ANAESTHETIC GASES SURVEY

BCH THEATRES

BELFAST CITY HOSPTAL

14, 20, 23 MARCH & 4 APRIL 2023

Survey conducted by [redacted], Chartered Occupational Hygienist

Contents

1. Executive Summary

The Health and Safety Executive (HSE) publish document EH40 Workplace Exposure limits (WEL's) for substances hazardous to health[1]. The limits are based on personal exposure over an eight-hour working day (8-hr TWA) with some substances being assigned a 15-minute Short Term Exposure Limit (STEL).

Substances that have been assigned a WEL are subject to the requirements of the Control of Substances Hazardous to Health Regulations[2]. The Regulations require employers to prevent or control exposure to hazardous substances. Control is defined as adequate only if the principles of good control practice are applied, (COSHH, ACOP, Schedule 2A), the WEL is not exceeded, and exposure to asthmagens, carcinogens and mutagens are reduced to as low as is reasonably practicable.

Sevoflurane:
The HSE currently does not publish a Workplace Exposure Limit (WEL), for sevoflurane; therefore, for risk assessment purposes, it was decided to adapt an Occupational Exposure Limit issued in Denmark, set at 5 parts per million (ppm), (8-hour time weighted average), taken from a safety data sheet supplied from Zoetis.

The National Institute for Occupational Safety & Health, NIOSH also publish a Recommended Exposure Limit (REL): Ceiling 2 ppm (60 minutes), for halogenated waste anaesthetic gas.

The adapted exposure limit was not exceeded on the days of survey in Main DPU & Theatres 5, with the highest result recorded at 0.131 ppm (or 2.6% of the adapted limit), the remainder of the results were found to be less than 0.8% of the limit.

Desflurane:
The HSE currently again does not publish a Workplace Exposure Limit (WEL), for desflurane; therefore, for risk assessment purposes, it was decided to adapt 5 ppm (8-hour time weighted average).
Desflurane was not detected above the laboratory limit of detection on any of the collected samples, with all results recorded at less than 5.2% of the adapted limit, with the procedural use of the gas was described as diffusion.

Nitrous Oxide:
The current Workplace Exposure Limit, set by the Health & Safety Executive for Nitrous Oxide is set at 100 ppm, expressed as an 8-hours, time weighted average (TWA), no short-term exposure limit has been assigned.

Simulated personal exposure to nitrous oxide in Main DPU & Theatre 5, were both found to be below the Workplace Exposure Limit, set by the Health & Safety Executive (HSE), with the highest result recorded at 4.6 ppm nitrous oxide (or 4.6% of the WEL), expressed as an 8-hours' time weighted average (TWA).

Additionally, at the request of the Critical Care Scientist, two longer term, static leak test samples were conducted, the results of which gave an average of 0.045 ppm & 0.061ppm (or 0.05% & 0.06% 0f the WEL), these results are best described as extremely low.

Formaldehyde:

The current Workplace Exposure Limit, set by the Health & Safety Executive for formaldehyde is set at 2.5 mg/m^3, expressed as an 8-hours, time weighted average (TWA) and 2.5 mg/m^3 short-term exposure limit (STEL).

The highest long term results were recorded at 0.015 mg/m^3 formaldehyde (or 0.6% of the WEL), expressed as an 8-hours' time weighted average (TWA).

Short term exposures during decanting of 10% buffered formalin were both found to be below the laboratory limit of detection, with both results recorded at less than 10% of the STEL.

Following these results, the BHSCT monitoring protocol, would recommend that air monitoring be repeated every 3 years.

2. Introduction

Following a request from [redacted] Health & Safety Manager, Belfast HSC Trust, an occupational hygiene survey was conducted in BCH Theatres on the 14th 20th 23rd of March & 4th of April 2023, the objective of the survey was to determine personal exposures to sevoflurane, desflurane, nitrous oxide & formaldehyde.

The monitoring process covered from start to finish of all procedures carried out in the Theatres, representing "worst case scenarios' in terms of personal exposures.

