EXECUTIVE REPORT DETAILING THE FINDINGS OF THE ULTRA LOW TEMPERATURE (ULT) FREEZER SURVEY OF THE CLINICAL SCHOOLS

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1 INTRODUCTION

The University of Cambridge is committed to reducing our energy-related emissions by 34% by 2020, cutting our total carbon footprint of 243,000 tonnes CO_2e. Of this figure, energy generation and use comprises 73,000 tonnes, of which energy intensive lab spaces are a current target. From findings in Yale University, because a significant amount of energy used in labs comes from appliances, and of those appliances, over 66% are from Ultra Low Temperature (ULT) Freezers (freezers that operate at a temperature below -60˚C), it was decided that a project be led to investigate the relevance of this issue in Cambridge.

We set out to conduct an audit of ULT freezers to find out how may we have, in order to see how big the issue is; how they are maintained, to assess how much energy we could save from correct maintenance; what is stored in them, to allow efficient and safe use of the freezer, and how they are purchased, to effectively develop purchasing policies.

We surveyed a representative sample of departments from the Clinical Schools residing on the Addenbrooke's hospital site. These included the Department of Psychiatry. The Department of Pediatrics, and the Cambridge Institute for Medical Research, a cross-departmental institute.

We surveyed a total of 58 freezers, found they were of mixed maintenance, had mixed sample storage procedures, and individual purchasing policies. This report identifies areas that are being performed excellently, and areas for improvement.

2 RESULTS AND DISCUSSION

2.1 AMOUNT OF FREEZERS AND GENERAL INFORMATION ABOUT THEM

In the Department of Psychiatry three ULT freezers were examined; one resides in the Douglas House site, and the other two in the Addenbrooke's site. Eight freezers were examined in the Department of Pediatrics . In the CIMR, part of the MRC building, there were a total of 58 freezers examined (this excluded the freezers owned and operated separately by the MRC).

This brings the total number of freezers assayed to 69 freezers across three departments. Some departments have few numbers of freezers, while others have a large number of them.

With regards to age, most freezers had an average age of 4-5 years; however, some were as old as 15 years, whilst others were almost brand new. Room, Make, Model, Serial Number and Voltage/Amperage information was easily obtainable, which will make an inventory quite easy to make from this data. However, most freezers already had an ID number with a label saying "Clinical School Asset Register".

Such a register would be most helpful to locate, as this would aid in identifying which freezers were over a certain age, as well as, if taken recently, would be an accurate snapshot of the number of freezers across the entire Clinical Schools.

2.2 Operation and Maintenance Findings

2.2.1 Temperature Set Point and Actual Temperature

100% of freezers from the Department of Psychiatry had freezers set at -80˚C. However, the actual temperatures were different; one was -78˚C, one fluctuated between -78˚C and -81˚C, and one was operating at -55˚C. (This specific freezer will be discussed in more detail in the recommendations section).

The Pediatrics Department had their freezers set at either -75˚C or -76˚C. With the exception of one freezer (-61˚C), all of these freezers were reaching their temperature set point.

The CIMR building had most freezers set and operating at -80˚C; however, some were set as low as -85˚C, and one was set at -86˚C.

Temperature set point is a controversial issue within most departments, with most believing that a temperature of at least -80˚C must be set in order to ensure prolonged sample security. Increasing the ULT freezer's set point lowers the ULT freezer's duty cycle, which in turn lowers the ULT freezer's energy consumption. Lowering the ULT freezer's duty cycle also extends the life of the ULT freezer because it decreases the frequency that the compressor cycles on and off. Based on calculations done by the National Institute of Health and UC Davis, raising the set point temperature of a ULT freezer by 5˚C cuts energy use by 3kWh every day. In addition to these data, a study done by the University of Harvard demonstrated that antibodies, antigens and nucleic acids could be stably stored for at least 20 years at a temperature of -70˚C.

