A Member of PHC Group

Decoding the Data

Understanding Refrigerator, Freezer, and Incubator Performance Metrics

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01

Introduction

Refrigerators, freezers, and incubators aren't always appreciated for the role that they play in scientific and medical research. But these pieces of equipment are crucial for facilitating breakthrough discoveries and protecting the quality and integrity of truly life-saving products. These pieces of equipment are, in many ways, the unsung heroes of the laboratory.

With refrigerators, freezers, and incubators playing such a key role in the modern laboratory, it's crucial that teams make the right choice when it comes to purchasing. To do that, laboratories must meticulously evaluate the performance data of available options.

However, performance claims for these pieces of equipment can be tricky to understand and compare — important definitions may not be well understood, data can be sparse, and research has revealed no standardized industry-wide guidelines on how to test and report on equipment performance. Without this guidance, understandably, product testing practices, data collection, and results presentation can also vary considerably between lab equipment providers. While ENERGY STAR® certification helps alleviate some of the difficulties by offering a standardized and transparent approach to measuring performance claims, it only addresses refrigerators and freezers, the data may not always be relevant for your real-world application, and not every lab equipment provider participates or publishes their results.

It's easy, therefore, to see why many prospective customers on the lookout for new equipment may struggle to understand performance data and make confident purchasing decisions.

In the worst case, organizations could end up buying equipment that does not adequately fit their needs, wasting precious time and organizational resources in the process.

To help alleviate these challenges, PHC Corporation of North America ("PHCNA") has created this in-depth eBook. After reading it, you'll know more about:

- The key performance metrics that can be particularly challenging to understand and compare
- *Why* these metrics can be so challenging to understand and compare, including how equipment testing, data collection, and data presentation can vary (and what that means for data interpretation)
- What you can do to better understand and interpret equipment performance data for more confident purchasing decisions

02

Key Performance Metrics
Recovery After Door Opening

Refrigerators | Freezers | Incubators

Recovery after door opening simply refers to how quickly equipment can return to set environmental conditions (temperature in the case of refrigerators and freezers; temperature/CO_2/humidity in the case of incubators) after the unit door is opened and then closed — and it is a key performance metric to consider when evaluating refrigerators, freezers, and incubators.

For refrigerators and freezers, a rapid temperature recovery minimizes unwanted and prolonged temperature deviation, which is critical for preserving the integrity of sensitive and valuable samples and products (such as mRNA vaccines)[1]. For incubators, a rapid recovery is required to help ensure consistent optimal cell culture performance.

Understanding and evaluating refrigerator and freezer temperature recovery — what makes it so difficult?

Despite their importance, refrigerator and freezer recovery data can be tricky to understand and compare for several reasons:

1. Variation in testing conditions

Many cold-chain products, such as refrigerators, freezers, and ultra-low temperature (ULT) freezers, will have ENERGY STAR® listed standardized recovery results that can generally give a good indication of real-world lab usage. However, many lab equipment providers conduct their own testing for a number of reasons, including to provide information additional to that provided by ENERGY STAR, or simply because they have not partnered with ENERGY STAR for product testing.

Where lab equipment providers do conduct their own testing, there can be room for confusion, since, naturally, testing practices and conditions can vary on account of the lack of standardized industry guidance.

Some of the most common variations when it comes to recovery testing are seen in four areas:

1. **Ambient testing temperature**
2. **Temperature probe placement**
3. **The number of inner doors opened (and for how long)**
4. **The tested unit's contents.**

Understanding how these conditions vary, and what the consequences are for test results, can be key for making better informed purchasing choices.

Variation in ambient temperature

Understandably, the ambient temperature at which refrigerators and freezers are tested is not necessarily the same across equipment providers. This is important, as different ambient temperatures can lead to different temperature gradients between the unit interior and the exterior environment, and, consequently, different temperature deviations and recovery times, even when the door is open for the same duration.

Variation in temperature probe placement

When it comes to measuring temperature recovery, temperature probe placement can vary between lab equipment providers, too. To understand why this may pose a challenge when reviewing data, we need to delve into how freezers and refrigerators work.

In most ULT and biomedical freezers, chilling comes through the unit walls, and temperature uniformity is subsequently achieved by convection. As such, the back and bottom of a freezer (that is, the location closest to the source of cooling, and furthest from the door-induced temperature change) will naturally remain colder during and after door opening, and will return to the set temperature faster. Thus, temperature probes placed towards the back lower corners of a unit during testing will read a faster temperature recovery, and probes at the top and front of a unit will read a relatively slower recovery. The situation is similar with refrigerators, which mostly rely on a single forced-air cooling system. Temperature probes placed close to the outlet of the forced air will naturally recover more quickly than probes placed elsewhere.

