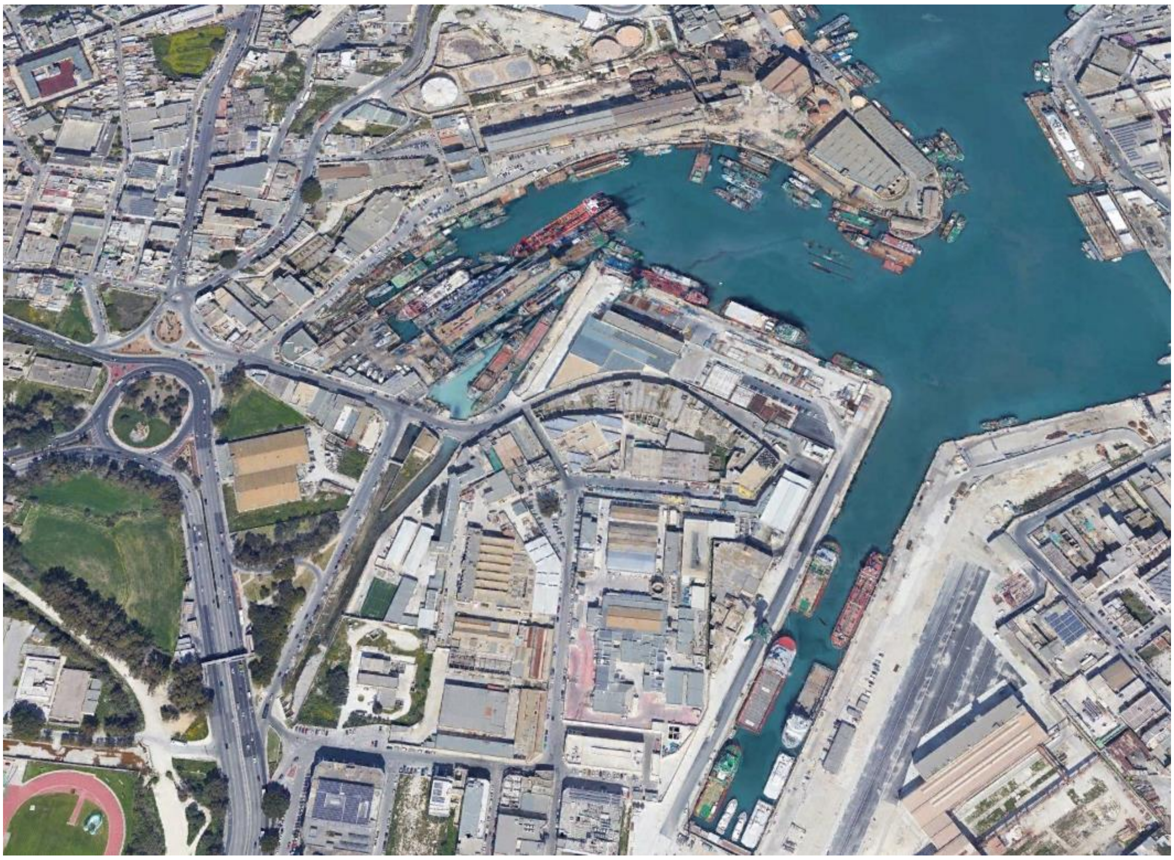
Marsa Thermal Treatment Facility: Operation of an incineration plant for hazardous wastes and animal by-products, and a rendering plant (Autoclave)

Application for Renewal of IPPC permit IP 0004/07/B



Version 2.0: February 2021

Cover image from Google Earth (2017)

Introduction

1. The Marsa Thermal Treatment Facility (MTTF) consists of a waste management facility originally designed for the treatment of abattoir wastes, that was eventually adapted to treat a specific range of clinical and other hazardous wastes. The facility currently includes the following specified activities (or directly associated activities as defined under the IPPC regulations) as specified under IP 04/07/B:

   - **Incinerator** or waste incineration plant from the receipt, temporary storage and incineration of specified wastes, together with the flue-gas treatment, and temporary storage on site of residues generated;
   - **Waste heat recovery boiler and economiser**, for energy recovery;
   - **Diesel tank farm**, to store fuel for on-site use;
   - **Blood coagulator** for the sterilisation of blood, and separation of blood coagulum from water;
   - **Wastewater treatment plant**, for treatment of waste waters on site;
   - **Autoclave** intended for treatment of animal by-products received on site, and eventual disposal in the incinerator; and
   - **Diesel Generator** to generate electric power in case of electricity failure.

   The above facilities are described in detail in the original IPPC application and Environmental Impact Statement, which are to be considered in conjunction with this application for renewal is based.

2. This plant was first approved in January 2006 by approval of development permit PA 2201/01, '*to install an incineration unit and adjacent cold store within incineration site at Public Abattoir to meet E.U standards*'; the IPPC permit IP 04/07 allowed its operation in October 2007. Additional permits on site included:

   - PA 3201/07 for stores and laboratory, decided concurrently with PA 2201/01;
   - PA 2585/13 for '*construction of an autoclave as an ancillary to the MTTF*' decided in August 2014;

   The operation of the autoclave was permitted via the issue of IP 04/07/B in April 2016, which also considered the variation in terms of change in site boundary, variation to the list of permitted wastes, waste delivery times, and waste acceptance procedures. This permit variation also considered a range of compliance issues which necessitated a range of improvements to site infrastructure and operation.

Scope of the application

3. This application is an application for renewal of permit for the '*operation of an incineration plant for hazardous wastes and animal by-products, and a rendering plant (Autoclave)*' as permitted under IP 0004/07/B.

4. The application for renewal includes the following documentation (as annexes), to facilitate review of implementation of permit requirements and operations:

- ANNEX I: ERA Review
- Annex II: Statutory Consultation Feedback
- Annex III: MCP Forms
- Annex IV: BAT Conclusions
- Annex V: Cesspit Inspection Report
- Annex VI: WWTP Contingency Plan
- Annex VII: Air Scrubber System PID
- Annex VIII: Autoclave Boiler Specifications
- Annex IX: Incinerator Specifications
- Annex X: Rerouting of Inc sewer to WWTP
- Annex XI: Drainage Layout at Autoclave section
- Annex XII: MTTF Sewage
- Annex XIII: Daily Average Dust Readings (BAT 25)
- Annex XIV: Controlling SO2 and HCL in Flue Gas
- Annex XV: Waste Checks Analysis
- Annex XVI: EMS Documentation
- Annex XVII: Acceptable Waste Streams
- Annex XVIII: Scrubber Control Details
- Annex XIX: Maintenance WWTP
- Annex XX: Storage & Residence Time of Main Waste Streams
- Annex XXI: Future Improvements
- Annex XXII: Methodology of Bottom Ash Characterisation
- Annex XXIII: WWTP Reservoirs Certification
- Annex XXIV: BAT Comparison Waste Water Treatment
- Annex XXV: Energy Flux Calculation
- Annex XXVI: 2nd Class Waste Water Readings

5. This application has been reviewed by the Environment and Resources Authority and other statutory consultees. The feedback provided in included in Annex I & II, and the feedback received has been consolidated into this application.

6. A review of the improvement programme indicates that various deliverables have not been implemented on the date stipulated within the permit, and work on these deliverables is still under way given the following constraints:

- Budgetary limitations and procurement processes have hampered effective delivery of elements requiring investment; and
- Turnover of critical qualified staff that were critical with respect to progress with respect to the implementation of required upgrades.

7. Although progress has been registered in the resolution of various long-standing compliance issues, implementation is still under way. Furthermore, an incident during 2020 resulted in damage to plant that requires remedial action. Further action is planned to address various points where environmental mitigation is deficient; measures to address these issues are defined in Annex XXI. In this regard, future variations to this permit will be submitted to address these issues.

8. Resolution of these issues needs to be considered as part of the renewal process of IP 0004/07/B, giving due attention to the establishment of an improvement programme with realistic time frames for implementation.

ANNEX I: ERA Review

Annex I: Comments regarding the IPPC application – Marsa Thermal Treatment Facility

Section A: Status of Improvement Programme

IP item	Requirement	Comment by WasteServ	Status & ERA comments 03.12.2019	Reply by WasteServ	ERA reply 17.04.2020	Reply by WasteServ 08.05.2020	ERA comment	Reply by WasteServ 27.01.2021
2	Submission of monitoring data from plant acceptance tests related to solvent storage and solvent line.	The operation of the solvent line has not proven viable and is being wound down. Alternative uses for this equipment may be considered as part of the future plans for this installation.	Wasteserv to clarify what current practises are in place for acceptance and disposal of solvents. Clarification is also being sought in terms of what other alternatives are being considered.	WSM does not accept solvents at the incinerator site.	WSM to indicate which EWC codes are to be removed from the waste acceptance list from the upcoming permit.	Refer to Annex XVII	Noted.	/
11	Submission of air emissions improvement plan. This shall include: a) Details as to how waste loads shall be managed so as to prevent exceedences of air emissions b) Details of additional abatement required	Improvements to the flue gas scrubbing system and the incineration process have been considered, to improve the emissions profile. However, the nature of the improvements required is contingent upon the actual performance of the plant once the autoclave is fully commissioned, allowing for completion of the required studies on management of air emissions.	The air emissions improvement plan has yet to be submitted. WasterServ to indicate when such a plan will be provided. WasteServ to indicate what improvements are being considered in the flue gas scrubbing system.	WSM has commissioned TeC to upgrade the existing waste to air mixture to ensure complete combustion of the waste. The secondary air ventilation system has been redesigned to allow better mixtures and uniform temperatures, lower flue gas volumes and better treatment. At the Autoclave section: A new Siemens PLC, new HMI and various electrodes and other components have been delivered. The final tests shall be carried out in the coming weeks. These upgrades shall consolidate the air emissions improvement.	WSM to indicate by when the air improvement plan shall be provided to the Authority for assessment.	The company has upgraded the operations at the incinerator and replaced the control hardware at the Autoclave section. (see Annex XVIII). The upgrades ensure that the pollutant limits are kept well below the threshold value. The company is committed to enhance the current air improvement plan to meet the requirements in the BATs and thus these shall be put in place prior to the renewal of the permit. A copy of the PID of the new PLC controlling the Scrubber system is found in Annex VII.	Noted, ERA will continue to discuss this matter with WSM through permit conditions. Noted.	/ /
12	Implementation of approved air emissions improvement plan.	Implementation can only commence once autoclave is fully operational, as described in previous point.	In connection with IP item 11, that the air emissions improvement plan, has yet to be submitted.	Details submitted in point 11.	Refer to point 11.			/
13	Submission of the following details regarding the waste water treatment plant,: (a) Associated emission levels, and comparison against the limits in Legal Notice 139 of 2002 as amended, and the requirements of the Water Services Corporation; (b) Comparison against BAT, in particular BAT on treatment of waste water as specified in section 5.1.5 of the BREF for Slaughterhouses and Animal By-products Industries; (c) Maintenance programme;	An application was submitted to Water Services Corp. on the 27th of September 2016. WSC have requested that WSM sign a voluntary agreement. In order to sign this agreement, WSM shall be performing further water analysis at WSC laboratories; the estimated completion of this process is expected to be the end of 2018. Furthermore, information as per point 13 is currently being compiled and shall be sent to ERA in Q4 2018.	Requested submissions are still pending. Wasteserv to indicate when the requested documentation can be submitted.	The WWTP equipment has received a major upgrade to address issues during commissioning in the last quarter of 2019. During the period January – February 2020 it is expected that the aerobic treatment stabilizes following the regeneration of the bacterial activities. WSC shall be asked in March 2020 to carry out tests as a final step prior to the achievement of the sewage discharge permit. This implies that coming March the parameters of the effluent shall be within the requirements of WSC.	WWTP to provide details on what upgrades have been carried on WWTP on site. Moreover, WSM to take note of WSC's comments provide in the Statutory Feedback.	Refer to Annex XIX. WSM is continuously monitoring the WW parameters to optimize the process. It is expected that the bacterial propagation process shall reach it optimal level by the end of May 2020, at which point WSC shall be asked to perform the routine tests on the WW.	Noted, ERA will continue to discuss this matter with WSM and WSC.	/

