Annex D5

Thermal Oxidizer, Landfill Gas Flare and Landfill Gas Generator Stack Emission Monitoring Results

Table D5.1 Thermal Oxidiser Stack Emission Monitoring Results

Parameters	**Monitoring Results (January 2022)**
NO_2	0.38 gs^{-1}
CO	0.047 gs^{-1}
SO_2	<0.015 gs^{-1}
Benzene	<4 x 10^{-5} gs^{-1}
Vinyl chloride	<3 x 10^{-5} gs^{-1}
Exhaust gas velocity	9.9 ms^{-1}
Parameters	**Monitoring Results (February 2022)**
NO_2	1.17 gs^{-1}
CO	0.06 gs^{-1}
SO_2	0.02 gs^{-1}
Benzene	<3 x 10^{-5} gs^{-1}
Vinyl chloride	<3 x 10^{-5} gs^{-1}
Non-methane Organic Carbons	3.6 x 10^{-3} gs^{-1}
Ammonia	6.52 x 10^{-2} gs^{-1}
Exhaust gas velocity	9.9 ms^{-1}
Parameters	**Monitoring Results (March 2022)**
NO_2	1.54 gs^{-1}
CO	0.04 gs^{-1}
SO_2	<0.01 gs^{-1}
Benzene	<3 x 10^{-5} gs^{-1}
Vinyl chloride	<2 x 10^{-5} gs^{-1}
Exhaust gas velocity	9.1 ms^{-1}

Table D5.2 Thermal Oxidiser Stack Continuous Monitoring Results

Date	**Gas Combustion Temperature (°C)**	**Exhaust temperature (K)**	**Exhaust gas velocity (ms^{-1}) [a]**
01 Jan 22	983	1246	
02 Jan 22	963	1236	
03 Jan 22	975	1231	
04 Jan 22	971	1234	
05 Jan 22	971	1242	
06 Jan 22	974	1243	
07 Jan 22	993	1265	
08 Jan 22	982	1242	
09 Jan 22	964	1235	
10 Jan 22	973	1232	
11 Jan 22	966	1230	
12 Jan 22	966	1223	
13 Jan 22	952	1226	
14 Jan 22	987	1241	
15 Jan 22	959	1223	
16 Jan 22	963	1223	9.9
17 Jan 22	975	1243	
18 Jan 22	968	1233	
19 Jan 22	956	1218	
20 Jan 22	979	1244	
21 Jan 22	968	1241	
22 Jan 22	975	1241	
23 Jan 22	970	1247	

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]
24 Jan 22	987	1235	
25 Jan 22	971	1232	
26 Jan 22	994	1264	
27 Jan 22	967	1232	
28 Jan 22	975	1242	
29 Jan 22	968	1230	
30 Jan 22	973	1236	
31 Jan 22	968	1234	
01 Feb 22	- [b]	- [b]	
02 Feb 22	- [b]	- [b]	
03 Feb 22	963	1221	
04 Feb 22	976	1232	
05 Feb 22	970	1227	
06 Feb 22	984	1234	
07 Feb 22	968	1231	
08 Feb 22	970	1236	
09 Feb 22	969	1228	
10 Feb 22	977	1239	
11 Feb 22	972	1232	
12 Feb 22	984	1241	
13 Feb 22	965	1231	
14 Feb 22	972	1220	9.9
15 Feb 22	969	1234	
16 Feb 22	966	1234	
17 Feb 22	975	1238	
18 Feb 22	975	1235	
19 Feb 22	969	1230	
20 Feb 22	958	1222	
21 Feb 22	975	1225	
22 Feb 22	963	1229	
23 Feb 22	980	1221	
24 Feb 22	964	1227	
25 Feb 22	976	1239	
26 Feb 22	981	1233	
27 Feb 22	964	1226	
28 Feb 22	1013	1219	
1 Mar 22	970	1230	
2 Mar 22	971	1221	
3 Mar 22	983	1244	
4 Mar 22	969	1223	
5 Mar 22	975	1234	
6 Mar 22	964	1219	
7 Mar 22	1015	1222	
8 Mar 22	983	1230	
9 Mar 22	974	1231	
10 Mar 22	972	1221	
11 Mar 22	969	1235	9.1
12 Mar 22	979	1237	
13 Mar 22	959	1223	
14 Mar 22	981	1232	
15 Mar 22	993	1248	
16 Mar 22	978	1227	
17 Mar 22	971	1232	
18 Mar 22	978	1233	
19 Mar 22	974	1228	
20 Mar 22	968	1222	
21 Mar 22	967	1225	