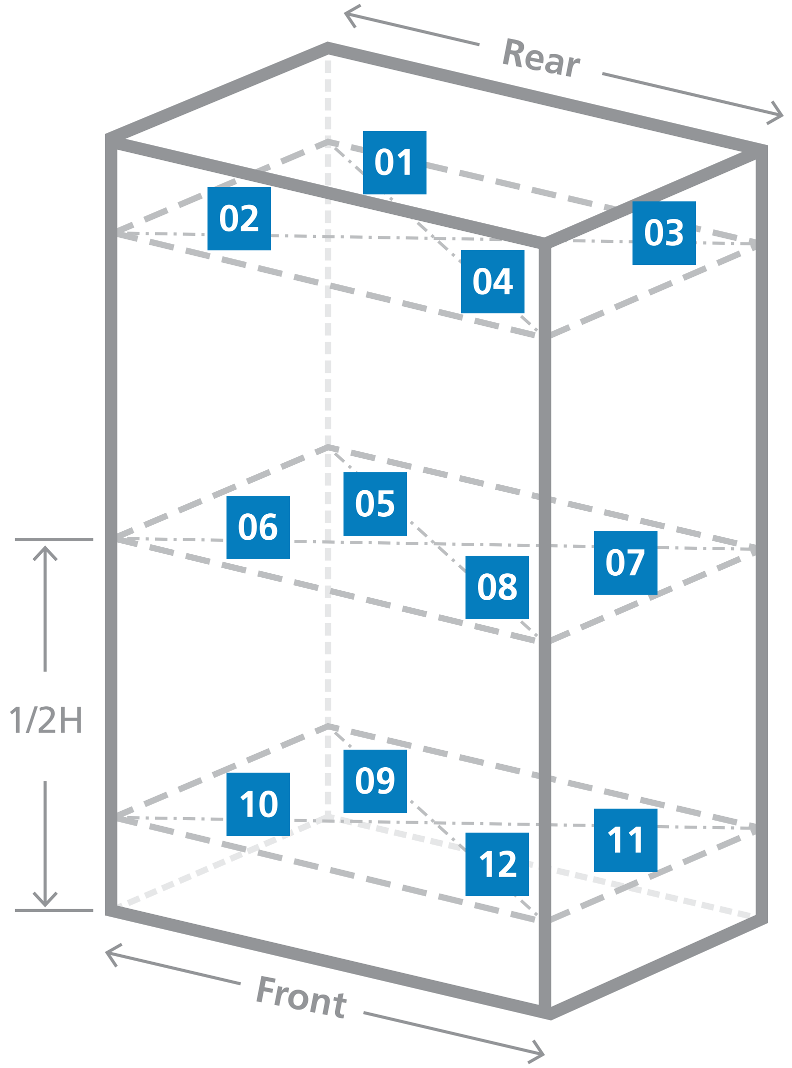


Figure 2: Schematic showing a 12-point mapping method for measuring temperature recovery in refrigerators and freezers. By comprehensively sampling the chamber space, this method allows for a more accurate insight into temperature recovery.

Inner door opening variation

Freezers — especially ULT freezers — often feature multiple inner doors to help maintain a more stable temperature and to reduce temperature fluctuation after outer-door opening. Exactly how many of the inner doors are opened — and the length of time they are open for — isn't always the same across different equipment providers' recovery testing, though.

So, what effect could this have on testing results? In short, studies that keep more doors closed are more likely to demonstrate smaller temperature increases and faster return to set point than studies that open more of their refrigerator or freezer's doors. Similarly, studies that open unit inner doors for a shorter duration are likely to demonstrate smaller temperature increases and faster return to set point than those where inner doors are left open for longer periods.

Variation in unit contents

Most of the energy expended by a refrigerator or freezer goes into cooling down the warm air that enters upon door opening. That means that the more a unit is filled (i.e., the less air space there is in the unit), the faster a unit can recover to its set point after door opening. It's for this reason that significant variation in unit filling can lead to very different recovery results.

ENERGY STAR is aware of this, and to overcome it, stipulates that units must be completely empty during recovery testing, essentially ensuring a readout of the worst-case scenario for recovery performance, to qualify for their rating. Non-ENERGY STAR testing, on the other hand, may involve completely empty units all the way through to filled units. Accordingly, when working with non-ENERGY STAR testing, understanding (and comparing) the units' likely performance in your lab can be tricky.

2. Data and claims may cover product families, rather than individual products

Aside from the variation in how lab equipment providers test their cold-chain products, there are other ways that recovery results can be difficult to interpret and decipher. One of the most important of these is how results are communicated.

For example, to limit the amount of data prospects have to review, lab equipment providers sometimes group different units within a product family together, providing overarching performance data for the family, rather than for each individual unit (while this is common with recovery data, it can also be seen with other performance metrics, too). But the performance results may not always apply to every unit within the product family. A claim might only, in fact, relate to the smallest unit in the range, which can make understanding true performance challenging without further research.

That said, many lab equipment providers are now providing unit-specific data to avoid confusion and add more clarity for prospective customers, which is a welcome change.

Be careful not to confuse distinct claims

- It can be very easy to confuse distinct (but similar sounding) claims when it comes to evaluating recovery performance.
- For example, claims about superior heat removal in cold chain products do not necessarily entail superior recovery.

Challenges in understanding, evaluating, and comparing incubator recovery

Unfortunately, getting to the bottom of recovery performance isn't much easier when it comes to incubators. Several challenges stand in the way.

Variation in testing conditions

Given the lack of industry-wide testing guidelines, it's no big surprise that testing for incubator recovery performance varies in much the same way as cold chain product recovery testing.

Door opening period

The amount of time that an incubator door is open during recovery testing can vary, which can have a big impact on results — opening the incubator door for a longer period of time will lead to a bigger change in temperature, CO_2 level, and humidity, entailing a longer recovery time.

On the other hand, if door opening during testing is brief, the incubator will need to recover from a smaller change, and recovery time will naturally be quicker. In either case, if the door opening duration does not match what is typical for general lab use or for your application specifically, the published recovery results may not match the performance you'll see in the lab.

Door opening speed

The speed of door opening can also impact recovery time. More specifically, a faster door opening can cause a faster change in chamber conditions which can lead to a longer recovery period compared to a slower door opening. This is due to the nature of the controlled environment within laboratory incubators. When the door is opened, the carefully regulated internal atmosphere (temperature, humidity, and gas composition) is disrupted as it mixes with the external room air. The speed of door opening affects the rate and extent of this mixing. Slower door openings allow for a more gradual exchange of air, potentially reducing the magnitude of these disruptions and, consequently, the time needed for recovery.

Crucially, a fast change in humidity may not just impact humidity recovery; it could also further impact CO_2 recovery. To understand how, we need to know about the two types of CO_2 sensors commonly used in incubators: infrared sensors and thermal conductivity sensors.