	(d) Training programme for staff; (e) Monitoring proposal; (f) Certification of impermeability by an independent warranted civil engineer or engineer.							
14	Submission of a land and groundwater risk assessment, and if required, a monitoring strategy and baseline report in line with European Commission and MEPA guidance pursuant to Regulations 9(3) and 16(2) of the Industrial Emissions (IPPC) Regulations, and condition.	A land and groundwater risk assessment was sent to ERA during November 2016.	Land and groundwater risk assessment has been submitted, ERA will be providing feedback in due course.		With respect to the land and groundwater risk assessment ERA is in agreement with the recommendations of the report that baseline monitoring is required. Such a requirement will be included as part of the improvement programme item in the upcoming permit. WSM to indicate whether any amendments/improvements have been carried out at the facility which may have affected the risk rating.	All improvements have been included already, namely: The connection of the upper and lower areas ensuring that all WW is being treated as illustrated in Annex X. The upgrade of the WWTP to meet the legal requirement.	Noted.	/
15	Certification from a competent company or engineer that the relevant fire safety procedures and equipment are in place, including emergency firefighting water supplies for use by the Civil Protection Department.	A fire risk assessment of systems and procedures was sent to ERA on March 2016.	Noted and considered as addressed.					/
16	Submission of proposals for treatment of bottom ash prior to landfilling.	A report on the study of bottom ash treatment was sent to ERA in May 2017.	The study of bottom ash treatment was submitted, and discussions are still underway.				Comments from Statutory Consultees refer.	Noted.
17	Authorisation from the Regulator for Energy and Water Services (REWS) for operations and for the storage of fuels, oils and other liquids not mentioned in Regulation 2 of LN 53 of 2010.	Authorisation from REWs was received in December 2016 was sent to ERA in November 2017.	Noted and deemed as addressed. Operator to also note REWS's comment.					/
18	Certification by an independent warranted civil engineer or engineer that the engineered site containment, cesspit and drainage systems on site are leak-proof and resistant to physical, mechanical and chemical stresses to which they may be subjected.	Certification of the engineered site containment, cesspit and drainage systems on site were sent to ERA on February 2017.	Submissions have been noted.					/
19	Certification by an independent warranted engineer that the pipes, pumps, valves and flanges forming part of the diesel transfer system are leakproof	Certification that the pipes, pumps, valves and flanges forming part of the diesel transfer system are leakproof was sent to ERA in April 2016.	Noted and deemed as addressed.					/

20	Implementation of conditions imposed by Water Services Corporation in 'no objection' letter dated 13th August 2015 (as found in Schedule 7 of the permit) and the related Voluntary Undertaking agreement	Discussions are ongoing with the WSC for the signing of the voluntary undertaking.	Noted, kindly see comments provided by the Water Services Corporation in the statutory feedback (Annex II).		Refer to comments in the statutory feedback (Annex II).			/
21	Submission of an updated plan of the sewage system of the installation	Included in Annex 4	Noted, kindly see comments provided by the Water Services Corporation and Planning Authority in the statutory feedback (Annex II).	Refer to 13 above.	Refer to comments in the statutory feedback (Annex II).			/
22	To compile ozone depleting substances equipment registration form in Schedule 5 and submit it to the Authority. This shall include any fixed or mobile refrigeration equipment (including refrigerated containers leased from third parties which is located on site for a period exceeding 6 months)	Data sent to ERA in June 2017.	Noted.					/
23	Submission of maintenance programme for all plant in the installation	Maintenance programmes for both the autoclave and the incinerator were sent in June 2017.	Maintenance programme submitted and has been noted.				Noted	/
24	Submission of an update to the noise report submitted in May 2012, to reflect the operations implemented on site	Noise reports were updated during 2017.	Noted and deemed as addressed.					/
25	Submission of updated list of delegate TCPs and their CVs and contact details	TCP details were updated in December 2017.	Noted and deemed as addressed, WSM is reminded that as per condition 2.3.15 Any changes in technically competent management (Person/s) and the name of any incoming person together with evidence that such person has the required technical competence shall be submitted to the Authority in writing within 5 working days of the change in management					/

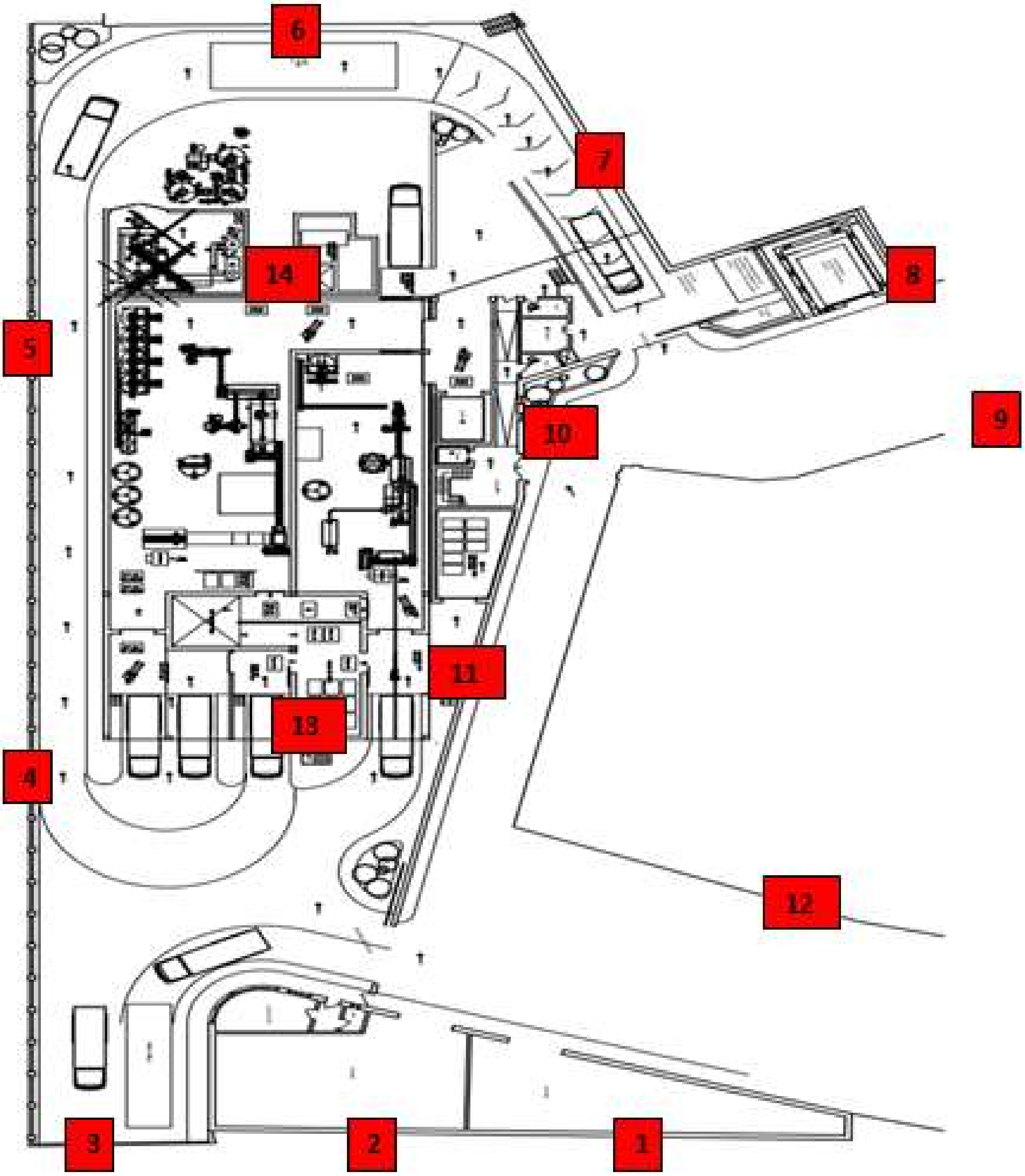
Section C: Other issues:

No.	Issue	Details	Reply by Wasteserv	ERA reply	Reply by Wasteserv	ERA reply	Reply by Wasteserv 27.01.2021
1	Autoclave commissioning	Reference is made to the replies on improvement programme number 11, WasteServ to provide the following details on the commissioning on the autoclave. a) What is the commissioning status of the autoclave? b) The autoclave was inaugurated in 2016, WasteServ to provide details as to why it is not fully operational. c) Details are required as to when the autoclave will be fully operational.	The project was commissioned on 23rd March 2016 and all WSM technical persons were provided with the necessary training.	From the submission of Annex 3_Commissioning of Autoclave Equipment, it is understood that Autoclave is being operated by a Agricarnitec as a third party. Kindly clarify.	The plant is being operated by: Triton Group 89, Wine Pressers Wharf, Marsa, MRS1912, Malta	Noted	/

No.	Issue	Details	Reply by Wasteserv	ERA reply	Reply by Wasteserv	ERA reply	Reply by Wasteserv 27.01.2021
2	Registration of Medium combustion plants	Kindly note that any medium combustion plants falling within scope of the medium combustion plant regulations S.L. 549.122 are to be registered. The registration form is attached as Annex III		Operator to provide reply	Being submitted as Annex III.	Noted, kindly submit clarifications with respect to how the rated thermal input was determined.	Incinerator Boiler / Heat Exchanger Assuming a system where there are no thermal losses or deficiencies, the heat in (the system), resulting from the burning of fuel in the combustion chamber, find itself in / gets transferred to the recovery boiler (heat exchanger). Therefore, what is registered as 'heat exchanged' in the heat exchanger (quoted as 3.931 MW), is hypothesised to be equal to the rated thermal input. To clarify that the boiler (heat exchanger) is not fuelled separated; rather it uses the heat from the exhaust gas which results from the combustion. Autoclave Boiler In a boiler, water is heated and turned into steam. In a theoretical system, the heat used to transform water into steam (cycle 1) is identical to the heat released when stream returns to water (cycle 2). The figure quoted, that of 'potenzialita heat output', is cycle 2. In a system where there are no thermal losses or deficiencies, the heat output to water is the thermal rated input.
3	Odour Issues on site	Operator to note that the issue of odours will be handled through the existing CED liaison on the matter. Notwithstanding ERA may request a number of odour related improvements to be carried out as part of the improvement programme of the upcoming permit.			Noted.		/

WasteServ Malta Ltd
Marsa Lower Area

Rodent control tamper proof stations



WasteServ Malta Ltd
Marsa Upper Incinerator Area
Rodent control tamper proof stations

Reduction of odours at MTTF – details from email sent to ERA on 09.09.2019.

The following is the action plan that is currently being implemented by WSM to mitigate the odour issues related to the management of the site. Together with the OMP, the company intends to alleviate the problems encountered by the neighbourhood.

