Derivation of Environmental Assessment Levels for Carbon Capture

Second Update

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CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Mitsubishi Heavy Industries (MHI) are supporting multiple companies in the deployment of Carbon Capture and Storage (CCS) technology in the UK. The Environment Agency (EA) is the statutory regulator for the Environmental Permitting process in England. The EA have stated that as part of the Permitting process, the Air Quality Impact Assessment (AQIA) undertaken in support of the Permit application must assess the potential impacts of all emissions from the CCS plant.

MHI CCS technology uses an amine-based solvent to preferentially strip CO_2 from the exhaust gases. The remaining exhaust gases are then released to atmosphere along with chemicals entrained from the solvent. The amine solvent contains chemicals that are reactive. These form degradation products through reactions with trace pollutants in the exhaust gases, notably nitrogen dioxide and nitric oxide, and further react once released into the atmosphere. The EA require that both the entrained and degradation chemicals are identified, and the potential impacts assessed within the AQIA.

In order to undertake the AQIA the emissions must be modelled using dispersion modelling. The results of the modelling are then compared to Environmental Assessment Levels (EALs), these being the maximum concentrations of a chemical in ambient air at which harm is negligible. However, the EA have published a limited suite of chemicals, and many do not have published EALs. The EA have instructed industry to derive EALs for these chemicals and provide a justification for their use.

MHI reviewed the list of chemicals and focused on the 26 that were identified as being emitted during trials at the Technology Centre Mongstad. Of note is that the nitramines and nitrosamines are grouped and compared to a common EAL, and therefore do not require separate EALs. Therefore, there are fifteen amines that require EALs, noting that the three amino acids do not require EALs as explained later. MHI followed the EA guidance and a position paper provided by the Carbon Capture and Storage Association (CCSA), on how to derive EALs, and the hierarchy of information. Following this methodology MHI derived EALs for the chemicals of interest as summarised below. MHI also provided a data pedigree to indicate the robustness of the EAL and therefore the potential risk of the EAL changing.

TABLE 1.1 DERIVED EALs

Chemical	1 hour EAL	24 hour EAL	Annual Mean EAL	Pedigree
	µg/m^3			
Round 1				
Methylamine	1900		15	B
Ethylamine	2800		22	B
Dimethylamine	2800		22	B
Diethylamine	4500		36	B
Monoethanolamine	400	100		A
Diethanolamine	3000		3	B
N,N-Dimethylethylenediamine	417	104		D
Ammonia	2500		180	A
N-Nitrosodimethylamine (sum total N-amines)			0.0002	A
Formaldehyde	100		5	A
Acetaldehyde	9200		370	A
Round 2				
N-(2-hydroxyethyl)acetamide			0.085	D
N-(2-hydroxyethyl)formamide			86	D
Round 3				
Ethylmethylamine	3640		28.6	D
Ethylethanolamine	300		50	C
Ethyl diethanolamine			440	D
Piperazine	49.5		16.5	C

1. INTRODUCTION

Mitsubishi Heavy Industries (MHI) Carbon Capture and Storage (CCS) system utilises amine-based solvent to preferentially strip CO_2 from exhaust gases. This process results in the emission to atmosphere of a multiple chemicals both directly entrained and due to degradation in the solvent and subsequent atmospheric reactions.

The Environment Agency (EA) require that the potential impacts of these chemicals is assessed in the Air Quality Impact Assessment (AQIA) that is required as part of the Permit application. A key element of the AQIA are the Environmental Assessment Levels (EALs), these being the maximum concentrations in ambient air at which potential harm to humans is negligible.

The suite of EALs published by the EA is limited, and many of the chemicals that are released from MHI's CCS process do not have EALs. MHI therefore engaged to derive EALs for MHI's CCS process. This report sets out the derived EALs, provides methodology for the derivation and a 'pedigree' to provide an indication of certainty in the derived EAL.

