UK Atomic Energy Authority

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Glossary of Terms

Abbreviation	Description
ALARP	As Low As Reasonably Practicable
ARM	Availability Reliability & Maintainability
AV	Anti-Vibration
CDM	Construction (Design and Management)
DOP	Dispersed Oil Particulate
HEPA	High Efficiency Particulate Air
HVAC	Heating Ventilation & Air Conditioning
LFL	Lower Flammability Limit
NR	Noise Rating
OPEX	Operational Experience
SIDD	Sequence and Interlock Definition Document
UKAEA	United Kingdom Atomic Energy Agency

1.0 Background

There is a requirement to install 11 gloveboxes within the existing Beryllium Workshop area, which will be re-named the Fusion Room (FR). The gloveboxes will be used to contain various research rigs undertaking experiments on radioactive materials. The primary radionuclide in the gloveboxes will be tritium, but there may also be activation products (including Co-60) as contamination and within the bulk of the materials. Other alpha/beta/gamma radioisotopes derived from fission reactors may be present as contamination on some samples.

Many of the gloveboxes are pre-existing units; the primary purpose of this BoD is to define the operational envelope of the gloveboxes as well as providing a concept design to be further developed into a detailed design for site installation. This document presents the stakeholder requirements identified for the research rigs and gloveboxes to be installed and operated in the Fusion Room (FR).

2.0 Introduction

A new active ventilation system to support ongoing activities in MRF building within the Fusion room is required [1].

The system will comprise of the following:

1. A new dry glove box extract to support the proposed 11 glove boxes to be located in the Fusion Room. In addition, the existing red extract system in the facility will be coupled with the new glovebox extract system. Such that, in the event of a fan failure at either the red extract or glovebox extract, the other fan can deliver the duty of both the red extract and glovebox extract systems.
2. Integrate the control philosophy of the existing red extract fan and the glovebox extract to enable them to act as duty/ standby in the event of either of the fans failing.

UKAEA have completed an option assessment which identifies that considerable advantages that can be gained by coupling the existing red extract system with the Glovebox extract system which will add complementary resilience in terms of duty/ standby for both the red extract and glove box systems. The glovebox extract shall be sited where the space for the provisional standby red extract fan is located, the ventilation control panel and inverters will be located within the space provision available for the standby red extract fan.

Glove box	RO	Arrival date at MRF	In use by	Box dims. L x w x h (m)	Box atm.	Services required							Glovebox		Inventory and Contaminants						
						Electrical		Flam gas flow (sccm)	Flam gas fill (L)	gas flow (sccm)	Gas fill (L)	Water	Hazards	Waste arisings type Liq/Solid /Gas/ Chemical	Comments	Normal LPM	Max LPM	Be	Tritium	α/β/γ	Comments
						240V	Other supplies														
*WPBB	R Walker	Jan 18	Build Feb 18	4x1.2x2	N_2	10 in box 10 external				He=1(O) Air valves	N2=30(O) He=10(O)	Chilled water	Tritium SAES getter 350W heater		19" rack somewhere	10	300	Y	500GBq		
*JET3-TRI	Z Kollo	Dec 17	Aug 18	**4x1 x2**	N_2	10 in box 10 external		H2=20(N) D2=20(N)	H2=0.2(O) D2=0.2(O)	N2=20(O) Air=20(O) He=20(O) Ne=20(O) Air valves	N2=70(O) He=70(O) Ne=70(O)	Chilled water (chillers available)	Tritium HV, microwaves Be samples, heaters	L,S,G	Intranet access	10	300	Target coupon	<5TBq		
*TriCEM	A H'worth	Trace T2 = autumn 2018. Full T2 in 2019	now	**4x1 x2**	N_2	10 in box 10 external		H2=20(N) D2=20(N)	H2=0.5(O) D2=0.5(O)	N2=20(O) Air=20(O) He=20(O) Ne=20(O) Air valves	N2=6(O) He=6(O) Ne=6(O)	Chilled water (Local closed loop chiller already purchased)	Tritium Microwaves, HV (<5kV), heaters, SAES getter	L,S,G	Intranet access	10	300	N	Full T2 <50TBq * Trace T2 ~ 400GBq	Tritium betas only	*31TBq will be the tritium inventory expected for full T2 phase Approx 400 GBq for "trace" tritium stage
NDA Permeation	R Lawless	TBC Latest Jun 2019 (RV)	TBC Latest January 2020 (RV)	**2.6x 1x1**	Air	10 in box 10 external	Over / under pressure		H2=3(N) D2=3(N)	He=1(O)	N2=3(N) Air=3(N) Synth air = 3(N)		Tritium	S,G,C	May stay in J25, decision mid 2018	10	300	N	250GBq		Isolator needs small table next to GB, should fit into allotted space as is.
HIDDEN	A H'worth	Summer 2019	Summer 2019	4x1 x2	N2	10 in box 10 external	X1 3 phase 415V supply	H=2000(N) D=2000(N) CH4=2000(N) CD4=2000(N)	H=4(O) D=4(O) CH4=4(O) CD4=4(O)	N2=20(N) Air=20(O) He=20(O) Ne=20(O) Air valves	N2=10(N) He=10(O) Ne=10(O)	Y (~10 LPM)	Tritium Microwaves, HV (<10kV), heaters, SAES getter	S,L,G,C	Intranet access	10	300	N	<50 TBq	Tritium betas	
Sample prep 1	J Lim				N_2	10 in box 10 external				Air valves		DI water supply	Tritium α/β/γ	L,S,G		10	300	Y	?	Y	20-25% perchloric acid in methanol 20% nitric acid in water/ethanol 20 Sodium hydroxide in water
Sample prep 2.	J Lim				N_2	10 in box 10 external						Di water supply	Tritium α/β/γ	L,S,G,C		10	300	Y	?	Y	3x1m^3 linked boxes
Soft waste	R Vale	October 2018	January 2019		Air	10 in box 10 external		O2=300(N)		Air valves			Tritium Acids for sample dissolution Gas from polymer combustion (HCl, HCN)	L,S,G, C	2.85kW + 1.48kW furnaces air-cooled	10	300	N	<1GBq	N	Ex-JET wastes so no alphas, primarily soft wastes but some metallic waste could also be processed. Tritiated water present in primary containment (glass)

ISS (WPTFV)	R Lawless	Summer 2018		4x1.2x2	N_2	10 in box 10 external	H/D/T		H2=5(O) D2=5(O)	He=1(N)	He=5(O) Ne=5(O)	N	N	L,S,G	<10L of LN2	10	300	N	Y	Tritium beta	Inventory TBC
TGHS (Riken rig for tritium storage and dispensing)	S Knipe	Jul 17	TBC	4x2 x1.5	Nitrogen		100V, 200V from dedicated transformers			He=1(O) Air valves	N2=10(N)	Y	Tritium Uranium beds	S,G	Box operates at positive pressure.	10	300	N	370TBq	Y	Uranium beds have gamma activity of 1,125 kBq
TDS rig	ABW	?	2 weeks after the arrival to MRF	035 x 0.4 x 0.4 **	N_2 only for sample isolator part	See USD attached	See USD attached	H2=20(N) D2=20(N)		Air valves	N2=4(N)	DI water supply for cooling system	Beryllium Tritium Uranium (external users)	L,S,G,C	Intranet access.	10	300	JET bulk Be samples and W coated CFC with Be and T deposits	<0.1GBq	Tritium betas	Discharges tritium to vent (low flow & inventory). Needs FC for sample storage Needs (small) FC for sample loading. Small N2 flush during sample change

"(N)" = in normal operations, so at least once per week
"(O)" = occasional, so less than once per week

3.0 HVAC System Design Objectives

This basis of design document sets out the concepts that shall be applied to the design of the ventilation systems associated with the MRF Glovebox Ventilation project.

