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Sustainability Statement

Client Name: The Francis Crick Institute
Client Project Name: Freezer Farm Cooling System
Project Location: Francis Crick Institute
Scitech Project Number: 30799

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1.0 Introduction

In accordance with the need for sustainable development, this document presents an overview of the sustainability principles underpinning the proposed Planning application.

This statement has been prepared in support of the proposal to provide resilience to the cooling system required to serve the “Freezer Farm” within the Francis Crick Institute at 1 Midlands Road.

This Statement has been prepared with input from Scitech, who are providing services advice to the Francis Crick Institute technical team.

This Sustainability Statement has been limited to the areas of building design related to the Planning proposal – specifically the cooling system changes and its implementation.

The existing “Freezer Farm” room on the Ground Floor of the building incorporates 114 low temperature freezers. These freezers store critical science samples at -80°C and are monitored to ensure that the storage conditions do not deviate from the required temperature.

For the freezers to operate correctly, the room housing them must be kept within a strict range of temperatures (19°C to 23°C). If the cooling to the area fails, the Freezer Farm room temperature would reach 27°C within 30 minutes and the freezers would start to fail – and subsequently risking the integrity of the critical samples within them.

Due to the close-control requirement of the environment, natural ventilation is not feasible.

1.1 Existing Systems

The Freezer Farm room is currently cooled by cassette style fan coil units, connected to the building centralised chilled water system.

It has been identified that there is a significant risk to critical samples in the circumstances of the building chilled water system failing. Additionally, during scheduled maintenance of the building chilled water system, the temporary cooling required is both impractical and presents its own resilience risks.

It has also been observed that the current design does not ensure an even temperature distribution throughout the room, therefore increasing the risk of the freezers going out of specification.

1.2 Proposed Changes

The main purpose of the proposed work is to provide resilience to the cooling of the Freezer Farm. This will be achieved by installing two additional chillers and associated cooling systems to serve the Freezer Farm. Each of these systems being sized to provide the full cooling load and therefore providing a full duty and standby arrangement.

A connection to the building chilled water system will be maintained to ensure back-up in the exceptional case of the failure of both dedicated chilled water systems.

It should be noted that the total cooling provided to the building will not be increased but instead moved to the new systems.

During the works, it is also proposed to improve the air distribution in the Freezer Farm room to ensure a uniform temperature distribution. This will be done by replacing the existing cassette fan coil units with Computer Room Air Handlers (known as CRAH), supplying a reconfigured room layout and designed to encourage an even environment to all freezers.

Again, it should be noted that the total cooling provided to the room will not be increased but instead be distributed more effectively within the space.

The most appropriate location for the two new chillers has been identified as the flat roof section adjacent to Ossulston Street (see Figs. 3 to 5). They will sit within an acoustic enclosure designed to meet the specified noise criteria.

2.0 Cooling Hierarchy Compliance Statement

2.1 London Plan

The London Plan and Camden Council require projects to follow the cooling hierarchy as outlined below:

Policy SI 4 Managing Heat Risk
A. Development proposals should minimise adverse impacts on the urban heat island through design, layout, orientation, materials and the incorporation of green infrastructure.
B. Major development proposals should demonstrate through an energy strategy how they will reduce the potential for internal overheating and reliance on air conditioning systems in accordance with the following cooling hierarchy:
1. Reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure.
2. Minimise internal heat generation through energy efficient design.
3. Manage the heat within the building through exposed internal thermal mass and high ceilings.
4. Provide passive ventilation.
5. Provide mechanical ventilation.
6. Provide active cooling systems.

The intention being, to reduce the built environments impact on the local and wider environment.

2.2 Freezer Farm Cooling System Compliance

Section A
Other than improvements to air distribution, the project does not include any changes to the Freezer Farm room or the building itself. The proposed new chillers will be installed on the roof within an acoustic enclosure. These will take load away from the existing cooling system and will therefore have minimal to no effect on the urban heat island.

Section B
The below discussion aims to show compliance to the cooling hierarchy through the limitations of the project area usage and decisions made during the design process:

1) Reduce the amount of heat entering a building

The heat gain entering the building from outside will not be affected by the proposed changes.

2) Minimise internal heat generation

The internal heat generation will not change with the proposed changes.

3) Manage heat within the building through exposed internal thermal mass & high ceilings

Due to the high and constant nature of the heat gains from the freezers, as opposed to cyclical heat gains from external sources (solar or conduction from raised external temperatures), introducing increased thermal mass or phase change materials would not be beneficial.

Extensive Computational Fluid Dynamic (CFD) modelling was undertaken to optimise the layout of the Freezer Farm room and Hot Air Containment (HAC) modules were identified as the most effective means of cooling the space. Please refer to the "Internal Computational Fluid Dynamics Report" (30677-BS-SP-0003) for further information.