No.	Element	Element Details	Target Date
1	Modus Operandi	Enforcement of instructions and practices (close door and housekeeping).	Already being done
2	Benchmark and Odour Monitoring Programme	Carrying out an Odour Benchmark and commissioning of a new Odour Monitoring Programme.	Q2 2020
3	WWTP	Replacement of parts and reinstatement of WWTP.	Q4 2019
4	Fridge	Better storage management of incoming waste through the installation of independent level compartments.	Q4 2020 but subject to procurement
5	Waste Marshalling Area	Upgrade of the Waste Marshalling Area through the installation of a containment structure.	Q3 2021
6	Air Scrubber	Replacement of faulty monitoring components in order to restore efficient functionality.	Q1 2020

Reduction of odours at MTTF – Update 02.03.2021

The following is an update on the entries shown in Page 1 of this document.

No.	Element	Element Details	Status	Comment 02.03.2021
1	Modus Operandi	Enforcement of instructions and practices (close door and housekeeping).	Already being done	/
2	Benchmark and Odour Monitoring Programme	Carrying out an Odour Benchmark and commissioning of a new Odour Monitoring Programme.	On-going	Talks on the methodology submitted for baseline study are on-going with the Authority.
3	WWTP	Replacement of parts and reinstatement of WWTP.	Closed	/
4	Fridge	Better storage management of incoming waste through the installation of independent level compartments.	Closed	Instead of the referenced project, Wasteserv opted for the purchase of 30 reefers. Reefers were delivered at Wasteserv's.

5	Waste Marshalling Area	Upgrade of the Waste Marshalling Area through the installation of a containment structure.	On-going	Refer to Annex XXI - Future Improvements.
6	Air Scrubber	Replacement of faulty monitoring components in order to restore efficient functionality.	Closed	Replacement of faulty monitoring components were replaced. This entry is now superseded given that air scrubber was destroyed by the fire. For the new setup, refer to Annex XXI - Future Improvements.

Emissions Calculation During Emergency Stack Operation

Total ERS open duration - maximum 60 minutes: 5 minutes

	CAT 1 (0-5 mins)		CAT 2 (6-15 mins)		CAT 3 (16-30 mins)		CAT 4 (31-60 mins)		TOTAL ESTIMATE	
Calculations	=IF(B10>=5, 5, B10)		=IF(B10>=D11, B10-B13,0)		=IF(D13>=15, B10-15, 0)		=IF(F13>15, F13-15,0)			
Duration ERS opened per Category (minutes)	**=B13**		**=IF(D13>=10, 10, D13)**		**=IF(F13>=15, 15, F13)**		**=H13**			
Average Flue Gas Flow Rate - open ERS (Nm^3/h):	10000	Nm^3/h	8500	Nm^3/h	5000	Nm^3/h	3000	Nm^3/h		
Total Flue Gas generated (Nm^3):	=(B15*B14)/60	Nm^3	=(D15*D14)/60	Nm^3	=(F15*F14)/60	Nm^3	=(H15*H14)/60	Nm^3		
Pollutant Contents:	**mg/Nm^3**	**g**	**mg/Nm^3**	**g**	**mg/Nm^3**	**g**	**mg/Nm^3**	**g**		
HCl	1000	=(B19*B16)/1000	300	=(D19*D16)/1000	100	=(F19*F16)/1000	10	=(H19*H16)/1000	=C19+E19+G19+I19	g
SO2	500	=(B20*B16)/1000	200	=(D20*D16)/1000	100	=(F20*F16)/1000	50	=(H20*H16)/1000	=C20+E20+G20+I20	g
CO	200	=(B21*B16)/1000	200	=(D21*D16)/1000	200	=(F21*F16)/1000	200	=(H21*H16)/1000	=C21+E21+G21+I21	g
NOx	400	=(B22*B16)/1000	400	=(D22*D16)/1000	200	=(F22*F16)/1000	200	=(H22*H16)/1000	=C22+E22+G22+I22	g
TOC	20	=(B23*B16)/1000	20	=(D23*D16)/1000	20	=(F23*F16)/1000	20	=(H23*H16)/1000	=C23+E23+G23+I23	g

PCDD/PCDF (Dioxins) - measurements on existing plants have proven, that at the end of combustion concentrations in the area of 0.1-0.5 ng/Nm3 occur. It is realistic, that during the fast cooldown and dilution after the stack, there will be no formatiion of dioxins (Not the proper conditions for the de novo synthesis).

Tec - Solution

FEASIBILITY STUDY

Project Title:

Upgrading of the Flue Gas Scrubbing System installed at the Thermal Treatment Facility, Marsa

Tender Document no.:

WSM 081/2013 of 24/09/2013

Contract no.:

WSM 177/2013 of 23/01/2014

Our reference no.:

2013/1510

Client:

WasteServ Malta Ltd

WasteServ Malta Ltd.
EkoCentre
Latmija Road
Marsascala, MSK 4613
MALTA

Date:

27/09/2014

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Sources & literature

BAT reference documents (BREFs) adopted under the IPPC Directive (2008/1/EC) and the Industrial Emissions Directive (2010/75/EU):

[1] Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector, February 2003

[2] Waste Incineration, August 2006

[3] Energy Efficiency

Other literature

[4] "Darlegung von Energieeinsparpotentialen einer Sondermüllverbrennungsanlage in der Viskosefaserindustrie", Bachelorarbeit von M. Schwaiger, Amberg 2011

[5] „Kalkhydrat vs. Natriumbicarbonat", L.-P. Nethe, Skriptum Vortrag 4. Fachtagung Trockene Abgasreinigung Essen, 2008

[6] „Thermische und mechanische Umwelttechnik – Luftreinhaltung und Abgasreinigung", Dr. C. Lanzerstorfer, FH-Wels, 2006/2007

[7] DWA-M 706-4 „DWA-Regelwerk Kraftwerke und Energieversorgungsbetriebe Teil4: Abwasser, das bei der Wäsche von Rauchgasen aus Feuerungsanlagen entsteht"

[8] Umweltbundesamt M116 „Dioxinminderung"

[9] State of the Art for waste incineration plants, Umweltbundesamt Federal Environment Agency Austria, 2002

1 Objectives of this feasibility study

The objectives and tasks of this feasibility study are defined in detail in the referring Tender Document no. WSM 081/2013.
The main objective is to define the optimum flue gas scrubbing system for the existing Thermal Treatment Facility at Marsa, Malta ("MTTF") in consideration of the different kinds of wastes which should be incinerated in future and in order to fulfill the respective IPPC emission limits.

Up to now, the Thermal Treatment Facility has been operated on hospital, pharma and abattoir wastes. Due to the high humidity of the not pre treated abattoir waste, there has to be incinerated a certain amount of fossil fuel (diesel) to provide thermal energy to evaporate the water and to incinerate the wastes properly.
The humidity of the incinerated waste causes a high water steam concentration in the flue gas (high amount of flue gas). The waste heat of the incineration process is recuperated in a water-steam-boiler; but the steam could only be used for the coagulator and the degasser. About 0.7 to 1.5 tons of steam per hour at 8 bar gage would be available for further use. Due to the discontinuous feed of the system, the steam production varies widely.

The future strategy is to replace the high calorific and expensive auxiliary fuel (diesel) by some high calorific waste fuels (mainly solvents, tank oil sludge – also possible: shredded wood from landfill) and finally to reduce the water content of abattoir waste by a pre treatment in an autoclave plant.
This allows cost reduction on diesel, more efficiency because of the use of waste heat and additional income because of higher quantities of treated waste.
The existing kiln and water-steam-boiler are considered to be appropriate for this strategy whilst the flue gas scrubbing system has to be upgraded. Nevertheless Tec-Solution advises to upgrade as well the defective design of the horizontal SCC, the dry slag discharge unit, the soot blower, the combustion control system including air management and the economizer.

In the future, there shall be incinerated the following types of hazardous and non hazardous waste:

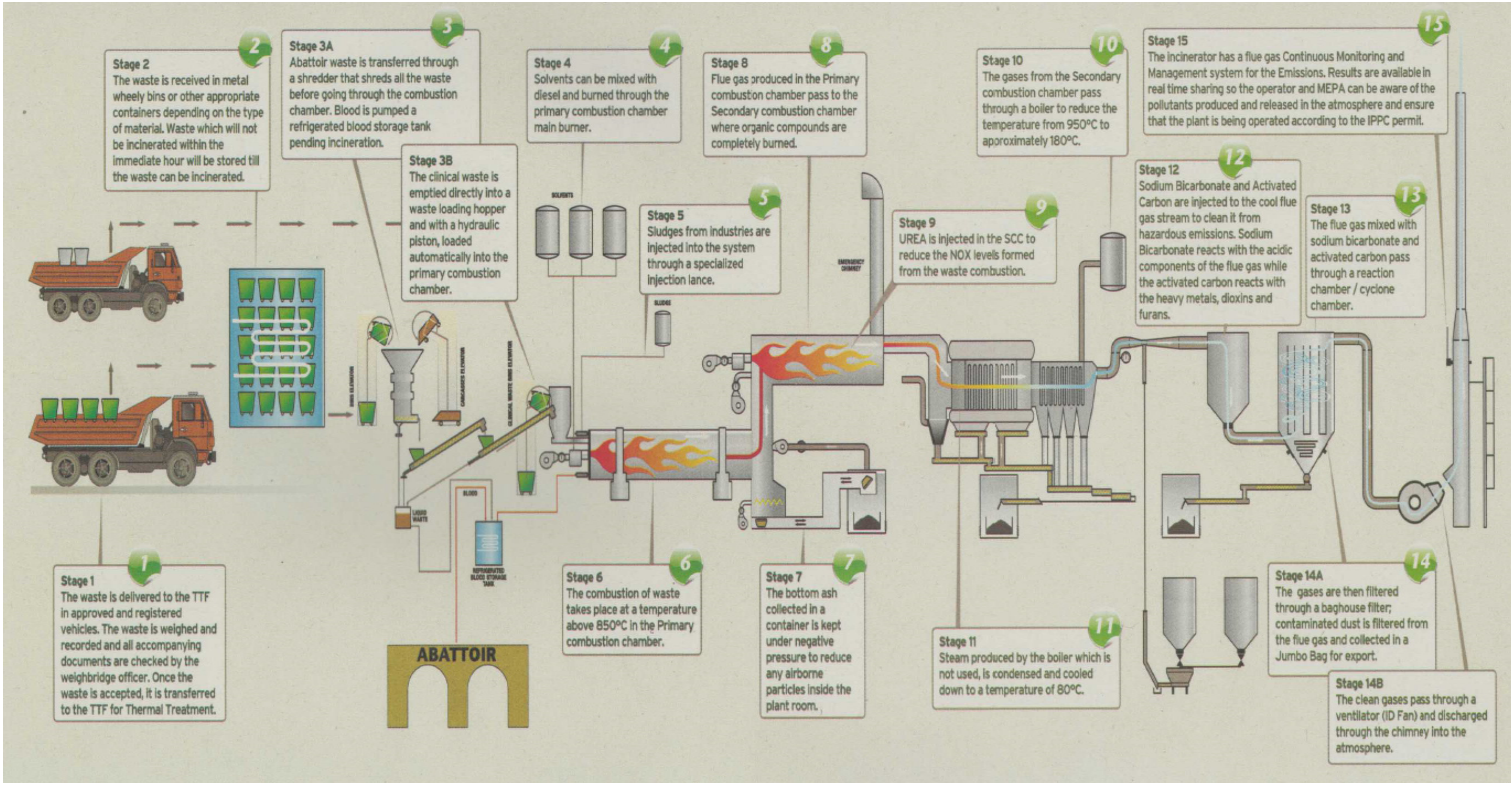
- clinical / healthcare and pharmaceutical waste
- shredded wood / shredded plastic (including PVC) / excavated landfill material
- industrial and effluent sludges/ tank oil sludge
- paint / waste oils/ workshop residues
- chemical deposits / chemical preparation waste
- combustion waste (TOC containing deposits)
- non-halogenated solvents
- dried blood and abattoir waste (autoclaved) or non dried abattoir waste

The new flue gas scrubbing system is to be designed according to the prospective kinds of wastes.

