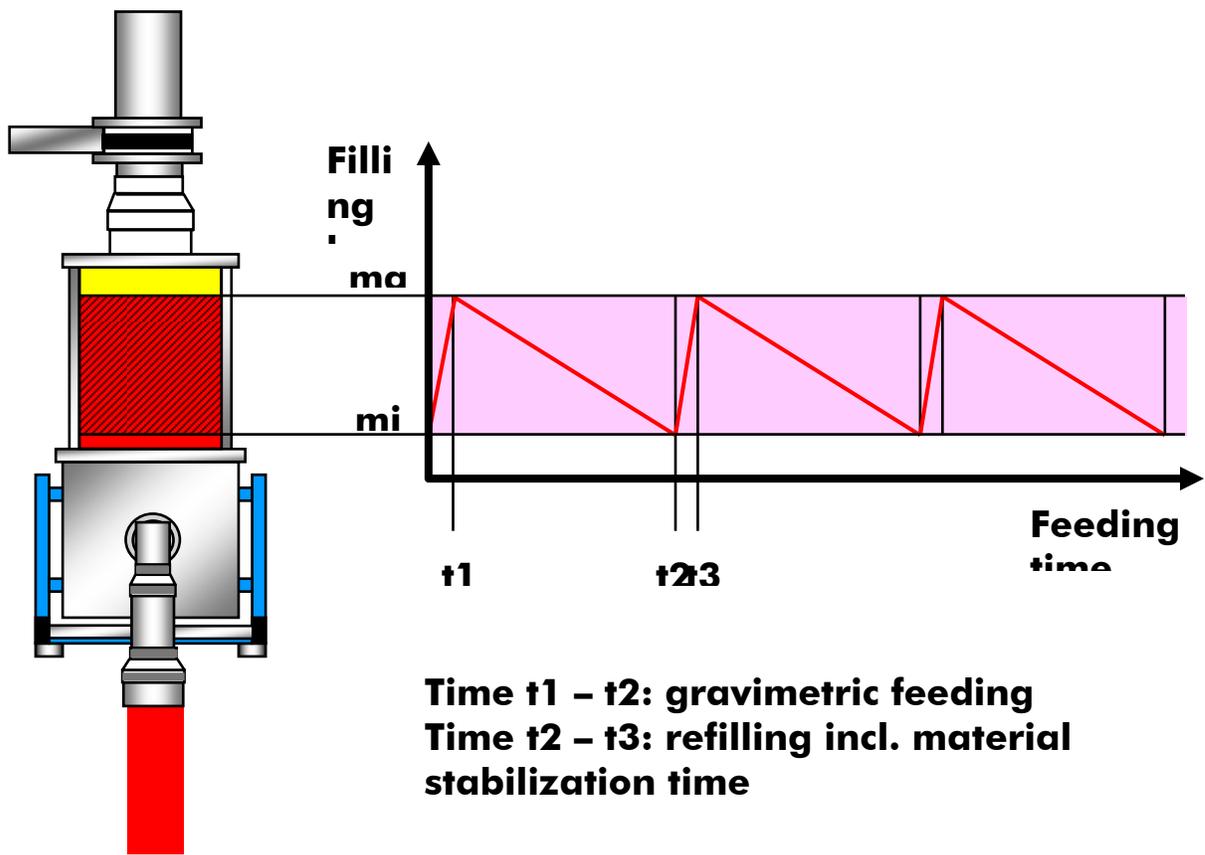
Components



Loss in Weight Feeder
Refill during Continuous Feeding



Loss in Weight Feeder
Continuous Feeding Graph



1. **Refill Frequency Calculation:**

Schematic 2 illustrates that the ingredient in the feeder is weighed. In Schematic 3, the feeding graph illustrates that the feeding cycle incorporates a direct gravimetric control portion (no refilling) and a refilling portion (when direct gravimetric control is suspended) and the feeder control is based on the previous direct gravimetric control portion.

Since the ingredient is weighed, the feeder hopper increases in stored volume in proportion to a longer gravimetric feeding portion. If the stored volume gets larger, the feeder becomes dimensionally larger and the scale has an increased capacity due to the increased load.

As a result, the refill frequency is decided carefully.

REFILL FREQUENCY AT MAXIMUM FEED RATE Refills/Hour	GRAVIMETRIC PORTION OF CYCLE Minutes
6	10
10	6
15	4
20	3
30	2

TABLE 1: Refill Frequency versus Gravimetric Control Portion of Feed Cycle

As a rule of thumb, for most loss-in-weight feed systems, particularly for powders and poor flowing granules, the refill frequency at maximum feed rate is selected to be 15 to 20 refills/hour. At feed rates less than max feed rate, the refill frequency is reduced since it takes longer for the ingredient to feed out during the gravimetric control portion.