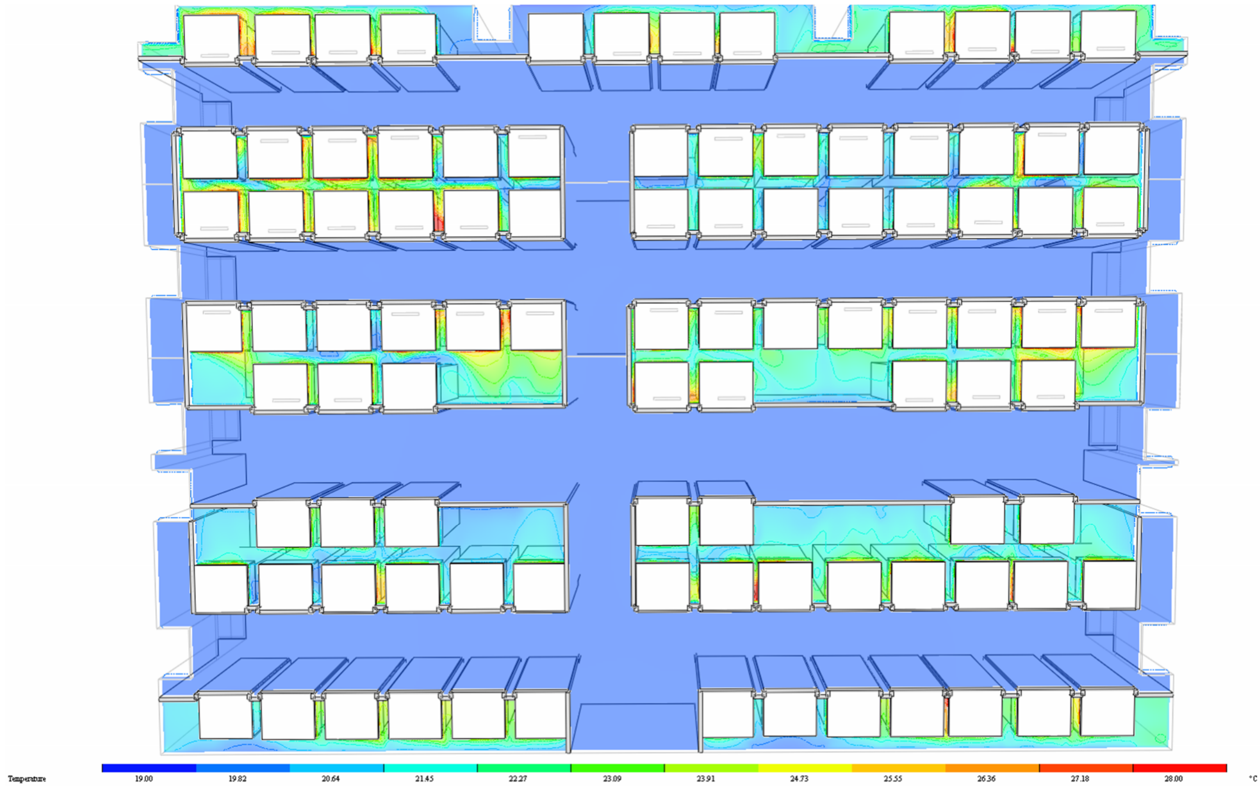

Fig. 1 – CFD Report Temperature Mapping Excerpt

4) Provide passive ventilation

Due to the high and continuous nature of the heat gains from the freezers, passive ventilation would not be sufficient to maintain the required temperature range within the Freezer Farm room.

5) Provide mechanical ventilation

Due to the constant nature and magnitude of the heat gains from the freezers, mechanical ventilation would not be sufficient to maintain the required temperature range within the Freezer Farm room. Given the temperature difference (between external and the room), large volumes of external air would need to be introduced to the space, requiring excessively large air movers (fans) which would be impractical and not feasible

6) Provide active cooling systems

To maintain the tight temperature range required, enhancing the existing active cooling system is the only viable solution.

It is noted that the proposed chillers include free-cooling, which will be available for the majority of the year when the external temperature is below internal limit.

2.3 Proposed Active Cooling Solution

As discussed in Section 1.1, connection to the building's existing chilled water system alone, does not provide the resilience required for the critical nature of the area. Therefore, during the Feasibility stage of the design, three alternative options were considered.

These options are listed below along with the advantages and disadvantages for each:

2.3.1 Option 1 - Existing Chilled Water System with DX Back-up

CRAH units served by the existing building chilled water system but provided with back-up via a DX (direct expansion refrigerant) system.

The DX condensers would reject heat to the Loading Dock, which would have the door opened with destratification fans running if the area became too hot.

Advantage	Disadvantage
Lower volume of service distribution, due to the use of small-bore pipework	A security protocol is required to mitigate extreme temperature issues in the loading dock
Works contained within the freezer farm and ground floor	Maintenance of equipment at high level in the loading dock
	DX coil will have a wider control band than chilled water
	Use of high/medium GWP refrigerant
	Will create a dry atmosphere within the room when DX backup is in use
	No energy savings

2.3.2 Option 2 – Three New Free-Cooling Chillers

CRAH units served by three new free-cooling chillers in a Duty/Duty/Standby configuration.

The 3 free cooling chillers would be located on the southeast L6 brown roof (later relocated), the chillers require an acoustic enclosure to satisfy the noise restrictions at the closest receiver.

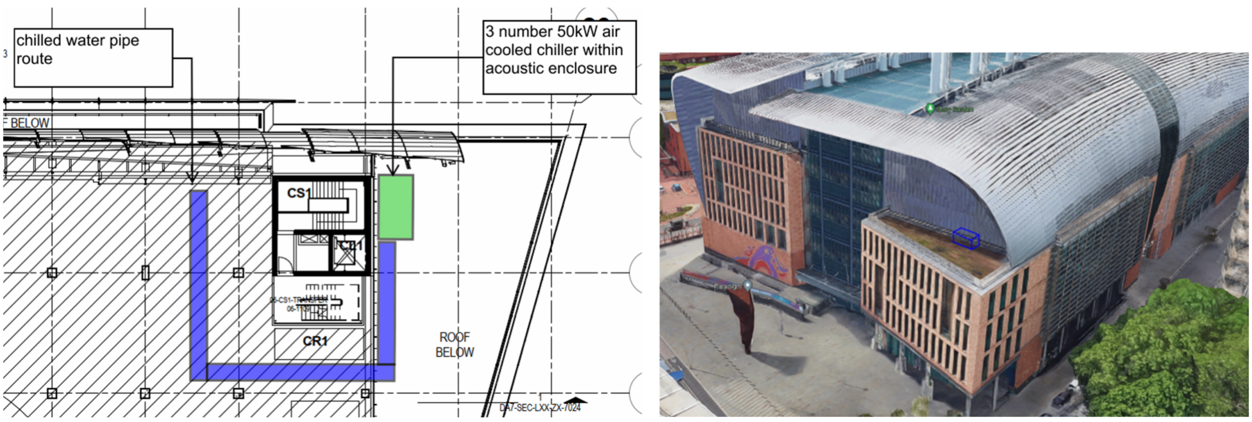

Fig. 2 – Option 2 Early Design Chiller Location

Advantage	Disadvantage
Free cooling chiller used, large energy savings	Planning application required
One pump skid required	Reduction in brown roof area
Single coil within CRAH unit, lowest SFP	Higher risk of downtime on N+1 vs N+N system
Least complete sequence of operation, easiest maintenance	Difficult coordination in the ground service corridor
The largest amount of work can take place without affecting the existing cooling system	Structural implications for new chillers and pipework routes

2.3.3 Option 3 - Existing Chilled Water System with New Water-Cooled Chiller Back-up

CRAH units served by the existing building chilled water system, with back-up and assist (in higher external temperatures) provided by a water-cooled chiller.

The water-cooled chiller would reject heat to the existing building chilled water system (without its chiller running), with the exhaust from an existing AHU (running 24/7) serving as the heat rejection method.

