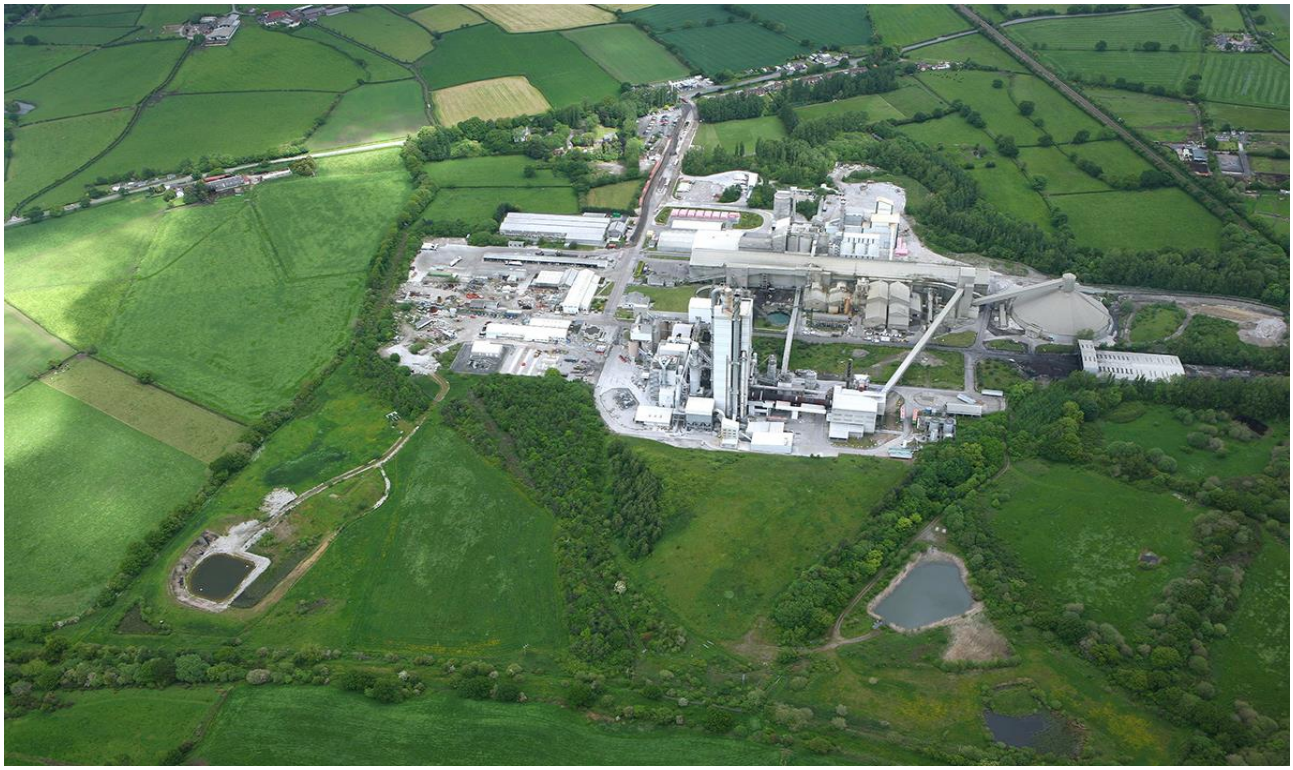
HEIDELBERG MATERIALS

Padeswood Carbon Capture Plant - FEED Phase

Emissions, Discharge and Waste Schedule

Document no. Rev 0-A: 215000-00190-000-EN-REP-00001



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PROJECT 215000-00190-000 - 215000-00190-000-EN-REP-00001: Padeswood Carbon Capture Plant - FEED Phase - Emissions, Discharge and Waste Schedule							
Rev	**Description**	**Originator**	**Reviewer**	**Worley Approver**	**Revision Date**	**Customer Approver**	**Approval Date**
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Revision History

Rev	Status	Section	Description of Change
A	IDC	All	Issue for Discipline Check
B	IFR	All	Issue for Review
0	IFU	Sections 2.1, 3.3, 4.1, 4.3.2 and 4.3.4	Issue for Use

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1. Introduction

1.1 Project Description

The Heidelberg Materials Padeswood Cement Works Carbon Capture and Storage (CCS) Project will enable post combustion carbon capture from the existing cement kiln 4 and from a new Combined Heat and Power (CHP) plant designed to provide the heat and electricity required to operate the Carbon Capture Plant (CCP).

