Vacuum Cooling Technology Manual

Vacuum Precooling for Fruits and Vegetables • Vacuum Rapid Cooling for Food • 30 Common Questions

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I. Basic Principles of Vacuum Cooling

1. Why can vacuum cool things down quickly?

The boiling point of water decreases as pressure drops. At normal pressure, water boils at 100°C; when the pressure drops to about 610 Pa, water boils at around 0°C.

Vacuum cooling makes use of this principle: the material is placed in a sealed chamber, and the air is pumped out to reduce the pressure inside the chamber to a few hundred pascals, causing moisture on the surface of the material to boil and evaporate at a low temperature. The

evaporation of water requires absorbing latent heat of vaporization, and this heat is taken from the material itself, so the temperature of the material drops accordingly.

In one sentence: cooling relies on water evaporation, not on blowing cold air.

2. Why must the equipment be equipped with a refrigeration system?

The evaporated water vapor must have somewhere to go. If the vapor is allowed to enter the vacuum pump directly, the pump will emulsify, its pumping speed will drop, and the process cannot continue.

Therefore, a water catcher (evaporator) is installed inside the chamber: water vapor condenses into ice on the surface of the water catcher and is retained there, while the heat is carried out of the chamber by the refrigerant of the refrigeration system and discharged. The evaporation temperature of the water catcher is usually controlled at -10~-5°C.

Equipment without a refrigeration system can only perform the task of "pulling a vacuum" and cannot perform a continuous and stable cooling process.

3. Why is the water trap set at -10~-5°C, not lower?

This temperature range is sufficient to condense water vapor at a few hundred pascals (the saturation temperature of water at that pressure is close to 0°C), while allowing the compressor to operate under reasonable working conditions. Simply lowering the evaporation temperature reduces compressor energy efficiency and causes frequent defrosting, which in turn slows down the cycle time per batch.

II. How to Distinguish the Two Types of Equipment

4. Differences Between Fruit and Vegetable Vacuum Precoolers and Food Vacuum Rapid Coolers

Item	Fruit and Vegetable Vacuum Precooler	Food Vacuum Rapid Cooler
Processing temperature	Room-temperature fruits and vegetables 25~30°C → target temperature	Hot food 80~90°C → target temperature
Typical scenarios	Farms, origin purchasing stations, cooperatives, planting bases	Cooked food plants, bakeries, central kitchens, prepared meal factories
Batch size	1000~6000 kg/batch	50~1000 kg/batch

Item	Fruit and Vegetable Vacuum Precooler	Food Vacuum Rapid Cooler
Primary purpose	Remove field heat, extend shelf life	Rapidly pass through the bacterial growth temperature zone, reduce moisture loss
Model naming convention	CVF-2000E-4P (2000 kg / evaporative cooling / 4 pallets)	CVF-600W-L (600 kg / water cooling / low-temperature type)

The two types of equipment operate in different temperature ranges and cannot substitute for each other: if hot food is processed as room-temperature fruits and vegetables, neither the pump set nor the water catcher can withstand the heat load.

5. How to Read Model Numbers

- Food vacuum rapid cooler: CVF-{batch capacity}{condenser}-{temperature code}, e.g. CVF-600W-L (600kg, water-cooled, low-temperature type 2~20°C), CVF-300A-N (300kg, air-cooled, ambient-temperature type)
- Fruit and vegetable vacuum precooler: CVF-{batch capacity}{condenser}-{number of pallets}P, e.g. CVF-2000E-4P, CVF-5000W-10P
- Vacuum freeze dryer: CVD-{shelf area}, e.g. CVD-1000 (10㎡), CVD-10000 (100㎡)
- Negative-pressure chamber: CVB-{internal cavity volume m³}, e.g. CVB-2.7

III. Process: Why Two-Stage

6. High-temperature materials must undergo rough pumping first

Taking a batch of 600 kg braised cooked beef as an example (loaded at 90°C, target 25°C, 18 minutes per batch):

Stage	Temperature range	Time	Cooling method	Cooling source
① Rough pumping stage	90°C → 50°C	3~5 min	Water ring pump rough pumping	Heat removed by water ring pump discharge water
② Fine pumping stage	50°C → 25°C	13~15 min	Water catcher + rotary vane pump	Cooling supplied by refrigeration system

The rough pumping stage uses a single-stage water ring pump (e.g., 2BV5061): the water ring simultaneously provides cooling and water capture, absorbing high-temperature water vapor and discharging it with the drain water. On-site water consumption is approximately 2.0 m³/h.

The fine pumping stage starts the refrigeration system and rotary vane pump: the water catcher condenses the remaining water vapor, the heat load drops, the pressure inside the chamber continues to decrease, and the material steadily drops from 50°C to 25°C.

The two-stage pumps are configured in parallel; the pipeline sequence must not be reversed.

7. How Much Heat Must Be Removed per Batch

For the same 600 kg batch of cooked beef:

Item	Calculation	Value
Specific heat of food	Cp = 1.424×0.60 + 0.837×0.40	1.189 kJ/(kg·K)
Heat to be removed from product	Q = 600 × 1.189 × (90−25)	46,371 kJ
Auxiliary heat load (product carts, cabinet leakage)	—	~2,400 kJ
Total	—	~48,700 kJ/batch

Only after the heat load is calculated can the compressor displacement and the water catcher area be determined.

8. What Determines Cooling Time

It mainly depends on three things: batch weight and specific heat capacity, material surface area and packaging format, and chamber sealing performance.