Advantage	Disadvantage
Small energy savings possible	Largest volume of plant required
No external plant required	The most complex sequence of operation
	Difficult coordination in the ground service corridor and in the L6 plantroom
	Disruption to the existing AHU 80 system
	Structural support of the proposed condenser unit/ heat exchanger on AHU 80 system

2.3.4 Proposed Solution – Option 2A

Option 2 was preferred, due to offering the most energy efficient and least disruptive solution.

Following further refinement, The Francis Crick Institute have opted for the following hybrid solution:

- CRAH units within the Freezer Farm room
- Chilled water provided by two new free-cooling chillers in a Duty/Standby configuration.
- A last resort back-up connection to the building's existing chilled water system

Note that the number of new free-cooling chillers was reduced from 3 No. 50kW units to 2 No. 100kW units and relocated to L6 roof adjacent to Ossulston Street (see Figs 3 to 5). This solution was designated Option 2A.

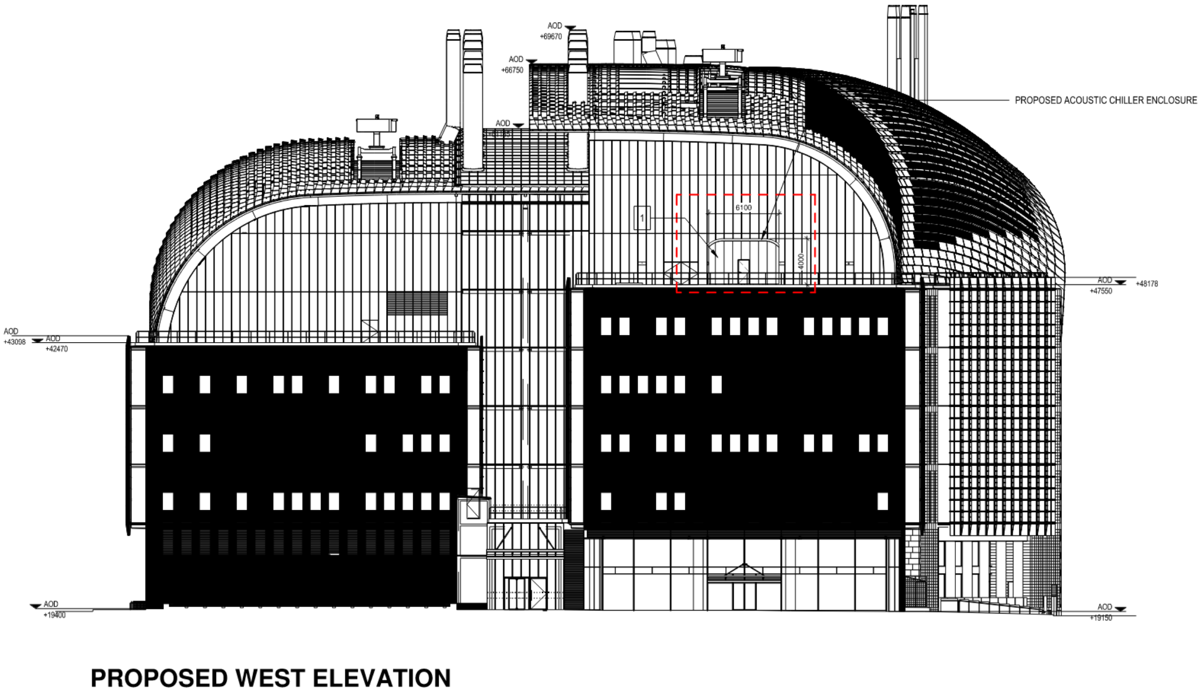

Fig. 3 – Option 2A Chiller Location (taken from 30799-AR-DR-3003)

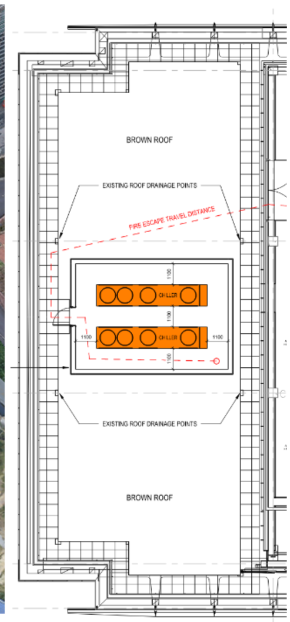

Fig. 4 & 5 – Option 2A Chiller Location (taken from Google Maps & 30799-AR-DR-1121)

One of the main benefits of the proposed solution is a reduction in energy usage. It has been estimated that the electrical energy to cool the space will be reduced by 15,000 to 25,000 kWhr/yr by introducing the free-cooling chillers.

2.4 Chiller Selection

The selected chillers have the ability to work in “free-cooling” mode, when the external ambient temperature is lower than that of the chilled water requirement.

This results in significantly reduced energy consumption, as the compressors operate for less time throughout the year. The ability to utilise free-cooling has also been boosted by the use of the CRAH units, which do not require chilled water at such low temperatures as the existing cassette units.

The selected CRAH units operate with a chilled water flow temperature of 12˚C and a return temperature of 18˚C. This contrasts with the cassette units operating at 6˚C /12˚C.

2.5 Climate Change Adaptation

The proposed design considers the potentially higher future external temperatures, by using the CIBSE 2050 future summer years London weather file, which should a provide long term solution to the storage of critical science sample for the Francis Crick Institute.

3.0 Conclusion

Along with general design good practice, the Cooling Hierarchy has been fully considered throughout the project, with the selected proposal reducing the overall energy usage of the Freezer Farm area.

Care has been taken to ensure that the new free-cooling chillers will have limited impact on the local environment by providing a suitable acoustic package and selected based on higher future temperatures considering Climate Change Adaptation.

The proposed design both reduces the energy consumption of the area, whilst providing the necessary resilience required for storing the critical science samples.

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Internal Computational Fluid Dynamics Report

Client Name: The Francis Crick Institute
Client Project Name: Freezer Farm Cooling System
Project Location: Francis Crick Institute
Scitech Project Number: 30799

A1	20th May 2025	Stage 4	CH	NA	AD
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1.0 Introduction

The report considers the normal operation scenarios and aims to demonstrate the design for the resilient cooling system for the freezer farm has mitigated the current hot spot issues and complies with the temperature limits set out in the user requirements summary.

The study uses IES VE Mirco flow software, which is a Computational Fluid Dynamics (CFD) package that is designed to model the environment and simulate airflow.

