Proposed Chemical Research Facility at Oakbank Trading Estate (Unit 9)

Fume emissions

Date	Author	Revision	Comment
10/10/23	Jim McIver	0	Original issue
20/11/23	Greig Chisholm	1	Added: 1. Revision control 2. Clarifications on technical details. 3. Updated number of FHs to 24. 4. Basic calculation of exposure.
07/02/2024	Greig Chisholm	2	Updated number of FHs to 48. Updated calculation sheet. Added summary and moved remaining content to appendix.

Scope

This document describes the fume emissions from a proposed low volume manufacturing facility at Oakbank Industrial Estate, Glasgow. The facility is to produce small volume, high value chemicals. The scales envisaged, based on current systems, range from 10's of milligrams to a maximum of 5g product. The primary containment and protection for the chemists within the facility will be fume cupboards. These are continuous airflow cabinets in which all hazardous chemistry is carried out. They protect the user by having a constant flow of air into the cabinet, preventing any harmful vapors within the cabinet from escaping. They are also bunded to capture any liquid spillages. The quantity of vapor is extremely small and is diluted by many orders of magnitude as it passes through the air handling system before being expelled into the atmosphere via a stack. This is a standard method of containment used in all chemistry laboratories and uses well established technology.

Summary

The amount of volatile material leaving each fume cupboard was calculated:

1. Normal operation = 0.0006 ppm.
2. After spillage of volatile diethyl ether = 43 ppm.

During normal operation, there is no exposure greater than the time weighted average for all common solvents in use at the site.

APPENDIX

Assumptions

1. This would be for a 'low flow', 'eco' model of fume hood, using Variable Air Volume (VAV) technology and a flow rate of 0.3->0.5m^{-2}.
2. Each reaction will use 1.2 L of solvent (150 mL for reaction, 300 mL for work-up and 750 mL for purification)
3. The facility consists of 48 fume cupboards.
4. Fume hood and fume cupboard are interchangeable terms.
5. Solvent evaporation and emission is mitigated by the use of closed solvent feed bottles using chemically resistant tubing, and small filtered air inlets.
6. Fume cupboards will hold 5 L of solvent in storage for use by the automated platform.
7. The amount of solvent held in storage in the fume cupboard is greater than any transient amount of other chemical introduced and will be used for all calculations.
8. Operations are 24/7.
9. The maximum volume that could be spilled is 1 L as this is the largest volume of single container used in the fume cupboard.
10. Volumetric airflow is 1800 m^3/h into each fume cupboard.
11. Evaporation rate under normal operations is constant across all fume cupboards.
12. Spillage occurs only in a single fume cupboard and the accompanying spike in evaporated material is diluted by the airflow from all other fume cupboards.
13. Dilution by further dispersion after the stack is not quantitatively considered but is estimated at a factor of 1,000. This is a very crude approximation and dilution is likely to be far higher at greater distances from the stack.
14. Our operating principle is that during normal operations, at the stack the exposure will be less than the time weighted average exposure limit sourced from EH40/2005 Workplace exposure limits (hse.gov.uk)

Detail

The following solvents will be used in the facility, with their associated time weighted average workplace exposure limits (TWA) in ppm:

- Acetone 30%, 500 ppm
- Acetonitrile 5%, 40 ppm
- Ethyl Acetate 15%, 200 ppm
- Diethyl ether 5%, 100 ppm
- Methanol 5%, 200 ppm
- Hexane 5%, 20 ppm
- Heptane 20%, 500 ppm
- Dichloromethane (DCM) <5%, 100 ppm
- Ethanol <5%, 1000 ppm

Gases - The fume hoods are equipped with 6 Bar Nitrogen and Argon, stepped down to 1-2 bar outlets and a minimal flow rate of 10-50mL a minute depending on process. It is envisaged that the Argon would be of minimal use.

There may be a 1 Bar Hydrogen line running to 3 fume hoods for low pressure hydrogenation reactions. This would not be used as a general gas, but as a reaction gas used in limited quantities via balloon overpressure ~500mL at 1 bar.

It is envisaged that the site will handle some cyano compounds, in solid form, and low molecular weight thiols. Any reaction carrying out this work will be equipped with appropriate in-line chemical scrubbers to trap and destroy evolved gases. These scrubbers will remove any volatile components and prevent them being exhausted by the air handling system. The scales will be small, in the range of 0.5g - 1g of material.

All chemicals and chemical processes are subject to a rigorous risk assessment process.

Two scenarios are considered:

1. Normal operation with an evaporation rate of 0.0012 Lh^{-1}.
2. Following a spillage an evaporation rate of 4 Lh^{-1}. This is a worst-case scenario, using diethyl ether – an extremely volatile solvent. Rate will be lower for other solvents.

Conclusion

The amount of volatile material leaving each fume cupboard was calculated for each scenario (ENG-CALC-1059-001):

3. Normal operation = 0.0006 ppm, diluted to 0.0000006 ppm on dispersion after the stack.
4. After spillage = 43 ppm, diluted to 0.043 ppm on dispersion after the stack.

During normal operation, there is no exposure greater than the time weighted average for all common solvents in use at the site.

In the event of a spillage of 1 L of diethyl ether (considered the worst-case scenario for rapid evaporation), there is no exposure greater than the time weighted average for all common solvents in use at the site.