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Date: 19 July 2018
Our ref.: KSZHJV/OUT/2018/07/03.01/000685

Environmental Protection Department
Branch Office
28/F, Southorn Centre,
130 Hennessy Road,
Wan Chai, Hong Kong
Attention: Mr. Alex H. K. Tang

Dear Sir,

Contract No. EP/SP/66/12
Integrated Waste Management Facilities, Phase 1
Flue Gas Emission Control Measures Implementation Plan (Rev. D)

Referring to your letter ref no. (22) in Ax(1) to EP2/G/G/131 dated 29 June 2018, we would like to submit herewith 3 hard copies and 1 electronic copy of the Flue Gas Emission Control Measures Implementation Plan (Rev. D) for your retention in accordance with Condition 1.8 and 2.7A of the Further Environmental Permit No.: FEP-01/429/2012/A.

The Flue Gas Emission Control Measures Implementation Plan (Rev. D) has been certified by the Environmental Team Leader and verified by Independent Environmental Checker as conforming to the recommendations contained in the approved EIA report (Register No.: AEIAR-163/2012).

Thank you for your kind attention.

Yours faithfully
For and on behalf of
Keppel Seghers – Zhen Hua Joint Venture

CHUNG Tai Tung, Peter
Project Manager

Encl.

PC/BW/KY/LC/ct

c.c. EPD - Mr W.P. YU - Principal Environmental Protection Officer (F: 3529 2991)
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環境保護署
Environmental Protection Department

Contract No. EP/SP/66/12
Integrated Waste Management Facilities, Phase 1

Keppel Seghers

吉寶西格斯－振華聯營公司
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FLUE GAS EMISSION CONTROL MEASURES IMPLEMENTATION PLAN

(Clause 2.7A, Further Environmental Permit No. FEP-01/429/2012/A)

Document No.

KSZHJV	/	312	/	FGECP	/	001	/	D
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	Prepared by:	Approved by:	Certified by:	Verified by:
Name	Leo Chow	Peter Chung	Gabriel Lam	Jovy Tam
Position	Environmental Monitoring Manager (KSZHJV)	Project Manager (KSZHJV)	ETL (Acuity)	IEC (ERM)
Signature				
Date:	16 July 2018	16 July 2018	18 July 2018	18 July 2018

Revision History

D	Response to EPD's comment issued on 29 June 2018	16 July 2018
C	Response to IEC's comment issued on 21 May 2018	21 May 2018
B	Response to IEC's and ET's comment	21 May 2018
A	First Issue for Comments	3 Apr 2018
Rev.	**DESCRIPTION OF MODIFICATION**	**DATE**

Contract No. EP/SP/66/12
Integrated Waste Management Facilities, Phase 1

Response to Comment issued by EPD on 29/6/18

Query	EPD's Comment	KSZHJV's Response
1	Section 3 Design Criteria, Section 4 Design Parameters, Section 5 Compliance Testing Proposals, Section 6 Preliminary Design, Section 7 Action and Limit Level of Air Pollutants, and Section 8 Response to Abnormal Conditions should be checked and handled separately in processing the Specified Process (SP) license application under the Air Pollution Control Ordinance. Please remove these sections from the Implementation Plan deposited pursuant to Conditions 2.7A of FEP-01/429/2012/A under the EIA Ordinance.	Noted and deleted those sections and related appendices C & D.
2	While Section 3 shall be removed from the submission, please be reminded that there should be updated set of operation parameters in the assessment for the VEP application as compared with those in the EIA report.	Noted.
3	It is noted that the concentration limits of NH_3 are provided in Section 2.1 in accordance with the Specification. However, as the EIA assessment has not covered the NH_3 emissions, we would reserve our comments on concentration limits of NH_3 at this stage and may provide our comments when handling the SP license application in due course.	Noted.

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APPENDICES

1 INTRODUCTION

1.1 Background

The Environmental Protection Department (EPD) Contract No. EP/SP/66/12, "Integrated Waste Management Facilities (IWMF) Phase 1", was awarded to Keppel Seghers–Zhen Hua Joint Venture (KSZHJV) in November 2017 under a design-build-operate (DBO) arrangement. The IWMF comprises: (a) an advanced thermal incineration plant with operation capacity of 3,000 tonnes per day (tpd) and (b) a mechanical sorting and recycling plant with design capacity of 200 tpd. The non-recyclables sorted from the mechanical plant will be sent to the thermal incineration plant for further treatment. Under any conditions, the total MSW feeding to the thermal incineration plant will not exceed 3,000 tpd. The project will be located on an artificial island to the south of Shek Kwu Chau.

An environmental impact assessment (EIA) study for the Project have been conducted and the EIA Report was approved under the Environmental Impact Assessment Ordinance on 17 January 2012. An Environmental Permit (EP) (EP No.: EP-429/2012) was granted to EPD on 19 January 2012 for the construction and operation of the Project. Subsequently, the EP was amended (EP No.: EP-429/2012/A) and a further EP (FEP) (EP No.: FEP-01/429/2012/A) was granted to the KSZHJV on 27 December 2017.

Pursuant to Clause 2.7A of the FEP, a Flue Gas Emission Control Measures Implementation Plan shall be developed and deposited with the Director of Environmental Protection.

1.2 Objective

The process and layout design of the Flue Gas Treatment System includes the following main equipment:

- Selective Non-Catalytic Reduction (SNCR) unit (built in the boiler first empty pass);
- First stage All-Dry system (operating at 240°C), with
  - Sodium bicarbonate injection ($NaHCO_3$);
  - Filter bag system;
  - Residue recirculation system;
- Selective Catalytic Reduction (SCR) unit (operating at ~ 235°C);
- External economiser unit (waterside integrated in the boiler circuit);
- Second stage All-Dry system (operating at 140°C), with
  - Dry, hydrated lime injection ($Ca(OH)_2$);
  - Powdered activated carbon (PAC) injection;
  - Filter bag system;
  - Residue recirculation system;
- Induced Draught (ID) fan, with silencer;
- Stack with Continuous Emissions Monitoring System (CEMS);

The flowchart of Flue Gas Treatment System and the target air pollutants to be removed at each stage are summarized in **Appendix A**.

This Flue Gas Emission Control Measures Implementation Plan covers the following aspect:

(i) Design standards and codes of practice;

2 DESIGN STANDARDS AND CODES OF PRACTICE

The Flue Gas Treatment System shall comply with:

- The Industrial Emissions Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), which replace the 2000/76/EC Incineration Directive
- The conditions of the Specified Process License and the Environmental Permit and the "A Guidance Note on the Best Practicable Means for Incinerator (Municipal Waste Incineration) BPM12/1(08)" published by EPD (all pollutant concentration limit values are expressed at reference conditions of 0°C temperature, 101.325 kPa pressure, dry and 11% oxygen content conditions).
- The Concentration Limits of NO_x stated in Contract Specification were used for the design of flue gas emission control
- Permanent accessibility to equipment will be in line with the requirements of EN14122-Safety of machinery – Permanent means of access to machinery.
- "A Guidance Note on the Best Practicable Means for Incinerator (Municipal Waste Incineration) BPM12/1(08)" published by EPD has been considered in the design
- Specification (Part C) Requirements for Process, Electrical and Mechanical Works (Clauses 2.1.4.1, 2.1.4.4, 2.4.11.34, 2.5, 2.6)
- Specification (Part D) Requirements for Operation and Maintenance (Clause 2.6.1.9) Relevant parts of the specification are attached in **Appendix B**.

2.1 Concentration Limit for Emission From Incinerators – Municipal Waste Incineration

Air pollutant from the subject incineration process of this IWMF project shall not exceed the concentration limits tabulated in the following **Tables 1 - 4**. The air pollutant concentration is expressed at reference conditions of 0˚C, 101.325kPa pressure, dry and 11% oxygen content conditions.

