



KEY CONSIDERATIONS WHEN
**PURCHASING AN ULTRA-LOW
TEMPERATURE FREEZER**



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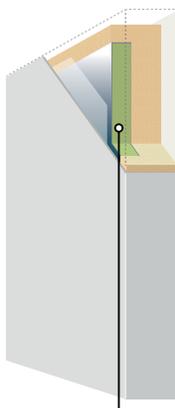
Overview



Ultra-low temperature (ULT) freezers are designed to operate between -86°C and -45°C , but usually operated at a set point of -70°C or -80°C . ULT freezers have a typical service life between twelve and fifteen years. When considering the replacement of a ULT ten years old, or older, there are many variables to consider. New technology solves some of the issues found in older freezers and reflects new trends in Ultra-low Range (ULR) freezer construction.

Types of ULT Freezers and Popular Options

- ULT freezers come in two basic types, chest freezers and upright freezers. Chest freezers are more efficient than uprights, but due to common space limitations fewer chest freezers are purchased. Less than 5% of ULT freezer sales are chest style. Chest freezers last longer because the efficiency of their design requires less use of the compressor. The same efficiency also allows for temperature set points to be reached more quickly, and maintained.
- One popular option is the twin ULT freezer with separate compressors. Some manufacturers also provide a backup compressor so if one fails, the other maintains temperature.
- ULT freezers with VIP insulation have more capacity within a small footprint, and so are a good option where floor space is limited. A VIP panel is thinner due to the lower thermal conductivity of a partial vacuum compared to the conventional foam insulation necessary to achieve the same thermal insulating properties. It is important to protect



Vacuum Insulated Panel inside a ULT freezer wall

the integrity of VIP panels. Cracks caused by temperature fluctuations can compromise the partial vacuum conditions and degrade insulating properties. Opening and closing the door of a VIP insulated freezer too frequently can lead to cracks in the insulation, causing failures.

- Another ULT freezer option is to have two compressors. In most freezers, twin compressors don't function as backups. They are independent and one functions as a high stage compressor that cools down the low stage condenser. This isn't a standard option in the industry yet because it is price prohibitive, but some manufacturers justify the price with performance improvements.

Refrigerants

- After CFC's were banned, ULT freezers switched to HCFC refrigerants. Currently, freezers which are the most energy efficient use hydrocarbon refrigerants (HFCs).
- The ULT freezer industry is trending towards using highly efficient, but flammable, refrigerants such as R170 Ethane, and R270 Propane. The United States and France do not yet allow flammable refrigerants despite the many years both have been in use elsewhere. ULT freezers using flammable refrigerants are popular in the European pharmacy industry, but not yet available in the United States due to regulatory restrictions. ULT freezers using flammable refrigerants are 50% more energy efficient than models using conventional refrigerants after pull down, and have decreased potential for oil logging.

How Long does it take for ULT Freezers to Cool?

- The pull down time is the time it takes to get to -80°C after set-up or installation. After a power failure, the time it takes to reach -60°C is called the holdover time.

