LINCOLN STORM LIMITED

WORLE QUARRY FACILITY

SITE ADDRESS:

WORLE QUARRY, LOWER KEWSTOKE ROAD, WORLE, WESTON-SUPER-MARE, ENGLAND, BS22 9LF

DUST & EMISSION MANAGEMENT PLAN

(DEMP)

VERSION NUMBER: 3.0

DATE: 8TH DECEMBER 2023

FOR PERMIT VARIATION PLEASE TREAT THIS AS DOCUMENT MA13

ISSUE AND REVISION RECORD

Revision	Date	Originator	Checker	Company Approver	Description of Changes
2.0	30th October 2023	Rupert McNeil	Umbrella Environmental (Andrew Lake)	Scott Mackenzie (Director)	Incorporation of planned plant upgrade and response to request for information of determining whether permit variation application can be considered duly made
3.0	8th December 2023	Rupert McNeil and Nick Lofthouse	Umbrella Environmental (Andrew Lake)	Scott Mackenzie (Director)	Reviewed and updated to incorporate process improvements

CONTENTS

1. Introduction

Lincoln Storm Limited (LSL) is a company which recycles lithium-ion battery materials.

It receives lithium-ion battery production waste, recalled and end-of-life lithium-ion battery material.

It shreds, dries and separates this material into a 'black mass' (cathode precursor material) product called 'Storm Black' and the associated by products of aluminium, copper, polymer and some ferrous (steel) fractions. Some waste water is also produced. Storm Black is sold to refiners, and the other materials are also sold for further processing, or, in the case of water, payment is made to exit it to a permitted treatment facility.

Lithium-ion battery material is stored at the site prior to processing or, in some cases, as a transit point for processing at other partner facilities outside the UK.

The site is in the area of North Somerset Council.

The site is not in an Air Quality Management Area.

The site has the potential to generate Dust as follows (where Dust is defined as Total particulate matter (in air).

- As lithium-ion battery material is shredded, dried and separated, particles of the material comprising NMC, copper, aluminium and other constituents in particle form could be released in particulate form. Abatement and sealing is required to prevent this. This Dust can enter the air if abatement is not in place and can be washed into groundwater if bunding and sealing is not in place.

- Dust may also be generated by vehicles at the site, but unless there has been a spillage or release this will not be dust from lithium-ion battery material and is minimised by hard standing surfaces and regular sweeping and cleaning.

The site generates or has the potential to generate emissions as follows:

- *Channelled emissions*: Given the use of bag filters, active carbon filters and wet scrubbers, there are no more than trace emissions from the process itself (no more than 0.33mg/m^3, being equivalent to 3.39g/h). The site will be powered by mains electricity with a small back up generator with a thermal inoput of less than 1 MW.

- *Fugitive emissions*: fugitive emissions could occur if adsorption systems (active carbon filters and extraction units) failed. However, at the point of failure of the abatement system, the production process (and therefore any potential emission generation) would cease. Therefore the risk of fugitive emissions is minimal.

- *Diffuse emissions*: diffuse emissions could occur from failure of seals in adsorption systems or through diffusion following spillage. As explained in the previous bullet point, at the point of failure of the abatement system, the production process (and therefore any potential emission generation) would cease. Therefore the risk of diffuse emissions is minimal.

The site infrastructure has been designed to control and eliminate emissions:

- All treatment operations take place in enclosed building and all storage areas are enclosed.

- All treatment operations have abatement in place in the form of adsorption systems. Specifically a series of abatement stages captures emissions (particulate and gaseous):

    - (for shredding only) process takes place underwater in an aqueous solution in a sealed recirculatory system.
    - (for all shredding, drying/cooling and separation processes) extraction fans pull air that may contain emissions into:
        - A bag filter
        - An active carbon filter
    - (for all shredding, drying/cooling and separation processes) any air that may contain emissions passes through a wet scrubber.

- All process and the plant as a whole have continuous emission monitoring, with elevated levels immediately shutting down the processing plant.

- Regular and frequent on-site maintenance including independent testing.

- Regular and frequent cleaning with vacuum cleaners and wipe downs.

- The site is fully bunded and sealed.

There are no specific planning permission conditions relating to dust or emissions.

This DEMP has been created to:

- Inform the process of varying the site's permit.

- Ensure all staff, contractors and advisors have a detailed shared understanding of the management of the risks associated with dust and emissions.

This DEMP forms part of the site's Operating Techniques and Environmental Management System OTEMS, and should be read with the other parts of the OTEMS, including the site's Fire Prevention Plan (FPP)

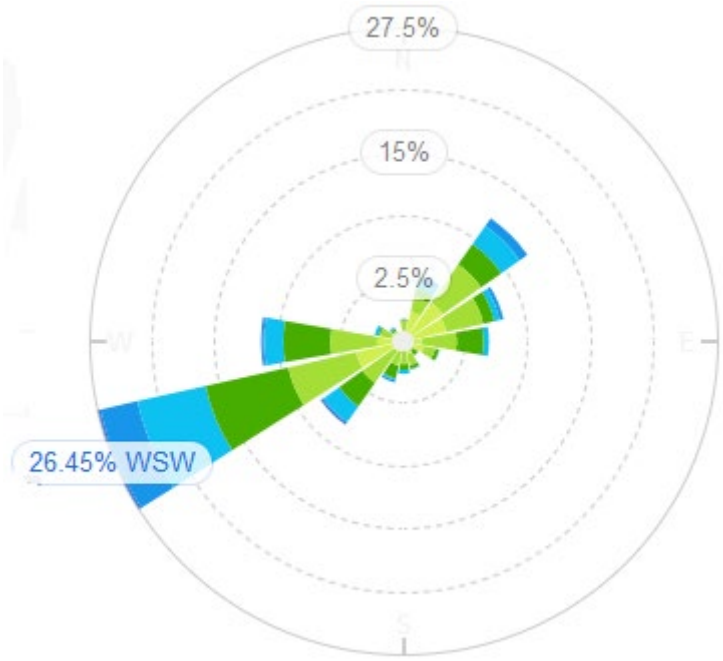
All staff and contractors working on site will be supplied with a copy of this DEMP, and a hard copy is kept in the site office.

This DEMP draws on the BAT Conclusions document for terms and techniques. A detailed discussion of how the operations at the site relate to the BAT conclusions is provided in **Annex 1.**

1.1 Sensitive receptors

Sensitive receptors have been identified up to 1 km around the site permit area. They are shown in Table 1 Sensitive Receptors up to 1 km and Figure 2 Sensitive Receptors Plan. The wind rose shown in Figure 1 Wind Rose shows the prevailing wind direction of west south westerly. The wind rose was taken from the Weston-Super-Mare weather station, approxc.3.2 km south west of the site.

Wind Rose



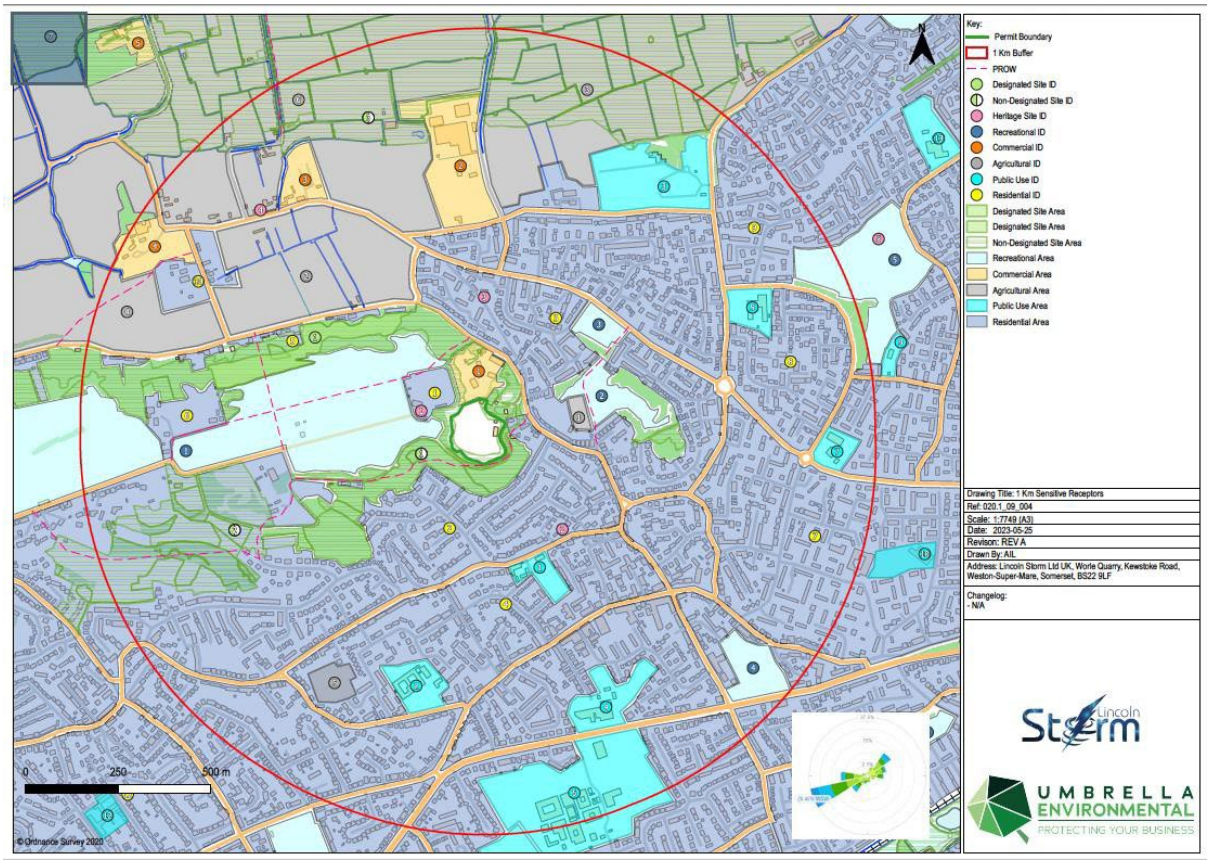
(www.willyweather.co.uk)

Sensitive Receptors up to 1 km

TYPE OF RECEPTOR	ID #	DESCRIPTION	DISTANCE FROM BOUNDARY (M) APPROX	DIRECTION
		SITE		
HUMANS AND PROPERTY		Site Workers	On site	-
		Site Visitors	On site	-
		COMMERCIAL		
	1	Multiple Commercial Units off Lower Kewstoke Road	0 m	N
	2	Manor Farm (business park)	470 m	N
	3	Ash Tree Holiday Park	657 m	NNW
	4	Home Farm Caravan Site	791 m	WNW
		RESIDENTIAL		
	1	Residential Property off Worlebury Hill Road	13 m	NW
	2	Residential Properties west of Lower Kewstoke Road and north of Church Road	65 m	E
	3	Residential Properties between Lower Kewstoke Road & Ebdon Road	127 m	ENE
	4	Residents of Worle	309 m	SSE
	5	Residential Properties off Kewstoke Road	435 m	WNW
	6	Residential Properties within Worlebury Golf Club	613 m	W
	7	Residential Properties between Queens Way and New Bristol Road	621 m	ESE
	8	Residents of Castle Batch	631 m	ENE
	9	Residents of Ebdon	706 m	WNW
	10	Residential Properties off Norton Lane	712 m	WNW
		PUBLIC USE		
	1	Worle Village Primary School	285 m	SSE
	2	St. Martins C of E Primary School	568 m	SSW
	3	Weston-Super-Mare Crematorium & Cemetery	596 m	NE
	4	Mendip Green Primary School	625 m	SSE
	5	St. Marks VA Ecumenical Church of England Primary School	674 m	ENE
	6	Worle Community School	805 m	SSE
	7	St. Marks Church Centre	825 m	E
	8	Mead Valley Community Primary School	979 m	S
		PUBLIC RIGHTS OF WAY (PROW)		
	1	Footpath between Lower Kewstoke Road & Pleshey Close	14 m	SSW
	2	Footpath between Lower Kewstoke Road & Worlebury Hill Road	138 m	NNW
	3	Footpath between Castle Road & Queensway	255 m	ESE

