3 Factors that Determine a Cooling Method for Electronics Testing

Understanding the pros and cons of cryogenic and compressor-based cooling systems

Cooling test subjects effectively depends on test requirements, facility resources, and cost considerations. Although matching the test subject's geometry to an appropriately sized chamber, platform, or test enclosure is an important first step when selecting a temperature system, identifying the best cooling method for the system is often the most challenging.

Compressor-based cooling uses compressors and conventional refrigerants in a closed-loop system; cryogenic cooling uses expendable Liquid Nitrogen (LN_2) or Liquid Carbon Dioxide (LCO_2) in an open loop system. Here are the key considerations for each:

1. TEMPERATURE TEST REQUIREMENTS

Temperature Ranges, Transition Rates, and Dwell Times

Test specifications dictate temperature ranges, transition rates, and dwell times. Cryogenic cooling offers the widest temperature ranges (-185 to +500°C, see Figure 1) with the fastest temperature transition rates (up to 100°C/min, see Figure 2). If your specifications require extreme temperature ranges, fast transitions, or management of high heat dissipation, then cryogenic cooling is the likely option for you.

Compressor-based systems (-100 to +300°C, 10°C/min) are better suited for long dwell times because a closed-loop system does not require expendable coolants. It is also worth considering that compressor-based systems have high temperature limitations because conventional refrigerants break down in ultra-high temperature applications. If both cryogenic and compressor-based systems can meet your test specifications, facility requirements and system cost are the next considerations.

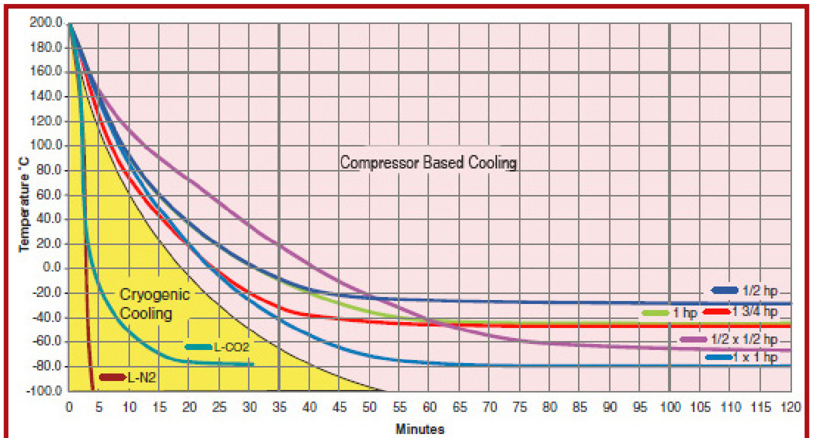

Figure 2: Cooling System Transition Rates

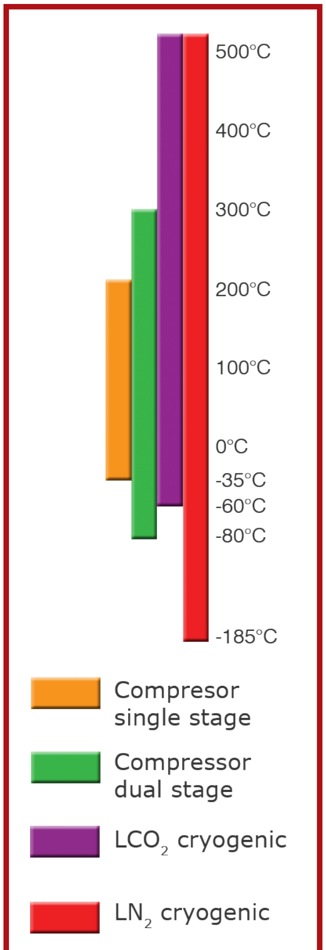

Figure 1: Cooling System Temperature Ranges

2. FACILITY RESOURCES

Coolant Supply, Coolant Exhaust, Facility Power, and System Footprint

If your facility is equipped with an LN_2 or LCO_2 bulk-delivery system, cryogenic cooling will be the easiest to integrate. Without bulk-delivery, cryogenic systems rely on dewars (portable tanks) to deliver coolant. Dewars can be cumbersome and may deplete before testing is finished. Regardless of the coolant delivery method, all cryogenic systems expel exhaust that must be managed.

Cryogenic exhaust is a result of the liquid coolant becoming gaseous and expanding at a ratio of up to 1:700. These large volumes of gas can force breathable oxygen out of rooms that are not properly vented. Managing cryogenic exhaust requires either venting the exhaust to the outside atmosphere or installing the system in a well vented area with an oxygen monitor nearby.

Compressor-based systems are closed loop systems that do not produce gaseous exhaust, but they do generate mechanical noise and heat. In some cases, steps must be taken to manage the heat especially if multiple compressor-based systems will be employed within a small area. Options for managing the heat include fans and ventilation or water-cooled condenser units. Your facility's power limitations must also be considered. Compressors and heaters require energy and as temperature ranges and transition rates increase, so too do the system's heating and cooling power requirements. Compressor-based systems typically require a minimum of 230V, 30A whereas cryogenic systems can operate on as little as 120V, 10A. And while both cooling systems can require high power, cryogenic systems typically stay within 30A because they do not rely on compressors for cooling.

The cooling system's size may also play a role if floor space is at a premium. Cryogenic systems can be stacked, allowing multiple chambers to operate in the same footprint.

3. COST CONSIDERATIONS

Cost to Buy, Operate, and Maintain

The true cost of the system goes beyond its initial purchase. Compressor-based systems have higher purchase and maintenance costs because they have more mechanical components (compressors, condensers, pumps, etc).

Cryogenic systems have a higher operating cost because they require replenishment of expendable coolants and more training for personnel. The general rule-of-thumb is that cryogenic cooling is less expensive short term and more expensive long term, while compressor-based cooling is more expensive short term but less expensive long-term.

CONCLUSION

With a myriad of factors to consider, deciding between cryogenic and compressor-based cooling systems can be difficult. Having a full understanding of the test requirements and the advantages of each cooling method is critical to making the best decision.

If you are not sure what system best fits your needs, contact our application engineers today. We have over fifty years of experience with all types of heating and cooling systems for testing chips, high-power devices, high-mass components, and other test subjects.

applications@inTESTthermal.com