Environmental Permit Application – Supporting Documentation Appendix E1 - Air Emissions Risk Assessment

Sawston Pilot Plant

Immaterial Limited

Unit 3, Cambridge South Business Park, Sawston, Cambridge, CB22 3FG

Prepared by:

SLR Consulting Limited

Floor 3, 86 Princess Street, Manchester, M1 6NG

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1.0 Introduction

This Air Emissions Risk Assessment (AERA) has been prepared in support of an application for a new bespoke Environmental Permit (EP) for an Installation to operate a Schedule 1 Part 2 Section 4.1 Part A(1) (a) activity 'Producing organic chemicals such as – (vii) organometallic compounds'.

The Operator will be Immaterial Limited (Immaterial), and the site is located at Unit 3, South Cambridge Business Park, Sawston, Cambridge, CB22 3FG (the Site).

The Site location is illustrated in Figure 1-1, showing the indicative locations of the proposed air emission release points.

Figure 1-1: Site Context

Aerial Imagery Source: Google Maps

1.1 Assessment Scope

The purpose of this AERA is to quantify potential impacts associated with process emission releases to the environment. A risk-based approach has been adopted focussing comprising the following volatile organic compounds (VOCs):

- Ethanol; and
- Acetic Acid.

The scope of the assessment is based on the approach prescribed within the EA's AERA guidance[1].

As per the EA's AERA guidance, VOC emission releases are not listed as a primary or secondary pollutant that requires consideration of ecological impacts. Therefore, the objective of this assessment is to determine the extent of potential air quality effects on human health.

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

2.0 Environmental Standards

Environmental standards for the VOC pollutants considered in this assessment have been established from guidance.

The AERA guidance provides environmental ambient thresholds for the protection of health, based on relevant legislation and Environmental Assessment Levels (EALs) defined by the EA. Where no EALs are provided within the EA's AERA guidance, a review of available research and information for each substance has been conducted to derive EALs.

The current AERA guidance includes EALs for acetic acid. There are EALs for ethanol provided in earlier versions of the methodology (H1) that have since been withdrawn. To enable the assessment of the impact of ethanol, the withdrawn H1 EALs have been used.

Table 2-1 sets out the environmental standards applied in the assessment. These are collectively termed Air Quality Assessment Levels (AQAL) throughout this report.

Table 2-1: Applied Human AQALs

Pollutant	AQAL		Source
	Averaging Period	µg/m^3	
Ethanol	Annual Mean	19,200	H1
	1-Hour Mean	576,000	H1
Acetic Acid	Annual Mean	250	AERA EAL
	1-Hour Mean	3,700	AERA EAL

3.0 Assessment Methodology

The assessment has been undertaken based on the approach prescribed within the EA AERA guidance.

3.1 Effective Release Height and Dispersion Factors

Table 3-1 provides the effective release height and dispersion factors used for each emission release point in the assessment.

The exact locations of the emission points are still to be finalised, but all emission points to air will be routed to the northwestern side of the building and grouped adjacent to each other (See Figure 1-1 and Figure 4 within Appendix A of the main technical supporting document).

All emission points will be located 3m above the maximum height of the building. However, will be fitted with a rain cap which will limit vertical emission velocity. As such, all emission points are assumed to have an effective release height of 0m.

Table 3-1: Effective Release Height and Applied Dispersion Factors

ID	Stack Height AGL (m)	Maximum Building Height AGL (m)	Stack Height Above Building (m)	Effective Release Height (m)	Dispersion Factor (µg/m^3/s)	
					Long-Term	Short-Term
A1	16.3	13.3	3.0	0	148	3,900
A2	16.3	13.3	3.0	0	148	3,900
A3	16.3	13.3	3.0	0	148	3,900
A4	16.3	13.3	3.0	0	148	3,900
A5	16.3	13.3	3.0	0	148	3,900
A6	16.3	13.3	3.0	0	148	3,900
A7	16.3	13.3	3.0	0	148	3,900

3.2 Background Datasets

The assessed VOCs (Table 2-1) are not routinely monitored or measured in the UK. Background concentrations of the VOCs are assumed to be negligible, as it is unlikely that other releases would occur in the surrounding environment.