2.2.2 Dust

In Psychiatry, 66% freezers fairly dusty filters, which would be reflected on the condenser, reducing its capacity to exchange heat with the environment. Pediatrics have a maintenance contract where dust is cleaned off every 6 months – this was clearly reflected in the lack of dust on the filters; similarly, almost 100% of CIMR's freezer fleet had very little or no dust on their filters.

The importance of a clean and non-dusty filter cannot be emphasized enough; Dust on the filter blocks the normal air flow through the condenser, which reduces the ability of the ULT freezer to dissipate heat. Any air flow that bypasses the clogged filter will result in air carrying dirt to deposit on the condenser. Dirt on the condenser prevents the effective heat transfer from the high stage refrigerant to the ambient environment. This can result in an increase of up to 10kWh per day, compared to dust-free filters.

2.2.3 Frost

The Pediatrics department performed very well in this area, with few freezers showing significant frost build-up around the door seal/on the inside doors of the freezer. However, both the Psychiatry and

CIMR ULT freezers showed significant frost build-up; in some cases, freezers were unable to be opened due to the amount of frost on the inside door.

Generally, as frost builds up on the evaporator coils the heat transfer rate in the ULT freezer cabinet is decreased due to the insulating effects of ice, which results in an increase in energy consumption.

2.2.4 Spacing

Most freezers across all departments showed good spacing of freezers, allowing efficient air exchange with the environment (however, see 3.2.3 about correct spacing of freezers for more details).

Location of freezers: each ULT freezer occupies 20-30 ft2 of valuable space. Due to space constraints in labs, numerous ULT freezers are stored in hallways. Most hallways are not designed not effectively remove heat generated from ULT freezers; therefore, ambient temperatures can be as high as 32˚C, especially during the summer months. Operating ULT freezers at these ambient temperatures increases energy consumption by as much as 24% and increases the risk for a ULT freezer to fail, which puts samples at risk.

2.3 Sample Storage Findings

On the whole, the findings of sample storage were more difficult to ascertain, as this is much more lab-dependent and not building manager-dependent.

2.3.1 Freezer Cleanouts

As most lab managers were not present, it was difficult to ascertain how often freezers were cleaned out. Cleaning out a freezer after 5 years of use typically can remove 30% of samples not needed for future research, saving on much-needed space and avoiding the purchase of another freezer.

2.3.2 Sample Inventories

Approximately 50% of freezer maps, showing where samples were and who was responsible for them, were posted on the freezer door. This greatly aids in accurately locating samples, reducing the amount of time the freezer door is left open, and therefore the amount of energy needed to cool it back down.

Labs will often have a more detailed inventory of what samples are in the ULT freezer located in the main laboratory. This was not possible to ascertain for most freezers; however, of those successfully surveyed, again about 50% of labs had a detailed inventory; fewer had an up-to-date one. This greatly aids in freezer cleanouts.

3 Recommendations

3.1 Keeping up the Good Work – Maintenance Contract and Dust Buildup

On the whole, freezers were subscribed to a preventative maintenance contract, which involves the cleaning of the filter to prevent dust accumulation. This is fantastic that almost all freezers are enrolled on this program, as it delivers both enhanced sample security and reduced energy usage (as well as prolonging freezer lifespan). Maintenance contracts should be renewed to keep up the great maintenance of these ULT freezers.

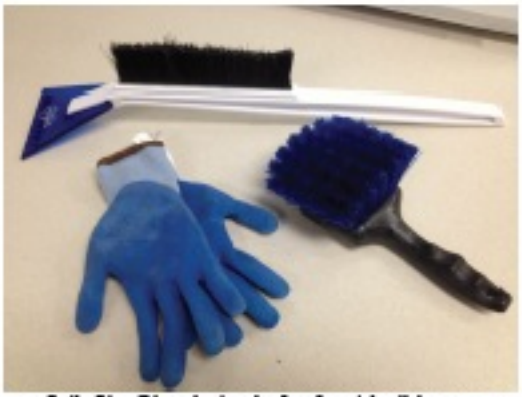
3.2 THE BAD – FROSTY/EMPTY/FREEZERS KEPT IN BAD AREAS

