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GREENING COLD STORAGE

DESIGN IMPROVEMENTS BALANCE SAMPLE INTEGRITY WITH GREATER ENERGY EFFICIENCY

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"The new breed of cold storage not only provides the ultimate in sample protection but is also kinder to the environment."

It is now accepted that we need to be more active in our efforts to reduce our effect on the planet and the depletion of its limited resources: turning off lights and electronic equipment, walking more, etc. But laboratory equipment such as cold storage units cannot be turned off overnight. Furthermore, such units must also provide consistently accurate and stable temperatures to ensure sample protection; requirements that have traditionally necessitated higher power consumption. The designers of Thermo Scientific cold storage products saw this as a challenge and looked at every single component involved in the operation of cold storage units to find ways to improve performance while reducing energy consumption.

Back to basics

Many different methods have been developed to remove heat from a space (the ultimate aim of any refrigeration system). These include but are not limited to chemical reactions (e.g., ammonia-based), electronics (e.g., Peltier circuits), laser-based cooling and even acoustic systems. Many of these have found niche applications, but the main technology associated with cold storage (refrigerators and freezers) is based on Faraday's original mechanical vapor-compression cooling concept. This simply involves compressing a suitable gas into its liquid phase and pumping it through/around the refrigeration space. As it passes through, it absorbs heat and in doing so returns to the gas phase. Heat is then ejected as the gas passes through the condenser. Modern household, commercial and laboratory refrigeration systems

have taken this concept and added new designs with novel technologies to achieve the desired cooling properties, which are different for each arena. Household systems are designed to store inexpensive groceries for occasional access, while commercial systems, though still suited for grocery storage, can withstand the rigors found in a local store or restaurant. However, neither system addresses the need to store DNA; RNA; proteins; and other precious, sometimes mission-critical, laboratory samples.

Fully spec'd

Laboratory cold storage systems are purpose-built and tested for lab environments—with the precise temperature controls required for sample preservation and integrity. This means they typically feature advanced alarm systems, tighter adherence to set-temperatures, faster temperature recovery, storage flexibility and a range of optional security features. Providing these features, and therefore the high level of sample integrity, generally requires greater power consumption than does a household or commercial system. For example, some freezers have two compressors, with one running continuously, and therefore it is not easy to be "green" when you absolutely must have sample integrity.

Revolutionary redesigns

Designing any product is hard and requires a thorough knowledge of all the requirements. Redesigning a successful product line is therefore even harder. In the laboratory market there are ad-

ditional complexities due to the distinct needs of end users, for example:

- *the great array of sizes required*
- *the different temperature ranges*
- *the various global electrical requirements, as well as the need for compliance with extensive, country-specific energy and safety legislation*

In cold storage units there are many necessary “energy sinks,” as well as some that can be eliminated. With the overall aim of increasing sample integrity, designers have looked at all such energy sinks as well as the associated components and subsystems to increase system efficiency. As a result, the new breed of cold storage not only provides the ultimate in sample protection but also is kinder to the environment.

Refrigeration subsystem

The “active” part of the cold storage system includes the compressor(s), evaporator, condenser, refrigerant and piping network. Innovative enhancements to each of the components in this subsystem now enable more efficient performance by providing superior heat removal, reduction of the heat expelled into the local environment and reduced energy usage. For example, advances in compressor technology have delivered a 20 percent improvement in efficiency over the past five years, and as a result, Thermo Scientific cold storage units do not waste energy.

It is said that “power is nothing without control” and the same is true for cold storage. New control algorithms have been developed to provide pinpoint management, not only for the internal storage space, but also for the compressors. This means that, instead of running 100 percent of the time, the compressors only switch on when they need to be on, further decreasing the energy used as well as the noise and heat output.



◀*Forma high-performance lab refrigerators and freezers feature convenient microprocessor controls and temperature recorders so users can monitor internal and external conditions.*

Defrosting is often taken for granted in household and commercial systems, since most are fitted with automated cycles operating on a set time interval. Furthermore, standard defrost cycles induce large

temperature fluctuations, which are great enough to be of concern for sample integrity. For laboratories, where cold storage systems are monitored and managed closely, there is not necessarily the need to have a defrost cycle at all. In such situations there needs to be additional storage capacity so that units can be defrosted while empty. If a manual defrost program is not suitable due to personnel, time or space restrictions, many cold storage products are fitted with an intelligent defrost program that monitors temperature differences across the evaporator. By doing this, defrost cycles are run only when absolutely necessary and cause only a minimal increase in the storage compartment temperature. This also has a positive impact on energy consumption, since the evaporator is maintained in prime condition.

