MS09	Mechanical Local Extract Ventilation and Fume Cupboards	UNIVERSITY OF LEICESTER

Document Control

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Design Guidance

1. This document shall be read in conjunction with the University Guidance Document "GD" series of guides and in particular the "Mechanical Ventilation" design guide.
    a. These other series of guides give overall guidance and refer to the need for "passive" designs wherever possible.
    b. Of course where LEV systems are required "passive" design is not possible and the LEV systems will require a mechanical supply make up system to supply make up air to the LEV extract.
    c. Systems should however be as energy efficient as possible with the inclusion of energy saving technologies wherever these make good economic paybacks. See later for details.
2. Reference should be made to the detailed University's mechanical technical specification. Where there are discrepancies between this document and the University standards clarification shall be obtained from the University before proceeding.
3. The University has declared a Climate Emergency and needs to reduce its carbon footprint. Building LEV extract and make up systems should be designed, where possible, with a view to reducing their energy consumption and therefore carbon footprint.
4. Where LEV extract and make up air systems are used, they shall be designed to separate the needs of extract containment from chemical storage as follows
    a. LEV fume cupboards should not normally be used to store chemicals and separate chemical store cabinets should be used for such storage. By this method
        - LEV systems with their corresponding mechanical make up air systems can be run to user demand timescales only and used as needed and not run continually.
        - Chemical store cabinets can be run from separate low air volume systems and run continually generally without need for make-up air systems as air volumes are very low.
5. Where Local Extract ventilation (LEV) is required, it is generally recognised that mechanical make up air systems will be required however this should not be taken as a "given" and an analysis should be undertaken as follows to determine if natural air make up is feasible. If the exhaust air volumes are very low then a natural air supply make up system may be considered. This may be the case if
    - The LEV extract is a simple small bench mounted extract nozzle dedicated to a local process
    - The LEV extract may consist of a single chemical store cabinet of low extract volume
    - Where mechanical supply air make-up systems are required then all air make-up systems should have audio-visual alarms installed within the laboratory. The following should be activated by pressure switch sensing differential pressure across make-up air fan
        1. green lamp, labelled "make-up airflow on", to indicate make up airflow operating
        2. red warning lamp, labelled "make-up airflow failed", and audible alarm to indicate make up airflow failed.
6. Where Local Extract Ventilation (LEV) is required, it should be designed to be energy efficient and demand driven as follows always noting that the below will be easier to achieve in new build scenarios than within existing refurbishment projects.
    a. Separate LEV extract from chemical store extract and run the LEV systems and their make up ventilation only to the demand profile needed. Run chemical store extracts 24/7.
    b. Use variable air volume LEV systems if possible and where these provide a reasonable economic payback.
    c. Modulate supply make up system air volumes to match the demand profile of the extract systems
    d. Where variable air volume LEV is used then special care must be taken to ensure efflux velocities at discharge stacks are maintained at the required design figures.

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Design Guidance

   e. Note that in refurbishment projects it may be necessary to replicate the existing philosophies rather than the more desirable variable volume alternatives.

7. Where chemical store cabinets are used then they shall be of a proprietary manufacture and designed for an extract air change rate of 20 ach/hr based upon internal cabinet volume.
   a. Cabinets will require ultra-low volume high suction fans
   b. Alarms are to be provided showing fan running and fan failure and these are to be both audible and visual.
   c. Alarms and indications are to have battery back-up.
8. Fire considerations for LEV Extract systems. Where the extract ventilation system is a Local Extract Ventilation (LEV) including Fume Cupboard extract, Safety Cabinet extract, Chemical Store extract and other local safety extract systems including cutting, welding and soldering fume extract then special considerations apply as follows.
   a. The operation of LEV systems in fire conditions is to be integrated with the overall building fire policy and main entrance fire override panel. The exact operation is to be determined on project-by-project basis.
   b. Fire dampers, with the exception of crush collars on suitably sized plastic ductwork, must not be used without prior written UoL agreement.
   c. The ducted extracts shall be routed to generally avoid crossing fire compartments or where this is not feasible then ducts shall be either
      - Provided with intumescent fire crush collars which is the preferred option
      - fully fire rated by means of construction materials and thickness (and issued with a fire certificate which will likely be difficult to obtain)
      - shall be enclosed within suitably rated boxing either solution shall fully maintain the building compartment fire integrity (and issued with a fire certificate which will likely be difficult to obtain).
   d. All fire dampers shall have an asset code and be added to the University asset schedule in an agreed format.
9. Laboratory Local Extract Ventilation
   a. Laboratory areas should be kept under negative pressure in relation to the surrounding areas with ventilation plant configured to draw contaminated air away from occupied areas. The recommendations of both CIBSE and HSE must be adopted in all areas where experimental or laboratory work is undertaken.
   b. The University’s Director of Safety Services, Public Health Department and Advisory Committee on Dangerous Pathogens may need to formally consulted with regards to the safe discharge of contaminated extract air from fume cupboards.
   c. Fume cupboards should be designed to operate via variable volume as opposed to a constant volume wherever possible. Where variable volume is used then the system and controls should be interlinked to the general room extract system such that the overall extract room volume is kept constant no matter whether the LEV is operational or not.
   d. Supply ventilation and supply air change rates shall generally be kept constant and be designed to make good total room extract whilst maintaining a negative room pressure and also to offset heat gains.
   e. All other standards regarding fume cupboards should comply with the latest European Standards
   f. General room supply and extract together with LEV extract should be demand based and reflect operational hours. Chemical store extract must be continual.
10. Ventilation Ductwork and Fan Design
    a. LEV extract shall generally be provided by means of solvent welded PVC ducting but if high acid content is present then polypropylene ducts shall be used.
    b. Ductwork shall be designed in accordance with the University standard mechanical specification and

