F & R Cawley Limited

Part B2 – Section 6 (ii)
Environmental Risk Assessment - Air

Introduction

An active air extraction system has been installed within the workshop and has been tested and certified as compliant with the relevant Directives. The extraction system has a carbon filter to minimise the presence of fine particles. Air is positively extracted to a small exhaust stack - Local Exhaust Vent (LEV). Shredding can only take place when the LEV extraction system is operational.

F&R Cawley appointed SOCOTEC to undertake stack emissions monitoring to determine the release of pollutants from the vapour emitted from the LEV during the lithium battery shredding process. The LEV is referred to as Stack 1 in this assessment.

The pollutants to be monitored were prescribed by SOCOTEC based on their understanding of the process and the constituents contained within the batteries. This information was supported by the results of the chemical testing of the black mass to assess its hazardous properties for waste classification purposes and a Hazardous Substances Monitoring Report to assess the risk to operatives working with the shredder.

Lithium batteries typically comprise the following substances:

- Lithium
- Iron
- Phosphate
- Copper
- Aluminium
- Nickel
- Manganese
- Cobalt
- Carbon (as graphite)
- Electrolytes (ethylene carbonate, dimethyl carbonate, ethyl methyl carbonate, propylene carbonate and diethyl carbonate)

The testing scheduled by SOCOTEC included the above determinands together with heavy metals (sum) and rubber fume.

The monitoring was undertaken by technicians from SOCOTEC on 28 and 29 September 2023 and again on 16 May 2024. The vapours from the battery shredding process are odourless and do not have any visible plume from the stack. The monitoring was undertaken for a period of 60 minutes, whilst the shredding plant was operational, except for heavy metals which were sampled for 120 minutes.

Environmental Assessment

A screening assessment has been carried out for the emissions from the battery shredding operations using the Environment Agency's guidance 'Air Emissions Risk Assessment for your Environmental Permit'[1] and the associated H1 Risk Assessment Tool.

Assessment Parameters

The parameters and assumptions used in the H1 risk assessment tool are summarised in Table 1 below together with the source of the data.

Item	Input Values	Data Source / Justification
Location of Stack 1	TL 06859 22997	National Grid Reference Finder
Stack Height	7.5m	On site measurement
Height of tallest building within 5m	5m	On site Measurement
Effective height of stack	0m	Stack height less than 3m higher than adjacent building
Stack Diameter	0.4m	SOCOTEC Stack Emissions Monitoring Report
Stack Area	0.13m^2	SOCOTEC Stack Emissions Monitoring Report
Total Flow	11,154m^3/hr	SOCOTEC Stack Emissions Monitoring Report
Efflux Velocity	26.3m/s	SOCOTEC Stack Emissions Monitoring Report
Average Stack Gas Temperature	20ºC	SOCOTEC Stack Emissions Monitoring Report
Operational Hours	2 hours per day	Battery shredder operates a maximum of 2hrs per day
Operating Mode	8%	Assumes site is operational 260 working days of the year (6,240hrs) with the battery shredder operating for 520hrs

Air Emission Concentrations

The results of the stack emissions reported by SOCOTEC are summarised below in Table 2. The results for the heavy metals represent the solid and vapour phases combined but it should be noted that the greatest proportion of the concentrations generally lie within the vapour phase. The full results from SOCOTEC are appended.

Determinand	Limit of Detection	Recorded Concentration (mg/m^3)	
Heavy Metals		**Test 1**	**Test 2**
Iron	0.02751mg/m^3	0.57418	1.0201
Aluminium	0.01834mg/m^3	0.15332	0.1743
Phosphorus	0.00917mg/m^3	7.43789	22.1633
Cobalt	0.00023mg/m^3	0.00032	0.0067
Copper	0.00142mg/m^3	0.00700	0.0014