Unlike infrared sensors (which are much more expensive), thermal conductivity sensors are less accurate when humidity levels change (their CO_2 readouts can 'drift')[2]. So, for incubators with thermal conductivity CO_2 sensors, a very slow door opening (which helps to prevent sharp humidity changes) would reduce the risk of sensor 'drift'. As a result, the CO_2 readout will be more accurate, and the incubator will be less likely to over- or under-shoot when returning to the set point. However, unless you open your incubator doors very slowly in your lab, you aren't likely to replicate such an accurate recovery when compared to infrared sensors which are not affected by changes in humidity.

Ambient temperature

As with refrigerator and freezer recovery testing, the ambient temperature used during incubator recovery testing can vary between lab equipment providers, both in terms of the actual temperature used, and how consistent that temperature is throughout testing. As noted earlier, a lower or higher ambient temperature will lead to a faster or slower temperature recovery readout. A carefully controlled, constant room temperature during testing might also lead to different temperature recovery rates relative to a room with a temperature that varies in a more natural way.

What's more, the ambient temperatures used in testing may only reflect annual averages. As a result, testing may not provide accurate insights into equipment performance during different seasons, where ambient temperatures in labs can still vary despite the dynamic control over air conditioning and heating systems.

Traffic in the testing space

The movement of researchers in the laboratory can significantly impact incubator recovery performance. Much like how a passing truck can cause turbulence that shakes a stationary car, people moving near an incubator can create air disturbances. Such disturbances can lead to more pronounced decreases in humidity levels and CO_2 concentration within the incubator.

Accordingly, tests conducted in isolated, low-traffic environments, therefore, may not accurately reflect the incubator's performance in a busy laboratory setting.

Understanding the consequences of hard-to-decipher recovery data

Significant variety in testing and data presentation can have consequences beyond making the evaluation process more complex and time consuming. In the worst cases, it could lead to purchasing equipment that simply isn't fit for purpose.

For freezers with slower-than-expected recovery, for example, the consequences can be significant. Over time, labs might experience compromised viability of sensitive samples and products, leading to experimental inconsistency, poorer quality products, and even product loss. Similarly, poorer-than-anticipated temperature, CO_2, and humidity recovery in incubators could lead to suboptimal cell culture performance and inconsistent experimental results.

Gaining a better understanding of recovery performance

So, what can you do to get clearer insight into the recovery performance of refrigerators, freezers, and incubators? For refrigerators and freezers, you should:

- **Ask to see original ENERGY STAR testing results:** While not all lab equipment providers will have ENERGY STAR recovery testing results, many will. Since ENERGY STAR testing is standardized and conducted by verified independent organizations, results will be easier to understand, interpret and compare, helping you make better and more confident decisions.
- **Ask for full details about the conditions used in testing:** If the lab equipment provider does not have ENERGY STAR data, be sure to ask them to share what experimental conditions were used for the recovery testing. In particular, ask for more information about:
  - **The ambient temperature:** Was it significantly warmer or cooler than your lab's ambient temperature?
  - **Temperature probe placement:** Where was the temperature sampled? Was it only at the lower back of the unit? Does the equipment provider also have recovery data for the top and front of the unit? Try to find out what the recovery is like for the warmest part of the refrigerator or freezer.
  - **Unit filling:** How full were the units during testing and what were they filled with? Ask yourself how this compares to your lab's anticipated usage.
- **Ensure you understand what different claims mean:** It's easy to get confused by claims that are related to, but not explicitly about, recovery. If you are unsure of what a claim means, or how it might correlate with the performance metric in question, you can always ask the equipment provider for more information. Most will be very happy to explain.

Requesting tailored testing for specific use-cases

For some use cases, available performance data simply won't be relevant to, or representative of your lab. If, after scrutinizing the available data and finding out more about the testing conditions used, you realize this is the case, then you could request more tailored testing.

More specifically, you can request boundary testing on the specific unit type you wish to purchase, with the equipment provider evaluating the unit under relevant conditions that simulate your lab, your product or samples, and your processes. Such testing can help you better evaluate whether the equipment will be fit for your intended application, saving significant time, money, and frustration.

For incubators, you should:

- **Ask for full details about the conditions used in testing:** ENERGY STAR does not evaluate incubators, so performance data will likely be the result of in-house testing by lab equipment providers. As such, be sure to ask about the conditions used in their testing. More specifically, ask about:
    - **Door opening duration and speed:** How slowly were the doors opened and how long were they left open? Ask yourself, is this reflective of how the equipment will likely be used in my lab?
- **Ambient temperature:** What was the ambient temperature? Was it warmer or cooler than your lab's average temperature? Was the temperature held constant or were different temperatures evaluated to reflect seasonal changes?
- **Extent of traffic in the testing space:** Was the incubator tested in an isolated environment or in a setting that simulates typical laboratory foot traffic? How many people were moving around the incubator during testing and how frequently? Does this match the level of activity in your lab?

03

Reliability and Robustness

Refrigerators | Freezers | Incubators

Reliability and robustness are important considerations when purchasing all kinds of equipment. But when it comes to the equipment that protects and preserves valuable biological samples, biomedical products, or cell cultures, these factors need to be top of mind.

While reliability and robustness are closely related, they are distinct concepts. **Reliability** can be defined as the predicted amount of time a piece of equipment will perform its expected function(s) under stated conditions without failure. Reliability in refrigerators and freezers is critical for ensuring continued and consistent protection of samples and products, and reliable incubators are key for undisrupted cell culturing operations. But that's not all. Having reliable equipment ultimately minimizes the total cost of ownership — the more reliable a unit, the less maintenance and repairs are required, and the less companies will have to pay to keep the equipment operational.

Robustness, on the other hand, refers to how well a product can accommodate long-term improper use or stressful environmental conditions and still work. Naturally, the more robust a product, the more cost-effective it is.