(a) Daily Average Value

Air Pollutant	**Concentration Limit (mg/m^3)**
Particulates *	10
Gaseous and vaporous organic substances, expressed as total organic carbon	10
Hydrogen chloride (HCl)	10
Hydrogen fluoride (HF)	1
Sulphur dioxide (SO_2)	50
Nitrogen oxides, expressed as nitrogen dioxide (NO_2)	80
Carbon monoxide (CO) **	50

Table 1 – Daily Average Value

(b) Half-hourly Average Value

Air Pollutant	**Concentration Limit (mg/m^3)**
Particulates *	30
Gaseous and vaporous organic substances, expressed as total organic carbon	20
Hydrogen chloride (HCl)	60
Hydrogen fluoride (HF)	4
Sulphur dioxide (SO_2)	200
Nitrogen oxides, expressed as nitrogen dioxide (NO_2)	160
Carbon monoxide (CO) **	100

Table 2 – Half-hourly Average Value

Note:

* Particulates – shall monitor Respirable Suspended Particulates

** excluding the start-up and shut-down phases

(c) Average value over the sampling period of a minimum of 30 minutes and a maximum of 8 hours

Air Pollutant	Limit Level (mg/m^3)
Cadmium and its compounds, expressed as cadmium (Cd)	Total 0.05
Thallium and its compounds, expressed as thallium (Tl)	
Mercury and its compounds, expressed as mercury (Hg)	0.05
Antimony and its compounds, expressed as antimony (Sb)	Total 0.5
Arsenic and its compounds, expressed as arsenic (As)	
Lead and its compounds, expressed as lead (Pb)	
Chromium and its compounds, expressed as chromium (Cr)	
Cobalt and its compounds, expressed as cobalt (Co)	
Copper and its compounds, expressed as copper (Cu)	
Manganese and its compounds, expressed as manganese (Mn)	
Nickel and its compounds, expressed as nickel (Ni)	
Vanadium and its compounds, expressed as vanadium (V)	

Table 3 – Average value over the sampling period of a minimum of 30 minutes and a maximum of 8 hours

(d) Average value over the sampling period of a minimum of 30 minutes and a maximum of 8 hours

Air Pollutant	Limit Level (ng I-TEQ/m^3)
Polychlorinated dibenzodioxins and polychlorinated dibenzofurans (see Section 2.2 for the calculation of equivalent concentration)	0.1

Table 4 – Average value over the sampling period of a minimum of 30 minutes and a maximum of 8 hours

The concentration limits for NO_x and ammonia (NH_3) from flue gas emission as specified in paragraph 2.1.4.3 of the Specification (Part C). See below.

	Concentration limit (mg/m^3)	
	(i) NOx	(ii) NH_3
(a) Daily average value	80	10
(b) Half-hourly average value	160	15
Note: Emission limits are reference to 0°C and 101.325 kPa, dry and 11% oxygen content conditions.		

Table 5 – Concentration Limits for NO_x and Ammonia

2.2 Calculation of Equivalent Concentration For Dioxins

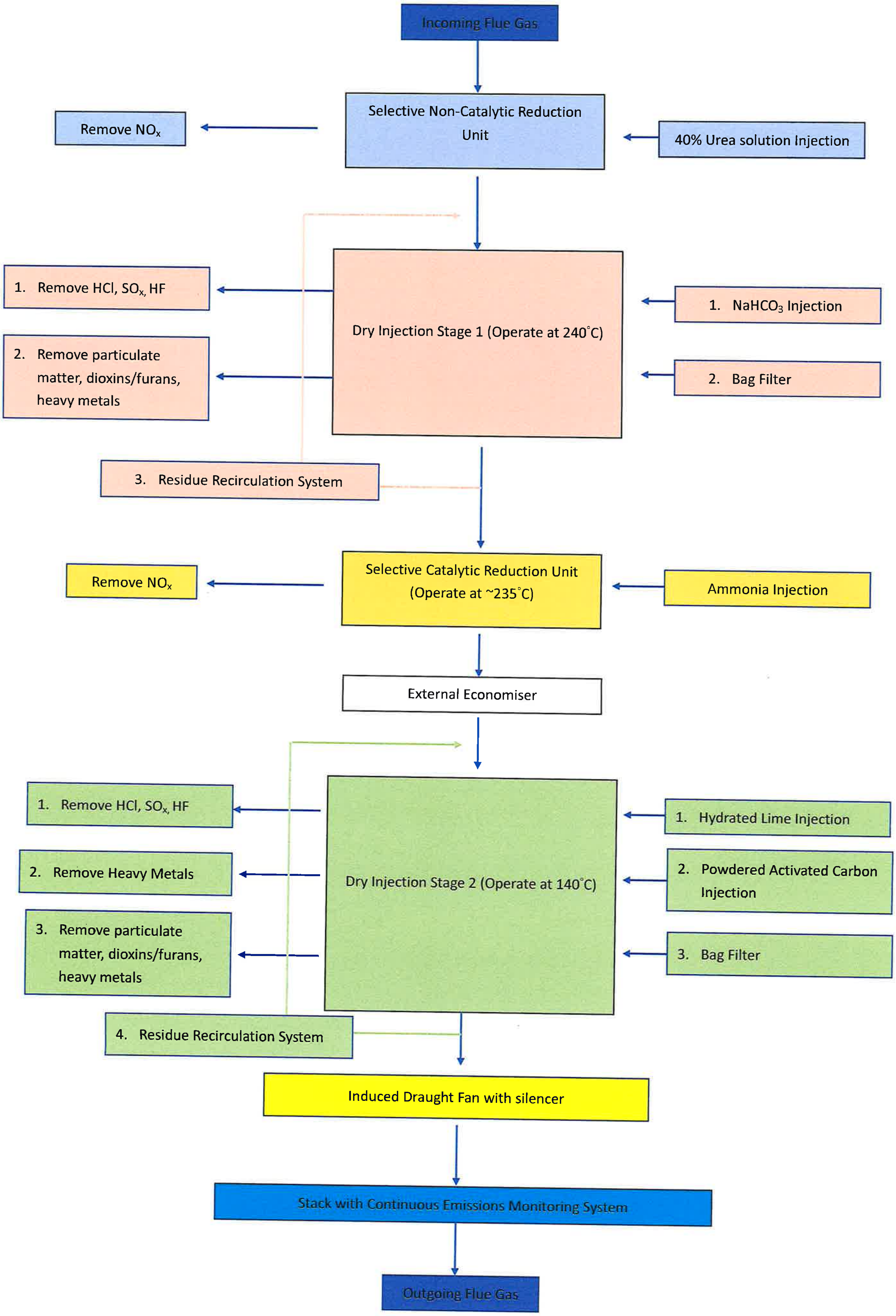
For the determination of total concentration of dioxins and furans, the mass concentrations of the following dibenzodioxins and dibenzofurans shall be multiplied by the following equivalence factors before summing:

		Toxic Equivalence Factor
2,3,7,8 -	Tetrachlorodibenzodioxin (TCDD)	1
1,2,3,7,8 -	Pentachlorodibenzodioxin (PeCDD)	0.5
1,2,3,4,7,8 -	Hexachlorodibenzodioxin (HxCDD)	0.1
1,2,3,6,7,8 -	Hexachlorodibenzodioxin (HxCDD)	0.1
1,2,3,7,8,9 -	Hexachlorodibenzodioxin (HxCDD)	0.1
1,2,3,4,6,7,8 -	Heptachlorodibenzodioxin (HpCDD)	0.01
	Octachlorodibenzodioxin (OCDD)	0.001
2,3,7,8 -	Tetrachlorodibenzofuran (TCDF)	0.1
2,3,4,7,8 -	Pentachlorodibenzofuran (PeCDF)	0.5
1,2,3,7,8 -	Pentachlorodibenzofuran (PeCDF)	0.05
1,2,3,4,7,8 -	Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,6,7,8 -	Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,7,8,9 -	Hexachlorodibenzofuran (HxCDF)	0.1
2,3,4,6,7,8 -	Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,4,6,7,8 -	Heptachlorodibenzofuran (HpCDF)	0.01
1,2,3,4,7,8,9 -	Heptachlorodibenzofuran (HpCDF)	0.01
	Octachlorodibenzofuran (OCDF)	0.001

Table 6 – Total Equivalence Factors

Appendix A

Flow Chart of Flue Gas Treatment System and The Target Air Pollutants



Appendix A - Flow Chart of Flue Gas Treatment System

Appendix B

Relevant Parts of Specification (Part C) and (Part D)

2.1.2 Incineration System Requirements

α 2.1.2.1 The Contractor shall provide an energy from waste (EfW) thermal treatment plant using a moving grate technology to be capable of treating 3,000 tonnes per day of MSW. The Facility shall safely and efficiently recover energy from the combustion processes to produce electrical energy using STG.

2.1.2.2 The incineration system and heat recovery boiler shall also be designed as follows:

(a) To ensure continuous combustion with stable and continuous steam generation.

(b) To ensure the amount of combustible material in the Ash and Residues is minimised.

(c) To ensure slagging and contamination in the combustion chamber is low.

(d) To cater for ash content of 30% (weight % as-received MSW).

(e) To cater for chlorine content of 1% (weight % as-received MSW).

(f) Meeting the Environmental Permit (EP) requirements as per Clause 1.38 of the Specification (Part A).

(g) The feeding mechanism for the combustion system shall be designed to be automatically interlocked so that feeding takes place only when appropriate emission requirement are fulfilled. The feeding sequence shall be interrupted immediately when these criteria are not fulfilled.

2.1.3 Ash and Residues Quality Requirements

α 2.1.3.1 Fly ash and air pollution control (APC) residues generated from the incineration process shall be treated by cement solidification or chemical stabilization, and meeting the requirements as stipulated in the relevant clauses of the latest Environmental Permit prior to disposal to the Designated Landfill.

2.1.3.2 The bottom ash shall comply with the following:

(a) Toxicity characteristic leaching procedure (TCLP) limits; and

(b) Total Organic Carbon (TOC) content less than 3% of the dry weight of the material.