Selected personnel (sevoflurane & desflurane) were fitted with a 3M, or a Draeger passive sampling badge, (nitrous oxide), a Thermal desorption tube, (nitrous oxide), a passive UMEX sampling badge (formaldehyde), which were all located on their lapels close to the breathing zone, the positioning, left or right lapel, was agreed with the individuals, where they considered the greatest concentration of gas was the most likely to occur.

3. Workplace Exposure Limits HSE

Analyte	WEL TWA		HSE Notation
	8 hours	15 min	
Nitrous Oxide (N_2O)	100 ppm	N/Q	N/Q
Formaldehyde	2.5 mg/m^3	2.5 mg/m^3	Carc
Sevoflurane	N/Q	N/Q	N/Q
Desflurane	N/Q	N/Q	N/Q

Carc: Capable of causing cancer and/or heritable genetic damage.
N/Q: None Quoted

"Sevoflurane is a sweet-smelling, non-flammable, highly fluorinated methyl isopropyl ether used as an inhalational anaesthetic for induction and maintenance of general anaesthesia, acute exposure issues are dizziness, drowsiness and headaches.

The HSE currently does not publish a Workplace Exposure Limit (WEL), for sevoflurane; therefore, for risk assessment purposes, it was decided to adapt an Occupational Exposure Limit issued in Denmark, set at 5 ppm (8-hour time weighted average), taken from a safety data sheet supplied from Zoetis.

The National Institute for Occupational Safety & Health, NIOSH also publish a Recommended Exposure Limit (REL): Ceiling 2 ppm (60 minutes), for halogenated waste anaesthetic gas.

4. BHSCT Monitoring Matrix

Exposure Monitoring Result % Against Exposure Limit	Frequency
100%+ Exposure Limit	Monitoring should be repeated as soon as the actions highlighted are in place and no longer than **8 weeks** after report is issued.
70-100% of the Exposure Limit	Monitoring should be repeated following the completion of highlighted actions and no longer **6 months** after report is issued. (Further repeat monitoring based on outcome of the monitoring report results)
30-69% of the Exposure Limit	Monitoring should be repeated following the completion of highlighted actions and no longer than **1 year** after report is issued. (Further repeat monitoring based on outcome of the monitoring report results)
0-29% of the Exposure Limit	Monitoring to be repeated **every 3 years** (on the basis that controls in palace are maintained and monitored)

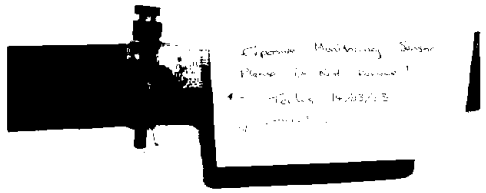
5. Results

Sevoflurane 14th March 2023	Badge Reference	Weight Detected (µgs)	Sevoflurane Conc. (ppm)	Sevoflurane TWA (ppm)	Adapted Limit Value (ppm)	Result as % of adapted limit value	Comment
[redacted], Scrub Nurse Main DPU Theatre	PX20153	<4 (<lod)	<0.075	<0.038	5	<0.8	Sampling commenced at 08.45 and ended 13.00 on 14 March 2023
[redacted], Anaesthetic nurse Main DPU Theatre	PX21183	<4 (<lod)	<0.075	<0.038	5	<0.8	
[redacted], Anaesthetist Main DPU Theatre	PX22180	<4 (<lod)	<0.075	<0.038	5	<0.8	
[redacted], Anaesthetic nurse Theatre 5	PX 19588	<4 (<lod)	<0.034	<0.038	5	<0.8	Sampling commenced at 09.00 and ended 18.00 on 14 March 2023
[redacted], Anaesthetist Theatre 5	PX20085	14	0.116	0.131	5	2.6	
Surgical scrub nurse, [redacted] Theatre 5	PX18750	<4 (<lod)	<0.034	<0.038	5	<0.8	
PX19846 Control Badge <4 µgs (lod) Limit of detection 4 µgs RPS Report No. 23-03072							