Challenges in ascertaining the reliability and robustness of refrigerators, freezers, and incubators

Despite the importance of reliability and robustness, it can be hard to properly evaluate these features of lab equipment for several reasons:

1. Unclear claims

Perhaps the most challenging part of vetting the reliability or robustness of a piece of lab equipment is that many claims can be vague. Ultimately, while such claims may be true, they may not provide prospective customers the concrete data and specifics to verify their validity.

2. Sparse data

In many cases, even when data is available, it may not give the full picture of a piece of equipment's reliability or robustness. Refrigerators, freezers, and incubators comprise multiple components, and while reliability and robustness data might be available for some of those components, it might be missing for others. Without that data, and without that fuller picture, it can be tricky to fully vet the equipment.

3. Customer references only show a ‘snapshot’

When trying to get a more balanced insight into the reliability and robustness of a piece of equipment, prospective customers may ask an equipment provider for customer references and testimonials. This, of course, makes sense — finding out how a piece of equipment performs directly from existing end-users can give you broader insights that might not be captured in published information.

However, references have some drawbacks. First, it can be hard to know whether references capture the full picture. Indeed, with so many users, and with references providing only a snapshot of information from the current user base, it’s likely that at least some aspects of equipment performance will not be addressed. Additionally, references are more likely to be from satisfied customers, which could result in a somewhat uneven presentation of user experiences.

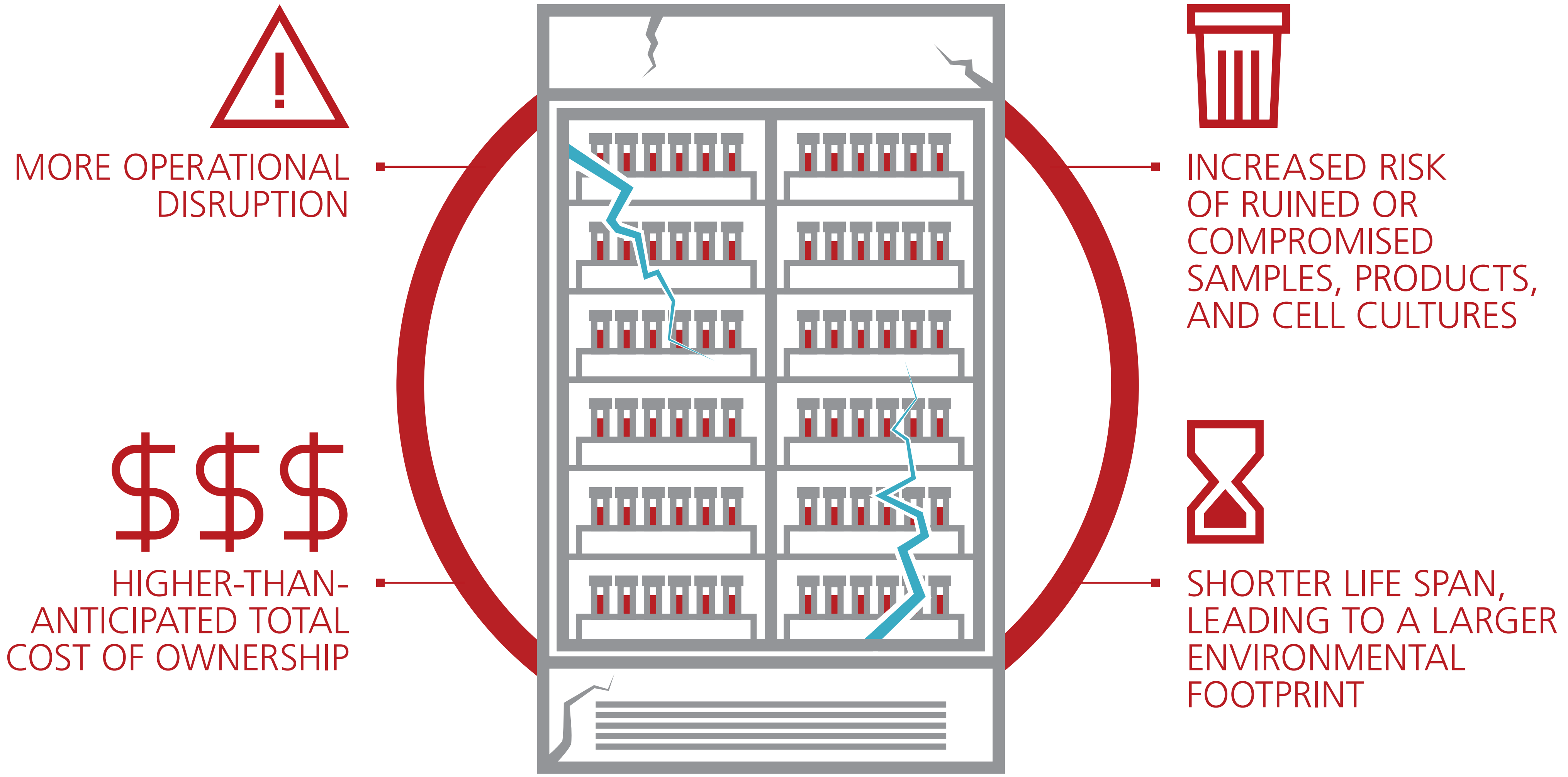
The importance of understanding equipment reliability and robustness

If you don't fully vet equipment for its reliability, you could end up with a piece of equipment that breaks down more frequently, which can result in:

- More operational disruption
- Higher-than-anticipated total cost of ownership
- Increased risk of ruined or compromised samples, products, and cell cultures
- Shorter life span, leading to a larger environmental footprint

Similarly, a poor understanding of your chosen equipment's robustness could leave you needing to replace the unit more frequently than planned, leading to greater costs as well as a larger environmental footprint.

