Cold storage

Temperature performance measurement in life science refrigerators

How is temperature performance in life science refrigerators measured and why is it important?

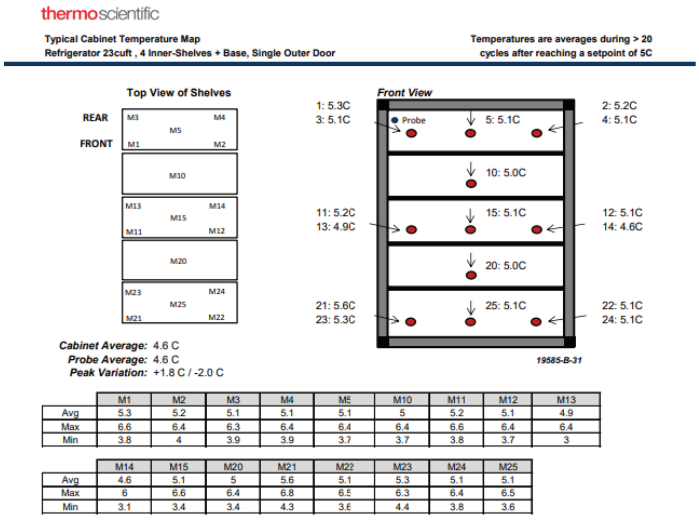
Laboratory refrigerators are a ubiquitous part of the life science industry whether it is a graduate student studying environmental pollutants, a pharmaceutical company developing the next generation of life saving treatments, or a blood bank storing critical blood supplies to support hospitals, clinics, and blood centers. These critical pieces of equipment are often overlooked and expected to 'just work', but what does 'just work' mean and how do we quantify lab refrigerator's performance and ensure that the equipment is maintaining temperature to ensure protection of its cargo?

Peak variation

Peak variation (PV) is the most straight forward metric for measuring temperature performance of a refrigerator as it reflects the maximum temperature difference between the coldest and warmest measured temperatures within the cabinet over the test period across all temperature monitoring devices (TMD). This can be reported as either a +/- value from the set point or as the total temperature difference between the two measurements.

While the resulting value for PV is straightforward the testing conditions, total measurements, and probe types can vary. For example, Thermo Scientific™ technical data sheets (TDS) measure PV across 24 probe locations over a period of >20 compressor cycles after the unit has reached it's setpoint. The probes used are open air, meaning they are measuring true air temperature and not a weighted sample simulated temperature and the units are in a temperature-controlled room at an ambient temperature of +20°C. The advantage of this test method is that it shows, without any external variables, how evenly a refrigerator circulates air throughout the cabinet and removes excess heat while minimizing 'cold spots', or pockets of air flow that can be significantly lower than the set point. The use of open air probes, rather than weighted probes, provides a much higher bar in terms of temperature performance as there is no delay in temperature reading with the additional weight of the probe. As the air temperature changes the change is captured immediately giving a very detailed view of the temperature changes within the cabinet and air flow patterns.

From the example in Figure 1 below you can see the robust level of detail that the large number of probes provides and gives a clear indication of the type of performance customers can expect.



	M1	M2	M3	M4	M5	M10	M11	M12	M13
Avg	5.3	5.2	5.1	5.1	5.1	5	5.2	5.1	4.9
Max	6.6	6.4	6.3	6.4	6.4	6.4	6.6	6.4	6.4
Min	3.8	4	3.9	3.9	3.7	3.7	3.8	3.7	3

	M14	M15	M20	M21	M22	M23	M24	M25
Avg	4.6	5.1	5	5.6	5.1	5.3	5.1	5.1
Max	6	6.6	6.4	6.8	6.5	6.3	6.4	6.5
Min	3.1	3.4	3.4	4.3	3.6	4.4	3.8	3.6

Figure 1. TSX2305GA TDS – Probe Location.

There are of course alternative methods for measuring PV in a laboratory refrigerator and the Environmental Protection Agency (EPA ENERGY STAR™ PV test is one such example. The ENERGY STAR test utilizes less than half the probes as the Thermo Fisher Scientific test, incorporates weighted TMDs, and includes brief door openings at regular intervals throughout the test. The use of weighted probes is to better reflect sample temperature, rather than actual air temperature within the cabinet while the door openings are intended to simulate day to day usage.

The Thermo Scientific™ PV test and the EPA ENERGY STAR PV test are both very valuable tests, and taken together help provide users with an understanding of what type of performance to expect from their laboratory refrigerator.

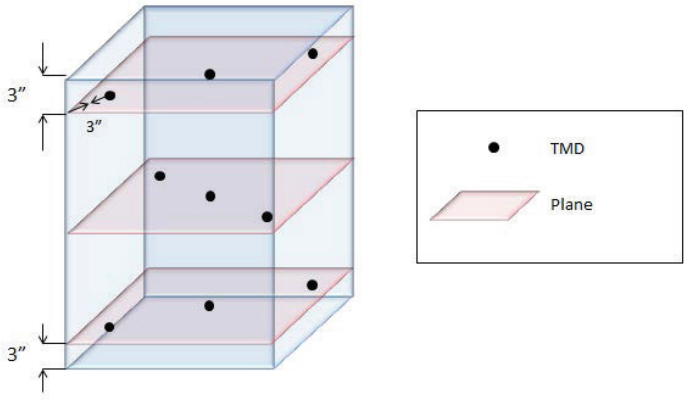


Figure 2. ENERGY STAR PV Probe Location.

Why does it matter?