	4	Footpath between Kewstoke Road & Worlebury Hill Road	467 m	W
	5	Footpath between Worlebury Hill Road & Pleshey Close	599 m	WSW
	6	Footpath between Kewstoke Road & Norton Lane	800 m	NW
	7	Footpath between Myrtle Farm & Foss Lane	863 m	NNW
		ROADS & RAILWAYS		
	-	Lower Kewstoke Road	131 m	N
	-	B3440	806 m	SSE
		RECREATIONAL		
	1	Worlebury Golf Club	20 m	W
	2	Lynch Farm Park	168 m	ENE
	3	Worle Juniors Football Ground	299 m	NE
	4	Worle Recreation Ground	775 m	SE
	5	Castle Batch (park)	878 m	ENE
		AGRICULTURAL		
	1	Allotment Gardens off Castle Road	183 m	E
	2	Packets of Arable Land north of Kewstoke Road and east of Norton Lane	359 m	NW
	3	Packets of Arable Land east of Collum Lane	539 m	NNE
	4	Packets of Arable Lane north of Kewstoke Road and west of Norton Lane	637 m	WNW
	5	Allotment Gardens off Church Road	647 m	SSW
	6	Packets of Arable Land north of Lower Norton Lane & east of Elmsley Lane	808 m	NNW
WATER		**SURFACE WATER**		
	-	Drainage Channels within Arable Land north of Kewstoke Road	363 m	NNW
		GROUNDWATER		
	-	Bedrock Aquifer - Principal	On site	-
	-	Superficial Aquifer - No Superficial Layer	On site	-
ENVIRONMENTALLY SENSITIVE		**DESIGNATED SITES**		
	1	Ancient Woodland - Worle Hill Woods	263 m	NW
		EUROPEAN DESIGNATED SITES		
		NON DESIGNATED SITES		
	1	BAP - Deciduous Woodland surrounding Worlebury Golf Club	0 m	S
	2	BAP - Low Calcareous Grassland off Helens Steps	580 m	WSW
	3	BAP - Coastal & Floodplain Grazing Marshes north of Northon and Ebdon	718 m	NNW
HERITAGE LOATIONS		**LISTED BUILDINGS AND PARKS**		
	1	Grade II Listed Building - Worle Tower Observatory	74 m	W
	2	c.8 No. Grade II Listed Buildings in Worle	257 m	SE
	3	3 No. Grade II Listed Buildings at 'The Newtons'	260 m	N
	4	3 No. Grade II Listed Farmhouses in Norton	743 m	NW

Sensitive Receptors Plan



2. Operations at the site

2.1 Waste deliveries to the site

Materials are delivered to the site by truck. Materials are in packaging as described in detail in the FPP, with waste acceptance procedures (including records) also as described in the FPP and elsewhere in the OTEMS. Vehicles will originate in the European Union or the UK and will be rated for emissions as prevailing EU or UK regulations require. Material leaves the site in sealed bags (or its original packaging if transferred only) and, in the case of waste water, by tanker.

The handling/processing of different waste streams is as described in the tables below.

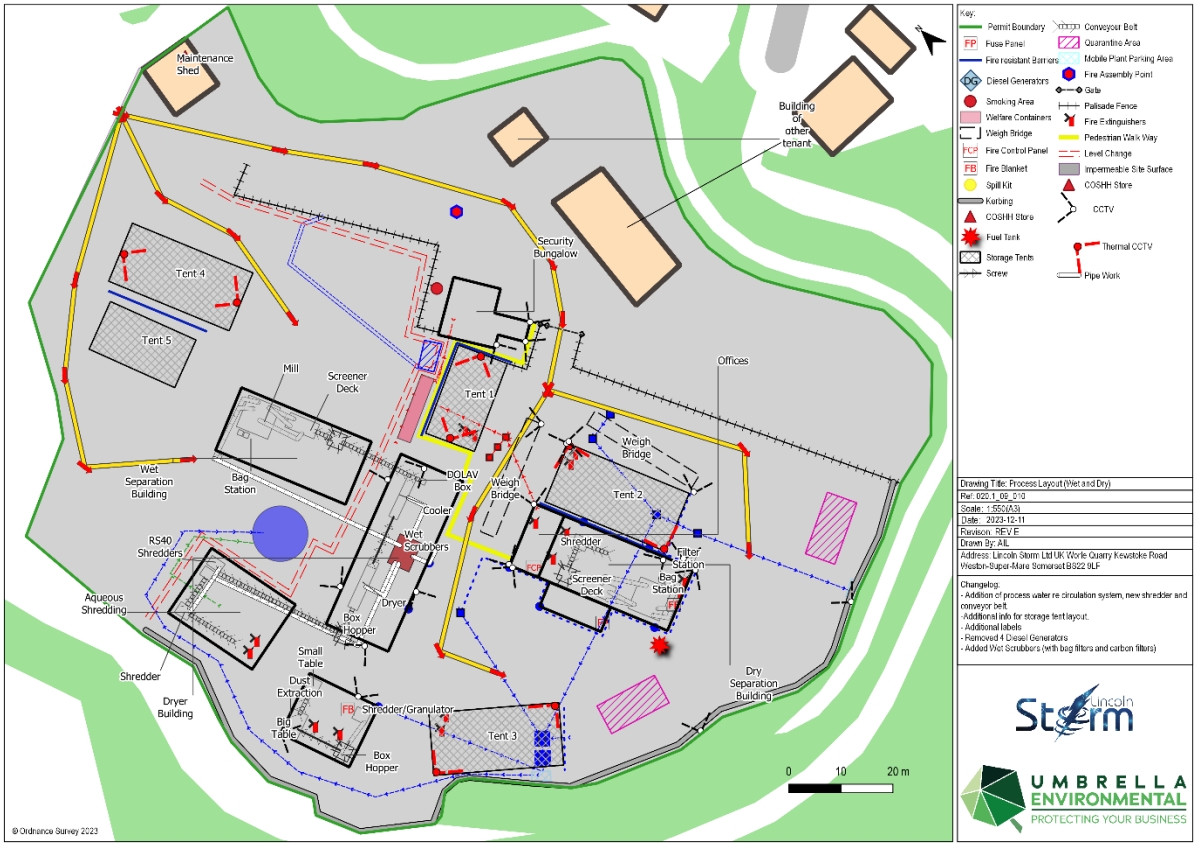
Waste types brought to the site

	C & M 2.4 MT (3 High)	Storm Black ™ 2.0 MT (1 high)	Polymer 0.45 MT (3 high)	Al & Cu 1.50 MT (2 high)	**Total MT in each tent**
Tent 1	-	-	17.1 MT	30 MT	**47.1 MT**
Tent 2	60.0 MT	-	-	-	**60 MT**
Tent 3	-	200 MT	6.75 MT	22.5 MT	**229.25 MT**
Tent 4	98.4 MT	-	-	-	-
Tent 5	60.0 MT	-	-	-	-
Total material held on site	218.4 MT	200 MT	23.85 MT	52.5 MT	**494.75 MT**
One line only in operation					
Weeks of production (storage period)	*2.275*	*3.33*	*2.385*	*2.02*	***~ 2***
Annual throughput	*5,678 MT*	*3,120 MT*	*620 MT*	*1,365 MT*	***10,783***
Daily arrival	*21 MT*	-	-	-	*21 MT*
Daily departure	-	*12 MT*	*2.4 MT*	*5.25 MT*	*19.65 [1]*
Two lines in operation					
Weeks of production (storage period)	*1.136*	*1*	*1.193*	*1.01*	*~ 1*
Annual throughput	*11,350 MT*	*6,240 MT*	*1,240 MT*	*2,730 MT*	*21,560*
Daily arrival	*42 MT*	-	-	-	*42 MT*
Daily departure	-	*24 MT*	*4.8MT*	*10.50 MT*	*39.30 MT [1]*

[1] In practice containers will arrive and depart less frequently than every day, but the average can be expected to be one 20 MT container each day, in and out with one line operational and two 20 MT containers in and out when two lines are operational.

2.2 Overview of waste processing, dust, and other emission controls

The site layout is shown in the plan below. Please refer to the OTEMS and its FPP for description of the site's operations and Appendix 1 for how these relate operations relate tol BAT requirements regarding dust and emissions and their control.



All processes take place in enclosed areas, with extraction (adsorption) and on sealed and impermeable surfacing. Materials are covered and in appropriate containers. Wind borne dust would only occur in the event of spillage.

2.3 Mobile plant and equipment

Mobile plant consists only of forklift trucks used to move material to and from storage areas. The models are Toyota 52-8FDF30 (x 1) and Clark GTS30D (x 2) and Clark GTS25D (x 2), with emission levels IIIA or higher. The maintenance schedule for this and other plant is described in the OTEMS, and follows manufacturers' specifications. As part of continuous improvement work the intention is to convert to electric battery forklifts[1]. Forklifts are switched off when not in use (no idling) for emission and fire prevention purposes).

[1] At that time location of charging points will be DSEAR compliant if / when operations are in scope of DSEAR.

2.4 Power sources

The site will be connected (subject to survey) to the national grid. This means that diesel generators would only used for emergency back-up power. **Annex 2** provides details on the back of generator, which will have a thermal input power of less than 1 MW and will not require abatement under the Medium Combustion Plant regulations. **Annex 3** provides information on the wet scrubbers being used.

3. Dust and particulate management

3.1 Responsibility for implementation of this plan

The implementation of this DEMP is the responsibility of all site personnel, under the supervision of the Technically Competent Manager (TCM), and the Site Manager and the Plant Manager as his deputies. It is reviewed regularly (as described for the review in the OTEMS). All staff are trained in the implementation of the DEMP.

3.2 Sources and control of fugitive dust and other emissions

The sources of dust and emissions are described in Section 1. The pathways are air (atmospheric dispersion) and water (through washing into drainage).

The controls to break these pathways are the use of enclosed buildings and plant, with seals and checks, extraction and sealed drainage as described in more detail in **Annex 1** (and abatement for generators as described in **Annex 2**).
Source-Pathway-Receptor-Routes

Source	Pathway	Receptor	Type of impact	Where relationship can be interrupted
Mud	Tracking dust on wheels and vehicles, then mud dropping off wheels/vehicles when dry	Humans and Property	Visual soiling, also consequent resuspension as airborne particulates	Remove mud/debris before vehicles before they leave site. A road sweeper to clear haul/access road as and when required.
Debris	Falling off lorries	Humans and Property	Visual soiling, also consequent resuspension as airborne particulates	Remove mud/debris before vehicles before they leave site. If required hire a road sweeper to clear haul/access road as and when required. Self contained wheel was installed.
Tipping, storage and sorting of wastes inside	Atmospheric dispersion	Humans and Property	Visual soiling and airborne particulates	Waste is unloaded from vehicles using fork lift trucks waste is also containerised and or on pallets.