[1] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

Determinand	Limit of Detection	Recorded Concentration (mg/m³)	
Lithium	0.00917mg/m³	0.01493	0.01325
Manganese	0.00114mg/m³	0.00125	0.00027
Nickel	0.00222mg/m³	0.00288	0.00105
Total Heavy Metals	0.06921mg/m³	8.19177	11.68684
VOC Screen			
Dimethyl carbonate		2.52	23.25
Ethylene carbonate		2.19	386.76
Ethyl methyl carbonate		241.87	1.98
Propylene carbonate		2.19	1.98
Diethyl carbonate		154.32	1.98
Sum of VOC screen	5.47mg/m³	403.09	415.94
Particulates			
Elemental Carbon	0mg/m³	0.0021	
Rubber Fume	0mg/m³	0.13	
Total Particulate Matter	0.32mg/m³	0.47	

Screening Assessment

Assessment Criteria

The Environment Agency uses Environmental Assessment Levels (EALs) to assess the acceptability of proposed emissions to air and their relative contribution to the environment from permitted facilities. EALs represent a concentration in ambient air at which no significant risk to public health is expected.

In March 2023, the Environment Agency released revised Environmental Assessment Levels (EALs), which are used within the H1 Risk Assessment Tool. However, there are only three published EALs for the determinands under assessment for lithium battery recycling, namely copper, manganese and nickel.

For those determinands without an EAL that are compounds or have the potential to form a compound once released to the atmosphere, the most appropriate EAL has been selected. The determinands where a substitution has been made are detailed in the following bullet points:

- Total Particulate Matter (TPM) has been assessed as Particulates (PM10).
- Rubber fume may comprise straight chain and cyclic aliphatic and/or aromatic hydrocarbons[2]. Therefore, benzene has been substituted to represent rubber fume as the worst case scenario.
- Phosphorus vapour when released to the atmosphere will rapidly react with oxygen and form phosphorus oxide and then phosphorus acid, which are both less toxic when compared to phosphorus in its elemental state. Phosphorus oxides are highly soluble and are quickly removed from the

[2] Rubber fumes and dusts SCOEL/OPIN/2016-402 Opinion from the Scientific Committee on Occupational Exposure Limits. Adopted September 2016. Publications Office of the European Union, 2016.

atmosphere. However, the particulate fraction of phosphorus may be protected with an oxide layer that prevents oxidation and extends its lifetime in the air[3]. The concentrations of phosphorus in the particulate and vapour phases recorded on site were 0.00342mg/m^3 and 7.43446 mg/m^3 in September 2023 and 0.0000172mg/m^3 and 22.163 mg/m^3 in May 2024, respectively. The particulate concentration has been used in this assessment and assessed against the compound phosphine. Phosphine is a highly toxic gas and this is considered to be a very conservative assessment.

- The VOC testing indicates the largest proportions to comprise ethylene carbonate and diethyl carbonate. Ethylene carbonate is a cyclic carbonate ether of ethylene glycol and carbonic acid with the formula $(CH_2O)_2CO$. Diethyl carbonate is an ester of carbonic acid and ethanol and has the formula $OC(OCH_2CH_3)_2$. These have been substituted for the compound diethylketone (3-pentanone) with the formula $C_5H_{10}O_3$.

A summary of the relevant EALs is provided below.

Determinand	Averaging Time	Environmental Assessment Level (EAL) µg/m^3
Copper	24 hour mean (long term)	0.05
Manganese	1 hour mean	1,500
Manganese	Annual mean	0.15
Nickel	1 hour mean	0.7
Particulates (PM10) (for TPM)	24 hour mean	50
Benzene (for Rubber Fume)	24 hour mean	30
Phosphine (for Phosphorus – particulates)	1 hour mean	42
Diethylketone	Annual mean	89,500

Lithium, cobalt, aluminium and iron are not identified as priority air pollutants and no EALs exist for these determinands. Furthermore, there are no other relevant compounds related to lithium, cobalt, aluminium or iron with a published EAL. Therefore, for these metals alternative risk assessment has been completed and is discussed in the following section.

There is no EAL for elemental carbon, however, there is an EU 8 hour exposure limit for diesel engine exhausts which is set at 0.05mg/m^3. The reported results from the LEV are significantly below this. Furthermore, elemental carbon will form part of the particulate matter, with past studies indicating PM10 to be formed by approximately 20% to 25% organic / elemental carbon in urban areas[4]. Therefore, a separate assessment of elemental carbon has not been undertaken.

Furthermore, the Air Quality Standards Regulations 2010 and UK Air Quality Strategy Objectives apply specific 'Limit Values' and 'UK AQS Objectives', respectively, for a number of determinands that pose a risk to air quality.

