PHCbi

A Member of PHC Group

Navigating Cold Storage Solutions

A practical guide to help choose the right refrigerators and freezers for your needs

Contents

01

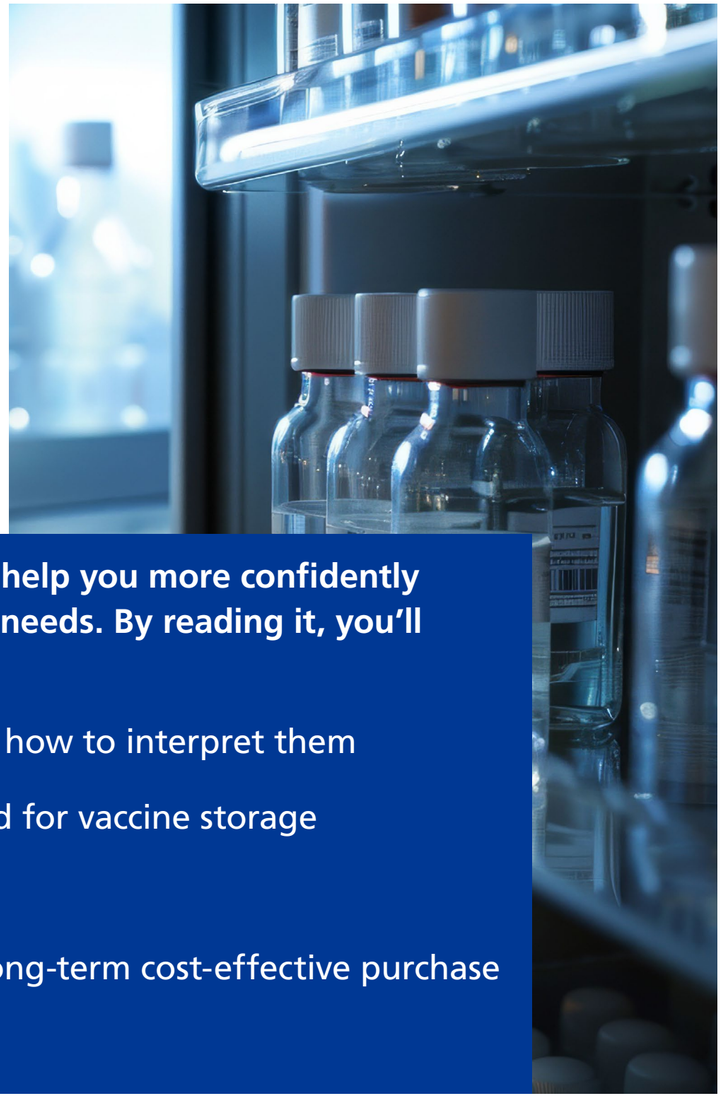
Introduction

Refrigerators, freezers, and ultra-low temperature (ULT) freezers play a vital, but often underappreciated, role in science, safeguarding precious samples and materials while ensuring scientific progress goes on unencumbered.

With recent advancements in medical treatments, the demand for cold storage units has surged. The development of mRNA vaccines during the COVID-19 pandemic, which requires storage at temperatures ranging from -80°C to -15°C,[1,2] has increased demand for ULTs by more than 500% according to some accounts.[3] The growth of cell and gene therapies has further driven the need for cold storage solutions.[4] As we continue to develop more novel, advanced therapies and vaccines, purchasing reliable, high-quality performance refrigerators and freezers will become ever more important for maintaining scientific progress.

Selecting the right cold storage solution, however, is challenging.

With so many different options, performance metrics, regulations, and features to consider, choosing a reliable cold storage unit that fits your needs can feel overwhelming. It's no surprise, then, that people might struggle to make a confident purchasing decision. Indeed, without knowing what to look for, decision makers risk buying a less than adequate refrigerator or freezer, wasting time and resources and, at worst, hampering any further research progress or compromising valuable products and samples.



This eBook provides practical, expert advice to help you more confidently purchase an optimal cold storage unit for your needs. By reading it, you'll learn more about:

- Key metrics to evaluate performance and how to interpret them
- Regulatory considerations to keep in mind for vaccine storage
- Sustainability considerations
- How to help maximize the chances of a long-term cost-effective purchase
- Key technological factors to look for

02

Capacity, Space, and Location

One of the first things to consider when looking for a new cold storage solution is the size and capacity that will best fit your current and projected research needs, and the size limitations of your facility.

Available floor space

The floor space you have available in your facility will be a big deciding factor when it comes to the most suitable style of refrigerator or freezer — upright models or chest models.

Upright models tend to have a smaller footprint,[5] so they can be ideal for making the best use of limited space. They are also ideal for storing materials that require frequent access. Chest models, on the other hand, typically have a larger footprint[6] (and so may not be suitable for space-strapped facilities), and are better suited for the long-term storage of materials that don't need to be accessed as often. They also reduce the range of temperature fluctuation between door openings as more cold air remains in the chamber compared to upright models that have the cold air leaving the chamber after each door opening.[7]

In addition to the unit's physical size, you also need to keep in mind ventilation clearance requirements when deciding on the best-fit unit for your floorspace; most refrigerators and freezers will require at least six inches of clearance to the sides and rear of the unit to allow the heat from the compressor to properly ventilate, and for easy access in case repair technicians need to access other parts of the unit.

Storage capacity

Another important initial consideration is the quantity of material that you'll need to store. High-volume capacity units are necessary for facilities with large-scale or long-term storage needs. For labs with fewer or more specialized storage needs, smaller volume units will generally suffice.

Unit capacity is often measured either by cubic foot capacity, or by how many standard 2-inch sample boxes they can hold. Careful consideration of these metrics helps ensure you select a solution that balances volume with practical usability for your specific needs.