Vehicle exhaust emissions Non-road going machinery exhaust emissions	Atmospheric dispersion	Humans and Property	Airborne particulates	Plant and delivery vehicles maintained in accordance with manufacturers guidance all with upward facing exhausts.
Processing	Atmospheric dispersion	Humans and Property	Airborne particulates	Localised extraction throughout processing.

Measures to Control Dust/Particles (PM10) and other Emissions

Abatement Measure	Description / Effect	Overall consideration and implementation	Trigger for implementation
Preventative Measures			
Enclosure within a building	All storage and processing enclosed within a building except for conveyors, which are provided with localised containment. Building provides a physical barrier between source and receptor.	Very effective despite costs and the high potential for disruption to already operational sites. Full enclosure from start of operation except for metal skip.	From start of operation.
Abatement Systems	Localised extraction provides mitigation at the most high risk areas for particulate release.	Implemented as a requirement for occupational health and safety, benefits local environment by preventing release of particulate matter.	From start of operation.
Site / process layout in relation to receptors	All processing/storage and transportation in process within	Designed of site to be enclosed from day 1 of operations.	From start of operation.

Abatement Measure	Description / Effect	Overall consideration and implementation	Trigger for implementation
	buildings or continament.		
Site speed limit, 'no idling' policy and minimisation of vehicle movements on site	Speed limit enforced on site No idling of vehicles or mobile plant. Mobile Plant and delivery vehicles maintained in accordance with manufacturers guidelines.	Easy to implement as part of good practice.	Will be used all the time that the site is operational and applied as 'best practice'
Minimising drop heights for waste. Use of enclosed chutes for waste drops/end of conveyor transfers and covered skips / storage vessels.	Waste arrives in containers or on pallets and is unloaded via forklift truck reducing potential for emissions.	Managed by Environmental Management System.	From start of operation.
Good house-keeping	Regular house keeping Removal of dust and particulate build up on mobile and static plant as well as clearing site surface of debris.	Daily site inspections at start and end of the day to inspect housekeeping of the site, targets where cleaning is required. Including site surface, haul/access road, weigh bridge and site perimeter. End of day clean down of equipment. Deeper cleans e.g. filters and cabs in accordance with manufacturers guidelines.	Site will carry out these inspections/ cleaning processes daily.
Sheeting of vehicles	Prevents the escape of debris, dust and particulates from	Waste arriving and dispatched waste are not known to be overly dusty.	From start of operation.

Abatement Measure	Description / Effect	Overall consideration and implementation	Trigger for implementation
	vehicles as they travel.		
Hosing of vehicles on exit	Vehicle washed down using a hose to remove dust, dirt and other particular matter as required.	Vehicle washed down as and when required. Extra focus in winter months for debris.	Inspections will be carried out on every vehicle as part of day to day operations as best practice. Self contained wheel was installed.
Easy to clean concrete impermeable surfaces	Site surface made of impermeable concrete pad with sealed drainage system. Regular housekeeping prevents build-up of loose debris/dusty material.	Dust and particulate reduction due to site surface and regular housekeeping Regular maintenance for site surface as other permit requirements require an impermeable site surface.	Infrastructure installed during construction of site and maintained as part of critical infrastructure for permit compliance, with a roadsweeper vehicle used across the site on a scheduled weekly basis.
Minimisation of waste storage heights and volumes on site	Waste height and volume is controlled by Fire Prevention Plan and HSG71 requirements at less than 4 m in height, waste is stored either in containers and or on pallets.	Part of daily operations.	From start of operation.
Remedial Measures			
On-site sweeping	On site housekeeping, sweeping of site surface and cleaning of equipment, Road sweeper as required.	Part of daily and weekly checks recorded in site diary.	A part of normal daily and weekly operations.

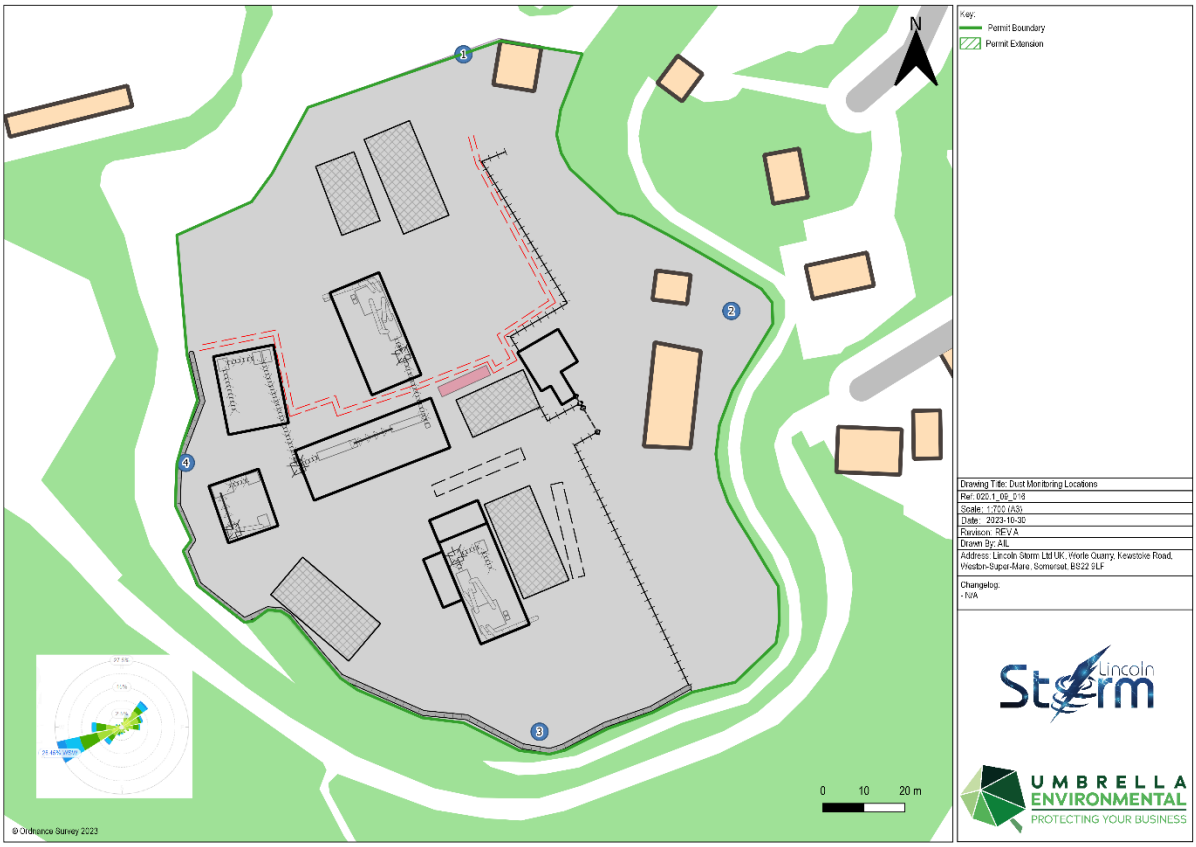
Abatement Measure	Description / Effect	Overall consideration and implementation	Trigger for implementation
Dust and particulate monitor with trigger alarm	Visual dust monitoring during operations as well as monitoring for PM2.5 to be carried out by static monitor see 020.1_09_016 Dust Monitoring Locations	For static monitors likely a trigger level of 75 ug/m3 (over a 5 min average) for PM10	A part of normal daily and weekly operations. The potential plant emission points will have continuous monitoring with a limit of 5ppm

3.3 Enclosure of waste processing and storage areas

The waste storage plan and enclosure of waste processing is described in the OTEMS and its FPP.

3.4 Visual dust monitoring

Monitoring occurs as part of all processing operations and as part of the Site Manager's responsibilities during working hours. Other site personnel are instructed to notify the Site Manager or their line manager if there is any dust accumulation, leakage or spillage spotted. Where dust is detected cleaning and/or emergency sealing (with impermeable / non-porous tape) will take place.
Where dust is seen or apart of the complaints procedure visual monitoring by staff will occur to identify if larger particles are escaping site at the locations on the plan below north, east, south and west.


N
Key:
Permit Boundary
Permit Extension
1
2
3
4
0 10 20 m
© Ordnance Survey 2023
Drawing Title: Dust Monitoring Locations
Ref: 020.1_09_016
Scale: 1:700 (A3)
Date: 2023-10-30
Revision: REV A
Drawn By: AIL
Address: Lincoln Storm Ltd UK, Worle Quarry, Kewstoke Road, Weston-Super-Mare, Somerset, BS22 9LF
Changelog:
- N/A
Lincoln Storm
UMBRELLA ENVIRONMENTAL
PROTECTING YOUR BUSINESS

4. Particulate matter monitoring

The site will operate a continuous emission monitoring system, with independent third party testing as part of the system. This will include:

- All processing and storage areas.
- At all points where emissions may be channelled into abatement.

Independent monitoring has already been carried out on the separation stack (0.33mg/m^3).

5. Actions when alarm is triggered

In the event of any material spillage and leakage all operations in the area will cease. Seals will be placed in buildings and openings and any dust accumulated will be removed by vacuum cleaning and/or wipe down. Visual monitoring will be carried out as per section 3.4.

If any continuous emission reading shows particulate levels of greater than 5 part per million (PPM), all processes will be shut down.

All processing and storage is either within a building/tent or covered (conveyor belts). Because of this it is not expected that increase in wind speed will impact dust creating and no trigger level has been identified for increases in wind speed because of this.

6. Reporting and complaint response

All complaints follow the procedure set out in the OTEMS. With the following complaints form being completed as a record

The TCM is responsible for responding to complaints and implementing the complaint procedure.
Upon receipt of a complaint, either directly from a neighbouring resident or indirectly via the Regulator. The following information will be requested but may not be provided in full:

- name;
- address;
- contact details;
- date(s) and time(s) to which the complaint relates; and
- nature of the complaint and any other details which may assist in the identification of the source, activity or circumstances which prompted the complaint.

The timings and description of the complaint will be analysed in conjunction with the activities and meteorological conditions logged on site without delay to identify the offending source or activity. The complainant may be asked to keep an ongoing log for correlation with the site operational log. Once the source or activity is identified suitable mitigation measures will be implemented immediately to prevent future dust emissions. Where contact details are made available, the complainant will be contacted within 24 hours to check that the mitigation has been effective.
The complaints information and subsequent investigation will be recorded in the form below

Engagement with the Community
Neighbours will be provided with contact details to make complaints/provide feedback as shown in Management Responsibilities below.
Reporting of Complaints
Form below provides details of how complaints will be noted and recorded. Following investigation of a complaint the complainant will be contacted to be informed what the source of the dust was, why the issue occurred and what mitigation measures have been implemented to prevent any re-occurrence.

Complaint Details	
Complainant Name	
Address Postcode	
Complainant Contact Details	

Tel	
Email	
Date	
Complaint Details	

Investigation Details	
Investigation carried out by -	
Name	
Position	
Date & time investigation carried out	
Weather conditions	
Wind direction and speed	
Investigation findings	
Feedback given to Environment Agency and/or local authority	
Date feedback given	
Feedback given to public	
Date feedback given	

Review and Improve	
Improvements needed to prevent a reoccurrence -	
Proposed date for completion of the improvements	
Actual date for completion	
If different insert reason for delay	
Does the noise and Vibration management plan/Emissions Management Plan need to be updated	
Date that the noise and Vibration management plan was updated	

Closure	
Site manager review date	
Site manager signature to confirm no further action required	

7. Availability DEMP

All site operational staff will be trained in the contents of the DEMP to ensure compliance and consistent operation of waste activities.
A copy of the DEMP will be made available at the site for reference purposes and is available on request to the Environment Agency and other interested parties.

