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Ultra-Low Freezer Design: Protecting Samples During Inner Door Openings

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Introduction

Ultra-low temperature freezers used in laboratories should be designed to protect the stored contents from unnecessary exposure to warmer temperatures. To help achieve this objective, most upright ultra-low freezers are designed with an inner door for each shelf within the unit, creating enclosed storage compartments inside the freezer. The purpose of the inner doors is to protect the samples stored in the other compartments when one of the inner doors is opened. Ideally, inner doors used in upright ultra-low temperature freezers would be designed to maintain temperatures across other parts of the storage space when a single inner door is opened. However, there is considerable variation in how manufacturers design these inner doors. Certain manufacturers use gaskets to seal the space around the inner doors and prevent warm, moist air from routinely entering the storage area.

In a previous study, the performance of a Helmer iUF126 Ultra-Low Freezer, which is designed with inner door gaskets, was compared to a competitive unit, which does not include inner door gaskets. The two units were tested to determine the increase in cabinet temperature when the outer door is opened. (The inner doors remained closed throughout the test.) After opening the outer door, the temperature was recorded over time. With the outer door open, and all inner doors closed, the previous evaluation demonstrated that inner doors with gaskets were more effective in maintaining cabinet temperature. Using a setpoint of -86ºC, models that used gaskets maintained storage temperatures less than -80ºC after 7 minutes of having the outer door open. However, the unit tested without inner door gaskets warmed to -50ºC within the same time period.

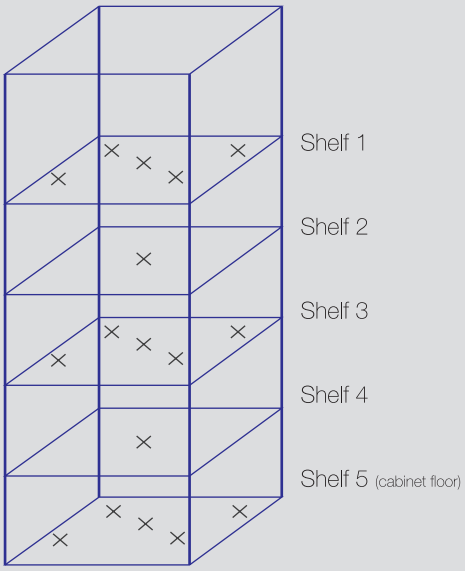
This study takes the performance evaluation noted above one step further. A similar protocol was used, however, after the outer door was opened, an inner door was also opened to simulate door openings to access research or clinical samples. This article evaluates the difference in performance across storage locations between ultra-low freezers that utilize gaskets and those that do not when one inner door has been opened.

Evaluation

The testing protocol compared the performance of a Helmer iUF126 Ultra-Low Freezer, which is designed with inner door gaskets, to a competitive unit, which does not include inner door gaskets. The two units were tested to determine the increase in cabinet temperature when the outer door and one inner door are both opened to a 90º angle. The cabinet average temperature was recorded over time with the doors left open until the temperature exceeded -50ºC. The test was repeated three times for each unit, with a different inner door (top, middle, or bottom) being opened each time.

The units were tested with 17 T-type thermocouples in air. All the thermocouples were installed with the sensing portion approximately 2" from the surface of each shelf. Both test units had 5 inner compartments. The thermocouples were distributed throughout the compartments as shown below:

Exhibit 1.
Location of 17 thermocouples used to measure air temperature.

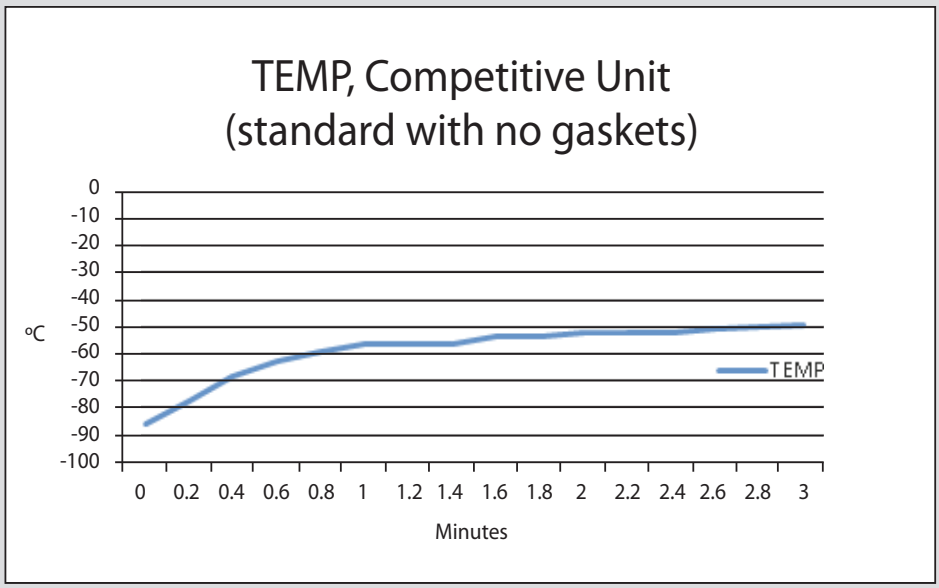


The cabinet temperature average used for these tests is the average of the individual shelf average temperatures. Time is in minutes, with 0 indicating the time of the last measurement before the door opening. Temperature is in degrees Celsius. The set temperature of the ultra-low freezers was -86ºC and ambient temperature was 24ºC, +/- 1ºC. The units were tested with both compressors running throughout the warmup period.