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Design Guidance

the latest relevant B&ES specifications.

c. Extract fans should be installed at the ends of runs and generally located such that there is no positive pressure ductwork within internal building areas including ventilated plant rooms.

d. Supply and extract velocities should be designed in accordance with CIBSE recommendations.

e. Extract ductwork velocities in systems shall be designed within the following velocities:
   - 6 to 9 m/sec – main runs
   - 15m/sec – discharge efflux velocity

f. Direct drive close coupled centrifugal fans are to be used. Belt drives are to be avoided where possible.

11. Duct and AHU Air Leakage Testing

a. Allowance should be made for the air leakage testing of all LEV ventilation supply and extract ductwork. The ductwork needs to meet the specified standards and if it does not it will need to be replaced as necessary. Retrospective resealing of ductwork will not be allowed.

b. The test should be carried out in accordance with the University standard mechanical specification or, if not stated in there, to B&ES ductwork leakage testing specifications DW143/144 to class B medium pressure standard as a minimum or better depending upon application.

c. The LEV specialist installations require negative pressure operation of extract ducting and these ducts shall also be tested under negative pressure to class B as a minimum or better depending upon application.

12. Duct Cleaning and Access Hatches

a. Access hatches on all LEV ductwork will need to be of the ultra-low leakage type with correct seals and fasteners. Such hatches shall employ gas tight gaskets.

b. Allowance should be made for the correct minimum number of access hatches to be provided for regular inspection and cleaning of all ventilation supply and extract ductwork. The installation contractor will be required to install as follows.

c. Access hatches need to be installed as detailed within BESA TR19 and as a minimum in accordance with Table 3 “location of access hatches” and to the sizes recommended in table 4&5.

d. For the avoidance of doubt all necessary access hatches are to be installed by the contractor during the works which will also include those additional hatches required for thorough cleaning and described within the table as “installed by the cleaning contractor”. See also the clauses below in this regard.

e. Additional hatches will be required at least every 6 metres run of duct over and above these requirements.

f. Greater numbers of access hatches will be required on kitchen extract systems as specified within TR19 table 9.

g. All ductwork shall be thoroughly cleaned internally following installation and prior to pressure testing. This shall be undertaken in accordance with the required standards in TR19 and minimum resulting cleanliness shall be as table 2 with the ductwork being classified as “medium cleanliness” except for all laboratory and specialist areas being required to be cleaned to “high cleanliness”.

h. The installation contractor will be required to appoint a specialist ductwork cleaning contractor to undertake this cleaning work. The appointed cleaning contractor shall advise on the need for all additional hatches necessary to complete this work. Any further access doors needed for this work, and any needed over and above those specified above, shall be installed as necessary to allow the cleaning contractor to complete the cleaning works.

i. Access hatches shall be included within non demountable partitions and ceilings if needed to access all ductwork hatches.

13. Controls, alarms and electrical power supplies for LEV systems.

a. The power for both the local LEV cabinet and the remote (roof) extract fan(s) shall be taken from their own locations. That is to say the cabinet from its laboratory room and the fan from its external

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Design Guidance

location. Both LEV local location and the roof fan(s) shall be clearly marked as to where the power source is located.

