



**LINCOLNSHIRE
ARCHIVES BUILDING
LINCOLN
FEASIBILITY STUDY
FOR
MECHANICAL
ENVIRONMENTAL CONDITIONS
FOR
THE STORAGE OF ARCHIVAL
DOCUMENTS**

DOCUMENT CONTROL SHEET



Project Title	LINCOLNSHIRE ARCHIVES BUILDING LINCOLN FEASIBILITY STUDY FOR THE MECHANICAL ENVIRONMENTAL CONDITIONS FOR THE STORAGE OF ARCHIVAL DOCUMENTS
Revision	01
Status	Discussion
Control Date	16-01-2011

Record of Issue

Issue	Status	Author	Date	Check	Date	Authorised	Date
01	Draft	Brian Jones	16-01-11	John Kelsey	16-01-11		

Distribution

Organisation	Contact	Copies

Note: Unless otherwise noted herein, the conclusions and recommendations contained in this report are based on the information supplied by the Client and visual inspection and testing (if any) described within. Mouchel Consulting Ltd can accept no liability in respect of differences between the actual structure and the information supplied except (i) where these are readily apparent by visual inspection or (ii) where physical investigation has been undertaken by, or under the control of Mouchel Consulting Ltd, and then only to the extent of such physical investigation.

CONTENTS

- 1.0 Introduction
- 2.0 Design Assumptions
- 3.0 Site Analysis
- 4.0 Building Form, Environmental Strategy
- 5.0 Building Services Proposals Overview

- 6.0 Mechanical Building Services Proposals
 - 6.2 Mechanical Services Proposals

- 9.0 Drawing Register

1.0 Introduction

1.1 This report has been compiled to outline the design of the mechanical and control building services provision and the environmental strategy for the refurbishment of Lincolnshire Achieves, in Lincoln. This document constitutes the development of a draft discussion document entitled Feasibility Study for the Mechanical Environmental Conditions for the Storage of Archival Documents.

Following the release of this draft version of this document outlining the proposals for environment conditions within in the archive buildings, we wish to invoke a discussion with workable comments to bring the Achieves air conditioning equipment to provide environmental conditions to comply with BS 5454

The objective of the design is to provide flexible energy efficient and cost effective services solutions for all environmental services and control systems whilst meeting or exceeding all recognised statutory and design criteria.

Other primary considerations in the selection of appropriate systems are flexibility, maintainability and operating costs, all of which will impact on the success of the day to day operation of the refurbished Achieve building.

This document has been prepared to provide a design intent proposal for the intended engineering services which reflects the current level of briefing.

New air handling units with full air conditioning cycles able to control the environmental conditions with inverter driven motors will control the humidity, heating and cooling conditions within each repository and the document reception area.

The low pressure heating requirements will be served from a series of new gas fired condensing boilers installed in the ground floor plantroom

The cooling cycle would be provided from new chiller plant located within the external car park where the bicycle shed is located.

A chilled water installation would be installed, two factors in mind, the first being the noise breakout generated by the plant can be controlled by positioning in such a place as to restrict the air borne noise to a minimum. Secondly a chilled water system with a correctly sized thermal storage buffer vessel will provide more precise control of the internal environment.

New TAC Building Management System controls have recently been fitted although further investigation will be necessary to ascertain their suitability to be able control the new system considering both the air temperature and the relative humidity in each repository and the document reception area, the call out chargers and regular maintenance costs will need to be carefully considered before a definite decision is finalised. The new plant will provide energy efficient plant thus resulting in a more efficient operation of the internal environment.



Where plant sizes and capacities are indicated, these are based on preliminary calculations and will be subject to further determination during the detailed design phase.

The Builders work element will involve the removal of the external cladding and the concrete building blocks to allow the removal and installation of the new air handling units, existing service riser positions within the buildings are to be co-ordinated to allow vertical & horizontal access for electrical and mechanical services. The existing bicycle storage enclosure will need to be repositioned within the archives external enclosure.