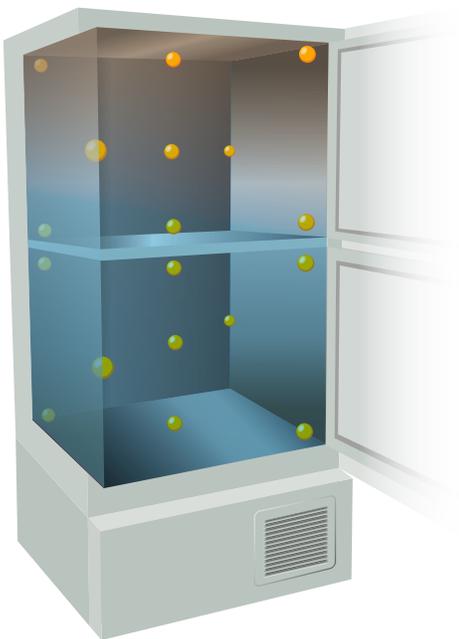


Key Considerations when Purchasing an Ultra-low Temperature Freezer

- After a door opens ULT freezers are designed to recover the temperature as soon as possible. Every time an upright ULT freezer door is opened it takes 10 minutes to recover its temperature back to its setpoint.
- Flammable refrigerant gas helps pull down faster, and saves around 15% electricity.
- Warm up can be slowed down by having effective insulation, door gaskets, and a claw door. All three are important.
- Quality manufacturers supply graphs to show how their systems compare to others with data on pull down, heating up, power consumption. Pull down and warmup numbers vary widely, with some systems taking 3 times as long as others. Be aware of the location inside the freezer where temperature was measured in the manufacturers' data, as pull down times measured in the middle of a chamber can vary considerably versus measuring at the top or bottom.

How Much Temperature Variation inside can be expected?

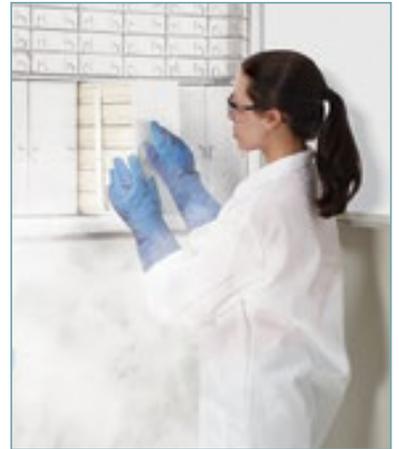
- It's important to select a ULT freezer with the best temperature uniformity. Typically, temperature variation is only a few degrees away from set point, but it is best to review the manufacturer's test data. The data should specify the location of the testing probes, typically top, middle, and bottom of inner chambers, and explain how loaded the freezer was during testing. It is typical that uniformity is better when a freezer is fully loaded.



● Temperature
Sensor
Location

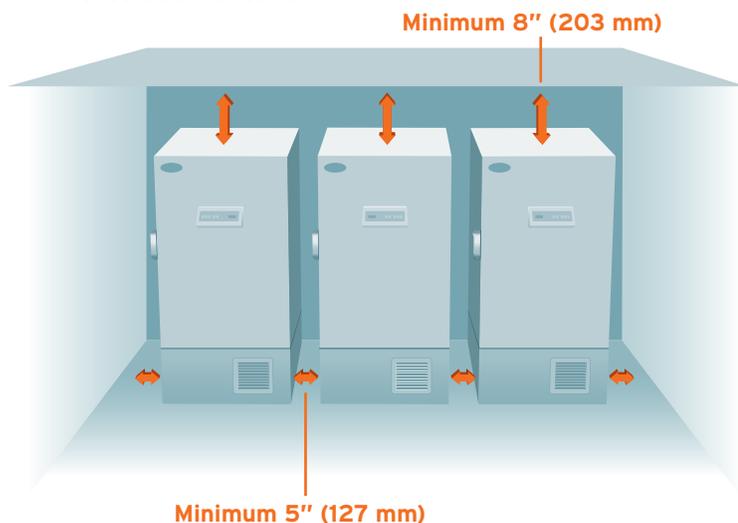
Size Matters - Capacities and Space

- To determine the size of freezer needed, users look at the capacity and how many racks and sample boxes it can store.
- A current trend is for freezers to have pull-out drawers, especially in large capacity freezers. But drawers and heavy inventory racks can make it difficult to reach and access the top compartments of the freezer for some technicians. In order to help alleviate this problem, some manufacturers offer options to access drawers from the side, making it easier to open and locate and return samples.
- The exterior size of a ULT freezer is of importance when considering capacity and efficiency. Energy consumption per cubic foot is higher for small freezers when compared to large freezers, but it may not be the primary factor when selecting a freezer.
- Labs with limited space often use freezers which are smaller based on size constraints. Energy costs become important for users in university or research settings, and many opt to purchase large freezers and share the space between groups in order to minimize energy consumption and look for the largest capacity at the lowest price possible per vial to determine the most efficient way to produce frozen vials.
- Users should consider if a mixture of strategies combining total efficiency as well as local needs may be suitable.
- How long the samples will remain stored in the freezer is also an important factor. Most ULT freezers are designed to reach at consistent set point and last that way for more than a decade.