- The local LEV source and the fan shall have controls interlinks running between the two by means of extra low voltage controls interlinks.
- Ideally the fan will have an inverter and the inverter will be interlinked to the LEV cabinet by low voltage controls wiring interlinks.

b. All LEV systems such as fume cupboards shall have battery backup on the controls panels provided as part of the system. In the event of the loss of power, the control panel shall provide audible and visual alarms advising the users of a loss of airflow to the fume cupboard.

c. For local LEV such as flexible arm bench hoses audible and visual alarms shall be provided for fan run, fan failure and individual outlet airflow indication shall be provided.

d. If the building has local power generation and essential circuits are provided then consideration shall be given to powering LEV systems from essential power supplies.

e. All LEV systems shall have a remote lockable override switch in the corridor outside the laboratory or user space to turn off in an emergency. This shall de-energise both fan and cabinet.

f. All new fume cupboards shall have self-closing sashes as standard.

g. All projects shall consider whether the LEV system is of a “critical” nature. This shall be determined by discussions with the Project manager and the Project H&S Stakeholder. If the LEV is considered “critical” then

- Power supplies for both LEV source and fans must be taken from a UPS system with 30 minutes duration. Note sources to each must be local as previous paragraphs.
- The fan system shall have twin fans operating in a run and standby configuration and arranged for automatic changeover on any failure with run and fail alarms for this set up local to the LEV cabinet.
- The local LEV source shall have additional alarms indicating, as a minimum, any fan failure, loss of power and these alarms shall be audible and visible.
- BMS interlinks shall be provided to give an alarm when a fan fails in a run and standby configuration.

14. Specification for Ducted Fume Cupboards

The following are the specifications for a general-purpose laboratory fume cupboard.

a. These are the minimum requirements.

b. Some of these features, such as the face velocity or the construction material, will need to be modified for a particular installation where, for example, the level of hazard is high or where the substances used are damaging to the normal materials of construction.

c. Amended or further requirements for a particular installation will be notified separately to Health and Safety Services and Asset Management and Compliance

Any new installations must be designed and installed by competent persons to meet the requirements of this Policy and of the HSE (HSG258: Controlling airborne contaminants at work). The design, construction and siting of all new ducted fume cupboards should conform to BS EN 14175-4:2004, to the specification given below.

15. Face Velocity

Face velocities should meet the below specification. Where face velocities differ from these values, containment may be reduced. Low fume cupboard air flow is more readily disrupted by general air movement within the room, whilst high face velocities can result in turbulence and eddies within the unit, thus allowing substances to escape.

Either:

a. No individual measurement in the plane of the sash less than 0.50 m/s and no measurement less than or greater than 20 % of the calculated average face velocity; or

Design Guidance

b. Type tested to BSEN 14175 Part 3 with average face velocity at sash height 400mm of 0.4m/s and no measurement less than 10% of the average no reading greater than 20 % of the calculated average, provided;
   - There must be no reading less than 0.36 m/s; Provided:
   - Containment is < 0.01 ppm;
   - Robustness of containment is < 0.1 ppm; with the sash set at 400 mm
   - This must be confirmed by Health and Safety Services and Asset Management and Compliance

   or

c. Type tested to BSEN 14175 Part 3 with average face velocity at sash height 500mm of 0.4m/s and no measurement less than 10% of the average no reading greater than 20 % of the calculated average, provided
   - Containment is < 0.005ppm,
   - Robustness of Containment is < 0.1 ppm and
   - Air Exchange Efficiency is < 10 seconds when the sash is set at 500 mm. This must be confirmed by Health and Safety Services and Asset Management and Compliance

   Installing fume cupboards with an average face velocity of <0.4m/s or converting an existing fume cupboard designed for flow rates >0.5m/s to 0.4m/s is prohibited.

   In any new building or substantial refit, systems should be variable volume rather than constant volume. Details are given earlier within this document. When replacing existing fume cupboards or adding new fume cupboards to an existing laboratory, the existing ventilation philosophy should be taken into account and it is accepted that variable volume systems may be cost prohibitive to install.

16. Hood Design
17. Cabinet Body

    The cabinet body should have raised edges to contain spillages and be made of a single sheet of material compatible with the substances used or generated in the system, such as ceramic or cast epoxy resin. Surfaces must be smooth, non-absorbent and easily decontaminated with any internal angles/joints/corners rounded, i.e. coved.

    a. It should have an aerodynamically styled facia (bevelled edges to opening) with a gap left between the aerofoil at the bottom of the facia and the front edge of the work surface.
    b. For constant air volume fume cabinets, there should contain an air bypass system, with the inlet located so as not to interfere with the aerodynamic facia and also to direct the expansion path from any explosion within the fume cupboard up and away from the operator.
    c. The dished area of the work surface must not extend under the aerofoil. A minimum distance of 50 mm is required between the edge of the dished area and the rear of the aerofoil.
18. Rear Baffle
    a. The exhaust slot formed between the bottom of the baffle and the rear of the work surface should be covered by a coarse arrestor to prevent tissues and other light items from being drawn into the exhaust system.