α 2.1.3.3 The Ash and Residues (namely, fly ash, APC residues and bottom ash) shall be handled in closed systems fully segregated from the ambient environment and transport in sealed containers by sea to the Designated Landfill.

2.1.4 Flue Gas Emission Requirements

2.1.4.1 For the design of the FGT system and the whole facility parts in contact with raw flue gas, the following raw flue gas parameters shall be observed:

Pollutant Loads in Raw Flue Gas				
Parameter	**Unit**	**(i) Minimum**	**(ii) Average**	**(iii) Maximum**
(a) Dust (heating surface cleaning not in operation)	g/Nm^3 (dry)	2	3.5	9
(b) Dust (heating surface cleaning in operation)	g/Nm^3 (dry)	8	10	20

Pollutant Loads in Raw Flue Gas				
(c) HCl	mg/Nm³ (dry)	600	1,500	4,000
(d) SO_x	mg/Nm³ (dry)	200	750	1,300
(e) HF	mg/Nm³ (dry)	1	2.5	20
(f) PCDD/F	ng/Nm³ (dry)	0.2	2	3
(g) NO_x (prior to SNCR)	mg/Nm³ (dry)	300	450	700
(h) CO	mg/Nm³ (dry)	-	50	100
(i) C_{total}	mg/Nm³ (dry)	-	10	20
Note: The pollutant loads in raw flue gas are reference to 0°C and 101.325kPa, dry and 11% oxygen content conditions.				

γ

β 2.1.4.2 Notwithstanding the design parameters in Clause 2.1.4.1 of the Specification (Part C), air pollutant emissions from incineration flue gas after treatment shall comply with the conditions of the Specified Process License, and the Environmental Permit or its latest varied version. The Contractor's attention is also drawn to the "A Guidance Note on the Best Practicable Means for Incinerators (Municipal Waste Incineration)" published by EPD. All pollutant concentration limit values are expressed at reference conditions of 0 Deg C temperature, 101.325 kPa pressure, dry and 11% oxygen content conditions.

2.1.4.3 Notwithstanding the flue gas emission limits that would be specified in the Specified Process License, the concentration limits for NOx and ammonia (NH_3) from flue gas emission shall be as below:

	Concentration limit (mg/m³)	
	(i) NOx	(ii) NH_3
(a) Daily average value	80	10
(b) Half-hourly average value	160	15
Note: Emission limits are reference to 0°C and 101.325 kPa, dry and 11% oxygen content conditions.		

2.1.4.4 The Contractor shall ensure that there shall be no formation of a visible plume from the Facility's stack at any time during the Operation under stable and normal conditions. A visible plume is considered to be the cause of adverse visual impact to nearby residents and public visitors to the Facility.

2.1.4.5 Allowable flue gas volumetric flow shall be in accordance with the approved EIA Report, and the latest further Environmental Permit, see Clause 1.38 and 1.39 of the Specification (Part A).

2.1.5 Mechanical Treatment Plant Process Requirements

α 2.1.5.1 The Contractor shall provide a Mechanical Treatment (MT) Plant using automatic waste sorting technology for the treatment of MSW with a capacity of 200 tonnes per day with a minimum bulk density of 300kg/m³ with a moisture content of minimum 40%. The Contractor's design

Supervising Officer's satisfaction that the pipe surfaces are well below corrosion-critical surface temperatures.

2.4.11.28 The positioning of the final superheater shall be carefully designed such that they can easily be maintained and replaced.

2.4.11.29 The Contractor shall include provision in the boiler design for the future replacement of superheater, economiser and evaporator sections. Unless otherwise consented by the Supervising Officer, removal of the aforesaid sections shall be vertical through the roof via removable louvres openings. Removal of structural steelwork, headers or steam pipes or the boiler house roof or walls shall be avoided wherever possible.

2.4.11.30 The openings for the supporting girders shall be designed for a minimum load of 20 tonnes.

2.4.11.31 The superheaters shall be located and positioned with the inlet and outlet headers located outside the flue gas stream. The superheater tubes shall be arranged to allow them to be fully drained. The superheater outlet header shall be provided with vents, safety equipment, drains and instrumentation. The vent lines from the superheated steam line shall be extracted to a roof vent which shall be fitted with a silencer.

2.4.11.32 External insulation of heat recovery boilers hot components shall be provided with hydrosilicon, stone or glass wool mats quilted on wire mesh. The insulation shall be furnished with an external cladding made of 1 mm thick aluminium or galvanised aluminium profiled metal sheeting.

2.4.11.33 The economiser sections of the heat recovery boilers shall be designed to extract heat from the flue gas down to a temperature that maximises energy recovery but also avoids low temperature corrosion. There shall be sufficient access into the economiser section of the boiler to allow inspection and maintenance.

α 2.4.11.34 If the Contractor designs the FGT facilities with SCR and sodium bicarbonate injection, boiler exit temperatures of around 240 Deg C shall be required for the reactions. In this case, the economiser packages shall be separated into internal and an external economiser sections, and the internal economiser part shall be used to maintain a constant flue gas temperature of 240 Deg C at the boiler exit throughout the operation period, namely, by controlled feed water preheating with an additional heat exchanger in the boiler drum. An external economiser section within the FGT facilities (downstream of the SCR) shall then be used for further heat recovery and to ensure a flue gas temperature of 140 Deg C or above at the stack.

2.4.11.35 Combustion control system shall be automated with monitoring and control capability for each Incineration Train and its associated equipment. The heat recovery boilers shall be controlled to deliver a constant flow of steam at the required temperature and pressure conditions for a particular waste firing rate. The range of acceptable waste firing rates and waste LHV shall be in line with the firing diagram. The control system shall prevent the operator from setting the live steam flow at a rate higher than the design stream flow at 110% MCR or at a rate lower than the minimum heat release in the firing diagram.

2.4.11.36 Each heat recovery boiler shall be equipped with its own boiler drum complete with all the required fittings for a uniform distribution of boiler water into the drum and a separation system for effective separation of water from the saturated steam. The boiler drum shall be sized and designed to maintain a stable water level in the event of load variations. The drum volume shall be large enough to prevent fluctuations in the drum water level as a result of customary load fluctuations with the heat available. Fluctuations of up to 15% of the nominal flue gas enthalpy δ 2.4.11.46 The ash conveying system shall be configured to allow the collected ash to be transferred into the bottom ash quench system or into the fly ash and APC residues collection and storage silo. The bottom ash quench system shall be designed to ensure no running water resulting in the bottom ash bunker. The Contractor shall provide details of the conveying system for review. The design shall be of transfer conveyors, compressed air conveying system or a combination of both, subject to the Contractor's design. Fly ash and APC residues collection and storage silos shall be designed to have a storage capacity of minimum 3 days at 100% MCR conditions. Materials of construction and surface protection shall provide good corrosion resistance against the content stored therein. Level/ weight indication and alarms shall be provided into the control system. Fly ash and APC residues storage shall be designed to minimise hard packing and caking of the content therein.

2.4.11.47 Sufficient process instrumentation (namely, level, temperature, pressure, flow and quality) shall be provided to safely control, operate and monitor the performance of the boiler. This shall include but shall not be limited to:

(a) Flue gas temperature throughout the heat recovery boiler including at the exit of each radiant pass, at the entry and the exit of each convective tube bundle and at the exit of the boiler

(b) Flue gas exhaust pressure as well as oxygen, carbon monoxide, sulphur dioxide and hydrogen chloride at the exit of the boiler. The content of the flue gases at the boiler exit shall also be used for the control of the FGT system.

(c) Flue gas flow rate including a calculated mass flow rate

(d) Boiler feed water flow rate and temperature

(e) Boiler drum level (meeting all safety requirements), pressure and temperature

(f) Superheated steam flow rate, pressure and temperature

(g) Water side temperature and pressure measurement at the inlet and outlet of all the convection passes.

2.4.12 Boiler Drainage System

2.4.12.1 Subject to the Contractor's design, a boiler drainage system shall be provided for the drainage of the boilers. This system shall as for a minimum, comprise with at least one boiler drainage holding tank with capacity for a single boiler water as minimum per Module and suitable boiler drainage pumping systems, where necessary.

2.4.12.2 The boiler drainage pumping systems shall be designed to transfer the drainage to the wastewater treatment plant for the water to be utilised for bottom ash quenching or the FGT (if suitable).

2.4.12.3 This boiler drainage holding tank shall be designed to act as a buffer tank before discharging for reuse or treatment.

2.5 Flue Gas Treatment System

2.5.1.1 The flue gas treatment (FGT) system process provided shall be based upon minimising operating costs, particularly in terms of reagent usage and air pollution control (APC) residues production but shall comply with the target emission levels set out in Clause 2.1.4 of Specification (Part C) and in the Specified Process Licence.

2.5.1.2 After heat recovery from the hot gases in the boiler, the flue gases shall be treated in a FGT system to ensure compliance with the requirements stated in the Specification. The FGT shall treat the flue gas to meet the following objectives:

(a) Satisfy the emission to air limits given in the approved EIA report and Specified Process Licence.

