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ULT FREEZER RACKING STUDY

IMPACT OF ULT RACKING UPON PERFORMANCE, UNIVERSITY OF OXFORD. AN INDEPENDENT STUDY CONDUCTED BY ANDY EVANS, GREEN LIGHT LABORATORIES WITH EPPENDORF FREEZERS SOURCED FROM SCIENTIFIC LABORATORY SUPPLIES.

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INTRODUCTION

Ultra Low Temperature (ULT) freezers are a predominantly used in life sciences for the long term storage of valuable samples and products. The use of racking can vary between organizations with some ULT freezers being completely racked (figure 1) whilst others are devoid of any racking whatsoever. Racking can be made of aluminium or stainless steel. This study set out to identify what impact of aluminium racking upon the temperature and energy performance of a ULT freezer at the -80C set point.

Figure 1. ULT freezer fully racked with temperature loggers in place.

TESTING THE IMPACT OF RACKING

The data was collected over a two week period at the Department of Plant Sciences, University of Oxford. The Eppendorf ULT freezer (F570h) tested was supplied for the study by Scientific Laboratory Supplies Ltd and the racking was supplied by Westbart. The racking was made of aluminium in the

format of front opening outers designed to house standard cryoboxes. The total weight of the aluminium racking used was 90kg. The unit was tested in an air conditioned laboratory where the ambient temperature was recorded at 19C (+/-1C). The ULT freezer had a temperature logger placed at the centre point of each of its shelf, with a further two loggers placed at the centre front and centre back points of the centre shelf (Compartment 3). This temperature logger recorded the internal temperature every minute, accurate to 0.1C. The temperature loggers used were MadgeTech Cryotemp Data Loggers, supplied by Wessex Power. Compartments were numbered in descending order meaning that the top compartment was labelled as compartment 1 and the bottom compartment is compartment 5. The energy monitors used had a kWh reading variance of +/- 1%. The ULT freezer was subjected to a number of tests. The tests measuring temperature and energy performance at the -80C set point without any door openings are summarized in Figure 1.

Measurement	Empty F570h ULT Freezer	Racked F570h ULT Freezer
Energy Consumption	7.57 kWh	7.20 kWh
Pull Down Time To -80C Set Point	4 Hours 10 Minutes	9 Hours 55 Minutes
Compartment 1 Average Temperature	-78.6C	-78.9C
Compartment 2 Average Temperature	-79.9C	-79.3C
Compartment 3 Back Avg. Temperature	-81.5C	-80.5C
Compartment 3 Middle Avg. Temperature	-80.2C	-79.4C
Compartment 3 Front Avg.Temperature	-80.4C	-79.5C
Compartment 4 Average Temperature	-79.2C	-79.2C
Compartment 5 Average Temperature	-76.7C	-77.4C
Compartment 1 Warm Up Time To -50C	4 Hours 19 Minutes	8 Hours 44 Minutes
Compartment 2 Warm Up Time To -50C	5 Hours 12 Minutes	11 Hours 4 Minutes
Compartment 3 Back Warm Up Time To -50C	5 Hours 55 Minutes	13 Hours 11 Minutes
Compartment 3 Middle Warm Up Time To -50C	5 Hours 54 Minutes	13 Hours 5 Minutes
Compartment 3 Front Warm Up Time To -50C	5 Hours 49 Minutes	13 Hours 2 Minutes
Compartment 4 Warm Up Time To -50C	6 Hours 10 Minutes	14 Hours 23 Minutes
Compartment 5 Warm Up Time To -50C	6 Hours 10 Minutes	14 Hours 24 Minutes

Figure 2. ULT Temperature and energy performance at -80C set point.

A number of timed door openings were also carried out. All doors were opened to a 90 degree angle and then closed within the allotted time. Figure 3 shows the temperature changes following a 60 second door opening. Please note that when reading the legend all data with the prefix E is from the empty freezer and data with the prefix R is from the racked freezers.

In total there were 4.5 minutes of door openings carried out on each unit configuration during those two weeks of testing. In the empty ULT freezer these door openings used 0.78 kWh of electricity whilst in the racked unit these door openings used 1.27 kWh or electricity.

