CO2 TIE INS – EFFLUENT TANK DISPERSION ANALYSIS

Contract No:	720097
Client's Name:	BOC Gases Ltd
Project Title:	BOC Teesside CO2 Tie-Ins
Project Location:	Teesside, UK

REVISION	**O1**	**Signature**	**F1**	**Signature**	**F2**	**Signature**
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REVISION HISTORY

Rev	Reason for Issue
O1	Issued for Comment

CONTENTS

Abbreviations	
BOC	British Oxygen Company
CO_2	Carbon Dioxide
COSHH	Control of Substances Hazardous to Health (Regulations)
DTL	Dangerous Toxic Load
HAZOP	Hazard and Operability
HPU	Hydrogen Production Unit
HSE	Health and Safety Executive
LIC	CO_2 Liquification Plant
MDEA	Methyl Di-Ethyl Amine
ppm	parts per million
SLOD	Significant Likelihood of Death
SLOT	Significant Likelihood of Toxicity
STEL	Short Term Exposure Limit
TAR	Turnaround

1. INTRODUCTION

1.1 Project Overview

Back in 2021, BOC planned installation of a Methyl Di-Ethyl Amine (MDEA) based Carbon Dioxide (CO_2) Recovery and CO_2 Liquefication Unit (LIC) to export food grade CO_2 at their Teesside Hydrogen Production Unit (HPU) located at the North Tees Site in Teesside, United Kingdom.

Wood plc were contracted to provide Engineering & Procurement services for the installation of the tie-ins required for the MDEA/LIC project, with the new units being designed by Linde Engineering to be integrated with the existing Hydrogen Plant at Teesside and will be tied into existing systems associated with the plant.

The scope of this phase of the project is to ensure the interface between existing plant and the new MDEA/LIC project is assessed correctly and designed accordingly to ensure safe integration, start-up and operation of the plant.

1.2 Scope

The project installed 11 tie-ins during the 2021 turnaround (TAR) to facilitate the installation of the MDEA and LIC units at a later date. These tie-ins are summarised below:

- Raw Syn gas export to the MDEA Unit
- Sweet gas return from MDEA Unit
- Off gas return from MDEA Unit
- Superheated Steam to LIC Unit
- Pass out steam from LIC Unit
- LP Condensate return from MDEA/LIC Unit
- Ammonia gas to vent from LIC Unit
- MDEA unit start up Nitrogen purge
- Wastewater from MDEA/LIC Unit
- RO permeate Water to MDEA/LIC Unit
- Demin Water to MDEA/LIC Unt.

One of the tie-ins (TP-009) will provide a connection to the existing effluent treatment tank TK-201

During the CO_2 tie-ins interface HAZOP back in February 2021, an action (Action 43) was raised to "*confirm that the existing vent on effluent treatment tank TK-201 can handle the foreseeable gas release that could occur due to 1-FV3060-.1 failing open*".

Linde have since confirmed that around 60Nm^3/hr of CO_2 at 2 barg could be routed from the LIC plant to the effluent tank through the new 2" effluent line 6505.

Given that this is a new demand on the existing vent on effluent tank TK-201, it is required to demonstrate that any risk from discharging CO_2 through this route is reduced so far as reasonably practicable.

This document reports the findings of the dispersion analysis carried out by Wood to determine the risk to people from exposure to CO_2 vapour through this route.

1.3 CO_2 Release Scenario

Wastewater tank TK-201 will receive wastewater from multiple outlets, including the new tie-in point from the MDEA/LIC plant, at a potential rate of 5000kg/hr. A scenario, recognised within the interface HAZOP, was for a breakthrough of around 60Nm^3/h CO_2 at 2barG through the newly installed 2" effluent line.

TK-201 is a flat bottom tank with an 8" atmospheric vent located at 7.3m elevation, which would discharge CO_2 at height and prevent pressure accumulation within the tank.

Figure 1 shows the side-on image of the effluent tank and the location of the vent (indicative only).