2. **Refill Volume and Total Feeder Volume Calculation:**

Having selected a refill frequency, the refill volume and total feeder volume can be calculated. It is best described by selecting an example.

Maximum Feed Rate	600 lbs/hr
Bulk Density	30 lbs/cuft
Refill Frequency selected at maximum feed rate	15 refills per hour

Calculation:

$$\text{Refill Volume} = \text{Max Feed Rate (lbs/hr)} \div \text{Bulk Density (lbs/cuft)} \div \text{Refill Frequency (refills/hr)}$$

For the Example: $600 \div 30 \div 15 = 1.33 \text{ cuft}$

The total feeder hopper volume has to take into account having a “heel” in the feeder at start of refill and “freeboard” to allow for the ingredient angle of repose and possible reduced bulk density due to aeration on filling.

As a result, the feeder hopper volume is typically sized to allow for a 20% “heel” and a 20% freeboard. A larger heel is recommended for highly floodable ingredients, up to 50%.

$$\text{Total Feeder Hopper Volume} = \text{Refill Volume} \div 0.6$$

For the Example: $1.33 \div 0.6 = 2.22 \text{ cuft}$

In the final feeder model selection, a hopper volume is usually selected as the closest larger standard hopper model for the feeder.

For the Example, if the closest larger standard hopper model is 2.5 cuft, it is the size selected.

3. **Refill Rate Calculation:**

Since during refill the feeder is not under gravimetric control, it is desirable to refill the feeder quickly (5 to 20 seconds). Best feeder performance during refill is obtained if the refill rate is consistent from refill to refill.

The refill rate calculation is:

$$\text{Refill Rate} = (\text{Refill Volume (cuft)} \div \text{Refill Time (seconds)} \times 60 (\text{seconds/minute})) + (\text{max feed rate (cuft/hr)} \div 60 (\text{minutes/hour}))$$

Example	Refill Volume	2.2 cuft (from previous example)
	Refill Time	10 seconds
	Feed Rate	20 cuft/hr

$$\begin{aligned} \text{Refill Rate} &= (2.2 \div 10 \times 60) + (20 \div 60) \\ &= 13.5 \text{ cuft/minute} \end{aligned}$$

3. **Refill Rate Calculation: - cont'd.....**

Refill is often provided by an upstream refill device (and hopper) being a bin activator, screw, rotary feeder, belt, vibrating tray. Aeration to actuate refill flow is not recommended, since highly fluidized ingredient (powder) enters the feeder.

As a rule of thumb, the refill rate can be calculated directly from the maximum feed rate.

From the example

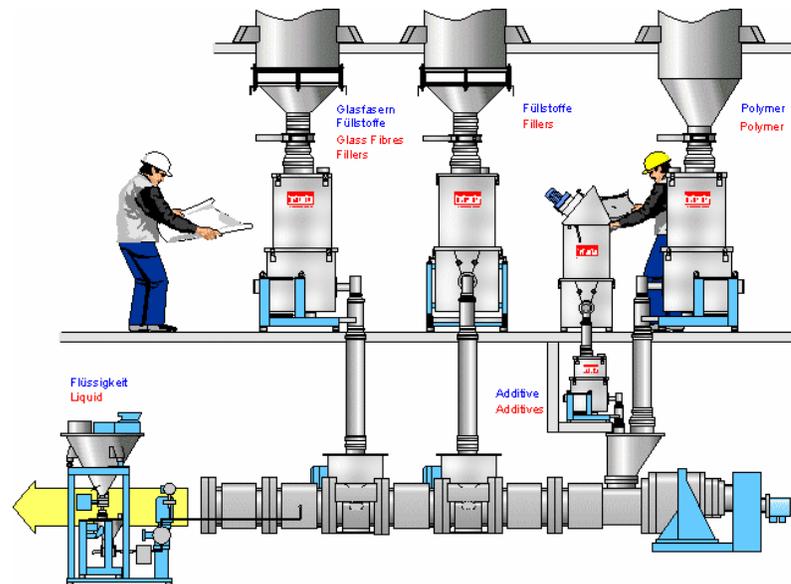
Max feed rate - 600 lbs/hr ÷ 30 lbs/cuft = 20cuft/hr.
Refill rate from calculation – 13.5 cuft/min x 60 = 810 cuft/hr.
Refill rate = 810 cuft/hr ÷ 20 cuft/hr which approximately equals 40 x max feed rate.