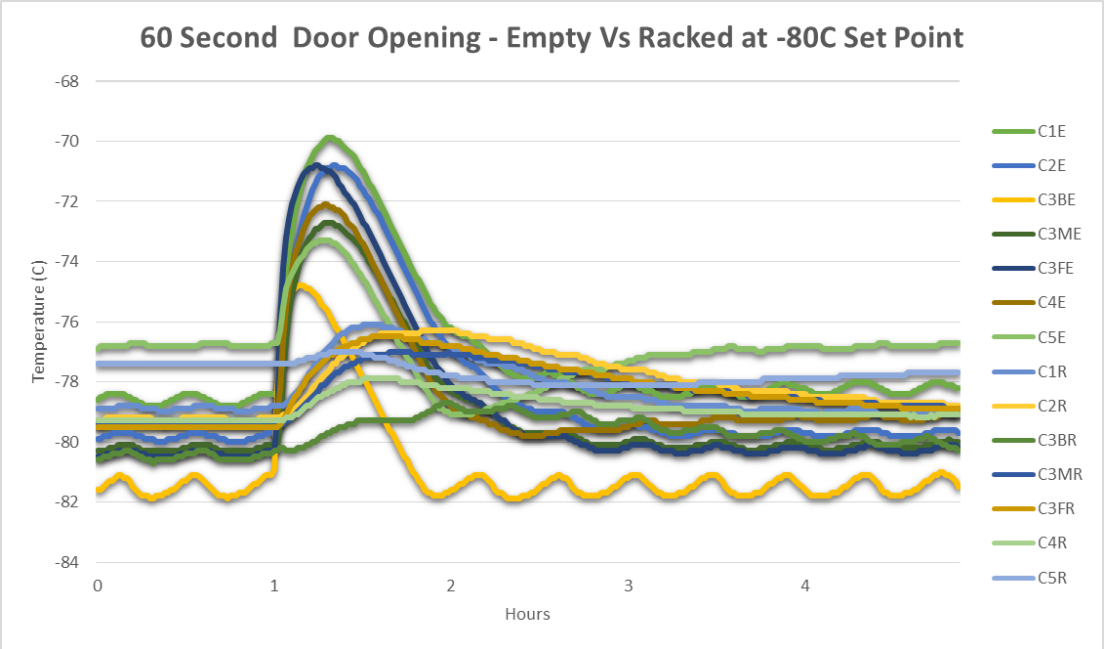

Figure 3. Effects of a 60 second door opening on ULT freezer compartment temperatures.

F570h ULT Freezer Compartment	Warmest Temperature Following: 60 Second Door Opening	90 Second Door Opening	120 Second Door Opening
Empty Unit, Compartment 1	-69.9C	-66.1C	-63.1C
Empty Unit, Compartment 2	-70.8C	-66.9C	-64.1C
Empty Unit, Compartment 3, Back	-74.8C	-71.9C	-69.9C
Empty Unit, Compartment 3, Middle	-72.7C	-69.3C	-66.6C
Empty Unit, Compartment 3, Front	-70.8C	-66.3C	-63.0C
Empty Unit, Compartment 4	-72.1C	-68.8C	-66.5C
Empty Unit, Compartment 5	-73.4C	-71.6C	-70.3C
Racked Unit, Compartment 1	-76.1C	-74.4C	-72.7C
Racked Unit, Compartment 2	-76.3C	-74.6C	-73.3C
Racked Unit, Compartment 3, Back	-78.7C	-77.6C	-76.8C
Racked Unit, Compartment 3, Middle	-77.0C	-75.4C	-74.4C
Racked Unit, Compartment 3, Front	-76.5C	-74.8C	-73.7C
Racked Unit, Compartment 4	-77.9C	-76.5C	-75.9C
Racked Unit, Compartment 5	-77.0C	-76.5C	-76.4C

Figure 4. Effect of timed door openings on ULT freezer compartment temperatures.

It was also observed that in the case of the empty ULT freezer, to recover temperature following a timed door opening was as follows 60 seconds = 2 hours, 90 seconds 2.5 hours and 120 seconds 3.5 hours. In the racked unit these recovery times double.

DISCUSSION

Although it was observed that the racked units take longer to recover from a door opening the unit remained significantly colder than a non-racked unit. As shown in figure 4, the racked unit was far more resilient to door openings. After a 60 second door opening temperatures in a racked unit will be as

much as 6C colder than an empty ULT freezer. With longer door openings of 90 and 120 seconds these temperatures can be up to 7C and 10C colder respectively. The temperatures recorded in the racked ULT freezer after a 120 second door opening were **colder** than those recorded in the empty ULT freezer following a 60 second door opening. The racking was able to absorb the heat following a door opening resulting in the lower rises in temperature. As the racked ULT freezer was cooling an extra 90kg of metal compared to when empty, there is an obvious energy cost for doing so.

The effect of the racking (figure 2) also resulted in the warmer temperatures observed in the empty ULT freezer (Compartments 1 and 5) being **colder** in the racked unit; there is a more even distribution of temperature. Although in other compartments temperatures rose by a maximum of 1C the insulative properties of the racking have resulted in at least a doubling of the warm up times to -50C, in some compartments this time was **133% longer**. This would give end users longer to manage the safe transfer of samples following a loss of power/failure. Also, although door openings were compared during this study it must be noted that when a ULT freezer is racked keeping an inventory and therefore locating contents is easier and faster. Therefore in a racked unit door openings would logically be shorter compared to that of an equally full non-racked ULT freezer. The impact of this in the racked ULT freezer would be even smaller rises in internal temperatures and a lower cost in electricity associated with accessing samples (providing end users were employing a proper inventory).

Furthermore, to save energy end users could fully rack a ULT freezer and operate it at warmer temperatures (-75C or -70C). The racking would greatly decrease the impact of a door opening ensuring that samples always remained at an acceptable temperature. This will be further explored in upcoming case studies.

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