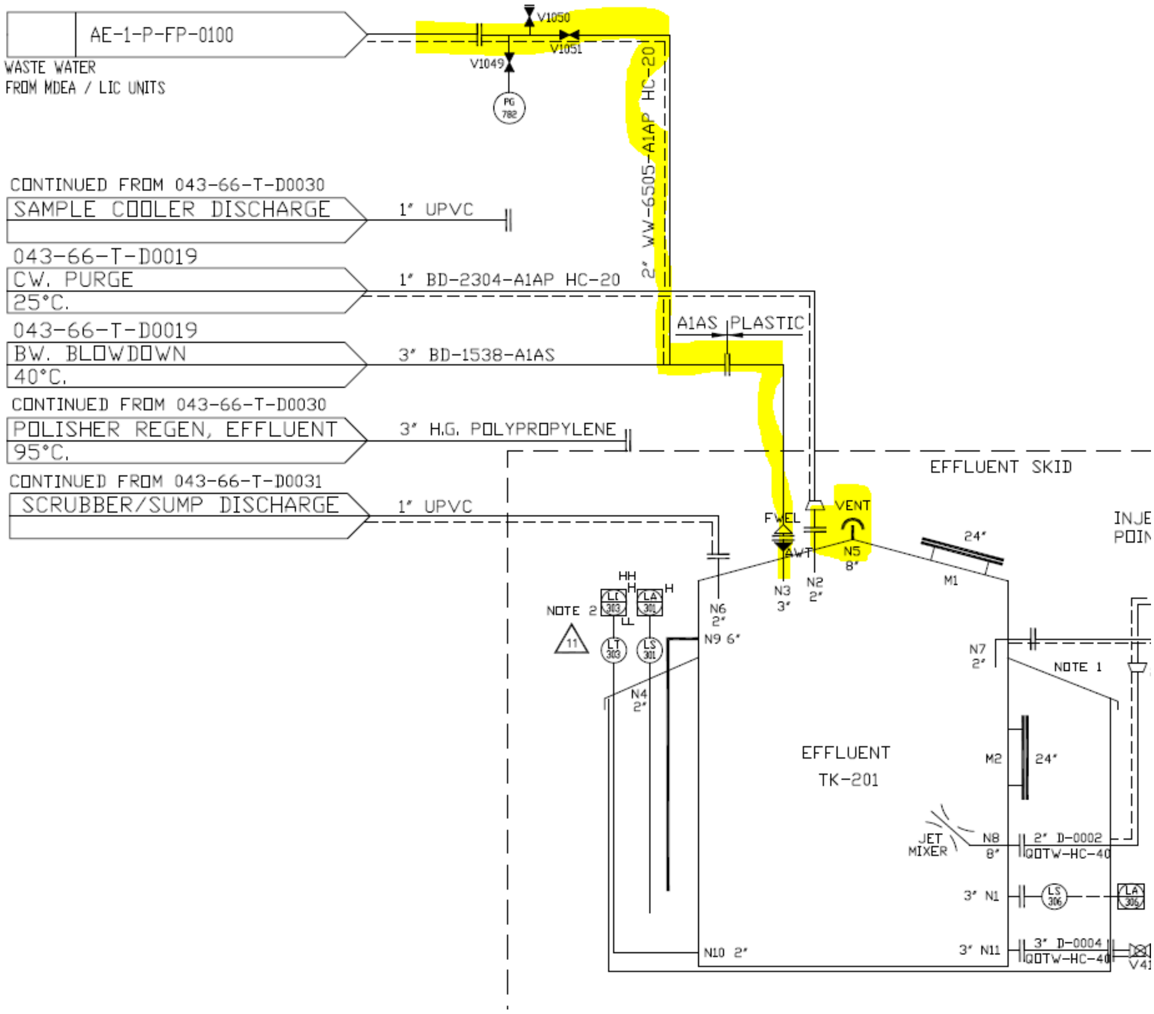

Figure 1 – Effluent Treatment Tank TK-201 with TP-009

2. CO_2 HAZARD

CO_2 is toxic, with a Dangerous Toxic Load (DTL) assigned by the Health and Safety Executive (HSE) for Specified Level of Toxicity (SLOT) and Significant Likelihood of Death (SLOD)[1] and Occupational Exposure Levels[2], so loss of containment has potential for harm to human health. It should be noted however that within these same documents, it is stated that "data available for carbon dioxide indicate that it does not meet the criteria for classification as a dangerous substance"[1].