Note that the results from such simulations are only as accurate as the input data to the model and form a prediction based on the closure of the complex numerical equations, namely those of the energy, momentum, continuity, turbulence dissipation and turbulence kinetic energy. On this basis some fundamental modelling assumptions are taken:

- CFD is a predictive tool that provides valuable feedback to the design team. However, it cannot replace real life nor can it be considered to be 100% accurate.
- The results are based on a steady-state condition, i.e. they represent a point in time when all variables are effectively fixed. These may vary compared to a real situation where occupancy and temperatures are transitory and so may well differ from the simulation.
- The software cannot physically replicate complex geometry off all elements in the freezer farm such as services bracketry, and other fittings. The louvres are approximated with obstacles having the same free area available and direction of airflow.
- The electrical distribution board loads have been assumed to be negligible. Lighting and other loads ignored for the basis of this report.

2.0 Model Setup

The model set-up is described in 3 sections, the hot aisle containment is described in section 2.1, freezer operation is described in section 2.2 and CRAH set-up is described in section 2.3.

The model set-up is based on the information listed below

Document Ref	Drawing Title
30799-BS-DR-1001	Freezer Farm - Ductwork Layout Drawing
30799-BS-DR-1101	Freezer Farm - Pipework Layout Drawing
Document Ref	**Schedule Title**
30799-BS-SC-0001	CRAH UNITS SCHEDULE

2.1 Layout

The layout of the freezer farm is based on drawing number 30799-AR-DR-1101 Ground Floor freezer farm client definition drawing.

Drawing 30799-AR-DR-1101 shows:

- 96 freezers
- The freezers are in 8 separate HACs
- There is a CRAH unit at the end of each cold aisle.

The layout shown in Figure 1 is from the IES VE Mirco flow model, the light grey lines show the room boundary. The solid lines show any objects that may obstruct airflow within the space.

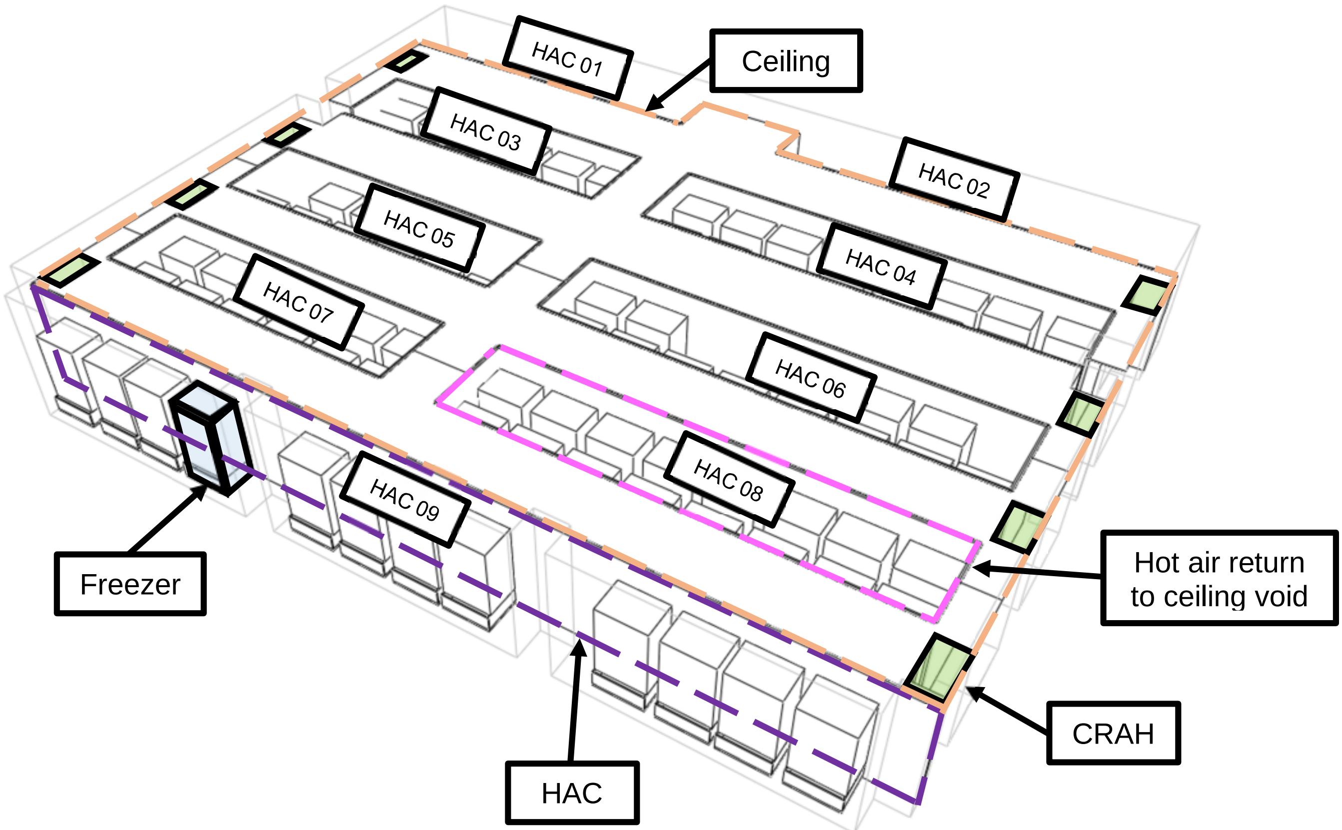

Figure 1: Room layout from IES VE Mirco Flow

The Hot Air Containment has been modelled as well sealed and the only gap is under the freezers that will allow a leakage air path through the hot aisle containment (HAC) and all other air flows through the freezer.

2.2 Freezers

The Freezers have been modelled as solid objects with a hollow path through the bottom mimicking the air path of the freezer. The condenser coil is modelled as a non-solid object allowing air to pass freely through it whilst picking up sensible heat.

When the Eppendorf 740h is maintaining -80°C and the door is closed the condenser circuit will cycle 31 minutes on, 7 minutes off. When the condenser circuit is running, 775W of sensible heat will be discharged from the coil and when the condenser circuit is off 0kW will be required.

To create a steady-state scenario 78 freezers have the condenser circuit running and 18 freezers have the condenser circuit off.