The AERA has been developed to consider process emissions from all Site operations. This ensures that potential cumulative air quality impacts are adequately assessed.

3.3 Outputs

Predicted pollutant concentrations are summarised in the following formats:

- Process contribution (PC) – the predicted contributions from the Site; and
- Predicted environmental concentration (PEC) – the resultant predicted concentration (i.e. PC + ambient background concentration value).

As per Section 3.2, background concentrations are assumed to be negligible, and all Site processes have already been considered within the context of the PC. The PC is therefore inherently cumulative and is reflective of the PEC.

3.3.1 Operational Envelope

The AERA has considered 1-hour and annual mean impacts associated with VOC emission releases (Section 2.0). The treatment of these outputs is discussed in further detail for each pollutant (Section 4.0).

The emission calculations focus on determining the maximum actual hourly release for each emission point, based on a 24/7 operation. Although a 24/7 process comprises a series of independently operating batch stages that do not release emissions continuously at each emission point. With regards to the treatment of the modelled outputs:

- **Short Term**: The assessment considers the actual maximum hourly emissions from each emission point, collectively assuming that emissions from every process could be released simultaneously within a single hour. This approach represents a composite worst-case scenario assuming simultaneous operation; and
- **Long Term**: The assessment assumes the actual maximum hourly emissions from each emission point occur continuously across the year, without adjustment e.g. 100%. This is a conservative approach because all emission points (excluding A5 and A6) do not release emissions continuously, even during 24/7 operation.

This methodology results in a conservative, worst-case assessment of potential impacts.

3.4 Assessment Criteria

Table 3-2 provides details of the AERA screening assessment criteria. It is conducted in two separate stages.

Table 3-2: AERA Screening Assessment Criteria

AQAL	Stage 1	Stage 2
Long Term AQAL	PC <1% the AQAL	PEC <70% of the AQAL
Short Term AQAL	PC <10% the AQAL	PC is <20% of the difference between the short-term AQAL minus twice the long-term background concentration

If emissions cannot be screened out at Stage 1, the assessor must proceed to Stage 2. If both Stage 1 and Stage 2 screenings fail, detailed modelling of emissions should be conducted.

As per Section 3.2, background concentrations are assumed to be negligible, and all Site processes have already been considered within the context of PCs. Therefore, it is not possible to perform Stage 2 for the assessment of short-term AQALs. In lieu of this, further assessment has been undertaken, comprising the calculation of the PEC for comparison with the relevant AQAL to inform the likelihood of risks arising.

4.0 Emission Quantification

Emission input data has been provided by Immaterial Limited.

Table 4-1 details the emission sources considered within the AERA. These are based on the emission points with a known VOC release.

Table 4-1: Summary of Emission Sources

Emission Point	Detail	Vent Diameter (m)	VOC
A1	Reactor	0.050	Ethanol and Acetic Acid
A2	Reactor	0.050	Ethanol and Acetic Acid
A3	Dewatering Buffer Tank Charging	0.050	Ethanol and Acetic Acid
A4	Blender	0.040	Ethanol and Acetic Acid
A5	Tray Dryer	0.040	Ethanol and Acetic Acid
A6	Tray Dryer - Activation	0.040	Ethanol
A7	Solvent Exchange	0.065	Ethanol and Acetic Acid

Note that the tray dryers that discharge via emission points A5 and A6 can each be used for either drying or activation, however coincident operation of both dryers solely for either drying or activation would not occur. For the purposes of this AERA, it has been assumed that A5 is being used for drying and A6 for activation.

To determine release limits for each emission point, the relevant Best Available Techniques (BAT) Conclusions (BATc) document prepared by the European Commission has been reviewed. Of relevance to the emission points is the Common Waste Gas Management and Treatment Systems in the Chemical Sector 2023 (WGC BATc).