For help with deciding on the best storage solution for your capacity and space needs, you can use the following decision tree:

1	**What is the required storage volume for your samples?**	
	High capacity for large volumes	*Go to **2** >*
	Moderate to low capacity for smaller volumes	*Go to **3** >*
2	**How much physical floor space is available in your lab or facility?**	
	Ample space for larger units	Consider **Chest Models** *(high-capacity storage but requires more floor space, ideal for bulk storage with less frequent access).*
	Limited space available	Consider **Large Upright Units** *(upright models with high storage density, designed to optimize space in compact areas).*
3	**Will the cold storage unit be placed in a controlled or restricted area, like a cleanroom?**	
	Yes, in a cleanroom or controlled space	Look for **Cleanroom-Classified Upright Units** *with compact profiles and low particle emissions (ISO-rated units suitable for restricted spaces).*[8]
	No, in a standard lab or room	*Go to **4** >*
4	**Do you need easy access to samples with limited floor space?**	
	Yes, frequent access in limited space	Consider **Slim-Profile Upright Models** *(small footprint and convenient access in tight spaces).*
	No, occasional access is fine	*Go to 5 >*
5	**Are you primarily storing smaller samples that benefit from organization?**	
	Yes, need to organize smaller samples	Consider **Upright Models with Racking Options** *(allows high-density, organized storage of smaller samples in a small footprint).*
	No, bulk storage is needed for larger samples	Consider **Standard Chest Models** *(more space-efficient for larger samples, where organization is less critical).*

03

Temperature Uniformity and Recovery

The most important function of a cold storage unit is to maintain the temperature of stored materials. To do this reliably, refrigerators and freezers must have good temperature uniformity and recovery.

But what do these measures actually mean?

Temperature uniformity refers to the consistency in temperature across different points within the unit's chamber. In cold storage units, every part of the chamber should maintain the same temperature to ensure all stored materials are kept in the same optimal conditions.

Temperature recovery is simply how quickly the unit can return to the set temperature after the door is opened (exposing the chamber to warm air) and then closed. A high-quality unit should have sufficient cooling capacity to quickly return the contents to the set temperature.

Without good temperature uniformity and recovery, a cold storage unit could end up compromising the integrity of stored materials, impacting their quality and viability.

Selecting cold storage units with optimal uniformity and recovery

Unfortunately, there is no 'one-size-fits all' value to look for when it comes to assessing uniformity and recovery metrics. Generally speaking, prospective buyers should look for units that return to temperature as quickly as possible after door opening and that don't give rise to hot or cold spots in the chamber.

Ultimately, though, the most important thing is to consider the needs and requirements of your specific application and select equipment that can adequately meet those needs. For instance, storing vaccines requires strict adherence to very specific storage temperatures (discussed in more detail in **Chapter 4**).

Understanding the impact of testing variation

To make sure a unit meets your specific temperature recovery and uniformity requirements, you'll need to understand and be able to interpret performance testing data. To do that, you'll need to understand variations in common testing conditions and how they can impact performance readouts.

Probe placement

Probe placement during testing can vary between cold storage equipment providers and can impact both temperature recovery and uniformity readouts.

When it comes to measuring uniformity, the number and location of probes can range from just one probe in the center of the unit, to multiple probes scattered evenly throughout. Fewer probes, or poorly positioned ones, can underestimate temperature fluctuations within the unit.

When evaluating temperature recovery, it is important to be aware that probes placed near the back, lower parts of a ULT chamber (away from the door and in close proximity to cooling systems) will read a faster temperature recovery than those at the top or front (positioned closest to the door and furthest from cooling systems). Similarly, for refrigerators, probes placed near the air-cooling outlet will recover more quickly than those elsewhere.

Unit contents

How full a unit is can also impact temperature recovery. Since most of the energy expended by a refrigerator or freezer goes into cooling down the warm air that enters upon door opening, the more a unit is filled (and thus the less air space there is in the chamber), the faster the refrigerator or freezer can recover.

Ambient temperature

The temperature of the testing area can impact temperature recovery readouts. When a unit is tested in higher ambient temperature conditions, there will be a larger temperature difference between the chamber and the air surrounding the unit, leading to a larger drop in temperature upon door opening, and thus a slower recovery following door closure (relative to the same unit tested at a lower ambient temperature).

Top Tip

To get a clearer idea of just how relevant manufacturer testing results might be for your application, ask yourself if the testing conditions reflect your anticipated usage of the equipment. Are probes placed in the areas where you will store samples or products? Are door opening durations realistic for your use case? If not, ask the equipment provider if they can conduct unit testing according to your requirements.

Features to look out for

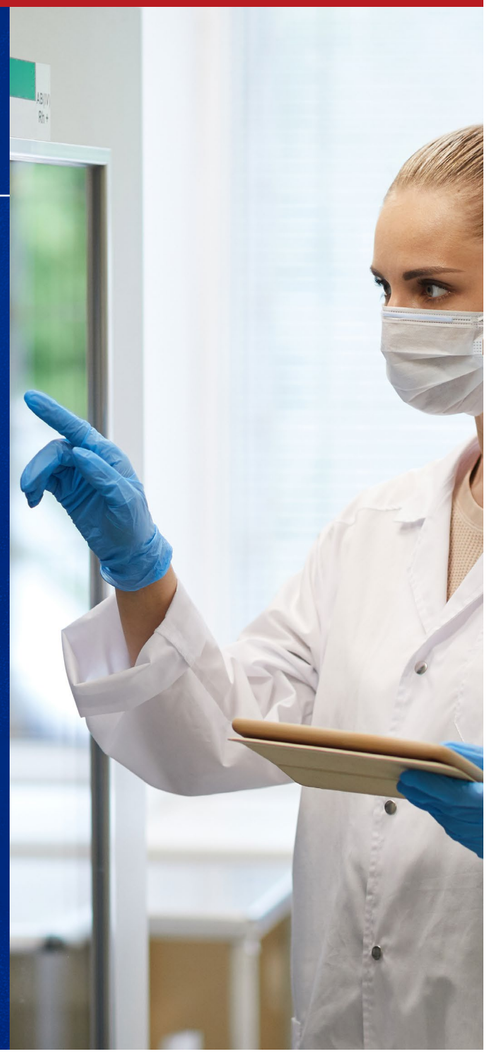
Beyond just looking at uniformity and recovery performance readouts, consider looking for units with the following features, which can help to ensure consistent chamber temperatures.