This rule of thumb changes for each refill frequency and refill time. In the example, 15 refills/hr and a 10 second refill were selected.

4. **Manual Refill Versus Automated Refill:**

In the refill frequency and volume calculations above, it is obvious that manually refilling a feeder hopper every 4 minutes is not a possibility.

The schematic below illustrates automated refill for feeders in an extrusion line. Please observe that the refill valve is very close to the inlet to the feeder. This prevents the ingredient from excessively entraining air (fluidizing) and impacting the heel of ingredient in the feeding with a force sufficient to cause a surge.



Schematic 1 – Example of Automatic Refill

In the above schematic, one of the feeders is shown being manually filled from a bag. However, the feeder being filled is a refill feeder, not the loss-in-weight feeder, which is below. The loss in weight feeder is automatically refilled from the refill feeder. A screw feeder (sized properly) is often a good refill selection for poor flowing ingredients compared to hopper, bin activator and valve.

4. **Manual Refill versus Automated Refill: - cont'd.....**

A manual refill normally refers to a direct manual refill of the loss-in-weight feeder from bags, boxes or drums. Typically, the refill is preferred to be performed once every hour or more. In our example, if refill occurred each hour, the feeder would have a hopper storage capacity of 20 cuft, plus heel, plus freeboard (33.33 cuft). This is a large hopper consuming more headroom than necessary.

Direct manual refill is normally provided for feeders with low feed rates where the normal hopper supplied with the feeder can store an hour or more of the ingredient.

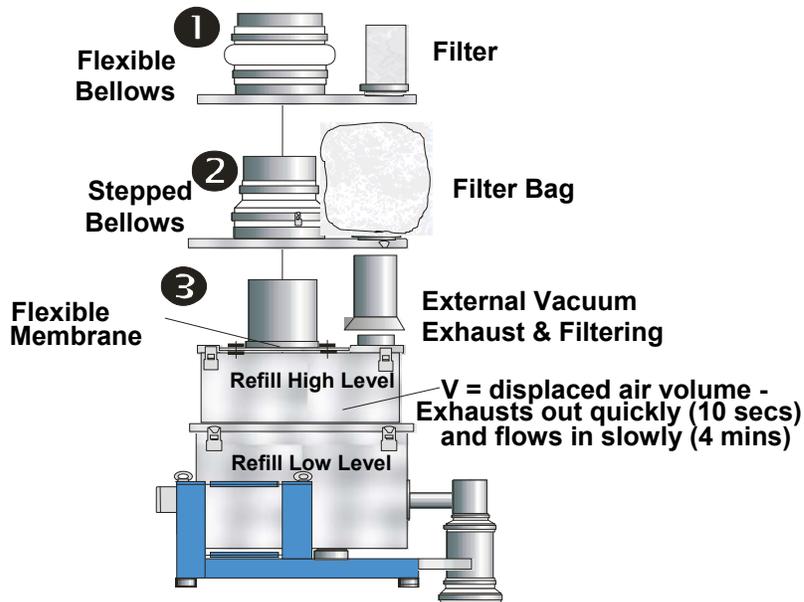
For Example: Feed Rate 5 lbs/hr
 Bulk Density 50 lbs/cuft

If the feeder has a hopper volume of 0.33 cuft, it needs to be refilled each 2 hours.

Please keep in mind that a loss in weight feeder is selected for highly accurate controlled rate feeding, not storing. Storing should be separate.

5. **Venting and Dust Collection During Refill:**

In the Schematic 5 below, 3 types of feeder venting are shown.



Schematic 2 – Venting a Loss-in-Weight Feeder

5. **Venting and Dust Collection During Refill: - cont'd.....**

During refill, the air (or atmosphere) inside the feeder hopper is displaced and must flow freely from the hopper (through the vent) so that there is only a small pressure build up in the feeder hopper.

Pressure build up (above atmospheric pressure which is acting on the outside of the feeder) can cause 2 bad consequences:

C1: the ingredient can be pushed out of the feeder (past the screw if it is a screw feeder;

And/or

C2: the flex connections can be expanded causing a force to be exerted on the outside of the feeder. These forces are vertical and sensed by the load cell. If the excess pressure is not completely vented before the gravimetric portion of the loss-in-weight feed cycle begins, the feeder weight signals will be erroneous and cause feed rate fluctuations, not following set point.

As a result, proper venting has a big influence on proper feeder performance.

The dusty air flow rate out of the vent equals the refill rate. In the previous example, we calculated the refill rate to be 13.54 cuft/minute.