The WGC BATc serves as the reference for establishing permit conditions and includes BAT-associated emission levels (BAT-AELs) relevant processes are expected to meet (Table 4-2).

Table 4-2: Review of BAT-AELs for VOCs

Pollutant	Source	BAT-AEL (mg/Nm^3)
Total VOC	WGC BATc	< 1 – 20 (1)

Table Notes:

Reference Conditions: Temperature: 273.15K

(1) The BAT-AEL does not apply to minor emissions (i.e. when the VOC mass flow is below 100gC/h) if no CMR substances are identified as relevant in the waste gas stream.

Emission estimates are based on maximum theoretical data currently available and assumes that all VOCs present in the gaseous phase will be at the vapour phase saturation point. These calculations are considered to present an over-estimate of the actual emissions that will be experienced. These calculations will be refined during the ongoing detailed design process. Despite this:

- All emission points will be designed to achieve total VOC mass emission rate below 100gC/h via abatement; and

- There are not proposed to be any emissions of CMR substances.

Therefore, as per Table 4-2, the BAT-AELs do not apply. Further information can be found in Section 9.1 of the main technical supporting document submitted as part of the Environmental Permit application.

4.1 Ethanol

Table 4-3 details the operating profile for ethanol to inform the basis of the AERA.

Table 4-3: Ethanol Operating Profile

Emission Point		Mass Actual (As Ethanol) Hourly Rate (g/hr)	Duration (hh:mm)	24/7 Operation		
				Occurrences per Week	Hours in Week	Long-Term Profile %
A1	Filling	8	00:06	17	1.7	1.0
	Heating	4	06:00	17	100.8	60.0
A2	Filling	8	00:06	17	1.7	1.0
	Heating	4	06:00	17	100.8	60.0
A3		20	00:45	17	12.6	7.5
A4		154	04:00	17	67.2	40.0
A5		190	08:00	21	168.0	100.0
A6		192	08:00	21	168.0	100.0
A7		182	00:30	21	10.5	6.3

The mass emission rate in Table 4-3 represents the maximum actual release occurring within a single hour, considering the duration of activity. For emissions lasting less than an hour, the release cycle will not reoccur within the same hourly period. A normalised emission rate (g/s) has been calculated for use in the AERA by dividing the hourly emission rate (g/hr) by 3,600. This calculation ensures that the AERA inherently reflects the true maximum hourly release rate.

A1 and A2 represent reactors operating in a sequential batch process with the potential to emit ethanol during the following phases:

- Filling (6 mins); and
- Heating (6 hours).

These phases do not occur simultaneously. Despite the short duration, the Filling phase has a higher hourly maximum emission rate. It has therefore been used in the AERA to facilitate a worst-case scenario for A1 and A2.

As outlined in Section 3.3.1, the maximum hourly release from each emission point is assumed to occur continuously across the year i.e. 100% profile, with no adjustment based on the projected operational profile (Table 4-3). This facilitates a cautious assessment. This also ensures that the use of Filling still retains a worst-case scenario at A1 and A2, as once the operational profile is applied, Heating will generate a higher annual mass emission rate.

Table A-1 details the ethanol emission inputs.

4.2 Acetic Acid

Table 4-4 details the operating profile for acetic acid to inform the basis of the AERA.

Table 4-4: Acetic Acid Operating Profile

Emission Point	Mass Actual (As Acetic Acid) Hourly Rate (g/hr)	Duration (hh:mm)	24/7 Operation		
			Occurrences per Week	Hours in Week	Long-Term Profile %
A1	0.2	06:00	17	100.8	60.0
A2	0.2	06:00	17	100.8	60.0
A3	1.5	00:45	17	12.6	7.5
A4	4.0	04:00	17	67.2	40.0
A5	2.0	08:00	21	168.0	100.0
A7	12.5	00:30	21	10.5	6.3

The mass emission rate in Table 4-4 represents the maximum actual release occurring within a single hour, considering the duration of activity. For emissions lasting less than an hour, the release cycle will not reoccur within the same hourly period. A normalised emission rate (g/s) has been calculated for use in the AERA by dividing the hourly emission rate (g/hr) by 3,600. This calculation ensures that the AERA inherently reflects the true maximum hourly release rate.