Traceability

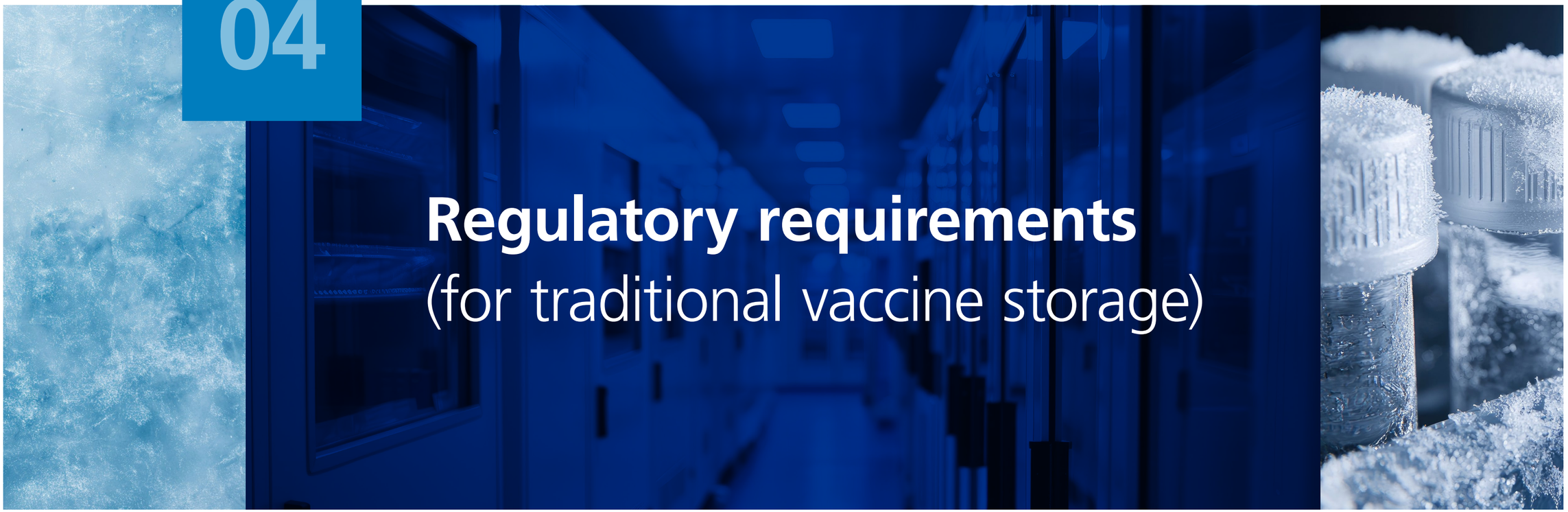
Units with access tracing capabilities, such as those afforded by electronic digital locks, key cards, or facial recognition, can help teams spot deviations from best practices (such as prolonged door openings) and swiftly address them. Traceability can therefore be a useful tool in helping reduce temperature excursions and protecting valuable stored products and samples.

Remote temperature monitoring systems

Look for units that can easily integrate with remote temperature monitoring systems. These systems allow organizations to track temperature in real time and can send instant alerts when temperatures fall outside of the appropriate range. This can help teams quickly identify and address temperature excursions to better protect the integrity of the unit's contents. Remote temperature monitoring systems tend to use Wi-Fi or Ethernet connectivity, however, there are other emerging methods of connectivity such as Bluetooth, cellular, etc.



04



Regulatory requirements
(for traditional vaccine storage)

If you are looking to purchase refrigerators or freezers to store traditional vaccines, there are additional regulatory requirements to consider.

Proper vaccine storage is vital in preventing and eradicating vaccine-preventable diseases; improper storage can reduce vaccine potency, resulting in inadequate immune response in patients. Poor vaccine storage can also lead to significant financial losses if vaccines are no longer usable, or if revaccinations are necessary.

Two guidelines help assure the adequate storage of vaccines — the CDC guidelines[9] and the NSF 456 guidelines[10] — with implications for your choice of refrigerator or freezer.

The CDC vaccine storage guidelines

Temperature requirements

Refrigerators: 36°F – 46°F (2°C – 8°C)

Freezers: -58°F – +5°F (-50°C – -15°C)

ULT freezers: -130°F – -76°F (-90°C – -60°C)

Refrigerator and freezer recommendations

The CDC recommends using purpose-built (otherwise known as pharmaceutical-grade) units that are specifically designed for the storing of biologics (including vaccines).[9] Such units come in a range of sizes, and often have features such as microprocessor-based temperature control and fan-forced air circulation to promote good temperature uniformity and recovery, ensuring stored vaccines are kept within the safe temperature ranges.[9]

Temperature monitoring device (TMD) recommendations

The CDC guidelines also state that every cold storage unit for vaccines must also have a temperature monitoring device that can maintain an accurate temperature history.[9] An accurate temperature history is critical for protecting vaccines, as it can help organizations identify whether vaccines have been stored at out-of-range temperatures at any point in their lifespan.[9]

Specifically, the CDC recommends a type of temperature monitoring device called a digital data logger (DDL), which provides the most accurate storage unit temperature information.[9] Unlike a simple minimum/maximum thermometer, which only shows the coldest and warmest temperatures reached in a unit, a DDL provides detailed information on all temperatures recorded at preset intervals, as well as details on how long a unit has been operating outside of its recommended temperature.[9]

For the full CDC recommendations regarding DDLs, see the **CDC vaccine storage and handling tool kit**.

Maintenance

The CDC also stresses the importance of regular maintenance (which is generally recommended, whatever your refrigerator or freezer application).[9] Looking for a unit that is easier to maintain and has features that reduce maintenance requirements, such as frost-reduction (discussed in more depth in **chapter 6**), could help reduce the time and costs associated with such maintenance.

The NSF 456 regulations

While the CDC provides broad recommendations, the NSF 456 standard defines specific performance-based criteria that cold storage units must meet.

Units have to be tested according to defined procedures and under strict conditions at accredited third-party testing organizations. Testing comprises three rigorous tests using vaccine simulation devices (VSDs):[11]

1. **Closed-door test:** with the unit door closed, all VSDs must stay within the allowed temperature range.
2. **Short door opening test:** the door is opened once every ten minutes over a period of three hours. The door is then opened once every five minutes for the next hour. During the total four-hour period, the VSDs must all stay in the allowed temperature range.
3. **Long door opening test:** after the short door opening test, the door is opened for three minutes. Once the door is closed, all the probes within the cabinet must recover to below 8°C for refrigerators, or below -15°C for freezers, within 15 minutes.

