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The Expanding Cold Chain:

Low and Ultra Low-Temperature Vaccine Freezers
for COVID-19 Vaccines and Future Pandemics

It's likely that in 2020 more people on the planet are concerned about vaccines, vaccine transport, and vaccine storage than at any other time in history.

Aside from this year, when was the last time a news reporter covered a story on the national network of freezers capable of storing vaccines? And how many people knew how cold an ultra low-temperature freezer could reach before the Pfizer-BioNTech COVID-19 mRNA vaccine hit the news?

Because of the COVID-19 pandemic and the possibility of future global viral pandemics to follow, hospitals, universities, public research bodies, clinics, pharmacies, and other institutions working in human health are either expanding their access to vaccine storage freezers or entering into the nationwide network of vaccine storage freezers for the first time

This guide is intended to help your workplace understand:

- What it needs
- How vaccine storage freezers work
- The freezer features that matter most for high-value vial storage, like COVID-19 vaccines
- How to run yours as efficiently as possible
- ...and just about everything else you want to know

This guide is written within the context of the current COVID-19 vaccine climate in North America (Jan 2021) - where two vaccines (Pfizer-BioNTech and Moderna) are approved and likely to provide the bulk of the initial vaccinations on the continent.

It's your quick reference for effectively participating in the most significant vaccine rollout of your life.

What does your workplace need?

Different vaccine technologies require different storage temperatures. The largest volume of existing vaccines require refrigerators, not freezers. This includes vaccines for things like hepatitis and the seasonal flu, which can be stored between 2°C and 8°C. The same goes for the HPV vaccine, diphtheria and tetanus vaccines, meningococcal vaccines, and the list goes on.

Others require low-temperature storage, in freezers that can operate between 0°C and -40°C, like Yamato's reliable LTF series. The MMRV vaccine, for example, must be stored between -25°C and -50°C, as does the zoster shingles vaccine.

Ultra low-temperature freezers are most commonly used for storing invaluable samples, like stem cells, cancer cells or organ tissue. The Ebola vaccine requires ultra low-temperature storage. They can reach temperatures from -40°C and -85°C.

moderna

The COVID-19 vaccine developed by Moderna can be stored in a freezer with a stable temperature of -20°C (a low-temperature vaccine freezer).

Pfizer BIONTECH

The COVID-19 vaccine developed by Pfizer-BioNTech can be stored in a freezer with a stable temperature of -70°C (an ultra low-temperature vaccine freezer).

Pfizer-BioNTech

The Pfizer-BioNTech vaccine ships in a purpose-designed thermal shipper. Once your facility receives a thermal shipper, and if you plan to keep doses stored in the shipper, the dry ice must be replaced after the first 24 hours and again every five days. You're urged to open the box a maximum of two times daily, ideally fewer. The vaccines can not stay in the thermal shipper for more than 15 days.

Once you add your diluent to this vaccine, the solution is good for only six hours, so a daily preparation routine must be built into your work day, and good planning for how much vaccine is needed that day.

Both vaccines must be given in two doses, with different timing between each dose. The Moderna vaccine requires 28 days between doses, while the Pfizer-BioNTech vaccine requires 21 days between doses.

moderna 28 Days

The Moderna vaccine requires 28 days between doses

Pfizer BIONTECH 21 Days

The Pfizer-BioNTech vaccine requires 21 days between doses

Once Moderna's vaccine is thawed in preparation for injection, it can be kept in a refrigerator between 2°C and 8°C for up to 30 days. Once Pfizer's vaccine is transferred to a refrigerator, it must be administered within five days.

Given the urgency of the current vaccination program across the US, it is unlikely that many vaccine doses, once delivered to pharmacies, hospitals, clinics, or other health agencies, will sit in cold storage for several months. This means f**or most locations, an upright low or ultra low-temperature freezer is going to be the preferred choice.**

Upright freezers store large quantities of materials that still require easy, ongoing access. Multiple levels of configurable storage make it easy to organize, track, and access your samples. Features like interior doors mean most vaccine vials aren't exposed to temperature fluctuations when the main exterior door is opened - limiting the possibility of vaccine spoilage associated with repeated warming and cooling.

**Note: If your location expects to receive a large shipment of doses, it's worth considering a two-tiered approach to vaccine storage. One (or more) chest freezer(s) where vials may be stored for several weeks while doses stored in your upright freezer are expended. The chest freezer will maintain even greater temperature stability over the medium to long-term and give the vaccines stored within a more hospitable environment. Also, if you are new to this type of cold storage, you will likely need to defrost your freezer annually (details later in this document), and preservation of your samples during defrosting requires multiple freezers. Planning for this eventuality now will save you a headache later.*

How do vaccine storage freezers work?

The short answer is - like all freezers, but colder.

The long answer is - they employ a lot of technology to reach and maintain low temperatures, eliminate temperature differential throughout the freezer box, maintain security, organize your vials/ samples, protect against unexpected factors, and eat up as little power (and $$$) as possible while operating.