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [(a)]
22 Mar 22	1028	1276	
23 Mar 22	Under maintenance		
24 Mar 22	1035	1246	
25 Mar 22	962	1214	
26 Mar 22	967	1217	
27 Mar 22	960	1218	
28 Mar 22	984	1236	
29 Mar 22	982	1223	
30 Mar 22	977	1234	
31 Mar 22	967	1228	
Average	975	1233	9.6
Min	952	1214	9.1
Max	1035	1276	9.9

Notes:
(a) The exhaust gas velocity was calculated based on the cross-section area of the stack and the gas flow and combustion temperature data measured during the stack emission monitoring.
(b) Stack emission monitoring was suspended on 1 and 2 Feb 2022 as the thermal oxidiser was not in operation.

Table D5.3 Landfill Gas Flare Stack Emission Monitoring Results

Parameters	Monitoring Results (January 2022)	
	Flare 1 – F601	**Flare 2 – F602**
NO_2	<0.01 gs^{-1}	<0.01 gs^{-1}
CO	0.032 gs^{-1}	0.04 gs^{-1}
SO_2	0.09 gs^{-1}	0.10 gs^{-1}
Benzene	1.3×10^{-5} gs^{-1}	1.6×10^{-5} gs^{-1}
Vinyl chloride	$<1.1 \times 10^{-5}$ gs^{-1}	$<1.3 \times 10^{-5}$ gs^{-1}
Exhaust gas velocity	4.3 ms^{-1}	2.0 ms^{-1}
Parameters	**Monitoring Results (February 2022) (Flare 1 – F601)**	
NO_2	<0.01 gs^{-1}	
CO	0.027 gs^{-1}	
SO_2	0.110 gs^{-1}	
Benzene	5.1×10^{-5} gs^{-1}	
Vinyl chloride	$<1.1 \times 10^{-5}$ gs^{-1}	
Non-methane Organic Carbons	4.1×10^{-3} gs^{-1}	
Exhaust gas velocity	4.4 ms^{-1}	
Parameters	**Monitoring Results (March 2022) (Flare 2 – F602)**	
NO_2	0.02 gs^{-1}	
CO	0.056 gs^{-1}	
SO_2	0.007 gs^{-1}	
Benzene	$<1.2 \times 10^{-5}$ gs^{-1}	
Vinyl chloride	$<1 \times 10^{-5}$ gs^{-1}	
Exhaust gas velocity	3.9 ms^{-1}	

Table D5.4 Landfill Gas Flare Stack Continuous Monitoring Results

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [(a)]	Operation Status
Flare 1 – F601				
01 Jan 22	-	-		Standby
02 Jan 22	-	-		Standby
03 Jan 22	1072	1115		In Operation
04 Jan 22	907	1143		In Operation
05 Jan 22	920	1133		In Operation
06 Jan 22	931	1163		In Operation
07 Jan 22	891	1023		In Operation
08 Jan 22	929	1143		In Operation
09 Jan 22	-	-		Standby
10 Jan 22	1077	1183		In Operation
11 Jan 22	-	-		Standby
12 Jan 22	854	1028		In Operation
13 Jan 22	1156	1184		In Operation
14 Jan 22	968	1133		In Operation
15 Jan 22	999	1133		In Operation
16 Jan 22	1051	1133	4.3	In Operation
17 Jan 22	1171	1133		In Operation
18 Jan 22	-	-		Standby
19 Jan 22	1076	1189		In Operation
20 Jan 22	-	-		Standby
21 Jan 22	1064	1223		In Operation
22 Jan 22	1037	1163		In Operation
23 Jan 22	1087	1163		In Operation
24 Jan 22	992	1123		In Operation
25 Jan 22	1015	1223		In Operation
26 Jan 22	-	-		Standby
27 Jan 22	-	-		Standby
28 Jan 22	-	-		Standby
29 Jan 22	-	-		Standby
30 Jan 22	-	-		Standby
31 Jan 22	-	-		Standby
01 Feb 22	-	-		Standby
02 Feb 22	-	-		Standby
03 Feb 22	-	-		Standby
04 Feb 22	-	-		Standby
05 Feb 22	-	-		Standby
06 Feb 22	-	-		Standby
07 Feb 22	-	-		Standby
08 Feb 22	-	-		Standby
09 Feb 22	995	1213		In Operation
10 Feb 22	-	-		Standby
11 Feb 22	-	-		Standby
12 Feb 22	930	1181		In Operation
13 Feb 22	-	-		Standby
14 Feb 22	816	1083	4.4	In Operation
15 Feb 22	-	-		Standby
16 Feb 22	-	-		Standby
17 Feb 22	-	-		Standby
18 Feb 22	-	-		Standby
19 Feb 22	-	-		Standby
20 Feb 22	-	-		Standby
21 Feb 22	832	1093		In Operation
22 Feb 22	-	-		Standby
23 Feb 22	-	-		Standby
24 Feb 22	-	-		Standby