Desflurane 23rd March 2023	Badge Reference	Weight Detected (µgs)	Desflurane Conc. (ppm)	Desflurane TWA (ppm)	Adapted Limit Value (ppm)	Result as % of adapted limit value	Comment
[redacted] Anaesthetic Nurse Theatre 7	PX19065	<3 (<lod)	<0.029	<0.033	5	<0.7	9 hours sample 23 March 2023
[redacted] Surgical Scrub Nurse	PX20764	<3 (<lod)	<0.029	<0.033	5	<0.7	
[redacted] Anaesthetist Theatre 7	Draeger 1	<5 (<lod)	<0.23 (<lod)	<0.26	5	<5.2	
Draeger 2 Control Badge <5 µgs (lod) Limit of detection 5 µgs MSLL Report 23-52108 RPS 23-04263 (lod) Limit of detection 3 µgs							

Nitrous Oxide 14th March 2023	Tube Reference	Weight Detected (µgs)	Nitrous Oxide Conc. (ppm)	Nitrous Oxide TWA (ppm)	WEL (ppm)	Result as % of adapted limit value	Comment
Simulated Personal Sample (Theatre 5)	477542-BCH	<0.5 (<lod)	<0.5	<0.6	100	<0.6	9 hours sample
Simulated Personal Sample (Main DPU Theatre at flow 1 anaesthetic machine)	858461-BCH	2.8	9.1	4.6	100	4.6	4 hours sample
Control Tube 858411 <0.5 µgs MSLL Report No. 23-51718 (lod) Limit of detection 0.5 µgs							

Nitrous Oxide 14th March 2023	Tube Reference	Weight Detected (µgs)	Nitrous Oxide Conc. (ppm)	Nitrous Oxide TWA (ppm)	WEL (ppm)	Result as % of WEL	Comment
BCH Theatres Leak Test	BCH-848456	0.5	0.045	N/A	100	0.05	144 hours sample
DPU Leak Test Patient Area	BCH-848459	0.6	0.061	N/A	100	0.06	128 hours sample



Control Tube 1123128 <0.5 µgs
MSLL Report No. 23-51902
(lod) Limit of detection 0.5 µgs

Formaldehyde 20th March 2023	Reference	Weight Detected (µgs)	Formaldehyde Conc. (mg/m³)	Formaldehyde TWA (mg/m³)	WEL/STEL (mg/m³)	Result as % of WEL/STEL	Comment
[redacted] (Theatre 6)	23-51902-006	0.2	0.013	0.015	2.5 WEL	0.6	9 hours sample
[redacted] (Theatre 3)	23-51902-004	0.2	0.013	0.015	2.5 WEL	0.6	9 hours sample
[redacted] (Decanting 10% buffered HCOH))	23-51902-005	<0.1 (lod)	<0.23	N/A	2.5 STEL	<10	Short term sample
Control Badge 23-51902-007 <0.1 µgs MSSL Report 23-51902 (lod) Limit of detection 0.1 µgs							

Formaldehyde 4th April 2023	Reference	Weight Detected (µgs)	Formaldehyde Conc. (mg/m^3)	Formaldehyde TWA (mg/m^3)	WEL/STEL (mg/m^3)	Result as % of WEL/STEL	Comment
[redacted] (DPU)	23-52496-002	<0.1 (lod)	<0.013	<0.007	2.5 WEL	<0.3	4.5 hours sample
Simulated Sample [redacted] (Decanting 10% buffered HCOH) DPU	23-52496-001	<0.1 (lod)	<0.23	N/A	2.5 STEL	<10	Short term sample
Control Badge 23-52496-003 <0.1 µgs MSSL Report Simulated Sample (lod) Limit of detection 0.1 µgs							

6. Conclusion & Recommendations

The results obtained on the days of survey were as follows:

Sevoflurane:
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Simulated personal exposure to nitrous oxide in Main DPU & Theatre 5, were both found to be below the Workplace Exposure Limit, set by the Health & Safety Executive (HSE), with the highest result recorded at 4.6 ppm nitrous oxide (or 4.6% of the WEL), expressed as an 8-hours' time weighted average (TWA).

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Short term exposures during decanting of 10% buffered formalin were both found to be below the laboratory limit of detection, with both results recorded at less than 10% of the STEL.