The new external louvers will be of the acoustic type required to restrict the noise level in the car park and the new local residential apartments along with acoustic ductwork attenuators to prevent the breakout of noise to the external and internal environments.

The programme of works for the new installation is to be commenced after the necessary debates and discussions with regard to this feasibility report have taken place within the month of January 2011, the design works can then begin and we should be at a tender stage at the end of February with tender out for the month of March 2011 with a contractor appointed to commence works by the first of April 2011. The completion of the works should be totally completed and commissioned by the end June 2011

2.0 Design Assumptions, Standards and Criteria

2.1 Design Standards

The detailed design and installation of the building services will be in accordance with CIBSE general standards, British Standards and codes of practice in conjunction with the relevant Building Regulations. However, the following documents are particularly pertinent to the Mechanical Environmental Conditions for the Storage of Archival Documents.

- **BS 5454:2000 recommendations for the Storage and Exhibition of Archival documents**
- **CIBSE Environmental design Guide A 2006-**
- **CIBSE Heating and ventilation, air conditioning and refrigeration Guide B 2002-**
- **CIBSE Reference Data Guide C -2007**
- **Oxford University libraries.**
- **HEVACOMP Design Data Base 25.01**
- **Integrated environmental solutions, Virtual Environment**

2.2 Building Regulations Related Issues

The building services design will comply with the statutory requirements of the Building Regulations by meeting the requirements of the Approved Documents.

The intention of this section of the report is to highlight the documents that relate specifically to the Building Services design, rather than describe all aspects of the design. The Building Services will be designed, during the detailed design phase to comply with the regulations listed below as a minimum.

2.3.1 Approved Document E (2003) – Acoustics

E4 Acoustic conditions (M & E Plant Systems only)

2.3.2 Approved Document F (1995) – Ventilation

F1 Means of ventilation

2.3.3 Approved Document G (1992) – Hygiene

G3 Hot water storage

2.3.5 Approved Document J (Amended 1992) – Heat Producing Appliances

J1 (air supply)

J2 (discharge of products of combustion)

J3 (protection of building).

2.3.6 Approved Document L (2006) – Conservation of Fuel and Power

L2B Buildings other than Dwellings.

3.0 Site Analysis

3.0.1 Site Location

Lincolnshire

Archives building

St Rumbold Street
Lincoln
Lincolnshire
LN2 5AB

Lincolnshire Archives was established as a county service in 1948 with the bringing together of the records collected by the Lindsey, Kesteven and Holland County Councils, and the Lincoln Diocesan Record Office. The Archives service was known as the Lincolnshire Archives Committee.

The service is now part of Lincolnshire County Council's Culture and Adult Education department and is based in modern offices in St Rumbold Street, Lincoln.

Lincolnshire Archives offers a public search room where members of the public are welcome to consult original archives, microfilm resources and library material relating to the county of Lincolnshire and its connections in other parts of the UK and overseas.

Records held at Lincolnshire County Council's Archives Service have been named as amongst 38 national collections designated as having outstanding national and international importance. The Bishops Rolls and Registers (dating from 1214/15) which form the core historical records of the diocese of Lincoln are of 'national and international significance'.

3.0.2 Site Orientation

The site is enclosed within a built up area by multi storey buildings in all directions.

The main building lies on a North South Axis.

3.0.3 Solar Gains and Daylight

The light colour of the building reflects the solar gains and the fact that the storage areas are in a basement of the buildings provides self shading to the contents of the repositories and the document reception area.