[3] Toxicological profile for White Phosphorous (1997). Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, GA, U.S.

[4] Interpretation of Particulate Elemental and Organic Carbon Concentrations at Rural, Urban and Kerbside Site, A.M. Jones and R.M Harrison, University of Birmingham funded by DEFRA.

The following annual limits are considered relevant to the battery recycling facility and will also need to be complied with.

Determinand	Averaging Time	Concentration	Environmental Standard	Allowed Exceedance (per year)
Benzene (substituted for rubber fume)	Annual mean	5µg/m^3	Limit Value	None
Particulates (PM10)	24 hr mean	50µg/m^3	Limit Value	Up to 35 times per year
Particulates (PM10)	Annual mean	40µg/m^3	Limit Value	None
Nickel	Annual mean	20ng/m^3	Target Value	None

Background Concentrations

Local air quality has also been considered as part of this assessment with background concentrations added to the H1 Risk Assessment Tool (where applicable). DEFRA UK Air Information Resource data has been used to estimate the baseline background concentrations for heavy metals, specifically copper. No specific data is available for the immediate site surroundings, with an annual mean background concentration being estimated for 2023 from urban London sites where copper emissions are recorded. A value of 29ng/m^3 has been utilised, which is below the EAL.

Test 1 Assessment

The results of the first stage of assessment are presented below. For copper, the Long Term Process Contribution (PC) exceeds 1% of the long term EAL. All other determinands pass the long and short term thresholds and no further assessment is required for these determinands.

Determinand	Long Term EAL (ug/m^3)	Long term PC (ug/m^3)	Long Term %PC of EAL (>1% = fail)	Short Term EAL (ug/m^3)	Short Term PC (ug/m^3)	Short Term %PC of EAL (>10% = fail)
Copper	0.05	0.0032	**6.42%**	0	0.0845	
Manganese	0.15	4.58 x 10^{-05}	0.03%	1500	0.0151	0%
Nickel	0.02	0.0001	0.53%	0.7	0.0346	4.97%
Particulates	40	0.0172	0.04%	50	3.3508	6.7%
Benzene (substituting rubber fume)	5	0.0048	0.10%	30	0.9268	3.09%
Phosphine (substituting phosphorus particulates)	0	0.0001		42	0.0413	0.1%
Diethylketone	7,160	8.8776	0.12%	89500	2924.21	3.27%

* Exceedances are shown in **Bold**

Test 2 Assessment

The results of the second stage assessment for copper have calculated the Predicted Environmental Concentration (PEC) for copper utilising the PC and background concentration. The long term PEC is less than 70% and is considered acceptable and no further assessment is required.

Determinand	Background Concentration (ug/m^3)	PEC Long Term (ug/m^3)	Long Term %PEC of EAL% (>70% = fail)
Copper	0.029	0.03	64.42%

Alternative Assessment for Determinands

Prior to the introduction of EALs, assessment used to be undertaken utilising Health and Safety Executive (HSE) Occupational Exposure Limits (OELs). The number of determinands with an EAL is significantly reduced compared to the OELs and the Environment Agency states that other sources of information may also be required to assess the potential risks from some determinands. For Lithium, cobalt, aluminium and iron, an OEL is available and an initial assessment has been undertaken with these assessment criteria.