Following these results, the BHSCT monitoring protocol, would recommend that air monitoring be repeated every 3 years.

[redacted]
Chartered Safety and Health Practitioner

7. References

1. EH40/2005 Workplace Exposure Limits [online]. Available: https://www.hse.gov.uk/pubns/priced/eh40.pdf

2. Control of Substances Hazardous to Health Regulations ACOP L5 [online]. Available: https://www.hse.gov.uk/pubns/books/l5.htm

Appendix I - COSHH ACOP Schedule 2A

Principles of good practice for the control of exposure to substances hazardous to health

Regulation 7(7)

(a) Design and operate processes and activities to minimise emission, release and spread of substances hazardous to health.

(b) Take into account all relevant routes of exposure – inhalation, skin absorption and ingestion – when developing control measures.

(c) Control exposure by measures that are proportionate to the health risk.

(d) Choose the most effective and reliable control options which minimise the escape and spread of substances hazardous to health.

(e) Where adequate control of exposure cannot be achieved by other means, provide, in combination with other control measures, suitable personal protective equipment.

(f) Check and review regularly all elements of control measures for their continuing effectiveness.

(g) Inform and train all employees on the hazards and risks from the substances with which they work, and the use of control measures developed to minimise the risks.

(h) Ensure that the introduction of control measures does not increase the overall risk to health and safety.

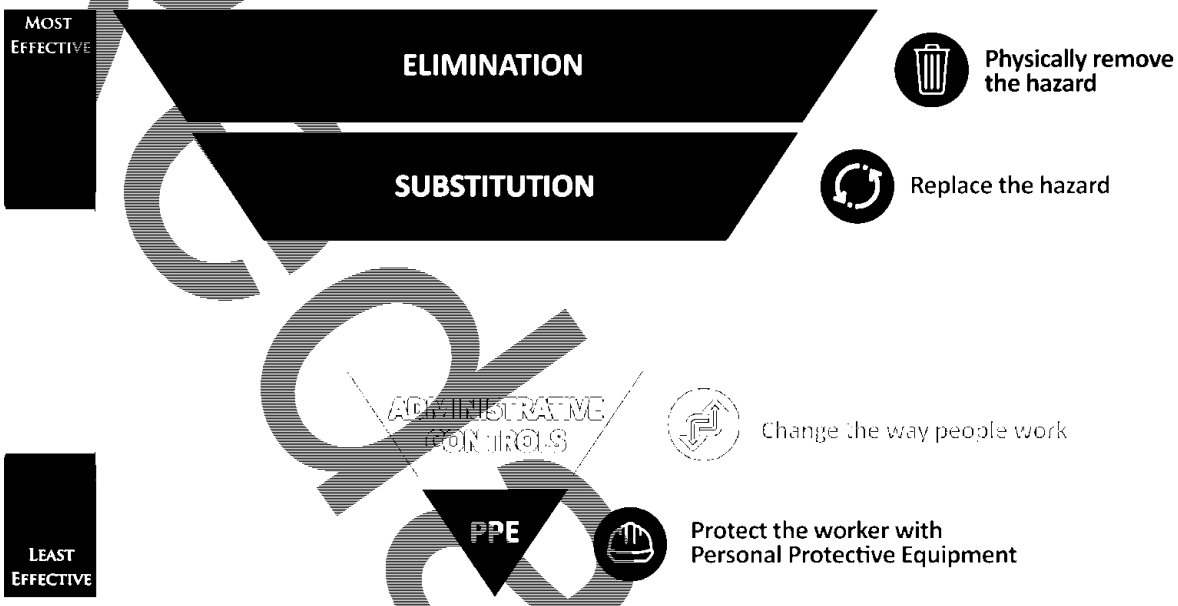
Further information on the principles of good practice for the control of hazardous substances can be found in paragraphs 99–119, and also on HSE's COSHH webpages at http://www.hse.gov.uk/coshh/

Appendix II - Hierarchy of Control

In line with COSHH regulations and the hierarchy of control, workplace exposure should be prevented by avoiding the use of the hazardous substance.