The cost of unreliable, non-robust refrigerators, freezers, and incubators



Gaining a better understanding of reliability and robustness

Getting a clearer and fuller picture of equipment reliability and robustness is possible. And it does not need to be difficult, either. To build on the information offered by lab equipment providers, consider also doing the following:

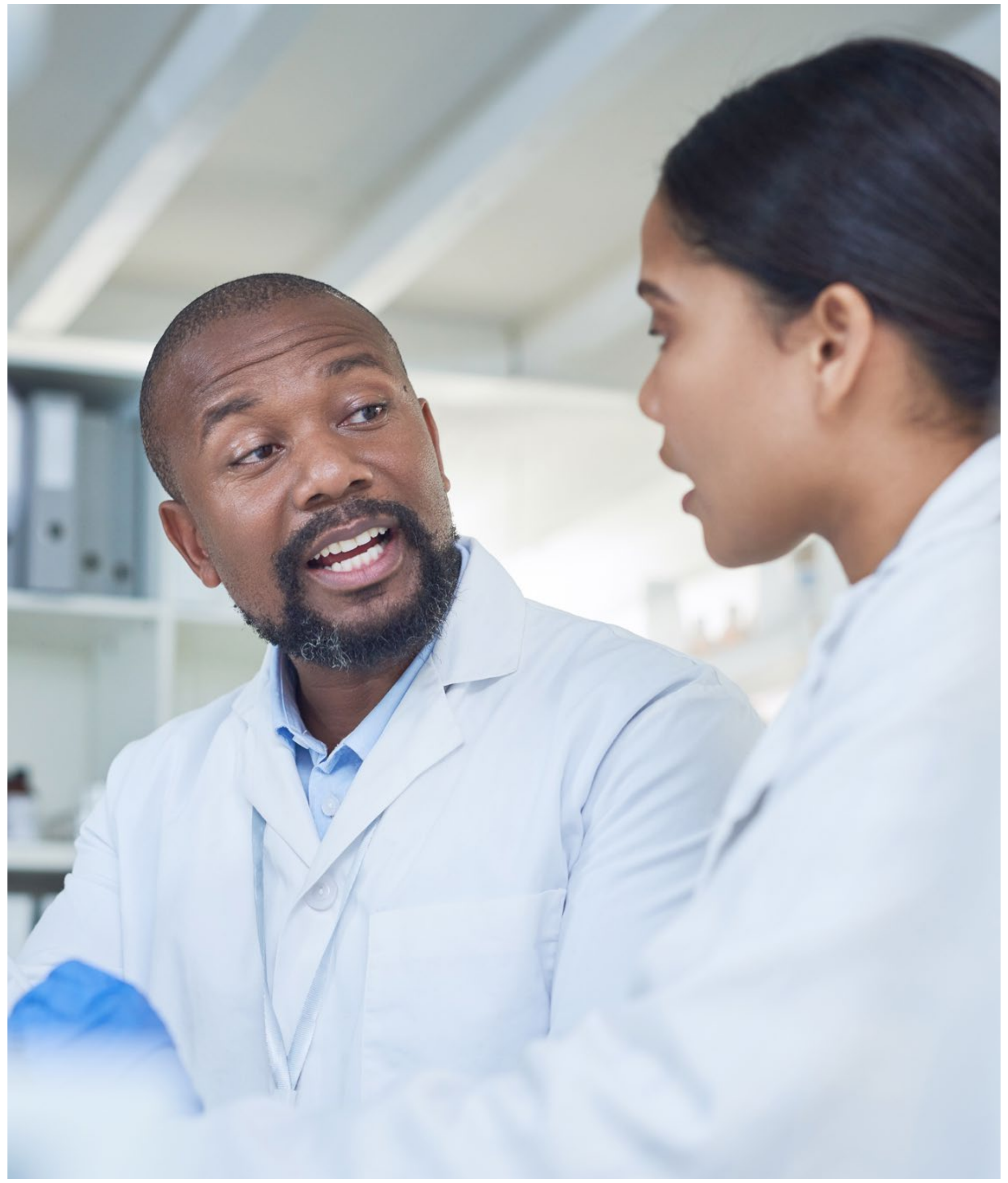
1. Connect with end-users in your own company

Your own organization could be home to numerous colleagues who currently use, or have previously used, the equipment you are considering for purchase.

It's beneficial to reach out within your organization to see if there are any such people, and to ask them for their honest experience of using the product. That way, you gain additional insights into various aspects of the product's performance, including how reliable and robust it is.

> "Many people would be surprised at how often a nearby lab or team is already using the exact equipment that they want to purchase. I would always recommend prospective customers reach out to their peers and colleagues when making purchasing decisions. They could be a goldmine of additional info to help support the decision-making process."

Joe LaPorte, Chief Innovation Officer, PHC Corporation of North America



2. Talk to repair technicians

As well as connecting with end-users, it can be immensely helpful to talk to repair technicians and facilities personnel. Having likely repaired many pieces of lab equipment throughout their careers, these people will be in a unique position to offer insight into which specific units and brands experience the most frequent reliability and robustness problems.

3. Seek insights from forums and social media channels

Public and professional forums, in addition to social media channels, can be an excellent source of extra information about lab equipment reliability and robustness (as well as other aspects of performance).

A quick scan through the relevant discussions in a forum such as r/labrats on Reddit, for instance, is often enough to get a good initial feel for the general community consensus about a product, as well as alerting you to any recurring issues or red flags. That said, prospective customers must, of course, keep in mind that the information from popular public forums cannot necessarily be taken at face value, so it is important to be diligent.

Professional forums and discussion areas that do not allow equipment provider participation (such as LabOps Unite), can be an even better option for getting honest and unbiased thoughts and feedback.