Unlike ethanol, the filling phase does not result in acetic acid emissions, as acetic acid is generated during the initial reaction activities, so there is no dual process to consider at A1 and A2. Instead, A1 and A2 operates under a single, continuous profile.

The treatment of modelled outputs is consistent with the approach outlined in Section 3.3.1.

Table A-1 details the acetic acid emission inputs.

5.0 Assessment Results

5.1 Ethanol

Predicted ethanol impacts are summarised in Table 5-5.

Table 5-1: Ethanol Impacts

AQAL			PC (µg/m³)	PC % of AQAL
Pollutant	Period	µg/m³		
Ethanol	Annual Mean	19,200	31.0	0.2
	1-Hour Mean	576,000	817.0	0.1

The PCs are insignificant. No further assessment or detailed modelling is therefore required.

5.1.1 Methanol Sensitivity Test

Immaterial has advised that whilst ethanol is expected to be the primary solvent used in the process, there are certain products where methanol would be used in place of ethanol, hence leading to potential emissions of methanol to air.

To facilitate an initial assessment of potential impacts associated with the emissions of methanol, it has been assumed methanol would be emitted to air from the same emission points and at the same emission rates as ethanol (Table A-1). Potential impacts have been assessed against the AERA methanol AQALs. Table 5-2 details the predicted impacts.

Table 5-2: Methanol Sensitivity Outcomes

AQAL			PC (µg/m³)	PC % of AQAL	PEC (µg/m³)	PEC % of AQAL
Pollutant	Period	µg/m³				
Methanol	Annual Mean	2,660	31.0	1.2	31.0	1.2
	1-Hour Mean	33,300	817.0	2.5	-	-

The 1-hour mean PC is insignificant (<10% of the AQAL).

The annual mean PC cannot be considered insignificant (>1% of the AQAL). However, analogous with the approach detailed in Section 3.2 for the other VOCs, background concentrations of methanol are assumed to be negligible. Therefore, the calculated PEC is <70% of the AQAL. No further assessment or detailed modelling is therefore required.

Despite this, the above methanol assessment adopts the ethanol emission inputs. As outlined in Section 4.1, the long-term assessment conservatively assumes that the maximum hourly emissions from each emission point are released continuously throughout the year, with no adjustments applied (e.g. 100%). This approach is conservative because the long-term profiles detailed in Table 4-3 suggest most do not release ethanol (or methanol) emissions continuously, even during 24/7 operation (except A5 and A6). These operational profiles have been factored to refine the methanol impact assessment. To add resilience to the assessment, the long-term profiles in Table 4-3 have been adjusted as follows:

- For emission points with a 100% long-term profile, no adjustment has been applied, as they already reflect continuous operation;
- For A1 and A2, a 100% operational profile is maintained to ensure that the Filling phase represents the worst-case long-term scenario. Although the Filling phase has

a higher hourly emission rate than Heating, it is recognised that the total annual emissions may be lower for Filling once the operational profile is considered, therefore assuming 100% captures this; and

- For all other emission points with long-term profiles less than 100%, the actual profiles (under 24/7 operation) have been doubled, aiming to provide further resilience.

The final adjusted operating conditions are detailed in Table 5-3. All other inputs remain unchanged.

Table 5-3: Methanol Applied Operating Profile

Emission Point		24/7 Actual Long-Term Profile %	Initial Assessment % (Section 3.3.1)	Applied Long-Term Profile %
A1	Filling	1.0	100.0	100.0
A2	Filling	1.0	100.0	100.0
A3		7.5	100.0	15.0
A4		40.0	100.0	80.0
A5		100.0	100.0	100.0
A6		100.0	100.0	100.0
A7		6.3	100.0	12.5

Once the revised long-term profile is accounted for, the annual mean PC is insignificant (<1% of the AQAL) (Table 5-4).