2. BACKGROUND

2.1 OVERVIEW

MHI CCS technology uses an amine-based solvent to preferentially strip CO_2 from the exhaust gases. The remaining exhaust gases are then released to atmosphere with trace amounts of entrained chemicals from the amine solvent. The amine solvent contains chemicals that are reactive. These form degradation products through reactions with trace pollutants in the exhaust gases, notably nitrogen dioxide and nitric oxide, and further react once released into the atmosphere. The EA require that both the entrained and degradation chemicals are identified, quantified and the potential impacts assessed within the AQIA.

In order to undertake the AQIA the emissions must be modelled using dispersion modelling. The results of the modelling are then compared to EALs. However, the suite of EALs is limited. Whilst the EA are deriving EALs for seven of the most common chemicals used in amine solvents, there are several additional chemicals which are emitted from the MHI process for which EALs are not published. The EA have instructed industry to derive EALs for these chemicals and provide a justification for their use.

2.2 CCSA POSITION PAPER

The Carbon Capture and Storage Association (CCSA), in conjunction with a range of industry members and UK regulators have produced a position statement on the hierarchy for deriving EALs [1].

1. Use of EALs published by the Environment Agency, SEPA, NRW or NIEA;
2. Use of an EAL published by recognised international agency, including USEPA, Agency for Toxic Substances and Disease Registry (ATSDR), World Health Organisation, International Agency for Research on Cancer, other national environmental agencies;
3. Using an EAL derived from published occupational health data (ie EH40, MSDSs, scientific literature etc.) using the Environment Agency 2012 derivation methodology;
4. Use of an EAL derived from primary collected toxicology data provided by a carbon capture technology licensor;
5. Read across of toxicology data from appropriate surrogate species based on and health end points;
6. Use of appropriate surrogate species based on chemical structure similarities and properties

[1] CCSA (Sept 2023) Environmental Assessment Levels and Disclosure of Amine Species - CCSA position paper

The CCSA hierarchy has been followed when deriving the EALs, and a 'data pedigree' assigned. This has been done to provide MHI with an understanding of the strength of the derived EAL and the risk of the EAL changing in the future, which could impact on the ability of project to be Permitted.

2.3 READ ACROSS METHOD

Where there are no EALs and no occupational exposure limits or standards, the 'read across' method is used based on a comparison (or read across) of the base toxicology data.

This method uses the principle of 'read across'. This is where a chemical without an EAL is compared to one that does have an EAL by means of referring back to the underlying toxicology profile for the chemical of interest. The following are noted on the 'read across' method:

- Requires the toxicology effect to be similar, for example acute irritation
- Requires the toxicology data to be similar, for example based on exposure in rats through the same pathway to allow like for like comparison
- Requires data to be comparable, LD50 or No Observable Acute Exposure Limit (NOAEL)

The EA have published an EAL for monoethanolamine, and this was used as the basis of the read across. Review of Material Safety Data Sheets for monoethanolamine and the chemical of interest is undertaken. Where the three criteria above are met, the toxicology data is considered appropriate for the read across method.

In the case of absence of any toxicological data for the chemical of interest the OECD Toolbox was used to generate profiles for key toxicological effects: mutagenicity, carcinogenicity, reproductive toxicity, and irritation/corrosion. Where the profiles thus generated and structures were deemed similar it was considered appropriate to read-across.

2.4 MHI DERIVATION OF RELEASED CHEMICALS

The following steps were undertaken to derive a list of chemicals for which EALs are required:

- MHI calculated all of the possible entrained and degradation chemicals that could be released. This resulted in a list of several hundred chemicals.
- MHI undertook testing of the amine solvent at Technology Centre Mongstad (TCM). During these tests measurements of emitted chemicals were undertaken to identify which chemicals are actually present in potentially detectable quantities and quantify these.

- MHI reviewed the list and noted that of the 26 chemicals identified, eight are Nitrosamines*1) and two are Nitramines*2). EA guidance states that in the case of nitramines and nitrosamines (N-amines) these should be summed and compared to the EAs EAL for Nitrosodimethylamine (NDMA). This negates the need for separate EALs for all of the N-amine species to be derived.