An NSF 456 certified unit will have passed all of the above tests, ensuring it can maintain the conditions necessary for safe traditional vaccine storage.

05

Reliability and robustness

To adequately protect its valuable contents, a refrigerator or freezer must be reliable and robust.

While reliability refers to the predicted amount of time a piece of equipment will perform its expected function(s) under stated conditions without failure, robustness refers to how well a product can accommodate long-term improper use or stressful environmental conditions and still work as new.

These qualities are vital not only for safeguarding samples and products but also for reducing disruptions and costs, since a reliable and robust unit will require fewer repairs and maintenance.

Assessing reliability and robustness

There are no specific standardized tests for reliability and robustness, making it hard to dependably assess these aspects of performance. However, there are several ways prospective buyers can build up a relatively good picture of a unit's reliability and robustness before purchasing.

Talking to colleagues

People within your own organization can be a valuable source of information. For example, colleagues may have already used, or be currently using, a unit that you are considering for purchase, and therefore may be able to offer helpful insights about their reliability or robustness (as well as other aspects of performance).

Repair technicians within your organization may also have valuable insights to share. Having potentially repaired many pieces of lab equipment in their careers, they may, for instance, be able to inform you of common issues they have faced with particular brands or units, or confirm if, in their experience, certain brands experience more frequent failures.

Social media forums

Public and professional online forums can be a useful source of information about the reliability and robustness of cold storage equipment. Reading through the relevant discussions on forums such as r/labrats on Reddit, for example, can give you an overview of the community consensus and opinion on the product and highlight any common issues or red flags.

That said, it is important to keep in mind that information on forums — particularly public forums — may not always be reliable, so remain diligent when using these as an information source. If possible, seek forums that do not allow employees of cold storage equipment vendors to participate in discussions, such as LabOps Unite.

Assessing the experience of the equipment provider

How long an equipment provider has been in the industry can also be an important indicator of the quality of the equipment they produce.

Companies who have spent longer in the industry will have learned valuable lessons about design and build quality that they can leverage to create more reliable and robust products. Furthermore, the longevity of a company can provide reassurance that they are good at what they do — while it may be easy to build a cold storage solution, building a good one that lasts is a difficult task that requires extensive industry experience.

Asking the vendor the right questions

Asking the vendor the right questions can also help you gather important information that can further build out your understanding of the unit's reliability and robustness. We recommend asking vendors the following:

01

The testing process: how long do you operate the refrigerator/freezer to assess robustness and reliability?

A shorter testing duration isn't likely to give you a very good insight into long-term reliability and robustness. Ideally, look for a provider that runs their cold storage equipment non-stop for at least six months before they take it apart and examine component wear and tear.

02

Critical components: what is the failure rate of critical components?

Key components to inquire about include compressors, door hinges (as they are a common point of breakage), and display controls, focusing on issues such as screen freezing or blackouts.

03

Manufacturer repairs: what are the most common repairs that need to be made to a unit?

Manufacturer repair records can provide valuable insights into how frequently equipment fails, and the most common points of failure.

04

Third-party analysis: has the reliability/ robustness been audited by an independent third party?

Assessment by an independent third party can provide further confidence in a unit's performance and verify that information provided by the manufacturer is accurate.

A key feature to look out for: Dual cooling systems (ULTs)

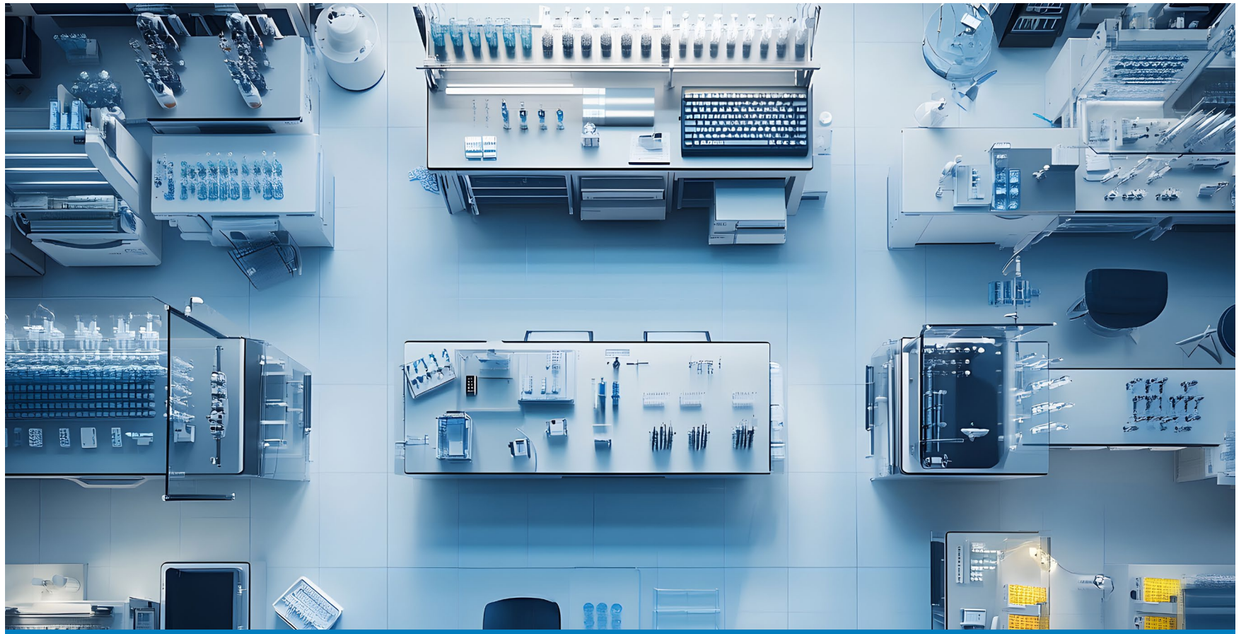
Having two independent cooling systems provides an extra layer of protection for valuable samples and products. In units with this feature, there are two independent refrigeration systems that provide a reliable -86°C temperature. In the event of an unexpected failure of one cooling circuit, the other can maintain the freezer in the -70°C range for a period of time until service can be arranged.