For the same 600 kg, bare cooling (without packaging) is much faster than palletized cooling with packaging; spreading in shallow trays is faster than stacking in a single block. Therefore, the first thing in a solution is to confirm the loading method, not to choose the machine first.

IV. Water Loss Rate and Quality

9. What Is the Approximate Weight Loss Rate

The weight loss in vacuum cooling comes from water evaporation and is practically controlled at 3~5%. The physical range is approximately 1~12%, depending on the moisture content of the material, the target temperature difference, and whether packaging is used.

For products with relatively low moisture content such as baked goods (moisture content 15~45%), the weight loss rate is usually 0.5~2%, which is within the normal range.

10. How to Reduce Moisture Loss

- Minimize the rough pumping stage as much as possible: a well-sealed chamber allows pressure to drop quickly, resulting in less evaporation loss
- Control the target temperature: the greater the temperature drop, the greater the evaporation
- Where packaging permits, add breathable film or spread product in shallow trays to reduce exposed surface area
- On the equipment side, the key is chamber sealing and water catcher efficiency—condense the water that should be condensed, rather than letting it "escape" through evaporation

11. Will It Affect Taste

Vacuum cooling is fast and the heating time is short, which is generally more beneficial for cooked food products than natural cooling or air cooling. Actual feedback from cooked food plants focuses on two points: stable product temperature and good consistency between batches.

V. Equipment Maintenance and Troubleshooting

12. Do pre-coolers and rapid coolers need defrosting

No separate defrosting program is required. A single batch takes about 15–30 minutes, and the frost on the surface of the water catcher is naturally melted during the temperature rise phase at the start of the next cycle.

13. Why Does the Cooling Time Keep Getting Longer

The pump unit and refrigeration system are usually not the first suspects. In most cases, it is air leakage in the chamber:

- Door sealing strips are damaged by impact, aged and deformed
- Valve seals are not tight (vacuum valve, vacuum breaker valve)
- Weld leaks in the chamber

If the pressure cannot drop, moisture evaporation slows down, and the cycle time per batch becomes longer. Perform a pressure holding leak test first, then check the equipment.

14. How to Match the Vacuum Pump

- Fruit and vegetable precoolers, food quick chillers: target vacuum level ≤600Pa, standard configuration is rotary vane pump (quick chillers use a two-stage setup of water ring pump + rotary vane pump)
- Roots pumps can increase pumping speed in medium-to-large precoolers (CVF-5000 and above, multi-pallet models); small-to-medium precoolers and food quick chillers are not

equipped with Roots pumps
- Freeze dryers target vacuum level ≤15Pa, requiring Roots pump + rotary vane pump (or even a three-stage pump set); the Roots pump requires the backing pump to first reduce pressure to approximately 1kPa before it can start

15. Cabinet Material

The cabinet of the fruit and vegetable precooler is made of Q235 carbon steel with rust-proof treatment on the inner wall, not stainless steel. Material selection depends on the application scenario and budget; the proposal list shall prevail at the time of procurement.

VI. What Customers Ask Most Often During Selection

16. What batch size should I specify

Base it on the output during the peak production hour, not the daily average output. For vacuum coolers, 1000–6000 kg/batch is common; for rapid coolers, 50–1000 kg/batch. For continuous production scenarios (e.g., 3 batches/hour), size the equipment according to the hourly peak.

17. How to Calculate Processing Space and Volume

Processing space refers to the net internal volume of the vacuum chamber (m^3). It has no proportional relationship with the overall machine weight—equipment weight is only related to transportation, installation, floor load-bearing, and lightweight design. One cannot use kg/m^3 to judge whether the structure is good or bad.

18. How to Choose Between Double Door and Single Door

For continuous production, a double-door configuration is recommended: front door for loading, rear door for unloading, allowing both processes to run simultaneously. For single-batch intermittent production or where space is limited, use a single-door configuration.

19. How to connect to downstream processes after cooling

After vacuum cooling, the surface temperature of the material has dropped to the target value, and it can directly enter the packaging, quick freezing, cold storage, or cold chain transport stages. When a continuous line is required, the loading and unloading method of the chamber (cart, conveyor rollers) must be determined during the solution design stage.

20. Actual Case Data

Customer Scenario	Model	Batch	Temperature	Time per Batch
Braised cooked beef (Hunan)	CVF-600W	600 kg	90°C → 25°C	18 min (3 batches/hour)

For more cases and parameters, refer to the actual proposal documents.

VII. Ten Common Misconceptions

1. Vacuum cooling relies on cold air for cooling → It relies on water evaporating under low pressure to carry away heat
2. No refrigeration system is needed → The water catcher must be addressed first, otherwise the vacuum pump cannot operate continuously
3. The lower the evaporation temperature, the better → -10~-5°C is a reasonable operating condition; the lower it goes, the worse the energy efficiency
4. The equipment needs defrosting → A single batch takes 15~30 minutes; the high-temperature phase of the next cycle naturally defrosts it
5. Slower cooling means the pump is broken → First check the chamber for air leaks (door gaskets, valves, welds)
6. Using kg/m³ to judge chamber construction → Volume and weight have no proportional relationship
7. Pre-coolers and rapid coolers are interchangeable → Different temperature ranges, large differences in heat load
8. The higher the water loss rate, the more normal → The actual controllable range is 3~5%
9. Selecting equipment based on average daily output → Select based on peak hourly output
10. Freeze dryers and rapid coolers are substitutes for each other → The former is for dehydration and preservation, the latter for rapid cooling; the process objectives are different

VIII. Contact Us

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Equipment selection must take into account the specific material, batch size, and site conditions, and is subject to the formal proposal and contract.