Based on test data provided by Eppendorf we are able to create a polynomial curve of the freezer internal pressure drop and fan speed relationship.
$Y = 0.00007648\ x^2 - 0.05613x + 19.7$
Y = Pressure drop (pa)
X = Fan speed (RPM)

Table 1 shows the condenser circuit operation based on test data supplied by Eppendorf.

Number of freezers	Model	Fan Speed (rpm)	Air Flow Rate (l/s)	Maximum external static available (pa)	Internal pressure drop (pa)	Condenser coil heat load (kW)	Dimensions (mm)	Gap Under Freezer (mm)
78	Eppendorf Cryocube F740h	950	0.064	15	35	0.775	1000x850x1850	50
18	Eppendorf Cryocube F740h	0	0	0	15	0	1000x850x1850	50

Table 1: Condenser circuit operation

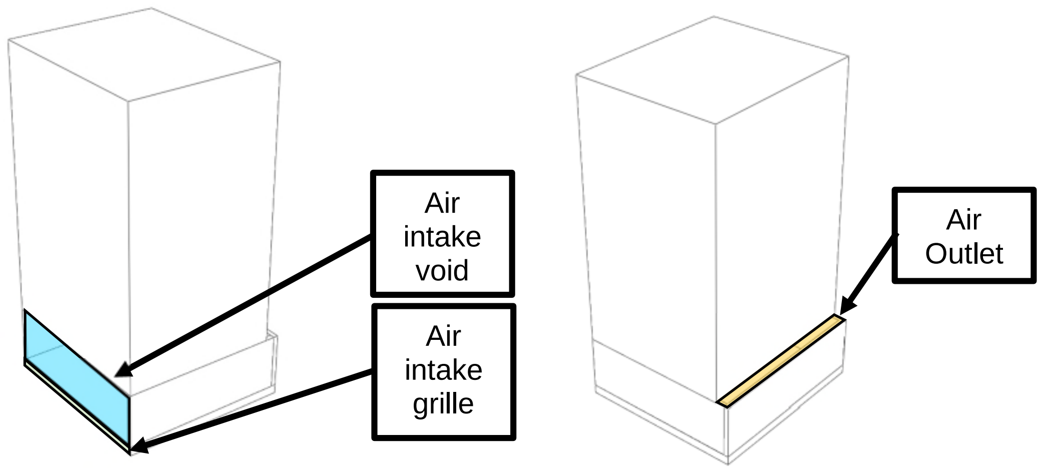

Figure 4: Freezer model IES VE Components

2.3 CRAH Unit

The CRAH units will be located close to the wall and have ducted connections to the ceiling void, thus in the IES VE Micro flow model the CRAH units are modelled as a space with a supply grille into the freezer farm and an extract grille from the ceiling void.

The theoretical flow rate required to displace the full heat load when N CRAH units (7 units) are operational is 0.713l/s. The flow rate used in the CFD study is lower than the CRAH selection data due to the design margin applied to the selection. The CRAH units will operate fixed speed to be set during the temperature mapping at the commissioning stage.

Number of Units	Model	Supply Air Temperature (°C)	Supply air temperature control	CRAH Air Flow Rate (l/s)	Supply air flow rate control
8	w-MEXT_DF_U_016_F02	19.5	Supply air temperature	0.877	Fixed fan speed

Table 2: CRAH unit operation

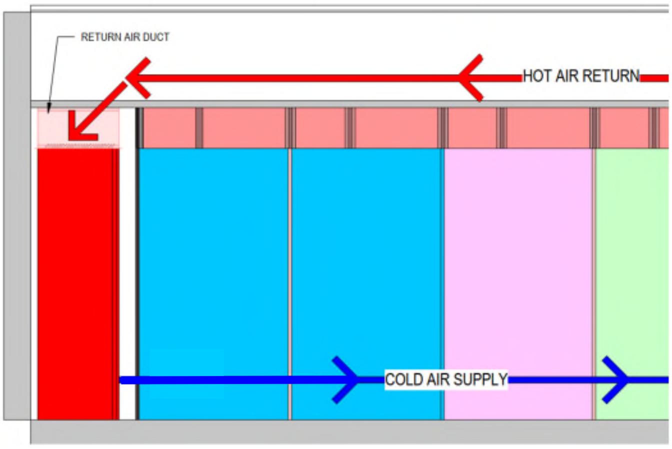

Figure 2: CRAH Unit Layout Section

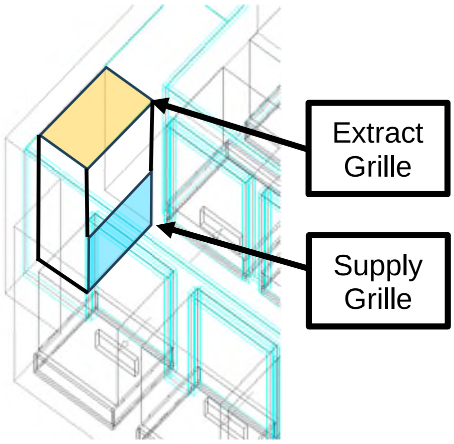

Figure 3: IES VE Mirco Flow Model CRAH

2.4 Surface temperature

The surface temperature of the walls has been assigned based on the results of our IES VE Apache thermal simulation. This allows the CDF model to consider the conduction gains from other spaces, external walls and through the HACs.

Wall	Surface Temperature (°C)
North	20.87
South	N/A (in HAC)
East	20.87
West	20.87
HAC 01	21
HAC 02	21
HAC 03	21
HAC 04	21
HAC 05	21
HAC 06	21
HAC 07	21
HAC 08	21
HAC 09	21

For full details of an IES VE ApacheSim please visit.
[IES Virtual Environment | The Leading Integrated Suite for Accurate Whole Building Performance Simulation (iesve.com)]

3.0 Simulation Results

3.1 Acceptance Criteria

For the simulation to pass the freezer inlet temperature must be 21°C ± 2°C, (maximum 23°C), as detailed in section 3.2 the simulation has passed.

3.2 Temperature

The Internal design conditions need to be a lined with the freezer manufacturers' requirements and limits set in the Francis Crick Institute’s user requirements specification shown below.

- Temperature 21°C ± 2°C, (maximum 23°C)
- Uncontrolled Relative Humidity

Figure 5 shows a peak temperature in the cold aisle at the freezer air intakes of 20°C based on this the freezer farm cooling system design is expected to maintain the temperature limits set in the URS in normal operation.