(The strategy and assumptions described above have been stated by the client if not named explicitly as Tec-Solution's statement. The task of Tec-Solution in the current project is the elaboration of a concept for the flue gas scrubbing system).

The main guideline for this feasibility study is the cited BAT-document on Waste Incineration issued in August 2006 which represents still the actual best available technologies in this field. This BAT-document has been adopted under the IPPC Directive (2008/1/EC) and the Industrial Emissions Directive (2010/75/EU).

Short description of the existing plant configuration at the MTTF:



Source: Information brochure on the Thermal Treatment Facility, WasteServ Malta Ltd, December 2011.

2 Criteria

The different available flue gas scrubbing technologies are evaluated according to the following criteria

1. Design data of the plant (e.g. kind of waste, size)
2. Required emission limits, efficiency on energy and ressources
3. Economical aspects (investment and operational costs)
4. Local conditions (e.g. availability of consumables, possibilities of disposal of residues, climate)
5. Number of existing plants using the referring technologies and availability of information on practical experiences
6. Process liability (stability in operation, robustness of equipment)
7. Possibilities for adaptations potentially required in future (e.g. regarding stricter emission limits, changing waste quality and quantities)

The main purpose of the Thermal Treatment Facility in Marsa is the treatment of waste with respect to the legal emission limits. The small size of the plant has to be considered in the choice of the flue gas scrubbing system. For example, energy losses in the flue gas scrubbing system might be negligible if a high pollutant reduction efficiency and a high reliability of the scrubbing system can be achieved.

The flue gas scrubbing system must be flexible enough to compensate peaks of emissions that are five times higher than the calculated average values due to the fluctuant performance of the rotary kiln incinerator and due to the fluctuant composition of hazardous wastes.

3 Literature research - Best Available Technologies

3.1 Incineration process

Above all, it has to be stated that an **optimal incineration process is the primary emission reduction method**. Many pollutants such as CO, organic compounds and NO_x can be directly influenced by temperatures and availability of oxygen in the combustion zones. However, secondary reduction methods (flue gas scrubbing systems) have to be applied in waste incineration plants in order to meet the legal requirements.

In this particular situation, the furnace type is already given – primary emission reduction methods have to focus on the optimisation of the installed rotary kiln.

Please see our further recommendations concerning the optimisation of the incineration process in chapter 5 of this document.

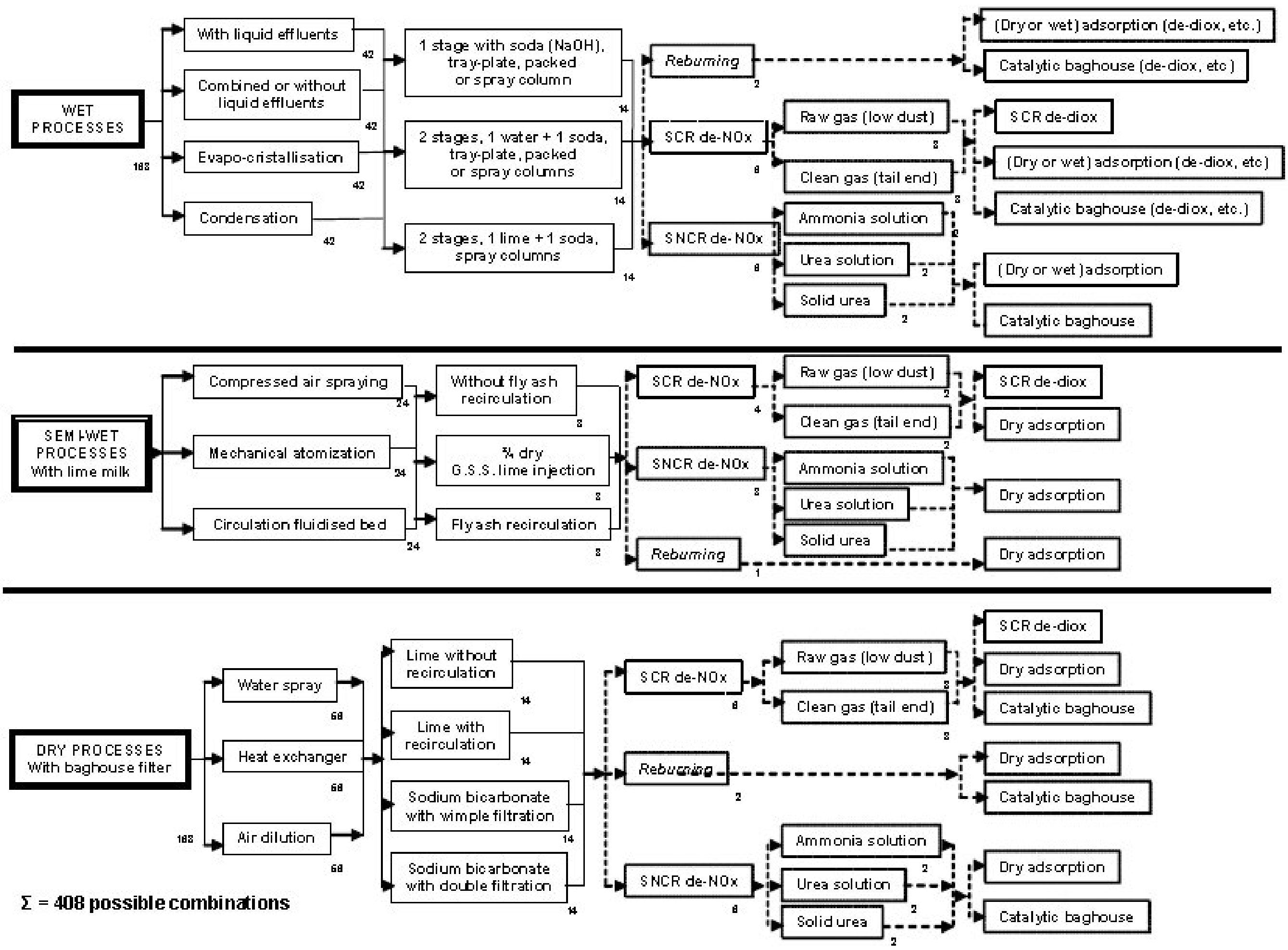
3.2 BATs on Flue Gas Scrubbing

The following emissions in the flue gas require reduction systems:

- **Dust**
- **CO**
- **HCl, HF, SO_2** (acidic gases)
- **NO_x**
- **NH_3**
- **PCDD/F**
- **VOC (volatile organic compounds)**
- **Heavy metals such as mercury**
- **Iodine, bromine** (if applicable)

The recirculation of flue gas may be applicable only if mainly high calorific wastes have to be incinerated.

Overview of all possible & applied systems for flue gas scrubbing in waste incineration plants (examples), source [2] figure 2.40:



Overview of applied systems in Hazardous Waste Incineration Plants (HWIP) in Europe – according to BAT-document 2006

40% of the HWIP require a spray cooler to cool the hot flue gases on the exit of the boiler before entering the flue gas treatment plant
(not necessary in the given situation – boiler exit temperature is already rather low 170°C)

Dedusting:

70% are equipped with a bag-house filter

54% are equipped with a dry ESP (only one installation with a wet ESP)

Reduction of acidic gases:

80% are equipped with an acidic and an alkali wet scrubber system; 30% of those have an additional scrubber for removal of specific components.

The remaining 20% use a dry or semi-dry scrubbing system (lime or sodium bicarbonate injection).

Reduction of NOx:

Most of the HWIP (29%) apply either SNCR (three installations) or SCR (four installations) reduction systems.

However, in 2006, 42% of the European HWIP have not been equipped with a NOx removal system and did not meet the emission limit of 200 mg/Nm³.

Reduction of PCDD/F:

67% inject activated carbon or other cokes before a bag-house filter
17% use a fixed-bed activated carbon (or brown coal cokes) filter (dry or wet)
8% do not have any boiler system and use quick quenching for PCDD/F reduction
Only one installation uses the SCR catalyst with a special coating also to reduce PCDD/F
[2]

Achieved emmission values in European Waste Incineration Plants

Source [2] table 5.2:

Substance(s)	Table 5.2: Operational emission level ranges associated with the use of BAT (see notes below) for releases to air (in mg/Nm³ or as stated)			
	Non-continuous samples	½ hour average	24 hour average	Comments
Total dust		1 – 20 (see split view 2)	1 – 5	In general the use of fabric filters give the lower levels within these emission ranges. Effective maintenance of dust control systems is very important. Energy use can increase as lower emission averages are sought. Controlling dust levels generally reduces metal emissions too.
Hydrogen chloride (HCl)		1 – 50	1 – 8	Waste control, blending and mixing can reduce fluctuations in raw gas concentrations that can lead to elevated short-term emissions. Wet FGT systems generally have the highest absorption capacity and deliver the lowest emission levels for these substances, but are generally more expensive. See Table 5.3 for consideration of criteria for selection between the main FGT systems, including cross-media impacts.
Hydrogen fluoride (HF)		<2 (see split view 2)	<1	
Sulphur dioxide (SO_2)		1 – 150 (see split view 2)	1 – 40 (see split view 2)	
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for installations using SCR		40 – 300 (see split view 2)	40 – 100 (see split view 2)	Waste and combustion control techniques coupled with SCR generally result in operation within these emission ranges. The use of SCR imposes an additional energy demand and costs. In general at larger installations the use of SCR results in less significant additional cost per tonne of waste treated. High N waste may result in increased raw gas NO_X concentrations.
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide for installations not using SCR		30 – 350	120 – 180	Waste and combustion control techniques with SNCR generally result in operation within these emission ranges. 24 hour averages below this range generally require SCR although levels below 70mg/Nm³ have been achieved using SNCR e.g. where raw NO_X is low and/or at high reagent dose rates) Where high SNCR reagent dosing rates are used, the resulting NH_3 slip can be controlled using wet FGT with appropriate measures to deal with the resultant ammoniacal waste water. High N waste may result in increased raw gas NO_X concentrations. (See also note 8 below in respect of small installations).
Gaseous and vaporous organic substances, expressed as TOC		1 – 20	1 – 10	Techniques that improve combustion conditions reduce emissions of these substances. Emission concentrations are generally not influenced greatly by FGT. CO levels may be higher during start-up and shut down, and with new boilers that have not yet established their normal operational fouling level
Carbon monoxide (CO)		5 – 100	5 – 30	
Mercury and its compounds (as Hg)	<0.05 (see split view 2)	0.001 – 0.03	0.001 – 0.02	Adsorption using carbon based reagents is generally required to achieve these emission levels with many wastes - as metallic Hg is more difficult to control than ionic Hg. The precise abatement performance and technique required will depend on the levels and distribution of Hg in the waste. Some waste streams have very highly variable Hg concentrations – waste pretreatment may be required in such cases to prevent peak overloading of FGC system capacity. Continuous monitoring of Hg is not required by Directive 2000/76/EC but has been carried out in some MSs
Total cadmium and thallium (and their compounds expressed as the metals)	0.005 - 0.05 (see split view 2)			See comments for Hg. The lower volatility of these metals than Hg means that dust and other metal control methods are more effective at controlling these substances than Hg.
Σ other metals	0.005 - 0.5			Techniques that control dust levels generally also control these metals
Dioxins and furans (ng TEQ/Nm³)	0.01 – 0.1 (see split view 2)			Combustion techniques destroy PCDD/F in the waste. Specific design and temperature controls reduce *de-novo* synthesis. In addition to such measures, abatement techniques using carbon based absorbents reduce final emissions to within this emission range. Increased dosing rates for carbon absorbent may give emissions to air as low as 0.001 but result in increased consumption and residues.