19. Internal Fittings
    a. Internal fittings, including sinks, must not be closer than 150 mm to the plane of the sash.
    b. Sinks, if fitted, must be integral to the work surface with no overhanging lips. Connections to the waste system must be via a small trap.
20. Sash
    a. The sash should move freely and have a maximum operating position of 400 mm or 500mm.
    b. Where a vertical sash is present, a form of sash stop must be incorporated to prevent opening past the maximum; this should be such that it cannot be overridden without deliberate action by the user.

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Design Guidance

c. The use of automatic sash closure systems should be utilised to increase safety and reduce energy consumed.

21. Audio-visual Indicators/ Airflow Monitors

An airflow indicator should be fitted to each fume cupboard to demonstrate correct functioning. This should incorporate an audible and visible alarm to warn of malfunction. These should be of a design whereby the airflow through the duct or orifice in the ceiling of the fume cupboard is monitored by a calibrated diode, or similar detection system, to provide an accurate, real-time signal of velocity / pressure / airflow linked into digital, audio-visual airflow indicators.

All digital airflow monitors must incorporate clear, visual representation of safe velocities across the inner plane and in the event of a malfunction should provide a visual and audible alarm notification. Parameters should include:

a. The current air flow, in m/s;
b. A green lamp, labelled "sash safe", to indicate the sash is below the designed sash height;
c. A red lamp, labelled "sash high", and audible alarm to indicate the sash is above the designed sash height; the alarm to be equipped with a mute button which is automatically re-set when the sash is returned to below the designed sash height;
d. A green lamp, labelled "airflow safe", to indicate the face velocity specified above is being exceeded at all points in the plane of the sash;
e. A red warning lamp, labelled "airflow failed", and audible alarm to indicate that the lowest value of face velocity is below the value specified above (for commissioning purposes, the alarm should be set to operate at not less than 90% of the specified value);
f. Battery back up to allow the air flow failed visual and audible alarms to sound in the event of a power failure.

22. Air Make-Up System

Air make up is required to replace the air exhausted from the room by a fume hood and other ventilation devices. See earlier in this document for details. Where this is necessary:

a. An air make-up system should be installed which provides 90 – 95%, filtered, heated, fresh air to replace the extracted air. This should be designed to provide slightly negative pressures within the laboratory. Category 2 laboratories should run at around minus 15pascals with regard to datum.
b. Within fume cupboard intensive laboratories:
    - The laboratory make-up air system should be integrated into the fume cupboard sash positions.
    - There should be a local button / panel system within the laboratory to allow for the ramping up of all fume cupboard velocities in the event of a dangerous spillage. This system should incorporate a function to revert back to standard velocity once the hazard has been cleared.

All air make-up systems should have audio-visual alarms installed within the laboratories that they serve. The following should be activated by pressure switch sensing differential pressure across make-up air fan:

- green lamp, labelled "make-up airflow on", to indicate make up airflow operating;
- red warning lamp, labelled "make-up airflow failed", to indicate a make-up failure.

23. Fume Discharge System

Extracted air must not re-enter buildings unless the contaminant has reached negligible concentrations. The fume extract and discharge system should display the following features:

a. Negative pressure inside the building LEV extract ductwork (fan positioned outside building).
b. Where fans cannot be positioned outside of the building, any positive pressure ducting must be as short as possible, be zero leakage and confined to within a roof top plant room area only and this plantroom must be well ventilated. This also only with written prior agreement from UoL.
c. Extract systems should incorporate an air flow control device for each fume cupboard served.
d. The extract system comprises a connection or connections to each fume cupboard, the ductwork, a fan or fans and a discharge flue or multi-flue stack. It may, as appropriate, also include equipment for regulating and indicating the extract rate, preventing reverse flow, preventing spread of fire and

Design Guidance

smoke, fume filtration, fume scrubbing, heat recovery, condensate collection, washdown and drainage.

e. The fan and motor specifications should assume highly flammable fume discharge. Motors should always be external to the airstream.

f. The extract system (together with the arrangements for laboratory make-up air) should be so designed as to minimise the sensitivity of the fume cupboard to the effects of outdoor wind and other sources of air disturbance. The discharge flue should be sited with due regard to the flow pattern of air around the building and should be sufficiently high to minimize the risk of fumes being drawn into buildings through open windows or air intake grilles.

g. The design of the ductwork (and its resulting resistance to the passage of air) and the fan should be such as to satisfy the maximum air flow requirement at operating temperatures for all fume cupboards served by the system. Fan capacities should exceed the operating requirements by at least 10%.

h. Multiple fume cupboards sharing a discharge stack must be balanced so the loss of one fume cupboard does not affect the use of the remaining fume cupboards

i. Ducting should have crush collars installed when passing through fire compartmentations (see earlier for details)

j. For critical fume cupboards, run and standby fans will be required together with an electrical supply UPS system (see earlier for details).

k. Ducting shall be specified based on the type of chemicals being discharged. Normally this will be PVC, however, for special applications such as high acid environments, polypropylene should be used.