06

Total cost of ownership (TCO)

When purchasing cold storage solutions, it is important to look beyond the initial cost and consider the additional associated costs that can mount up over the product's lifespan — in other words, it is important to consider the unit's total cost of ownership (TCO). There are numerous factors that can impact a refrigerator's or freezer's TCO, and failure to consider them at the buying stage can mean that a seemingly cost-effective unit can become a financial burden in the long run.

Key factors contributing to TCO



Floor space requirements

An often-overlooked aspect of the overall cost of a unit is the price of the floor space it occupies in the lab. Keep in mind that the cost per sq. ft can vary significantly depending on your location, so it is essential to keep this in mind when exploring cold storage unit options.

Energy efficiency

Another contributor to overall costs is energy efficiency. More energy efficient systems will naturally consume less power for the same activity, directly reducing operating costs. Over time, these energy cost savings may offset the higher initial purchase price, making energy-efficient models potentially more cost-effective in the long run.[12]

A good way to determine a unit's energy efficiency is by using official ENERGY STAR® ratings, which can be verified by the presence of the ENERGY STAR logo. Since ENERGY STAR testing is standardized, these ratings allow easier comparison across manufacturers and models, too.

To make sure you can better evaluate a product's energy efficiency in the context of your own application, it is important to also understand how testing conditions affect energy consumption. There are two important variables that impact energy efficiency readouts (and if testing isn't done by ENERGY STAR, these factors may not be the same from unit to unit).

Accessory usage

Accessory usage during energy-efficiency testing can, understandably, impact energy consumption results. Testing with accessories switched off, for instance, will result in lower energy consumption than testing with accessories on. Therefore, it's important that all accessories are turned on during testing for the most accurate energy consumption results.

Ambient temperature

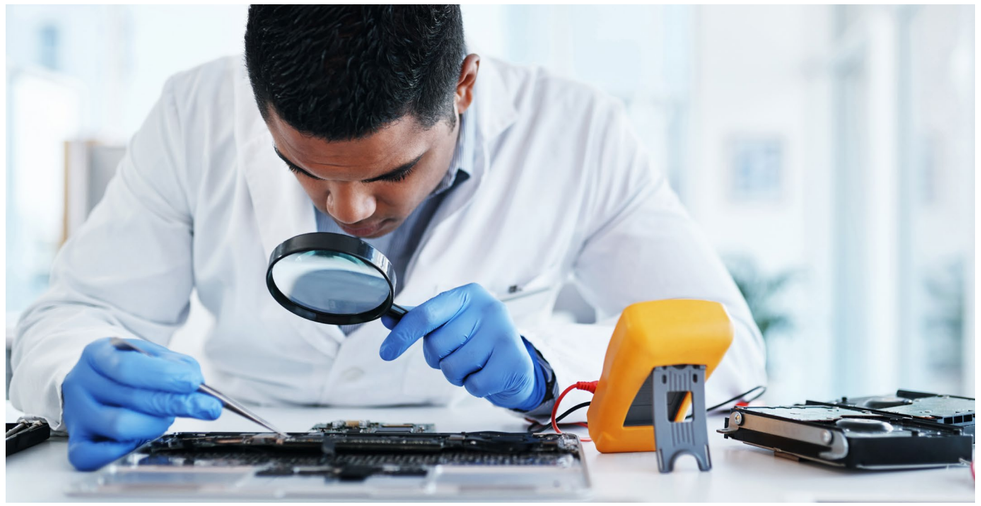
Ambient temperature not only affects temperature uniformity and recovery (as noted earlier), but also impacts energy consumption. The ambient temperature determines how hard a unit has to work to maintain its low internal chamber temperature - the higher the ambient temperature during testing, the more energy a unit will consume to maintain its chamber temperature.[13]

Reliability

Purchasing a reliable unit is essential for reducing TCO, as unreliable equipment can significantly increase operational costs over time.

For unreliable units, the cost of repairs and replacement of key components can quickly accumulate. The downtime resulting from repairs and breakdowns can also decrease productivity and potentially result in the loss of samples or materials, further driving up costs.

See **chapter 5** for tips on how to vet a unit for reliability before purchasing.



Maintenance

Regular maintenance is crucial for extending the life of cold storage units, preventing costly breakdowns, and minimizing downtime. By purchasing units that require less maintenance, or are easier to maintain, businesses can reduce the associated expenses.

Features to look for

When choosing cold storage equipment, certain features can help lower the TCO:

Frost reduction (ULTs)

Frost build-up can damage freezer components, put pressure on the freezer outer door, and reduce energy-efficiency. Clearing the frost buildup is therefore an essential but time-consuming part of maintenance.

A ULT that reduces the accumulation of frost decreases maintenance time, freeing up staff for more valuable activities and improving productivity. Additionally, less frost accumulation ensures that the freezer is functioning optimally, helping maintain energy efficiency and reduce the frequency of repairs (further lowering costs).

Warranties

Outside of performance considerations, the type of warranty that accompanies a cold storage unit can have a significant impact on TCO. To reduce overall costs, decision makers should look for a parts and labor warranty, as opposed to a parts-only warranty.

While a parts-only warranty means you won't need to buy parts for repair (which are often only a small fraction of the total cost of repair), you'll still need to arrange, manage, and pay for labor, which can be very expensive and time-consuming.

A full parts and labor warranty, however, covers parts and labor expenses, and will also mean you don't need to arrange the repair work, making it a more cost-effective and less time-consuming option in the long run.

Calculating total cost of ownership

With so many factors to consider when it comes to TCO, it can be helpful to create a cost table that tracks and compares the key factors across different units. On the right is a blank template of such a table.

	Unit 1	Unit 2
Annual floor space cost Unit footprint (sq.ft) x annual floor space cost (e.g., $/sq.ft)		
Annual unit energy cost Energy consumed (kWh/day) x 365 x local energy cost (cents/kWh) x 100		
Estimated annual unit maintenance cost (labor and parts)		
Annual unit LN_2 cost (relevant if purchasing an LN_2 ULT unit) LN_2 tank rental cost + LN_2 cost + LN_2 delivery cost		
Annual operational cost Annual floor space cost + annual unit energy cost + annual unit maintenance cost + annual LN_2 cost		
Predicted length of ownership (years)		
Lifetime operational cost Annual operational cost x predicted length of ownership		
Initial unit purchase cost		
Total cost of ownership Lifetime operational cost + initial purchase cost		

07

Sustainability

Reducing environmental impact is becoming an increasingly important focus in the life sciences sector. Cold storage equipment can be a significant contributor to an organization's environmental impact, so it's important to select the most sustainable option that fits your application.