- **Lithium -** when lithium vapour and particulates are released to the atmosphere, at room temperature, they will form lithium hydroxide due to the moisture in the air. Lithium hydroxide will strongly absorb to carbon dioxide in air forming lithium carbonate. A review of lithium hydroxide human health assessments by Accelerated Assessment of Industrial Chemicals Australia indicates that exposure to lithium via vapours is not expected to be toxicologically relevant due to the negligible low vapour pressure[5]. A review of human health assessment criteria for lithium and its compounds has been undertaken. The Health and Safety Executive (HSE) has published short term occupational exposure limits (15 min) for lithium hydride and lithium hydroxide, 0.02mg/m^3 and 1mg/m^3, respectively. Comparison of the reported results indicates the stack emissions to be significantly below these exposure limits. No long term exposure limits have been identified.
- **Cobalt -** when cobalt particulates and vapour are released into the air it will be relatively unreactive. Occupational exposure studies have been undertaken and dermal contact and inhalation are valid exposure pathways. Oxides would only be formed at high temperatures. The HSE has published long term occupational exposure limits (8 hour) for cobalt and its compounds: 0.1mg/m^3. Comparison of the reported results indicates the stack emissions to be significantly below this exposure limit. No short term exposure limit has been identified.
- **Aluminium –** aluminium is highly reactive with air forming oxides that are then relatively stable. The HSE has published long term occupational exposure limits (8 hour) for aluminium metals and oxides (inhalable dust): 10mg/m^3. Comparison of the reported results indicates the stack emissions to be significantly below this exposure limit. No short term exposure limit has been identified.
- **Iron –** iron will also form an oxide when exposed to air. The HSE has published short and long term occupational exposure limits (8 hour) for iron salts and iron oxide fume. These exposure limits are summarised below.

[5] Lithium Hydroxide: Human Health Tier II Assessment (February 2015) IMAP Group Assessment Report,

Determinand	Long Term Exposure Limit	Short Term Exposure Limit
Iron Salt (as Fe)	1	2
Iron Oxide Fume (as Fe)	5	10

Comparison of the reported results for iron indicates the stack emissions to be at or below both the short and long term exposure limits.

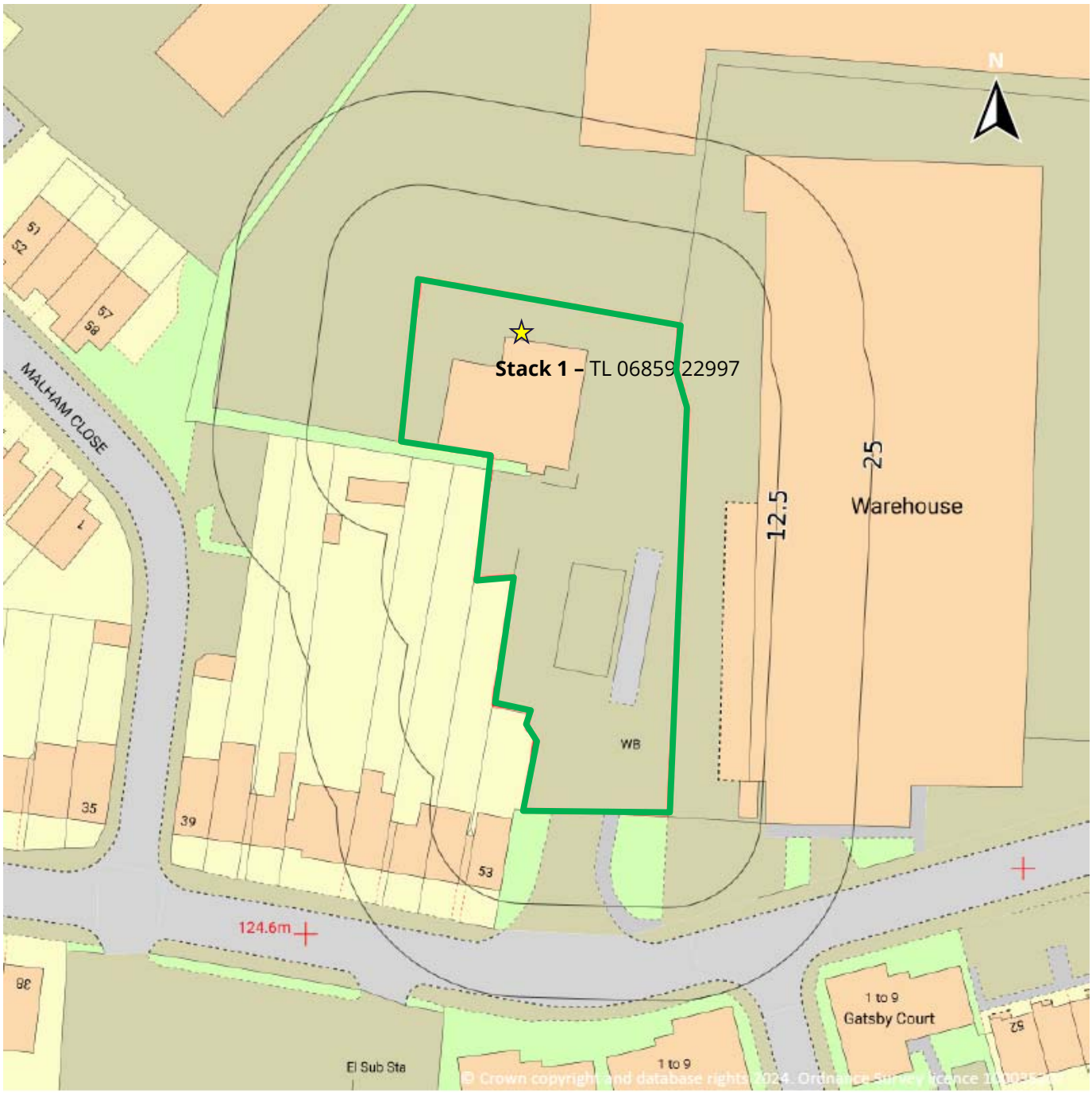
The risk from lithium, cobalt, aluminium and iron is considered low and no further detailed assessment has been completed.