Where The Freezer Will be Located Matters

- The location in which a freezer will be placed is important in determining the size and which model will be used.
- Whether the freezer will be located alone, or within a group of freezers is also a matter for consideration.
- Regional considerations, such as average air temperature, should be considered if a freezer will be located in a space without climate control.
- ULT freezers are not flash freezers or blast freezers. They are meant to store and conserve product that is already frozen. Excellent freezers might be able to tolerate being loaded full of warm product, but regular ULT freezers will break down with time under that type of use. It is best to load the chamber at most a quarter full with free-frozen product, and avoid putting warm product into it. A facility such as a blood bank, which has a high volume of warm product which must be cooled quickly, might make the mistake of purchasing a ULT freezer when a blast freezer would be more appropriate. Continued use of a ULT freezer to rapidly cool warm product can cause the freezer to suffer mechanical failure more quickly.
- Freezers need proper ventilation so the warm air can reach the return registers. A minimum space of 8" (203 mm) on top and clearance of 5" (127 mm) on the sides and back should be maintained.



Avoid side by side spacing unless a ULT freezer is located in a specially designed freezer farm. There should be no storage on top of a ULT freezer.

- Another major consideration is if the freezer will need to pass through a standard-sized door opening. Most freezers are built to international standards of 90 cm (35 1/2") wide and 2 m (78 3/4") high, the size of a standard European door. A rule of thumb manufacturers recommend is to purchase as big a freezer at the best price per ft³ capacity that still will be able to pass through the door. Larger freezers should have parts which can be removed to fit it through a door.
- The decibel rating of a ULT freezer becomes important if it will be located next to an office or other quiet work space. Good quality freezers need not be noisy; NuAire ULT freezers are rated at only 47dba, versus competitive freezers rated at as much as 73dba.

Avoiding Frost

- Frost can accumulate on ULT freezers when water vapor comes into contact with cold interior surfaces. Frost buildup can interfere with closing inner doors or even the outer door if excessive frost turns into ice. Every ULT freezer will accumulate frost, this is simply the nature of very low temperature surfaces when humidity is present.



- The best freezers provide features to minimize frost buildup. For example, claw latches to secure inner freezer doors, tighten the hinge against the gasket. Low-wattage halo bypass heaters help keep gaskets around the outer door clean. Insulation on the inner doors as well as the outer doors help maintain temperature to the greatest extent possible.

Key Considerations when Purchasing an Ultra-low Temperature Freezer

- Most ULT freezers that are designed for environments having a maximum humidity of 80% and 32°C maximum ambient air temperature. ULT freezers typically make use of air-cooled condensers, so if the ambient temperature is too high, cooling efficiency is degraded. Avoid placing a ULT freezer in an area exposed to direct sunlight, or in an enclosed area without adequate ventilation. If it is necessary to place freezers closer than 10 cm in an enclosed area, water cooled condensers may be needed.
- Oil logging, or ice buildup in the refrigerant, can become an issue in ULT freezers. In the mid-1980's, almost every ULT freezer had this problem due to paraffin wax-based oils. This type of wax was prone to solidify in capillary tubes. Wax-free synthetic oils largely eliminated this problem. However, ice can still form in capillary tubes for other reasons.
- To prevent oil logging, manufacturers use heaters inside the capillary tubes to prevent oil from becoming too cold. Oil can also be run through separators outside of the system to remove ice and reduce maintenance down time due to oil logging.
- Some ULT freezers provide voltage boosters, for buildings that provide less than the rated 220V in the USA or 230V in Europe. There is a greater need for voltage boosters in the United States where it is common to have 208V available, instead of 220V. A freezer compressor will fail much more quickly if run it at lower than correct voltage. The a voltage booster can lengthen the life of a compressor.
- Backup kits are also an important consideration if a freezer is located in areas where power failures are common. CO₂ backup kits alert staff of a power problem, while maintaining set temperature for a short time to allow staff to correct the problem. If a ULT freezer is located in an area experiencing frequent power outages (which lacks backup generators) or susceptible to hurricanes and/or other natural disasters, consider backup options.