*1) N-Nitrosodimethylamine, N-Nitrosodiethylamine, N-Nitrosomethylethylamine, N-nitrosodiethanolamine, N-Ethyl-N-(2-hydroxyethyl)nitrosamine, 1-nitrosopiperazine, 1,4-dinitrosopiperazine, N-Nitrosomorpholine
*2) 2-(ethylnitroamino)ethanol, 1-nitropiperazine

This process produced a final list of chemicals. Deriving EALs for those chemicals that are actually detected is considered to be pragmatic in order to keep the list to a sensible length, and noting that many of the chemicals that could theoretically be produced will not be present.

3. SUMMARY OF DERIVED EALs

The EALs derived are summarised in Table 3.1. The method used for derivation of each EAL is then detailed in Section 4. Note that the EALs differ in averaging period depending on whether risk is acute, chronic or both.

TABLE 3.1 DERIVED EALs

Chemical	1 hour EAL	24 hour EAL	Annual Mean EAL	Pedigree
	µg/m^3			
Round 1				
Methylamine	1900		15	B
Ethylamine	2800		22	B
Dimethylamine	2800		22	B
Diethylamine	4500		36	B
Monoethanolamine	400	100		A
Diethanolamine	3000		3	B
N,N-Dimethylethylenediamine	417	104		D
Ammonia	2500		180	A
N-Nitrosodimethylamine (sum total N-amines)			0.0002	A
Formaldehyde	100		5	A
Acetaldehyde	9200		370	A
Round 2				
N-(2-hydroxyethyl)acetamide			0.085	D
N-(2-hydroxyethyl)formamide			86	D
Round 3				
Ethylmethylamine	3640		28.6	D
Ethylethanolamine	300		50	C
Ethyl diethanolamine			440	D
Piperazine	49.5		16.5	C

4. DETAILED DERIVATION OF EALs: OVERVIEW

The detailed derivation of the EALs in Table 3.1 are set out in this section. For some EALs the derivation is very straightforward as the EAL is directly published in a peer reviewed resource. For others there is a requirement to apply a derivation method to calculate the EAL. For completeness, the method, data source and derived EALs are set out for each chemical.

Following the CCSA position paper hierarchy, the following sources were consulted when deriving the EALs in order of preference and pedigree:

- Pedigree A: EA EALs
    - Environment Agency for England: Air emissions risk assessment for your environmental permit[2]
- Pedigree B: EALs from other international bodies
    - United States Environmental Protection Agency (USEPA) Chronic Dose-Response Values[3]
    - USEPA Acute Dose-Response Values[4]
    - Agency for Toxic Substances and Disease Registry (ATSDR) Toxic Substances Portal[5]
    - New York State DAR-1 Guidelines for the Evaluation and Control of Ambient Air Contaminants[6]
- Pedigree C: EALs derived from Occupational Health Standards
    - DNEL values derived from REACH [7]

[2] Environment Agency for England (Accessed December 2023) Air emissions risk assessment for your environmental permit https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
[3] USEPA (accessed December 2023) Prioritized Chronic Dose-Response Values https://www.epa.gov/system/files/documents/2021-09/chronicfinaloutput_9_29_2021-12-46-18-pm_0.pdf
[4] USEPA (Accessed December 2023) Acute Dose-Response Values for Screening Risk Assessments table2.pdf (epa.gov)
[5] Agency for Toxic Substances and Disease Registry (Accessed December 2023) Toxic Substances Portal https://wwwn.cdc.gov/TSP/index.aspx
[6] New York State DAR-1 Guidelines for the Evaluation and Control of Ambient Air Contaminants (accessed December 2023) https://extapps.dec.ny.gov/docs/air_pdf/dar1.pdf
[7] European Chemicals Agency (accessed May 2024) Search for REACH registrations https://echa.europa.eu/mt/information-on-chemicals

    - United Kingdom Health and Safety Executive EH40 Workplace Exposure Limits[8]
    - Occupational Safety and Health Administration: Permissible Exposure Limits – Annotated Tables[9]
- Pedigree D: EALs derived from toxicology data
    - Where used, specific sources are indicated

In the case of the EALs that have a pedigree of 'D' these values are highly uncertain. There are no derived EALs and instead these are based on limited toxicology data, in this case the LD50 (rat) or read-across. This is a crude metric for understanding the potential impacts and further work is recommended to strengthen these EALs.