Summary

The approaches and relevant operational procedures that have been implemented during the operational trials of the lithium battery recycling plant will form part of the Environmental Management System (EMS) and these are considered adequate to address the emissions to air. Further detailed monitoring is not currently considered necessary. However, further emissions monitoring has been scheduled to ensure consistency of results and will be undertaken on an annual basis. Assessment of these concentrations will be completed to ensure that the emissions do not present a risk to local air quality.

Appendices

Appendix I – Site Plan



Appendix II – H1 Assessment

Main

Enter your information in the relevant cells. Click the "Enter" key of your keyboard to go to the next field. Select your sector from the dropdown menu

Facility reference information

Company name:	F & R Cawley
Location:	1 Covent Garden Close, Luton
Permit number:	MP3397NF
Sector:	
Authorising Body:	Environment Agency

Describe the objectives

Main | Objectives | Environment Assessment Home | Output Tables | Reference Information

Depending on the reason for the assessment you will need to complete different parts of the tools

Select the type of assessment:

Environmental assessment of the emissions from the Local Exhaust Vent (Stack 1) associated with battery sl | Env A

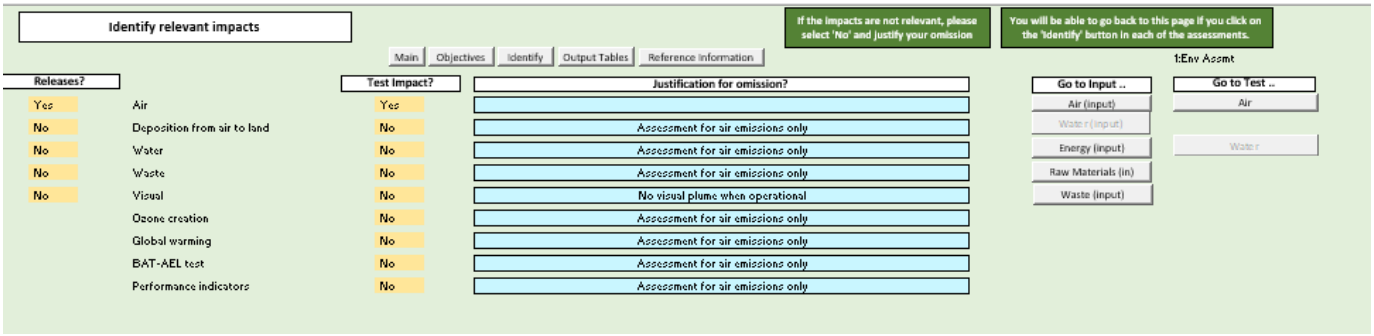
Air	Water	Energy	Raw materials	Waste
Yes	No	No	No	No

