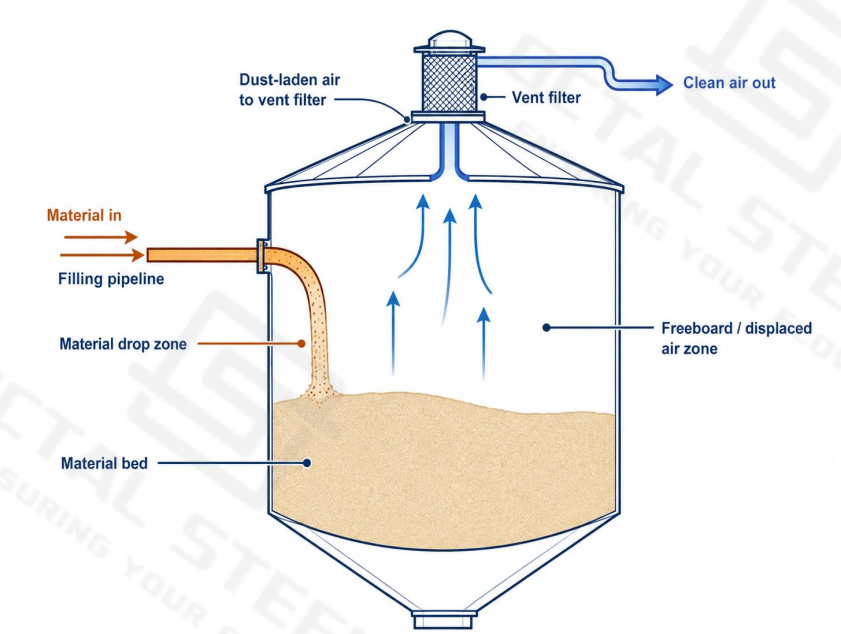
1. Complete Filling and Air-Flow Path

During silo filling, material enters through a conveying line or a mechanical feeder while the displaced air rises through the vessel and exits via the roof venting system. In a well-configured spiral silo, the filling path, internal drop zone, vent filter and clean-air outlet operate as one connected flow path.



Key Functional Relationship

- **Filling pipeline** delivers the bulk solid into the silo at the required rate.
- **Vent filter** releases displaced air while retaining entrained dust.
- **Air path continuity** is required from the material freeboard to the filter outlet.
- **Level devices** monitor inventory and support overfill protection.
- **Control interlocks** coordinate the filter, filling equipment and stopping sequence.

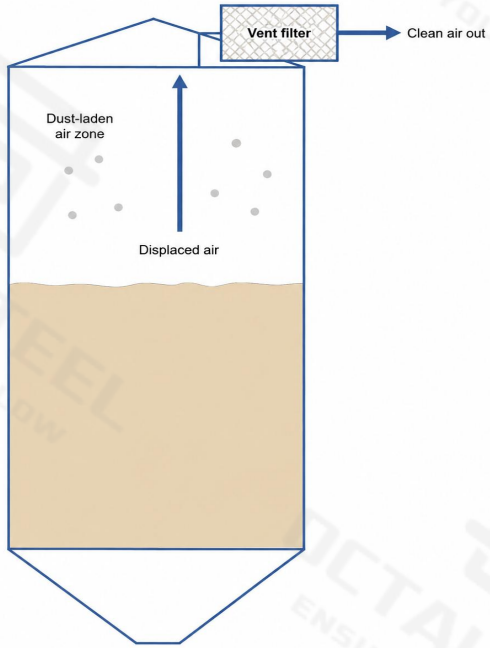
Step	What Happens	Main Check Point
1. Start filling	Material enters through pipe, screw, elevator or feeder	Inlet position and feed rate
2. Build inventory	Bulk solid occupies volume and pushes internal air upward	Freeboard and level trend
3. Venting	Displaced air and entrained fines pass to the roof vent filter	Filter duty and clean-air discharge
4. Stable filling	Material flow and air release remain balanced during loading	Pressure stability and no leakage

2. Displaced Air and Filter Duty

The venting system is sized by the gas that must leave the silo during filling. That gas may include displaced freeboard air, conveying air from pneumatic transfer, and fine dust carried upward from the inlet stream. Filter duty therefore depends on the actual filling method and fill rate, not on silo volume alone.