(b) Not generate a wastewater stream unless this wastewater stream can be managed without resulting in any effluent discharge to sea. There shall be no discharge to sea.

(c) Minimise operating cost by reducing and optimising reagent usage and minimising APC residues generation.

(d) Provide for future technological advances and facilitate the retrofit of such technologies can be envisaged during the design phase of the project.

2.5.1.3 Each Incineration Train shall have its own dedicated FGT system and associated equipment. The FGT process shall be based upon a highly reliable and proven design. It shall have operating references demonstrating compliance.

2.5.1.4 The FGT system shall consist of the following major process units and components:

(a) Selective non-catalytic reduction (SNCR) system (installed inside the combustion chamber);

(b) Injection of sodium bicarbonate ($NaHCO_3$);

(c) First reaction chamber for sodium bicarbonate ($NaHCO_3$) reactions;

(d) First stage fabric filter system with recirculation of reagents;

(e) Ammonia water (NH_4OH) injection and selective catalytic reduction (SCR) system

(f) External economiser for further heat recovery;

(g) Injection of powder activated carbon (PAC) and hydrated lime (Calcium Hydroxide, $Ca(OH)_2$ or equivalent);

β (h) Second reaction chamber for powder activated carbon (PAC) and hydrated lime (or equivalent) reaction;

(i) Second stage fabric filter system with recirculation of adsorbent;

β (j) Induced draft (ID) fan (refer to Clause 2.6 of the Specification (Part C)); and

β (k) Stack (refer to Clause 2.6 of the Specification (Part C)).

2.5.1.5 The FGT shall be fully automated and shall include but not limited to the following components:

(a) Various instrumentations and CEMS;

(b) Handling, storage and dosing of reagents; and

(c) Collection, storage and discharge of APC residues.

2.5.1.6 The Contractor shall design the FGT systems taking into account that all chemicals and APC residues shall be shipped to/from the Facility in a remote island setting. The Contractor shall take into consideration of the supply chain management in connection with supplies of reagents and chemicals from non-local suppliers.

2.5.1.7 The FGT system shall be capable of continuous operation across the operating range of all possible flue gas flow rates from 60% to 110% MCR of the Incineration Train. The process shall be able to operate during short term overload situation peaks in the flue gas flow rate up to 120% MCR of the Incineration Train. The FGT system shall be able to cope with fluctuations in flue gas flow and pollutant loads, including but not limited to fluctuations when boiler cleaning is being undertaken.

2.5.1.8 The FGT system shall be provided with facilities (lifting equipment, isolation dampers, etc.) sufficient to provide for maintenance procedures to be performed in a rapid and efficient manner.

2.5.1.9 The entire FGT system shall be automatically controlled and also be controllable via the control system and integrated with SCADA/DCS system.

2.5.1.10 Thermal expansion shall be considered in the design of the FGT system, either as a result of normal operation, during start-up and shutdown or during an exceptional event.

2.5.1.11 To ensure high Module electrical efficiency, flue gas re-heating should be avoided at any point of the FGT system.

ζ 2.5.1.12 The FGT system shall be provided with sufficient sampling points for measurements to be taken to comply with the Environmental Permit and the Specified Process Licence for monitoring the operation of the FGT system and the efficiency of each process unit of the FGT system. The flue gas treatment efficiency shall refer to the pollutant loads removal efficiency.

2.5.1.13 Dead or cold spots shall be avoided throughout the design of the FGT system.

2.5.1.14 A fire and explosion assessment shall be provided for the entire FGT system and associated reagent and APC residues storage and handling systems. The Contractor shall ensure the FGT system complies with all relevant regulations in HK. The design of the FGT system shall also comply with the relevant clauses of the European Union's latest Appareils destinés à être utilisés en Atmosphères Explosibles (ATEX) directives.

2.5.1.15 All pneumatic conveying systems shall be designed with attention to wear at changes in direction of pipelines.

2.5.1.16 All manway openings, inspection doors and other access points into the FGT system shall be provided with an air-tight seal, a safety circuit or safety lock and an open/close signal to the control system and integrated with SCADA/DCS system.

2.5.2 Selective Non-Catalytic Reduction (SNCR) System

2.5.2.1 The Contractor shall provide a NOx reduction system using a combination of selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) technologies to reduce the NOx emission to limit as specified in Clause 2.1.4 of the Specification (Part C). The Contractor shall provide a technical description on how the NOx emissions shall be managed in the design submissions. This technical description shall include example reference plants.

2.5.2.2 The entire NOx reduction system shall be designed, installed and operated to minimise ammonia slip into the treated flue gas.

2.5.2.3 The SNCR system shall include but not limited to the following:

(a) The reagent storage and handling requirements of the SCR system shall be as applicable to the SNCR system for ammonia solution or urea.

β (b) The SNCR system shall dose reagent into the flue gas stream at a suitable location. Reagent injection nozzles shall be installed in the combustion chamber / boiler at multiple positions and levels. There shall be automatic control of reagent injection flow rate which shall be linked to the NOx CEMS instrumentation. The optimal injection position (level) shall be determined automatically by usage of the data from the temperature profile monitoring in the first boiler pass (namely, by AGAM system as per Clause 2.4.6.12 of the Specification (Part C)).

(c) The system shall provide an atomised and well distributed flow of reagent throughout the gas stream. The operating temperature range for the SNCR injection system shall be stated in the design submissions.

(d) Duty and standby transfer and feed pumps shall be provided.

2.5.3 Injection of Sodium Bicarbonate ($NaHCO_3$)

2.5.3.1 Dry Sodium Bicarbonate ($NaHCO_3$) powder shall be injected into the flue gas flow and, through dry sorption to chemically react and combine with the chlorine-, fluorine- and sulphur-containing flue gas components.

2.5.3.2 If any other additive should be injected at this point in the Contractor's design, the feed of the single dry chemicals shall be separated so that every single feed can be controlled and optimized separately.

2.5.3.3 Sodium bicarbonate injection shall be injected upstream to the reaction chamber in order to have a longest possible reaction distance.

2.5.3.4 The reagent usage shall be continuously monitored. The usage rate of reagent shall be controlled based upon the pollutant emission levels.

β 2.5.3.5 The Contractor shall provide details of the physical and chemical properties of the selected sodium bicarbonate to meet the emission requirements as per Clause 2.1.4 of the Specification (Part C).

2.5.4 First Reaction Chamber for Sodium Bicarbonate ($NaHCO_3$) Injection

2.5.4.1 The Contractor shall provide a diversion reactor chamber forming part of the flue gas duct, in order to allow a proper mixing and reaction of the formerly injected sodium bicarbonate with the flue. This shall be located upstream of the first stage fabric filter to ensure effective capture of APC residues, reagent and dust in the flue gas.

2.5.4.2 An acid gas treatment process based upon wet scrubber shall not be acceptable.

2.5.4.3 To improve the reagent usage efficiency of the system, partially used reagent shall be recirculated to maximise reagent contact, minimise reagent usage and to further dampen spikes in the incoming flue gas.

2.5.4.4 The reaction chamber shall be provided with equipment to inject used reagent from recirculation. Man access and inspection doors shall be provided.

2.5.5 First Stage Fabric Filter System with Reagent Recirculation

2.5.5.1 First stage fabric filter system shall be used for deposition of all fly ash particles, deposition of reaction products from the injection of sodium bicarbonate and deposition of free radical particles of pollutants from the exhaust gas with simultaneous optimization of the additive utilization.

2.5.5.2 A complete fabric filter system shall be provided, comprising of multiple compartment with multiple filter bags in each compartment, to filter the incoming flue gases to remove the unreacted additive, reaction products, carry-over fly ash and other particulate matter.

2.5.5.3 The installation shall comprise of a series of separate compartments, each containing row of filters, such that any one compartment can be isolated and taken out of service for maintenance and repair with the other operating compartments. When one compartment is out of service, the remaining compartments shall provide adequate performance to fully meet the duty performance requirements of the FGT process. Each compartment shall include all the necessary inlet and outlet dampers and instrumentation to ensure complete functionality when one compartment is off-line.

2.5.5.4 The filter bags material shall be capable of working with high temperatures (up to 260 Deg C) for continuous periods and the cages that the fabric material is attached to shall be corrosion resistant and suitable for the working environment.

2.5.5.5 The filter bags shall be of an appropriate material considering the following parameters. Details of the filter bags in term of performance with regard to these parameters shall be provided by the Contractor.

(a) Particle size;

(b) Fabric filter operational temperature;

(c) Compatible with the flue gas chemistry in terms of moisture and acidity/alkalinity;

(d) Abrasiveness of the particles;

(e) Fabric permeability;

(f) Fabric flexibility and strength – in particular coping with cleaning; and

(g) Air to cloth ratio.