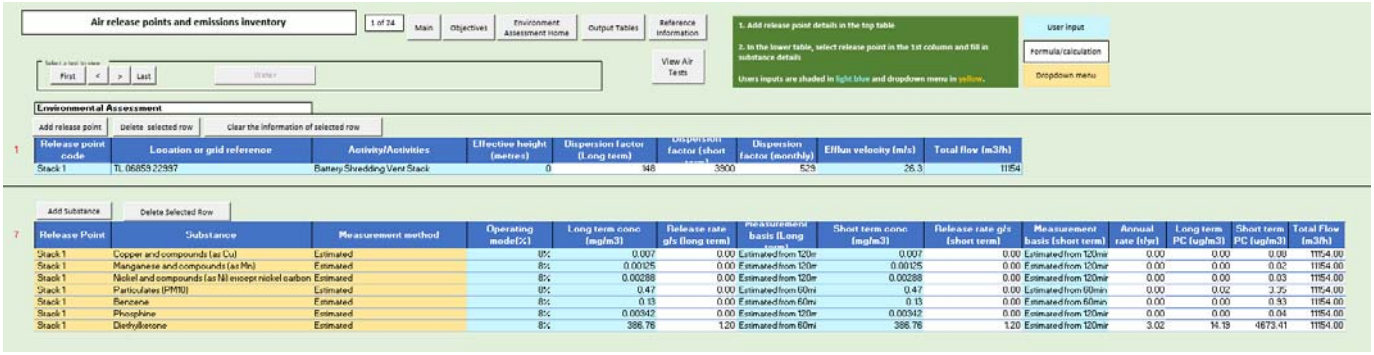
Please select whether you have releases in the dropdown menus above

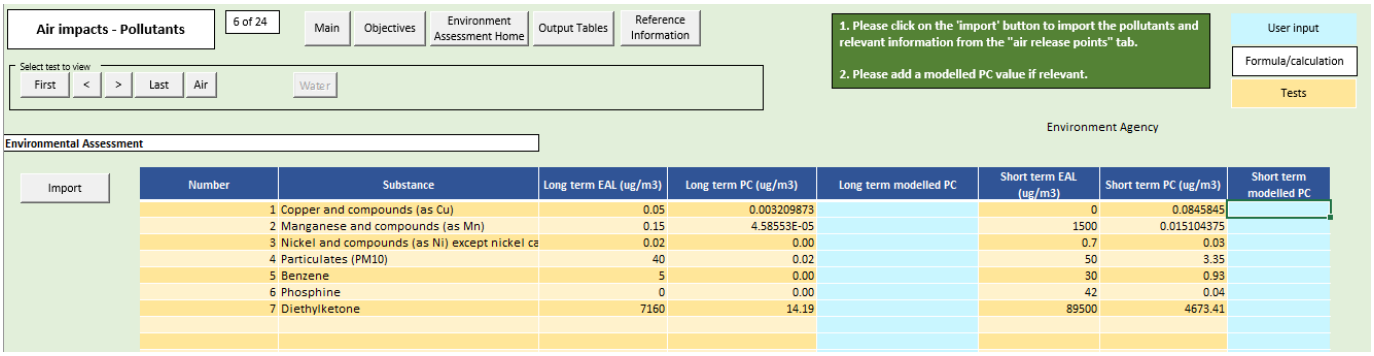
Activities	
1	Shredding added as new permit
2	
3	
4	
5	
6	
7	
8	
9	
10	