8. Summary

The DEMP seeks to ensure that by the adoption of industry best practice and appropriate measures, dust emissions are adequately controlled within the site and do not cause any significant impacts on amenity or the environment beyond the permit boundary.
This DEMP describes how the operator is fully committed to operating responsibly and in compliance with the Environmental Permit.
The DEMP will be reviewed annually and in the event of any complaint regarding dust emissions to ensure its provisions remain effective.
This DEMP should be read alongside the Lincoln Storm Limited Hazardous Emissions Calculations and Air Emmissions Risk Assessment.

Annexes

Annex 1: Application of the BAT Conclusions to the site and to this DEMP

This DEMP adheres to the requirements of the BAT Conclusions document in respect of BAT 1, BAT 2, BAT 3, BAT 4, BAT 8, BAT 14, BAT 19, BAT 20, BAT 21, BAT 23, BAT 25, BAT 27, BAT 28, BAT 29, BAT 30, BAT 41 and BAT 49. These are the BATs considered to be relevant to this DEMP, as described below.

The purpose of the facility is the manufacture of 'Storm Black'. This is a 'black mass' product. A number of by products are produced by this process, including:

- Aluminium granules;
- Copper granules;
- Polymer (in flake form); and
- Ferrous fraction.

Storm Black takes the form of a powder, as illustrated in the photograph below.

Although in granule or flake form, aluminium, copper and polymer may also contain small particulates. Ferrous fractions take a larger form.

Storm Black contains the following components:

Table 1: Storm Black Componen

Storm Black component	**CAS[1] code**
Graphite, C	CAS 7782-42-5
NMC (Lithium Nickel Manganese Cobalt Oxide), $LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$	CAS 182442-95-1
Lithium hexafluorophosphate	CAS 21324-40-3
Poylmer PVDF – Poly(vinylidene fluoride) -(C2H2F2)n- (by-product, separated)	CAS: 24937-79-9
Copper (by-product, separated)), Cu	CAS 7440-50-8
Aluminium (by-product, separated), Al	CAS 7429-90-5

The input will contain lithium hexafluorophosphate but our black mass will not. As this is removed first stage under water there is no chance this will be present in the dust.

LSL considers its production process to qualify as the '*processing or production*' of '*fine materials*' and therefore the facility requires an '*emissions management plan for dust*', given its proximity to sensitive receptors ('*within 500m of a sensitive receptor such as a home*').

This '*Dust and Emissions Management Plan (DEMP)'* also covers risk management of potential emissions to water.

The DEMP serves several purposes, showing how the facility will fulfil its obligations:

- under the Pollution Prevention and Control (England and Wales) Regulations 2000 ('PPCR") and other requirements set out in the Environment Agency's guidance.
- to protect the health and safety of its employees under the COSHH and DSEAR regulations.
- Under the Medium Combustion Plant regulations (MCP).

Approach

In the absence of specific best practices being published for Lithium-ion battery recycling, the DEMP has, on the Agency's advice as part of the duly-making process, used the Agency's guidance for *Waste electrical and electronic equipment (WEEE): appropriate measures for*

permitted facilities, for Treating metal waste in shredders: appropriate measures for permitted facilities, and for *Chemical waste: appropriate measures for permitted facilities.*

Therefore it sets out:

- The identification and characterisation of emissions from the processes and the appropriate measures taken to control them at source.

- The abatement and control equipment that will be used.

- Simplified process flow sheets for any emissions, details of emission control and abatement techniques for emissions to air and water, including details of performance, diagrams of the relevant main plant items, treatment and abatement plant design, dismantling processes, control system philosophy and how the control system incorporates environmental monitoring information and venting and emergency relief provisions.

- Handling of abnormal operating conditions, specifically unexpected releases and shut down, i.e. measures to prevent fugitive or accidental emissions.

- Through this how any escape of material will not breach environmental quality standards and benchmarks and/or cause significant environmental impact.

- Process monitoring in respect of emissions.

It uses the BAT Conclusions document for its definitions, where the relevant definitions are considered to be as follows (with site specific interpretations):

Term used	Definition and Site Applicability
Channelled emissions (*noting that these will be removed through use of wet scrubbers after the bag filter and active carbon filter stages*).	*Definition* Emissions of pollutants into the environment through any kind of duct, pipe, stack, etc. This also includes emissions from open-top biofilters. *Site applicability* The only channelled emissions from the site will be steam from dryer and emissions from the five diesel generators. Plans are being prepared as part of continuous improvement to channel the steam into a condenser so that steam is converted to waste water (for disposal to a permitted site for treatment), and for the site to be

	connected to the national grid (so that diesel generators would become back up generators only, albeit abated with ad-blue SCRs or via wet scrubber systems).
Continuous measurement	*Definition* Measurement using an 'automated measuring system' permanently installed on site. *Site applicability* LSL is engaging with its independent testing contractor, SOCOTEC and its plant suppliers on the installation of the monitoring solutions for the site.
Diffuse emissions	*Definition* Non-channelled emissions (e.g. of dust, organic compounds, odour) which can result from 'area' sources (e.g. tanks) or 'point' sources (e.g. pipe flanges). This also includes emissions from open-air windrow composting. *Site applicability* At the site, diffuse emissions would arise from failures in containment in extraction systems, eg through diffusion through unsealed screw holes and other openings, or in the event of a spillage event.
Direct discharge	*Definition* Discharge to a receiving water body without further downstream waste water treatment. *Site applicability* There is no direct discharge at the site, and the bunded and sealed nature of the site

	means that it would not occur in the event of an accidental discharge (eg water used in fire fighting).
Emissions factors	*Definition* Numbers that can be multiplied by known data such as plant/process data or throughput data to estimate emissions. *Site applicability* To be used as required for emission calculations for channelled emissions (see above and as detailed in the Lincoln Storm Limited Hazardous Emissions Calculations and Air Emmissions Risk Assessment.
Existing plant	*Definition* A plant that is not a new plant. *Site applicability* All plant at the site is considered to be /new plant'. There is no 'old plant'.
Fugitive emissions	*Definition* Diffuse emissions from 'point' sources. *Site applicability* At the site fugitive emissions could only occur if there was a failure of the filters or abatement systems. However, failure of the abatement stops the plant, and plant is a continuous system and only low volumes are held within the processing plant. The potential is therefore low.

Hazardous waste	*Definition* Hazardous waste as defined in point 2 of Article 3 of Directive 2008/98/EC. *Site applicability* Given the nature of lithium-ion battery material and following discussions with the Agency any material containing NMC is considered hazardous and therefore all material is currently considered hazardous on a precautionary basis. All input and output material will also be stored in accordance with HSG71.
Indirect discharge	*Definition* Discharge which is not a direct discharge. *Site applicability* There is no indirect discharge at the site (see Direct discharge, above).
Major plant upgrade	*Definition* A major change in the design or technology of a plant with major adjustments or replacements of the process and/or

	abatement technique(s) and associated equipment. *Site applicability* The plant will operate with best available techniques and be powered from the grid, and with the combined abatement system of bag filters, active carbon filters and wet scrubbers. No major plant upgrades are therefore planned at this time.
New plant	*Definition* A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions. *Site applicability* All plant at the site is considered to be new plant.
Output	*Definition* The treated waste exiting the waste treatment plant. *Site applicability* The Storm Black product is the main and most valuable output. The other outputs include: aluminium, copper, polymer and waste water.

Periodic measurement	*Definition* Measurement at specified time intervals using manual or automated methods. *Site applicability* Periodic measurement by staff or SOCOTEC is at least as frequent as BAT requires.
Sensitive receptor	*Definition* Area which needs special protection, such as residential areas and areas where human activities are carried out. *Site applicability* The site's sensitive receptors are shown on the site plans.
Waste input	*Definition* The incoming waste to be treated in the waste treatment plant. *Site applicability* The waste input at the site is solely lithium-ion battery material and principally that with EWC 16 06 05. It is anticipated that material from production waste will also be received as EWC 16 03 03 as off specification batch material. The large number of waste codes in the application are to 'future proof' the permit given the uncertainty over the codes that may be used by different competent

	authorities and/or waste producers in future.
Water-based liquid waste	*Definition* Waste consisting of aqueous liquids, acids/alkalis or pumpable sludges (e.g. emulsions, waste acids, aqueous marine waste) which is not liquid biodegradable waste. *Site applicability* This is waste water from aqueous shredding and waste water from the sealed drainage. This will be tested and treated to remove any HF or other similar hazardous material. Treatment will be off site.
Copper (pollutant)	*Definition* Copper, expressed as Cu, includes all inorganic and organic copper compounds, dissolved or bound to particles. *Site applicability* The lithium ion battery material contains copper, which is also an output of the site.
Dust	*Definition* Total particulate matter (in air). *Site applicability*

	As explained above, 'Dust' produced at the site may contain NMC, aluminium, carbon, copper or polymer and arise from shredding, drying or separation.
Nickel	*Definition* Nickel, expressed as Ni, includes all inorganic and organic nickel compounds, dissolved or bound to particles. *Site applicability* Nickel is a component of NMC.
HEPA	*Definition* High-efficiency particle air (filter) *Site applicability* With plant suppliers and consultants we are ensuring that filters are both ATEX and HEPA rated[2].
LDAR	*Definition* Leak detection and repair *Site applicability* See discussion regarding BAT 14.

[2] an ATEX-rated filter and a HEPA-rated filter are not equivalent and serve different purposes. ATEX (ATmosphères EXplosibles) refers to a European Union directive that sets regulations for equipment intended for use in potentially explosive atmospheres. ATEX-rated filters are designed to prevent the ignition of flammable substances, such as gases, vapours, or dust, that could be present in industrial environments. These filters are constructed to minimize the risk of generating sparks, arcs, or high temperatures that could trigger an explosion. On the other hand, HEPA (High-Efficiency Particulate Air) filters are designed to remove a high percentage of airborne particles from the air passing through them. HEPA filters are highly efficient in capturing particles as small as 0.3 micrometres with an efficiency of 99.97%. They are commonly used in various applications, including cleanrooms, HVAC systems, and medical facilities, to improve air quality by removing allergens, dust, pollen, mould spores, and other particulate matter. While both types of filters play important roles in maintaining safety and air quality, they serve different purposes and have distinct design considerations. ATEX-rated filters focus on preventing explosions in potentially hazardous environments, while HEPA filters are primarily concerned with removing airborne particles from the air. Abatement at the site will be subject to continuous emission monitoring and the process will shut down if set thresholds are exceeded (see above).

LEV	*Definition* Local exhaust ventilation system *Site applicability* There are LEVs for the shredder, dryer, and separation processes. These have been and are being independently tested by SOCOTEC[3].

BATs 1 to 4

The DEMP operates within the OTEMS, which incorporates all of the requirements of BAT 1, BAT 2, BAT 3, and BAT 4.

BAT 8: monitoring of channelled emissions to air

The relevant substances are:

- Dust which will be monitored at least once every six months. Monitoring will be to confirm that filters and containment from shredding, drying and separating are not emitting Dust.

- Metals and Metalloids (Cobalt, Copper, Nickel, and also Aluminium, Manganese and Lithium) will be monitored at least annually. Monitoring will be to confirm that filters and containment from shredding, drying and separating are not emitting these Metals and Metalloids.