Since the feeder is often feeding powders or other dusty ingredients, the vented air must be filtered and preferably have the dust that is caught in the filter, fall back into the hopper.

Filters are typically provided as follows:

F1: Very small filling area Cartridge filter - for plastic pellets only. It plugs if exposed to dust.

F2: Filter Bag Connected to Lid of Feeder: - it has a larger surface area than the cartridge, but, typically, not even close to the surface area required to filter highly dusty air at the vent rates generated from filling a loss-in-weight feeder.

F3: Direct Connected Dust Collection System, No Fan/Pulse Cleaning: - since the flow from the feeder vent is pressurized, it isn't necessary that the dust collector have a fan. It is only necessary that the surface area of the filter is large enough to produce a low-pressure drop across the filter. The filter should be supplied with a reverse pulsejet to "backwash" the filter.

This type of filtering should have a dual filter. Backwashing occurs in only one filter at a time so that the air pulse can be vented in the other filter.

This filter can be directly connected to the feeder, preferably through a flex connection, otherwise it is weighed. The refill time may need to be extended to allow for the backwash flow to fall into the feeder hopper. This is because the filtered dust is not weighed in the filter, it becomes weighed when it flows back into the feeder. Its flow back rate causes the feeder to erroneously increase the feed rate by the flow back rate.

5. **Venting and Dust Collection During Refill: - cont'd.....**

F4: Remote Connected Dust Collection System with Fan:

This type of dust collection is often provided. It incorporates a fan that should have a higher vacuum flow rate (at the vent inlet on the feeder) than the feeder vent flow rate.

The preferred vent connection is shown in Schematic 5. The vent piping does not contact the feeder. The vacuum flow rate in excess of the feeder vent positive flow rate is taken from the surrounding atmosphere. This prevents fugitive dust from going into the atmosphere.

The vacuum should be turned off when refill is finished.

If the vacuum line is connected to the vent, the differential pressure between the inside of the feeder and outside, causes the flex connections to be sucked in and cause a force on the scale and upsets feed rate control.

Also, air must flow into the feeder during gravimetric feeding as explained next. As a result, the vacuum exhaust line should not be directly connected.

Comment; if feeder hoppers require a pressurized inert gas “blanket”, gas pressure shouldn’t exceed 4” inches water column and pressure compensation at the flex connections is required. If the process into which the feeder is feeding is pressurized, the pressure should not exceed 4” inches water column and pressure compensation at the flex connections is required

6. **Venting During Gravimetric Feeding Cycle:**

As ingredient feeds out of the feeder, the ingredient stored in the feeder hopper empties. Air (or other gas) must flow in the vent to displace the ingredient that has flowed out of the feeder.

As outlined in 5 (above) and 6 the vent serves 2 purposes, it provides two distinct flows:

- a flow out of dusty air during refill,
- a flow in of atmospheric air during gravimetric control portion of feed cycle.

SUMMARY:

➤ **Refilling Loss-in-Weight Feeders**

- Extrusion applications are continuous.
- For loss-in-weight feeders to feed continuously they require a simultaneous refill when the feeder hopper empties.
- During refill, the feed rate is not under gravimetric control.
- For best control, it is best to refill quickly, 5 to 20 seconds.
- Hopper volumes are sized, typically for 15 refills per hour with 60% of the total feeder volume refilled.
- Plastic pellets can have 30 or more refills per hour.
- Hoppers are smaller with more frequent refills.
- As a rule of thumb, size refill rate at 25 x max. feeder feed rate, as a minimum.
- Best operation occurs if refill time is consistent from refill to refill.
- Refill flow velocity entering feeder should be low, avoid close to feeder inlet.
- The refill connection is sealed and flexible.
- Don't aerate the ingredient to induce it to flow from the refill hopper, feeders work best with deaerated ingredients.
- Loss in weight feeders are designed for feeding, not storing.

➤ **Venting a Loss-in-Weight Feeder**

- A Loss-in-Weight feeder hopper must be vented.
- Gas pressure inside the feeder should be the same as the atmospheric pressure outside the feeder. (Pressure Compensation option discussed elsewhere).
- Clean air (or gas) must be allowed to enter the feeder hopper during gravimetric feeding cycle.
- Dusty air (or gas) must be allowed to exhaust the feeder during refill.
- Exhaust rate is calculated knowing refill volume and refill time.
- The vent (exhaust) connection must be either a dust sock (for non-dusty ingredients) directly mounted on the hopper.
or a
- Non-touching vacuum exhaust connection or a properly sized filter with reverse pulse jet cleaning.