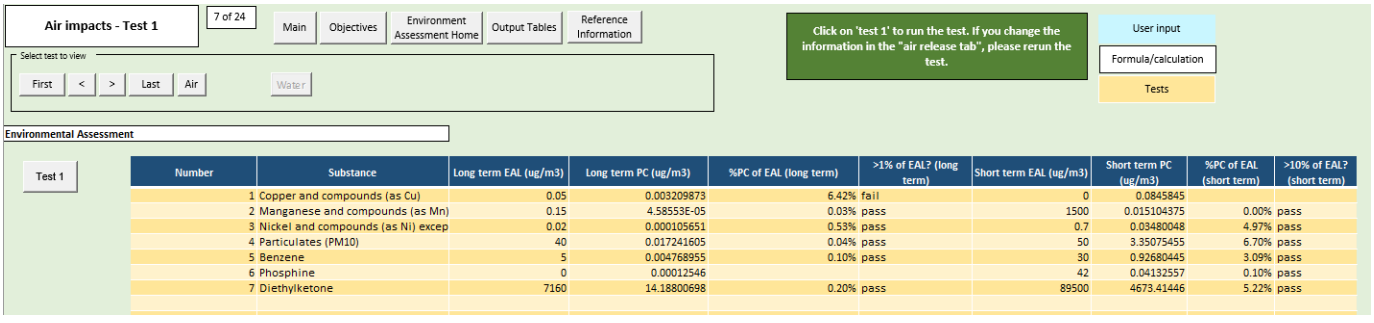
Go to Environmental Assessment

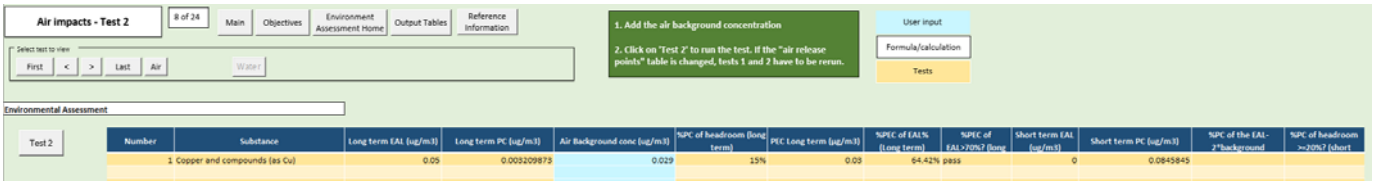
Clear Environmental Assessment


Identify relevant impacts
If the impacts are not relevant, please select 'No' and justify your omission
You will be able to go back to this page if you click on the 'identify' button in each of the assessments.
Main
Objectives
Identify
Output Tables
Reference Information
1:Env Assmt
Releases?
Test Impact?
Justification for omission?
Go to Input ..
Go to Test ..
Yes
Air
Yes
Air (input)
Air
No
Deposition from air to land
No
Assessment for air emissions only
Water (input)
No
Water
No
Assessment for air emissions only
Energy (input)
No
Waste
No
Assessment for air emissions only
Raw Materials (in)
No
Visual
No
No visual plume when operational
Waste (input)
Ozone creation
No
Assessment for air emissions only
Global warming
No
Assessment for air emissions only
BAT-AEL test
No
Assessment for air emissions only
Performance indicators
No
Assessment for air emissions only


Air release points and emissions inventory
1 of 24
Main
Objectives
Environment Assessment Home
Output Tables
Reference Information
View Air Tests
1. Add release point details in the top table
2. In the lower table, select release point in the 1st column and fill in substance details
Users inputs are shaded in light blue and dropdown menu in yellow.
User input
Formula/calculation
Dropdown menu
First
<
>
Last
Water
Environmental Assessment
Add release point
Delete selected row
Clear the information of selected row
Release point code
Location or grid reference
Activity/Activities
Effective height (metres)
Dispersion factor (Long term)
Dispersion factor (monthly)
Efflux velocity (m/s)
Total flow (m3/h)
1
Stack 1
TL 06853 22937
Battery Shredding Vent Stack
0
148
3900
529
26.3
11154
Add Substance
Delete Selected Row
Release Point
Substance
Measurement method
Operating mode(%)
Long term conc (mg/m3)
Release rate g/s (long term)
Measurement basis (Long term)
Short term conc (mg/m3)
Release rate g/s (short term)
Measurement basis (short term)
Annual rate (t/yr)
Long term PC (ug/m3)
Short term PC (ug/m3)
Total Flow (m3/h)
7
Stack 1
Copper and compounds (as Cu)
Estimated
0.007
0.00
Estimated from 120mi
0.007
0.00
Estimated from 120mi
0.00
0.00
0.08
11154.00
Stack 1
Manganese and compounds (as Mn)
Estimated
0.00125
0.00
Estimated from 120mi
0.00125
0.00
Estimated from 120mi
0.00
0.00
0.02
11154.00
Stack 1
Nickel and compounds (as Ni) except nickel carbon
Estimated
0.00288
0.00
Estimated from 120mi
0.00288
0.00
Estimated from 120mi
0.00
0.00
0.03
11154.00
Stack 1
Particulates (PM10)
Estimated
0.47
0.00
Estimated from 60mi
0.47
0.00
Estimated from 60mi
0.02
3.35
11154.00
Stack 1
Benzene
Estimated
0.13
0.00
Estimated from 60mi
0.13
0.00
Estimated from 60mi
0.00
0.00
0.93
11154.00
Stack 1
Phosphine
Estimated
0.00942
0.00
Estimated from 120mi
0.00942
0.00
Estimated from 120mi
0.00
0.00
0.04
11154.00
Stack 1
Diethylketone
Estimated
386.76
1.20
Estimated from 60mi
386.76
1.20
Estimated from 120mi
3.02
14.19
4673.41
11154.00