2.5.5.6 The filters shall be formed by elongated bags that are stabilised individually in a supporting cage. The flow through the filter bags shall be from the outside to the inside. The particulates shall deposit at the outside of the bags.

2.5.5.7 The assembly shall be accessible on both the clean and dirty sides to undertake inspection and maintenance. Each compartment shall be accessible for replacement of the filter bags, and hopper access shall be provided for inspection and cleaning. Lifting equipment shall be provided for the assembly and disassembly of the filter bags. Rodding and blockage clearing points shall be provided to enable all pinch points and potential blockage areas to be cleared. On the clean side, there shall be access for bag replacement as well as access to the bag supports and air blast tubes. Main air manifolds and control valves and differential pressure gauges and transmitters shall be outside the compartments to allow maintenance without the need to open access doors.

2.5.5.8 The filter assembly shall incorporate trace heating below any insulation, to enable pre-heating of the structure during start-up from cold or during transient operating conditions. The heating system shall be temperature controlled to automatically operate whenever required to prevent any internal condensation which may cause corrosion, blockage or damages. In addition to pre-heating, separately controlled heaters shall be installed in the hopper areas below the filters, to prevent condensation during start-up and shutdown. Anti-bridging devices shall also be provided.

2.5.5.9 The filter assemblies shall incorporate loads cells to alarm for excessive build-up of reagent and particulates within the hopper areas.

2.5.5.10 The air-to-cloth ratio and differential pressure drop shall be determined by the Contractor for optimal performance for the fabric filter and shall be subject to consent by the Supervising Officer.

2.5.5.11 Filters shall be cleaned by means of reverse air jet cleaning which shall be operated automatically. There shall also be provisions for manual cleaning of any row of bags directly from the control system. Automatic cleaning shall be initiated by an increase in pressure drop across the filters reaching a pre-determined start value (increase in pressure drop due to build-up of reagent and particulates), and operating until the overall differential pressure drops below a pre-determined stop level. When next required to start, the cleaning sequence shall recommence with the next bags in the cleaning sequence, to ensure that all bags are equally used and cleaned. As each set of bags are cleaned, the remaining bags continue to operate as normal. In addition to cleaning being initiated by pressure differential, there shall also be equipment to initiate cleaning under overriding timer control or by manual intervention.

2.5.5.12 Reverse air jet for cleaning shall flex and inflate the filter bags, causing the reagent and particulates build-up to be dislodged and fall into the hoppers.

2.5.5.13 The FGT shall achieve its design flue gas cleaning rate over the whole operating cycle (namely, immediately prior to air jet operation, during air jet operation, immediately after air jet operation, and during the period as the reagent and particulates again builds up on the filters prior to the next cleaning cycle during which period the filtration rate and chemical reaction may alter due to the build-up of reagent and particulates on the filter). The system shall be designed such that fluctuations in differential pressure during cleaning are minimised.

2.5.5.14 Filter sleeves/ bags shall be chosen to optimise bag life/ replacement costs. The guaranteed life time for these bags shall be a minimum of 3 Operating Years.

2.5.5.15 The fabric filter shall be complete with access platforms, safety locking doors and viewing ports. The fabric filter system shall be designed to allow easy removal of cages and bags.

2.5.5.16 The fabric filter cleaning system shall use dry and oil free compressed air. The fabric filter system shall be equipped with an air accumulator tank to cater for the high demand of compressed air during filter bag cleaning.

2.5.5.17 All the dampers associated with the fabric filter system shall be automatically actuated and they shall be capable of being operated from a local control panel and also from the CCR.

2.5.5.18 The fabric filter shall be equipped with a safety system that can detect build-up of APC residues, particularly to highlight the potential risk of smouldering.

2.5.5.19 The first stage fabric filter system shall be designed with a reagent recirculation system to allow reuse of reagents. This shall include hoppers, material measuring systems and conveying systems to allow effective recirculation as well as removal of surplus APC residues from the system to silos.

2.5.5.20 In the event of shutdown, the contents of the recirculation system including all conveyors shall be transferred into the fly ash and APC residues collection and storage silo.

2.5.6 Ammonia Water (NH_4OH) Injection and Selective Catalytic Reduction (SCR) System

2.5.6.1 The selective catalytic reduction (SCR) of nitrogen oxides shall comprise the reaction of ammonia water (NH_4OH) or other reducing agents (urea) with nitrogen oxides (NO and NO_2) at temperatures of 180 – 420 Deg C.

2.5.6.2 Upstream to the catalytic reactor, the required amount of reducing agent shall be injected into the flue gas duct. After evaporation of ammonia and water and decomposition of reducing agent, the gaseous ammonia shall flow through a mixing zone to ensure the mixing of the ammonia and the nitrogen oxides.

2.5.6.3 The SCR system shall have but not limited to the following:

(a) The SCR system shall have a catalyst system to manage with the flue gas with consideration of dust and other pollutants in the flue gas that could affect the longevity of the catalyst.

(b) The Contractor shall have due considerations on the design of the catalyst structure to consider risk of blockage but also needs to be balanced with need for increased surface to improve efficiency.

(c) Provision of an isolating system.

(d) The SCR system shall be designed to fit within the footprint of the FGT system.

(e) The SCR system shall be designed to minimise head losses impact, which may increase power consumption on the induced draft fan.

(f) The Contractor shall provide all necessary instrumentation and control for safe automatic operation without manual intervention

(g) The SCR system shall be designed for safe and easy replacement of catalyst.

(h) The SCR system shall be provided with sampling points for monitoring and extracting the catalyst as necessary.

(i) Provision of additional space adequate for a 25% expansion of the catalyst volume shall be provided.

2.5.7 External Economiser

α 2.5.7.1 Flue gas flow shall pass through an external economiser for feed water heating after SCR. The control of this external economiser shall maintain a flue gas temperature of 140 Deg C or above at the stack exit.

2.5.7.2 For requirements of the economiser, please refer to Clause 2.4 of the Specification (Part C).

2.5.8 Second Reaction Chamber for PAC and Hydrated Lime (or Equivalent) Injection

2.5.8.1 The Contractor shall provide a dry or semi-dry chemical reaction chamber forming part of the flue gas duct, in order to neutralise remaining acid and remove remaining acid gases by the injection of hydrated lime (Calcium Hydroxide, $Ca(OH)_2$) or equivalent reagent with acid gas reactive properties. Powdered activated carbon (PAC) shall also be dosed into the flue gas stream to ensure the removal of metals and organic pollutants from the flue gas. This shall be located upstream of a second stage fabric filter to ensure effective capture of APC residues, reagent and dust in the flue gas. The reaction chamber may be supplied as diversion reactor.

2.5.8.2 An acid gas treatment process based upon wet scrubber shall not be acceptable.

2.5.8.3 The reaction chamber shall be provided with equipment to inject used reagent from recirculation. Man access and inspection doors shall be provided.

2.5.8.4 To improve the reagent usage efficiency of the system, partially used lime (or equivalent) and PAC reagent shall be recirculated to maximise reagent contact, minimise reagent usage and to further dampen spikes in the incoming flue gas.

2.5.8.5 The reaction chamber and associated mechanical handling equipment shall be designed to allow for quick change of atomisers or injection systems. If an atomisation system is used then at least one spare atomiser per Incineration Train shall be provided. A lifting system shall be positioned to allow safe and easy change. The reaction chamber shall be designed to prevent the formation of APC residues on the walls of the vessel.

2.5.8.6 The reagent usage shall be continuously monitored. The usage rate of reagent shall be controlled based upon pollutant emission levels.

2.5.8.7 The Contractor shall provide details of the physical and chemical properties of the selected PAC to meet the emission to air requirements.

2.5.9 Second Stage Fabric Filter System with Reagent Recirculation

2.5.9.1 Requirements for second stage fabric filter system shall be as stated for first stage fabric filter system in Clause 2.5.5 of the Specification (Part C), with the exception of the requirements in Clause 2.5.5 of the Specification (Part C), where the filter bags material for the second stage fabric filter system shall be capable of working with temperatures up to 160 Deg C.

2.5.9.2 The second stage fabric filter system shall be designed with a reagent recirculation system to allow re-use of reagents. This shall include hoppers, material measuring systems and conveying systems to allow effective re-circulation as well as removal of surplus APC residues from the system to fly ash and APC residues collection and storage silos.

2.5.9.3 In the event of shut down, the contents of the recirculation system including all conveyors shall be transferred into the fly ash and APC residues collection and storage silo.

2.5.10 Flue Gas Ducts

2.5.10.1 The flue gas ducts shall be designed to avoid the separation of fly ash and other residues (namely, APC residues). The velocity of the flue gas shall be sufficiently high to prevent this.

2.5.10.2 The flue gas ducts shall be a gas-tight construction.

ε 2.5.10.3 Flue gas duct sections shall be designed and formed parts using welded steel sheeting in accordance with EN 10025-2 Grade S235JR with any required reinforcements made out of sectional steel.