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status
25 Feb 22	-	-		Standby
26 Feb 22	-	-		Standby
27 Feb 22	-	-		Standby
28 Feb 22	-	-	-	Standby
1 Mar 22	-	-		Standby
2 Mar 22	-	-		Standby
3 Mar 22	-	-		Standby
4 Mar 22	986	1181		In operation
5 Mar 22	-	-		Standby
6 Mar 22	-	-		Standby
7 Mar 22	-	-		Standby
8 Mar 22	-	-		Standby
9 Mar 22	880	1133		In operation
10 Mar 22	-	-		Standby
11 Mar 22	-	-		Standby
12 Mar 22	-	-		Standby
13 Mar 22	-	-		Standby
14 Mar 22	-	-		Standby
15 Mar 22	-	-		Standby
16 Mar 22	-	-	3.9	Standby
17 Mar 22	-	-		Standby
18 Mar 22	-	-		Standby
19 Mar 22	-	-		Standby
20 Mar 22	-	-		Standby
21 Mar 22	-	-		Standby
22 Mar 22	-	-		Standby
23 Mar 22	-	-		Standby
24 Mar 22	-	-		Standby
25 Mar 22	-	-		Standby
26 Mar 22	990	1223		In operation
27 Mar 22	830	1093		In operation
28 Mar 22	880	1113		In operation
29 Mar 22	860	1073		In operation
30 Mar 22	-	-		Standby
31 Mar 22	950	1173		In operation
Average	972	1143		
Min	816	1023	3.9	
Max	1171	1223	4.4	
Flare 2 – F602				
01 Jan 22	824	1058		In Operation
02 Jan 22	820	1060		In Operation
03 Jan 22	822	1061		In Operation
04 Jan 22	827	1071		In Operation
05 Jan 22	824	1049		In Operation
06 Jan 22	826	1069		In Operation
07 Jan 22	828	1069		In Operation
08 Jan 22	826	1074		In Operation
09 Jan 22	1082	1226		In Operation
10 Jan 22	908	1119		In Operation
11 Jan 22	970	1148		In Operation
12 Jan 22	905	1102		In Operation
13 Jan 22	923	1062		In Operation
14 Jan 22	904	1093		In Operation
15 Jan 22	1171	1099		In Operation
16 Jan 22	877	1283	2.0	In Operation
17 Jan 22	874	1061		In Operation
18 Jan 22	872	1067		In Operation
19 Jan 22	873	1060		In Operation