Results

Graph 1: Time for Average Cabinet Temperature to Reach -50°C - Competitive Unit

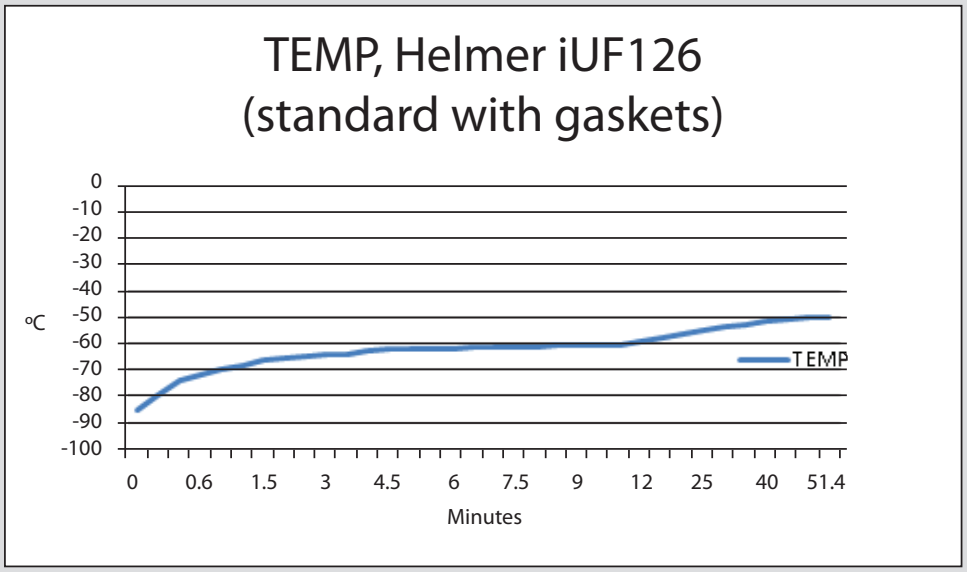
- Unit does not come with inner door gaskets
- Outer door left open
- Top inner door left open



The time for the average cabinet temperature to reach -50ºC with the outer door and top inner door open was 3 minutes.

Graph 2: Time for Average Cabinet Temperature to Reach -50ºC - Helmer Scientific iUF126

- Inner door gaskets installed (standard configuration for unit)
- Outer door left open
- Top inner door left open



The time for the average cabinet temperature to reach -50ºC with the outer door and top inner door open was 51.4 minutes.

Discussion

The purpose of the inner doors in an ultra-low freezer is to protect the contents stored on the shelves behind each inner door (referred to as compartments). When one inner door is opened so that a user can access the products stored inside the compartment, the other inner doors serve to protect the contents in other compartments from being exposed to warm ambient air. Inner doors also help limit the amount of moisture entering the cabinet, thereby minimizing frost build-up in areas of the cabinet used for sample storage.

Exhibit 2:
Summary of Time for Average Cabinet Temperature to Reach -50° with Outer Door and One Inner Door Opened

Open Inner Door Location	Helmer iUF126 Inner door gaskets installed (standard configuration for unit)	Competitive Unit Unit does not come with inner door gaskets
Top	51.4 minutes	3 minutes
Middle	8.5 minutes	5 minutes
Bottom	10.3 minutes	4 minutes

The summary table above demonstrates that there is a difference in the performance of ultra-low freezers that are designed with inner door gaskets compared to those that are not. When the top inner door of the iUF126 was opened, the average cabinet temperature did not rise above -50ºC until more than 51 minutes had elapsed. In comparison, the competiive unit rose to -50ºC in just 3 minutes. The other two inner door locations also represent a significant difference in freezer performance. When the middle door was opened, the iUF126 remained below -50ºC for 3.5 additional minutes compared to the competitive unit, which represents 65% better performance. The additional 3.5 minutes would give users of the freezer more time to access stored items prior to the temperature in other compartments being impacted by the middle door being opened. When the bottom door was opened, the iUF126 stayed below -50ºC, more than twice as long as the competitive unit.

This testing proves the importance of a specific design element, inner door gaskets, to the performance of an ultra-low freezer. Ultra-low freezers that include gaskets on the inner doors limit the intrusion of warm, moist air into the cabinet locations with closed inner doors, protecting the stored contents and minimizing frost build-up.

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