The focus of this analysis is the potential impact on people so the Short-Term Exposure Limit (STEL) of 15,000ppm, as given in EH40/2005, has been used as the concentration of interest.

3. DISPERSION ANALYSIS

3.1 Source Terms

3.1.1 Software

The analysis reported in this document has been performed using DNV-GL's consequence modelling software Phast (v9.0), the industry standard tool for modelling fires, dispersions and explosions.

3.1.2 Material

CO_2 (toxic) is listed as one of the standard materials in Phast so was selected for use in this instance. The default settings for the material in Phast were retained.

3.1.3 Release Scenario

The potential release was identified during the interface HAZOP, where there is potential for gas breakthrough of CO_2 to the process condensate line to BL and the flat bottom effluent treatment tank TK-201. TK-201 has an atmospheric vent which could fail to relieve the pressure within the tank.

The worst case identified is if valve 1-FV-3060.1 fails open, with Linde Engineering estimating a release of around $60Nm^3$/hour of CO_2 which would discharge to atmosphere at a height of 7.3m.

The boundary conditions for this relief case are given by Linde Engineering as:

- Maximum flow: $60Nm^3$/hr
- Pressure: 2barg

[1] Toxicity levels of chemicals, HSE, https://www.hse.gov.uk/chemicals/haztox.htm, accessed 16/7/24.
[2] EH40/2005 Workplace exposure limits, HSE, https://www.hse.gov.uk/pubns/priced/eh40.pdf, accessed 16/7/24.

3.1.4 Weather Parameters

To provide a representative data set of the extents of a release, the three standard prevailing weather parameters within the Phast package were considered appropriate for use in this instance:

- Category 1.5/F – wind speed 1.5 m/s stable conditions
- Category 1.5/D – wind speed 1.5 m/s neutral conditions
- Category 5/D – wind speed 5 m/s neutral conditions

3.1.5 Concentrations of Interest

The basis of the dispersion analysis was to determine the risk to people who may be exposed to CO_2 from a release through the effluent treatment tank TK-201 vent. Therefore, a conservative approach was taken to consider the occupational exposure limits imposed by EH40/2005 (15,000ppm).

15,000ppm represents the 15-minute STEL aligned to the Control of Substances Hazardous to Health Regulations 2002 (COSHH).

3.2 Dispersion Model

The model built in Phast is based on a release of CO_2 at 2 bar gauge pressure at a temperature of 38^{o}C. The release was modelled using the DNV Phast short pipe scenario from a pressure vessel through an orifice orientated vertically to represent the 8” vent on effluent treatment tank TK-201. An assumption was taken that the vent is raised 0.3m from the tank. The leak size was modelled iteratively to achieve the maximum release rate of 60 Nm^3/hr provided in technical query TQ-002. With a volumetric flowrate of 60Nm^3/hr, the total mass associated with this release scenario is calculated within Phast as 312kg, providing a mass flowrate of:

$$Mass\ flowrate = \frac{312}{3600} = 0.087\ kg/s$$

The mass flowrate was rounded up to 0.1kg/s, to estimate a worst-case scenario and allow for some discrepancy in the stated CO_2 flow.

3.3 Results

The results show that concentrations of 15,000ppm were not found by Phast when modelling using the information provided within this document.

It is noted that a release in the circumstances considered does not result in any toxic or STEL impacts, however if the mass flow of CO_2 was to increase beyond the linearly scaled down flow mentioned in section 3.2, further modelling would be required. To note, when modelling mass flows up to 0.21kg/s (over twice the predicted release), no concentrations of 15,000ppm were observed by Phast.

4. CONCLUSION

The PHAST modelling indicates that a CO_2 release through TK-201 vent due to breakthrough via valve 1-FV3060.1 failing open, presents no risk of exposing people to harmful levels (15,000ppm for more than 15 minutes) of CO_2 vapour based on the information provided.