Air impacts - Pollutants
6 of 24
Main
Objectives
Environment Assessment Home
Output Tables
Reference Information
1. Please click on the 'import' button to import the pollutants and relevant information from the "air release points" tab.
2. Please add a modelled PC value if relevant.
User input
Formula/calculation
Tests
Select test to view
First
<
>
Last
Air
Water
Environment Agency
Environmental Assessment
Import
Number
Substance
Long term EAL (ug/m3)
Long term PC (ug/m3)
Long term modelled PC
Short term EAL (ug/m3)
Short term PC (ug/m3)
Short term modelled PC
1 Copper and compounds (as Cu) 0.05 0.003209873 0 0.0845845
2 Manganese and compounds (as Mn) 0.15 4.58553E-05 1500 0.015104375
3 Nickel and compounds (as Ni) except nickel ca 0.02 0.00 0.7 0.03
4 Particulates (PM10) 40 0.02 50 3.35
5 Benzene 5 0.00 30 0.93
6 Phosphine 0 0.00 42 0.04
7 Diethylketone 7160 14.19 89500 4673.41


Air impacts - Test 1
7 of 24
Main
Objectives
Environment Assessment Home
Output Tables
Reference Information
Click on 'test 1' to run the test. If you change the information in the "air release tab", please rerun the test.
User input
Formula/calculation
Tests
Select test to view
First
<
>
Last
Air
Water
Environmental Assessment
Test 1
Number
Substance
Long term EAL (ug/m3)
Long term PC (ug/m3)
%PC of EAL (long term)
>1% of EAL? (long term)
Short term EAL (ug/m3)
Short term PC (ug/m3)
%PC of EAL (short term)
>10% of EAL? (short term)
1 Copper and compounds (as Cu) 0.05 0.003209873 6.42% fail 0 0.0845845
2 Manganese and compounds (as Mn) 0.15 4.58553E-05 0.03% pass 1500 0.015104375 0.00% pass
3 Nickel and compounds (as Ni) excep 0.02 0.000105651 0.53% pass 0.7 0.03480048 4.97% pass
4 Particulates (PM10) 40 0.017241605 0.04% pass 50 3.35075455 6.70% pass
5 Benzene 5 0.004768955 0.10% pass 30 0.92680445 3.09% pass
6 Phosphine 0 0.00012546 42 0.04132557 0.10% pass
7 Diethylketone 7160 14.18800698 0.20% pass 89500 4673.41446 5.22% pass


Air impacts - Test 2
8 of 24
Main
Objectives
Environment Assessment Home
Output Tables
Reference Information
1. Add the air background concentration
2. Click on 'Test 2' to run the test. If the "air release points" table is changed, tests 1 and 2 have to be rerun.
User input
Formula/calculation
Tests
First
<
>
Last
Air
Water
Environmental Assessment
Test 2
Number
Substance
Long term EAL (ug/m3)
Long term PC (ug/m3)
Air Background conc (ug/m3)
%PC of headroom (long term)
PEC Long term (µg/m3)
%PEC of EAL% (Long term)
%PEC of EAL>70%? (long
Short term EAL (ug/m3)
Short term PC (ug/m3)
%PC of the EAL-2*background
%PC of headroom >=70%? (short
1 Copper and compounds (as Cu) 0.05 0.003209873 0.029 15% 0.03 64.42% pass 0 0.0845845

Report test results | Clear Output tables

Air

Option	Substance	Test 1	Test 2
1	Copper and compounds (as (	Fail	Pass
1	Manganese and compounds	Pass	
1	Nickel and compounds (as N	Pass	
1	Particulates (PM10)	Pass	
1	Benzene	Pass	
1	Phosphine	Pass	
1	Diethylketone	Pass	