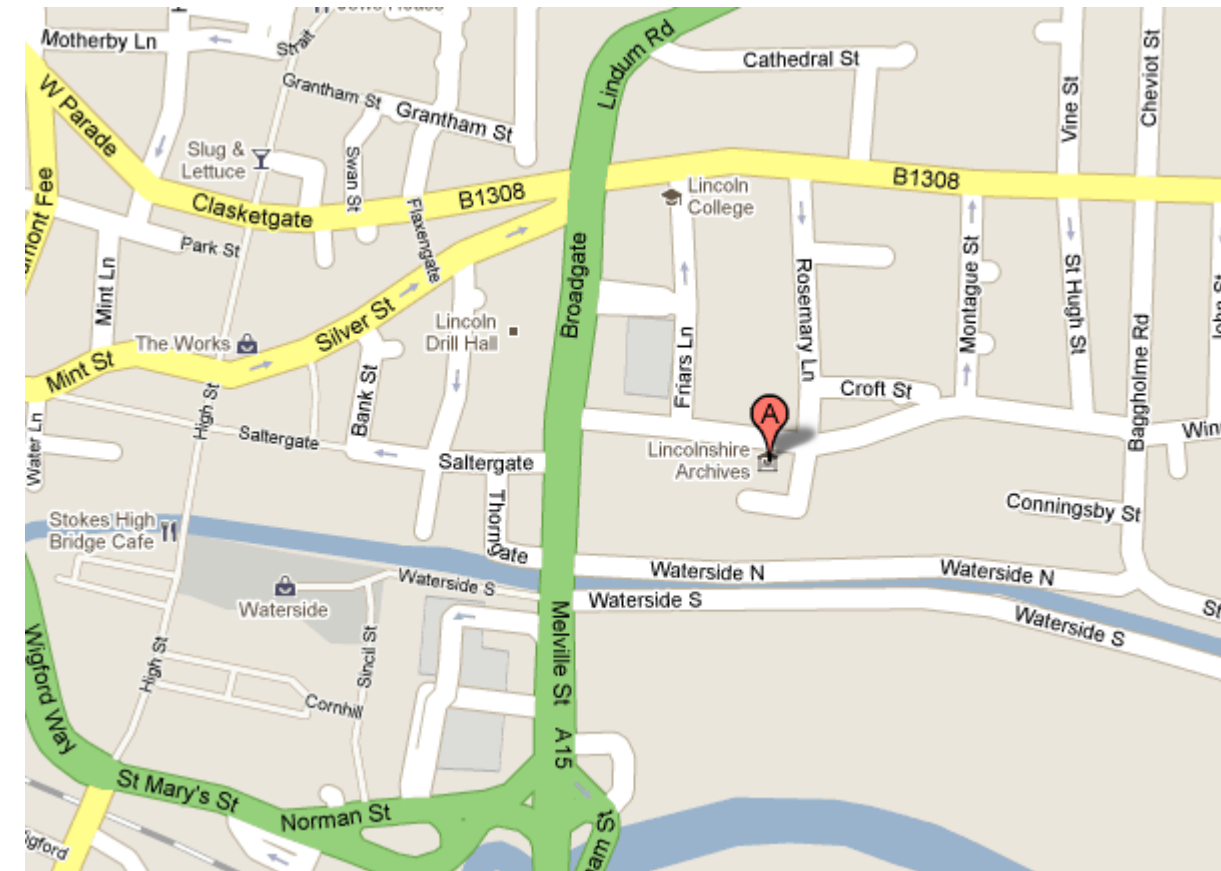
3.0.4 Acoustics

The facility is to be designed to meet the acoustic requirements of The Noise Rating – NR 35 curves are developed by the International Organization for Standardization (ISO) to determine the acceptable indoor environment for hearing preservation, speech communication and annoyance. The noise rating graphs for different sound pressure

levels are plotted at acceptable sound pressure levels at different frequencies. Acceptable sound pressures level varies with the room and the use of it.

3.0.5 Pollution

The building is located in an urban area close to Lincoln city centre, and as such is subject to pollution due to noise, car exhaust and general poor air quality. The standard of filtration will be designed to BS5454 for the general ventilation with carbon filters to remove the pollution produced from car exhaust by-products. The environmental factors of temperature, humidity, light, and atmospheric and particulate pollutants can all cause degradation reactions to the stored materials.