Substances not included in Directive 2000/76/EC on waste incineration:				
Ammonia (NH_3)	<10	1 – 10	<10 (see split view 1)	Effective control of NO_X abatement systems, including reagent dosing contributes to reducing NH_3 emissions. Wet scrubbers absorb NH_3 and transfer it to the waste water stream.
Benz(a)pyrene	For these substances there was insufficient data to draw a firm BAT conclusion on emission levels. However, the data provided in Chapter 3 indicates that their emission levels are generally low. PCBs, PAHs and benz(a)pyrene can be controlled using the techniques applied for PCDD/F. N_2O levels are determined by combustion technique and optimisation, and SNCR optimisation where urea is used.			Techniques that control PCDD/F also control Benz(a)pyrene, PCBs and PAHs
PCBs				
PAHs				
Nitrous oxide (N_2O)				Effective oxidative combustion and control of NO_X abatement systems contribute to reducing N_2O emissions. The higher levels may be seen with fluidised beds operated at lower temperatures e.g. below ~900 °C

NOTES:
1. The ranges given in this table are the levels of operational performance that may generally be expected as a result of the application of BAT – they are not legally binding emission limit values (ELVs)
2. ∑ other metals = sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V and their compounds expressed as the metals
3. Non-continuous measurements are averaged over a sampling period of between 30 minutes and 8 hours. Sampling periods are generally in the order of 4 – 8 hours for such measurements.
4. Data is standardised at 11 % Oxygen, dry gas, 273K and 101.3kP
5. Dioxin and furans are calculated using the equivalence factors as in EC/2000/76
6. When comparing performance against these ranges, in all cases the following should be taken into account: the confidence value associated with determinations carried out; that the relative error of such determinations increases as measured concentrations decrease towards lower detection levels
7. The operational data supporting the above-mentioned BAT ranges were obtained according to the currently accepted codes of good monitoring practice requiring measurement equipment with instrumental scales of 0 – 3 times the WID ELV. For parameters with an emission profile of a very low baseline combined with short period peak emissions, specific attention has to be paid to the instrumental scale. For example changing the instrumental scale for the measurement of CO from 3-times the WID ELV to a 10-times higher value, has been reported in some cases, to increase the reported values of the measurement by a factor of 2 – 3. This should be taken into account when interpreting this table.
8. One MS reported that technical difficulties have been experienced in some cases when retrofitting SNCR abatement systems to existing small MSW incineration installations, and that the cost effectiveness (i.e. NO_X reduction per unit cost) of NO_X abatement (e.g. SNCR) is lower at small MSWIs (i.e. those MSWIs of capacity <6 tonnes of waste/hour).

SPLIT VIEWS:

1 **BAT35**: Based upon their knowledge of the performance of existing installations a few Member States and the Environmental NGO expressed the split view that the 24 hour NH_3 emission range associated with the use of BAT should be <5 mg/Nm^1 (in the place of <10 mg/ Nm^1)

2 **BAT35**: One Member State and the Environmental NGO expressed split views regarding the BAT ranges in table 5.2 (air). These split views were based upon their knowledge of the performance of a number of existing installations, and their interpretation of data provided by the TWG and also of that included in this BREF document (e.g. in Chapter 3). The final outcome of the TWG meeting was the ranges shown in Table 5.2, but with the following split views recorded: total dust 1/2hr average 1 - 10 mg/Nm^1; NO_X (as NO_2) using SCR 1/2hr average 30 - 200 and 24hr average 30 - 100 mg/Nm^1; Hg and its compounds (as Hg) non-continuous 0.001 - 0.03 mg/Nm^1; Total Cd + Tl non-continuous 0.005 - 0.03mg/Nm^1; Dioxins and furans non-continuous 0.01 - 0.05 ng TEQ/Nm^1. Based on the same rationale, the Environmental NGO also registered the following split views: HF 1/2hr average <1 mg/Nm^1; SO_2 1/2hr average 1 – 50 mg/Nm^1 and 24hr average 1 – 25 mg/Nm^1.

Source [2]:

Criteria	Wet FGT (W)	Semi-wet FGT (SW)	Dry lime FGT (DL)	Dry sodium bicarbonate FGT (DS)	Comments
Air emissions performance	+	0	-	0	• in respect of HC1, HF, NH_3 & SO_2 wet systems generally give the lowest emission levels to air • each of the systems are usually combined with additional dust and PCDD/F control equipment • DL systems may reach similar emission levels as DS & SW but only with increased reagent dosing rates and associated increased residue production.
Residue production	+	0	-	0	• residue production per tonne waste is generally higher with DL systems and lower with W systems with greater concentration of pollutants in residues from W systems • material recovery from residues is possible with W systems following treatment of scrubber effluent, and with DS systems
Water consumption	-	0	+	+	• water consumption is generally higher with W systems • Dry systems use little or no water
Effluent production	-	+	+	+	• the effluents produced (if not evaporated) by W systems require treatment and usually discharge – where a suitable receptor for the salty treated effluent can be found (e.g. marine environments) the discharge itself may not be a significant disadvantage • ammonia removal from effluent may be complex
Energy consumption	-	0	0	0	• energy consumption higher with W systems due to pump demand – and is further increased where (as is common) combined with other FGT components e.g. for dust removal
Reagent consumption	+	0	-	0	• generally lowest reagent consumption with W systems • generally highest reagent consumption with DL – but may be reduced with reagent re-circulation • SW, and DL & DS systems can benefit from use of raw gas acid monitoring (see 4.4.3.9)
Ability to cope with inlet variations of pollutant	+	0	-	0	• W systems are most capable of dealing with wide ranging and fast changing inlet concentrations of HC1, HF and SO_2. • DL systems generally offer less flexibility – although this may be improved with the use of raw gas acid monitoring (see 4.4.3.9)
Plume visibility	-	0	+	+	• plume visibility is generally higher with wet systems (unless special measures used) • dry systems generally have the lowest plume visibility
Process complexity	- (highest)	0 (medium)	+ (lowest)	+ (lowest)	• W systems themselves are quite simple but other process components are required to provide an all round FGT system, including a waste water treatment plant etc.
Costs - capital	Generally higher	medium	Generally lower	Generally lower	• additional cost for wet system arises from the additional costs for complementary FGT and auxiliary components – most significant at smaller plants
Costs – operational	medium	Generally lower	medium	Generally lower	• there is an additional operational cost of ETP for W systems – most significant at smaller plants • higher residue disposal costs where more residues are produced, and more reagent consumed. W systems generally produce lowest amounts of reagents and therefore may have lower reagent disposal costs. • op. costs include consumables, disposal and maintenance costs. Op. costs depend very much on local prices for consumables and residue disposal.
Note: + means that the use of the technique generally offers an advantage in respect of the assessment criteria considered 0 means that the use of the technique generally offers no significant advantage or disadvantage in respect of the assessment criteria considered - means that the use of the technique generally offers a disadvantage in respect of the assessment criteria considered					

Table 5.3: An example assessment of some IPPC relevant criteria that may be taken into account when selecting between wet/semi-wet/dry FGT options

The following reduction technologies have already been pre selected according to the given situation:

3.2.1 Pre-dedusting

The following pre-dedusting technologies are listed in the BREF Source [2].

- Dry electrostatic precipitators (dESP)
- Wet electrostatic precipitators (wESP)
- Cyclones and multi-cyclones
- Bag filter

Conclusions:

Dry electrostatic precipitators and bag filters are most commonly applied in waste incineration plants. Investment costs for dESP and bag filters are considered to be similar whilst operation costs are higher at bag filters due to the higher pressure drop (higher energy consumption). Bag filters require close maintenance and attention referring the flue gas temperature.

In general fabric filters show the highest efficiency in dust separation. The precipitation efficiency of dESP is dependent on the dust layer resistivity which is influenced by the waste composition. Particularly in hazardous waste incineration, the precipitation efficiency may vary rapidly due to a changing waste composition.

The PCDD/F concentrations may increase during their residence time in ESP. [2]

Our experience shows that especially fine dust emissions are reduced best in fabric filters. When using wet scrubbing systems, it is very important to minimise the fine dust content as it might cause operational problems due to sludge in the scrubber. When using a SCR system, very low dust levels are also required in order to avoid gratings on the catalyst.

The dust separated in fabric filters is retained solid and dry, whereas in wet dedusting systems the dust is dissolved in water which has to be purified again.

Practical experiences showed that wESP, especially those with packing material (fillers), may cause low operational availability and high efforts at the annual turnover due to caking of the wet dust on the internals even if water is purified continuously in the wESP.

ESP have to be shut down when reaching too high CO concentrations in the flue gas for reasons of fire and explosion protection. [4]

Our customer ABRG in Austria had substituted an electrostatic precipitator in 2011 by a fabric filter with positive effects regarding the dust transfer into the wet flue gas cleaning plant.

Our costomer Kelheim Fibres in Baveria is actually seeking to substitute the electrostatic precipitator by a fabric filter as well to achieve better results regarding dust emissions. Both installations treat various hazardous wastes with high salt and heavy metal contents.

The permission for the MTTF defines emission levels of < 5 mg/Nm³ (half hour average as well as daily average) which can be easily reached with a bag filter whereas ESP reach < 5-25 (dry) or < 5-20 (wet) mg/Nm³. The lower figures may be reached with special ESP models. [2]

The flue gas temperature post to the economiser is between 160° and 180°C. The implementation of filter bags with a design temperature > 240 °C in combination with the regulation of the temperature level of 170-220°C and a safety shut down of the furnace when exceeding 235°C at this point is

recommended. The filter material has to be resistant the specified flue gas composition PTFE recommended for the pre dedusting filter.
The filter bags should be precoated after each change of bags with $Ca(OH)_2$ or sodium bicarbonate to provide in-depth filtration.

3.2.2 Flue gas polishing system

The following pre-dedusting technologies are listed in the BREF Source [2].

- Wet electrostatic precipitators (wESP)
- Electrodynamic venture scrubbers
- Agglo-filtering modules
- Ionisation wet scrubbers
- Bag filter

A flue gas polishing system is applied for the final reduction of emissions during normal operation, to handle peaks of pollutants due to the variability of hazardous wastes incinerated or to balance operational disorders in preceeding scrubbing units.

Conclusions:

Existing reference plants with ionisation wet scrubbers have not been documented in the BREF [2]. Electrodynamic venture scrubbers are installed at the municipal waste incineration plants Spittelau and Simmeringer Haide as a main scrubbing system (not for polishing).
According to the BREF document, an agglo-filtering module is used at an installation in Toulouse (F), but practical experiences are not reported.
Bag filters with adsorbent injection as a polishing system are widely used in waste incineration plants (f.ex. ABRG Arnoldstein, Villas Villach, Simmeringer Haide, (AUT), Tronville and Ocreal (F)).