Cabinet design

Condensation around the doors of cold storage units has always been a problem, no matter what size the system is, since it can reduce the effectiveness of the seal. When the seal is compromised, there will be a resultant increase in energy consumption and warming of the precious samples and the doors could possibly freeze shut. The most common solution to this is to gently heat the seal threshold, which creates two further problems: the introduction of heat into the cold space and increased power consumption to heat the threshold and then to remove the excess heat added to the sample compartment. New designs eliminate the need for heat around the doors and therefore both save energy and protect samples.



◀*Revco PLUS ultra-low temperature freezers feature up to ten secure inner doors for enhanced compartmentalization, minimizing sample exposure to warm ambient air.*

Ultra-low temperature (ULT) freezers store samples at or near -80°C, the temperature at which biochemical reactions are minimized. Therefore it is essential that, when samples are being retrieved from the freezer, a minimal amount of cold escapes and as few samples as possible are exposed to ambient conditions. This makes the interior design and layout of the units extremely important. The first key design feature is compartmentalization, such that each compartment has a separate internal door to keep

the cold in. Larger ULTs can have up to ten compartments, which ensures that very few samples are affected by inventory access. As a dividend of concentrating on sample protection, less energy is consumed in returning a compartment back to its desired operating temperature. Another excellent way to speed up sample retrieval is to use sliding rack systems, which also provide better use of the full storage capacity.



◀ *Racks and consumables are essential companions for maximizing sample protection and energy-efficiency with your storage system.*

Knowing where samples are important to speed up retrieval, so being able to see the contents within a cold storage unit is a big advantage. The Revco high-performance +4°C to -30°C

range offers glass doors as an option, enabling full-length views of the sample storage space.

A further improvement in the passive elements of cold storage comes in the form of new and innovative insulation, using non-HFC blowing agents as well as providing excellent insulation properties and therefore reducing power consumption. Improvements to insulation also mean that less is needed and walls can be thinner, enabling more storage space within a defined footprint. New insulation materials also provide a much better environmental profile, so there are fewer production, use or disposal issues.

Education

There is one last area that is being addressed by major manufacturers that can have a large influence on sample integrity, as well as environmental friendliness—end user education. Many of the features above that have been engineered to provide advantages also require a level of instruction. For example:

1. *Buy only what is needed. It is always best to buy a cold storage unit that matches usage requirements. It is counterproductive and false economy to buy a unit that will remain partially filled for most of its life.*
2. *Accurate lists. Although it may be obvious, it is essential to keep*

clear inventory lists and maintain a sensible storage system. If these actions are not taken, users could be fishing around for their samples for longer than is desired, exposing many more samples to the harsh effects of ambient room temperature.

3. *Plan ahead. With a clear inventory system and an exact list of which samples are needed, users can plan their sample recovery. This minimizes unwanted sample exposure.*
4. *Simple maintenance. Keeping seals clean and free from damage ensures that doors close properly. Furthermore, the refrigeration system has an air filter that becomes clogged over time but can be easily cleaned—doing this regularly ensures that the system can maintain maximum efficiency.*

“Many cold storage products are fitted with an intelligent defrost program that monitors temperature differences across the evaporator.”

Establishing standards

Due to their complexities, laboratory products cannot presently be covered by the Energy Star rating system. Thermo Scientific cold storage product development teams are working with U.S. federal groups, including the Environmental Protection Agency (EPA) and the Department of the Environment (DOE), to establish criteria for extending the Energy Star system to the laboratory sector.

Conclusions

There are several selection criteria to consider when evaluating the proper laboratory cold storage solution: 1) Temperature Stability and Recovery; 2) Sample Integrity Protection; and 3) Safety and Security. By introducing greater efficiency with an aim to improve 1 and 2, manufacturers have also provided an excellent environmental dividend. Combining these advances with end user education ensures that, although it is not easy to be green in the laboratory, it is at least possible now.

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