Figure 5 shows a temperature rise of <0.5 °C across the freezer farm from CRAH 04 to freezer X. In rooms such as the Francis Crick Institute freezer farm with a high air change rate, most of the heat is transferred via convection thus the low heat rise due to conduction from the ceil and HAC despite their high U-values.

The temperature rise across the freezer farm is very low, because of this if there is an extreme failure and the system switches over to the building's chilled water system, we expect the cold aisle temperature to drop to 16°C±2°C. When the CRAH units are served by the main building's 6°C - 12°C chilled water system the CRAH supply air temperature will drop to 15.7°C due to limitations of the coil selection. Whilst 16°C±2°C is temperature is outside of the limits set in the URS the temperature at the freezer intake grille is greater than the limits set by the manufacturer.

Figure 5: Z plane temperature plot 0.08m above FFL, scale 19°C - 20°C

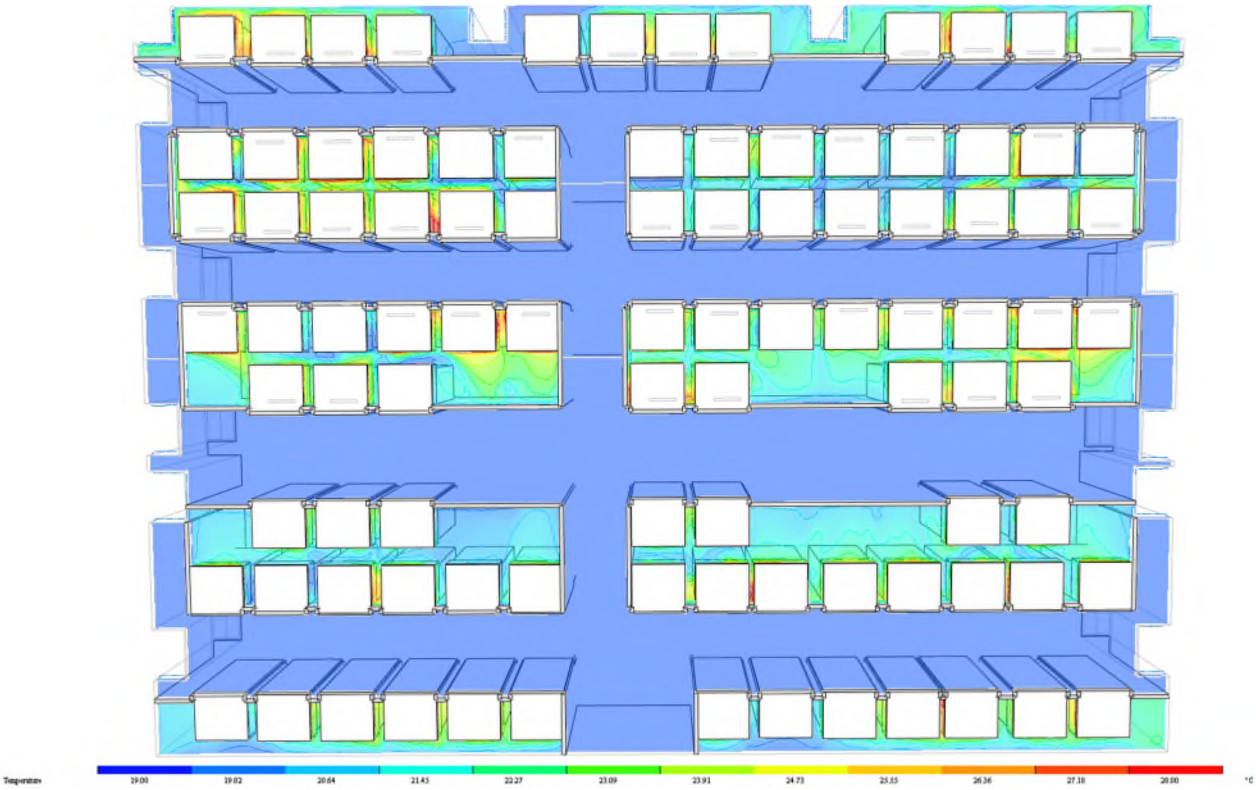

Figure 6: Z plane temperature plot 0.56m above FFL, scale 19°C - 28°C

The Eppendorf 740h cooling system is sized based on an internal freezer temperature of -86°C and a room temperature of 30°C. Figure 7 shows the peak temperature of hot air that is discharged up the back of the freezer is 35°C, this peak temperature is quickly diluted to be 29°C.