Conventional and radiological functions are to be provided, with the principle function being to support containment of nuclear materials. The ventilation systems shall be designed in accordance with ES_0_1738_1_Issue 1 – Ventilation Systems for Radiological Facilities Design Guide [3].

The design objectives of the ventilation systems are as follows:

- To support the existing multi-barrier approach to containment of contamination sources by providing a cascaded air flow regime.
- To maintain gloveboxes at a depression relative to the room in order to support safe operations and containment of active materials.
- To control the plant environment for personnel & equipment by incorporating heating and cooling where necessary into the HVAC systems.
- To provide the necessary HEPA filtration to remove as far as practicable any airborne contamination from the ventilation extract air streams to ensure discharges are within acceptable limits.
- To provide ventilation for glove boxes as required by the individual processes.
- To provide glove boxes with an emergency inward airflow in the event of a breach of containment (minimum 1 m/s through a fully breached 150 mm diameter glove port). This functionality is to be provided by a controlled HEPA filtered in-bleed.
- To optimise energy usage wherever practicable provided the Process and Safety requirements are not jeopardised e.g. minimising air throughput through the containment facility and glove boxes.
- Potential positive pressurisation of the glove boxes from the nitrogen supply system during fault conditions shall be minimised by provision of appropriate restriction devices within the gas supply pipework.
- To minimise as far as practicable, potential conventional hazards such as fire or asphyxiation.
- To couple the existing red extract fan with the proposed glovebox extract fan with a Normally closed (NC) damper in order to provide system resilience.
- Update the control philosophy to enable the red extract fan and the glovebox extract fan to act as duty / standby in the event of fan failure.
- Incorporate a heater battery in the resistive air in bleed to enable protection of the Secondary HEPA safe change filter downstream.
- To provide a provision to enable the glovebox extract to be re-routed via the EDS (Exhaust Detritiated system) system which is to be fitted at a later date.

3.1 Ventilation Systems

The glove boxes shall be housed in the Fusion room located within the MRF building, secondary safe change HEPA filter bank (duty / standby) and glove box extract fan shall be housed within the filter room and fan room respectively within the MRF building. The design of this facility is being developed in conjunction with the HVAC systems' design.

The new glove boxes shall be ventilated by a new extract system which shall enable breach flow protection to the gloveboxes in the event of a fully open 150 mm glove port. The system shall apply two stages of HEPA filtration to the glovebox extract airstream namely primary HEPA filtration at the glovebox and a secondary safe change filtration (duty/ standby) with a provision to add a third stage of filtration namely tertiary safe change HEPA filtration at a later date and incorporate a glovebox extract fan prior to connection to the stack. The MRF's existing red extract system shall be coupled into the new glovebox extract system in order to provide system resilience in terms of duty / standby.

Glove Box	Size (L x W x H) (m)	Atmosphere
*WPBB	4.0 x 1.2 x 2.0	N2
*JET3-TRI	3.0 x 1.0 x 2.0	N2
*Tri Chem	4.0 x 1.0 x 2.0	N2
NDA Permeation	2.6 x 1.0 x 1.0	Air (TBC)
WPTFV Isotope separation	TBC	TBC
Sample Prep 1	TBC	N2
Sample Prep 2	TBC	N2
Soft Waste / Hard Waste / Permeation	TBC	Air (TBC)
ISS	TBC	N2
TGHS (Riken rig for Tritium storage and dispensing	4.0 x 2.0 x 1.5	Nitrogen
TDS rig	0.35 x 0.4 x 0.4	N2

*Initial ventilation requirement only for removal of nuisance gases. Nitrogen box atmosphere not required until tritium ops.

There is a potential for one of the gloveboxes (soft waste) to be connected as a potential fume cupboard due to the high air volumes needed during pyrolysis. This shall be developed further during detailed development.

The proposed layout for the gloveboxes boxes in the Fusion room (see Figure 01 below).

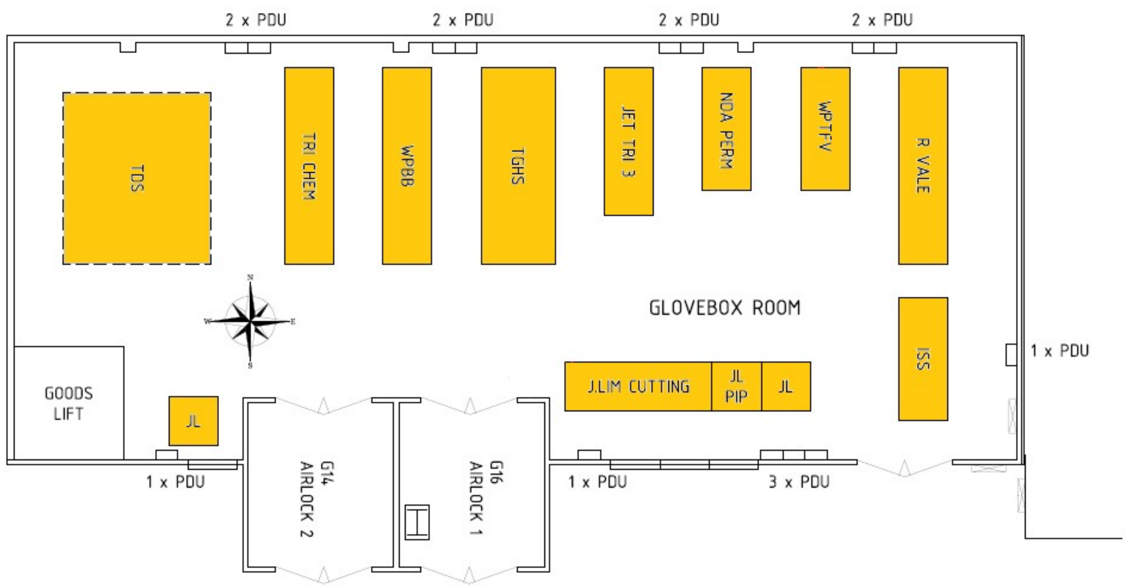

Figure 01. Proposed Layout of Additional Glove Boxes

4.0 Containment and Ventilation Philosophy

4.1 Containment Definition

Containment of sources of radiation and contamination is the main objective for ventilation philosophy of nuclear facilities, to protect the general public, the environment and plant operatives under normal and fault conditions. As a result, the principles of containment and ventilation are inseparable and are a fundamental requirement for both the building and the process plant within any radiologically controlled facility. The term ‘containment’ refers to those parts of the plant, equipment and building structure provided specifically to limit the escape of radioactive and toxic substances. Glove boxes, fume cupboards and rooms in which they are located are examples of containment.

4.2 Zone Segregation

A sealed containment is the most effective way to prevent the escape of particulate and gaseous substances. However, this is normally impractical for nuclear facilities when there is a need for the provision of penetrations within containment barriers for personnel access and transfer of materials & equipment. This leads to a requirement to provide further barriers, which themselves have further penetrations leading to a design philosophy where the contained material or process is surrounded by multiple barriers enclosing zones of progressively lesser contamination potential until the external environment is reached.

The building layout, as thus described, normally consists of a number or series of barriers enclosing zones, which are classified according to their contamination potential. The number of barriers will depend upon the sources of contamination, the efficiency of each barrier and the number and type of penetrations.

The system for zone segregation currently used on the UKAEA Site is as referred to in ES_0_1738_1 [3]. In this system, the plant is divided into four zones; Supervised, LOW, MEDIUM and HIGH, indicating the greater hazard potential and therefore the greater degree of control/restriction required.