4.0 Building Form, Environmental Strategy

4.0.1 Building Form and Environment Strategy

The building form is compact, over two storeys with a basement achieve, with the building service elements at the rear of the building, along with the car park facilities. The individual departments have been separated into discrete departments.

The blocks are interlinked by ground floor internal corridor spaces within the facility to circulate and through the use of a lift and staircases.

The environmental strategy for good low energy design relies on the following elements:

- Noise attenuation between the each repository and the document reception area and plantrooms to the external environment, to be can be provided in a compact and cost effective manner.
- Automatic controls providing better control and hence improved air quality for the classroom occupants
- Full Air conditioning mechanical ventilation systems have been adopted in each repository and the document reception area.

Each of the major air conditioning properties as stated in BS 5454 regarding the control of the ideal environment for archived materials shall be explained and simplified for further debate.

Ambient Air Temperature.

It has been frequently stated that for every 10 °C rise in temperature, the rate of chemical degradation reactions in traditional library and archive material, such as paper and books, is doubled.

Conversely for every 10 °C drop the rate is halved. Heat coupled with low relative humidity will eventually lead to desiccation and embrittlement of certain materials – leather, parchment/vellum, paper, adhesives, the adhesive binders on audio and video cassettes, etc.

Heat together with high relative humidity encourages mould growth and creates an environment conducive to pests and insects.

Cold less than 10 °C together with high relative humidity and poor air circulation will lead to dampness and eventually mould growth.

Relative humidity (RH)

Relative humidity (RH) is expressed as the ratio in percent of vapour pressure in a sample of moist air to the saturation vapour pressure at the same temperature.

If the water vapour in one cubic metre of air, at normal atmospheric pressure, was extracted and weighed, the absolute humidity of the sample of air would be known and expressed as grams of water per cubic metre of air (g/m³).

The hygrometric chart below shows the maximum amount of water vapour a cubic metre of air can hold at certain temperatures. As air temperature increases, the amount of water vapour air can hold increases.

For example at 10 °C air can hold no more than 9 grams of water vapour. The air is at its maximum absolute humidity and is said to be saturated. At 20 °C the saturation point is 17 g/m³. Therefore, if a cubic metre of air in a closed container at 20 °C contains 9 grams of water vapour, the absolute humidity is 9 g/m³. If 3 grams of water is added to the container, it will evaporate and increase the absolute humidity to 12 g/m³. If another 8 grams of water is added, 5 grams will evaporate and 3 grams will remain as a puddle on the bottom of the container because air at 20 °C can only hold 17 g/m³.

The relative humidity of the air in the container when only 9 grams of water vapour was present would have been: absolute humidity of sample air

$$\frac{\text{Absolute humidity of sample air}}{\text{Absolute humidity of saturated air}} = \frac{9}{17} = 0.53 \text{ or } 53\%$$

RH is temperature-dependent. If no additional moisture is added to the air, as the temperature increases, the RH decreases.

Conversely, if the air in the container is cooled to 15 °C, the RH will rise, even if no more water is added. At 15 °C the air can only hold 12.5 g/m³ of water vapour:

$$\frac{\text{Absolute humidity of sample air}}{\text{Absolute humidity of saturated air}} = \frac{12.5}{17} = 0.72 \text{ or } 72\%$$

If the air were cooled to 9 °C, it would become saturated with water vapour, and the RH would rise to 100%. If the air were cooled any further, droplets would form on the side of the container because the air must give up some of its moisture as condensation. The temperature at which condensation first occurs (the temperature at which the air reaches saturation) is called the **dew point**. As has been stated, if the water content of a room is fixed, a sudden lowering of temperature will cause a rapid rise in the relative humidity, leading to condensation and possibly resulting in mould and other problems excess moisture causes.