All monitioring will be overseen by and validated by independent third parties.

BAT 49: Emissions to Air

See above re the use of cyclones, fabric filters and adsorption.

[3] The LEV systems will be reviewed by LEV engineers and is expected to involve the installation of wet scrubbers as part of the systems. SOCOTEC's specific recommendations included: Ensure the has a log book and system manual. Ensure the log book is completed as required, Fit suitable air flow indicators to allow operators to quickly check that the system is functioning prior to use, Ensure that the strip curtains are maintained regularly and replaced promptly if damaged, Regularly inspect the filters as part of a routine inspection and maintenance programme, Consider replacing some of the flexible ducting with a solid alternative, Consider relocating the filter unit outside of the workplace in an attempt to further limit recirculation of contaminants, If both particulate and gas/vapour filtration is required the two filters should be placed in series. This would allow the particulate to be filtered out, with the remaining air then passing through the activated carbon bed, removing the remaining gases and vapours,

- Ammonia, if used as part of an Ad-blue[4] abatement Selective Catalytic Reduction (SCR) system for diesel generators will be monitored at least every six months. However, if abatement uses a wet scrubber[5] process no pollutants would be involved.

BAT 14 Diffuse Emissions to Air

The techniques of BAT 14 are deployed as follows:

a. Minimising the number of potential diffuse emission sources:

Treatment of 16 06 05 material

Diffuse emissions could arise when material enters or leaves a process stage, eg whole on or dropped from a conveyor into or out of the shredder or dryer, into the separation plant or funnelled into a bag from the separation plant. The use of extraction plant for each stage (shredding, drying and separation) with active carbon filters minimises the risk of Dust being diffused into the air. All pipe work and ducting is sealed (with additional taping around any joints or screw holes through which Dust may be diffused. All extraction plant is contained within covered buildings or dedicated external cabinets (with hatches, flaps or roller doors for access). Where material enters plant for shredding, drying or separation, it is through flaps into the hopper. Given the value of any Dust (it comprises NMC) it is captured in fabric 'sock' filters for recovery.

[4] AdBlue abatement systems use ammonia. AdBlue is a registered trademark for a solution that consists of 32.5% urea and 67.5% deionized water. It is used in Selective Catalytic Reduction (SCR) systems to reduce nitrogen oxide (NOx) emissions from diesel engines. In the SCR process, AdBlue is injected into the exhaust stream, where it undergoes a chemical reaction with the NOx gases. The urea in AdBlue decomposes into ammonia (NH3) when exposed to the high temperature of the exhaust gases. The released ammonia then reacts with the NOx in the presence of a catalyst, converting the harmful nitrogen oxides into nitrogen (N_2) and water (H_2O), which are environmentally benign. The use of ammonia in AdBlue abatement systems is a key component of the SCR technology, which has been widely adopted in the automotive industry to meet stringent emission regulations for diesel engines.

[5] A wet scrubber, also known as a wet scrubber system or wet scrubbing system, is an air pollution control device used to remove pollutants such as nitrogen oxides (NOx) and particulate matter from industrial exhaust gases. Wet scrubbers primarily operate through a process called absorption. It works as follows: Gas Contact: The exhaust gas containing NOx and particulates enters the wet scrubber chamber, where it is brought into contact with a liquid, usually water or a water-based solution. Atomization or Spray: The liquid is atomized or sprayed into the scrubber chamber, creating a fine mist or fog of droplets. The droplets serve as a medium for pollutant capture. Absorption: As the gas and liquid droplets come into contact, a series of physical and chemical processes take place. NOx and other acidic gases can dissolve into the liquid phase through chemical reactions and absorption. Particulates can be captured through mechanisms like impaction, diffusion, or condensation, as they collide and adhere to the liquid droplets. Scrubbing Medium: The liquid in the wet scrubber system acts as a scrubbing medium. It can be recirculated within the system to enhance pollutant removal efficiency. Separation: After the absorption process, the gas and liquid mixture goes through separation devices, such as mist eliminators or demisters, which remove the liquid droplets from the gas stream. Disposal or Treatment: The captured pollutants, including NOx and particulates, are now present in the liquid phase. Depending on the specific requirements and regulations, the liquid effluent may undergo further treatment or be properly disposed of, ensuring that the pollutants are safely managed. Wet scrubbers are effective in removing both NOx and particulates from exhaust gases, making them a versatile and widely used technology in various industries to control air pollution. The specific design and operation parameters of a wet scrubber system can vary depending on the targeted pollutants, gas flow rates, and other factors.

Steam from the dryer

On the current configuration (as set out in the accompanying permit variation documents), the dryer has stack which emits steam (after particulates have been removed by active carbon filters). This will pass finally into a wet scrubber.

b. Selection and use of high integrity equipment

The standard for all equipment from which Dust and other emissions may occur is that they be ATEX, LEV and/or DSEAR rated/ compliant as appropriate/required. Whereas the organic compounds commonly used in lithium-ion battery electrolytes, such as ethylene carbonate (EC), dimethyl carbonate (DMC), diethyl carbonate (DEC), and propylene carbonate (PC), are generally not considered highly corrosive. However, their corrosive properties can vary depending on the specific concentration and conditions of use. As explained in the risk assessmrnt it is also important that no flash point is reached when these compounds are in aqueous solution. Shredding under water in the aqueous system will maintain a flash point above 60C.

c. Corrosion prevention

Equipment is stainless steel, sealed, and / or painted, and/or lubricated to minimise risk of corrosion. Of the material contained in lithium ion battery material:

- lithium nickel Manganese cobalt oxide (NMC) is not inherently corrosive.
- lithium hexafluorophosphate (an inorganic salt used as electrolyte, dissolved in an organic solvent) can be corrosive. It can corrode aluminium[6], stainless steel[7] and copper[8] and given the use aluminium and stainless steel in the plant this risk needs to be mitigated. See above for mitigation of this and flash point risk.
- The various electrolyte compounds are not generally considered corrosive but can exhibit mild corrosive behaviour under some circumstances[9].

[6] Aluminum is highly reactive with fluoride ions, and contact with LiPF6 electrolyte can lead to corrosion of aluminum components.
[7] Certain types of stainless steel alloys, particularly those containing high levels of chromium and nickel, can experience corrosion when exposed to fluoride ions.
[8] Copper is also susceptible to corrosion in the presence of fluoride ions.
[9] The organic compounds commonly used in lithium-ion battery electrolytes, such as ethylene carbonate (EC), dimethyl carbonate (DMC), diethyl carbonate (DEC), and propylene carbonate (PC), are generally not considered highly corrosive. However, their corrosive properties can vary depending on the specific concentration and conditions of use. While these organic solvents are not typically corrosive to metals or other materials, they can exhibit mild corrosive behaviour under certain circumstances. For example, if the electrolyte solution becomes contaminated with water or other impurities, it can increase the likelihood of corrosion.
Moreover, the presence of moisture or high humidity can promote corrosion in the presence of these organic solvents. If there is direct contact between electrolyte solutions or concentrated organic solvents and certain sensitive materials, particularly metals like aluminum, copper, or certain types of stainless steel, it can lead to corrosion or degradation of these materials.

d. Containment, collection and treatment pf diffuse emissions

As explained above all treatment stages take place in enclosed buildings, and with extraction to bag filters, active carbon filters and for shreddinga drying also wet scrubbers..

As part of the continuous improvement programme, the following is being planned:

- Feasibility of all enclosed areas and treatment plant being kept at negative pressure; and
- Supplementing of extraction systems (for Dust control and diesel emissions) with wet-scrubber systems.

e. Dampening

The aqueous shredding process performs a dampening function, mitigating Dust release, as the process is carried out underwater.

f. Maintenance

The maintenance schedule is described in the OTEMS.

g. Cleaning of waste treatment and storage areas

All treatment areas, conveyors and surfaces are cleaned with a combination of vacuum cleaner units and wipe down materials, on a daily basis.

h. Leak detection and repair (LDAR) programme

The only organic compounds present are in the electrolyte. As part of normal operations where electrolyte may be present, the effectiveness of the extraction processes will be confirmed with regular checks using sniffing (i.e. hand held organic compound analysers) and / or hand held optical gas imagers.

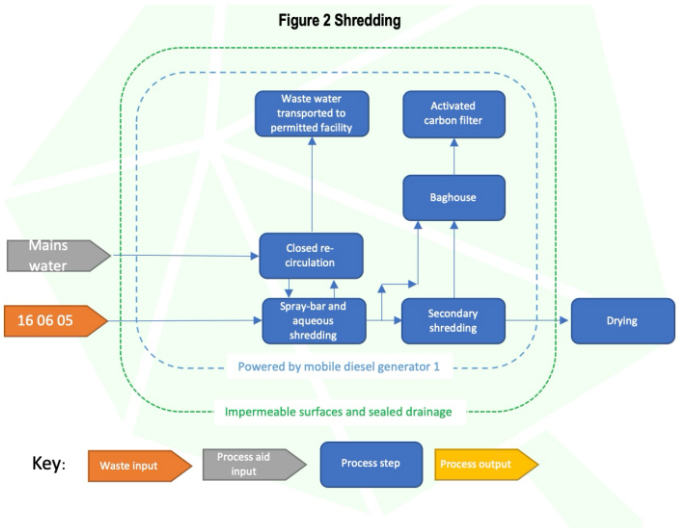
BAT 19: Emissions to water

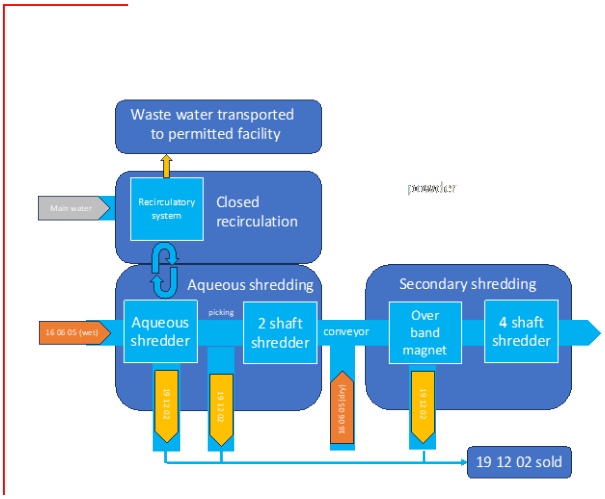
The techniques of BAT 19 are deployed as follows:

a. Water management

Water is only used in the aqueous shredding process, as shown in the diagram below.

Figure 2 Shredding





The volume of water in the system is c. 50,000 litres, which is contained within a closed loop. The water is changed following 2000 MT being processed through the system. If 21 to 42 MT are input each working day, the current expectation is that water will be changed every 10 to 20 weeks. The waste water will contain some electrolyte residue and graphite (material which will pass through the systems screens. Given the presence of the electrolyte residue there is a risk that if the concentration in the aqueous shredding solution exceeds a certain level the flash point of the aqueous solution could fall below 60C. The system and concentration levels will be tested to establish when the solution needs to be replaced to ensure that flashpoint remains above the required level.

b. Water recirculation

See (a) above.

c. Impermeable surface

All areas in the site have impermeable surfaces and sealed drainage.

d. Techniques to reduce the likelihood and impact and overflows and failures from tanks and vessels

The aqueous shredding process is sealed, as is the storage tank for other waste water, and the site itself is sealed and bunded with a capacity to hold over 1 million litres.

e. Roofing of waste treatment storage areas

All waste storage areas are covered as explained in the OTEMS and FPP.

f. Segregation of water streams

The two waste water streams are the water from interceptors and drains and the water from the aqueous shredding. Both are separate and taken away by tanker separately to the appropriate permitted facility for waste water treatment by an appropriately licenced haulier.

g. Adequate drainage infrastructure

The site is bunded and has sealed drainage. All water, including rainwater is stored and transported off site.

h. Design and maintenance provisions to allow detection and repair of leaks

Drainage surveys are carried out for underground components (as provided as part of the baseline report for the site in the Adler and Allan report). All drainage systems and sealing are inspected daily as part of site monitoring and maintenance.

i. Appropriate buffer storage capacity

This is provided through the drainage system and pumping and storage to the waste water tank.