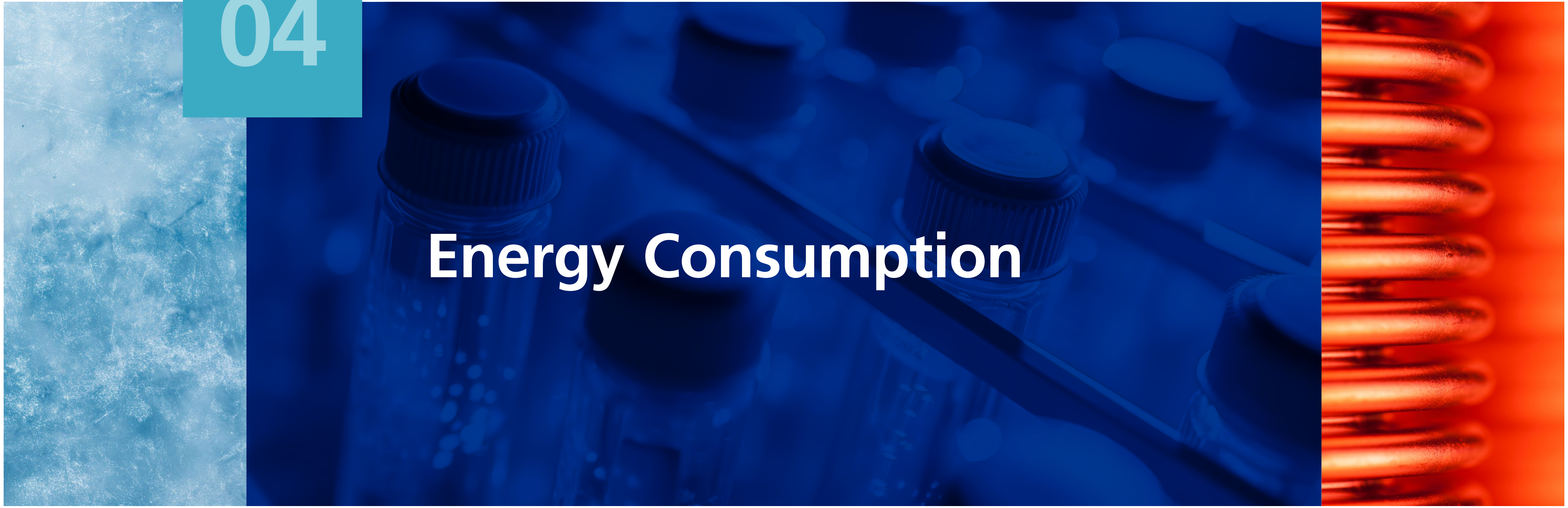
4. Find out how long the equipment provider has been in the industry

Equipment providers aren't likely to survive long in the refrigerator, freezer, or incubator markets without delivering products that are reliable and robust. That's why it is important when making purchasing decisions to check whether the equipment provider has been around and manufacturing this specific type of equipment for a long time.

> "Over the last 40 years in this sector, I've seen a lot of refrigerator, freezer, and incubator providers come and go. An established and long legacy is a promising indicator of reliable and robust products."

Joe LaPorte, Chief Innovation Officer,
PHC Corporation of North America

04



Energy Consumption

Refrigerators

Freezers

Incubators

Energy consumption is a measure of the energy used by a piece of equipment in a given unit of time — most often kilowatt-hours per day (kWh/day). Energy consumption is a key consideration when buying lab equipment such as refrigerators, freezers, and incubators, since it can directly impact:

- A lab's operational costs
- Heat output (and therefore the ability and/or energy required to maintain a stable and consistent lab environment)
- The ability to meet increasingly ambitious sustainability targets

This performance metric is a big focus for refrigerators and freezers, and less so for incubators, and for good reason — refrigerators and freezers are much bigger energy consumers, leading to much higher potential for soaring energy costs and negative environmental impact.

Challenges in evaluating energy consumption

Although energy consumption should, in theory, be easy to measure, it can be very difficult to get accurate and relevant insights into this metric. There are several reasons for this:

1. ENERGY STAR® testing methods may not reflect real-world equipment usage

While ENERGY STAR-listed data is generated by independent third parties according to standardized testing, and is a very useful guide, it may not mirror real-world use cases for many prospective refrigerator and freezer customers. For example, ENERGY STAR typically measures refrigerator and freezer energy consumption over a 24-hour testing period, which may not always allow enough time for unit accessories to kick in and consume energy.

2. Variation in testing conditions when not using ENERGY STAR® testing

Given the point above, refrigerator and freezer providers often seek to share more representative testing for energy consumption — over longer time periods, for instance. However, since such testing will fall outside of the scope of ENERGY STAR, it may not be standardized, and can vary considerably across lab equipment providers. The most common areas of variation are discussed in the following page.

Variation in accessory usage

Modern refrigerators and freezers come with a variety of accessories to maintain smooth operation, such as water-cooling units and electric door heaters to prevent ice build-up on freezer door gaskets. But which accessories are turned on and used during testing will likely vary between lab equipment providers. This, of course, can have a huge impact on the energy consumption readout: results of energy consumption tests where accessories are not set to real-world conditions can affect energy results.

Ambient temperature

As already mentioned in the chapter on recovery after door opening, the ambient temperatures used in refrigerator and freezer testing can differ considerably. But the ambient temperature doesn't just impact recovery speeds — it also dictates how hard the unit must work (i.e. how much energy it must consume) to maintain its internal temperature. Conducting testing at an ambient temperature lower than is typical for a lab, for instance, would necessitate less energy to keep the refrigerator or freezer contents cool, and so produce a lower energy consumption readout.

Results "based on ENERGY STAR® testing methods". What does it mean?

When evaluating different refrigerator and freezer options, prospective customers can come across a variety of different wordings with regards to ENERGY STAR-related data. But they don't all mean the same thing.

For example, there is a difference between official ENERGY STAR results and results that are "based on ENERGY STAR testing methods". While the former is conducted by independent third-party testers, the latter uses testing that has not been verified by ENERGY STAR, and may have been performed in-house.