By additional use of adsorbent material in a bag filter polishing system also remains of PCDD/F, Hg and organic or acetous compounds may be removed (depending on the kind of adsorbent used).
PCDD/F should mainly be reduced by primary measures (incineration), the memory effect
of PCDD/F on the scrubber plastic should be negligible compared to emissions from an suboptimal incineration process. The operation temperature of the scrubbers should be held constant. This was confirmed by an Austrian expert on flue gas pollutants from waste incineration plants, Dr. Kurt Scheidl company *Envirolab*.
When using the adsorbent “Dioxorb” (Walhalla Kalk), different kinds of pollutants can be reduced: f.ex. HCl, HF, SO_3, SO_2, Cd, Hg, PCDD/F, polychlorinated biphenyls, polycyclic aromatic hydrocarbons. The supplier offers customised blends of this adsorbent which mainly consists of lime, sulphidically endowed clay minerals and if required activated carbon (organic substances may also be reduced by the clay minerals).
In the polishing system the consumption of the expensive adsorbent will be very low, the predominant quantity of adsorbent can be recycled in the reactor and the rest can be fed into the rotary kiln. Used Dioxorb can still be helpful to reduce SO_2 emissions already in the combustion of the rotary kiln furnace.
It is possible to use the existing fabric filter and dosing equipment for the polishing system.

As a first step the HOK which is actually used can be substituted with a clay mineral and activated carbon mix that enables higher dosing rated without the risk of a dust explosion.

3.2.3 Reduction of acid gases

The following BAT reduce HCl, HF and SO_2 emissions:

- **Dry sorption:**
  A pre-dedusting system is not necessary.
  The sorption agent (e.g. lime, mostly sodium bicarbonate) is added dry, the dry reaction products (dust) are separated in a fabric filter. Re-circulation of residues is possible to improve reagent utilisation.
  Temperature range when using sodium bicarbonate: 180-220°C
- **Semi-dry sorption (spray absorption):**
  A pre-dedusting system is not necessary. The sorption agent is added in an aqueous solution (e.g. lime milk) or suspension (e.g. white lime in a slurry). Water evaporates and the dry reaction products are separated in a fabric filter. Re-circulation of residues is possible to improve reagent utilisation.
  Temperature range: 135-150°C
- **Flash-dry sorption (conditioned sorption):**
  A pre-dedusting system is not necessary. Water is injected previous to injection of the dry sorption agent. The dry reaction products (dust) are separated in a fabric filter. Re-circulation of residues is possible to improve reagent utilisation.
  Temperature range: 135-150°C
  [2], [5]
- **Wet scrubbing:**
  A pre-dedusting system is required. The flue gas flow is fed into an aqueous solution containing the reagent (e.g. NaOH or milk of lime). The reaction products are aqueous solutions or suspensions. Drained residues are obtained after waste water treatment.
  Different wet scrubber types are used: jet / rotation / venturi / dry tower / spray / packed tower scrubbers (comparison sees below).
  Required temperature at the entry of the scrubber: ~ 80°C (due to scrubber material)
  → a preceding quench is required to cool down the hot flue gas stream. For a long lifetime of the scrubbers operation temperatures at the end of the scrubbers between 65 and 75°C are recommended.
  In the first scrubbing stage, HCl and HF are absorbed in water which is continuously recirculated whilst a small amount of fresh water is added and the equal amount of acidic water is discharged to the waste water treatment plant. The water of the first scrubber is operated at a pH 0.5 to 1 due to the HCl and HF absorption. The pH of 1 also allows also $HgCl_2$ removal from the flue gas to the washing water (metallic Hg is not generally affected).
  At a pH of 1, deposition of SO_2 is low, so a second stage is required. The flue gas passes via the demister the second scrubber stage where NaOH or lime stone / lime milk ($CaCO_3$ or $Ca(OH)_2$) is added to obtain a pH of 6-8. The basic agent reacts with SO_2 to a salt (water-soluble salts such as Na_2SO_4 respectively water-insoluble salts such as $CaSO_4$). Residues of HCl and HF are also converted to salts in the second scrubber stage (water-soluble NaCl respectively water-insoluble

$CaCl_2$). If the flue gas contains bromine or iodine, these elements condense at the low temperatures in the scrubber and can be deposited with the washing water.
Filling / packing material may increase the reaction surface in the scrubber.
From the bottom of the scrubber, the precipitated $CaSO_4$ respectively the aqueous Na_2SO_4-solution is discharged to the waste water treatment plant.
If limemilk or lime stone is used, water-insoluble salts there is the risk of encrustations and more complex installations are needed.

$CaCO_3$ is the cheapest reagent. $CaCO_3$ scrubbers are mainly used in large scaled plants and if a buyer for gypsum (building industry) is available. If gypsum shall be sold, a low content in heavy metals in the flue gas is required. If gypsum cannot be sold, it has to be land filled. In smaller plants, mainly NaOH (rather expensive reagent) scrubbers are used as investment costs are lower. The scrubber water containing Na_2SO_4 might be discharged in the sea if heavy metals and other solid particles can be reduced in the waste water treatment plant to fulfill the requirements of the local conditions for discharging to the sea.
Nevertheless, smaller deposits of $CaCO_3$ in the scrubber are also possible when using NaOH. This depends on the water hardness; cloggings are avoided by periodically discharging of a small amount of washing water.

After the wet scrubbers, droplets should be removed from the flue gas to prevent salt deposits on the following equipment, particularly if SCR is applied.
[2], [6]

- **Direct desulphurisation:**
  The addition of absorbents (e.g. calcium or calcium/magnesium compounds) to the combustion chamber allows the partial discharge of sulphur already during incineration. See also “flue gas polishing systems” chapter 3.2.2. [2]

Information on different wet scrubber types:

Jet scrubber:

Lower pressure drop (lower energy consumption), high water consumption, average separation efficiency

Venturi scrubber:

high pressure drop (high energy consumption), low water consumption, good separation efficiency, no buffer volume for fluctuant flue gas pollutant concentrations (for more flexibility, several venturis in parallel would be needed).

Dry tower scrubber:

low water consumption, good average seperation efficiency, no buffer volume for fluctuant flue gas pollutant concentrations.

Spray scrubber:

From our experience, the spray scrubbers have the lowest complexity in design, the cheapest spare parts and less pressure loss than venturis and the lowest wear and tear.
High buffer volume for fluctuant flue gas pollutant concentrations but higher energy costs for pumps due to the huge water amount circulated in the system (in the small scale of the proposed installation around 58 kW)

Packed tower scrubbers

Similar to spray scrubber, but higher pressure loss, slightly better separation efficiency but less availability due to cleaning effort for the packaging. Cleaning of the acidic scrubber packaging is a dangerous job that has to be carried out very carefully.
Due to his reason, the waste incineration plant Villas Austria has substituted a packed tower scrubber based on NaOH by a lime milk spray scrubber in 2012.

Conclusions:

The wet scrubbing process can be used for reduction of acid gases as well as Hg^{2+} (as $HgCl_2$) and proved to be the most effective technology regarding the reduction of emissions (highest removal efficiency) and the reduction of residues (lowest excess stoichiometric factors).
The main disadvantage of wet scrubbing systems is the high water consumption (ranges from 100-500 l/to waste input) which can be reduced by appropriate water treatment and by low temperatures before scrubber inlet (temperature of 170°C is rather low). The waste water has to be treated. [2]

PCDD/F may be adsorbed on the wet scrubber plastic and be desorbed rapidly again by temperature increase – peak in PCDD/F-emission possible (memory effect, description see also 3.2.7). Constant operation temperature and a downstream PCDD/F reduction unit is required to avoid these peaks.

Experiences from installed plants show that peaks of acidic flue gas pollutants can be easily handled when using wet scrubbing systems because the large quantity of washing solution is effective as a buffer solution. When using dry or semi-dry systems, it is more difficult to react rapidly on peaks or changes in the flue gas composition as the whole automatic control system / dosing system reacts rather slowly.
Peaks in the flue gas composition are very likely in hazardous waste incineration.

The dry, semi-dry and flash-dry sorption processes require overdoses of reagents, even if re-circulation is applied. This causes high residue amounts. High operational costs for reagents and residues have to be considered. Highest stoichiometric ratios are required at dry sorption whilst semi-dry and flash dry sorption processes enable higher reactivity of the reagent.

With the existing construction of economiser, the flue gas temperature at the exit of the boiler (exit of economizer) is in the range of 160 to maximum 200°C. In semi-dry and flash-dry sorption processes, it is required to inject a certain amount of water (as it is needed to trigger the reactivity of the absorbens). This amount of water has to be evaporated completely by the flue gas and causes a temperature drop whilst the flue gas temperature should not fall below the acidic dew point (135-165 °C depending on gas composition - SO_3, HCl, HF).

The results of the data acquisition showed that the economiser outlet temperatures are rather too low and too fluctuating for semi-dry or flash-dry process. Existing waste incineration plants f.ex. Kaucuk Kralupy (CZ) showed problems in semi-dry scrubbers due to insuitable flue gas temperatures. Other examples (MSZ3 in Russia, Neubrücke in Germany) showed that semi-dry scrubbing systems are likely to clogging.

We advise that a wet scrubber should not be equipped with filling / packaging material as the clearing and cleaning of the material might interfere with the health and hygiene standards at the Thermal Treatment Facility / near abattoir site. The cleaning of the contaminated packaging material with a power washer has to be carried out very carefully, and the washing water must not get into the drainage system.

Typical wet scrubber performance figures and economical aspects

Substance(s)	Reduction efficiency range (%)	Achieved emissions				Comments
		½ hour average (mg/Nm³)	daily average (mg/Nm³)	annual average (mg/Nm³)	specific emission (g/t waste input)	
HCl		0.1 – 10	<5	0.1 - 1	1 – 10	Very stable outlet concentrations
HF		<1	<0.5	<0.1- 0.5	<0.05 – 2	Very stable outlet concentrations
SO_2		<50	<20	<10	<5 – 50	Requires reaction stage and absorbent (lime or NaOH) SO_2 ½ hour averages may fluctuate more

Table 4.32: Emission levels associated with the use of wet scrubbers
[1, UBA, 2001, 2, Infomil, 2002, 12, Achternbosch, 2002]

Economics
Capital cost information for the technique is shown in the table below:

FGT component	Estimated investment cost (M EUR)	Comments
Two stage wet scrubber	5	including waste water treatment
Three stage wet scrubber	7	including waste water treatment
External scrubber effluent evaporation plant	1.5 – 2	
Spray absorber for internal effluent evaporation	1.5	Cost estimate believed to be on the low side
Costs estimated relate to a 2 line MSWI of total capacity 200 kt/yr		

Table 4.36: Estimated investment costs of selected components of wet FGT systems
[12, Achternbosch, 2002] [74, TWGComments, 2004]

The key cost aspects of this technique compared to the alternatives are:

- higher capital investment costs than other systems, mainly due to the effluent treatment plant and the higher number of process units required
- operational costs associated with disposal of residues may be lower, due to the lower specific residue production, which are normally wet. [74, TWGComments, 2004]
- labour costs higher due to increased complexity of system.

Driving force for implementation
This technique has been implemented where:

- emission limit values have been set at or below those detailed in Directive 2000/76/EC
- disposal costs for flue-gas treatment residues are high
- input waste composition is particularly difficult to predict/control
- input waste may contain high and variable loads of acid gases or heavy metals (i.e. ionic mercury) [74, TWGComments, 2004]
- salt containing effluent may be discharged (e.g. to the sea).

Example plants
Wet flue-gas scrubbing is widely used throughout Europe for a full range of waste types.