BAT 20: Waste water treatment

No waste water treatment currently occurs at the site, other than that lime is added to the aqueous solution to neutralise any HF and/or H3PO4 which may be present.

BAT 21: Emissions from accidents or incidents

The techniques of BAT 21 are deployed as follows:

a. Protection measures, b. management of incidental/accidental emissions, and c. incident/accident registration and assessment system

These are covered in the OTEMS and FPP.

BAT 23: Energy Efficiency

The techniques of BAT 22 are described in the Energy Efficiency Plan, but in the context of this DEMP it should be highlighted that the site will, subject to successful survey by National Grid be put onto the grid with one iesel generator with thermal input below 1 MW remaining only for emergency back-up.

BAT 25: Emissions to Air

The techniques of BAT 25 are deployed as follows:

a. Cyclone

The only process which uses a cyclone is the dry separation plant, where cyclones convey particles from the comminution process to the sieving process. There are no emissions to air as the particles are conveyed through sealed tubes.

b. Fabric filter

Fabric filters[10] are used in all extraction and filtering systems, in the shredding process, the drying proves and the dry separation process. As illustrated **Annex 5** gives the specifications of dryer bag house filters and the filter material. The filters are designed to keep Dust emissions within the acceptable BAT-Associated emission level (BAT-AEL) for channelled dust emissions to air from the mechanical treatment of waste (as set out in Table 6.3 of the BAT Conclusions document). This sets a BAT-AEL over the sampling period of 2-5 mg/Nm^3 of Dust. As shown in **Annex 6** and the independent stack test performed by SOCOTEC the MCERTS testing for Total Particulate Matter had a result of 0.33 mg/m^3 (and 3.39 g/hr) within calculated uncertainties of +/- 0.65 (6.78). The filter is therefore considered to be effective in ensuring the BAT-AEL is adhered to. As soon as permitted, the same test will be performed on the shredders, al/cu separation unit and dryer, to ensure they are operating within the BAT-AEL limit.

c. Wet scrubbing

See footnote 2 above, and wet scrubbing will supplement bag filters and active carbon filters for dust and VOC abatement at the shredding and drying/cooling stages.

d. Water injection into the shredder

The aqueous shredder, as described above, performs this function (see earlier description), as well as being a means of implementing BAT 27.

[10] Fabric filters, often referred to as bag filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a fabric filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.

BAT 27: prevention and reduction of emissions from deflagrations

The nature of lithium-ion batteries, and specifically the presence of electrolyte compounds means that deflagrations can occur if appropriate preventative measures are not put in place. The following techniques are deployed.

a. Deflagration management plan

This DEMP and the OTEMS of which it forms part are the deflagration management plan. Deflagration can occur if electrolyte in lithium-ion battery material is ignited by sparks from the shredding or cutting blades. This is prevented by the use of the aqueous shredding system described above.

b. Pressure relief dampers

The aqueous shredding process means that pressure relief dampers are not necessary.

c. Pre-shredding

The aqueous shredding process means that pre-shredding is not necessary. Secondary shredding occurs after the aqueous shredding has taken place.

Note that deflagration could occur if, in particular, polymer material is heated to its ignition point (c. 400 degrees centigrade) in the dryer. The operating temperature of the dryer is kept below this level. Explosivity testing is being carried out on all materials, which will also determine whether any process is in the scope of DSEAR.

BAT 28: Energy Efficiency

The shredder feed is kept stable with a regular interval between lithium ion battery modules entering the aqueous shredding system.

BAT 29: Emissions to Air

The following technique is deployed:

a. Adsorption

This involves a heterogeneous reaction in which gas molecules are retained on a solid or liquid surface that prefers specific compounds to others and thus removes them from effluent streams. When the surface has adsorbed as much as it can, the adsorbent is replaced or the adsorbed content is desorbed as part of the regeneration of the adsorbent. When desorbed, the contaminants are usually at a higher concentration and can either be recovered or disposed of. The most common adsorbent is granular activated carbon.

All processes have active carbon filters. These will be supplemented by wet scrubber units.

BAT 30: Explosions

Materials are being tested for determine whether processes fall within the scope of DSEAR. The management of explosions comes from adherence to DSEAR requirements. The risk may occur in two places: in the dryer if temperatures exceed safe levels and in the dry separation line if the particulates are ignited (eg by a spark). The dry separation line is ATEX rated and use forced ventilation (with directional venting). The initial plan for DSEAR adherence is contained in the independent report by Stallard Kane, which will be repeated for all other plant. The dryer unit will also have an inert gas blanket installed to further mitigate this risk. Other mitigations, including the risks from hot works, are covered in the OTEMS and FPP.

BAT 41: Emissions to Air

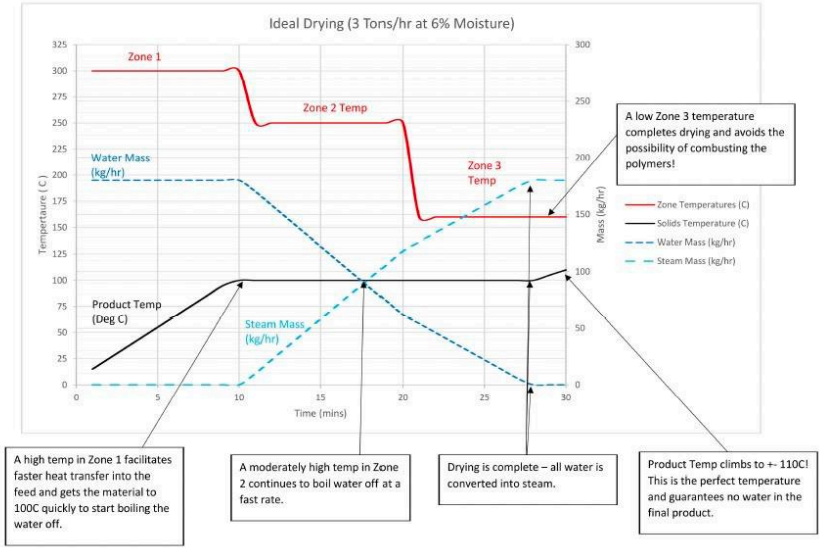
See BAT 29 above

Annex 2: Generators and Steam

LSL intends to move its power source to the national grid. One diesel generator would serve as an emergency back up generators, being an AKSA generators AD410(EU) generator with a rated thermal input of less than 1 MW.

In addition, the dryer emission point produces steam (H2O) generating 561,000 kg of steam for an annual running of 3,120 hours a year. This passes through a bag filter and an active filter and then into a wet scrubber where it will be condensed (i.e. the wet scrubber will operate as a condenser). A chart showing the curve of steam production is attached at the end of this Annex.

Water emissions from dryer (without condensation system)



Annex 3: Wet scrubber

AUTO EXTRACT SYSTEMS

A.E.S. 34775/CG

The following specification and subsequent quotation is to be considered budgetary pending receipt of the materials Dust Report, Hazardous Area Classification document (HAC) and MSD (if available) as discussed during the site visit.

System design parameters are as per the Control of substances Hazardous to Health 2002 (Amended), Regulation 7, Schedule 2A as per HSG 258 Controlling Airborne Contaminates at Work.

Further consideration has been made as per the Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) and IEC 60079-10 Hazardous Area Classification.

The below system is specified to be placed externally in non-hazardous areas (as defined under IEC 60079) and is not rated under 2014/34/EU ATEX Equipment Directive for use in Hazardous Areas.

Scope of Works.

- Supply and fit AES RotoClone Wet Collector with required additional controls for capture and control of lithium dust. Details below.
- Supply and fit interconnecting smooth bore clip safe ducting including all fixtures and fittings to connect to existing 250mm diameter spigot from shredder enclosure.
- Supply and Fit inline Explosion Proof Isolation (Non-Return) Flap Valve with interconnecting 3mm fully welded explosion proof ducting between valve and filter (valve details below).
- We have included LEV Commissioning.
- We have included working at height access equipment.

Please note: Current assumptions include:

- The wet collector being placed externally in a safe location with adequate clearance around.
- Electrical works and water connections are provided by others.
- Ducting route is no more than 10mtrs.

RotoClone

AES AAF Rotoclone Wet Dust Collector made from Carbon steel complete with:

- Overflow Weir including electronic water control.
- Exterior C3 Standard Paint RAL 7074.
- Interior 200micron Bituamous Paint.
- Backward Laminar floor-mounted fan set c/w 7.5kW motor and Anti-vibration mounts and attenuation.
- Control panel including soft start for 7.5kW and hawker level control (non-hazardous area only).
- Panel and Water Level Control commissioning in the UK.

Auto Extract Systems Ltd, D16 Rivington Court, Moss Industrial Estate, Leigh, Greater Manchester, WN7 3PT
+44 (0)1942 267 444 | info@autoextract.co.uk
autoextract.co.uk

Explosion Isolation Flap

- **BFV250MS-ST3(300)**
- Explosion Isolation Valve Normally open flap Size: DN250 (10")
- Construction: Mild steel (powder coated RAL 3000) ST3 Class (Kst up to 300 bar.m/s)*
- Includes:
  - BFV Counter Flanges
  - BFV Position indicator (24v DC)
  - BFV Dust Sensor (24v DC)

**Including metallic dusts (Kst up to 350 bar.m/s)*

This new extraction wet filter will be placed externally in a suitable area consisting of a solid base such as concrete, that will be flat, level and suitably thick.

NB: A.E.S will not cut any asbestos material; if asbestos is found or suspected then the client will require a specialist contractor to cut the outlet(s) at his cost.

All electrical connections and interconnecting wiring to our extraction fan and the loose provided starter is not included in the contract price and will be carried out by others.

The proposed system is designed to fully comply with the latest H.S.E guidance. It is also designed for 100% utilisation (E.g. all points open at once). The specified 'duty-point' of any system can make significant differences to the final cost to any comparative quotation. All extraction fans have manufacturer supplied fan curves where choosing the appropriate fan is vital to the outcome of the system design. Using an inferior extraction fan (Kw) with either reduced design Airflow (m3/h) or reduced Pressure (Pascal's) can save money but would seriously impact on the extraction rates achieved.

Total Price for the above works will be £ 43,207.00 plus V.A.T at current rate.

NB: - Due to the unprecedented circumstances affecting the supply of many raw materials which is affecting many industries, our prices cannot be held for more than 30-days and are subject to change.