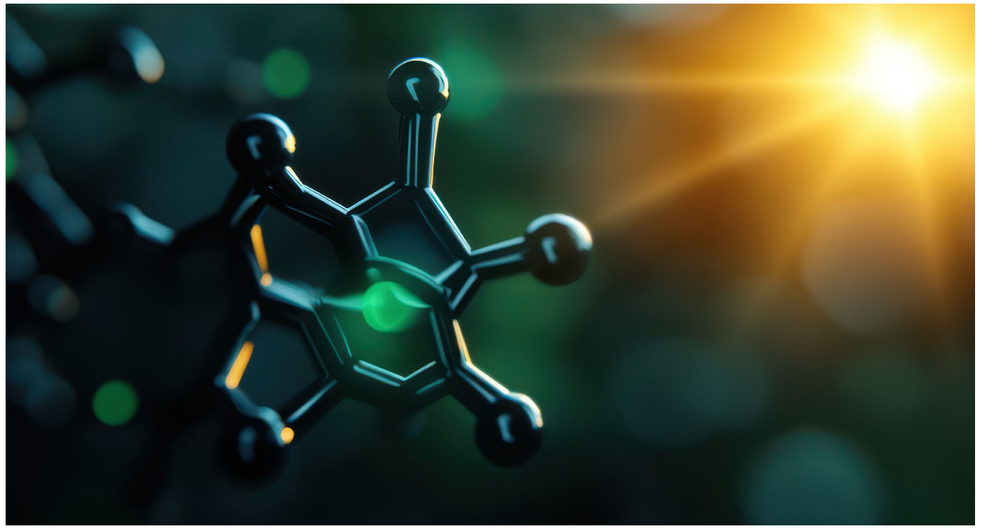
Key considerations for sustainability

Energy efficiency

Please note that the information below applies exclusively to US markets.

Units with greater energy efficiency consume less energy to achieve their required functions and are thus more environmentally friendly. Look for official ENERGY STAR certification, as this provides assurance that a unit meets stringent energy efficiency criteria.

Be aware, however, that the requirements for ENERGY STAR certification are changing after June 30th, 2025. Due to advances in cold storage efficiency, the baseline for efficient energy consumption will be reduced, meaning >80% of the products that currently have an ENERGY STAR certification may lose it after June 2025. As such, check with vendors that the product in question will still be part of ENERGY STAR after the changes (as this will ensure you purchase a product that continues to be among the most energy efficient on the market).



Natural refrigerants

Different refrigerants have drastically different environmental impacts.

To determine the level of impact of the refrigerants used in a cold storage unit, purchasers can look at their Global Warming Potential (GWP) by doing a simple internet search. GWP is a measure of the relative impact of different greenhouse gases on global warming compared to carbon dioxide, which is assigned a value of 1. For instance, a refrigerant with a value of 12 would be 12 times more polluting than CO_2.

One of the most popular refrigerants used today, R-134a, has a GWP of 1,430. However, newer, natural refrigerants that are much more environmentally friendly are now available. Hydrocarbon refrigerants such as isobutane (R600A) and isopropane (R290), which have GWP scores of 3, for example, are becoming increasingly popular as an alternative to higher GWP refrigerants.[14]

As well as being better for the environment[15], natural hydrocarbon refrigerants are also more energy efficient, resulting in lower running costs.

Product support

Looking for manufacturers that are committed to continuing supply of parts after the end of production will mean organizations can use their unit for longer before buying a replacement, reducing the number of units going to waste, and saving costs associated with more frequent unit replacements.

Equipment end-of-life considerations

Cold storage units can still have a significant environmental impact even at the end of their life, particularly if they go to landfill. As such, when purchasing a cold storage unit, look for companies that offer take back programs for old products, and be sure to confirm what they do with the units once they receive them. If they simply send the old units to landfill, then the take-back program does little to mitigate environmental impact.

Some companies also offer programs whereby old equipment can be donated to developing countries, helping to both minimize e-wastage in landfill, and giving organizations a unique opportunity to access critical equipment they might otherwise struggle to purchase.