Captured CO_2 will be transported by pipeline to the HyNet CO_2 main pipeline at Northop Hall AGI for onward transportation to storage offshore in depleted gas fields operated by Eni UK.

The whole project will enable the production of net zero cement for use in the UK construction industry.

The detailed process description is covered in Ref 1.

1.2 Document Purpose

Heidelberg Materials (HM) is committed to excellence in environmental operation and performance, ensuring that systems are in place and resources are available to meet this commitment. HM aims to operate and maintain its facilities in a manner to avoid operational incidents that are detrimental to the environment.

As is stated in the "HM Sustainability Policy", HM is committed to managing, monitoring, and reducing, where practicable, the environmental impacts caused by the PROJECT activities through continual improvement of operations.

As such, it is important that all PROJECT waste streams are identified, characterised and monitored in an effort to understand and manage the impact of the PROJECT on the environment.

This report has been prepared to document the known wastes and emissions for the PROJECT, and to as far as possible characterise these waste streams. It is acknowledged that it may not be possible to fully characterise all waste streams within the FEED stage of the project due to limited availability of data. Therefore, the summary of emissions shall be updated and refined as by the engineering, procurement and construction (EPC) contractor to ensure most up to date information is captured.

1.3 Abbreviations and Definitions

Abbreviation	Description
CCP	Carbon Capture Plant
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EPC	Engineering and Procurement and Construction
FEED	Front End Engineering Design

Abbreviation	Description
HM	Heidelberg Materials
kg/h	Kilograms per hour
LDAR	Leak Detection and Repair (Systems)
MHI	Mitsubishi Heavy Industries
NaOH	Sodium Hydroxide
NH_3	Ammonia
NO_x	Oxides of Nitrogen
PPE	Personnel Protection Equipment
ppmvd	Parts per million volume, dry
SCFM	Standard Cubic Feet per Minute
SCR	Selective Catalytic Reduction (Catalyst)
SO_2	Sulphur Dioxide
TBC	To Be Confirmed
WMP	Waste Management Plan

Table 1-1: Table of Abbreviations

1.4 Technical Terms

Term	Description
COMPANY	Heidelberg Materials
CONTRACTOR	Consortium of Worley Europe Limited and Mitsubishi Heavy Industries Limited (MHI)
DELIVERY PARTNER	Company other than the prime COMPANY and CONTRACTOR associated with the delivery of the PROJECT.
LICENSOR	MHI entering a Licensing Agreement with the CLIENT
PROJECT	Padeswood Carbon Capture Plant
SUB-SUPPLIER	The organisation selected by the SUPPLIER/VENDOR to supply the part of equipment and services.
SUPPLIER/VENDOR	Company / organisation suppling equipment, materials or services.
WORK	Shall mean all and any of the WORKs and / or services and / or materials required to be provided under the Contract with CLIENT.

Table 1-2: Table of Terms

1.5 References

Ref	Document Number	Document Title
Ref 1	215000-00190-000-PR-REP-00006	Process Description
Ref 2	215000-00190-000-EN-PLN-00002	Waste Management Plan
Ref 3	215000-00190-710-PR-HMB-00001	Heat and Material Balance
Ref 4	215000-00190-000-PR-LST-00006	Relief Load Summary
Ref 5	215000-00190-000-EN-BOD-00001	Environmental Basis of Design

Table 1-3: Table of References

2. Solid Waste

2.1 Solid Waste: Construction Phase

The construction phase waste types and quantities have yet to be established. As such, this section only mentions the waste streams typically encountered during construction activities based on prior experience and will need refinement for the PROJECT by the EPC contractor.