3.2.1 Defrost – purchasing freezer defrosting kits for labs

Freezers are often very frosty on the doors, which prevents the gasket seals from stopping air flow between the freezer and the ambient environment. Freezers need to be defrosted either monthly of half-yearly with soft tools; sharp tools must be avoided, which can damage the rubber sealing. Brush off excess ice on the doors and on samples with these tools into an appropriate receptacle. If concerned about missing your receptacle and soaking the floor, make sure you have absorbent materials on the floor. A typical freezer kit is pictured below, kindly published by the University of California Davis.

DEPARTMENT OF FROST PROTECTION

Frosty Friends: The campus or institution can promote good frost hygiene by distributing frost brushes or soft cloth wipes branded with their conservation program. A short handled bucket brush has lots of bristles, while a long handled auto windshield brush reaches into the back of ULT freezers and has a scraper built into it. Both can be obtained for $3-$5 when purchased in bulk. Rubberized gloves can make this frosty chore easier.



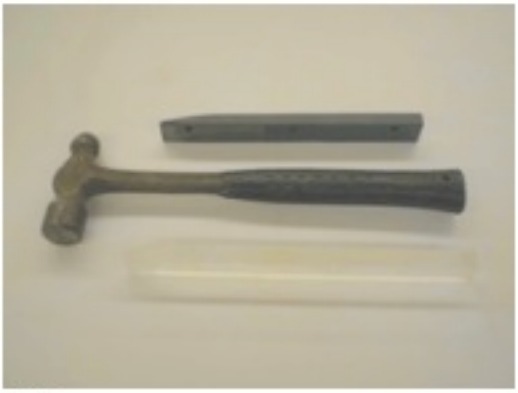


Figure 8 (left). Simple tools for frost build-up prevention.
Figure 9 (right). Blunt defrosting tools are very important, and can be made from soft Polyvinyl Chloride (PVC) or Polypropylene (PP) plastic and used with gentle hammering if needed.

Another point: While defrosting, check the gaskets and rubber seals around the freezer door. If seals are broken, schedule a repair.

3.2.2 Temperature set point

As previously mentioned, increasing the temperature set point by 5˚C can result in savings of 3kWh per day. Temperatures can and should be raised to -70˚C. Not only does this not impact sample security, as demonstrated by several studies done at Harvard University, it increases their security by lowering the duty cycle of the ULT freezer and thus increasing its life span.

3.2.3 Space management and ambient temperature

ULT freezers need at least 8” of clear space on the top, and a minimum of 5” of clear space in the rear and on both sides. The latter, ensuring both sides have at least 5” of clear space, needs to be implemented; all other factors are okay.

Freezers that are operating in ambient temperatures higher than 32˚C are not effectively transferring heat from the high stage refrigerant to the ambient environment. For every 1˚C drop in ambient

temperature, the energy consumption will fall buy approximately 2%. All freezers that were kept in hallways where HVAC systems cannot deal with maintaining set temperatures need to placed in dedicated equipment rooms that are operating below this temperature.

3.2.4 Sample Storage and Purchasing new freezers

Labs need to host annual freezer cleanouts to remove samples that are no longer needed; not only will this free up more space for the existing freezer, it will also prevent the purchasing of new freezers.

If the freezer is full of relevant, clearly labeled samples, before the purchase of a new freezer is attempted, labs should ask neighboring labs whether they would be willing to share freezer space. It was found that across almost all departments, freezers were rarely full, and some were much less than half full.

As a last resort, a new freezer should be purchased (this should also be done if the existing freezer is more than 10 years old). Please approach the Environment and Energy department prior to your purchase, who will be happy to advise you on specific models that are reliable and energy efficient.

3.2.5 Backups

Backup freezers are a vital component of a building, allowing samples to be securely stored in the case of failure. However, when backups are not being used, they should be set at a set point temperature of -60˚C, to reduce both energy and extent the life of the freezer by lowering duty cycle.