[8] United Kingdom Health and Safety Executive (accessed December 2023) EH40 Workplace Exposure Limits https://www.hse.gov.uk/pubns/priced/eh40.pdf
[9] Occupational Safety and Health Administration (Accessed December 2023) Permissible Exposure Limits – Annotated Tables https://www.osha.gov/annotated-pels/table-z-1

5. DETAILED DERIVATION OF EALs: PHASE 1

5.1 METHYLAMINE

The review for Methylamine identified:

TABLE 5.1 METHYLAMINE: PEDIGREE B

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	Yes
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The New York DAR guideline values for Methylamine are:

1 hour 1900µg/m^3

Annual mean 15µg/m^3

As these are public health based limits, these can be used directly and no further derivation is needed.

5.2 ETHYLAMINE

The review for Ethylamine identified:

TABLE 5.2 ETHYLAMINE: PEDIGREE B

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	Yes
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The New York DAR guideline values for Ethylamine are:

1 hour 2800µg/m^3

Annual mean 22µg/m^3

As these are public health based limits, these can be used directly and no further derivation is needed.

5.3 DIMETHYLAMINE

The review for Dimethylamine identified:

TABLE 5.3 DIMETHYLAMINE: PEDIGREE B

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	Yes
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The New York DAR guideline values for Dimethylamine are:

1 hour 2800µg/m^3

Annual mean 22µg/m^3

As these are public health based limits, these can be used directly and no further derivation is needed.

5.4 DIETHYLAMINE

The review for Diethylamine identified:

TABLE 5.4 DIETHYLAMINE: PEDIGREE B

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	Yes
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The New York DAR guideline values for Diethylamine are:

1 hour 4500µg/m^3

Annual mean 36µg/m^3

As these are public health based limits, these can be used directly and no further derivation is needed.

5.5 MONOETHANOLAMINE

The review for Monoethanolamine identified:

TABLE 5.5 MONOETHANOLAMINE: PEDIGREE A

Data Source	Data available
EA EAL	Yes
USEPA Chronic Dose-Response Values	No review required
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The EA EAL guideline values for Monoethanolamine are:

1 hour 400µg/m^3

24 hour mean 100µg/m^3

As these EA EALs, these can be used directly and no further derivation is needed.

5.6 DIETHANOLAMINE

The review for Diethanolamine identified:

TABLE 5.6 DIETHANOLAMINE: PEDIGREE B

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	Yes
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The USEPA dose-response values for Diethanolamine are:

1 hour 3000µg/m^3

Annual mean 3µg/m^3

As these are public health based limits, these can be used directly and no further derivation is needed.

5.7 N,N-DIMETHYLETHYLENEDIAMINE

The review for N,N-Dimethylethylenediamine identified:

TABLE 5.7 N,N-DIMETHYLETHYLENEDIAMINE: PEDIGREE D

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data	Yes

As there are no EALs for N,N-Dimethylethylenediamine and no occupational standards EALs are derived using the read across method detailed in Section 2.3.

Review of Material Safety Data Sheets for monoethanolamine and N,N-dimethylethylenediamine identified that:

- The toxic effect is the same, this being acute irritation
- Both have an LD50 for oral exposure of rats
- There are no toxicology outcomes present for N,N-dimethylethylenediamine that are not present for monoethanolamine (mutagenic, carcinogenic or teratogenic effects)

As such, the read across method was deemed appropriate as a comparison of monoethanolamine to N,N-dimethylethylenediamine. The method was applied as follows:

- EALs for monoethanolamine:
  - 1 hour 400µg/m^3
  - 24 hour 100µg/m^3
- LD50 rat, oral monoethanolamine: 1089mg/kg
- LD50 rat, oral N,N-dimethylethylenediamine: 1135mg/kg
- Derived conversion factor: 1.04
- Derived EALs for N,N-dimethylethylenediamine
  - 1 hour 417µg/m^3
  - 24 hour 104µg/m^3

5.8 AMMONIA

The review for Ammonia identified:

TABLE 5.8 AMMONIA: PEDIGREE A

Data Source	Data available
EA EAL	Yes
USEPA Chronic Dose-Response Values	No review required
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The EA EAL guideline values for Ammonia are:

1 hour 2500µg/m^3

24 hour mean 180µg/m^3

As these EA EALs, these can be used directly and no further derivation is needed.