Inclusion/Exclusions List

Description	Auto Extract Systems	Client
Exhaust Extraction Equipment as Detailed Above	*	
Extraction Fan(s) & Outlet Transition(s) as Detailed Above	*	
Spiral Ductwork & Fittings	*	
Bracketry/Supports for Ductwork	*	
Any Lagging or Insulation of Ductwork		*
Any Pressure Testing of Ductwork		*
Deliveries of Equipment to Site	*	
Offloading of Deliveries on Site		*
Forklifts / Telehandlers / Cranes & Operatives for Positioning		*
Safe Powered Access Equipment to Install the System(s)	*	
Any Fixed Scaffolding / Roof Anchorage Systems		*
Building Works (Sealing Around Holes / Cutting Ceiling Tiles etc.)		*
Mechanical Installation	*	
Main Electrical Supply to Within 10-metre of Fan Motor(s)		*
Final Electrical Wiring Connections		*
Electrical Works / Replacement Parts Due to Incorrect Wiring by 3rd Parties		*
CAD Drawings	Optional - POA	
Commissioning	*	

L.E.V Testing

A free of charge L.E.V test / commission will be carried out following completion of the electrical wiring of the above system(s).

The L.E.V testing of all Local Exhaust Ventilation (L.E.V) systems is a `legal requirement` in Law.

Regulation 9 of the CoSHH Regulations requires that all control measures, e.g. Local Exhaust Ventilation (L.E.V's), provided by an employer are properly maintained, regularly examined, and thoroughly testing of an on-going basis and records kept. It specifically states that:

(1) Every employer who provides a control measure should ensure that it is maintained in an efficient state, good repair, and good working order.
(2) L.E.V plant must be examined & tested at least every 14-months. Some substances and processes are subject to a shorter interval.
(3) A record of the examination and test should be kept for at least 5-years (and must be available for inspection by H.S.E inspectors upon request)

After the system(s) has been electrically wired and confirmation received by our office, an initial appraisal test will be carried out. This initial comprehensive report forms the benchmark for the system(s) for year one and for the following annual on-going test(s) in subsequent years. All documentation including manuals and product information will be available to view through our secure website portal.

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Annex 5: Specifications of dryer bag house filters and the filter material

The dryer filters use fans with the following specifications:

Dryer section

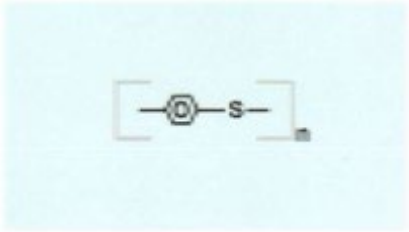
Fan Designation	**BC15 Size 450 A/1.0 Single Inlet Arr 4**
Impeller Type	Backward Curved Blade
Operating Speed	2850 r/min
Drive Arrangement	**Direct Drive, Via VSD by othe**
Finish	Our Standard Paint
Motor Details	**1.5kW 2 Pole**
Make	WEG IE3
Enclosure	TEFC
Electrical Supply	380V/3Ph/50Hz
Fan Duty	
Flow Medium	Air
Volume	**1500** Am³/hr
Static Pressure	**1.5** kPa at 0.92kg/m³
Absorbed Power	**0.8** kW at 0.92kg/m³ (110°C)
Operating Temp.	110°C

Rotary cooler section

Fan Designation	**BC25 Size 400 B/0.9 Single Inlet Arr 4**
Impeller Type	Backward Curved Blade
Operating Speed	2850 r/min Via VSD by Others
Drive Arrangement	**Direct Drive**
Finish	Our Standard Coastal Paint
Motor Details	**1.5kW 2 Pole**
Make	WEG IE3
Enclosure	TEFC
Electrical Supply	380V/3Ph/50Hz
Fan Duty	
Flow Medium	Air
Volume	**1500** Am³/hr
Static Pressure	**1.5** kPa at 1.2kg/m³
Absorbed Power	**0.8** kW at 1.2kg/m³ (20°C)
Operating Temp.	20°C

Both Baghouses make use of 36 OFF PPS Cloth and Cage Filter Socks each in a 6x6 layout. I have attached the datasheet of the PPS Filter Cloth Material above. Both Baghouses have reverse pulsing systems for cyclic cleaning of the bags. At the maximum fan flow rate of 1500m^3/hr, the Bags have an air to cloth ratio of 0.02m/s (3.9Ft/minute). The filter material specification is shown overleaf.

THE POLYPHENYLENSULPHIDE FIBRE (PPS)



The PPS fiber, developed in 1973 in the USA is now distributed by the Amoco Company (Ryton®, among others, as a high grade fiber. The PPS fiber (Sulfar Fiber) is made from p-dichlorobenzene and sodium sulphide. The spinning is accomplished by a melt spinning process.

The very good resistance to hydrolysis, alkalis, and acids has permitted, under certain circumstances, that the PPS fiber will be an alternative to PTFE fiber. The main field of application for PPs filter media is in the sphere of firing or heating systems of all kinds.

Typical Characteristics:

- Thermoplastic
- Insoluble
- High resistance against hydrolysis
- Self extinguishing in open air

The Specific Characteristics of the Polyphenylene-Sulphide Fibre

Thermostability	Constant: 190°C or Maximum: 200°C
Melting Point	280°C - 290°C
Spontaneous Combustion Temp.	500°C
LOI - Value	39 – 41 %
Density	1.37 g/cm³
Tensile Strength (Standard Conditions)	50 cN/tex
Moist Uptake	0.6% at 65% rel.humidity &21°C
Resistance to Hydrolysis	Excellent
Resistance to Acids	Excellent
Resistance to Alkalis	Excellent
Resistance to Oxidation	Moderate
Resistance to Organic Solvents	Excellent

Annex 6: SOCOTEC stack test results on dry separation line

STACK EMISSIONS MONITORING REPORT

SOCOTEC

Units C & D
Bankside Trade Park
Cirencester
GL7 1YT
Tel: 01285 700 593

Your contact at SOCOTEC LTD
Mike Davies Business Manager - South Tel: 07976 297 465 Email: mike.davies@socotec.com

Operator & Address:
Lincoln Storm Ltd Worle Quarry Lower Kewstoke Road Weston-super-Mare BS22 9LF

Permit Reference:
EPR Permit: EPR/BB3139RA/V002

Release Point:
Main Stack

Sampling Date(s):
17th March 2023

SOCOTEC Job Number:	LSO 230335
Report Date:	27th March 2023
Version:	1
Report By:	Jose Navarro
MCERTS Number:	MM 19 1542
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Mike Davies
MCERTS Number:	MM 02 087
Business Title:	MCERTS Level 2 - Business Manager
Technical Endorsements:	1, 2, 3 & 4
Signature:	

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Lincoln Storm Ltd operates a shredded cells to break up and disintegrate metals process at Weston-super-Mare which is subject to EPR Permit EPR/BB3139RA/V002, under the Environmental Permitting Regulations 2010.

SOCOTEC LTD were commissioned by Ray Wiggan to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, EPR/BB3139RA/V002.

Plant

Main Stack

Operator

Lincoln Storm Ltd
Worle Quarry
Lower Kewstoke Road
Weston-super-Mare
BS22 9LF

EPR Permit: EPR/BB3139RA/V002

Stack Emissions Monitoring Test House

SOCOTEC - Cirencester Laboratory
Units C & D
Bankside Trade Park
Cirencester
GL7 1YT
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
The results of this testing relate only to the emission release point(s) listed in the report.
MCERTS accredited results will only be claimed where both the sampling and analytical stages are MCERTS accredited.

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	Units	Result	Calculated Uncertainty +/-	Emission Limit Value (ELV)	Accreditation
Total Particulate Matter	mg/m³	0.33	0.65	-	MCERTS
Particulate Emission Rate	g/hr	3.39	6.78	-	
Moisture	%	1.16	0.04	-	MCERTS
Stack Gas Temperature	°C	21	-	-	MCERTS
Stack Gas Velocity	m/s	15.9	0.39	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	11261	579	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	10328	531	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	10209	525	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	10328	531	-	

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.

Reference conditions are 273K, 101.3kPa without correction for water vapour

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Total Particulate Matter Run 1	17 March 2023	08:45 - 09:45	60 minutes
Preliminary Stack Traverse	17 March 2023	08:20 - 08:30	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Shredded cells to break up and disintegrate metals
Continuous or batch	Continuous
Product Details	Delamination and Separation Plant
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Normal, i.e. 1.5 tonne/hr average (max 2 tonne/hr)
Fuel used during monitoring	N/A
Abatement	Bag filter
Plume Appearance	Plume visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency technical Guidance 'Monitoring stack emissions: techniques and standards for periodic monitoring'.

MONITORING METHODS							
Species	Method Standard Reference Method / Alternative Method	SOCOTEC Technical Procedure	UKAS Lab Number	Method Accreditation	Limit of Detection (LOD)	Calculated MU +/- % Result	Calculated MU +/- % ELV
Total Particulate Matter	SRM - BS EN 13284-1	AE 104	1015	MCERTS	0.33 mg/m³	200%	N/A - No ELV
Moisture	BS EN 14790	AE 105	1015	MCERTS	0.01%	3.2%	N/A - No ELV
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	5 Pa	2.4%	N/A - No ELV
Volumetric Flow Rate	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	-	5.1%	N/A - No ELV

BS EN 14790 has been validated over a range of 4 - 40%. It is however the prefered method of the Environment Agency for concentrations below 4%

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody details. Unless otherwise stated the samples are archived at the analysis lab location.

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Analysis Accreditation	Analysis Lab	Analysis Report No. Date of Analyis	Archive Period
Total Particulate Matter	Gravimetric	AE 106	1015	MCERTS	SOCOTEC (Cirencester)	N/A	8 Weeks

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Moisture	Gravimetric	AE 105	1015	MCERTS	SOCOTEC Cirencester	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	Value	Units	Requirement	Compliant	Method
Lowest Differential Pressure	186	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	15.5	m/s	-	-	-
Highest Gas Velocity	16.5	m/s	-	-	-
Ratio of Gas Velocities	1.1	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	15.9	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes	BS EN 15259
No local negative flow	Yes	-	-	Yes	BS EN 15259

DUCT CHARACTERISTICS		
	Value	Units
Shape	Circular	-
Depth	0.50	m
Width	-	m
Area	0.20	m^2
Port Depth	50	mm

SAMPLING LINES & POINTS		
	Isokinetic	Non-Iso & Gases
Sample port size	4" BSP	-
Number of lines used	1	-
Number of points / line	4	-
Duct orientation	Vertical	-
Filtration	In stack	-
Filtration for TPM	QF	-

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Permanent
Inside / Outside	Outside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	Yes
Platform has removable chains / self closing gates at the top of ladders	Yes
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	No

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements as specified in current EA Guidance.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Sample points

Only one Port available due to platform size/shape.