If this cannot be done, exposure should be minimised by modifying the process and/or applying engineering controls, such as enclosure and/or LEV.

Only where adequate control of exposure cannot be achieved by these means alone, should RPE be used in addition to these measures to control the remaining or residual risk.



1. Eliminate. remove a process or substance completely,
2. Substitution. change chemicals and or processes with a less hazardous one,
3. Engineering. provide enclosures, LEV, guarding, ventilation,
4. Administrative procedures, training, information, signage, supervision,
5. PPE. Personal Protective Equipment.

Appendix III: Laboratory Certificates of Analysis

[redacted]

Certificate of Analysis

Report No.: 23-03072-1

Issue No.: 1
Date of Issue 21/03/2023

Customer Details: [redacted]

Customer Contact: [redacted]

Customer Order No: [redacted]

Customer Reference: Not Supplied

Quotation Reference: [redacted]

Description: 7 soil samples

Date Received: 16/03/2023

Date Started: 16/03/2023

Date Completed: 21/03/2023

Test Methods: Details are available on request (refer to MCERTS code against relevant results)

Notes: None

[redacted]

UKAS TESTING

[redacted]

[redacted]

Results Summary

Report No.: 23-03072-1

Customer Reference: Not Supplied

Customer Order No: [redacted]

Customer Sample No	PX 20152	PX 21183	PX 22180	PX 19588	PX 20085	PX 18750	PX 19846
Determinand	**CAS No**	**Codes**	**SOP**	**RL**	**Units**		

[redacted]

Deviating Samples

Report No.: 23-03072-1

Customer Reference: Not Supplied

Customer Order No: [redacted]

RPS No.	Customer No.	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation

[redacted]

Report No.: 23-03072-1

Key Code	Description

Certificate Notes	Description

[redacted]

Certificate of Analysis

Report No.:	**23-04263-1**
Issue No.:	**1**
Date of Issue	**18/04/2023**
Customer Details:	[redacted]
Customer Contact:	[redacted]
Customer Order No.:	[redacted]
Customer Reference:	Not Supplied
Quotation Reference:	Q23-01980
Description:	2 soil samples
Date Received:	27/03/2023
Date Started:	17/04/2023
Date Completed:	17/04/2023
Test Methods:	Details available on request (refer to SOP code against relevant results)
Notes:	None

[redacted]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

[redacted]

[redacted]

Results Summary

Report No : 23-04263-1

Customer Reference : Not Supplied

Customer Order No : [redacted]

Determinand	CAS No	Codes	SDP	RL	Units

[redacted]

Deviating Samples

Report No.. 23-04260-1

Customer Reference: No Supplied

Customer Order No: [redacted]

RPS No	Customer No	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation

[redacted]

Deviating Samples

Report No.: 23-04260-1

Customer Reference: Not Supplied

Customer Project: [redacted]

RPS No	Customer No	Customer ID	Date Sampled	Containers Received	Deviating	Reason for Deviation

[redacted]

CERTIFICATE OF ANALYSIS - Rev. 1

Supplement to MSSL reference: 23-52108

Report date: 12-04-2023

Customer: [redacted]

Customer contact(s): [redacted]

Customer reference:
Customer PO:
Customer sampling date:
Date received: 27-03-2023

Analysis started: 31-03-2023
Analysis complete: 04-04-2023
Containing: Yes

This report shall not be reproduced except in full, without approval of the laboratory.
Results only relate to the samples as received.
Performance is contingent upon accurate information being provided by the customer and customer compliance with the event sample handling and storage conditions prior to receipt at the laboratory.
All opinions and interpretations expressed within the report are outside the scope of accreditation.

Accreditation key:
Y - SC 13525 UKAS M - MCERTS
N - Not Accredited (S) - Sub-contracted

Notes: Supplement issued to include results in pentanol samples 001 and 002.