2.5.10.4 The flue gas duct shall have an optimized flow resistance to keep friction/pressure losses at a minimum.

2.5.10.5 The flue gas duct at the boiler exit shall have sufficient straight duct arrangements to allow the measurement of raw flue gas characteristics including but not limited to flow, temperature, oxygen and emissions from the boiler including but not limited to sulphur dioxide and hydrogen chloride. These measurements shall be used as a part of the FGT control devices in order to minimise response times in case of pollutant peaks or quick changes in raw flue gas pollution.

2.5.11 Induced Draft Fan and Stack

2.5.11.1 Please refer to Clause 2.6 of the Specification (Part C).

2.5.12 Various Instrumentations and CEMS

2.5.12.1 The FGT system shall include all instruments necessary for its safe and correct automatic operation, along with those required for alarm purposes. These shall include but not limited to the following:

(a) Temperature sensors at the inlet and outlet of the FGT system;

(b) Temperature sensors after each treatment step of the FGT system;

(c) Pressure indicators at the inlet to the FGT system;

(d) Measurement of NO_X, SO_2, HCl, H_2O, O_2, CO at the inlet of the FGT system;

(e) Level sensors for filter hoppers, recirculation surge hoppers and silos;

(f) Measurement of HCl, SO_2, dust after first stage fabric filter system;

(g) Filter cleaning controllers;

(h) Load cell weighing systems;

(i) Pre-heat controls and instrumentation;

(j) Blower and air receiver pressure control;

(k) Pressure differential measurement; and

α (l) Upstream measurement of flue gas constituents before the FGT through dedicated process control instruments to provide quick control for reagent dosing.

2.5.12.2 All CEMS instrumentation shall be supplied with transmitters and displays to facilitate local monitoring and control, and acquired signalling for the SCADA/ DCS system monitoring and data logging purpose.

2.5.12.3 For requirements of the CEMS, please refer to Clause 2.9 of the Specification (Part C).

2.5.13 Carbon Monoxide and Unburnt Organic Compounds Control

2.5.13.1 The gases associated with incomplete combustion shall be minimised through effective combustion control within the grate and combustion chamber. Incomplete combustion shall be minimised to ensure compliance with emissions to air limit requirements.

2.5.14 Handling, Storage and Dosing of Reagents

2.5.14.1 Equipment such as silos shall be fitted with filters and the tipping apron and ash storage area shall be designed to minimise and contain odour and dust emissions.

2.5.14.2 All storage tanks for ammonia, ammonia solution or urea shall be double-walled steel tanks.

Ammonia Solution or Urea Storage and Dosing

2.5.14.3 The storage and dosing system for ammonia solution or urea shall include but not be limited to the following equipment:

(a) Offloading, and filling point to be located and designed to comply with the relevant code and regulations issued by the FSD;

(b) Duty and standby transfer and feed pumps;

(c) Emergency showers and eye wash facilities adjacent to the storage system;

(d) Bunded storage tank(s) to provide minimum 2 weeks storage when each Incineration Train is operating at 100% MCR;

(e) Controlled vents with appropriate air management from the tank to manage emissions and in order to meet Environmental Permit and exposure limits for operatives;

(f) Appropriate drainage to contain and manage spillages; and

(g) Adequate provision of valves, relief valves, containment systems on pipelines, dosing rigs and storage tanks to provide for the safe operation and in compliance with the Environmental Permit.

Sodium Bicarbonate Storage, Dosing and Handling

2.5.14.4 The Facility shall have sodium bicarbonate storage and transfer equipment to supply and dose sodium bicarbonate into the flue gas ducts upstream to the first reaction chamber.

2.5.14.5 The sodium bicarbonate system shall include all necessary equipment to provide a complete system for the reception, storage, transfer and dosing of powdered sodium bicarbonate into the flue gas ducts upstream to the first stage fabric filter.

2.5.14.6 The sodium bicarbonate storage and dosing shall include a tanker offloading discharge point for filling the sodium bicarbonate silo, complete with all necessary pipework, valves, pressure limiting and relief devices, for the safe transfer sodium bicarbonate into the storage silos. A fill control station shall be supplied adjacent to the fill point to provide control of the filter, as well as level indication and over-fill alarm. There shall be audible as well as visual alarm at the vehicle offloading point (namely, ground level). Equipment/systems required for off-loading of sodium bicarbonate from vessels, loading of sodium bicarbonate to delivery tanker, etc. should also be included.

2.5.14.7 The sodium bicarbonate storage silos shall be complete with level instruments, anti-bridging, anti-rat-holing and anti-flooding equipment, and load cells for content measurement. The weigh system shall operate on a continuous basis.

2.5.14.8 The roof of the storage silos shall include level control equipment, access cover, vacuum and pressure relief valves (2 nos. with manual changeover to enable testing and maintenance), and suitably sized vent and filter, with auto-cleaning of the filter by reverse jet or equivalent means.

The roof shall be protected by hand railing, and access shall be via access stairways. There shall be at least two manway openings with each silo. These shall be easily opening and form a tight seal when closed.

2.5.14.9 The sodium bicarbonate shall be transferred into intermediate hoppers or an equivalent system, each complete with level controls, load cells, filtered vents, and they shall be complete with all necessary flexible and sealed connections. All intermediate hoppers or equivalent shall be filled on a weight basis. They shall also include equipment to prevent anti-bridging and anti-rat holing.

2.5.14.10 Sodium bicarbonate dosing shall be controlled by means of continuously operating metering system, and discharge from each intermediate hopper shall be via duty and standby conveying system.

2.5.14.11 The sodium bicarbonate storage silo(s) shall provide at least 2 weeks of storage capacity when each Incineration Train is operating at 100% MCR.

2.5.14.12 The design shall consider the potential risk of moisture and formation of large lumps, therefore heating systems and thermal insulation shall be included depending upon the nature of the reagent.

Powdered Activated Carbon (PAC) Storage and Injection

2.5.14.13 As part of the FGT system, a powdered activated carbon (PAC) injection system shall be provided as the final measure for controlling mercury, dioxins, furans and other organic micro pollutants from the flue gas. The PAC injection system shall comprise PAC storage, feed and injection system. The Contractor shall devise a standby arrangement between the incinerator lines such that when the dedicated PAC injection system fails, the PAC injection system on the adjacent incinerator line shall provide the standby supply of PAC to both its incinerator line and the failed line, or provide a complete standby PAC injection system to each incinerator line.

2.5.14.14 PAC Storage and transfer equipment to supply and dose PAC into the reaction tower shall be sized to meet the air emission requirements. The key air emission parameters are metals in the flue gas, dioxins & furans and total organic compounds (TOC). The storage silos shall be sized to provide at least 2 weeks of PAC storage when each Incineration Train is operating at 100% MCR.

2.5.14.15 The Contractor shall provide details of the physical and chemical properties of the selected PAC to meet the air emission requirements.

2.5.14.16 The PAC system shall include all necessary equipment to provide a complete system for the reception, storage, transfer and dosing of PAC, including, but not limited to tanker discharge point for filling the PAC silo, complete with all necessary pipework, valves, pressure limiting and relief devices, etc. for the safe transfer of PAC into the storage silo. A fill control station shall be supplied adjacent to the fill point to provide control of the filter, as well as level indication and over-fill alarm. There shall be audible as well as visual alarm at the vehicle offloading point (namely, ground level). Equipment/systems required for off-loading of PAC from vessels, loading of PAC to delivery tanker, etc. should also be included.

2.5.14.17 The PAC storage silo shall be complete with level instruments, anti-bridging, anti-rat-holing and anti-flooding equipment, and load cells for content measurement. The weigh system shall operate on a continuous basis.

2.5.14.18 The roof of the storage silo shall include level control equipment, access cover, vacuum and pressure relief valves (2 nos. with manual changeover to enable testing and maintenance), and suitably sized vent and filter, with auto-cleaning of the filter by reverse jet or equivalent means. The roof shall be protected by handrailing, and access shall be via access stairway. There shall be at least two access hatches with each silo. These shall be easily opening and form a tight seal when closed.

2.5.14.19 Discharge of PAC from the silo shall comprise a rotary discharge valve & isolating valve, intermediate hopper and metering equipment. The intermediate hopper shall incorporate level controls, load cells, filtered vent and aeration, and be complete with all necessary flexible and sealed connections. The intermediate hopper shall be refilled from the PAC Silo, on low level as measured by the load cells.

2.5.14.20 Transfer to the reactor tower shall be by a pneumatic conveying system, and shall include associated blower. The PAC shall discharge directly into the reactor tower upstream of the lime (equivalent) discharge nozzles. The design shall include measures to reduce the combustible and explosive risk associated with powdered activated carbon.

Hydrated Lime (or Equivalent) Storage and Dosing

2.5.14.21 The Facility shall have hydrated lime (or equivalent) storage and transfer equipment to supply and dose hydrated lime (or equivalent) into the reaction tower or absorber.

2.5.14.22 The lime (or equivalent) system shall include all necessary equipment to provide a complete system for the reception, storage, transfer and dosing of powdered lime (or equivalent) into the reaction tower or absorber.