Moderate changes over a long period of time produce minimal stress in materials that are free to expand and contract.

Fluctuations of temperature and relative humidity affect the dimensions and mechanical properties of organic materials and can lead to damage if they occur even over a short period of time.

The actual repositories may have to be divided into different storage facility air conditioning systems as temperature and humidity can not be defined for all types of library material –

The first point that needs to be understood about temperature and relative only values and ranges that humidity is that there is no one ideal level for all types of library material –A temperature or humidity that is acceptable for one object may be disastrous for another. For example, photographic film, magnetic recordings, and digital carriers require low storage temperatures and relative humidity levels if their longevity is to be ensured; whereas parchment and vellum items require an RH higher than 50% if they are to retain their flexibility.

There is extensive research to suggest that paper will retain its chemical stability and physical appearance for longer at a constant, low storage temperature below 10 °C and relative humidity (30–40%).

However, while the paper text-block in a leather or vellum binding may benefit from being kept at a low RH, the binding will inevitably suffer. Leather and vellum need an RH of at least 50% if they are to continue to operate mechanically.

The argument of chemical versus mechanical damage or content versus artefact has to be carefully considered when deciding what temperature and relative humidity ranges will have the most benefit for particular collections. We would value the expert advice from the staff and curators with regard to the types of artefact stored within Lincolnshire Archives storage facility

Gaseous pollutants

Gaseous pollution is caused overwhelmingly by the burning of fuels. Pollutants such as sulphur dioxide, hydrogen sulphide, and nitrogen dioxide combine with moisture in the air to form acids that attack and damage library material. Ozone is a powerful oxidant which severely damages all organic materials. It is a product of the combination of sunlight and nitrogen dioxide from automobile exhaust; it may also be produced by electrostatic filtering systems used in some air conditioners, as well as by electrostatic photocopy machines.

Particulate pollutants

Particulate pollutants, such as soot, dirt, and dust abrade, soil, and disfigure materials. Dust and dirt that have absorbed gaseous pollutants from the air become sites for harmful chemical reactions when they settle on library material. Particulate pollutants can also aid mould growth. Materials, such as magnetic and optical media, are very sensitive to dust and dirt.

Dust is commonly a mixture of fragments of human skin, minute particles of mineral or plant material, textile fibres, industrial smoke, grease from fingerprints, and other organic and inorganic materials. There are often salts such as sodium chloride (carried in from sea spray or on skin fragments) and sharp gritty silica crystals. In this chemical mixture are the spores of countless moulds, fungi, and micro-organisms which live on the organic material in the dust such as fingerprints, for example, serve as good culture

media. Much of the dirt is hygroscopic water attracting, and this tendency can encourage the growth of moulds, as well as increase the corrosiveness of salts, hydrolysis, and the release of acids.

Light

Although the lightning is beyond the scope of this report careful consideration should be given to the control of the lighting systems with unmanned areas have the lighting turn off

Light is energy and energy is required for chemical reactions to take place. All wavelengths of light – visible, infrared, and ultraviolet (UV) – promote the chemical decomposition of organic materials through oxidation. Higher-energy ultraviolet is the most harmful. However, light in all its forms, especially in the presence of atmospheric pollutants, leads to a weakening and embrittlement of cellulose, adhesives, cloth, and skin materials. Light can cause some papers to bleach and others to yellow or darken; it can also cause media and dyes to fade or change colour, altering the legibility and appearance of documents, photographs, art works, and bindings. The following factors concerning light should be known by all those responsible for preserving library material:

Chemical reactions initiated by exposure to light continue even after the light source is removed and materials are put into dark storage. Light damage is irreversible. The effect of light is cumulative. The same amount of damage will result from exposure to a strong light for a short time as to a weak light for a long time.

100 lux (the unit of measure of illuminance) on a picture for 5 hours gives it an exposure of 500 lux-hours, equivalent to 50 lux for 10 hours.