[redacted]

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Analysis of target anaesthetic(s) from Dräger ORSA-5 badge(s) by GC/MS (solvent desorption)

MSSL sample ref:	23-52108-001	23-52108-002
Customer sample ref:	Drager 1	Control tube
Customer sampling time (min):	540	-

Determinand	Units	LOD	Acc.		
Desflurane	µg	5.0	\	<5.0	<5.0
	mg/m³	Calc.	\	<1.6	-
	ppm	Calc.	\	<0.23	

[redacted]

CERTIFICATE OF ANALYSIS

MSSL reference: 23-51718

Report date: 29-03-2023

Customer [redacted]

[redacted]

Customer reference: -
Customer PO: -
Customer sampling date: -
Date received: 17-03-2023

Analysis started: 22-03-2023
Analysis complete: 23-03-2023
Conforming: Yes

Results only relate to the items tested. Results apply to the samples as received.

Conformance is contingent upon accurate information being provided by the customer and customer compliance with relevant sample handling and storage conditions prior to receipt at the laboratory.

All opinions and interpretations expressed within this report are outside Marchwood's scope of accreditation.

Accreditation Key:

Y : ISO 17025 UKAS M : MCERTS
N : Non Accredited (S) : Subcontracted

Notes:

[redacted]

Analysis of nitrous oxide from molecular sieve thermal desorption sampling tube(s) by TD-GC/MS

MSSL sample ref:	23-51718-001	23-51718-002	23-51718-003
Customer sample ref:	858461 - BCH/DPUsimulated at flow l anaesthetic machine	477542 - BCH simulated personal theatre 5	Control - 858411
Exposure time (min):	240	540	-

Determinand	Units	LOD	Acc.			
Nitrous oxide	µg	0.5	N	**2.8**	<0.5	<0.5
	ppm	Calc.	N	**9.1**	<0.72	-
	ppm	Calc. [1]	N	**4.6**	<0.81	-
	mg/m^3	Calc.	N	**17**	<1.3	-
	mg/m^3	Calc. [2]	N	**8.3**	<1.5	-

[1] Results are expressed as 8 hr TWA ppm

[2] Results are expressed as 8 hr TWA mg/m^3

[redacted]

CERTIFICATE OF ANALYSIS

MSSL reference: 23-51902

Report date: 04-04-2023

Customer: [redacted]

[redacted]

Customer reference: -
Customer PO: -
Customer sampling date: -
Date received: 22-03-2023

Analysis started: 23-03-2023
Analysis complete: 30-03-2023
Conforming: Yes

Results only relate to the items tested. Results apply to the samples as received.

Conformance is contingent upon accurate information being provided by the customer and customer compliance with relevant sample handling and storage conditions prior to receipt at the laboratory.

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Accreditation Key:

Y : ISO 17025 UKAS M : MCERTS
N : Non Accredited (S) : Subcontracted

Notes:

[redacted]

Analysis of nitrous oxide from molecular sieve thermal desorption sampling tube(s) by TD-GC/MS

MSSL sample ref:	23-51902-001	23-51902-002	23-51902-003
Customer sample ref:	BCH 858459 Leak Test	BCH 848456 Leak Test	BCH Control Leak Tests 1123128
Exposure time (min):	7680	8640	-

Determinand	Units	LOD	Acc.			
Nitrous oxide	µg	0.5	N	**0.6**	**0.5**	<0.5
	ppm	Calc.	N	**0.061**	**0.045**	-
	ppm [1]	Calc.	N	**0.98**	**0.81**	-

[1] Results are expressed as 8 hr TWA ppm

[redacted]

CERTIFICATE OF ANALYSIS

MSSL reference: 23-52490

Report date: 19-04-2023

Customer: [redacted]

[redacted]

Customer reference:

Customer PO: -

Customer sampling date:

Date received: 05-04-2023

Analysis started: 11-04-2023

Analysis complete: 12-04-2023

Conforming: Yes

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Results only relate to the items tested. Results apply to the samples as received.

Conformance is contingent upon customer claims on being provided by the customer and customer compliance with relevant sample handling and storage conditions prior to receipt at the laboratory.

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Accreditation Key:

Y - ISO 17025 UKAS M - MCERTS

N - Not Accredited S - Subcontracted

Notes:

[redacted]

[redacted]

[redacted]

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