4.3 Radiological Classification of Areas

The design of the ventilation systems will be based upon this system for classifying areas for potential contamination. The levels of potential contamination for the UKAEA Site are as follows:

- Supervised – Clean area free from radioactive contamination, whether surface or airborne.
- LOW – Substantially clean areas with the lowest contamination potential level. These areas are maintained at the smallest depression.
- MEDIUM – Areas have some surface contamination and have the potential for airborne contamination. These areas are maintained at an increased depression to LOW areas as they have a higher contamination potential level compared to LOW areas.
- HIGH – Areas are maintained at the largest depression and have the highest contamination potential level.

In addition, the introduction of a sub-division of zones is sometimes necessary to provide further segregation. This ensures that any loss of containment is localised and hence gives a more recoverable position e.g. filter room segregated from a local fan room. The segregated areas can be subjected to trend monitoring of containment performance which can be useful when total containment is not practical; i.e. leakage is inevitable but can be controlled.

4.4 Principle of Cascade Ventilation to Support Containment

Where penetrations are required within the barriers between areas of different contamination and radiation potential for example doorways, the construction material and methods used in the nuclear industry lead to barriers that are less than 100% efficient. The containment provided at these barriers is enhanced by the ventilation system, which creates pressure gradients and causes air to flow from areas of low to high potential contamination. This is achieved by maintaining HIGH areas at the greatest negative pressure, with air flows cascaded from LOW areas via MEDIUM areas to the HIGH areas through engineered and adventitious routes.

The principle of a cascaded system, where air passes through more than one classification of area, effectively reduces the number of separate ventilation streams and subsequently the amount of air requiring treatment.

In adhering to these principles the design and operation of the plant will ensure that the plant does not become a significant source of internal operator dose uptake and that the aerial effluent discharges from the ventilation systems remain within the site allowable discharge targets.

As the principal consideration for ventilation design in nuclear facilities is based on the principle of containment and the cascade of air across zone boundaries, air distribution patterns for operator comfort are often considered to be a lower priority.

4.5 Radiological Classification of Areas

The following radiological classification of areas have been used.

LOW Contamination Classification Areas – Glove boxes

The primary radionuclide in the additional glove boxes within MRF will be tritium, but there may also be activation products (including Co-60) as contamination and within the bulk of the materials. The classification for the gloveboxes as advised by the safety case lead suggests a very low contamination from the gloveboxes which are unshielded. Many of the Glove boxes are pre-existing units and it is likely that these will need to be tested / re-commissioned as part of the new system design. As such, glove boxes shall contain active materials in mobile form during normal operations and shall form a primary containment of the process.

Based on an ALARP argument, as these gloveboxes are unshielded with very low levels of contamination, these gloveboxes do not need the same level of filtration requirement as a nuclear glovebox. However, incorporating nuclear engineering best practice these gloveboxes shall have a primary terminal HEPA filter within the glovebox, a secondary safe change HEPA filter (duty / standby) and a spatial provision for incorporating a tertiary safe change HEPA filter which shall be with a stub in the ductwork complete with shut off dampers and blank off plate and a motorised damper in the ductwork to ensure a tertiary stage of HEPA filtration could be added at a later date without disrupting plant operations. Thus providing adequate consideration to the defence in depth philosophy thereby underpinning nuclear safety.

The ventilation requirements for the glove box suites are given in the basis of design document which has been developed from the concept design; completed by UKAEA. The following section provides an overview of the operation of the gloveboxes, please refer to section 8 and the concept VFD produced [1] which provides the extent of the contract.

Glove box Operations

The glove box depression relative to the containment facility in normal operation shall be maintained between 250 Pa and 500 Pa with a normal set point of 375 Pa with clean HEPA filters. Each glove box shall have air inlet HEPA filters and outlet extract HEPA filters in an arrangement suitable for continued operation where applicable.

The glove box extract system shall include a controlled HEPA filtered in-bleed depression control system for an event of a breach flow condition of 1 m/s minimum velocity across a 150 mm diameter glove port for a single glove box. The glove box ventilation shall aim to maintain between 1-5 air changes per hour to minimise the disturbance of products. Heat dissipated from equipment e.g. the oven, may require the air change rate to be increased. Air shall also enter the glove boxes at low velocities and at an optimal position to minimise disturbance of products.

In order to minimise migration of activity, each glove box shall be ventilated with individual supplies and extract points. Transfer tunnels or hatches between glove boxes shall be provided to allow transfers between glove boxes. Transfer tunnels shall be isolated at one end when not in use, such that there is no flow to adjacent glove boxes via transfer tunnels and the space within the transfer tunnel is not a dead area. Transfer hatches shall temporarily connect glove box atmospheres for the short period of time for which a package is being transferred between glove boxes.

Nitrogen supply hoses are required for purging in the WPBB, JET3-TRI, Tri Chem and Sample Prep glove box. In the event of a Nitrogen supply failure, potential positive pressurisation of the glove box shall be minimised by inclusion of an orifice plate type restriction within the glove box. The orifice shall be sized to ensure that the flow of Nitrogen to the glove box shall not exceed the breach flow protection flow rate in the event of failure to open of the main Nitrogen supply regulator valve.

An abatement at source principle shall be applied on the glove box extract system by placing the first stage of HEPA filtration as close as practicable to the glove box.

Some of the glove boxes shall have an air / nitrogen atmosphere and no pyrophoric materials nor any generation of hydrogen or other potentially explosive gases are anticipated. The presence of hydrogen or any pyrophoric materials shall be confirmed by the Process Engineering discipline / individual glovebox users during in the Scheme Design Stage.

LOW Contamination Classification Areas

The Gloveboxes facility located in the Fusion room is envisaged to be LOW contamination classified areas during normal operations. This area is currently held at a nominal depression to the surrounding areas to minimise potential for discharges from the process areas through adventitious gaps and supply transfer door grilles. There is currently no supply to the Fusion room with extract being maintained by the amber extract system. The containment facility includes an airlock between the MRF areas and the glove box suite.

Differential pressure indicating controlling alarms shall be provided to monitor the working depression in the containment facility with respect to MRF operating areas. The system shall be configured to prevent structural damage to the containment facility due to under-pressurisation, caused by closure of the in-bleed dampers while the extract fans remain in operation.

5.0 Basis of Design

5.1 Internal Environmental (Glovebox) Conditions

The internal temperatures will vary according to a number of factors including occupancy and use of heat generating equipment.

Area	Temperature Limits	% Relative Humidity
Containment Facility, normally occupied areas	As per Existing Design	Not controlled
Plant Rooms, Normally unoccupied areas	As per Existing Design	Not controlled
Glove boxes	As per Existing Design	Not controlled

5.2 Design Life

The HVAC systems’ design lives are 10 years to continue to provide extract ventilation and to retain the proposed tritium infrastructure within the MRF building.

5.3 Design Noise Levels

The following target room noise levels shall apply to operational HVAC plant and are considered to provide appropriate conditions for the nature of the rooms:

Area	Noise Rating (NR)	Approximate dB(A)
Glovebox Facility, MRF surrounding area, normally occupied areas	NR50	56
Plant Rooms, Normally unoccupied areas	NR70	76 (80-85 dB(A) [9]

From CIBSE Guide A [3] which states dB(A) ≈ NR + 6.

The Noise at Work Regulations 2005 SI 2005/1643, give two action levels for daily or weekly personnel noise exposure. The lower exposure action level is 80 dB (A) and the upper exposure action level is 85dB (A). The exposure limit value is given as 87 dB (A).