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status
20 Jan 22	843	1045		In Operation
21 Jan 22	900	1120		In Operation
22 Jan 22	873	1096		In Operation
23 Jan 22	1080	1241		In Operation
24 Jan 22	933	1204		In Operation
25 Jan 22	905	1132		In Operation
26 Jan 22	965	1142		In Operation
27 Jan 22	997	1120		In Operation
28 Jan 22	939	1134		In Operation
29 Jan 22	967	1160		In Operation
30 Jan 22	957	1153		In Operation
31 Jan 22	1090	1223		In Operation
01 Feb 22	-	-		Standby
02 Feb 22	-	-		Standby
03 Feb 22	-	-		Standby
04 Feb 22	924	1015		In Operation
05 Feb 22	845	1083		In Operation
06 Feb 22	830	1073		In Operation
07 Feb 22	870	1113		In Operation
08 Feb 22	850	1093		In Operation
09 Feb 22	850	1083		In Operation
10 Feb 22	840	1063		In Operation
11 Feb 22	850	1068		In Operation
12 Feb 22	850	1068		In Operation
13 Feb 22	880	1123		In Operation
14 Feb 22	870	1073		In Operation
15 Feb 22	850	1073	4.4	In Operation
16 Feb 22	850	1037		In Operation
17 Feb 22	860	1083		In Operation
18 Feb 22	860	1080		In Operation
19 Feb 22	850	1039		In Operation
20 Feb 22	-	-		Standby
21 Feb 22	890	1113		In Operation
22 Feb 22	830	1038		In Operation
23 Feb 22	900	1083		In Operation
24 Feb 22	830	1066		In Operation
25 Feb 22	850	1053		In Operation
26 Feb 22	870	1063		In Operation
27 Feb 22	850	1057		In Operation
28 Feb 22	830	1076		In Operation
1 Mar 22	850	1043		In operation
2 Mar 22	850	1043		In operation
3 Mar 22	850	1055		In operation
4 Mar 22	850	1053		In operation
5 Mar 22	860	1083		In operation
6 Mar 22	830	1053		In operation
7 Mar 22	850	1083	3.9	In operation
8 Mar 22	840	1073		In operation
9 Mar 22	880	1033		In operation
10 Mar 22	880	1103		In operation
11 Mar 22	860	1093		In operation
12 Mar 22	850	1113		In operation
13 Mar 22	870	1073		In operation
14 Mar 22	880	1123		In operation
15 Mar 22	830	1073		In operation
16 Mar 22	840	1083		In operation
17 Mar 22	830	1073		In operation
18 Mar 22	880	1093		In operation

Date	Gas Combustion Temperature (°C)	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status
19 Mar 22	840	1073		In operation
20 Mar 22	830	1093		In operation
21 Mar 22	850	1093		In operation
22 Mar 22	-	-		Standby
23 Mar 22	820	1043		In operation
24 Mar 22	880	1083		In operation
25 Mar 22	850	1063		In operation
26 Mar 22	880	1083		In operation
27 Mar 22	840	1073		In operation
28 Mar 22	-	-		Standby
29 Mar 22	-	-		Standby
30 Mar 22	840	1083		In operation
31 Mar 22	890	1113		In operation
Average	878	1090	4.2	
Min	820	1015	3.9	
Max	1171	1283	4.4	

Notes:

(a) The exhaust gas velocity was calculated based on the cross-section area of the stack and the gas flow and combustion temperature data measured during the stack emission monitoring.

Table D5.5 Landfill Gas Generator Stack Emission Monitoring Results

Parameters	Monitoring Results (January 2022)
NO_2	0.008 gs^{-1}
CO	0.050 gs^{-1}
SO_2	0.009 gs^{-1}
Benzene	2×10^{-6} gs^{-1}
Vinyl chloride	$<1.3 \times 10^{-6}$ gs^{-1}
Exhaust gas velocity	7.8 ms^{-1}
Parameters	**Monitoring Results (February 2022)**
NO_2	0.016 gs^{-1}
CO	0.056 gs^{-1}
SO_2	0.002 gs^{-1}
Benzene	$<3 \times 10^{-6}$ gs^{-1}
Vinyl chloride	$<2 \times 10^{-6}$ gs^{-1}
Non-methane Organic Carbons	2×10^{-4} gs^{-1}
Exhaust gas velocity	11.9 ms^{-1}
Parameters	**Monitoring Results (March 2022)**
NO_2	1.54 gs^{-1}
CO	0.04 gs^{-1}
SO_2	<0.01 gs^{-1}
Benzene	$<3 \times 10^{-5}$ gs^{-1}
Vinyl chloride	$<2 \times 10^{-5}$ gs^{-1}
Exhaust gas velocity	9.1 ms^{-1}

Table D5.6 Landfill Gas Generator Stack Continuous Monitoring Results

Date	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status (Landfill Gas Generator in Operation)
01 Jan 22	840		In Operation (ENGB)
02 Jan 22	839		In Operation (ENGB)
03 Jan 22	839		In Operation (ENGB)
04 Jan 22	842		In Operation (ENGB)
05 Jan 22	842		In Operation (ENGB)
06 Jan 22	841		In Operation (ENGB)
07 Jan 22	841		In Operation (ENGB)
08 Jan 22	835		In Operation (ENGB)
09 Jan 22	840		In Operation (ENGB)
10 Jan 22	839		In Operation (ENGB)
11 Jan 22	841		In Operation (ENGB)
12 Jan 22	839		In Operation (ENGB)
13 Jan 22	-		Under maintenance
14 Jan 22	845		In Operation (ENGA)
15 Jan 22	838		In Operation (ENGA)
16 Jan 22	853	7.8	In Operation (ENGA)
17 Jan 22	836		In Operation (ENGA)
18 Jan 22	844		In Operation (ENGA)
19 Jan 22	843		In Operation (ENGA)
20 Jan 22	846		In Operation (ENGA)
21 Jan 22	846		In Operation (ENGA)
22 Jan 22	849		In Operation (ENGA)
23 Jan 22	840		In Operation (ENGA)
24 Jan 22	846		In Operation (ENGA)
25 Jan 22	846		In Operation (ENGA)