2.5.14.23 The lime (or equivalent) storage and dosing shall include a tanker off-loading discharge point for filling the lime (or equivalent) silo, complete with all necessary pipework, valves, pressure limiting and relief devices, for the safe transfer of lime (or equivalent) into the storage silos. A fill control station shall be supplied adjacent to the fill point to provide control of the filter, as well as level indication and over-fill alarm. There shall be audible as well as visual alarm at the vehicle offloading point (namely, ground level). Equipment/systems required for off-loading of lime from vessels, loading of lime to delivery tanker, etc. should also be included.

2.5.14.24 The hydrated lime (or equivalent) storage silos shall be complete with level instruments, anti-bridging, anti-rat-holing and anti-flooding equipment, and load cells for content measurement. The weigh system shall operate on a continuous basis.

2.5.14.25 The roof of the storage silos shall include level control equipment, access cover, vacuum and pressure relief valves (2 nos. with manual changeover to enable testing and maintenance), and suitably sized vent and filter, with auto-cleaning of the filter by reverse jet or equivalent means. The roof shall be protected by handrailing, and access shall be via access stairways. There shall be at least two manway openings with each silo. These shall be easily opening and form a tight seal when closed.

2.5.14.26 The hydrated lime (or equivalent) shall be transferred into intermediate hoppers or an equivalent system, each complete with level controls, load cells, filtered vents, and they shall be complete with all necessary flexible and sealed connections. All intermediate hoppers or equivalent shall be filled on a weight basis. They shall also include equipment to prevent anti-bridging and anti-rat holing.

2.5.14.27 Lime (or equivalent) dosing shall be controlled by means of continuously operating metering system, and discharge from each intermediate hopper shall be via duty and standby conveying system.

2.5.14.28 The hydrated lime (or equivalent) storage silo(s) shall provide at least 2 weeks of storage capacity when each Incineration Train is operating at 100% MCR.

2.5.14.29 The design shall consider the potential risk of moisture and formation of large lumps, therefore heating systems and thermal insulation shall be included depending upon the nature of the reagent.

2.5.15 Collection, Storage and Discharge of Residues

2.5.15.1 Fly-ash and APC residues separated from the boiler sections and as part of the FGT process shall be transferred into fly ash and APC residues collection and storage silos, by appropriate elevators and conveyors or compressed air conveyance.

2.5.15.2 Each fly ash and APC residues collection and storage silo shall be complete with level instruments, anti-bridging, anti-rat-holing and anti-flooding equipment, access hatches, filter system and load cells. Discharge from each of the fly ash and APC residues collection and storage silo to the Ash and Residues treatment and handling system shall be via an actuated isolating valve and a rotary discharge valve arrangement. There shall be at least two access hatches with each silo. These shall be easily opening and form a tight seal when closed.

2.5.15.3 The roof of the fly ash and APC residues collection and storage silo shall include level alarm equipment, access cover, vacuum and pressure relief valves (with manual changeover to enable testing and maintenance) and suitably sized vent and filter, with auto-cleaning of the filter by reverse jet or equivalent means. The roof shall be protected by handrailing, and access shall be via stairways.

δ 2.5.15.4 Each Incineration Train shall be provided with its own fly ash and APC residues collection and storage silo, with a minimum combined storage capacity of fly ash and APC residues of at least of 3 days operation when the Incineration Train operating at 100% MCR and the FGT system operating at maximum loading as per Clause 2.1.4 of the Specification (Part C).

2.5.15.5 For the purpose of payment on the actual tonnage of Ash and Residues handed on the Artificial Island, the load cells of the fly ash and APC residues collection and storage silos shall be used for the weight measurement. Accuracy of the load cells for each silo shall be +/- 1% or better. The fly ash and APC residues collection and storage silos shall be designed, arranged and automatically controlled in such a way that all the APC residues discharged quantity shall be weighed and logged by the operation management system prior to entering the Ash and Residues treatment and handling system.

2.5.15.6 The Contractor shall engage an accredited certifying body or the manufacturer to conduct on site calibration and certification of the accuracy of the load cells measurement prior to putting all the silos into operation. The Contractor shall engage an accredited certifying body or the manufacturer to conduct half-yearly calibration and certification of the load cells to ensure accuracy.

2.5.15.7 The Contractor's attention shall be drawn to the storage provision for Ash and Residues as per Clause 2.8.1 of the Specification (Part D).

α 2.5.15.8 The Contractor shall submit his design on the Ash and Residues treatment and handling system as per Clause 2.1.3.1 of the Specification (Part C) in his design submissions for the Supervising Officer's consent.

2.5.16 Others

Structural Support and Access

2.5.16.1 All silos, conveyors, ducts and all other equipment forming the FGT system shall be suitably braced and supported for all static and dynamic loadings by structural steel. The installation shall also provide all walkways, stairs, ladders, platforms, handrailing and other safety features to enable safe and free access to all areas of the FGT system which require regular inspection, cleaning or other maintenance. Facility shall also be provided to enable the safe and easy removal and replacement of equipment either for cleaning or for repair/replacement.

2.5.16.2 Access for regular maintenance shall include, but not be limited to:

(a) Filter hopper conveyors and hopper access doors;
(b) Filter top access doors and filter compartment isolation valves;
(c) Recirculation hopper and associated screw conveyors;
(d) Lime (or equivalent) silo;
(e) PAC silo;
(f) Ammonia solution or urea storage tanks;
(g) Sodium bicarbonate silo; and
(h) Fly ash and APC residues collection and storage silo.

2.5.16.3 Covers to access manways shall be hinged and manways shall be provided with dust-catchers.

Insulation & Trace Heating

2.5.16.4 The complete FGT System installation shall be considered for the necessity of providing trace heating and thermal insulation.

2.5.16.5 The requirement for trace heating shall be to meet the requirements of the media within. Where appropriate, this shall be to prevent the risk of condensation resulting in coagulation of the powdered media, both during periods of operation and shut-down. Heating shall also be provided where it is necessary to raise or maintain media temperature, and/or to initially raise the temperature during start-up.

2.5.16.6 Insulation shall be provided to aid the operation of trace heating. It shall also protect against excessive heat loss and to prevent personnel coming into contact with high temperature surfaces. Insulation shall be protected by a suitable grade of suitably corrosion protected metallic cladding.

2.5.16.7 The level of protection provided shall be appropriate to the needs of the media within, and to avoid the risk of condensation, both during operating, start-up procedure and shut down periods. As a minimum, trace heating, insulation and cladding shall be provided for conveying systems, silo hoppers, filter casings, and hoppers.

2.6 Induced Draft (ID) Fan System and Stack

2.6.1 Induced Draft (ID) Fan System

2.6.1.1 The ID fan system shall ensure all flue gases are drawn through the process at all times and that treated flue gas is discharged through the stack. It shall maintain a negative pressure at the furnace/ combustion chamber so that no unpurified exhaust gases can escape from the plant through leaks.

2.6.1.2 One duty dedicated ID fan, complete with one standby auxiliary motor shall be provided for each Incineration Train. The fan speed in all normal operating conditions shall be selected to be 20% below the maximum speed of the fan for continuous operation. The ID fan and main drive shall be designed for 120% of the maximum flue gas flow that can occur in normal operation conditions. This 120% of the maximum flue gas flow shall not be designed to be achieved by operating the ID fan variable speed drive (VFD) in overdrive mode, at setting exceeding 100% or exceeding 50Hz.

2.6.1.3 The selection of the ID fan shall be based on pressure drop calculations, which shall be submitted as part of the design submission for the Supervising Officer's consent.

2.6.1.4 All steps required preventing impermissible negative pressure or excess pressure in the exhaust ducts and throughout the entire exhaust system shall be taken, and shall be designed to cope with operational disturbances. Disturbances include unintentional blocking of the exhaust routes, namely, as a result of faulty flap operation.

2.6.1.5 The fan shall be provided with vibration dampeners and vibration monitoring. The fan shall be balanced and the first critical speed shall exceed the maximum running speed by 10%.

2.6.1.6 The ID fans shall be equipped with, but not limited to:

(a) Temperature monitors for fan bearings;

(b) Vibration detectors;

(c) Drain systems connected to the wastewater management systems;

(d) Silencer and noise attenuation equipment;

(e) Inspection access;

(f) Expansion joints; and

(g) Insulation.

2.6.1.7 The ID fan shall be controlled by a VFD unit. The control of the furnace pressure shall be provided by speed control of the ID fan that shall operate automatically based on pressure measurements and set-points established in the control system and available to operators to vary via the control system.

2.6.1.8 Materials of construction of the ID Fan's components in contact with the flue gas shall be of type suitable for use in a corrosive and erosive environment specific to this Facility as per the table below. Written substantiation and confirmation from the ID Fan manufacturer on the suitability of the proposed materials of construction and compliance of design life requirement as per Clause 1.1.1.9(e) of the Specification (Part C) shall be submitted for the Supervising Officer's consent.