Table 5-4: Methanol Sensitivity Outcomes: Revised Long Term Operational Profile

AQAL			PC (µg/m^3)	PC % of AQAL
Pollutant	Period	µg/m^3		
Methanol	Annual Mean	2,660	22	0.8

No further assessment or detailed modelling is therefore required.

5.2 Acetic Acid

Predicted acetic acid impacts are summarised in Table 5-5.

Table 5-5: Acetic Acid Impacts

AQAL			PC (µg/m^3)	PC % of AQAL
Pollutant	Period	µg/m^3		
Acetic Acid	Annual Mean	250	0.8	0.3
Acetic Acid	1-Hour Mean	3,700	22.1	0.6

The PCs are insignificant. No further assessment or detailed modelling is therefore required.

Appendix A Emission Release Information

Environmental Permit Application – Supporting Documentation Appendix E1 - Air Emissions Risk Assessment

Sawston Pilot Plant

Immaterial Limited

SLR Project No.: 405.065240.00001

20 November 2024

Table A-1: Emission Concentration Inputs: Ethanol

Emission ID	Vent Diameter (m)	Max Duration in an Hour	Temperature (°C)	Maximum Hourly Volumetric Flow		Emission Concentration (mg/Nm^3)	Maximum Emission Rate (as Ethanol)		Actual Efflux Velocity (m/s) (2)
				Actual (Am^3/hr)	Ref (Nm^3/hr)		Hourly (g/hr)	Normalised Per Second (g/s) (1)	
A1	0.050	0.10	20	2.0	1.9	4,293	8	0.00222	2.83
A2	0.050	0.10	20	2.0	1.9	4,293	8	0.00222	2.83
A3	0.050	0.75	20	1.0	0.9	21,464	20	0.00556	0.19
A4	0.040	1.00	20	4.0	3.7	41,362	154	0.04282	0.88
A5	0.040	1.00	20	2.3	2.1	88,657	190	0.05278	0.51
A6	0.040	1.00	20	3.4	3.2	60,605	192	0.05333	0.75
A7	0.065	0.50	20	114.0	106.2	1,713	182	0.05056	19.09

Normalised Conditions: Temperature: 273.15K.

(1) Emission rate normalised to per second over an hour (g/s), calculated by dividing the hourly emission rate by 3,600.

(2) Actual efflux velocity considering the duration of release in an hour.

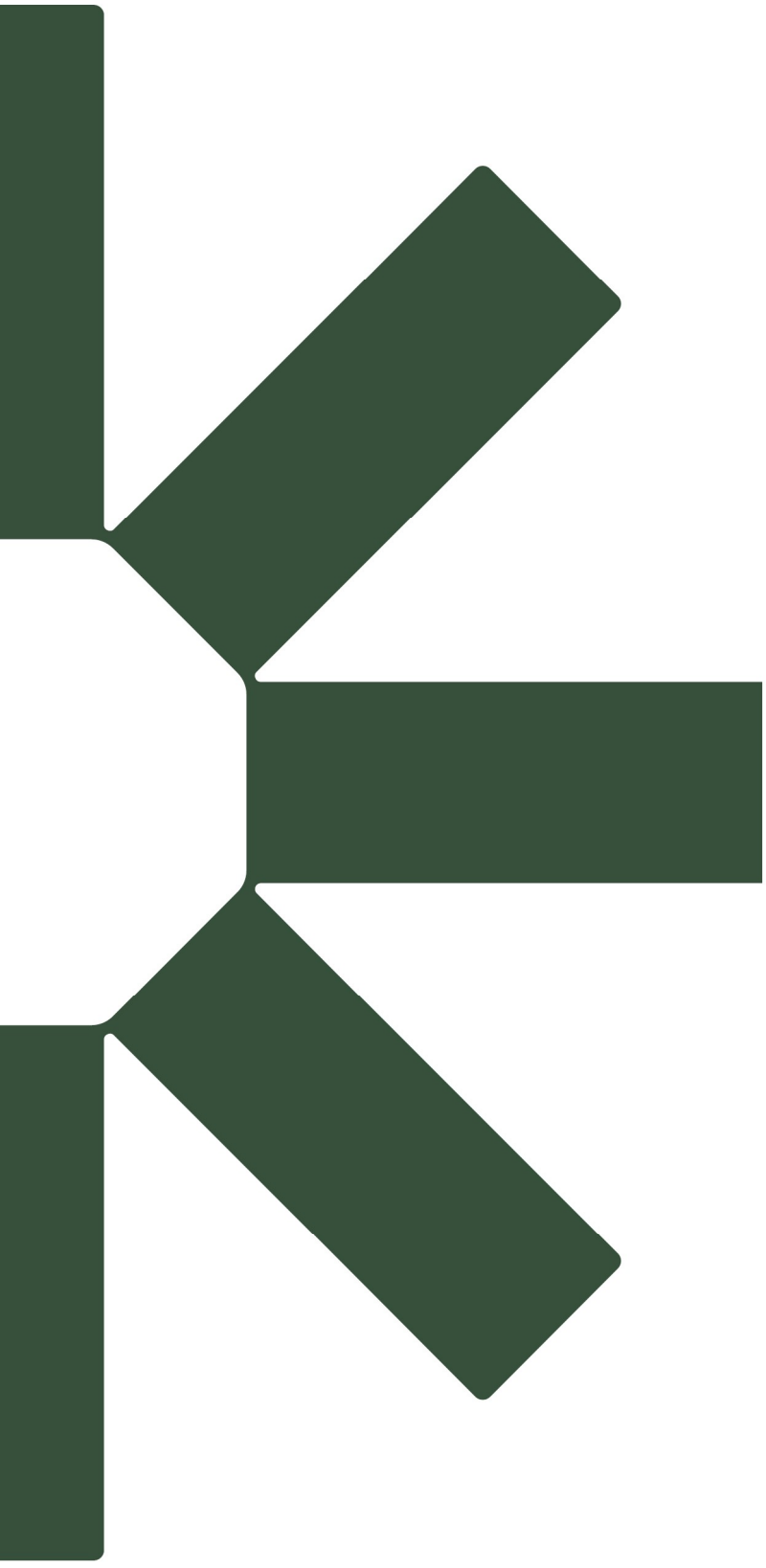
Table A-2: Emission Concentration Inputs: Acetic Acid

Emission ID	Vent Diameter (m)	Max Duration in an Hour	Temperature (°C)	Maximum Hourly Volumetric Flow		Emission Concentration (mg/Nm^3)	Maximum Emission Rate (as Acetic Acid)		Actual Efflux Velocity (m/s) (2)
				Actual (Am^3/hr)	Ref (Nm^3/hr)		Hourly (g/hr)	Normalised Per Second (g/s) (1)	
A1	0.050	1.00	20	2.0	1.9	105	0.2	0.00005	0.28
A2	0.050	1.00	20	2.0	1.9	107	0.2	0.00006	0.28
A3	0.050	0.75	20	1.0	0.9	1,610	1.5	0.00042	0.19
A4	0.040	1.00	20	4.0	3.7	1,073	4.0	0.00111	0.88
A5	0.040	1.00	20	2.3	2.1	933	2.0	0.00056	0.51
A7	0.065	0.50	20	114	106.2	118	12.5	0.00347	19.09

Normalised Conditions: Temperature: 273.15K.

(1) Emission rate normalised to per second over an hour (g/s), calculated by dividing the hourly emission rate by 3,600.

(2) Actual efflux velocity considering the duration of release in an hour.



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