Visible and infrared light sources, such as the sun and incandescent light bulbs, generate heat. An increase in temperature accelerates chemical reactions and affects relative humidity.

Daylight has the highest proportion of UV radiation and therefore must be filtered.

Fluorescent lamps are low-pressure mercury discharge lamps which produce

UV radiation which in turn excites a phosphor coating that emits visible light.

The use of different phosphors is responsible for the various colour characteristics these lamps exhibit. Although fluorescent lighting is high in ultraviolet content, it is usually installed in libraries because it generates less heat and is more economical to operate.

Light levels must be kept as low as practically possible in storage, reading, and display areas.

Fluorescent light tubes should be fitted with UV filter sleeves; these sleeves are effective only for a few years and so should be checked periodically.

When storage areas are not in use it should be mandatory to switch off lights.

Recommended light levels

200–300 lux is acceptable levels for reading rooms,

In stack and storage areas 50–200 lux is sufficient.

Light sources with ultraviolet radiation emissions above 75 microwatts per lumen require filtering.

5.0 Existing Building Services Plant

5.0.1 Existing Plant

Existing Hamworthy Gas Fired Atmospheric Boilers

The boiler plant is in poor state of condition and is operating extremely inefficiently the boiler and associated plant requires replacement. Because of the relative age and condition of all the plant spare parts are increasingly difficult to resource with certain spares which have become impossible to obtain such as the main heating boilers, availability of service will not be guaranteed. Repair of the existing plant will prove to be uneconomic and will only provide a short term solution, the main option would be to replace the existing system with new, this will provide a long-term energy efficient solution to the Achieves site unforeseen future problems.

Existing Air handling units

Levels 0, 1, 2, 3, and 4 form the component parts of the original archive storage facility;

- Levels 0– Basement repository 3, 4, 5 and 6 served by Air Handling Unit No 4, shall have a new air handling unit and control system
- Levels 1– Foyer, Search room and Archaeology store served by Air Handling Unit No 2
- Levels 2– Sub-Basement repository 1, 2 and Document reception served by Air Handling Unit No 3 shall have a new air handling unit and control system
- Levels 3– Secure store lecture room, plantrooms and antiquities store served by Air Handling Unit No 6 shall have a new air handling unit and control system
- Levels 4– Conservationist workroom, offices and conservation laboratory served by Air Handling Unit No 5



Figure 5.0.1 –Achieve Buildings

5.02 M & E Services Levels 2–Sub-Basement repository 1, 2 and Document reception served by Air Handling Unit No 3.

Located in the upper tier of the plantroom type Metair 8451/3 the unit controls the fresh air by via a Belimo motorized control damper to repository 1 and 2.



The problem reported with AHU03 is that the attenuator on the discharge side of the fan has collapsed and therefore is restricting the supply air flow; the extra resistance is causing a very high pressure drop of 1.37kpa before the attenuator. This statement is confirmed by the figures measured in table 1

The humidifier supply operating pressure requires a much lower working pressure for the steam to be successfully injected into the supply air stream, therefore until the attenuator is repaired or removed the steam cycle will never work correctly.

Air change rate at design	Measured air change rate REP 1	Measured air change rate REP 2
10 air changes and hour	2.84 AC/hr	1.75 AC/hr

There are 3 motorised dampers on each fan the supply HCP have observed that one damper is ceased and none of the over motorised damper have been seen to function

Table 1 below from, HCP is the actual recorded results of each ductwork system compared against the original design

Table 1	Name plate	Design	Actual
FAN VOLUME	7.75m3/s	7.75m3/s	1.9m3/s
% DESIGN	100%	100%	25%

5.03 Levels 0–Basement repository 3, 4, 5 and 6 served by Air Handling Unit No 4

Located in the upper tier of the plantroom type Metair 8451/3 the unit controls the fresh air by via a Belimo motorized control damper to repository 3 and 4.