Input Condition	Effect on Venting and Filter Duty
Pneumatic filling rate	Raises total vented-gas volume and usually becomes the governing case for filter sizing
Mechanical filling rate	Mainly displaces internal air; lower gas load but still requires a clear vent path
Fine-particle content	Increases dust carryover and filter-cleaning demand
Material fluidization tendency	Can increase suspended dust and prolong settling after filling stops
Filter pressure drop	Rises when filter area is too small or when cleaning is ineffective

What the Filter Must Handle

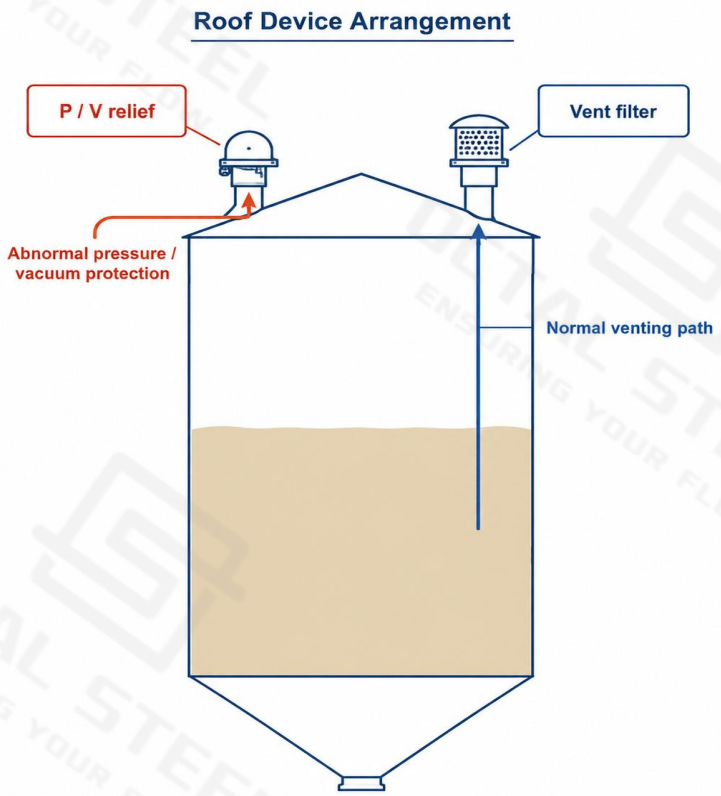


- **Displaced air** is the air originally inside the silo that must leave as inventory increases.
- **Conveying air** is additional gas introduced by pneumatic transfer; it can be larger than the displaced-air volume.
- **Filter area and cleaning method** must keep pressure drop within the normal operating range during continuous filling.
- **After-run time** is often required after feed stops so the filter can release the remaining dusty air and complete cleaning.

A vent filter is a process device for normal gas release. It should not be treated as the primary abnormal-pressure protection device.

3. Pressure Protection Devices

Pressure protection is required because filling can create overpressure, while extraction, cooling or blocked venting can create vacuum conditions. The vent filter, pressure-relief device and vent piping should be arranged as separate but coordinated functions.