24. Siting of the Fume Cupboard

The distance from the plane of the sash to any space used frequently or for movement of other personnel should be at least 1000 mm.

a. The distance between the plane of the sash and a bench opposite to it and used by the same operator should be at least 1400 mm.

b. There should be no opposing wall (or other obstruction likely to affect the airflow) within 1400 mm of the plane of the sash for a single fume cupboard. This may need to be as much as 2000 mm for a higher airflow fume cupboard or a bank of fume cupboards.

c. Any room air supply diffuser should not cause an airflow exceeding 0.2 m/s within 400 mm of the sash

d. No fume cupboard should be positioned with either side closer than 300 mm from a wall or similar obstruction.

e. No large obstruction, e.g. an architectural column, projecting beyond the plane of the sash should be within 300 mm of the side of the fume cupboard.

f. No doorway should be within 1000 mm of the plane of the sash or within 300 mm of the side of a fume cupboard.

g. No fume cupboard should be installed in a position where it is likely to be affected by another item of equipment. In particular, the distance from the plane of the sash to the sash of an opposing fume cupboard, to the face of an open fronted safety cabinet, or to the edge of an exhaust hood, should be carefully considered.

h. If a fume cupboard is not designed to contain a possible fire or explosion, the fume cupboard should not be sited in a position where exit from a work space to the only escape route will necessitate passing directly in front of the fume cupboard.

25. Ventilated under LEV Cabinet Chemical Storage

Part of the under storage should be fitted out for the storage of toxic, corrosive or flammable substances. For fume cupboards that are designed to be turned off when not in use, and this will generally be the operating parameter, a separate fan should be used for the chemical store and details are given earlier in this document regarding this.

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Design Guidance

For fume cupboard systems that are designed to run continually, and this is not the general case, then the chemical store extract may be connected to the fume cupboard extract system. This only by means of prior written agreement with UoL.

26. Corrosive substances:
    Consideration should be given to any services installed and the impact of any corrosive vapours on any services. A 200 mm, black on yellow, triangular *corrosive* hazard warning sign conforming to *The Health and Safety (Safety Signs and Signals) Regulations 1996* should be applied to the door this compartment. The compartment and its fittings should be non-corrodible and fitted with 50 mm deep, corrosion proof trays for spill containment near centre and at bottom (the distance between these two trays should allow the storage of 2.5 litre Winchester bottles in the bottom of the cupboard).

    The compartment should be vented at low level via a small duct connected into a suitable exhaust duct. See earlier for chemical store extract system requirements.

27. Flammable substances:
    A 200mm, black on yellow triangular highly flammable hazard warning sign conforming to the *The Health and Safety (Safety Signs and Signals) Regulations 1996* should be applied to this compartment. The compartment and its fittings should be non-corrodible and fitted with 50 mm deep, trays for spill containment near centre and at bottom (the distance between these two trays should allow the storage of 2.5 litre Winchester bottles in the bottom of the cupboard).

    The compartment should be vented at low level via a small duct connected into a suitable exhaust duct. See earlier for chemical store extract system requirements.

28. Additional Optional Features
    a. Fire suppression systems may be installed where there is a very high risk of fire.

29. Emergency response
    Fume cupboards must continue to run in the event of a fire alarm. The following will be required.
    a. Installation of remote kill switch to turn off fume cupboards, see earlier for details.
    b. Installation of crush collars in ductwork where this passes across fire compartments. See earlier for details.
    c. Installation of an over-ride to increase fan speed to remove contaminants from the air in case of significant spillage.
30. Special Features
    The following are special features that may be required where it is not possible or it is impractical to control a fume at source:
    a. Wash down and fume scrubber in the exhaust system e.g. for work with hydrofluoric acid or perchloric acid.
    b. Filters may be installed in the discharge duct in certain situations where the fume discharge may not clear the building.
    c. Where the amount of heat released is likely to exceed 2 kW, higher airflow may be is needed.

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