Date	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status (Landfill Gas Generator in Operation)
26 Jan 22	847		In Operation (ENGA)
27 Jan 22	848		In Operation (ENGA)
28 Jan 22	847		In Operation (ENGA)
29 Jan 22	847		In Operation (ENGA)
30 Jan 22	843		In Operation (ENGA)
31 Jan 22	847		In Operation (ENGA)
01 Feb 22	836		In Operation (ENGB)
02 Feb 22	842		In Operation (ENGB)
03 Feb 22	841		In Operation (ENGB)
04 Feb 22	841		In Operation (ENGB)
05 Feb 22	843		In Operation (ENGB)
06 Feb 22	844		In Operation (ENGB)
07 Feb 22	845		In Operation (ENGB)
08 Feb 22	836		In Operation (ENGB)
09 Feb 22	844		In Operation (ENGB)
10 Feb 22	847		In Operation (ENGB)
11 Feb 22	847		In Operation (ENGB)
12 Feb 22	846		In Operation (ENGB)
13 Feb 22	845		In Operation (ENGB)
14 Feb 22	846	11.9	In Operation (ENGA)
15 Feb 22	845		In Operation (ENGA)
16 Feb 22	846		In Operation (ENGA)
17 Feb 22	844		In Operation (ENGA)
18 Feb 22	845		In Operation (ENGA)
19 Feb 22	841		In Operation (ENGA)
20 Feb 22	843		In Operation (ENGA)
21 Feb 22	841		In Operation (ENGA)
22 Feb 22	841		In Operation (ENGA)
23 Feb 22	840		In Operation (ENGA)
24 Feb 22	840		In Operation (ENGA)
25 Feb 22	841		In Operation (ENGA)
26 Feb 22	841		In Operation (ENGA)
27 Feb 22	842		In Operation (ENGA)
28 Feb 22	842		In Operation (ENGA)
1 Mar 22	842		In Operation (ENGA)
2 Mar 22	844		In Operation (ENGA)
3 Mar 22	841		In Operation (ENGB)
4 Mar 22	843		In Operation (ENGB)
5 Mar 22	845		In Operation (ENGB)
6 Mar 22	844		In Operation (ENGB)
7 Mar 22	841		In Operation (ENGB)
8 Mar 22	840		In Operation (ENGB)
9 Mar 22	842		In Operation (ENGB)
10 Mar 22	842		In Operation (ENGB)
11 Mar 22	842		In Operation (ENGB)
12 Mar 22	844	9.1	In Operation (ENGB)
13 Mar 22	844		In Operation (ENGB)
14 Mar 22	844		In Operation (ENGB)
15 Mar 22	845		In Operation (ENGB)
16 Mar 22	846		In Operation (ENGB)
17 Mar 22	846		In Operation (ENGB)
18 Mar 22	847		In Operation (ENGB)
19 Mar 22	847		In Operation (ENGB)
20 Mar 22	848		In Operation (ENGB)
21 Mar 22	847		In Operation (ENGB)
22 Mar 22	849		In Operation (ENGB)
23 Mar 22	846		In Operation (ENGB)

Date	Exhaust temperature (K)	Exhaust gas velocity (ms^{-1}) [a]	Operation Status (Landfill Gas Generator in Operation)
24 Mar 22	842		In Operation (ENGB)
25 Mar 22	844		In Operation (ENGB)
26 Mar 22	850		In Operation (ENGB)
27 Mar 22	850		In Operation (ENGB)
28 Mar 22	843		In Operation (ENGB)
29 Mar 22	841		In Operation (ENGB)
30 Mar 22	846		In Operation (ENGB)
31 Mar 22	846		In Operation (ENGB)
Average	844	9.5	
Min	835	7.8	
Max	853	11.9	

Notes:

(a) The exhaust gas velocity was calculated based on the cross-section area of the stack and the gas flow and combustion temperature data measured during the stack emission monitoring.