The regulations states that an employer, who carries out work which is likely to expose employees to noise at or above the lower action level of 80db (A) shall make personnel hearing protection available. If an employee is likely to be exposed to noise, at or above the upper exposure action level of 85dB (A), the regulations state that the employer shall reduce

5.4 Ductwork Velocities

The following figures are derived from CIBSE Guide B2 and should be used as a guide for initial plant layout & space allocation. An element of change & design flexibility shall be used as the design progresses in order to define an operational envelope considering all scenarios.

- **Maximum ductwork velocities**

- Main Headers – 7 m/s (Pressure loss per meter of duct not exceeding 1 Pa/m)
- Main Branches – 5 m/s (Pressure loss per meter of duct not exceeding 1 Pa/m)
- Sub Branches – 4 m/s (Pressure loss per meter of duct not exceeding 1 Pa/m)
- Connection to grilles and diffusers – 2.5 m/s (Grilles and diffusers already for part of the existing site infrastructure)

Glove box extract system pipework velocities

The pipe velocities within the glove box extract system during normal and fault scenarios shall be modelled on the PIPENET program during the design phases of the project.

Simulation of the normal and relevant fault scenarios with clean and dirty HEPA filters shall be undertaken in order to provide a high level of confidence in the system's ability to provide the required performance.

To ensure satisfactory performance, during the detailed design consideration shall be given to potential contamination drop out in the pipework during normal operation. In order to avoid this, the air flow velocity in the extract ductwork should ideally be above 5m/s.

Particular attention shall be given to pressure loss within the extract system pipework during the breached glove port fault condition, with HEPA filters dirty. The pipework shall be sized to ensure that the system can provide the 1 m/s containment air flow in this condition.

6.0 Industry Guides and Standards

6.1 Sellafield Ltd Engineering Standards

The HVAC design shall be produced in accordance with the relevant ES standards including but not limited to the following:

Design Guides

- ES_0_1738_1_Issue 1 – Ventilation Systems for Radiological Facilities Design Guide [3]
- ES_0_1503_1_Issue 1 – Design of Alpha Glove Box Plant and Equipment [16]
- ES_1_0003_1_Issue 1 – Graphical Symbols for Process and Mechanical Equipment [17]

HEPA Filters and Housings

- ES_0_1702_1_Issue 1 – Selection of Air Filters and Filtration Installations in Ventilation Systems [18]
- ES_0_1705_2_Issue 2 – Type Testing and Approval of High Efficiency Particulate Air (HEPA) Filters [19]
- ES_0_1711_1_Issue 1 – Design Standard for Safe Change HEPA Filter Housings in Ventilation Systems [20]
- ES_0_1711_2_Issue 1 – Manufacture of Safe Change HEPA Filter Housings in Ventilation Systems [21]
- ES_0_1730_2_Issue 3 – Manufacture of Filter Media for use in High Efficiency Particulate Air (HEPA) Filter/Inserts [22]
- ES_0_1737_2_Issue 2 – Filter Inserts High Efficiency Particulate Air (HEPA) Circular Plug-In 470 and 950 Litres/Second Capacities [23]
- ES_1_1707_1_Issue 1 – HEPA Filter Efficiency Testing Guidance Notes for Designers [24]
- AESS 44/13075 Filter high efficiency particulate air HEPA screw mounting 3 & 6 litres per second [45]
- AESS 30/95200 Filter inserts high efficiency particulate air (HEPA) circular plush through 12.5 - 160 litres per second capacities [46]

Ventilation Fans

- ES_0_1710_1_Issue 1 – Design Guide for Centrifugal Fans for Process and High Integrity Ventilation Systems. Specification for Type "B" and "D" Fans [25]
- ES_0_1710_2_Issue 1 – Manufacture for Centrifugal Fans for Process and High Integrity Ventilation Systems. Specification for Type "B" and "D" Fans [26]

Ventilation Dampers

- ES_0_1715_1_Issue 2 – Design Guide for Ventilation Dampers [27]
- ES_0_1715_2_Issue 2 – Manufacture of Ventilation Dampers [28]

Ventilation Heating and Cooling Coils

- ES_0_1701_1_Issue 1 – Design Guide for Coils for Heating and Cooling Air in Ventilation Systems [29]
- ES_0_1701_2_Issue 1 – Manufacture of Coils for Heating and Cooling Air in Ventilation Systems [30]

Ductwork

- ES_0_1720_1_Issue 2 – Design Guide for Low and High Integrity Ventilation Ductwork [31]
- ES_0_1723_2_Issue 2 – Manufacture of High Integrity Stainless Steel Ventilation Ductwork [32]

Manufacture and Fabrication

- ES_0_5361_2_Issue 1 – Cleaning of Metals Stainless Steels [33]
- ES_0_5363_1_Issue 1 – The Evaluation of Materials for Contact with Stainless Steel [34]
- ES_0_5391_2_Issue 1 – Fabrication of Plant & Equipment (Stainless Steel) [35]
- ES_0_5523_2_Issue 1 – Plate, Stainless Steel – Specification for Steel Number 316L/1.4404 [36]
- ES_0_5533_2_Issue 1 – Sheet and Strip – Steel No 1.4404 (Formerly Grade 316L) [37]

Piping

- ES_0_1952_1_Issue 1 – Piping Design Piping Categorisation [38]
- ES_1_2321_1_Issue 2 – Instrument Piping [39]
- ASTM A_312/A_312M – Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes [47]
- ASTM A_182/A_182M - Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service [48]
- ASME B16.5 – Pipe Flanges and Flanged Fittings [49]
- ASME B16.9 – Factory-Made Wrought Butt-Welding Fittings [50]
- ASME B16.21 – Non-Metallic Flat Gaskets for Pipe Flanges [51]

Ventilation Instrumentation

- ES_1_2306_1_Issue 1 – Air Flow Measurements in Active Ducts and Stacks [40]
- ES_1_2313_1_Issue 2 – Differential Pressure Measurement for Ventilations Systems [41]
- ES_1_2327_1_Issue 1 – Valve Actuation [42]
- ES_1_2505_1_Issue 1 – Stack and Duct Sampling & Monitoring Principles [43]

6.2 CIBSE Guides

The following CIBSE Guides may be referenced during the design:

- CIBSE Guide A 2015: Environment Design [4]
- CIBSE Guide B 2016: Whole Series [5][6][7][8][9]
- CIBSE Guide C 2007: Reference Data [10]
- CIBSE Guide E 2010: Fire Safety Engineering [11]
- CIBSE Guide F 2012: Energy Efficiency in Buildings [12]
- CIBSE Commissioning Code A 1996 (2006): Air Distribution Systems [13]

6.3 HVCA Specifications

The following HVCA Specifications may be referenced during the design:

- HVCA Specification DW/143 A Practical Guide to Ductwork Leakage Testing [14]
- HVCA Specification DW/144 Specification for Sheet Metal Ductwork [15]

7.0 Statutory Requirements

The following statutory requirements shall be applied where relevant:

The Health and Safety at Work etc. Act 1974

The Act is concerned with health, safety & welfare in connection with work, the control of dangerous substances and certain emissions to the public. The Act places broad, general duties on employers, employees, manufacturers, designers and suppliers of work equipment & materials in the workplace. The design shall be such that it allows the duties of the HSW Act 1974 to be met. To assist in achieving this requirement, the following UK Regulations will be addressed in the design.

Management of Health and Safety at Work Regulations 1999 SI 1999/3242

These Regulations require employers to assess risks to health and safety and record findings. They must then implement measures to control risks, appoint competent people, set up emergency procedures and provide information and training for employees and anyone else who needs to know.

