SUMMARY OF ULT PERFORMANCE RESULTS

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In 2009, Thermo Fisher Scientific contracted with Creative Thermal Solutions, Inc. of Urbana, Illinois to conduct a series of performance tests on Thermo Scientific brand and competitor ultra low temperature freezers (ULTs) in their thermal evaluation testing labs. Summarized results and the raw data for the results below are now available on the CTS maintained ftp site, ftp://creativethermal.dyndns.org/, user name: thermo, password: 2009test. These data will be available throughout 2010.

Market research tells us that performance, as it relates to sample protection and energy efficiency, are important attributes for ULT freezers. Summarized below are data which provide an overview of performance and energy efficiency of Thermo Scientific brand and competitive ULT freezers.

In order to determine how well a freezer could maintain a cold temperature in the presence of a heat load and to judge the impact of a heat load on samples already in the freezer, the following test was performed. First, the average BTU reserve capacity is a measure of a freezer's ability to maintain a cold temperature across the entire cabinet in the presence of a heat load. Accordingly, a heating coil was placed in the bottom center of the freezer and encased in an enclosure to allow the heat to escape into the cabinet in a uniform manner. The freezers were set to "bottom out temperature," which is the lowest temperature the freezer can maintain. The bottom out temperatures range from approximately -88 to -83 depending on the manufacturer and are displayed in the graphs as the 0 watt control.. An electrical current was then applied to the coil producing set amounts of heat (40 watts, 60 watts, 90 watts and 120 watts). Once the heat load of 40 watts was applied, the freezer warmed to the lowest temperature it was able to maintain. After the temperature stabilized and was documented, additional heat loads were applied to the cabinet with the coil. Figure 1 shows each freezers' performance with increasing heat loads. The temperature shown is an **average** of 16 themocouples (T1-T16) which were placed as is shown in Diagram 1.

Figure 1:

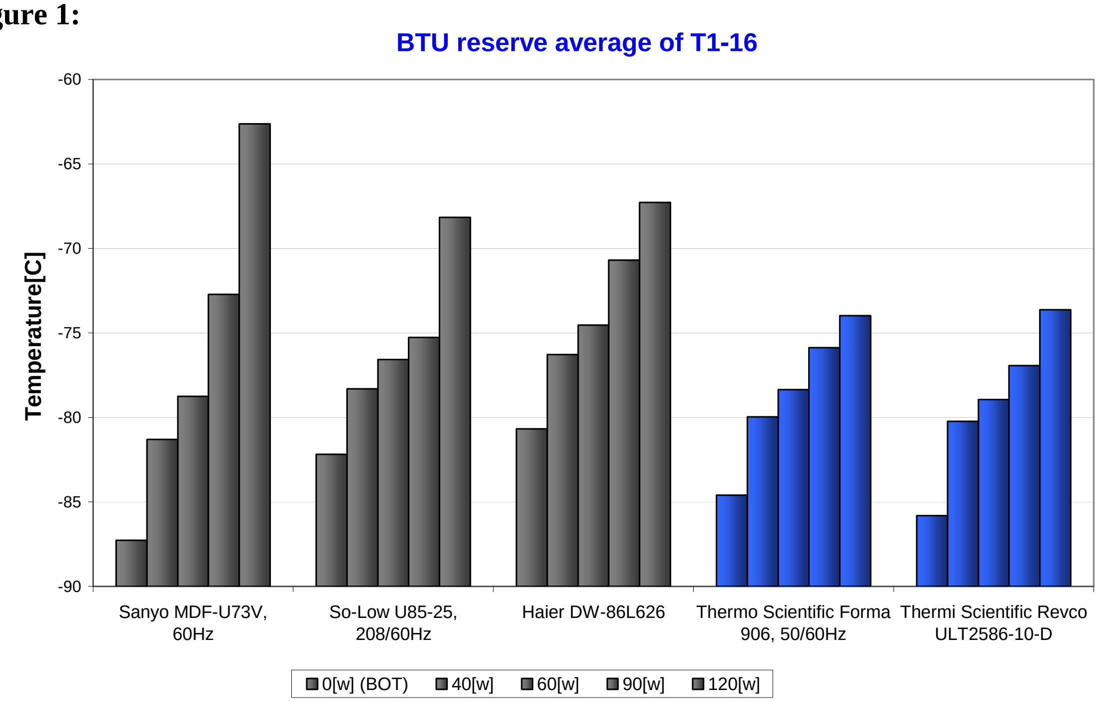


Figure 2 shows this same data **but only for** the thermocouple 16 (T16). T16 is the only thermocouple whose location is different because of differences in design between ULT manufacturers. T16 was located within 1 inch of the manufactures' display/control probe location. Manufactures place the display/control probe in the center back, lower right or various other locations. As the data indicate, the temperature at the display/control probe location (T16) is not necessarily the average temperature of the cabinet and can differ by more than 5^oC.