This technology includes:

Multiple (two) hermetic compressors. Within each, a motor and compressor are housed in a single, sealed unit. This design eliminates the need for compressor maintenance, reducing the chance that vaccines will be exposed to warming temperatures during said maintenance. Additionally, it allows the freezer to recover quickly after warming caused by door opening. But it also generates heat - the opposite of what you want.

Compressor cooling. Running a constant flow of refrigerant through the compressors themselves makes your workspace more comfortable since excessive heat doesn't bleed into the surrounding environment. More importantly, however, is that it eliminates the possibility of heat transfer to samples inside the freezer and abutting the compressors.

Variable-stage compressors. A freezer with compressors capable of running in variable stages (at, for example, 20% capacity or 100% capacity, rather than simple ON and OFF) results in smaller and fewer temperature fluctuations, even with external temperatures up to 30°C.

Low-pressure designs. Interior layouts engineered for low pressure so temperatures are uniform in every corner of the freezer box.

Access control. Users can be given access to the contents of the freezer using custom passcodes. This allows managers to limit access to those workers with the skills and experience required, and to track access in case of a spoilage/waste event. Theft is also a concern, as vaccines have been targeted in previous pandemics. Access control is a reliable answer to this threat.

Temperature tracking. Either remotely or in your freezer's built-in interface, temperature tracking is an important feature for transparency. It ensures you can verify the continuation of the cold chain necessary to preserve the vaccine.

Power backups. You have no control over your local power utility and an outage could spoil your entire supply and cost tens of thousands of people their access to the COVID-19 vaccine. Unless you have a reliable power back up, like several models of low and ultra low-temperature freezer do. Some models can be configured to sound an alarm, send an email and text to the site manager, and run for up to 30 hours on backup power.

Naturally, different freezer models employ different combinations of features, but they can be lumped into two categories:

- Freezers with essential features
- Freezers with convenience features

Although with the scrutiny that will fall on the health services during COVID-19 vaccine deployment, many of the features previously considered conveniences (like remote access control and text alarm notifications) contribute to transparency and accountability, and may now be considered essential in many scenarios.

How to run your low or ultra low-temperature freezer efficiently

Modern ultra low-temperature freezers use about as much energy as a single-family home, and they're twice as efficient as older models. At the University of British Columbia in Canada, around 6% of all campus energy use comes from cold storage. Fume hoods are about the only other gear to use more energy (and they use about 3x as much).

Orienting your freezers for efficiency saves your budget and extends the lifespan of the freezer itself, and doesn't have to impact the performance of the freezer.

How do you do that?

Set the temperature to what your vaccine needs, not what the freezer can achieve. Generally, raising an ultra low-temperature freezer's set point to -70°C reduces its energy consumption by more than 20% over a set point of -80°C. According to studies, freezers also work about 56% harder to maintain that -80°C set point, resulting in significantly more wear on your compressors (and reducing the lifespan of the entire freezer)[1].

Think before you open the door. Opening the door less frequently and for shorter durations will reduce temperature fluctuations and, accordingly, energy consumption. As you plan out your vaccine deployment schedule, organize your vials inside the freezer to limit door opening as much as possible. If workers with access know exactly where their next set of vials is located, it should only take a few seconds to retrieve them and close the door(s). Fill space gaps in your freezer with frozen water bottles to reduce the temperature fluctuations associated with door opening.

Defrost your freezer at least annually. Some freezers eliminate this need with automatic defrost technology. This is only available in units with a maximum low temperature of -30°C due to temperature dynamics below this level. Manual defrosting consists of multiple steps that take about two days to complete. Every lab needs a backup freezer to store samples during defrosting. If you don't perform this maintenance, your freezer will die before its time and consume energy gluttonously in its short lifespan.

How to defrost your vaccine freezer next year

Move your vaccines to a different freezer in small batches (if you leave both doors open, you'll spoil your vaccines in transit).

Turn off the freezer, unplug it from the wall, leave the door open, and let the ice melt.

Wipe the interior surfaces of the freezer with a clean towel.

Perform a final drying and overall wipe with a microfiber cloth.

Close the doors, plug the freezer back in, and allow it to drop all the way down to your set temperature before you begin transferring vaccines back.

Vaccine storage for the pandemic and beyond

The CDC reports that between 5% and 20% of vaccines spoil during distribution, including immediately before injection. The freezer you choose is your contribution to reducing that number.

It's possible that COVID-19 vaccination will become as regular as flu vaccination. It's possible that single-dose vaccines will be as effective as multi-doses. It's possible that many pharma companies will develop quality vaccine candidates over the next year and rely on the same type of vaccine storage as Pfizer-BioNTech and Moderna, or different types.

What we know for certain right now is that the national cold chain must necessarily be enhanced. That includes the ability to store and deploy a wide range of vaccine types in a distribution model that is equitable. Access issues will emerge in underserved parts of the country, and **your clinic, pharmacy, hospital, research organization, or other, can contribute to getting valuable vaccines to the people who need them most by solidifying your place in the cold chain now.**

[1]PG&E, SCE, SDG&E Study 'Ultra Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories'