FICHTNER
Consulting Engineers Limited

Viridor Runcorn CCS Ltd – Runcorn CC Facility

Response to Additional Questions

Additional questions raised on 30 May 2024

1 Introduction

The following technical note has been produced to respond to question 6 raised in the Schedule 5 Notice dated 30 May 2024. The question from the permitting officer is italicised and in ***bold font***.

2 Air Quality Assessment

Further to the Schedule 5 Notice issued on 17/04/2024 and your response of 17/05/2024 provide additional information in respect of Q4a. Justify the suitability of the source terms (inputs to the ADMS model), explain how the exhaust temperature, velocity and mass emissions were estimated and discuss their potential ranges/variability. In your justification, please also include the process CO2 pressure and temperature conditions and CO2 phase(s). The values were not included in your response. The input parameters to Aspen Flare System Analyser (AFSA) software may suffice.

Response:

Suitability of source terms into ADMS model

As explained in response to Q4 of the Schedule 5 Request, issued on the 17 May 2024, the inputs to the ADMS software were obtained using CO_2 venting results from Aspen Flare System Analyser (AFSA) (v14) which is also used to size the plant venting header(s) and stack. The CO_2 process conditions (i.e. inlet temperature and pressure) and outlet vent conditions, as determined using the AFSA modelling software, are provided in Table 3 in Appendix A. It is confirmed that the CO_2 is in the gas phase throughout the entire process.

CO_2 exhaust temperature, velocity and mass emission variability

Exhaust mass emission varies with the CO_2 venting scenario considered and values were estimated using operating conditions and preliminary equipment data for the Carbon Capture Plant (CCP). The exhaust velocity was calculated by AFSA internal calculation methods and its range partly depends on the CO_2 mass emission considered and partly on the vent pipework sizes considered/sized by AFSA. The vent headers and stack size were sized for the highest mass emission rate, i.e. out of spec CO_2 full flowrate (See Table 3 in Appendix A),and kept constant for the CO_2 venting scenarios considered. Exhaust temperature was calculated by AFSA internal calculation methods and its variation depends on interrelated factors including vent piping pressure drop which in turn is a function of the mass emission and piping parameters (roughness, lengths, fittings etc) as well as ambient heat transfer assumptions.

To simulate the potential variation for the CO_2 exhaust temperature, velocity and mass emission, the following CO_2 venting scenarios mass emissions have been modelled in AFSA and are shown in Table 3 in Appendix A:

- Full process flowrate venting; and
- Maintenance venting at ambient conditions and operating conditions.

The full process flowrate venting is for venting out of specification CO_2 from the CCP while maintenance venting is for depressurising the plant equipment to carry out maintenance activities.

Consideration of range of CO_2 vent conditions

The ADMS modelling results presented in the Air Quality Assessment were based on the highest flow rate scenario (continuous venting of out of spec CO_2) and the lowest temperature for this scenario of -6.17°C. All other scenarios, as presented in Table 3 in Appendix , result in less than 10% the CO_2 emission rate of the worst-case continuous venting of out of spec CO_2. However, the ADMS model has been run for two additional scenarios to confirm that the results presented in the Air Quality Assessment were representative of the worst-case scenario. The additional scenarios modelled are:

1. Continuous venting of CO_2 during minimum turndown: 30% of the maximum flow rate and mass emissions (not included in Table 3; source terms factored from 100% flow rate scenario).
2. Deoxygenation package venting during maintenance: 10,000 kg/h at the lowest release temperature of -34.31°C.

The ADMS model input parameters for these scenarios are presented in Table 1. The results, as a percentage of the workplace exposure limit (WEL), are presented in Table 2.

Table 1: Flue Gas Conditions – CO_2 Vent

Item	Unit	Out of spec CO_2 venting, 100% load	Out of spec CO_2 venting, 30% load	Deoxygenation package
Temperature	°C	-6.17	-6.17	-34.31
Volume at actual conditions	Am^3/h	39,350	11,805	4,410
Flue gas exit velocity	m/s	22.43	6.73	1.40
Heat capacity (Cp)	J/°C/kg	853.2	853.2	779.0
Molar mass	g	44.01	44.01	44.01
Release rate of CO_2	tph	140	42.0	10.0
	g/s	39,000	11,700	2,778

Table 2: Impact of CO_2 Venting

Averaging period	Ground level maximum as a % of the WEL		
	Out of spec CO_2 venting, 100% load	Out of spec CO_2 venting, 30% load	Deoxygenation package
Maximum 15-minute	34%	6.4%	0.88%
Maximum 8-hour	15%	3.9%	0.62%

As shown, the maximum predicted ground level concentrations of CO_2 in each of the additional scenarios modelled are much lower than in the 100% continuous venting scenario which was presented in the Air Quality Assessment.

Summary

This response presents the AFSA model inlet conditions and outputs (including variability in the outputs), demonstrates the suitability of ADMS for the modelling of CO_2 venting from the CCP, and confirms that the worst-case CO_2 venting scenario was presented in the Air Quality Assessment.

Appendices

A CO_2 vent parameters

Table 3: CO_2 venting scenarios and vent parameters variation

CCP System/Vent Location	Venting Scenario	Emission Rate (kg/h)[(1)]	Inlet Pressure (bara) [(2)]	Inlet Temp (°C)[(3)]	Vent Exit Velocity or Range (m/s)[(4)]		Vent Exit Temp Range (°C)[(5)]	
					Min	Max	Min	Max
Upstream of CO_2 metering Package	Out of spec CO_2 continuous venting	140,000	40	40	22.3	22.8	-6.17	-0.71
Stripping Column & Reflux Drum	Maintenance (Operating Pressure and Temperature)	12,670	2.1	40	2.2	2.4	19.90	38.92
Compressor Package	Maintenance (Ambient Temperature)	8,900	10.8	15	-	1.5	3.10	12.75
	Maintenance (Operating Pressure and Temperature)	8,900	12.8	62	1.6	1.7	20.71	51.41
De-hydration Package	Maintenance (Ambient Temperature)	8,500	34.8	15	1.2	1.4	-33.93	5.50
	Maintenance (Operating Pressure and Temperature)	8,500	40	40	1.3	1.4	-5.88	11.02
Deoxygenation Package	Maintenance (Ambient Temperature)	10,000	34.9	15	1.4	1.7	-34.31	4.18
	Maintenance (Operating Pressure and Temperature)	10,000	40	40	1.6	1.7	-5.88	10.51
Inlet Piping to Compressor Package	Maintenance (Ambient Temperature)	4,580	1.9	15	-	0.8	13.97	14.88
	Maintenance (Operating Pressure and Temperature)	4,850	2.1	40	0.8	0.9	17.02	8.92
Outlet Piping to Compressor Package	Maintenance (Ambient Temperature)	8,900	34.6	15	1.3	1.5	-33.54	5.59
	Maintenance (Operating Pressure and Temperature)	8,900	40	40	1.4	1.5	-5.88	11.03
CO_2 Metering Package	Maintenance (Ambient Temperature)	2,600	34.9	15	0.4	0.44	-34.31	11.79
	Maintenance (Operating Pressure and Temperature)	2,600	40	40	-	0.4	-5.88	13.68

Notes:

Outlet Pressure is 1.013 bara for all scenarios.

[(1)] Emission mass flowrate based on preliminary estimate of equipment CO_2 inventory and assumed venting duration, or on the full process flowrate of captured CO_2 (for the continuous venting of out of spec CO_2 scenario).

(2) Inlet pressure based on the operating pressure, the coincidental isochoric pressure with assumed ambient temperature of 15°C, or the compressor settle out pressure (for venting of the compressor package).

(3) Inlet temperature based on the operating temperature, the ambient temperature of 15°C, or the compressor settle out temperature (for venting of the compressor package).

(4) Vent exit velocity is a function of mass emission/volumetric flow rate.

(5) Vent exit temperature variation due to vent pipework pressure drop and whether heat transfer is modelled or not.