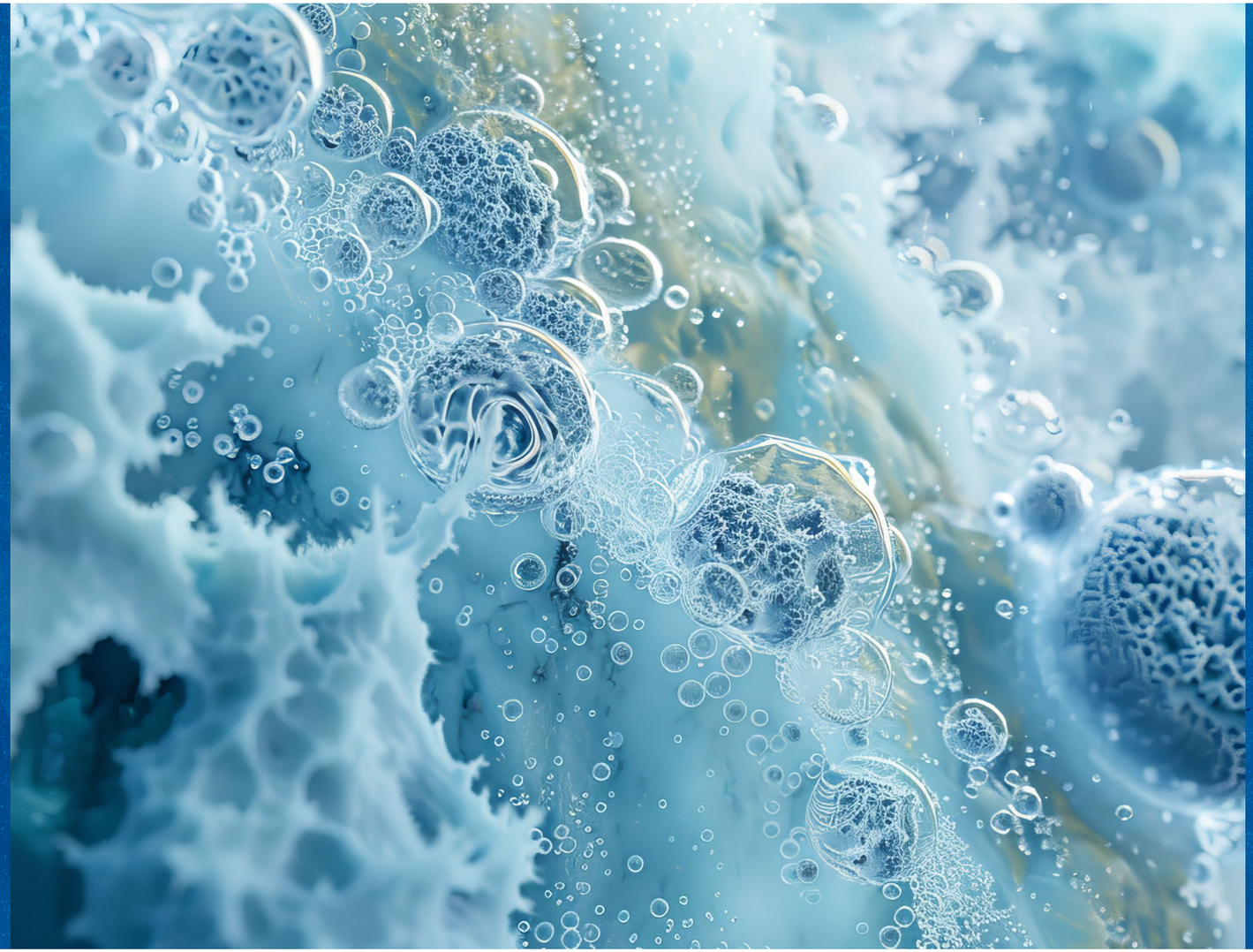
08

Technological considerations

In addition to the wealth of features discussed throughout this eBook, there are several other important technological considerations to be aware of when purchasing cold storage equipment.

ULTs: liquid nitrogen (LN_2) vs mechanical

When selecting ULTs, two primary cooling technologies are available: liquid nitrogen (LN_2) systems and mechanical refrigeration. Understanding the advantages and limitations of each is critical for selecting a unit that best meets your needs.



How the two technologies work

Liquid nitrogen systems

In LN_2 freezers, liquid nitrogen is stored in highly insulated containers and achieves extremely low temperatures through vapor expansion (transitioning from liquid to gas).

Mechanical ULT freezers

These systems employ multiple refrigeration cycles using a blend of refrigerants to reach ultra-low temperatures. High-insulation materials, such as blown-in foam and vacuum insulation panels (VIP), help maintain temperature consistency.

Advantages of mechanical ULT freezers over LN_2

Lower operational costs

Mechanical freezers have much lower operational costs than LN_2 freezers, with LN_2 freezers having continuous costs associated with the procurement, delivery and handling of LN_2.[16] By far the largest cost is that of the LN_2 itself, though — on average an LN_2 freezer consumes up to $9000 worth of LN_2 a year.[16]

By comparison, mechanical freezers consume only electricity, the cost of which amounts to only around $700 a year.[16]

Safety considerations

Handling and storing LN_2 poses risks including: asphyxiation, frostbite from accidental exposure, and potential container explosions (if not properly vented). Mechanical freezers reduce these risks by relying solely on electrical power, enabling safer operation.

Environmental impact

Producing liquid nitrogen is energy-intensive, involving high-pressure liquefaction of atmospheric air. With the process being only 25% efficient, a significant portion of nitrogen is also wasted during production.[16] This inefficiency contributes to a higher environmental footprint compared to the mechanical freezers, which rely only on electricity.[16]

When to consider LN_2 freezers

Despite their limitations, LN_2 freezers may be preferable for applications that demand rapid cooldown rates, or when maintaining extremely low, stable temperatures over extended periods is critical. Their simplicity and independence from electrical grids also make them valuable in areas where a stable power supply can't be guaranteed.

Choosing between LN_2 and mechanical ULT freezers ultimately depends on your operational priorities, cost considerations, and safety requirements. Assessing these factors will help ensure that the cryogenic storage solution you select is right for your needs.

Integration with existing systems

Ensuring a new refrigerator or freezer integrates seamlessly with current systems is critical for efficient operations and reliable data management. There are several key features to look out for to help increase chances of a smooth integration.

Rack compatibility and capacity (ULTs)

Ensure that new ULT freezers have rack systems compatible with current cold storage equipment. This compatibility is crucial for maintaining efficient workflow and optimizing storage capacity. Additionally, having interchangeable racks and similar capacity to current cold storage units allows for easy sample transfer between units during preventative maintenance or repairs, minimizing downtime and protecting sample integrity.

Hardwired connectivity options

For facilities located in remote areas or regions prone to signal interference, hardwired connections are more reliable than wireless connections. Choosing a unit with options for hardwired connections can therefore lead to a more reliable integration with other lab equipment.

Connectivity to alert and notification systems

New storage units should be able to seamlessly integrate with common facility alert systems, enabling real-time notifications of temperature fluctuations or system issues. This integration is crucial for timely identification of — and response to — issues, and thus for maintaining sample and product safety.

Advancements in cold storage technology

Cold storage technology is continually improving. One notable advancement comes in the form of **inverter compressors**. Unlike old 'on-off' compressors, inverter compressors dynamically and rapidly adjust their speed based on the immediate cooling requirements, helping to reduce energy consumption and enabling better temperature uniformity and recovery after door opening.