Construction phase activity	Waste	Management option
Demolition and site clearing	Vegetation	Composting
	Topsoil	Reuse
	Concrete, asphalt and gravel	Reuse
	Scrap metal	Recycle
	Fuel Oil	Hazardous waste management facility
	Asbestos	Hazardous waste management facility
Earthworks	Excavated material	Reuse
	Potentially contaminated soils	Contain in bunded area and treat at dedicated facility Off-site treatment facility or landfill
Construction	Scrap metal (including offcuts, pipes, wire, welding rod, cladding etc.)	Recycle
	Concrete waste	Reuse Landfill
	Plastic waste	Recycle
	Treated and/or contaminated wood waste	Hazardous waste management facility
	Untreated and/or uncontaminated wood waste	Reuse
	Packaging material: metal	Recycle
	Packaging material: plastic	Recycle
	Packaging material: cardboard/paper	Recycle
	Construction chemicals: adhesives, coatings, cleaners, solvents etc.	Hazardous waste management facility
	Used paint	Hazardous waste management facility
	Empty chemical and paint containers	Hazardous waste management facility
	Glass (broken windows etc.)	Recycle
	Cable and cable stripping	Recycle
	Vehicle waste: used tyres, used batteries, hydraulic fluid, used oil, filters, brake pads, coolant etc.	Hazardous waste management facility
	Soil contaminated with hydrocarbons (due to spills)	Contain in bunded area and treat at dedicated facility Off-site treatment facility or landfill

Construction phase activity	Waste	Management option
	Contaminated absorbent material from cleaning of spills	Hazardous waste management facility
	Broken light bulbs and lighting tubes	Hazardous waste management facility
	Electronic waste	Recycle
	Food waste	Composting
	General waste	Recycle Landfill
	Contaminated PPE	Hazardous waste management facility

Table 2-1: Construction Phase Solid Waste

2.2 Solid Waste: Commissioning Phase

At this phase of the project the solid wastes during the commissioning phase are not fully known and will be established by the EPC contractor.

Due to the nature of the PROJECT solid wastes during the commissioning phase are anticipated to be minor and likely limited to the form of empty containers (for example for the solvent, catalysts, absorbents, desiccants, oil drums etc.) which should be returned to supplier for recycling.

Potential spills of solid catalyst material may also occur during this phase which will be appropriately removed as per the Waste Management Plan (Ref 2).

2.3 Solid Waste: Operation Phase

The identified solid wastes from the carbon capture facility have been summarised in Table 2-2.

Source	Frequency	Material Waste	Disposal
Filter Elements **215000-00190-720-PR-PID-12014**	Intermittent	Guard filter – cartridge type	Mechanical filter elements and activated carbon from the filtration systems will require disposal, local regulations shall be adhered to but are often sent to hazardous waste landfill
SCR Catalyst	Occasional	TBC	Removed and disposed of by specialist 3rd party contractor
Dehydration Desiccant	Occasional	TBC	Removed and disposed of by specialist 3rd party contractor

Table 2-2: Operation Phase Solid Waste

2.4 Solid Waste: Decommissioning and Deconstruction

At this phase of the project, the solid wastes during the decommissioning and deconstruction phases are not fully known and will be established by the EPC contractor.

Deconstruction wastes are expected to be similar to those produced during construction (Table 2-1) with additional wastes associated with removal of the facilities. The specific waste streams produced during deconstruction are subject to the project elements removed and the chosen management of the waste produced, both of which are not fully known at this phase. Several waste types can be reused, for example piping, white materials, control room technological equipment etc. This will be established by the EPC contractor.

3. Liquid & Aqueous Discharges

3.1 Liquid & Aqueous Discharges: Construction Phase

Types and volumes of liquid wastes during the construction activities will be established in later phases of the PROJECT by the EPC contractor. Construction liquid wastes can be managed by appropriate planning and preparation, for example ensuring drips are caught using absorbent mats, and digging appropriate drainage causeways to allow for collection of (ground water) liquid wastes for treatment (if required) and or discharge to sewage system.