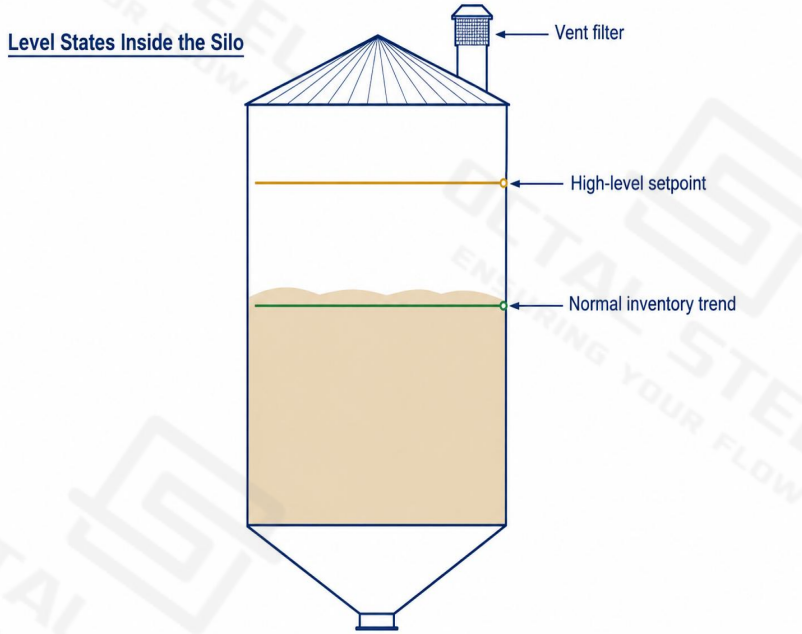


Device	Main Function	Typical Trigger / Design Focus
Vent filter	Releases displaced air and retains entrained dust during normal filling	Normal filling duty, gas volume and dust loading
Pressure-relief device	Opens under abnormal positive pressure to protect the silo shell	Blocked filter, conveying upset or rapid gas surge
Vacuum protection	Prevents excessive inward loading when internal pressure drops below safe range	Extraction with insufficient make-up air, filter blockage or thermal contraction
Vent piping and nozzles	Connect the vessel to the roof devices without creating unnecessary flow restriction	Pressure drop, maintenance access and weather protection

A vent filter supports normal venting, but abnormal positive pressure and vacuum conditions still require dedicated protection based on the silo design basis.

4. Level Measurement and Overfill Protection

Inventory measurement and overfill protection serve different purposes. A continuous level sensor provides operating information, while an independent high-level alarm provides protective action when filling must stop before material reaches the roof or the venting equipment.



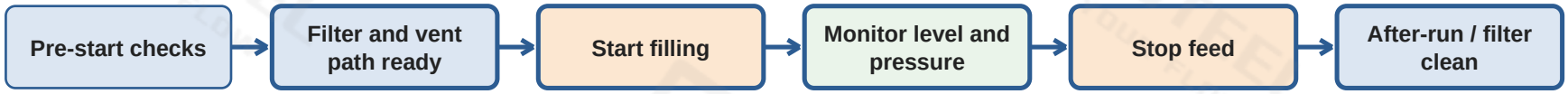
Device / Signal	Primary Role	Practical Note
Continuous level sensor	Measures inventory during filling and discharge	Supports process control but is not the only overfill protection layer
High-level alarm	Independent protective signal to stop filling before overfill	Should remain effective even if the continuous reading drifts or fails
Control interlock	Stops the feed source and locks out restart until reset conditions are satisfied	Coordinates conveyor, blower, rotary valve or diverter operation

A usable overfill-protection layer requires three elements together: independent detection, a positive stop command, and a defined response from the filling equipment.

5. Normal Filling Control Sequence

Stable filling depends on sequence control. The venting path must be available before material enters the silo, and the stopping sequence must allow the remaining dust-laden air to clear the vessel and the filter.

Control Flow



Sequence Stage	Required Confirmation	Purpose
1. Pre-start	Silo available, outlet status known, no protective trip active	Prevents filling into an unavailable or already full vessel
2. Vent path ready	Vent filter in service and any cleaning system enabled	Ensures displaced air has a clear release path
3. Start filling	Feed source starts in the correct sequence	Stabilizes the inlet stream and avoids surges
4. Monitor	Level, pressure trend and abnormal signals are observed	Maintains controlled filling under normal duty
5. Stop feed	High level reached or target inventory achieved	Stops material input before overfill occurs
6. After-run	Short delay for venting and filter cleaning before full shutdown	Clears residual dusty air from the silo and roof equipment

6. Abnormal Conditions and Protective Response

Protective functions should target the actual filling and venting hazards rather than provide only alarms. The response should stop the cause of the problem, place the system in a safe state, and leave enough information for follow-up inspection and restart control.

Abnormal Condition	Likely Cause	Protective Response
Vent-filter blockage or high differential pressure	Excess dust loading, ineffective cleaning or undersized filter	Stop filling, maintain safe vent path if possible, inspect filter condition and cleaning system
Rising silo pressure	Blocked vent path, conveying upset or excessive gas inflow	Trip the filling source; pressure-relief device protects the vessel if pressure continues to rise
Vacuum condition	Extraction or cooling with insufficient make-up air, or blocked venting	Stop the causative process and allow vacuum protection to admit air or relieve the condition
High-level alarm actuated	Inventory reached the protective setpoint or continuous level reading is unreliable	Stop filling immediately and require operator confirmation before restart
Conveying-line plug / material surge	Inlet blockage release, unstable feeder operation or transfer upset	Hold or stop the feed source, inspect the line and verify venting / level conditions before resuming
Power loss or controls fault	Loss of sequencing, filter cleaning or level signal handling	Place filling equipment in a fail-safe stop condition and restart only from the defined pre-start sequence

Protective philosophy: the vent filter handles normal venting, the pressure-relief device handles abnormal pressure, the level alarm prevents overfill, and the interlock system coordinates the response.