To comply with these regulations Design Hazard Inventories and Risk Assessments will be produced as part of the design and the ventilation plant procurement specification will request that the plant supplier provides appropriate operating and maintenance instructions.

Manual Handling Operations Regulations 1992 SI 1992/2793 & Amended SI 2002/2174

The Employer must prevent potential injuries from manual handling as far as is reasonably practicable.

These regulations apply to any manual handling operations, which may cause injury at work.

The regulations place a duty on the employer to avoid the need for his employees to undertake any manual handling operations at work, which involve a risk of their being injured. Where this cannot be avoided a risk assessment shall be carried out and the risks reduced.

To comply with these regulations lifting beams will be specified in plant rooms where practicable to reduce the requirement for manual handling. Design Hazard Inventories

produced in the design will address manual handling operations which cannot be reasonably avoided.

Electricity at Work Regulations 1989 SI 1989/635 & Amended SI 1996/192, SI 1997/1993

These regulations impose health and safety requirements with respect to electricity at work. They impose requirements as to systems, work activities and protective equipment.

Compliance with the current IEE wiring regulations (BS 7671 [44]) is likely to achieve compliance with these regulations as far as design and construction is concerned.

To comply with these regulations, the procurement specifications, for any mechanical plant containing electrical equipment (e.g. motors), will request that the equipment meets the current IEE wiring regulations.

Electrical Equipment (Safety) Regulations 1994 SI 1994/3260

These regulations apply to all electrical equipment for use between 50-1000V and require manufacturers of electrical equipment to place on the market only equipment, which does not jeopardise the safety of people and property.

To comply with these regulations, the procurement specifications, for any mechanical plant containing electrical equipment (e.g. motors), will request that the equipment meets these Regulations and carries a CE marking.

Construction (Design and Management) Regulations 2015 SI 2015/51

The Construction (Design and Management) (CDM) regulations cover the management of health, safety and welfare when carrying out construction projects.

To comply with these regulations the designer shall produce a register of design residual risks, general hazard checklists, a CDM risk assessment and an outline installation method statement in the design process.

Control of Substances Hazardous to Health (COSHH) Regulations 2002 SI 2002/2677 & Amended 2003/978 & 2004/3386

The aim of these regulations is to protect workers health from hazardous substances used at work. The employer should prevent exposure to hazardous substances as far, as is reasonably practicable and then, if not practicable, assess the risk.

To comply with these regulations the design will register the use of a potentially hazardous substance and request that a formal COSHH assessment to be carried out on that substance.

Provision and Use of Work Equipment Regulations (PUWER) 1998 SI 1998/2306 & Amended 2002/2174

These regulations give a general duty to an employer to supply safe equipment and give adequate information, instruction and training on its use.

To comply with these regulations there is a requirement under PUWER to provide clear instructions and information for the safe operation and maintenance of the equipment. The procurement specifications for the mechanical plant shall request that the equipment supplier provide appropriate operating and maintenance instructions. Any integration of proprietary items will be addressed with regard to the principles of the 'Hierarchy of Risk Control' and written instructions.

Supply of Machinery (Safety) Regulations 2008 SI 2008/1597 & Amended 2011/2157

These regulations apply to relevant machinery, which must be supplied safe and shown to be so and must be capable of being erected and put into service safely.

To comply with these regulations the 'Application of the Machinery Directive' and the 'Risk Assessments for the Safety of Machinery' will be applied as part of the design. In addition, the Procurement Specifications, for any mechanical plant, which constitutes a machine under these regulations, will request that the equipment meets these regulations and carries a CE marking. For such machines the supplier of the machine shall maintain the Technical File and affix the CE mark and a copy of the Declaration of Conformity shall be requested from the machine supplier.

Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 SI 1998/2307 & amended SI 2002/2174

These regulations require that the risks from lifting equipment and lifting operations be managed safely. This includes ensuring that lifting equipment is suitable for safe use in its application, the safe working load is clearly displayed on the equipment, the equipment is installed and positioned correctly, work is planned accordingly for a competent person to use the equipment safely and that the equipment undergoes thorough & routine examinations.

Noise at Work Regulations 2005 SI 2005/1643

These regulations place duties on the employer to control an employee's exposure to noise, reduce noise risks, carry out assessments of noise levels, maintain equipment and provide information and training.

To comply with these regulations, during the design, noise levels likely to be generated by operating equipment will be requested from equipment suppliers. The design will incorporate measures to reduce noise levels where appropriate to comply with the in room noise ratings.

The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations SI 1996/192 & Amended 2001/3766 & 2005/830

These regulations apply to both electrical and mechanical equipment and protective systems for use in potentially explosive atmospheres. Such equipment must bear the CE marking.

The Dangerous Substances and Explosive Atmospheres Regulations 2002 SI 2002/2776

These regulations place requirements on the employer for the purpose of eliminating or reducing risks to safety from fire, explosion or other events arising from the hazardous properties of a dangerous substance in connection with work. Where a dangerous substance is, or is liable to be present at the workplace, an employer shall make a suitable and sufficient assessment of the risks to his employees which arise from that substance.

The regulations also require the employer to classify places at the workplace where an explosive atmosphere may occur into hazardous or non-hazardous places. Where a dangerous substance is present at the workplace, the measures to be carried out by the employer include the elimination or reduction of risk, the provision of information, instruction and training on the appropriate precautions and actions to be taken by the employee in order to safeguard himself and other employees at the workplace, the clear identification of any associated hazards, and to protect the safety of his employees from an accident, incident or emergency related to the presence of a dangerous substance at the workplace. To comply with these regulations with respect to dangerous substances the design will register the use of a potentially dangerous substance.

The Construction Products Regulation 2013 SI 2013/1387

These regulations place requirements on the suppliers of a construction product (meaning an item which is incorporated in a permanent manner in works) to ensure that the product meets essential requirements. The essential requirements relate to mechanical resistance and stability, safety in case of fire, hygiene, health and the environment, safety in use, protection against noise and energy economy and heat retention. If the product obtains a CE mark this is taken to mean that it meets the essential requirements.

To comply with these regulations equipment specifications will request that the relevant equipment meet these Regulations and carries a CE marking.

The Simple Pressure Vessels (Safety) Regulations 1991 SI 1991/2749 & Amended SI 1994/3098

These regulations place requirements concerning safety, which must be satisfied before a vessel can be taken into service. They cover vessels containing air or nitrogen with a capacity between 50 bar litres and 10,000 bar litres and for pressures between 0.5 bars and 30 bars.

To comply with these regulations, the Procurement Specifications, for any pressure vessels, which come under these regulations, will request that the vessels meet these Regulations and carry a CE marking.

The Pressure Equipment Regulations 1999 SI 1999/2001 and Amended SI 2002/1267 & 2015/399

These regulations place requirements on the designer and manufacture of pressure equipment and assemblies to ensure that they are safe and they meet the essential safety requirements covering design, manufacture and testing.

To comply with these regulations all of the services will be assessed, during the design, to establish if PER 1999 applies to that service. If PER 1999 is applicable, all of the equipment on that system will be classified according to the charts within the regulations to establish the applicable requirements. The Procurement Specifications will request that applicable equipment meets these Regulations and carries a CE marking where appropriate.

Pressure Systems Safety Regulations 2000 SI 2000/128

These regulations impose safety requirements on designers, manufacturers, suppliers and users relating to pressure systems.

To comply with these regulations all of the services will be assessed, during the design, to establish if PSSR 2000 applies to that service. If PSSR 2000 is applicable, all of the equipment on that system will be assessed to ensure that it complies with regulation 4, which covers design and construction.