Figure 2:

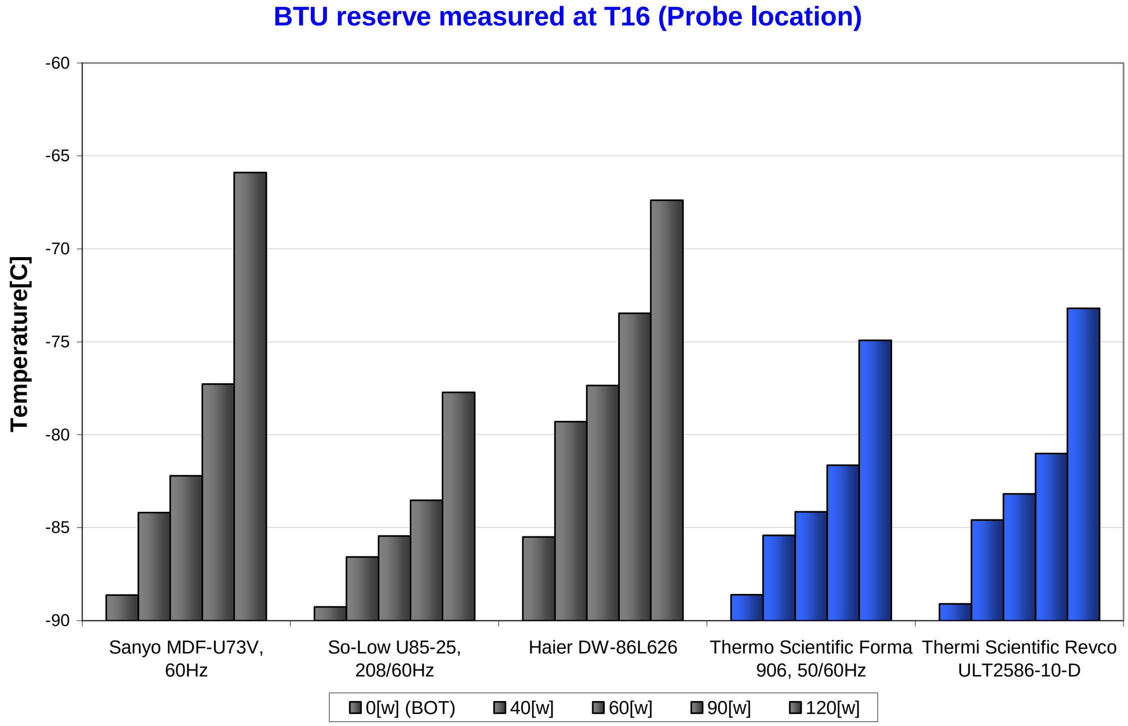


Figure 3 demonstrates the time it takes for an empty ULT to warm from -80^oC to -50^oC during a simulated power outage and is based on an average cabinet temperature. During prolonged power outages, freezers will warm over time. The length of time to warm is based on the cabinet's insulation properties and the door seal. Fully-loaded or partially loaded freezers will warm more slowly than an empty freezer. However, this test provides a baseline for this performance.

Figure 3:

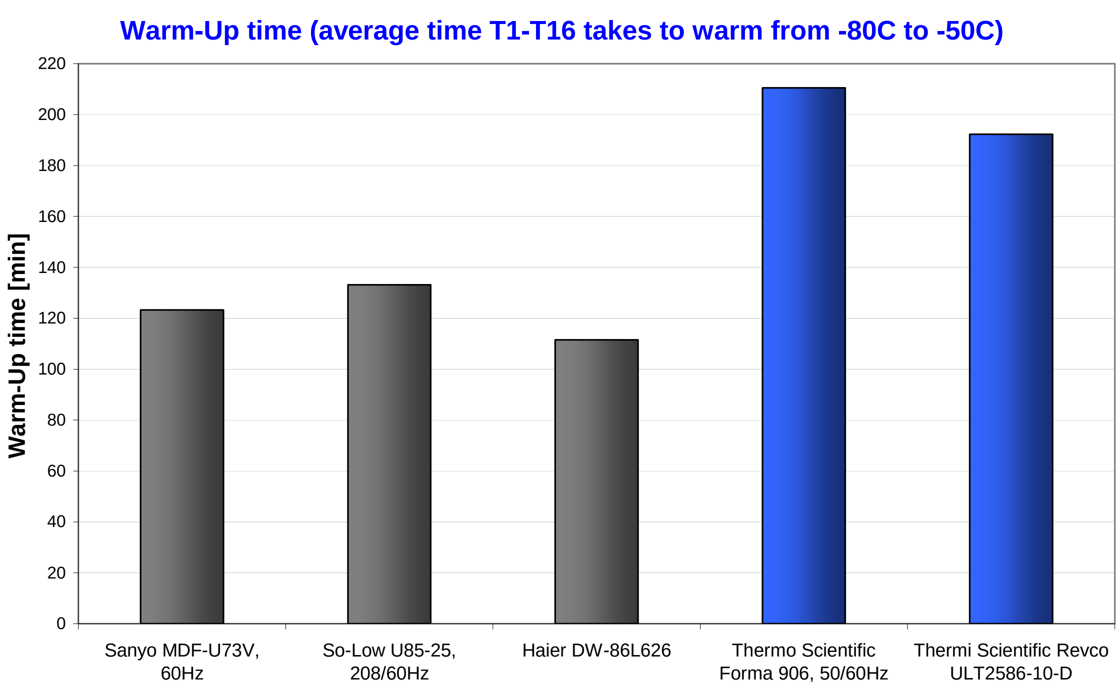


Figure 4 demonstrates the energy consumption in kilowatt hours of a freezer during normal cycling at a -80°C set point. Lower energy consumption results in lower operating costs over time. For instance, a 10% lower energy usage for a ULT can be expected to save over $900 during a 10 year period based on US DOE energy cost averages of 10.4 cents/ kilowatt hour (http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html).