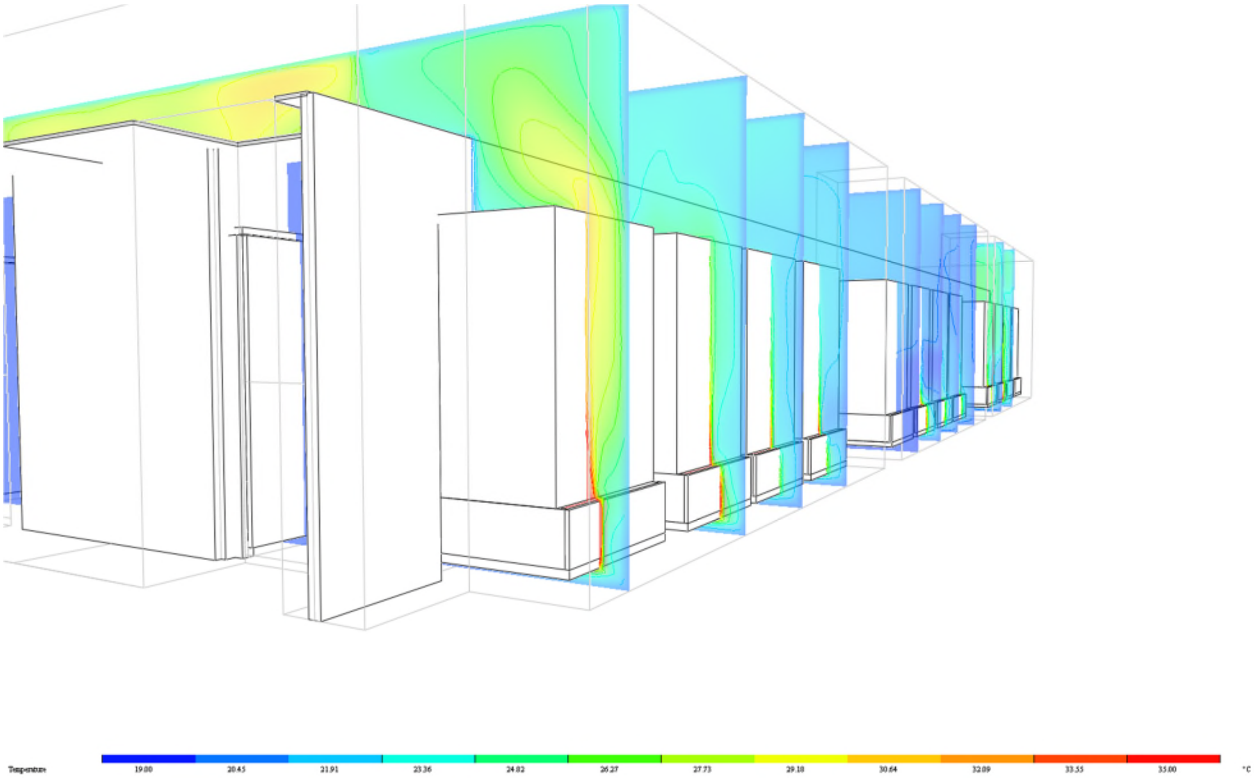

Figure 7: X plane temperature plot 17.78m from east wall, 19°C - 35°C

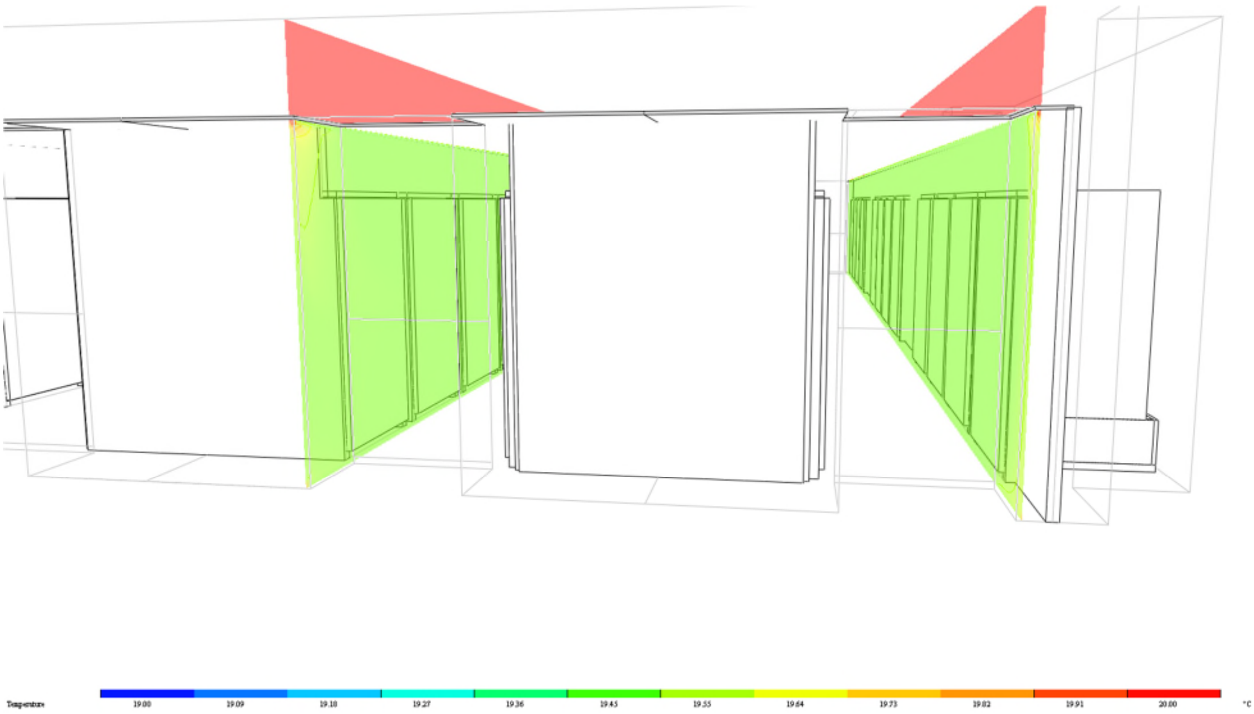

Figure 8: Y plane temperature plot 8.17m and 12.53m from north wall.

3.3 Pressure

The Eppendorf F740h condenser fan has 35pa – 65pa of available static pressure external to the freezer intake grille. Figure 9 shows the velocity pressure at the intake grille of the closest freezer to the CRAH outlet is 0.4-0.8pa, this shows that the condenser fan's available static pressure is comfortably high enough to overcome the velocity pressure created by the CRAH unit.

It is important when commissioning the CRAH unit system not to set the fan speeds too high, as this will create greater velocity pressures in the cold aisle and may cause the freezer closest to the CRAH to be staved of airflow. If the CRAH fan flow rate exceeds that drawn by the freezer condenser fans by too much, increased pressure will be generated as the CRAH tries to drive air through the leakage paths under the freezer, through the HACs and the freezer itself. If the CRAH starts to drive air across the freezer condenser this may create issues with the freezer condenser fan control and lead to inefficient operation.

Based on experience we expect the required CRAH fan flow rate to be higher, creating a greater velocity pressure in the cold aisles due to the HAC construction leakage.