Components	Materials
(a) Impeller	Steel grade 1.8928 or better
(b) Shaft	Steel grade 1.0570 or better
(c) Housing and nozzles	Steel grade 1.0036 or better

2.6.1.9 The fan shall be designed to facilitate rapid maintenance. Lifting equipment shall be provided for removal of impeller and motor.

2.6.1.10 Flexible coupling between the fan shaft and motor shaft shall be provided.

2.6.1.11 If the ID fan fails (namely, in event of power failure), operation shall be automatically maintained by the auxiliary motor operating in a specified speed range of 250 to 300 rpm. This ensures extraction of exhaust gases whenever it is necessary to shut down the incinerator.

2.6.1.12 The auxiliary motor shall be designed as a low-speed motor with belt drive and a centrifugal clutch to the ID fan shaft.

2.6.1.13 A noise enclosure shall be provided for the ID fan. The enclosure shall be accessible, provided with lighting, forced ventilation and gate for maintenance activities to be carried out on the fan in-situ. The enclosure shall be designed to be rapidly dismantled when required to carry out maintenance on the fan.

2.6.1.14 Greasing of fan bearings shall be accessible from outside the noise enclosure.

2.6.1.15 Cabinet housing shall be provided for the variable speed drive unit.

2.6.1.16 The ID fan shall be designed to operate throughout the possible operating temperatures of the flue gas during normal and also during abnormal conditions.

2.6.1.17 Due to the potential for fan rotation cause by stack effect a brake shall be provided on the ID fan.

2.6.1.18 In case of shutdown of an Incineration Train, the ID fan shall continue to operate to ensure the safe shutdown of the boiler and other equipment.

γ **2.6.2 Stack (Chimney)**

γ 2.6.2.1 The chimney shall be self-supporting and it shall be fully insulated. There shall be one flue for each Incineration Train and the flues shall be grouped into two chimneys (each consists of 3 flues). The flue gas efflux velocity and stack discharge height shall be a minimum of 15 m/s and 150m above ground level respectively.

2.6.2.2 The design of the stack shall follow the requirements as per BS EN 13084 (Free-standing chimneys), or other equivalent as consented by the Supervising Officer.

2.6.2.3 The stack system shall include but not limited to the following essentially parts and components:

(a) A bearing external tube made of steel sheeting, with a corrosion-prevention paint coating;

(b) An internal tube made of corten or equivalent as a flue for each Incineration Train with thermal insulation, outlet protection, support tube drainage via the condensate collection floor and outlet pipe;

γ (c) Footing structure for each flue as a static connection between the support tube and anchor;

β (d) An inspection opening of DN800 at the stack to provide access to the interior of the support tube;

(e) Circumferential platform at the stack outlet area with circumferential railing, access via stepladder;

(f) CCTVs along access at top of the stack and safety gear and devices to facilitate easy and safe rescue of the injured along the stack access and from the top by trained personnel;

(g) Stepladder, hot galvanised from the ground up to the stack outlet with a hoop guard as well as the required intermediate platforms/rest landings, with climbing safety system and associated harnesses;

γ (h) Installation of obstacle lights in accordance with the requirements stipulated in Clause 1.90 of the Specification (Part A); and

(i) Equipment for earthing and lightning protection in keeping with general lightning protection regulations.

2.6.2.4 The stack shall be completely sealed not allowing any water ingress. Any rainwater collected in the flues shall be discharged to the wastewater treatment plant.

β γ 2.6.2.5 The Contractor shall observe the requirements under Clauses 1.38 and 1.39 of the Specification (Part A) and carry out his design of the stack in accordance with the approved EIA report and the latest further Environmental Permit, which include but not limited to:

γ (a) Requirements related to air quality impact as per Clause 3b.6.2.4 of the approved EIA report;

γ (b) Requirements related to health impact as per Clause 9b.5.1.1 of the approved EIA report;

γ (c) Requirements related to landscape and visual impact as per Clause 10b.10.2.5 and Table 10b.15 of the approved EIA report;

γ (d) Requirements related to submission of landscape and visual plan as per Condition 2.11 of the amended Environmental Permit; and

γ (e) Requirements related to mitigation measures on air quality impact during Operation as per Condition 2.32 of the amended Environmental Permit.

γ 2.6.2.6 The Contractor shall clearly set out in his design the approach to incorporating the flues within the stack and how the CEMS equipment shall be arranged to ensure each flue is properly monitored. The positions of CEMS equipment shall be as guided by United Kingdom Environment Agency's Monitoring Certification Scheme (MCERTS) emissions monitoring equipment supplier and European Union Standards or equivalent. They shall also be in line with the latest version of the EPD's emissions monitoring guidance as per the "A Guidance Note on The Best Practicable Means for Incinerators (Municipal Waste Incineration)". A safe and easy accessible working platform and sampling ports shall be provided to facilitate periodic taking of emission samples from the stack as per Clause 2.6.4.2 of the Specification (Part D). Actual positions of the sampling ports shall be agreed on site with the Supervising Officer.

2.7 Waste Heat Recovery and Power Generation

2.7.1 General

ε 2.7.1.1 The Contractor shall efficiently recover the heat released from the combustion processes occurring in the incineration process. This heat shall be used to produce superheated steam, which in turn shall be used to generate electrical energy via steam turbine generators. The onsite electrical power generated shall be the primary source of electrical power for the Facility and the Surplus Electricity shall be exported into the Power Company's power grid, to the vessels of the operator(s) of RTSs whilst berthing at the Artificial Island, and to the CLP Equipment Room in the IWMF Substation. The design of the waste heat recovery and power generation shall ensure maximum power production with minimum on-site power consumption.

2.7.1.2 Design submissions shall include all equipment selection and design calculations for the waste heat recovery and power generation system complete with justifications of the selection.

2.6.1.5 The Incineration shall be autothermic and heat the flue gas to at least 850°C for at least 2 seconds. The Contractor shall implement all necessary measures including operating of the auxiliary burners to sustain the incineration when such requirements cannot be complied with.

2.6.1.6 The Contractor shall ensure any short term or long term variation of the quantity, composition or characteristics of MSW shall not dramatically influence the MSW feeding rate of the Facility. The Contractor shall constantly review the operation strategies to cater for the government policies, initiatives and action programmes on waste management.

2.6.1.7 The Contractor shall be responsible for treating the combustion flue gas generated from Incineration to comply with the requirements as stipulated in the Environmental Permit and Specified Process License.

2.6.1.8 The Contractor shall formulate strategies to minimise the consumptions of chemicals and maximise the efficiency in flue gas treatment. Fluctuation or surge in the flue gas volume shall not influence the performance of flue gas treatment.

α 2.6.1.9 The Contractor shall continuously monitor the emissions of Incineration using the CEMS. An action level shall be set at 95% of emission concentration limits stipulated in the Specified Process License to provide early alarm and the Contractor shall cease MSW feeding when such action level is reached. An audible and visual alarm annunciation at the SCADA/ DCS master workstations and Employer's workstation shall be initiated upon the detection of such event. The Contractor shall formulate a plan to demonstrate the strategies when the action level is reached. The plan shall include details such as operation of the auxiliary burners while ceasing the MSW feeding and preparations for shut down when the emission limits is going to be reached.

2.6.1.10 The Contractor shall have due considerations to optimise the extraction of metal from the bottom ash. The extracted metal shall be managed with the Recyclables collected from the Mechanical Treatment Plant.

2.6.1.11 The Contractor shall properly operate the Incineration Plant to optimise the thermal efficiency of Heat Recovery Boilers, steam operation conditions, and Gross Electrical Efficiency as stipulated in the Registered Design.

2.6.1.12 The Contractor shall ensure the thermal efficiency of Heat Recovery Boilers is at least 85% throughout the Operation. The thermal efficiency of Heat Recovery Boilers shall use the data recorded in the SCADA/DCS and shall be calculated as stipulated in the Registered Design.

2.6.1.13 The Contractor shall ensure there is sufficient Auxiliary Power Supply to emergency shut down the Incineration Plant at any time during the Operation.

ε 2.6.1.14 The Contractor shall operate and maintain the boiler water treatment plant to provide boiler water for the Incineration, and the performance of the boiler water treatment plant shall comply with the requirements as set out in the Specification (Part C).

2.6.2 MSW lower heating value determination

α 2.6.2.1 The MSW lower heating value (LHV) shall be determined by using the Incineration Plant as a calorimeter, following the principles described in the ASME Power Test Code 4 for Stationary Steam Generating Units and ASME PTC 34-2007 for Waste Combustors with Energy Recovery or other method approved by the Employer.

2.6.2.2 The Contractor shall submit a plan to inspect and validate/ verify the MSW LHV determination method to the Employer for consent. The Contractor shall carry out the inspection / validation / verification of the MSW LHV determination method according to the plan consented by the Employer during the Condition Survey. The Contractor shall submit a report after the