5.9 N-NITROSODIMETHYLAMINE

The review for N-Nitrosodimethylamine identified:

TABLE 5.9 N-NITROSODIMETHYLAMINE: PEDIGREE A

Data Source	Data available
EA EAL	Yes
USEPA Chronic Dose-Response Values	No review required
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The EA EAL guideline values for N-Nitrosodimethylamine are:

Annual mean 0.0002µg/m^3

As these EA EALs, these can be used directly and no further derivation is needed.

5.10 FORMALDEHYDE

The review for Formaldehyde identified:

TABLE 5.10 FORMALDEHYDE: PEDIGREE A

Data Source	Data available
EA EAL	Yes
USEPA Chronic Dose-Response Values	No review required
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The EA EAL guideline values for Formaldehyde are:

1 hour mean 100µg/m^3

Annual mean 5µg/m^3

As these EA EALs, these can be used directly and no further derivation is needed.

5.11 ACETALDEHYDE

The review for Acetaldehyde identified:

TABLE 5.11 ACETALDEHYDE: PEDIGREE A

Data Source	Data available
EA EAL	Yes
USEPA Chronic Dose-Response Values	No review required
USEPA Acute Dose-Response Values	No review required
ATSDR	No review required
New York DAR-1 Guidelines	No review required
EH40	No review required
OSHA Exposure Limits	No review required
Toxicology data	No review required

The EA EAL guideline values for Acetaldehyde are:

1 hour mean 9200µg/m^3

Annual mean 370µg/m^3

As these EA EALs, these can be used directly and no further derivation is needed.

6. DETAILED DERIVATION OF EALs: PHASE 2

Additional EALs have also been derived for the following substances:

- N-(2-hydroxyethyl)acetamide: Read-across
- N-(2-hydroxyethyl)formamide: Read-across
- Ethylmethylamine Read-across
- Ethyl ethanolamine REACH DNEL
- Ethyl diethanolamine Read-across
- Piperazine REACH DNEL

6.1 N-(2-HYDROXYETHYL)ACETAMIDE

The review for N-(2-hydroxyethyl)acetamide identified:

TABLE 6.1 N-(2-HYDROXYETHYL)ACETAMIDE: PEDIGREE D

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data	Yes

As there are no EALs for N-(2-hydroxyethyl)acetamide and no occupational standards, EALs are derived using read-across to acetamide using the OECD Toolbox profile to assess toxicological reactivity.

OECD Toolbox profiles are similar. A DART profiler present for acetamide is not present for N-(2-hydroxyethyl)acetamide therefore read-across to acetamide is considered a worst case scenario. N-(2-hydroxyethyl)acetamide gives a negative result in the reverse bacterial mutation assay and an oral LD50 of 22880 mg/kg bw in mouse is noted.

Both structures have a similar molecular weight and are acetamides.

- New York DAR guideline value for acetamide is:
  - Annual mean 0.05 µg/m^3
- Molecular weight acetamide: 59
- Molecular weight N-(2-hydroxyethyl)acetamide: 103
- Conversion factor: 1.7
- Converted DAR for N-(2-hydroxyethyl)acetamide
  - Annual mean 0.085 µg/m^3

6.2 N-(2-HYDROXYETHYL)FORMAMIDE

The review for N-(2-hydroxyethyl)formamide identified:

TABLE 6.2 N-(2-HYDROXYETHYL)FORMAMIDE: PEDIGREE D

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data	Yes

As there are no EALs for N-(2-hydroxyethyl)formamide and no occupational standards, EALs are derived using read-across to formamide using the OECD Toolbox profile to assess toxicological reactivity.