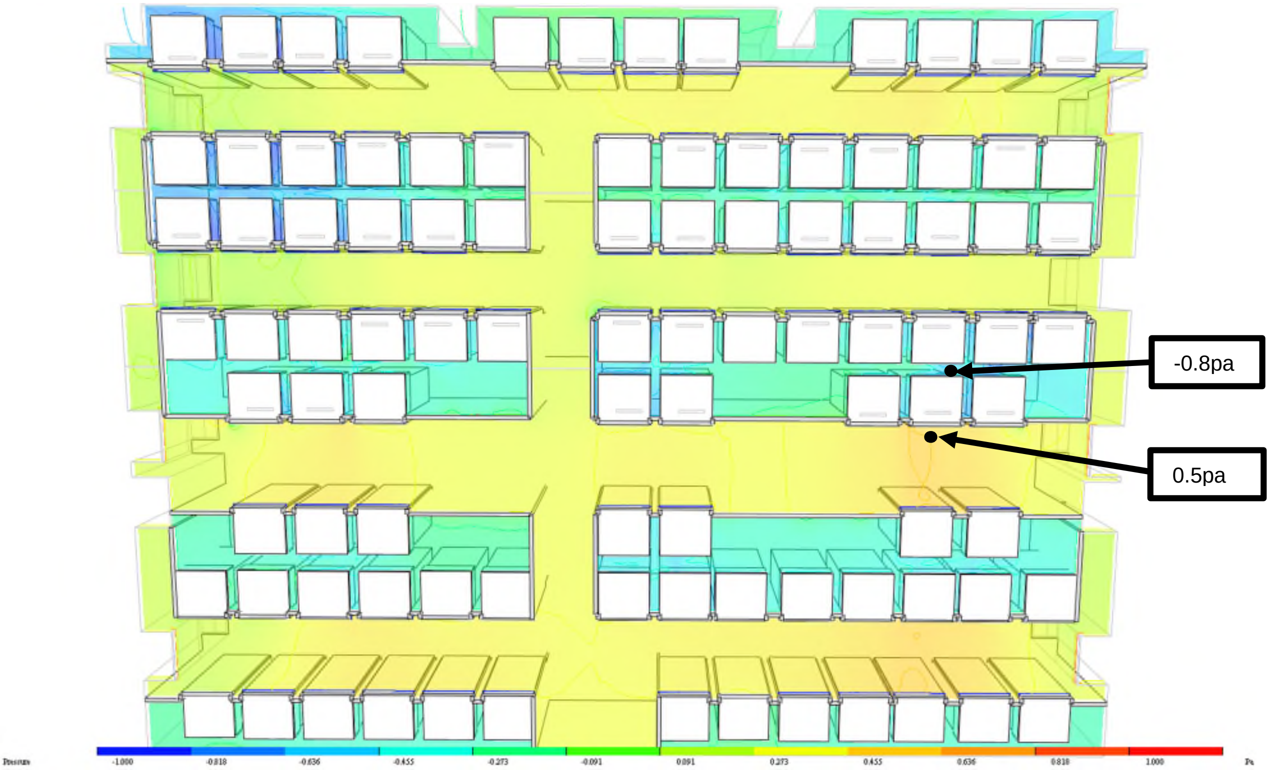

Figure 9: Z plane pressure plot 0.08m above FFL

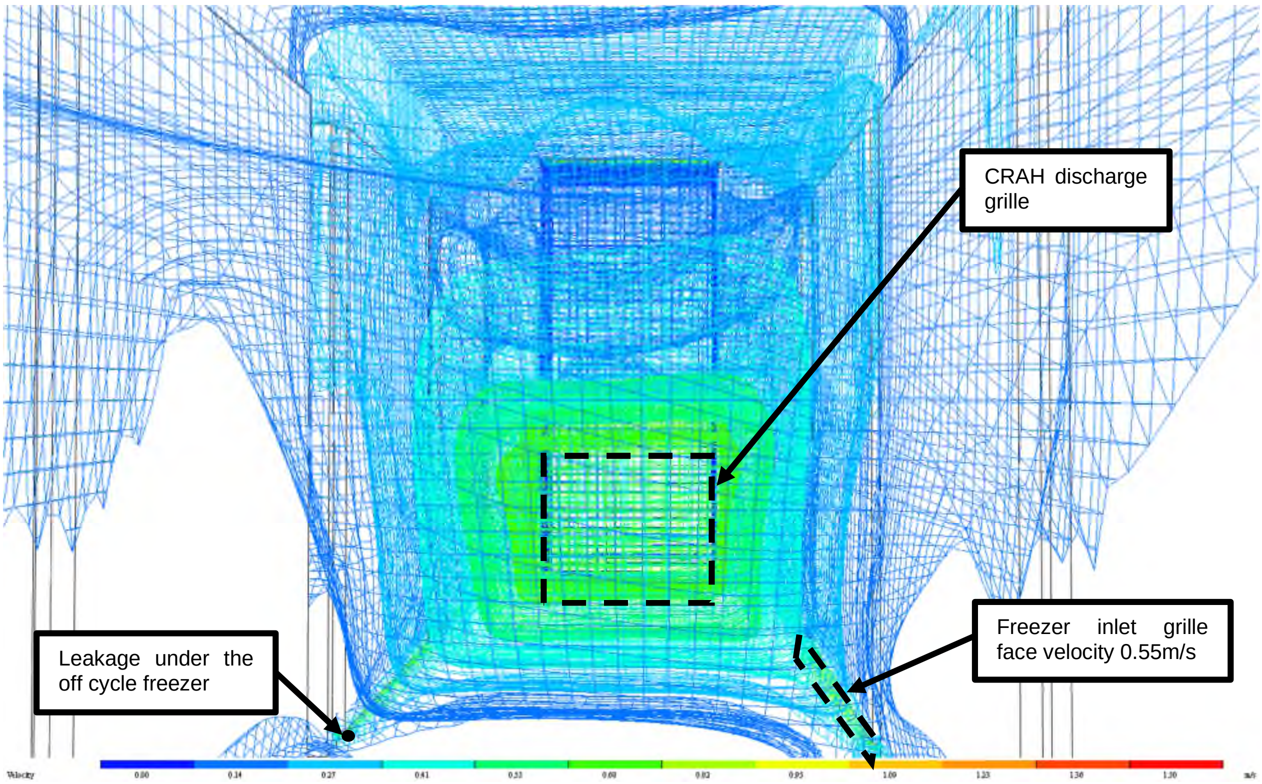

Figure 10: Figure XX: 3D velocity contour plot.

4.0 Conclusion

- The simulation of 7 running CRAH units and 78 freezers in the on-cycle and 18 freezers in the off-cycle shows that the freezer farm should be maintained within the temperature limits of 21°C±2°C set in the URS.

- The temperature rise across the freezer farm is less than 0.5°C, because of this, if there is an extreme failure and the system switches over to the building's chilled water system, we expect the cold aisle temperature to drop to 16°C±2°C. When the CRAH units are served by the main building's 6°C - 12°C chilled water system the CRAH supply air temperature will drop to 15.7°C due to limitations of the coil selection. Whilst 16°C±2°C is temperature is outside of the limits set in the URS this temperature at the freezer intake grille is greater than the limits set by the manufacturer.

5.0 Recommendation

We would recommend further investigation into decreasing the room temperature to reduce the work done by the freezer compressor and the heat rejected into the room. If the room temperature is decreased this would increase the work done by the chiller but we would expect the chiller EER to be 3 – 3.5 times greater EER than the freezers thus reducing the overall power consumption of the overall system.