Only official ENERGY STAR testing results can be accompanied by the official ENERGY STAR logo, so keep an eye out for this when exploring aspects of refrigerator and freezer performance such as energy consumption.

The consequences of a poor understanding of energy consumption

Misinterpreting or underestimating the actual energy consumption of a refrigerator or freezer can lead to unexpected challenges. Most notably, labs could find themselves spending much more money on energy bills, both as a direct result of the unit's energy consumption and owing to greater energy requirements to keep the lab cool (since less energy-efficient refrigerators and freezers expel more heat into their surroundings).

Gaining a better understanding of energy consumption

Perhaps the most important step prospective customers can take to build a clearer picture of a refrigerator or freezer's energy consumption is to ask for more information about in-house testing conditions. For example, be sure to ask about:

- **Accessory usage:** Which accessories were turned on and used during the testing?
- **The ambient temperature:** What was the ambient temperature in the testing space?

Once you have this information, ask yourself, does the equipment provider's in-house testing reflect my anticipated usage patterns and the environmental conditions of my lab?

05

Variance and Uniformity

Refrigerators

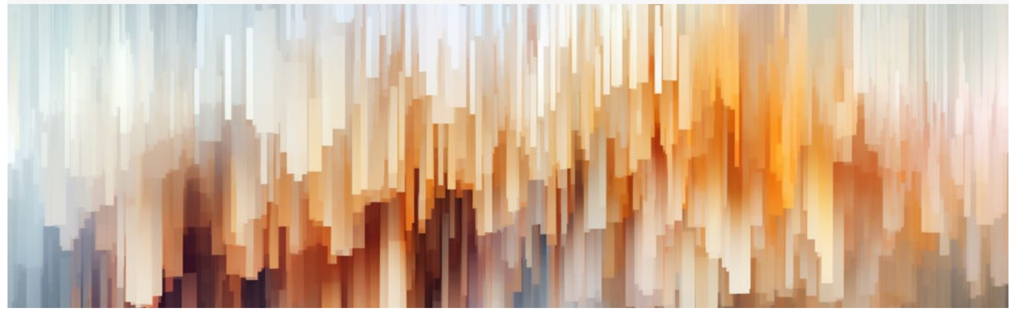
Freezers

Incubators

Uniformity measures the consistency of temperature across different points within a defined area. It indicates how evenly the temperature is distributed.

Peak variance (or peak variation) refers to the maximum temperature difference observed between the coldest and warmest points within the monitored area over a specified period.

Peak variance and uniformity are key performance metrics to evaluate when evaluating refrigerators, freezers, and incubators, since spatial/temporal temperature consistency are paramount for sample, product, and cell culture quality, as well as experimental results reproducibility.



Challenges in understanding variance and uniformity

There are several reasons why prospective customers may find it hard to obtain a clear understanding of a refrigerator, freezer, or incubator's uniformity or variance.

1. Confusing definitions

The first challenge is that many prospective customers misunderstand the difference between the two metrics. For example, it is common to think that an acceptable variance entails an acceptable uniformity, but this is not the case.

> "Confusions around definitions can be a major obstacle to getting a piece of equipment that really fits your needs. Unfortunately, there are many places where people can trip up. Perhaps the most common, though, is in the difference between peak variance and uniformity. It's vital that purchasing decision-makers have a clear understanding of both these metrics."

Joe LaPorte, Chief Innovation Officer, PHC Corporation of North America

2. Variation in probe placement

The number and location of probes used to measure temperature uniformity can vary dramatically — from a single temperature probe in the center of a unit to multiple probes comprehensively sampling the unit's internal space. But having such variety in probe placement can, of course, significantly alter readouts, with some approaches producing results that might not be as relevant for real-world equipment usage.

Placing temperature probes only in the center of an incubator, for example, will not offer data that is relevant for end-users that primarily place their cultures towards the front of the incubator chamber (a common practice), or who fill their incubators with cell culture plates. Using just one temperature probe will also, of course, not capture any spatial temperature variation at all, in which case uniformity is not truly being measured.

Taking stock of the potential impacts

Misunderstanding or inappropriately evaluating a refrigerator, freezer, or incubator's uniformity and peak variance can have significant and unwanted impacts on lab operations. When it comes to refrigerators and freezers, suboptimal spatial and temporal temperature consistency can spell disaster for samples and products that must stay within a strict temperature range. In the worst cases, samples or products could be compromised or lost, potentially leading to poor reproducibility, project delays, and financial losses.

While poor uniformity and peak variance in incubators can lead to similar issues with reproducibility, it can also lead to another issue: increased contamination risk. That's because, in an incubator where temperature differs throughout the chamber, cold pockets can develop, leading to condensation buildup where unwanted microorganisms can thrive. In such a scenario, a whole unit's contents may need to be discarded, potentially entailing experimental re-runs that can stymie research and add to work burden and project costs.

What can you do to better understand and evaluate uniformity and variance?

To get the best insight into a product's temperature peak variance and uniformity, it is important to:

- **Be clear on the distinction between peak variance and uniformity**, and understand that a good average peak variance does not necessarily entail a good uniformity.
- **Ask for more information about in-house testing conditions**. More specifically:
  - Ask about the temperature sampling strategy: How many probes were used and where were they placed within the chamber? Ask yourself, does the experimental design reflect my anticipated real-world usage?

06

Biological Contamination Control

Refrigerators | Freezers | Incubators

Biological contamination of cell cultures is a pervasive problem that can devastate precious cell cultures. Unwanted yeasts, bacteria, and viruses in your culture can reduce viability, hamper productivity, and lead to experimental results that aren't reproducible. It's no surprise, then, that vendors often add features to their incubators to help reduce the growth and proliferation of undesirable microorganisms.