The OECD Toolbox profiles were similar. A DART profiler for formamide is not present for N-(2-hydroxyethyl)formamide therefore read-across to acetamide is considered a worst case scenario. Both structures have a similar molecular weight and are formamides.

- New York DAR guideline value for formamide is:
  - Long term 43 µg/m^3
- Molecular weight formamide: 45
- Molecular weight N-(2-hydroxyethyl)formamide: 89
- Conversion factor: 2
- Converted DAR for N-(2-hydroxyethyl)formamide
  - Annual mean 86 µg/m^3

6.3 ETHYLMETHYLAMINE

The review for Ethylmethylamine identified:

TABLE 6.3 ETHYLMETHYLAMINE: PEDIGREE D

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data	Yes

As there are no EALs for ethylmethylamine and no occupational standards, EALs are derived using read-across to dimethylamine using the OECD Toolbox profile to assess toxicological reactivity.

The OECD Toolbox profiles were similar for both chemicals. Both structures are secondary amines and have a similar molecular weight. It is noted that read-across to diethylamine could also be similarly justified but dimethylamine was chosen as the worst-case scenario as it has a slightly lower New York DAR guideline value.

- The New York DAR guideline values for Dimethylamine are:
  - 1 hour 2800µg/m^3
  - Annual mean 22µg/m^3
- Molecular weight dimethylamine: 45
- Molecular weight ethylmethylamine: 59
- Conversion factor: 1.3
- Converted DAR for ethylmethylamine
  - 1 hour 3640µg/m^3
  - Annual mean 28.6µg/m^3

6.4 ETHYL ETHANOLAMINE

The review for Ethyl ethanolamine identified:

TABLE 6.4 ETHYL ETHANOLAMINE: PEDIGREE C

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data (REACH DNEL)	Yes

The published REACH DNELs for ethyl ethanolamine are:

Long term 50µg/m^3

Short term 300µg/m^3

As these are public health based limits, they can be used directly and no further derivation is needed.

6.5 ETHYL DIETHANOLAMINE

The review for Ethyl ethanolamine identified:

TABLE 6.5 ETHYL DIETHANOLAMINE: PEDIGREE D

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data	Yes

As there are no EALs for ethyl diethanolamine and no occupational standards, EALs are derived using read-across to methyl diethanolamine using the OECD Toolbox profile to assess toxicological reactivity.

The OECD Toolbox profiles were similar for both chemicals. Both structures are tertiary amines and have a similar molecular weight.

The REACH DNEL for methyl diethanolamine is:

Long term 400µg/m^3

- Molecular weight methyl diethanolamine: 119
- Molecular weight ethyl diethanolamine: 133
- Conversion factor: 1.1
- Converted DNEL for ethyl diethanolamine
    - Long term 440µg/m^3

As this is a public health based limit, it can be used directly and no further derivation is needed.

6.6 PIPERAZINE

The review for Piperazine identified:

TABLE 6.6 PIPERAZINE: PEDIGREE C

Data Source	Data available
EA EAL	No
USEPA Chronic Dose-Response Values	No
USEPA Acute Dose-Response Values	No
ATSDR	No
New York DAR-1 Guidelines	No
EH40	No
OSHA Exposure Limits	No
Toxicology data (REACH DNEL)	Yes

The published REACH DNELs for piperazine are for worker exposure:

Long term 100µg/m^3

Short term 300µg/m^3

DNELs based on worker exposure group are applicable to general population exposure when corrected with an intra-species assessment factor of 0.5 and by a factor of 0.33 to account for the difference in breathing rate[12].

The corrected REACH DNELs for piperazine suitable for the general population are:

Long term 16.5µg/m^3

Short term 49.5µg/m^3

As these are public health based limits, they can be used directly and no further derivation is needed.

[12] ECHA Practical guide 14: How to prepare toxicological summaries in IUCLID and how to derive DNELs Version 1. ECHA-12-B15-EN