Type	Description	Treatment
Hydrotest water	Large volume of potentially lightly chlorinated water from hydrotesting	TBC
Rinse water	Water contaminated with preservation oil from rinsing of packing prior to start-up	TBC
Concrete wash water	Wash water from concrete wagons/trucks, containing suspended concrete particles and high pH concentration (alkaline)	Suspended particles are allowed to settle for water/solid matter separation. Separated Liquid effluent is to be treated through mixing mineral acids or diluted CO_2 (in water) to balance pH
Sanitary Waste & Sludge	Domestic (grey and black) wastewater and sludge effluent	Appropriate plumbing/piping networks to transport sanitary wastewater to existing sewage water lines.
Solvents	Toxic/hazardous liquid substances left over from construction activities e.g. white spirit, adhesives, cleaning products.	Solvents must be collected and periodically transported offsite to specialist treatment & recycling facility.
Oil and Greases	Oil and grease in ground water from lubrication and vehicle use	Collection of contaminated water. Physical separation of the oil by air floatation methods and skimming oil layer. Biological oxidation of remaining suspended/dissolved oil/grease droplets within contaminated water
Stormwater	Uncontaminated stormwater	TBC
	Chemical Contaminated	Collection and offsite treatment by 3rd party.
	Oil Contaminated	Oil separator / treatment by 3rd party [TBC]

Table 3-1: Construction Phase Typical Aqueous Effluents

3.2 Liquid & Aqueous Discharges: Commissioning Phase

Similar to construction phase, the types and volumes of liquid wastes during the commissioning phase are to be determined by EPC contractor.

Liquid wastes during the commissioning stage are anticipated to be minor and will likely include wash water run-off, potential solvent drips, spent amine from the solvent reclaimer during cleaning, and spills of lubrication/mineral oils and potential leaks from the pipe works and units during testing and preparation to bring the units up to operational capacity.

Localised drips and small spills can be collected using absorbent mats or similar methods for eventual 3rd party disposal. Wash water runoff will be collected by site drainage system for eventual treatment.

3.3 Liquid & Aqueous Discharges: Operation Phase

The liquid and aqueous discharges from the operation of the carbon capture facility are listed in Table 3-2. Parameters are taken from the latest revision of Heat and Material Balance (Ref 3).

Source	Frequency	Flow Rate (kg/h)	Temp. (°C)	Composition	Disposal
Water and Waste Water Treatment Package (740-ZZ-001) [1]	Continuous	TBC	TBC	Sludge.	Pumped to Cement plant for reuse
				Treated waste water.	Reused as fire water
					Reused as cooling water makeup
					Pumped to utility stations for reuse
Quencher (720-TW-001)	Continuous	52,000	50 - 60	Flue gas condensate	Reused as cooling water makeup
		TBC	TBC	Waste water	Pumped to Cement plant for reuse
Reclaimer	Continuous	20	60	Reclaimed water and solvent waste	Pumped to Cement plant for reuse
Acid Wash Concentrator (720-ZZ-002)	Continuous	22	70	Acid Wash waste water	Pumped to Cement plant with reclaimer waste for reuse
Cooling Tower (740-T1-001)	Continuous	14,100	25	Blowdown	Offtake upstream of UF/RO for Firewater Offtake downstream of UF/RO for boiler Feed Water, Demin Water and service water
Facilities	Continuous	TBC	TBC	Sewage	Routed to tie-in with existing plant sewage system
Stormwater Drainage System (amine contamination)	Intermittent	TBC	TBC	Stormwater contaminated with toxic solvent	Removed by 3rd party waste handler in vacuum tanker
Stormwater Drainage System (no contamination)	Continuous	TBC	TBC	Uncontaminated stormwater	Pumped from drain drum to oily water separator and into treatment facility for reuse in cooling water makeup
Absorber and regenerator shutdown (720-TW-002A/B & 720-TW-003)	Intermittent	TBC	TBC	Rinse water	Pumped to waste water treatment package

[1] Composition is required to establish where this stream can be used in cement plant

Table 3-2: Operation Phase Liquid & Aqueous Discharges

3.4 Liquid & Aqueous Discharges: Decommissioning and Deconstruction Phases

At this phase of the project, the solid wastes during the decommissioning and deconstruction phases are not fully known and will be established by the EPC contractor.

Decommissioning and deconstruction wastes are expected to be similar to those produced during construction (Table 3-1). Rinse water will be used to wash down elements of the project and is expected to be treated onsite using the existing water treatment facilities.

4. Atmospheric Emissions

4.1 Atmospheric Emissions: Construction Phase

During the construction phase of the project the typical sources of direct atmospheric emissions will be from combustion of fuel used for the following purposes:

- Onsite construction vehicles
- Temporary & portable power generators
- Temporary & portable heating requirements
- Material Transport Vehicles
- Construction Personnel transport vehicles.

Options for reduction of emissions from the above sources include (but not limited to) use of alternative low(er) emission fuels, using high efficiency generators, minimise events where transport vehicles are not carrying a full load and use of grid electricity rather than using diesel for power generation/heating. Use of purchased grid electricity will constitute scope 2 emissions (indirect).

Other sources of emissions include Scope 3 emissions (emissions arising from the supply chain) including fuel and energy consumption during the manufacturing process of the various materials, parts and equipment procured for the construction.

There will also be emissions from use of vehicles and vessels used to transport the materials and equipment packages to the project site. Reduction of the Scope 3 emissions can be achieved by sourcing manufacturers with lower carbon intensities (CO_2 emitted per tonnage of material generated). These will be manufacturer facilities that utilise renewable energy sources and/or low emission fuels.

Consideration for supplier/manufacturer distance relative to the project site can also help reduce emissions through shorter transport/shipping distances of the purchased goods and materials.

Dust emissions are also likely to be produced from transport and mobile plant vehicle movement around site. Dust abatement activities to reduce dust emissions include regular spraying of unmade and internal service roadways, covering of friable materials in open trucks and stockpiles, and management of loading/unloading and stockpiling activities to reduce drop heights and minimise loose material exposure to wind.

4.2 Atmospheric Emissions: Commissioning Phase

Typical emissions to the atmosphere during the commissioning phase will include small flue gas emissions from the main stack during commissioning tests prior to the start-up of the absorber units. Commissioning emissions will depend on the start-up timeline and duration and will be influenced by stability testing requirements. Appropriate planning and emission management preparation will help minimise emissions during this phase of the PROJECT. Emission volumes from the stack during commissioning are to be estimated by EPC contractor.

Drying of the pipelines (after washing) will need to be done. This is typically performed with Nitrogen or similar inert gas. Nitrogen requirement can be reduced by swapping to air in final stages of drying (if feasible).

CO_2 via the vent stack is also expected prior to reaching normal operation (see Table 4-3 for composition).

4.3 Atmospheric Emissions: Operation Phase

4.3.1 Flue Gas

The project includes one main source of flue gas emissions, the new stack (720-SK-001). During standard operation the stack will continually operate. The available emission parameters taken from the Heat and Material Balance (Ref 3) are given in the table below.

Composition	Mol %
Carbon Dioxide	0.99
Water	8.96
Oxygen	8.35
Nitrogen + Argon	81.70
Other Pollutants	**ppmvd**
Carbon Monoxide	≤11.1
NO_x	≤33.7
SO_2	≤1
Solvent	**-**
Other Parameters	
Flow Rate Design (kg/h)	374,764
Flow Rate Norm (kg/h)	304,254
Temperature (°C)	100

Table 4-1: Operation Phase Flue Gas Stack Emissions - Design Case

4.3.2 Steam Vent

The plant includes one unit which will vent steam. Vent parameters and details are provided below.

ID	Source	Contents	Pressure (BARG)	Temp (°C)
710-TW-001	Deaerator	Steam	1.84	132

Table 4-2: Operation Phase Steam Vent

4.3.3 CO_2 Vent

In the operation phase, for maintenance and emergency scenarios CO_2 will be routed to the stack when it cannot be transferred to the HyNet pipeline. The CO_2 vent will be routed from the CO_2 compressor to connect upstream of the Gas-Gas Heat exchanger to be heated and emitted

through the stack with flue gas. Vent parameters taken from the Heat and Material Balance (Ref 3), as estimated at the CO_2 compressor, are provided below.

Composition	ppmvd
Carbon Dioxide	≥99.9 mol%
Water	≤40
Oxygen	≤10
Nitrogen + Argon	≤480
Other Pollutants	**ppmvd**
Carbon Monoxide	TBC
NO_x	≤10
SO_2	≤1
Solvent	-
Other Parameters	
Flow Rate Design (kg/h)	112,313
Flow Rate Norm (kg/h)	57,200
Temperature (°C)	40

Table 4-3: Operation Phase CO_2 Vent

4.3.4 Tank Vents

The plant includes several tanks and other units which will be outfitted with vents. Details of venting will be provided in the Relief Load Summary (Ref 4). Vent parameters are provided below.

Tank	Vent Contents	PID/UFD
Raw Water Buffer Tank (740-TK-001)	Air, trace water	215000-00190-740-PR-PID-00065
Demin Water Tank (740-TK-002)	Air, trace water	215000-00190-740-PR-PID-00062
Flue Gas Condensate Tank (740-TK-003)	Air, trace water	215000-00190-740-PR-PID-00071
RO Reject Tank (740-TK-004)	Air, trace water	215000-00190-740-PR-PID-00072
Ammonia Storage Bullet (740-TK-008)	NH_3, air	215000-00190-740-PR-PID-00019
Fire Water Tank (740-TK-009)	Air, trace water	215000-00190-740-PR-PID-00052
CCP Effluent Storage Tank (740-TK-010)	Air, trace water	215000-00190-740-PR-PID-00076
Caustic Soda Tank (720-TK-003)	NaOH	215000-00190-720-PR-PID-14007
Wash Water Tank (720-TK-005)	Air, trace water	215000-00190-720-PR-PID-14005
Dilute Wash Water Tank (720-TK-006)	Air, trace water	215000-00190-720-PR-PID-14005
Fresh Solvent Tank (720-TK-007)	NH_3	215000-00190-720-PR-PID-14004
Sulphuric Acid Tank (720-TK-010)	H_2SO_4	215000-00190-720-PR-PID-14009
Drain Drum (740-VZ-003)	Air, trace water	215000-00190-740-PR-PID-00049
Activated Carbon Scrubber (740-ZZ-007)	Air, trace water	215000-00190-740-PR-PID-00019

Table 4-4: Operation Phase Tank Vents

4.3.5 Intermittent Relief Devices and Vents

Flue gas from the cement plant will be intermittently emitted through the stack in scenarios where the flue gas cannot be treated, for example when the boiler is not operating. In these

situations, flue gas from the cement plant will bypass the CHP and CCU to vent through the stack with the composition displayed in Table 4-5.

Composition	Mol %
Carbon Dioxide	15.19
Water	12.80
Oxygen	10.25
Nitrogen + Argon	61.68
Other Pollutants	**ppmvd**
Carbon Monoxide	538.3
NO_x	327.7
SO_2	8.8
Solvent	-

Table 4-5: Operation Phase Cement Plant Flue Gas Composition

4.4 Fugitive Emissions

4.4.1 Hydrocarbon Fugitives

Fugitive emissions are anticipated for components (i.e., valves, flanges, connector, seals etc) on the various piping and equipment serving gaseous process streams which will result in diffuse releases of hydrocarbons (primarily methane from the flue gas and natural gas handling lines).

Although each individual leak is trivial in isolation, across an entire facility these can amount to a tangible portion of the overall carbon footprint of the facility which will inevitably increase across the facility life as the components degrade.

4.4.2 Carbon Dioxide Fugitives

Fugitive leaks are anticipated to occur from the CO_2 compressor (730-CP-001). Due to limited information available on the actual seal leak rate, an engineering estimate of 3 SCFM has been applied.

4.4.3 Fugitive Mitigations

Mitigations to reduce the quantity and volume of leaks can be achieved through rationalisation of number of potential fugitive sources, reducing complexity of piping design, operating lines at lower pressures as far as practical, designing for appropriate/corrosion resilient materials and choosing low leak components.

For those components that make it into the final build, periodic leak detection and repair (LDAR) should be implemented as part of standard maintenance to prevent escalation of fugitive emissions.

4.5 Atmospheric Emissions: Decommissioning and Deconstruction Phases

At this phase of the project, the atmospheric emissions during the decommissioning and deconstruction phases are not fully known and will be established by the EPC contractor.

Decommissioning and deconstruction wastes are expected to be similar to those produced during construction (Section 4.1 and 4.2).

During deconstruction and removal of the Project elements, there will be the potential for releases of residual gases stored during operations, e.g. tanks etc. However, in most cases the residual gases will be flue which, during decommissioning, will be flushed out with nitrogen and vented to atmosphere.