However, figuring out which incubator has the right contamination control performance for your needs is no easy feat.

Challenges in understanding contamination control performance

As with many of the performance areas discussed so far, one of the main difficulties in building a clear understanding of what each unit is capable of and how they compare, comes down to experimental variation across equipment providers. In the case of contamination control, the variation generally concerns three variables:

1. Variation in the chosen contaminant

A whole host of biological agents can contaminate cell cultures, each with different impacts on cell culture health and with different levels of relevance for different laboratories and areas of research.

This is crucial since the contaminants used in contamination control experiments can vary considerably, and good resistance to one contaminant doesn't guarantee resistance against others. So, if a chosen contaminant is less relevant for your lab or application, the experimental results may not provide the level of insight you need to properly evaluate the incubator's real-world contamination control capabilities.

2. Variation in a contaminant's concentration

Unfortunately, it's not just the contaminant itself that can vary. The concentration of the contaminant can vary widely too. This can make it equally difficult to interpret or compare results. If the contaminant's concentration is well above that anticipated in your laboratory, confidently interpreting the capabilities of real-world contamination control becomes a difficult feat.

3. Variation in the decontamination control method

There are a wide range of passive and active methods to minimize the risk of contaminants entering an incubator. These methods range from utilizing certain chamber materials (such as copper for the chamber interior), filtering (such as using HEPA filters), and decontamination protocols such as UV light, high heat sterilization, and hydrogen peroxide fumigation.

However, some methods take an excessive amount of time to complete, while others might overcompensate in their decontamination efforts and inadvertently lead to cell culture failure. Over time, some methods can significantly impact the incubator environment. For example, constant filter changes can lead to excess waste, and harsh chemical decontaminants can also build up in the chamber. When it comes to decontamination performance, one must observe how the performance results are presented in a respective white paper as the conditions of the performance testing may not lead to a realistic conclusion or result. For example, the performance of a decontamination system can be shown to be ineffective against either an excessive amount of contamination load that exceeds what a typical laboratory space experiences or a highly specific and unlikely set of conditions that lead to a heavily biased result against the targeted competitor. Ideally, decontamination performance should have realistic and repeatable expectations that can be measured, observed, and properly documented.

Getting a better understanding of contamination control capabilities

Thankfully, arming yourself with a few questions to ask equipment providers can be the difference between staying in the dark and having a much clearer understanding of the relevance of testing results.

Key questions to ask include:

- What contaminants were used in the study?
- At what concentration were the contaminants present in the testing environment or introduced into the incubator?
- What method of decontamination was used?

Once you've gathered this information, ask yourself:

- Does this data give me a good indication of how the incubator might perform in my lab and for my application?
  - Are the contaminants used in the studies a relevant risk?
  - Is the contaminant concentration realistic?
  - Is the tested decontamination cycle time and process compatible with our lab's workflow and turnover needs? If the answer to the latter set of questions is no, it is worth asking the equipment provider for other available contamination control data, or if additional testing can be performed to better reflect your intended use.

07 Parameter Control

Refrigerators

Freezers

Incubators

For an incubator to support optimal cell culture, it must be able to meticulously control a range of parameters, including temperature, gas concentration, and humidity. Refrigerators and freezers, too, must be able to accurately control (and provide accurate readouts of) temperature if samples and products are to remain at the highest level of quality long-term.

Understanding parameter control: why it can be a challenge

The key challenge with understanding how finely an incubator, refrigerator, or freezer can control critical parameters lies in the difference between specifications and results. More specifically, many prospective customers mistake specifications *for* the results, overlooking the critical difference between the two — that the specification is a ‘goal’, and the results are the actual performance data.

An example can help illustrate the issue. While an incubator might have a ‘goal’ or specification of 95% humidity (+/-5%), the actual experimental data might indicate the chamber can only reach 92% humidity (which is still within the stated specification). The problem arises when prospective customers assume that the incubator can consistently achieve 95% humidity levels, which may not be possible.

Many prospective customers mistake specifications *for* the results.

Consequences of not understanding true real-world parameter control

Not having the fine parameter control that your application needs can have large consequences. Poorer-than-expected ability to fine-tune parameters could lead to result inconsistencies, compromised sample or product quality and integrity, and higher costs.

Getting a clearer picture of parameter control

The answer to these challenges is straightforward. Prospective customers simply need to keep the difference between specifications and results top of mind when reviewing parameter control claims in equipment providers' web pages and marketing and sales materials. If only specifications seem to be available, then be sure to ask for the performance data.

08

More confidently evaluating refrigerator, freezer, and incubator performance claims

Refrigerators

Freezers

Incubators

Refrigerators, freezers, and incubators are often not the first thing people think of when discussion turns to scientific research and the latest medical advancements. But without these pieces of equipment, much of this research and many of these advancements simply wouldn't be possible.

Naturally, then, there's a lot at stake when deciding which refrigerator, freezer, or incubator to purchase for your laboratory. Indeed, the decision must be informed by a thorough and deep understanding of the equipment's performance.

However, this is much easier said than done. Several obstacles stand in the way of a proper understanding of refrigerator, freezer, and incubator performance — from extensive experimental variation to sparse data and commonly misunderstood terminology.

But prospective customers need not be stuck in a state of confusion or uncertainty when evaluating such equipment. With a clear knowledge of the obstacles, and armed with the right questions for lab equipment providers, companies can carve a smoother and faster path to better product understanding — and ultimately more confident decision-making.

Want to access more insights that will let you optimize your laboratory operations? Then sign up for our eNewsletter where we'll share insights, practical advice and the latest product updates.

Access expert insights

Or, contact a member of our team if you have questions around selecting the right refrigerators, freezers, and incubators for your laboratory.

Get personalized guidance

Don't let uncertainty hold you back. Equip yourself with the knowledge and support you need to make the best choices for your laboratory's success.

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