3.2.4 Reduction of NOx

The primary NOx reduction measures are related to the incineration process. Our recommendations on optimisation of the incineration process are listed in chapter 3.1 of this document. In waste incineration plants, there have to be applied also secondary NOx reduction measures. BAT are the SCR and the SNCR processes. In both cases, NOx are reduced by NH_3 and under consumption of O_2 to nitrogen and water.

SCR:

The selective catalytic reduction of NOx is achieved by addition of air mixed with ammonia (reducing agent) to the flue gas and passing over a catalyst, usually a mesh (e.g. platinum, rhodium, TiO_2, zeolites). These materials catalyse the reduction of NOx by NH_3 and O_2 to nitrogen and water. Temperatures of 180-450°C, usually 220-240°C are required.
Reduction efficiency is typically > 90%, the overdosing rate of the agent is very low.

The catalyst is damageable by too low temperatures, high dust concentrations and so-called catalyst poisons (e.g. acids, salts). Temperature regulated bypasses to the catalyst (e.g. for start up) have been installed for many existing plants. The catalyst has to be installed post to de-dusting and removal of acidic gases. The flue gas generally has to be reheated as temperatures at the end of the flue gas scrubbing system are rather low, particularly if wet or semi-dry scrubbing systems are applied.
To reduce the additional energy demand for reheating, heat exchangers are widely applied (e.g. transfer of the heat of flue gas prior to entering a quenching zone / wet scrubber to the flue gas prior to SCR).
Special multi layer SCR systems are available for the additional reduction of PCDD/F.

SNCR:

Nitrogen oxides ($NO + NO_2$) are removed by selective non catalytic reduction – the reducing agent (evaporated ammonia NH_4OH or urea CH_4N_2O in air) is injected into the post combustion zone of the furnace (temperatures between 850-1000°C). The effective mixing of flue gases and the reducing agent and sufficient gas residence time are important for a proper reduction of NOx.
Reduction efficiencies of more than 60-80% require an overdosage of the reducing agent which can lead (particularly at lower temperatures) to emissions of ammonia (ammonia slip).
There is also the risk to build NOx from incineration of injected ammonia (particularly at higher temperatures) if the equipment is not designed or operated properly.
Urea is cheaper but leads to relatively higher N_2O emissions compared to the use of ammonia.

Conclusions:

In general SCR is considered to be better where higher NOx reduction efficiencies are required (high raw flue gas NOx levels occur and/or low final flue gas NOx levels required). However, particularly at smaller plant sizes the SNCR process may be the better technique regarding technical and economical aspects (investment costs for SCR are higher, operational risks of damaging the catalyst). [2]

If an SNCR system based on ammonia is applied for the reduction of NOx, the overdose of NH_3 might be discharged into the wet scrubber's water (if wet scrubbers are applied) - NH_3 slip cannot be registered on the stack. In this case, we recommend to limit the ammonia dosage by the combustion control system to avoid that ammonia is discharged into the wet scrubber's washing water (water emission limits have to be respected).

At the MTTF, a SNCR system based on urea is already installed. From today's prospect , it is possible to meet the required emission limits with SNCR instead of SCR system when incinerating the future waste mix, but the incineration and SNCR processes have to be optimised accordingly (see recommendations in chapter 4). If those optimisations cannot be applied, the flue gas scrubbing plant could be upgraded by a SCR system (for this later update, no significant additional costs are expected compared to installing the SCR system at once).
Strabag energy technologies (a supplier of catalyst systems) has recommended to use a flue gas polishing system (e.g. dry adsorption based on clay minerals and activated carbon) prior the catalyst to avoid damage on the catalyst.

Another alternative method for NOx reduction has been investigated during the visit of the IFAT fair (Munich, 06/05/2014, Dieter Liebisch, Mary-Grace Micallef):
Catalytic filter bags (supplier *Gore*) could also be used for NOx reduction. Due to the fact, that the bags can be easily damaged by sulphur peaks and the replacement of a damaged set of filter bags would be very expensive (140,000 € per change), this possibility has been dismissed in this study.

3.2.5 Reduction of mercury emissions

Due to its high volatility, almost all of the mercury contained in the waste passes to the flue gas during incineration. Mercury may appear in the flue gas in its elementary (metallic) form (Hg^0) as well as in its ionic form (Hg^{2+}) as a chloride ($HgCl_2$). If the incinerated waste contains a high amount of chlorine (which is likely in hazardous waste and rather unlikely in sewage sludge), mercury will mainly appear as Hg^{2+} ($HgCl_2$) and may be discharged in the wet scrubber (first stage at pH of 0-1), if applied. The waste waters have to be treated accordingly (heavy metal deposition (e.g. as the water non soluable salt HgS). Ionic mercury can also be removed by chemi-adsorption on activated carbon if a certain sulphur content in the flue gas is available or if activated carbon with a special sulphur impregnation is used.
Metallic mercury can be deposited on sulphur doped activated carbon, hearth furnace coke or zeolites. Prefarably, Hg^0 should be converted to Hg^{2+} as overall Hg removal is more efficient in the ionic form. This can be realised by high chloride contents in the waste incinerated or by adding oxidants. If sulphur dioxide neutralisation in the furnace by adding limestone is applied, the proportion of Hg^0 can be reduced.
If the chlorine input is around 4 % w/w of the total waste input, and if a wet scrubbing system for deposition of chlorides is applied it is likely that the Hg deposition rate is close to 100% without any other Hg reduction measures. [2]

Conclusions:

As waste composition may vary widely in hazardous waste incineration, measures for the reduction of both metallic and ionic mercury should be provided (e.g. wet scrubbers and flue gas polishing system with use of activated carbon). It has to be assumed that Hg levels in the waste are rather high and peaks may occur which cannot easily be handled if only adsorption processes (dry or semi-dry flue gas scrubbing) is applied – a wet scrubbing system succeded by a flue gas polishing system are recommended.

3.2.6 Reduction of other heavy metals

Other heavy metals are mainly converted into non-volatile compounds and deposited with flue ash. Thus, an effective dedusting unit has to be applied also for the reduction of other heavy metals. [2]

3.2.7 Reduction of organic carbon emissions

The primary measure for the reduction of organic carbon emissions is an effective combustion process (see also 3.1).
The flue gases of waste incineration plants may contain traces of a wide range of organic compounds such as

1. Halogenated aromatic hydrocarbons
2. Polycylic aromatic hydrocarbons (PAH)
3. Benzene, toluene and xylene (BTX)
4. PCDD/F

The most effective reduction method for compounds 1-3 is the complete incineration. If proper incineration conditions are given, no other reduction measures for compounds 1-3 should be necessary to achieve the permitted emission values.

PCDD/F and their precursor compounds (e.g. polychlorinated biphenyls and diphenymethanes) may also be destroyed by proper incineration, but denovo-synthesis post to combustion causes again the contamination of the flue gas with PCDD/F.
Denovo-synthesis is possible on certain metal surfaces (e.g. copper) which enable catalytic reactions of carbon/compounds with inorganic chlorine; especially in fly ash or filter dust at 200-450 °C or in electrostatic precipitators.
PCDD/F may be adsorbed on the plastic of wet scrubbers at temperatures of 60-70 °C. If the temperature is increased by a few degrees, it is possible that a high load of PCDD/F is desorbed to the flue gas causing a peak of PCDD/F emissions if no further downstream reduction measures are applied ("memory effect").

For this reason, further measures for the reduction of PCDD/F have to be taken into consideration. The following methods are BAT:

a) **Dedusting** of flue gas, because PCDD/F are likely to adsorb on dusts
b) **Adsorption e.g. on activated carbon, zeolites** (followed by dedusting). [2]
These adsorbents can be added together with absorbing agents for acidic gases in dry or semi-dry scrubbing systems. If using activated carbon, the risk of dust explosions and fire have to be evaluated. Some of the issues to be considered are:
   - activated carbon should not be used at temperatures above 180°C (risk of ignition) in solid bed adsorbers.
   - not more than 1 kg of activated carbon on 5000 Nm^3/h flue gas (critical limit ~ 1 kg / 3000 Nm^3). The exact figure has to be determined according to the type of activated carbon used!
   - inertisation of activated carbon by adding roughly 80 % of another inflammable (inert) agent is possible. The exact relatio necessary for inertisation has to be determined according to the type of activated carbon used. This inertisation only prevents dust explosions, but do not prevent fire f.ex. in a static layer or bed of bulk solids!

Activated carbon also adsorbs mercury, pure zeolites donot [5].
Used activated carbon which contains PCDD/F and Hg could be recirculated to the furnace to destroy PCDD/F. This is only applicable if Hg can be discharged by converting to $HgCl_2$ (high chlorine content in the waste input required) and absorbed into the washing water of a wet scrubber with pH 0-1. It has to be considered that some local regulations in the EU donot allow re-burning.

c) **Adsorption on lignite coke / hearth furnace coke in moving bed adsorbers**

Such adsorbers can be placed directly behind wet flue gas scrubbers. Preheating above the acid dew point is not required. Almost all flue gas emissions may be adsorbed or filtered in the filling of grained Hearth Furnace Coke (HFC). This is especially applicable for the highly effective reduction of residual contents of HCl, HF, SO_2 , PCDD/F and heavy metals (e.g. Hg^0 and $HgCl_2$) behind wet scrubbers.
The moving bed equipped with a multitude of double funnels provides a minimum consumption of HFC due to the ideal distribution of flue gas over the reactor.
The operation temperature has to be controlled carefully to avoid creation of CO and to prevent fire (evaluation required).

d) **Adsorption on carbon impregnated plastics**

PCDD/F can be adsorbed on specially carbon impregnated plastic inlayers which are posed in the wet scrubber. On this material, the "memory effect" (desorption) will not occur but the inlayers have to be removed for disposal, or, if permitted, burned in the furnace. The achieved outlet concentration is 2-3 ng TEQ/Nm^3 which does not meet the emission limit of 0.1 ng/Nm^3 - further downstream reduction is required.

e) **Oxidising catalysts**

If a SCR catalyst is chosen, a special multi-layer on the SCR catalyst can provide also PCDD/F reduction but the catalyst design has to be adopted (bigger catalyst).
Catalytic bag filters: Required temperature > 190°C [2]. Catalyst poisons (e.g. acids) have to be avoided – these catalytic bag filters are considered to be not suitable (see also 3.2.4).

f) **Rapid quenching of flue gases**

Quenching of the hot flue gases directly after combustion zone to reduce the residence of flue gases in temperature zones that may give rise to additional de-novo PCDD/F synthesis. Not applicable in this existing plant.

Conclusions:

A high effective dedusting system (method a) should be chosen in order to discharge particle bound PCDD/F.
The use of the adsorbent activated carbon or lignite coke (method b or c) is attractive to reduce not only particle bound PCDD/F, but also metallic mercury (Hg^0) which could not be converted to $HgCl_2$ and deposited in the wet scrubber. However, method b) is preferred because it is more commonly applied than method c) and the existing fabric filter could be used for the flue gas polishing system based on method b).

<u>Combination of method b) succeeding to wet scrubbers:</u>
The experience from existing plants shows that pre dedusting separates the main part of PCDD/F from the flue gas. The main part of mercury can be discharged as $HgCl_2$ in a wet scrubber. In order to respect the emission limits, remaining residues and peaks of PCDD/F and metallic mercury are

effectively adsorbed by activated carbon in a flue gas polishing system. As the continuous loads of PCDD/F and Hg after pre dedusting and wet scrubbers are low, the consumption of activated carbon is rather low and the apparatus for adsorption may be of a simple design (f.ex. baghouse filter with dosage of adsorbentia in the raw gas duct and dust recirculation equipment).