What Facilities Concerns Are There?

- ULT freezers need chilled process water, reliable power, and vacuum.
- High quality freezers provide a manual way for operators to release the door when vapor lock occurs, with a vacuum release valve
- Higher end freezers also need data ports to communicate logged data or for remote temperature sensing, and some need battery backup power.
- Freezers located in areas with seismic activity have brackets that secure the unit to the walls.
- The proper power source is important, as well as correct receptacles in the area where the ULT freezer is located. Most are 208V-2230V at 60 Hz, 15 Amp single-phase circuits, but some customers need 115V with 20Amp single-phase circuits. Very few freezers are able to maintain even -57C at 115V and 15Amp, the exception being small, low interior volume freezers.
- The facility manager should be aware of additional heat load the ULT freezer will cause. Energy management strategies to mitigate the additional heat load may involve consolidating all of the freezers into one room with adequate cooling, or dispersing the heat load by separating ULT freezers to different locations.
- "Advances in ULT freezer compressor design, insulation, and cabinet design have resulted in greater efficiencies to store samples. However, the efficiency of ULT freezers decreases over time, due to loosening seals, refrigerant loss, degraded lubricants, fatigue in mechanical systems , or poor maintenance. Each year of a ULT freezer's age translates in to approximately 3% increase in energy consumption. Some ULT freezers age well; therefore, it is highly recommended to test every freezer to verify the need for replacement."
- Some customers have a committee managing cold storage which watches energy use and performance over time.
- Regularly testing old freezers over time will show which ones are the poor performers. A four to six hour test with a plug-in energy meter helps compare the voltage, wattage, and amperage drawn for each freezer.

Energy Concerns



Maintenance Often Depends on Lab Cleanliness

- According to the EERE, dust-free freezers use less energy than dusty freezers at the same temperature. ULT freezers require a lot of ventilation. Dust or grime on the filters blocks air flow and reduces the ability to dissipate heat. Dirt on the condenser increases the amount of energy the compressor needs. Keeping the dust to a minimum and ensuring it doesn't get into the freezer will prolong the freezer's life.
- It is important that condenser filters are checked, cleaned, washed, or replaced, and that coils are cleaned with a vacuum, brush, or wet towel. Condenser filters are reusable and don't need to be changed. Those with front access are easier and faster to maintain since no tools are needed. But, if front access isn't available, virtually all freezers come on wheels that lock so they can be moved to clean.
- If a freezer was located in a temperature-controlled clean room, maintenance needs would be minimal. But, many are located industry locations near windows, open doorways, or high traffic areas. In addition, some laboratories do not perform the recommended maintenance frequently enough. This includes cleaning the filters and condenser fan, as well as removing frost at least every three months.

Price Is Always a Consideration

- To offer low cost freezers, manufacturers eliminate certain components. Low cost freezers are risky for users who need stable, reliable performance and other options that indicate product quality.
- Moderately priced freezers will provide consistent -85 temperatures and protect against oil logging. They may even include USB ports to plug in and manually download operation data. VIP options exist in this category, and the same freezer performance can be had paying double.
- Users who need quality control to validate their product or maintain histories such as in the pharma industry, use higher end freezers. Higher end freezers will provide better refrigeration and automated data logging options that track the operations, events, temperatures, and alarms.

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