Peak variation when looked at from a +/- or total variation perspective may seem small but in reality a PV of, for example 4°C at a setpoint of 5°C is now potentially moving cargo within the refrigerator outside of the 2°C to 8°C target range and potentially experiencing close to freezing temperatures.

The most obvious and immediate impact of wide peak variation and temperature performance is in good manufacturing practice (GMP) environments. In these applications a high or low temperature alarm outside of the 2°C to 8°C operating range can be costly in terms of time, money, and results. This will typically trigger a deviation and quality process to document the temperature excursion as well as understanding what caused the temperature fluctuation. This can cost thousands of dollars to the organization and be a drain on productivity. In addition to the organizational costs there is the more pressing concern of the impact to the contents of the refrigerator.

While some contents are resilient to temperature fluctuations, items such as fetal bovine serum (FBS), antibody dilutions, expensive media and reagents, and most importantly whole blood, vaccines, medications, and therapies can be impacted and have a negative impact on downstream results. Degradation of FBS, media, and reagents can be accelerated when exposed to warmer temperatures for extended periods and impact downstream results and have major implications to research. Clinical and analyzer kits can be somewhat more resilient to high or low temperatures but frequent fluctuations can reduce shelf life, and similar to other items, accelerate degradation. Whole blood when stored at temperatures close or below freezing can be rendered unusable straining already challenged supply chains for blood.

How does Thermo Fisher Scientific ensure sample integrity?

Thermo Fisher Scientific is committed to providing laboratories, clinics, and research organizations with the peak performing fit for purpose laboratory refrigerators that ensure sample integrity and downstream results. Thermo Fisher provides detailed and straight forward performance data for all of our laboratory refrigerators including PV, temperature stability, and temperature uniformity so end users can make informed choices and be confident in our cold storage solutions.

PV performance for Thermo Scientific™ TSX and TSG Series laboratory refrigerators is validated not only by rigorous internal test procedures, but also through third party testing. The test data in Figure 3 from the EPA for ENERGY STAR certification demonstrates how Thermo Scientific TSG and TSX Series laboratory refrigerators provide industry leading temperature performance when compared to a wide range of competitors on the market (https://www.energystar.gov/productfinder/product/certified-lab-grade-refrigeration/results). As demonstrated in Figure 3 laboratory refrigerators on the market can have wide swings that could result in temperatures above +10°C or below 0°C, depending on the direction of the temperature variation, resulting in costly deviations or worse yet unknown damage to the contents of the refrigerator. It's important to also note that the ENERGY STAR test uses weighted probes meaning actual air temperature will vary to a greater degree, and that even in the instances in which competitors are remaining inside the 2°C to 8°C envelope they're much closer to the outer boundaries of the acceptable temperature range and additional door openings, extended door openings, or frequent loading of room temperature cargo could easily push it well outside of the acceptable temperature range. Thermo Scientific TSX and TSG series fit for purpose laboratory refrigerators help give researchers and clinicians confidence in the cold storage environment needed to optimize their results and operations.

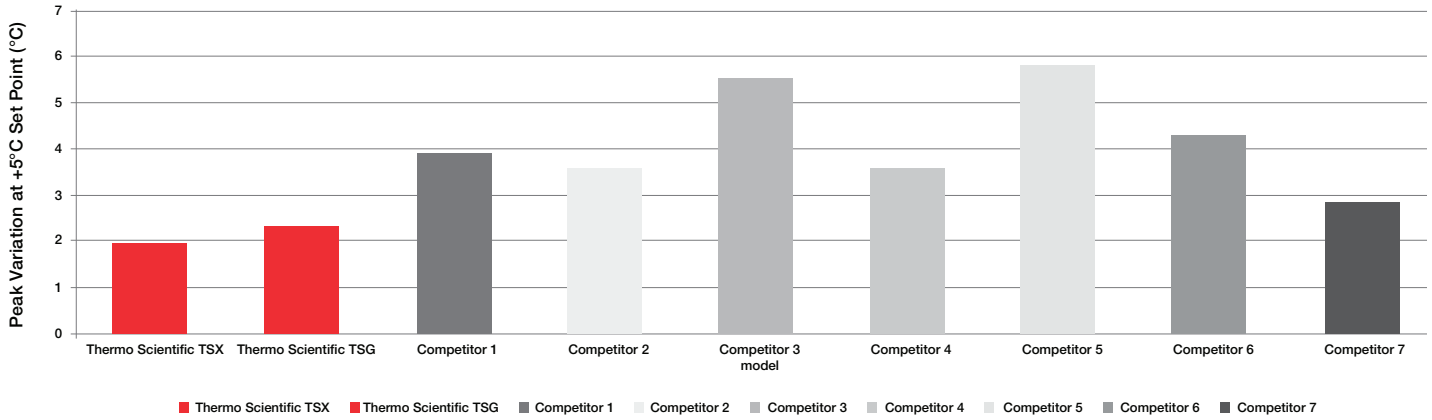


Figure 3. EPA ENERGY STAR Peak Variation Test Results.

Conclusion

While laboratory refrigerators are rarely top of mind when thinking of critical research they're integral to any laboratory, clinic, or research organization's operation and results. PV is one of the most important and yet straightforward metrics for understanding unit performance and the Thermo Scientific TSX and TSG Series refrigerators provide industry leading performance in this critical category. Thermo Fisher Scientific provides robust data to support researchers in making informed decisions about the cold storage for their lab, and results are proven out through third party testing.

Learn more at **thermofisher.com/labrefrigerators**