The problem with AHU04 motorised fresh air damper which also serves the smoke extract fan cannot fully closed and therefore fresh air and return air is being pulled from not only repository 3 and 4 but also from outside. HCP can not manually close this damper as the spindle is broken and there is no access door to try and ease the damper, therefore the fresh air cannot be proportional balanced or controlled.

Air change rate at design	Measured air change rate REP 3	Measured air change rate REP 4
10 air changes and hour	6.83 AC/hr	7.2 AC/hr

There are 3 motorised dampers on each AHU 4 and none of the over motorised damper have been seen to function

Table 2 below from, HCP is the actual recorded results of each ductwork system compared against the original design

Table 2	Name plate	Design	Actual
FAN VOLUME	4.863m3/s	4.863m3/s	3.38m3/s
% DESIGN	100%	100%	70%

5.04 Levels 3– Antiquities store served by Air Handling Unit No 6.

5.05 Boilers

5.0.2 Outline Design Proposals

Levels 0– Basement repository 3, 4, 5 and 6 served by Air Handling Unit No 4

Levels 2– Sub-Basement repository 1, 2 and Document reception served by Air Handling Unit No 3

Levels 3– Antiquities store served by Air Handling Unit No 6

The M & E ventilation services within Levels 0, 2 and 3, will be renewed and replaced, with new AHU upgrades complete with full air conditioning cycles.

The purpose of our specifically designed air conditioning system is to control the filtration, air movement, temperature and humidity of the repositories atmospheric environments. Air conditioning is always associated with the cooling and dehumidification processes of air conditioning.

An Air cooled chillers which will consist of condensers and compressors will be located externally in the position where the bicycle sheds are situated, chilled water will be provided to serve new the air conditioning processes for AHUs 3, 4 and 6.

Consideration should be given to renewing the existing split Freon DX air conditioning units the cooling loads could be include in the new chiller loads and new evaporators installed in the relative spaces, this would remove the need for maintenance of the existing spilt units and provide more accurate control of the two areas served by the units.

The full control over relative humidity by the addition of moisture by means of a humidifier and the use of a humidistat will provide humidity control to the repositories, the two existing humidifiers if suitable shall be reutilized for each space.

Mixed flow describes a method of air distribution from an air conditioning with a ventilation system attached. It has been and still is the most widely used method of supplying air into an atmosphere being air conditioned. The air distribution will re-use the existing high level wall grilles from the existing ductwork system.

Archives air conditioning as the name implies is solely to provide an environment for the majority of shored achieved materials as stated in BS 5454.

- Humidity from a range of between 45% and 60% relative humidity
- Temperatures. 13-16 °C little used material.
- Temperatures. 16-19 °C frequently used material.

Filtration

- Panel filter G3
- Bag filters F7.

Noise

The Noise Rating level (NR) for different uses should not exceed the Noise Ratings indicated in the table below

Noise rating curve	Application
NR 25	Concert halls, broadcasting and recording studios, churches
NR 30	Private dwellings, hospitals, theatres, cinemas, conference rooms
NR 35	Libraries, museums, court rooms, schools, hospitals operating theatres and wards, flats, hotels, executive offices
NR 40	Halls, corridors, cloakrooms, restaurants, night clubs, offices, shops
NR 45	Department stores, supermarkets, canteens, general offices
NR 50	Typing pools, offices with business machines
NR 60	Light engineering works
NR 70	Foundries, heavy engineering works

The facility is to be designed to meet the acoustic requirements of NR 35 curves are developed by the International Organization for Standardization (ISO) to determine the acceptable indoor environment for hearing preservation, speech communication and annoyance. The noise rating graphs for different sound pressure levels are plotted at acceptable sound pressure levels at different frequencies. Acceptable sound pressures level generally varies with the room and the use of it.

6.0 Existing ductwork systems