Figure 4:

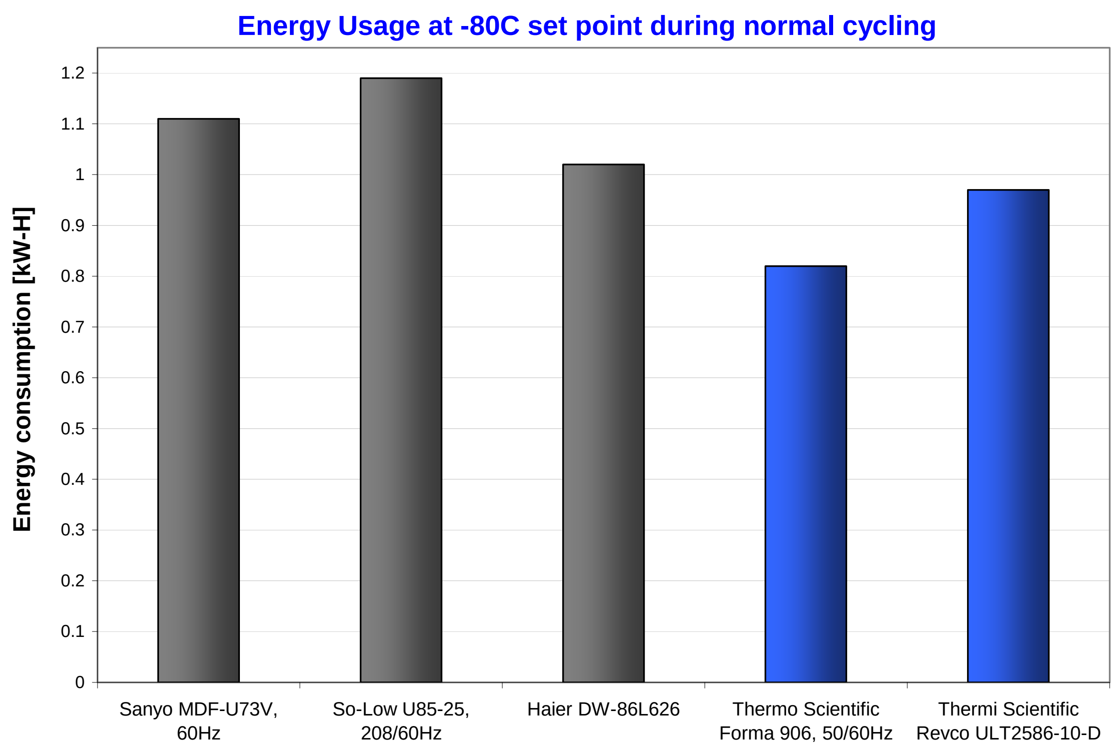
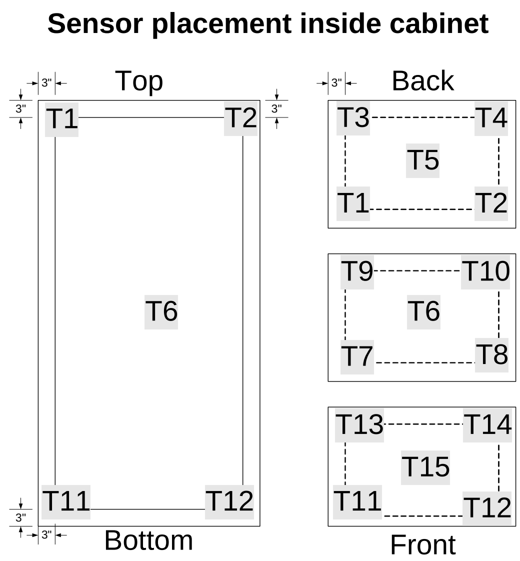


Diagram 1:



16 thermocouples were mounted inside the cabinet for temperature measurements. The locations of the TC sensors were the same for all ULTs except thermocouple 16 (T16). T16 was mounted within 1" of the temperature probe. Therefore the location of the T16 is dependent on where the temperature probe is. Some models were in the middle of the cabinet but some were at the bottom. Note: All shelves were taken out for all ULTs for performance testing.

Thermo Scientific brand ULT freezers are designed to deliver high performance with low energy usage. This is achieved in part through refrigeration system design, insulation and door seal properties as well as control probe location.