The Procurement Specifications will request that applicable equipment meets these regulations.

8.0 HVAC Systems Descriptions

8.1 New Glove Box Extract System including Existing Red Extract System

The new glove box extract system shall serve the glove boxes as listed in the earlier Section. Please refer to the concept VFD[1] produced by UKAEA for the extent of this contract.

The glove boxes air inlet HEPA filters including differential pressure instrumentation and alarms form part of UKAEA provision. The ventilation design scope consists of designing the connection pipework to each of the gloveboxes to achieve a breach flow condition, which is anticipated to be an 80mm connection for each of the gloveboxes. The design also includes providing a 28mm pipe connection complete with valves for the process discharge located downstream for each of the gloveboxes. Please refer to the concept VFD [1] for the extent of the contract provision. Each of these gloveboxes would be connected on to the glovebox header which is anticipated to be 150mm / 200mm diameter pipe running along the perimeter to form a “ring main” with a secondary safe change HEPA outlet anticipated to be 75 L/s duty/ standby to ensure continued operation during required filter maintenance/changes.

The filter sizes and arrangement of the safe change filter housings shall be determined in the design phases of the project. Isolation valves shall be provided as required on inlet and outlet connections to primary HEPA filters at each glove box.

The glove box extract system shall be constructed from high integrity 316L stainless steel pipework and fittings to ASTM A312_A 312M [47], manufactured/tested in accordance with ES_0_1723_2 [32] and ASME B16.9 [50]. Pipework flanges shall be 316L stainless steel to ASTM A182_A 182M [48], manufactured to ASME B16.5, Class 150.

The glove box extract pipework shall connect into a main extract header, it is envisaged that the main glovebox extract header shall form a “ring main” loop with a provision to be connected on to the future EDS system which is to be fitted at a later date and shall then exit the glovebox facility and route to the existing plant room(s).

The ductwork routing shall be confirmed in the design phase of the project. A controlled HEPA filtered in-bleed depression control system shall be provided in the event of a breach flow condition at a 150 mm diameter glove port where a 1 m/s minimum velocity is required, which shall be located downstream of the EDS system. The resistive in bleed shall incorporate an electrical heater battery with a humidistat control downstream before the secondary HEPA filters to ensure that the extract air RH is maintained below 80% and the filters are not blinded.

The in-bleed shall be connected to the glove box extract header duct upstream of the secondary safe change HEPA filters it is envisaged that the resistive air in bleed will be located within the Fusion room; the depression in the extract header duct shall be controlled by speed control of the extract fan or using a fixed speed fan which shall be determined in the design phase of the project. The breach flow in-bleed system shall be complete with a HEPA filter, isolation valve and orifice plate and an electrical heater battery.

The glove box extract system shall have a single stage of HEPA filtration located in the filter room prior to tie in into the main discharge and onto the stack discharge. A spatial provision shall be made with a motorised damper and two stubs complete with a motorised damper and blank off plate within the extract ductwork such that a tertiary stage of HEPA filtration could be added at a later date. The primary HEPA filter bank shall each comprise of 100% duty & standby filters. The filter sizes shall be determined in the design phases of the project which is anticipated to be 75L/s duty.

The HEPA filter housings shall be of the stainless steel safe change circular housing type in accordance with ES_0_1711_1 [20] & ES_0_1711_2 [21], with circular HEPA plug inserts to ES_0_1737_2 [23]. The HEPA filter housings shall be individual units arranged in a bank complete with inlet and outlet header ducts. To facilitate filter changing, manual isolation dampers shall be provided upstream and downstream of each filter housing. The safe change facility shall use conventional safe change bagging techniques and shall allow safe, manual and fully contained filter changing.

The Secondary safe change HEPA filter housings shall be provided with a HEPA filters in-bleed facility, which shall be opened during filter change operations to maintain a depression of approximately 60 Pa within the safe change housing/PVC bag, by leakage through the closed isolation dampers.

Dispersed Oil Particulate (DOP) injection, sample and return points shall be included to enable the secondary and tertiary HEPA filter banks to be efficiency tested whilst in service and after filter changing in accordance with ES_1_1707_1 [24]. The primary HEPA filters local to the glove boxes and those for breach flow protection are not required to be provided with DOP injection, sample and return points.

A duty extract fan shall be included in the design and located in the plant room downstream of the safe change HEPA filter banks. The glovebox extract fan shall be SRZ12D/90/475/5 and shall be manufactured by Fan Systems Ltd [2]. Fan motors shall be 2.2kW, 2 pole, 400/3/50 suitable for inverter drives and shall be IE3 Energy Efficient. The Glovebox extract fan shall be coupled with the red extract fan with a motorised damper connection. During normal operation both the red extract and glovebox extract shall run as independent systems, in the event of a fan failure (either the red extract or the glovebox extract), the motorised damper could be opened to enable the other fan (which has been sized to cater the duties of both the systems) to take over.

The extract fan shall be designed, manufactured and tested in accordance with ES_0_1710_1 [25] and ES_0_1710_2 [26]. Fans shall be type ‘D’ and the material of construction shall be stainless steel complete with Anti-Vibration (AV) mounts and inlet & outlet gas tight flexible connections.

The HVAC design shall be subject to safety assessment and hazard analysis however it is anticipated that the following controls and interlocks shall be required: -

- The glovebox extract fans shall automatically changeover on failure to the duty red extract fan via the motorised damper.
- The auto changeover control system for the extract fans shall comprise of 2 out of 3 voting system, which is hard wired and independent of the control system.
- To detect fan failure, alarms shall be initiated by loss of flow, low fan differential pressure and low fan speed; and fan auto changeover shall be carried out only when at least two of the three alarms are initiated.
- The extract fan shall be provided with A and B power supplies.

The glove box extract system shall then tie-in to the existing red extract system followed by connection into the stack extract system for discharge to atmosphere.

The inclusion of suitable instrumentation & control equipment for the HVAC extract system shall be developed in the design phases of the project to allow for safe & efficient operation of the services and overall HVAC system.

8.2 HVAC Design Deliverables

The following are the HVAC Design Deliverables which need to be produced during the design development process:

Scheme Design Phase:

- Constructability Report
- Interface Schedules
- Design Risk Assessment
- Plant Asset List
- Fire Strategy Report
- Plant Layout & Interface Drawings
- Scheme Design Review Report
- Commissioning / Decommissioning Philosophy
- Civil / Structural input (if needed)
- Health & Safety File (Content & Structure)
- ARM/FMEA Study Reports
- Scheme Drawings
- Pressure Drop calculations (Excel Spreadsheet)
- PIPENET model
- Input into SIDD
- HAZOP 1 Attendance
- Equipment Sizing Calculations
- Outline Installation Method Statement

Detailed Design Phase:

- Review Finalise DRA
- Final ARM Reports
- Detail Design Review/ Report
- Test & Commissioning Specification
- Plant Equipment (Asset) Maintenance Schedule
- O&M Manuals
- Health & Safety File
- Production (Technical) Specifications
- Production Drawings
- Finalised Calculations
- Civil / Structural report (if needed)
- SIDD Input (Update)
- HAZOP 2 Attendance

9.0 Environmental Health and Safety Requirements

9.1 Seismic Design Requirements

There are no seismic requirements for the glove box and ventilation systems.

9.2 Fire Protection

The nuclear fire assessment and fire compartments shall remain the same in the existing MRF facility. The containment facility shall be a one hour fire rated compartment and shall be subject to conventional and nuclear fire safety assessments during the design. The ventilation design shall be produced in accordance with the findings of these assessments.