APPENDICES

CONTENTS

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	Method Standard Reference Method / Alternative Method	SOCOTEC Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
Total Particulate Matter	SRM - BS EN 13284-1	AE 104	1015	MCERTS	1
Moisture	BS EN 14790	AE 105	1015	MCERTS	1
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	P2947	Horiba PG-350 Analyser	-	Laboratory Balance	P3225
Box Thermocouples	P2947	FT-IR	-	Tape Measure	P3136
Meter In Thermocouple	P2947	FT-IR Oven Box	-	Stopwatch	P1343
Meter Out Thermocouple	P2947	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P2947	Signal 3030 FID	-	Barometer	P341
Oven Box	-	Servomex	-	Digital Micromanometer	P1940
Probe		JCT Heated Head Filter	-	Digital Temperature Meter	P2675
Probe Thermocouple	P2971	Thermo FID	-	Stack Thermocouple	P2322
Probe		Stackmaster	-	Mass Flow Controller	P3226
Probe Thermocouple		FTIR Heater Box for Heated Line	-	MFC Display module	P3289
S-Pitot	P1587	Anemometer	-	1m Heated Line (1)	-
L-Pitot		Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P2769	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	P2208	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	-
Inclinometer (Swirl Device)	P2594			20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES

Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
-	-	-	-	-	-

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	MCERTS Number	MCERTS		TE / H&S Qualifications and Expiry Date				
		Level	Expiry	TE1	TE2	TE3	TE4	H&S
Jose Navarro	MM 19 1542	MCERTS Level 2	Jun-24	Oct-25	Dec-25	Dec-25	Nov-25	Jun-24
Alistair Holmes	MM 13 1218	MCERTS Level 1	Jan-24	-	-	-	-	Mar-28

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY					
Parameter	Sampling Times	Concentration mg/m³	Uncertainty mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	08:45 - 09:45 17 March 2023	0.33	0.65	-	3.4
Blank	-	0.33	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

Acetone Blank Value mg/l	Acceptable Value mg/l
0.3	10

FILTER INFORMATION

SAMPLES								
Test	Filter & Probe Rinse Number	Filter Start Weight g	Filter End Weight g	Mass Gained on Filter g	Probe Rinse Start Weight g	Probe Rinse End Weight g	Mass Gained on Probe g	Combined Total Mass Gained g
Run 1	317630	0.14348	0.14344	-0.00004	85.29310	85.29320	0.00010	0.00050

If total mass gained is less than the LOD then the LOD is reported

BLANKS								
Test	Filter & Probe Number	Filter Start Weight g	Filter End Weight g	Mass Gained Filter g	Probe Start Weight g	Probe End Weight g	Mass Gained Probe g	Combined Total Mass Gained g
Run 1	317629	0.14367	0.14358	-0.00009	89.29430	89.29440	0.00010	0.00050

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — TPM

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	Kpa	100
Stack static pressure, P_{static}	pa	140
$P_s = P_b + P_{static}$	Kpa	100.1
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	14.2
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0176932
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		1.610
Gas meter correction factor, Y_d		1.011
Mean dry gas meter temperature, T_m		292
Mean pressure drop across orifice, DH	mmH_2O	74.180
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	1.513
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.5304
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		20.9
% oxygen reference condition		21
O_2 Reference Factor $O_2\ Ref = \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0116
	%	1.16
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	213.64
Mean stack gas temperature, T_s	K	294
Gas density $_{(wet,\ ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.176
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	16.00

Molecular weight of dry gas, M_d		
CO_2	%	0.03
O_2	%	20.90
Total	%	20.93
N_2 (100 -Total)	%	79.07
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.84
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.72
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.20
$Q_a = (60)(A_s)(V_s)$	m^3/min	188.6
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	170.9
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	172.92
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.15
Nozzle area, A_n	mm^2	29.71
Total sampling time, q	min	60
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	97.5
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	-0.00004
Mass collected in probe, M_p	g	0.00010
Total mass collected, M_n	g	0.00050
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.327
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.331
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		3.39

As the total mass gained was less than the LOD, the LOD has been reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST

LEAK RATE						
Run	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Acceptable Leak Rate litre/min	Leak Tests Acceptable?
Run 1	27.13	0.14	-	-406.4	0.54	Yes

In BS EN 13284-1:2017 a post sampling leak check is not required.

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	97.49	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.33	No ELV	N/A - No ELV

The above is based on both the Filter and rinse uncertainty

BLANK VALUE				
Run	Overall Blank Value mg/m^3	Daily Emission Limit Value mg/m^3	Acceptable Blank Value mg/m^3	Overall Blank Acceptable mg/m^3
Blank 1	0.33	-	-	-

FILTERS					
Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-use Filter Conditioning Temperature °C	Post-use Filter Conditioning Temperature °C
Run 1	Quartz Fibre	47	22	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	08:45 - 09:45 17 March 2023	2.7966	2.8108	0.0142	1.2	0.01	3.2

Moisture Quality Assurance							
Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	60	1530	27.1	0.14	-	0.54	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.50	m
Stack Width, W	-	m
Stack Area, A	0.20	m^2
Average stack gas temperature	21	°C
Stack static pressure	0.14	kPa
Barometric Pressure	100	kPa

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m^3 p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m^3 pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m^3 pi
CO_2	44	1.963059	0.028571	0.000286	0.000561	0.028241	0.000282	0.000554
O_2	32	1.427679	20.900000	0.209000	0.298385	20.658365	0.206584	0.294935
N_2	28	1.249219	79.071429	0.790714	0.987775	78.157247	0.781572	0.976355
H_2O	18	0.803070	-	-	-	1.156147	0.011561	0.009285

Where: p = M / 22.41 pi = r x p

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2867	kg/m^3
Wet Density (STP), P_{STW}	1.2811	kg/m^3
Dry Density (Actual), P_{Actual}	1.1801	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.175	kg/m^3

Where:

P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

$P_{STW} = (P_{STD} + pi \text{ of } H_2O) / (1 + (pi \text{ of } H_2O / 0.8036))$

$P_{Actual} = P_{STD} \times (Ts / Ps) \times (Pa / Ta)$

$P_{ActualW} = P_{STW} \times (Ts / Ps) \times (Pa / Ta)$

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	17 March 2023
Time of Survey	08:20 - 08:30
Velocity Measurement Device:	S-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	DP pt Pa (average of 3 readings)	DP pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.05	199.3	20.3	21	15.5	3.0	-	<15
2	0.13	199.3	20.3	22	15.5	3.0	-	<15
3	0.38	222.1	22.7	21	16.3	3.2	-	<15
4	0.45	225.4	23.0	21	16.5	3.2	-	<15
Mean	-	211.5	21.6	21	15.9	3.1	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value mmH2O	End Value mmH2O	Difference %	Outcome	Start Value mmH2O	End Value mmH2O	Difference %	Outcome
Run 1	140	138	1.4	Pass	138	137	0.7	Pass

To complete a compliant pitot leak check a pressure of over 80 mmH_2O (or 800 Pa) is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

S-Type Pitot Stagnation Check				
Run	Stagnation (Pa)	Reference (Pa)	Difference (Pa)	Outcome (Permitted +/- 10 Pa)
Run 1	140	143	-3.0	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Average Differential Pressure	199	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	15.5	m/s	-	-
Highest Gas Velocity	16.5	m/s	-	-
Ratio of Gas Velocities	1.1	-	< 3 : 1	Yes
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes
No local negative flow	Yes	-	-	Yes

Calculation of Stack Gas Velocity, V		
Velocity at Traverse Point, V = K_{pt} x (1-e) * Ö(2 * DP_{pt} / $P_{ActualW}$)		
Where: K_{pt} = Pitot tube calibration coefficient (1-e) = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, Va	**15.9**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	21	0	°C
Total Pressure	100.14	101.3	kPa
Oxygen	20.9	21	%
Moisture	1.16	1.16	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	15.93	m/s
Stack Area (A)	0.20	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	11260.94	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	10328.07	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	10208.66	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	10328.07	m^3/hr

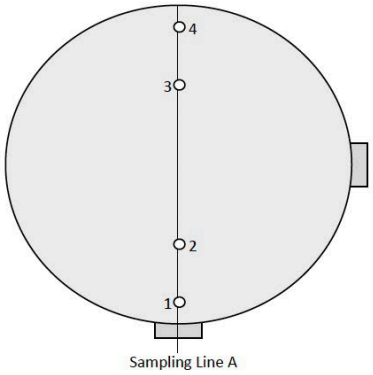
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

Nomenclature:
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % Vol
O_2a = Oxygen, Actual Conditions, % Vol
O_2s = Oxygen, Reference Conditions, % Vol

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK DIAGRAM

	Value	Units
Stack Depth	0.50	m
Stack Width	-	m
Area	0.20	m^2



○ Isokinetic sampling point
● Isokinetic sampling points not used
● Non Isokinetic/Gases sampling point

Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
-	-	-	-

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	10.0	0.05	< 15
2	25.0	0.13	< 15
3	75.0	0.38	< 15
4	90.0	0.45	< 15
-	-	-	-
-	-	-	-
-	-	-	-
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-	-	-	-
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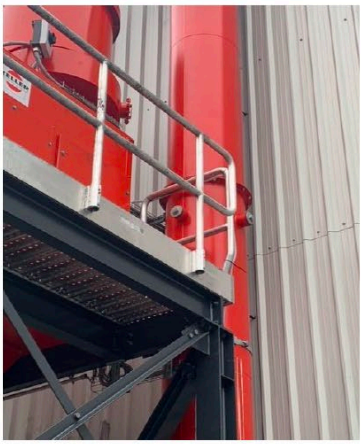
-	-	-	-

SAMPLING LOCATION



APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER

Run	Sampled Volume m^3	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Limit of Detection % by mass	Leak %	Uncollected Mass mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5% of ELV**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.003	2.0	0.50	1.0	N/A	0.5000	-	-
as a %	0.20	0.68	0.50	1.0	N/A	N/A	0.52	N/A
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**N/A**	**Yes**	**N/A**

Run	Volume (STP) m^3	Mass of particulate mg	O_2 Correction -	Leak mg/m^3	Uncollected Mass mg	Combined uncertainty
Run 1	1.39	0.5000	1.0	0.0010	0.00029	-
MU as mg/m^3	0.00	0.3267	-	0.0010	0.00019	**0.33**
MU as %	1.33	100.0000	-	0.298	0.0577	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.65**	**mg/m^3**	**200.02**	**% Result**	**N/A**	**% ELV**

(k is a coverage factor which gives a 95% confidence in the quoted figures)
Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume m^3	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**
Run 1	0.0030	2.0	0.50	1.0	N/A	-
as a %	0.20	0.68	0.50	1.0	N/A	0.52
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**

Run	Volume (STP) m^3	Mass Gained mg	O_2 Correction -	Leak mg/m^3	Uncollected Mass mg	Combined uncertainty
Run 1	1.39	14200	1.0	27.97	58	-
MU as % v/v	0.02	0.008	-	0.004	0.005	**0.02**
MU as %	1.33	0.70	-	0.30	0.41	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.04**	**% v/v**	**3.17**	**%**

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	15.9	m/s
Measured Volumetric Flow rate at Actual Conditions	11261	m³/hr

Performance Characteristics & Source of Value	Units	Values	Requirement	Compliant
Uncertainty of Local Gas Velocity Determination				
Uncertainty of pitot tube coefficient	-	0.010		
Uncertainty of mean local dynamic pressures	-	1.68		
Factor loading, function of the number of measurements.	3 readings	0.591	minimum 3	Yes
Range of measurment device	pa	1000		
Resolution	pa	1.00		
Calibration uncertainty	pa	32.43	<1% of Value or 20 Pa whichever is greater	Yes
Drift	% range	0.10		
Linearity	% range	0.06	<2% of value	Yes
Uncertainty of gas density determination				
Uncertainty of molar mass determination	kg/mol	0.00003		
Uncertainty of temperature measurement	K	1.50	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	511		
Uncertainty associated with the calculation of density	kg/m3	0.007		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0002		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.20
Expanded uncertainty at a 95% Confidence Interval	0.39

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval	%
Expressed as a % of the Measured Velocity	1.2
Expanded uncertainty at a 95% Confidence Interval	2.4

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	295
Expanded uncertainty at a 95% Confidence Interval	579

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval	%
Expressed as a % of the Measured Volumetric Flow Rate	2.6
Expanded uncertainty at a 95% Confidence Interval	5.1

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

END OF REPORT

Thank you for choosing SOCOTEC for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink