Promethean Particles®

Site Testing of Pilot-scale Unit

CCUS Innovation 2.0

Key Knowledge Deliverable 4.1

May 2025

Key Knowledge Deliverable Cover Sheet

This Key Knowledge Deliverable (KKD) has been produced by Promethean Particles Ltd. as part of the Department for Energy Security and Net Zero £1bn Net Zero Innovation Portfolio (NZIP) - CCUS Innovation 2.0 programme. The document is reflective of the status of the project at the time of writing. The material presented could have been subject to change as the project matured. These documents should not be considered a full representation of the final project.

Description of KKD D4.1 - Delivery and Installation of Unit

This deliverable report demonstrates the successful installation of the MONET testing unit at a CCUS Incubation facility within a UK power station, through a successfully completed site acceptance testing (SAT) procedure.

KKDs to be released in full:

D6.4 - Marketing Material Creation

D6.5 - Conference Presentations and Trade-Show Exhibitions

KKDs to be released after redaction:

D3.2 - Control and Safety System Manufacturing

D3.4 - Build of Capture Rig

D4.1 - Installation of Capture Rig

D4.3 - Rig Operation and Decommissioning

D5.1 - CAPEX Technoeconomic Analysis (TEA)

D5.2 - OPEX TEA

D5.3 - Life Cycle Analysis (LCA)

D6.6 - Stakeholder Analysis

Contents

Planning for Site Integration and Testing

Document demonstrating and detailing the successful installation of the rig at the test site facility.

Attached Documents Appendix

Appendix 1 - D4.1 MONET Completed SAT Procedure

Project:	**Promethean MONET (23-239)**	**Client:**	**Promethean Particles**
	MOF-based Negative Emissions Technology	**Location:**	**Installed**
		Issue Date:	**17/09/2024**
		Issue No:	**Rev B**

SAT & FAT Testing Procedure

#	Stage	Description	Completed Date	Signed (FAT)	Completed Date	Signed (SAT)	Comments
1a	Functionality Testing	F-101 starts. Run F-101 for 5 minutes to ensure it is functioning correctly.	02-Oct	FM	16-Oct	FM	
1b	Functionality Testing	Witness readings on PT-1011	02-Oct	FM	16-Oct	FM	0.22barg
1c	Functionality Testing	Witness readings on FT-1012	02-Oct	FM	16-Oct	FM	186Am³/hr
1d	Functionality Testing	Check for QT-3011 CO2 readings	02-Oct	FM	16-Oct	FM	0.13%
1e	Functionality Testing	Witness "started in manual" alarm.	02-Oct	FM	16-Oct	FM	
1f	Functionality Testing	Throttle the outlet valve towards closed, until a "low flow" alarm is shown	02-Oct	FM	16-Oct	FM	
1g	Functionality Testing	Stop F-101 manually	02-Oct	FM	16-Oct	FM	
1h	Functionality Testing	Start F-101 manually	02-Oct	FM	16-Oct	FM	
1i	Functionality Testing	F-101 stops from E-STOP, Unable to restart on HMI.	02-Oct	FM	16-Oct	FM	
1j	Functionality Testing	Witness low pressure alarm and low flow alarm (SP-04 and SP-05)	02-Oct	FM	16-Oct	FM	
1k	Functionality Testing	F-101 functional testing complete, to undertake further functional testing all E-STOPS will need resetting to proceed with the following steps. Manually twisting and releasing F-101 E-STOP and global e-stop. Using the illuminated push buttons (IPB) on the front of panel, reset F-101 and global E-STOP. Both LEDs should extinguish once these steps are complete. Once all LEDs are not illuminated, use the HMI alarm page on top right hand corner click "accept alarms" and then "reset alarms". All alarms and alerts should disappear.	02-Oct	FM	16-Oct	FM	All flowmeters show an out of range alarm on startup. Clears once in operation
2a	Functionality Testing	H-101 blower starts. If testing with ambient air, initially an increase in ambient temperature is expected due to compression effects. Once H-101 has operated for a reasonable period, a decrease from the initial readings before H-101 was started are expected. Run H-101 for 5 minutes.	02-Oct	FM	16-Oct	FM	
2b	Functionality Testing	Witness "started in manual" alarm.	02-Oct	FM	16-Oct	FM	
2c	Functionality Testing	Stop H-101 manually	02-Oct	FM	16-Oct	FM	
2d	Functionality Testing	Start H-101 manually	02-Oct	FM	16-Oct	FM	
2e	Functionality Testing	H-101 blower stops on E-STOP. Unable to restart on HMI	02-Oct	FM	16-Oct	FM	

SAT & FAT Testing Procedure

#	Stage	Description	Completed Date	Signed (FAT)	Completed Date	Signed (SAT)	Comments
2f	Functionality Testing	H-101 functional testing complete, to undertake further functional testing all E-STOPS will need resetting to proceed with the following steps. Manually twisting and releasing H-101 E-STOP and global e-stop. Using the illuminated push buttons (IPB) on the front of panel, reset H-101 and global E-STOP. Both LEDs should extinguish once these steps are complete. Once all LEDs are not illuminated, use the HMI alarm page on top right hand corner click "accept alarms" and then " reset alarms". All alarms and alerts should disappear.	02-Oct	FM	16-Oct	FM	
3	Functionality Testing	QT-3011 shows readings on HMI, no leak on sensor seal. With ambient air, expect ~421ppm (0.04%) of CO2. Readings can vary as much as +/- 300ppm. Readings falling between 121ppm and 721ppm proves sensor is reading within the accuracy range. Failure of this will require testing with flue gas, providing the safety and quality of construction and installation aspects have been deemed satisfactory.	02-Oct	FM	16-Oct	FM	>0.07%, outside of expected range. Reading 0.13%/0.14%
4a	Functionality Testing	CV-06/16/14/15/24/25 open on HMI	02-Oct	FM	16-Oct	FM	
4b	Functionality Testing	CV-06/16/14/15/24/25 close on HMI	02-Oct	FM	16-Oct	FM	
5a	Functionality Testing	P-101 starts from HMI Panel. This should be operated for less than 10 seconds, it is just to witness the pump turning on and off	02-Oct	FM	16-Oct	FM	
5b	Functionality Testing	Readings witnessed on PT-1013	02-Oct	FM	16-Oct	FM	0.20barg
5c	Functionality Testing	Readings witnessed on FT-1014.	02-Oct	FM	16-Oct	FM	
5d	Functionality Testing	Readings witnessed on QT-1015.	02-Oct	FM	16-Oct	FM	0.40%
5e	Functionality Testing	P-101 stops manually	02-Oct	FM	16-Oct	FM	
5f	Functionality Testing	P-101 starts manually	02-Oct	FM	16-Oct	FM	
5g	Functionality Testing	P-101 stops from E-STOP, Unable to restart on HMI	02-Oct	FM	16-Oct	FM	
5h	Functionality Testing	P-101 functional testing complete, to undertake further functional testing all E-STOPS will need resetting to proceed with the following steps. Manually twisting and releasing P-101 E-STOP and global e-stop. Using the illuminated push buttons (IPB) on the front of panel, reset P-101 and global E-STOP. Both LEDs should extinguish once these steps are complete. Once all LEDs are not illuminated, use the HMI alarm page on top right hand corner click "accept alarms" and then " reset alarms". All alarms and alerts should disappear.	02-Oct	FM	16-Oct	FM	
6a	Functionality Testing	H-102 / 103 start from HMI panel	02-Oct	FM	16-Oct	FM	
6b	Functionality Testing	H-102 / 103 stops manually from HMI	02-Oct	FM	16-Oct	FM	
6c	Functionality Testing	H-102 / 103 starts manually from HMI	02-Oct	FM	16-Oct	FM	
6d	Functionality Testing	H-102 / 103 stops on the global E-STOP, unable to restart from the HMI panel.	02-Oct	FM	16-Oct	FM	
7a	Functionality Testing	F-101, H-101, P-101 started manually	02-Oct	FM	16-Oct	FM	
7b	Functionality Testing	Testing of all drives inclusive of F-101, H-101, P-101 on the global E-STOP to ensure they stop and cannot be restarted without the required input from the operators. Also ensuring that all control valves close on E-STOP initiation	02-Oct	FM	16-Oct	FM	
7c	Functionality Testing	All E-STOPS will need resetting to proceed with the following steps. Manually twisting and releasing F-101 / H-101 /P-101 E-STOP and global e-stop. Using the illuminated push buttons (IPB) on the front of panel, reset F-101 / H-101 /P-101 and global E-STOP. Both LEDs should extinguish once these steps are complete. Once all LEDs are not illuminated, use the HMI alarm page on top right hand corner click "accept alarms" and then " reset alarms". All alarms and alerts should disappear.	02-Oct	FM	16-Oct	FM	
8a	Manual 'Adsorption' mode testing	Valves for startup positioned, as per Operating Instructions Rev B Table 1	02-Oct	FM	16-Oct	FM	
8b	Manual 'Adsorption' mode testing	Manually position control valves as per Process Description & Control Philosophy for Adsorber 1 adsorption.	02-Oct	FM	16-Oct	FM	
8c	Manual 'Adsorption' mode testing	H-101 then F-101 turned on manually	02-Oct	FM	16-Oct	FM	

SAT & FAT Testing Procedure

#	Stage	Description	Completed Date	Signed (FAT)	Completed Date	Signed (SAT)	Comments
8d	Manual 'Adsorption' mode testing	Witness increase in pressure on PT-3012	02-Oct	FM	16-Oct	FM	0.2barg
8e	Manual 'Adsorption' mode testing	Witness increase in pressure on PT-3013.	02-Oct	FM	16-Oct	FM	0.2barg
8f	Manual 'Adsorption' mode testing	Witness readings on FT-3017	02-Oct	FM	16-Oct	FM	140Am³/hr
8g	Manual 'Adsorption' mode testing	Witness readings on TT-3014	02-Oct	FM	16-Oct	FM	10.7°C
8h	Manual 'Adsorption' mode testing	Witness readings on QT-3010	02-Oct	FM	16-Oct	FM	83%rh
8i	Manual 'Adsorption' mode testing	Witness readings on QT-3015	02-Oct	FM	16-Oct	FM	0.13%
8j	Manual 'Adsorption' mode testing	Witness readings on QT-3016	02-Oct	FM	16-Oct	FM	97%rh
8k	Manual 'Adsorption' mode testing	F-101 and H-101 to remain operating	02-Oct	FM	16-Oct	FM	
8l	Manual 'Adsorption' mode testing	Manually position control valves as per Process Description & Control Philosophy for Adsorber 1 desorption.	02-Oct	FM	16-Oct	FM	
9a	Manual 'Adsorption' mode testing	Manually position control valves as per Process Description & Control Philosophy for Adsorber 2 adsorption.	02-Oct	FM	16-Oct	FM	
9b	Manual 'Adsorption' mode testing	Witness increase in pressure on PT-3022	02-Oct	FM	16-Oct	FM	0.2barg
9c	Manual 'Adsorption' mode testing	Witness increase in pressure on PT-3023.	02-Oct	FM	16-Oct	FM	0.2barg
9d	Manual 'Adsorption' mode testing	Witness readings on FT-3017	02-Oct	FM	16-Oct	FM	140Am³/hr
9e	Manual 'Adsorption' mode testing	Witness readings on TT-3014	02-Oct	FM	16-Oct	FM	10.7°C
9f	Manual 'Adsorption' mode testing	Witness readings on QT-3010	02-Oct	FM	16-Oct	FM	83%rh
9g	Manual 'Adsorption' mode testing	Witness readings on QT-3015	02-Oct	FM	16-Oct	FM	0.13%
9h	Manual 'Adsorption' mode testing	Witness readings on QT-3016	02-Oct	FM	16-Oct	FM	97%rh
10	Manual 'Adsorption' mode testing	Inspect both vessels once pressure has relieved, ensure there is no visible damage or deformations	02-Oct	FM	16-Oct	FM	
11a	Manual 'Desorption' mode testing	H-101 then F-101 turned off manually	02-Oct	FM	16-Oct	FM	
11b	Manual 'Desorption' mode testing	Confirm Adsorber 1 desorption valve positions, then start P-101	02-Oct	FM	16-Oct	FM	
11c	Manual 'Desorption' mode testing	Witness decrease in pressure on PT-3012	02-Oct	FM	16-Oct	FM	-0.98barg
11d	Manual 'Desorption' mode testing	Witness decrease in pressure on PT-3013.	02-Oct	FM	16-Oct	FM	-0.98barg
11e	Manual 'Desorption' mode testing	Witness readings on FT-1014	02-Oct	FM	16-Oct	FM	
11f	Manual 'Desorption' mode testing	Witness readings on PT-1013 (100mbara)	02-Oct	FM	16-Oct	FM	
11g	Manual 'Desorption' mode testing	Witness readings on QT-1015	02-Oct	FM	16-Oct	FM	0.40%
11h	Manual 'Desorption' mode testing	Turn off P-101	02-Oct	FM	16-Oct	FM	
11i	Manual 'Desorption' mode testing	Close CV-14	02-Oct	FM	16-Oct	FM	
12a	Manual 'Desorption' mode testing	Manually position control valves as per Process Description & Control Philosophy for Adsorber 2 desorption.	02-Oct	FM	16-Oct	FM	

SAT & FAT Testing Procedure

#	Stage	Description	Completed Date	Signed (FAT)	Completed Date	Signed (SAT)	Comments
12b	Manual 'Desorption' mode testing	Start P-101	02-Oct	FM	16-Oct	FM	
12c	Manual 'Desorption' mode testing	Witness decrease in pressure on PT-3022	02-Oct	FM	16-Oct	FM	-0.98barg
12d	Manual 'Desorption' mode testing	Witness decrease in pressure on PT-3023.	02-Oct	FM	16-Oct	FM	-0.98barg
12e	Manual 'Desorption' mode testing	Witness readings on FT-1014	02-Oct	FM	16-Oct	FM	
12f	Manual 'Desorption' mode testing	Witness readings on PT-1013 (100mbara)	02-Oct	FM	16-Oct	FM	
12g	Manual 'Desorption' mode testing	Witness readings on QT-1015	02-Oct	FM	16-Oct	FM	0.40%
12h	Manual 'Desorption' mode testing	Stop P-101	02-Oct	FM	16-Oct	FM	
13	Manual 'Desorption' mode testing	Inspect both vessels once vacuum has relieved, ensure there is no visible damage or deformations	02-Oct	FM	16-Oct	FM	
14a	Automatic Control Testing (Normal Operation)	Providing all previous steps have passed, automatic control testing can commence. Valves for startup positioned, as per Operating Instructions Rev B Table 1	02-Oct	FM	16-Oct	FM	
14b	Automatic Control Testing (Normal Operation)	Process Description & Control Philosophy Rev C Section 4.1.3 to be used as reference. Ensure all pre-requisite checks (page 12) have been completed and the operator is satisfied.	02-Oct	FM	16-Oct	FM	
14c	Automatic Control Testing (Normal Operation)	Process Description & Control Philosophy Rev C Table 15: Operator to press 'Enable' on HMI and follow the steps provided on the sequence.	02-Oct	FM	16-Oct	FM	
14d	Automatic Control Testing (Normal Operation)	Witness adsorption and desorption functioning as expected on Adsorber 1 and 2.	02-Oct	FM	16-Oct	FM	
14e	Automatic Control Testing (Normal Operation)	Test Sequence Step 13 (Process Description & Control Philosophy Rev C, 'Shutdown' page 15). Ensure system shuts down in the correct order and operates as expected.	02-Oct	FM	16-Oct	FM	
14f	Automatic Control Testing (Regeneration)	Operator to reference Process Description & Control Philosophy Rev C Table 16 (page 16). 'Enable' CO_2 capture skid regeneration sequence. Witness F-101 and H-101 turning off.	02-Oct	FM	16-Oct	FM	
14g	Automatic Control Testing (Regeneration)	Witness full sequence and ensure during switchover to regeneration mode that the relevant equipment has changed to their respective positions/states/.	02-Oct	FM	16-Oct	FM	
14h	Automatic Control Testing (Regeneration)	Shows temperature increase on the local gauge and the vessel feels warmer. Temperature reading to be verified with an IR temperature gun, once vessel has stayed at the set point for at least 15 minutes to allow heat transfer through the metal vessel walls. Accuracy of IR gun to be determined to provide range of temperatures from the setpoint to verify temperature gauge on jacket is functioning as designed.	02-Oct	FM	16-Oct	FM	Heating Times: 14°C ambient, 14km/h SE winds V-301: 34.5minutes V-302: 31 minutes
15	Automatic Control Testing (Shutdown)	Test Sequence Step 12 (Process Description & Control Philosophy Rev C, 'Shutdown' page 17). Ensure system shuts down in the correct order and operates as expected.	02-Oct	FM	16-Oct	FM	

Final Comments:

1) CO_2 sensors reading higher than expected, beyond the range of error. Noted that the readings changed with temperature
2) Flow meters different but potentially due to P&T differences. Also, both sensors are calibrated for flue gas in TWO different compositions. Not for air with consistent composition
3) Clarification required for vacuum pump usage during heated regeneration

Vessel Vacuum Loss Rate:

1:38pm: -0.96barg
1:48pm: -0.76barg
1:58pm: -0.62barg
2:08pm: -0.53barg
2:18pm: -0.43barg
2:28pm: -0.38barg

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