Where ventilation ductwork passes through fire compartments, fire dampers to the equivalent rating of the boundaries shall be incorporated i.e. ductwork penetrating the containment facility shall be one hour fire rated.

Typically, fire dampers are not used in glove box extract systems as the extract pipework may achieve one hour fire rating by virtue of the pipe thicknesses and spurious fire damper failure to the closed position would lead to loss of depression within the gloveboxes.

Fire dampers shall be of the electrically actuated, fail closed type with open and closed position indication. Fire triggers shall not be used. The detailed fire damper control philosophy shall be determined during the detailed design.

Subject to fire safety assessments and consultation with the Chief Fire Officer, it is envisaged that the glove box and red extract ventilation systems shall continue to run during a fire situation with some controls available to the Fire Officer. The status of fire dampers and fans, and the HVAC System Equipment functionality required, will be available at the remote Fire Control Panel at MRF entrance; this shall be developed in the design phases of the project.

9.3 Asphyxiation/Confined Spaces

The use of nitrogen within the glovebox facility results in a potential asphyxiation hazard. A safety assessment to determine the asphyxiation/confined space risks & mitigating actions shall be carried out in the design phases of the project. Reasonably practicable measures and the outcome from the safety assessment shall be incorporated into the ventilation systems design to support the mitigation of asphyxiation hazards.

9.4 Maintenance Access to Ventilation Equipment

As far as practically possible, equipment shall be located to minimise working at height during maintenance operations. Where it is necessary to perform operations such as inspections, cleaning or routine maintenance at above floor level, specific consideration shall be given to access at the design stage.

Adequate space shall be incorporated into layout arrangement for filter changes and fan maintenance.

9.5 Hazardous Areas, Explosive Gases

An assessment to establish the potential for hazardous atmosphere is to be undertaken in accordance with the DSEAR regulations 2016.

9.6 Energy Efficiency

The following measures shall be considered during the ventilation design in order to reduce the energy usage:

- Minimising air flow through facility and thus reducing the energy consumption of the extract ventilation fans.
- Using variable speed fan over single speed fan as appropriate
- Using IE3 Energy Efficient motors.
- To minimise airborne effluent arisings within the glove box to minimise waste burden on the glove box extract primary HEPA filter during operations and hence limit the number of required filter changes.

10.0 Ventilation Control Philosophy

The new glove box ventilation system including the existing red extract system tie-in, shall be controlled and operated from a control panel located in the fan area of the HVAC plant room. The existing control philosophy shall be updated as part of this contract to enable the existing red extract fan and the proposed glovebox fan to act as duty / standby in the event of either of the fans failing.

The control systems and protection systems shall, where practicable, be clear, be physically separate and will not share equipment or services. Equipment will only be shared in the event of fan failure.

The design shall aim to prevent unauthorised access to or interference with systems important to safety. No means will be available to alter the configuration, logic or data of a system important to safety other than via a specifically engineered and safeguarded route.

Vetoing of systems within safety functions shall be avoided. Provision shall be made in the design where this is unavoidable.

Testing and maintenance of protection systems shall not have the potential to initiate a fault sequence.

10.1 Fans and Fan Drives

The glove box and red extract system fans shall automatically changeover on failure of either of the duty extract fans. The auto changeover control system for the extract fans shall comprise of two out of three voting system, which is hard wired and independent of the control system. To detect fan failure, alarms shall be initiated by loss of flow, low fan differential pressure and low fan speed; and fan auto changeover shall be carried out only when at least two of the three alarms are initiated. The duty extract fan shall be connected to independent A and B power supplies.

Motor thermistors for over-temperature protection and fan shaft condition monitoring sensors for early identification of bearing failure will be fitted to the glove box extract fan motors and drives.

Fans Start-up and Shutdown

The ventilation systems are dependent on each other for the purposes of maintaining a cascade flow of air through the facility. The glove box extract system will pull air from the surrounding MRF areas and ventilate the glove box and plant room enclosures to provide sufficient make up air to the glove boxes.

Subject to a radiological safety assessment, the hierarchy for system start-up and shutdown will be:

- Start red extract system
- Start glove box extract system
- Start amber extract system
- Start space supply and extract system
- Shutdown space supply and extract system
- Shutdown amber extract system
- Shutdown glove box extract system
- Shutdown red extract system

The control philosophy including the system hierarchy for start-up and shutdown shall be developed in the design phase of the project.

10.2 System Controls

Detailed control sequences of the ventilation systems shall be developed at the detailed design phase and described in the Sequence and Interlock Definition Document (SIDD).

Glove Box Header Depression Control

A differential pressure instrument shall monitor the depression within the glove box extract system header relative to the adjacent area and shall alarm locally in a central location to initiate investigation and remedial action.

Glove Box Depression Control

Glove box supply air in bleed, depression monitoring and instrumentation forms part of UKAEA provision.

The in-bleed control system shall have a differential pressure and flow measurement instrumentation. A high differential pressure alarm shall give indication of filter blinding and a low differential pressure shall give indication of a potential failed filter. The flow measurement shall be for indication and alarm with the appropriate alarm set-points determined in the design phases of the project when system resistance calculations are undertaken.

10.3 Interlocks

Requirement for safety related interlocks shall be determined during safety assessment and hazard analysis however, it is considered that the following interlocks are required:

- The main space supply and extract duct motorised isolation dampers shall automatically close on depression in the glovebox facility or on failure of either the glovebox extract fan or the red extract fan.

10.4 Instrumentation

Sufficient indicating, recording instrumentation and controls shall be available to the plant operator to provide adequate monitoring of the state of the plant and ventilation systems, warning of any safety related change of state, and the means of identifying, initiating and confirming all necessary safety actions including those required for accident management and recovery.

All alarms, indications, measured value displays, etc. will be designed to be available to the operators locally at control panels and via a group alarm remotely. The operators will be alerted to all alarms both visually and audibly. The control panels will be provided with accept, mute and reset facilities for all alarms, and it will not be possible to reset an alarm whilst the alarm condition remains. There shall be a clear, unambiguous means of confirming to operating personnel that a demand for a safety action has arisen and that the safety action has been successful.

The reliability, accuracy, stability, response time, range and readability of instruments will be adequate for their required service. All instruments and limit switches having electrical interfaces will operate on 24V DC power supply.

Each pressure device (gauge, indicator, transmitter, etc.) will be provided with a valve manifold to enable the device to be isolated, calibrated and the zero point checked without affecting the measured service. Every pressure or flow instrument sensing line connected to active extract ducts will be provided with a miniature in-line HEPA filter.

11.0 Availability, Reliability and Maintainability

The HVAC system design shall assess the equipment at detailed design for Availability, Reliability & Maintainability (ARM). The assessment shall be based on a qualitative approach and does not include a numerical analysis. Many aspects of the HVAC design are already commonly used at UKAEA so there is a significant amount of Operational Experience (OPEX) and therefore the majority of the HVAC elements identified are seen as low risk.

ARM characteristics have a key impact on operational effectiveness and performance of equipment. The ARM assessment shall identify tasks which will provide reliability and maintainability guidance which will be incorporated into the design as good engineering practice.

The ARM analysis will predominately be based on the following factors:

- OPEX of equivalent designs operating in other facilities at the UKAEA site including MRF.
- Manufacturer’s data (where available) or standard industry data sources
- Good engineering practice

Each system shall be broken down into its functionality and the key components will be identified to ensure that the failure modes are understood. Maintenance tasks can then be identified to reduce & mitigate the risk of failure and demonstrate that adequate reliability & availability can be attained. The maintenance strategy for each system shall be identified.

The ventilation systems shall use the dual arrangement for HVAC fans, while the duty and standby filters shall provide continued operation during required maintenance.

12.0 Discharges Sampling and Monitoring

The new glove box and red extract systems shall tie into the existing stack which shall utilise the existing alpha and beta sampling & monitoring systems.

No further alpha or beta monitoring is required for the glovebox extract systems, prior to discharge via the stack.

13.0 System Interfaces and Service Requirements

13.1 System Interfaces

There are numerous boundaries and interfaces associated with the MRF glove box suite project between engineering disciplines and project stakeholders. These interfaces shall be detailed within a ‘Design Decisions Log, Action Tracker & Interface Schedule’ document which shall be a live document on the project’s Shared site if possible.

13.2 Service Requirements

The following services will be required for the operation of the ventilation systems:

- Electrical power for the operation of fans and controls (A&B supplies where necessary)

14.0 Installation, Testing and Commissioning

14.1 Installation

An Outline Installation Method Statement, CDM Risk Assessment and Residual Risk Register shall be produced during the preliminary design in accordance with the CDM Regulations, these documents shall be provided to the installation contractor to form the basis of their detailed installation method statement.

14.2 Testing and Commissioning

The design shall incorporate adequate test points and flow control devices for commissioning. During detailed design a commissioning strategy document shall be produced. Design support shall be available to facilitate testing and commissioning.

Inactive testing of the HVAC system plant equipment shall be organised at the manufacturer’s site where acceptance by UKAEA is required prior to the equipment being delivered to the UKAEA site. The Factory Acceptance Test plan shall be developed in the detailed design phase of the project.

14.3 Operator Training

Operation and maintenance manuals shall be provided with equipment which shall be stipulated in the procurement specification document.

Provision of operator training is typically the responsibility of the project and is undertaken prior to active commissioning. The following key elements are to be addressed:

- Training opportunities under an integrated commissioning team
- Use of simulation software of training Operators
- Operator attendance and training at works
- Use of development rigs/mock ups for training

15.0 Decommissioning Philosophy

All HVAC plant shall be designed to ensure ease of decommissioning and shall be considered throughout the design phase. Features to consider include the following:

- Use of manageable lengths of duct and pipe
- Flanged equipment connections and sections of duct and pipe where possible
- Consideration of ease of dismantling, bagging and removal
- Consideration of blanked or isolated connections at strategic positions to facilitate connection to alternative temporary ventilation systems during decommissioning
- Requirements for wash down points
- Sufficient access points for inspection and monitoring

References

[1] MRF Fusion Room Glovebox extract system VFD

[2] Fan systems Ltd datasheets

[3] ES_0_1738_1_Issue 1 Ventilation Systems for Radiological Facilities Design Guide

[4] CIBSE Guide A 2015: Environmental Design

[5] CIBSE Guide B0 2016: Applications and Activities – HVAC Strategies for Common Building Types

[6] CIBSE Guide B1 2016: Heating

[7] CIBSE Guide B2 2016: Ventilation and Ductwork

[8] CIBSE Guide B3 2016: Refrigeration and Air Conditioning

[9] CIBSE Guide B4 2016: Noise and Vibration Control for Building Services Systems

[10] CIBSE Guide C 2007: Reference Data

[11] CIBSE Guide E 2010: Fire Safety Engineering

[12] CIBSE Guide F 2012: Energy Efficiency in Buildings

[13] CIBSE Commissioning Code A 1996 (2006): Air Distribution Systems

[14] HVCA Specification DW/143: A Practical Guide to Ductwork Leakage Testing

[15] HVCA Specification DW/144: Specification for Sheet Metal Ductwork

[16] ES_0_1503_1_Issue 1 – Design of Alpha Glove Box Plant and Equipment

[17] ES_1_0003_1_Issue 1 – Graphical Symbols for Process and Mechanical Equipment

[18] ES_0_1702_1_Issue 1 – Selection of Air Filters and Filtration Installations in Ventilation Systems

[19] ES_0_1705_2_Issue 2 – Type Testing and Approval of High Efficiency Particulate Air (HEPA) Filters

[20] ES_0_1711_1_Issue 1 – Design Standard for Safe Change HEPA Filter Housings in Ventilation Systems

[21] ES_0_1711_2_Issue 1 – Manufacture of Safe Change HEPA Filter Housings in Ventilation Systems

[22] ES_0_1730_2_Issue 3 – Manufacture of Filter Media for use in High Efficiency Particulate Air (HEPA) Filter/Inserts

[23] ES_0_1737_2_Issue 2 – Filter Inserts High Efficiency Particulate Air (HEPA) Circular Plug-In 470 and 950 Litres/Second Capacities

[24] ES_1_1707_1_Issue 1 – HEPA Filter Efficiency Testing Guidance Notes for Designers

[25] ES_0_1710_1_Issue 1 – Design Guide for Centrifugal Fans for Process and High Integrity Ventilation Systems. Specification for Type "B" and "D" Fans

[26] ES_0_1710_2_Issue 1 – Manufacture for Centrifugal Fans for Process and High Integrity Ventilation Systems. Specification for Type "B" and "D" Fans

[27] ES_0_1715_1_Issue 2 – Design Guide for Ventilation Dampers

[28] ES_0_1715_2_Issue 2 – Manufacture of Ventilation Dampers

[29] ES_0_1701_1_Issue 1 – Design Guide for Coils for Heating and Cooling Air in Ventilation Systems

[30] ES_0_1701_2_Issue 1 – Manufacture of Coils for Heating and Cooling Air in Ventilation Systems

[31] ES_0_1720_1_Issue 2 – Design Guide for Low and High Integrity Ventilation Ductwork

[32] ES_0_1723_2_Issue 2 – Manufacture of High Integrity Stainless Steel Ventilation Ductwork

[33] ES_0_5361_2_Issue 1 – Cleaning of Metals Stainless Steels

[34] ES_0_5363_1_Issue 1 – The Evaluation of Materials for Contact with Stainless Steel

[35] ES_0_5391_2_Issue 1 – Fabrication of Plant & Equipment (Stainless Steel)

[36] ES_0_5523_2_Issue 1 – Plate, Stainless Steel – Specification for Steel Number 316L/1.4404

[37] ES_0_5533_2_Issue 1 – Sheet and Strip – Steel No 1.4404 (Formerly Grade 316L)

[38] ES_0_1952_1_Issue 1 – Piping Design Piping Categorisation

[39] ES_1_2321_1_Issue 2 – Instrument Piping

[40] ES_1_2306_1_Issue 1 – Air Flow Measurements in Active Ducts and Stacks

[41] ES_1_2313_1_Issue 2 – Differential Pressure Measurement for Ventilations Systems

[42] ES_1_2327_1_Issue 1 – Valve Actuation

[43] ES_1_2505_1_Issue 1 – Stack and Duct Sampling & Monitoring Principles

[44] BS_7671 – IEE Wiring Regulations

[45] AESS 44/13075 – Filter high efficiency particulate air HEPA screw mounting 3 & 6 litres per second

[46] AESS 30/95200 – Filter inserts high efficiency particulate air (HEPA) circular push through 12.5 - 160 litres per second capacities

[47] ASTM A_312/A_312M – Standard Specification for Seamless, Welded, and Heavily Cold Work Austenitic Stainless Steel Pipes

[48] ASTM A_182/A_182M – Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Services

[49] ASME B16.5 – Pipe Flanges and Flanged Fittings

[50] ASME B16.9 – Factory-Made Wrought Butt-Welding Fittings

[51] ASME B16.21 – Non-Metallic Flat Gaskets for Pipe Flanges