09

Feature recommendations summary

Throughout the eBook, we have recommended looking for cold storage units with various features. We've summarized these features and their benefits in the table below for easy reference:

Feature	Description	Benefits
Access-tracking capabilities	Systems that track access, such as with digital locks, key cards, or facial recognition, to monitor usage and identify deviations in best practices	Helps organizations swiftly address issues (such as prolonged door openings) to minimize temperature fluctuations
Dual cooling systems (ULTs)	ULT freezers with two independent cooling circuits that help maintain reliable temperatures. If one circuit fails, the other can keep the chamber in the -70°C range	Provides an extra layer of protection for valuable samples and helps ensure uninterrupted temperature control until maintenance can be arranged
Frost reduction (ULTs)	Minimizes frost accumulation within the freezer	Reduces maintenance time, ensures optimal energy efficiency and helps prevent damage to components, leading to potential cost savings
Monitoring system connectivity	Enables easy integration with remote systems that track temperatures in real time and send alerts for immediate issue resolution	Helps maintain consistent temperature control, reduces energy consumption, and ensures sample and product safety by preventing potential temperature excursions
Inverter compressors	Compressors that quickly and dynamically adjust their speed based on immediate cooling requirements	Faster response to temperature fluctuations (leading to faster recovery), and more efficient energy usage (compared to "on-off" compressors)
Hardwired connectivity options	Enables wired connectivity to other systems and equipment	Ensures secure and reliable connectivity in facilities in remote areas or where signal interference is common

10

Choosing the ideal cold storage solution for your needs

Refrigerators and freezers, while often overlooked, play an integral role in the life sciences industry, safeguarding valuable samples and products to facilitate scientific progress and improve lives. Selecting the right refrigerator or freezer for your needs is therefore crucial.

But that's easier said than done.

Organizations looking to purchase a refrigerator or freezer will need to consider a wealth of factors and features to find an option that's right for their needs, which can quickly become overwhelming.

However, having absorbed the information and top tips summarized in this guide, and by making use of the questions and tools, you'll be in a much better position to understand what to look for, where to look for it, and how to engage with vendors to find a cold storage solution that meets your specific application and sustainability goals in the most cost-effective way.

Driven by a commitment to protect science, we deliver laboratory refrigerators and freezers known for their reliability, durability, performance, and sustainability. Our user-centric designs and advanced features also ensure operational ease and effortless use.

Backed by a rich cultural heritage of excellence, our cold storage equipment empowers labs worldwide to deliver seamless scientific progress with confidence.

Browse our broad selection of cold storage solutions today, or **reach out to one of our knowledgeable team members** to discuss how our solutions can meet your specific cold storage needs.

Product pages

Contact us

References

1. European Medicines Agency. Spikevax: EPAR - Product Information. European Medicines Agency website. https://www.ema.europa.eu/en/medicines/human/EPAR/spikevax. Accessed January 10, 2025.
2. Pfizer, Inc. Pfizer and BioNTech Submit COVID-19 Vaccine Stability Data. Pfizer News. https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-submit-covid-19-vaccine-stability-data. Accessed January 10, 2025.
3. Nature. The demand for ultracold storage has soared—and with it, the need for sustainability best practices. https://www.nature.com/articles/d42473-021-00361-7#:~:text=The%20world%20of%20laboratory%20freezers,some%20accounts%20more%20than%20500%25. Accessed January 10, 2025.
4. Cell and Gene Therapy. The rise of gene & cell therapy and the resulting need for in-house production facilities: A guide. https://www.cellandgene.com/doc/the-rise-of-gene-cell-therapy-and-the-resulting-need-for-in-house-production-facilities-a-guide-0001. Accessed January 10, 2025. .
5. PHC Corporation of North America. Ultra Low Temperature Freezers (-150ºC/-86ºC). https://www.phchd.com/eu/biomedical/preservation/ultra-low-freezers. Accessed January 20, 2025.
6. National Institutes of Health. Freezer Challenge guide. 2022. Microsoft Word - NIH Freezer Challenge Guide Dec 14, 2022. Accessed January 10, 2025.
7. Lab World. A Guide to Selecting an Ultra-Low Temperature Freezers. https://www.thelabworldgroup.com/blog/guide-to-ultra-low-temperature-freezer/ Accessed January 10, 2025.
8. International Organization for Standardization. Cleanrooms and associated controlled environments — Part 14: Assessment of suitability for use of equipment by airborne particle concentration. 2016. ISO 14644-14:2016(en), Cleanrooms and associated controlled environments — Part 14: Assessment of suitability for use of equipment by airborne particle concentration. Accessed January 10, 2025.
9. Centers for Disease Control and Prevention. Vaccine Storage and Handling Toolkit. CDC website. https://www.cdc.gov/vaccines/hcp/storage-handling/index.html. Accessed January 10, 2025.
10. National Sanitation Foundation International. NSF/ANSI 456: Vaccine Storage Standard. 2021. https://webstore.ansi.org/standards/nsf/nsfansi4562021a?srsltid=AfmBOor1xNPFr_0NuI_CAO3dk2ASK0-XknbLpbrTGkYzn08yAG7N8zgN. Accessed January 10, 2025.
11. Thermo Fisher Scientific. Vaccine Storage Standards by NSF International Whitepaper. https://assets.thermofisher.com/TFS-Assets/LPD/Technical-Notes/Vaccine%20Storage%20Standards%20by%20NSF%20International%20Whitepaper.pdfAccessed January 10, 2025.
12. Practice Greenhealth. Mayo Clinic: Replacing Freezers Leads to Energy and Cost Savings. Practice Greenhealth. https://practicegreenhealth.org/tools-and-resources/mayo-clinic-replacing-freezers-leads-energy-and-cost-savings Accessed January 10, 2025.
13. Gumapas LAM, Simons G. Factors affecting the performance, energy consumption, and carbon footprint for ultra-low temperature freezers: case study at the National Institutes of Health. World Rev Sci Technol Sust Dev. 2013;10 (1/2/3):129.
14. American Biotech Supply. Environmentally Friendly Refrigerants. https://americanbiotechsupply.com/environmentally-friendly-refrigerants/. Accessed January 20, 2025.
15. Hwang Y, Jin DH, Radermacher R. ARI: Global refrigerant environmental evaluation network (GREEN) program comparison of hydrocarbon R-290 and two HFC blends R-404A and R-410A for medium temperature refrigeration applications. Final interim report. Air-Conditioning, Heating, and Refrigeration Institute; March 2004. https://www.ahrinet.org/system/files/2023-06/Green%20Program%20Report%20Final-03-04_0.pdf Accessed January 10, 2025.
16. PHC Corporation of North America. The Future of Cryogenic Storage: A Comparative Analysis Between Liquid Nitrogen and Mechanical Freezers. 2024. https://pages.services/markitbiomedical.com/energy-use-in-cryogenic-storage-white-paper/?utm_source=linkedin&utm_medium=social&utm_content=11.11.24. Accessed January 10, 2025.