Combination of method b) with dry scrubbing systems:
Dry scrubbing systems based on clay minerals and activated carbon can be effective for PCDD/F reduction but generate a lot of hazardous waste to dispose – operational costs are very high.
The use of activated carbon for reduction of Hg and PCDD/F simultaneously to sodium bicarbonate does not use the full potential of the sodium bicarbonate, due to the fact that it works best in the temperature window between 240-300°C wherelse the Hg starts evaporating at 180 to 200°C from the activated carbon. Activated carbon concentrations in the flue gas must be kept under certain limits, if used in a temperature window between 180 and 235°C.

→ The selected technology for this study is to optimise the incineration in order to keep the PCCD/F creation low and to discharge the bulk of the Hg concentration in wet scrubbers. Succeedingly, the remaining PCCD/F and Hg shall be reduced in a flue gas polishing system (dry adsorption by agents activated carbon/clay mineral/ lime hydrate with a fabric filter) in the temperature window between 150 and 160°C. The already existing fabric filter could be reused for this flue gas polishing system. As the agents are overdosed, the bulk of the dust is recirculated in the flue gas polishing system and a smaller amount should be discharged by re-burning in the rotary kiln in order to avoid the discharge of dangerous waste out of the flue gas polishing system. In this way, the sink for organic compounds will be the incinerator and the sink for heavy metals will be the sludge of the wet scrubbers. This allows an overall minimisation of hazardous residues.

We expect that the re-burning of the adsorbens from the flue gas polishing system is licensable due to the long residence time in the rotary kiln (> 3 sec). This has already been approved in principle by Dr. Michael Sant / MEPA.
ABRG in Arnoldstein Austria is using this method successfully for reducing PCDD/F in the flue gases of their rotary kiln and of their fluidised bed incinerator (both on hazardous waste).

If required, the flue gas scrubbing system can be upgraded by a multi-layer SCR catalyst to finally reduce PCDD/F to the required emission limits (Scenario 3). The SCR catalyst has been evaluated as an optional add-on to the recommended flue gas scrubbing system. With the given data material, it cannot be determined at the moment if an additional catalyst is required or not.

3.2.8 Reduction of greenhouse gases

- CO_2 emissions are reduced by increasing the plant's overall efficiency and reduction of the fossil fuel input – optimisation of the incinerator, use of generated steam to lower the waste fuel's water content
- CO and hydrocarbons have to be avoided by complete incineration (depending on temperatures and residence time in the combustion chamber)
- N_2O is likely to appear at lower combustion temperatures (< 850 °C) – the optimum combustion temperature to avoid both NOx and N_2O emissions is reported to be in the range of 850-900 °C

- If not properly controlled, the creation of N_2O is also possible in plants using SNCR systems, like the existing urea injection ore ammonia water evaporation. [2]

3.3 BATs on the Treatment of Waste Water from wet flue gas scrubbing systems

At the MTTF, waste waters arise from:

- boiler drain water (waste waters from water steam cycle)
- cleaning activities
- site drainage (rain water)
- condensed waste water from a future animal by product pre-treatment (drying process)
- the wet flue gas scrubbing system, if applied in future

3.3.1 Optimum operation of the incinerator

See also chapter 3.1.

3.3.2 Reduction of water consumption and re-use of waste water

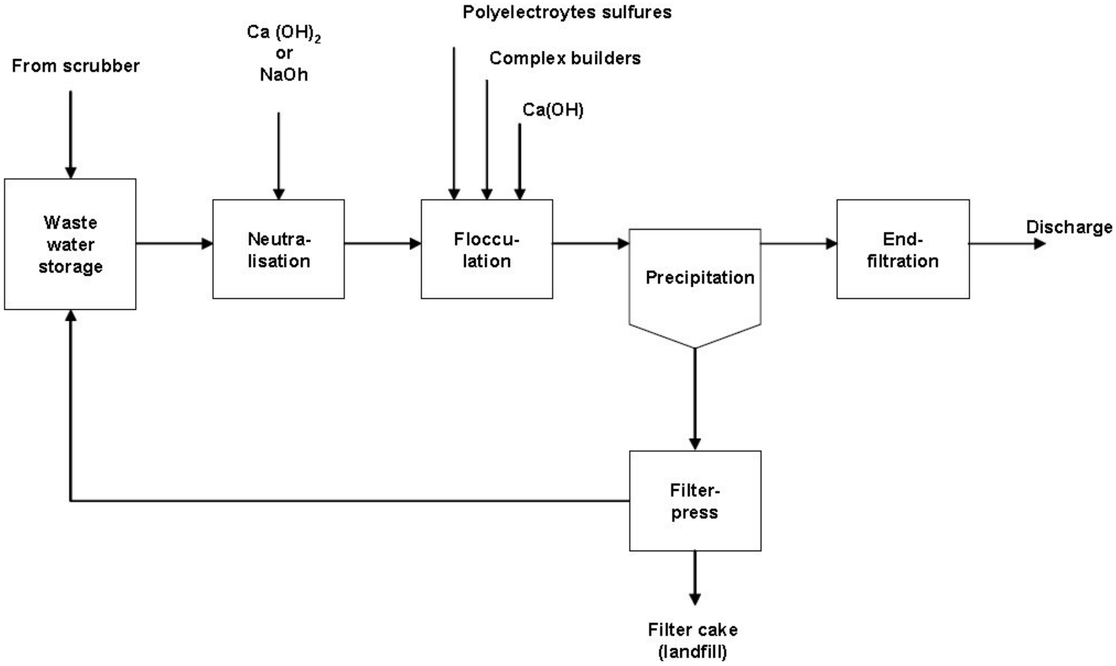
The water consumption of a wet flue gas scrubbing system can be reduced by appropriate design (application of best available technologies) and proper operation of the plant (effective control of process parameters, appropriate maintenance, operation with in the design limits…).
The process should be designed with attention to reduction of water consumption and to maximisation of reuse of waste water, but also with attention to large enough water buffer volumes in the waste water treatment plant to handle peaks. [2]

3.3.3 Physico-chemical treatment

Physico-chemical waste water treatment plants require special operational attention, as they are quite sensitive systems.

3.3.3.1 Treatment of the united waters from scrubber 1+2

The main process steps are:



1. **Waste water storage**

The buffer volume for the united effluents of scrubber 1 and 2 should be large enough to equalise peaks or operation disturbances downstream the waste water treatment plant.

2. **Neutralisation or alkalinisation of the polluted waste water:**

Commonly, lime milk ($Ca(OH)_2$) is used for neutralisation or alkalinisation of the waste water (depending on the required pH of the flocculation agents used succeeding).

The use of lime results in the precipitation of sulphites and sulphates as gypsum (if not already separated and discharged directly after scrubber 2 using lime).

Rarely, discharging of $Na_2SO_{3/4}$ (soluable sulphites / sulphates) to surface water is allowed (e.g. if there are no heavy metals and low SO_2 concentrations in flue gas) → NaOH can be used for neutralisation instead of lime, resulting in a lower production of filter cake (as the salts are discharged as a water soluable compound) → not possible in this case (flue gas contains heavy metals, fluctuant and higher SO_2 concentrations),

3. **Flocculation** of pollutants

Heavy metals are flocculated and precipitated by flocculation agents (poly-electrolyts, $FeCl_3$,TMT15-complex-builders). The different kinds of heavy metals (Hg, Ni, Cd, …) require different optimum pH levels for flocculation and precipitation. Therefore, a technology was selected where the heavy metals are flocculated in more pH-steps by dosing additional base agent ($Ca(OH)_2$).

4. **Precipitation – Sedimentation** (settlement of the formed sludge)

The flocculated heavy metals and gypsum (if not already separated directly after a lime type scrubber 2) precipitate in settling tanks. At a pH range between 8 and 9, also fluorides (discharged to the water in scrubber 1) precipitate.

5. **Filter press** (dewatering of the sludge)

The precipitated sludge is commonly dewatered in filter presses (dry solids contents of 40-60 %).

6. **Endfiltration** of the effluent

Sand filters and/or active carbon filters are used for the "polishing" of aqueous effluents. Solids such as remaining heavy metal compounds are further reduced. Active carbon filters reduce PCDD/F or other organic residues.
This is recommended especially for the waste water treatment of effluents from hazardous waste incineration flue gas scrubbing plants.
The treated waste water may still contain neutral water soluable salts like $CaCl_2$ which might not be admissible to be discharged to sweet water. [2], [7]

7. **Ion exchanger plant**

The water can be purified further in mixed bed units containing resins (for example LEWATIT TP 207 from LANXESS). By using a technology similar to that of a water softener, very low quantities of dissolved metals such as Cadmium, Zinc, Lead and Nickel or other contaminants are removed from the effluents. The removal of minerals has a second beneficial effect of maintaining the pH balance of the water at or near neutral by removing ions that would tend to make the water more acidic.

8. **pH check / final neutralisation**

In a last step the pH value is checked and corrected if necessary to maintain quality requirements of discharge to sea or drain.

Other process steps could be (not needed in this case):

- Coagulation
- NH_3 stripping: If an SNCR system is applied for the reduction of NOx, the overdose of NH_3 might be discharged into the wet scrubber's water. NH_3 stripping may be required in the waste water treatment plant if the overdosing rate is too high (SNCR system not properly designed / malfunction of incineration process) – this process step should be avoided by proper design and operation and has not been included in the plant concept of this study.

3.3.3.2 Treatment of separate wastewater from scrubber 1 and 2

The separate treatment of waste waters from scrubber 1 and 2 is recommendable at larger plant sizes and if scrubber 2 is operated on NaOH.
The effluent of scrubber 1 is neutralised by $Ca(OH)_2$, flocculation agents are added and mercury is precipitated. The sludge containing mercury is drained and discharged.
After this step, the pre treated effluent of scrubber 1 contains soluable salts like $CaCl_2$. Succedingly, this effluent is united with the effluent of scrubber 2 containing $Na_2SO_{3/4}$. More $Ca(OH)_2$ is added if needed in order to precipitate all the sulphites/sulphates as gypsum ($CaSO_{3/4}$).
Gypsum is drained and discharged.
The treated waste water still contains neutral soluable salts (NaCl, $CaCl_2$).
This method gives the possibility to discharge mercury containing sludge separately from the non problematic gypsum sludge (could be reused in the building industry).
The main disadvantage is the higher complexity.
Mercury containing sludge may also be received separately from gypsum if scrubber 2 is operated on $Ca(OH)_2$ and if gypsum is precipitated directly in the scrubber 2 before the waste waters of scrubber 1 and 2 are united. [2]

3.3.3.3 Biological treatment

The purification of waste water by micro organisms is not appropriate for waste waters from a hazardous waste flue gas cleaning plant as these effluents contain a varying pollutant load. [2]

3.3.4 Evaporation of waste waters

Beside the physico-chemical treatment, the BAT-document [2] also describes the evaporation of non treated waste water from wet scrubbers, which is not applicable in this case (concentration of pollutants in the incineration plant has to be avoided).
The evaporation of already treated waste water in a steam-heated exchanger would be applicable but is recommended only if there is enough waste heat at the plant and if the treated waste water cannot be discharged into receiving waters (high energy consumption).
Solid residues from evaporation (salts) have to be landfilled. [2], [7]
At the MTTF, the steam recuperated from incineration shall be used for the pre treatment of animal by products in the future.

4 Basic design data

4.1 Data acquisition

The main data sources for the feasibility study have been:

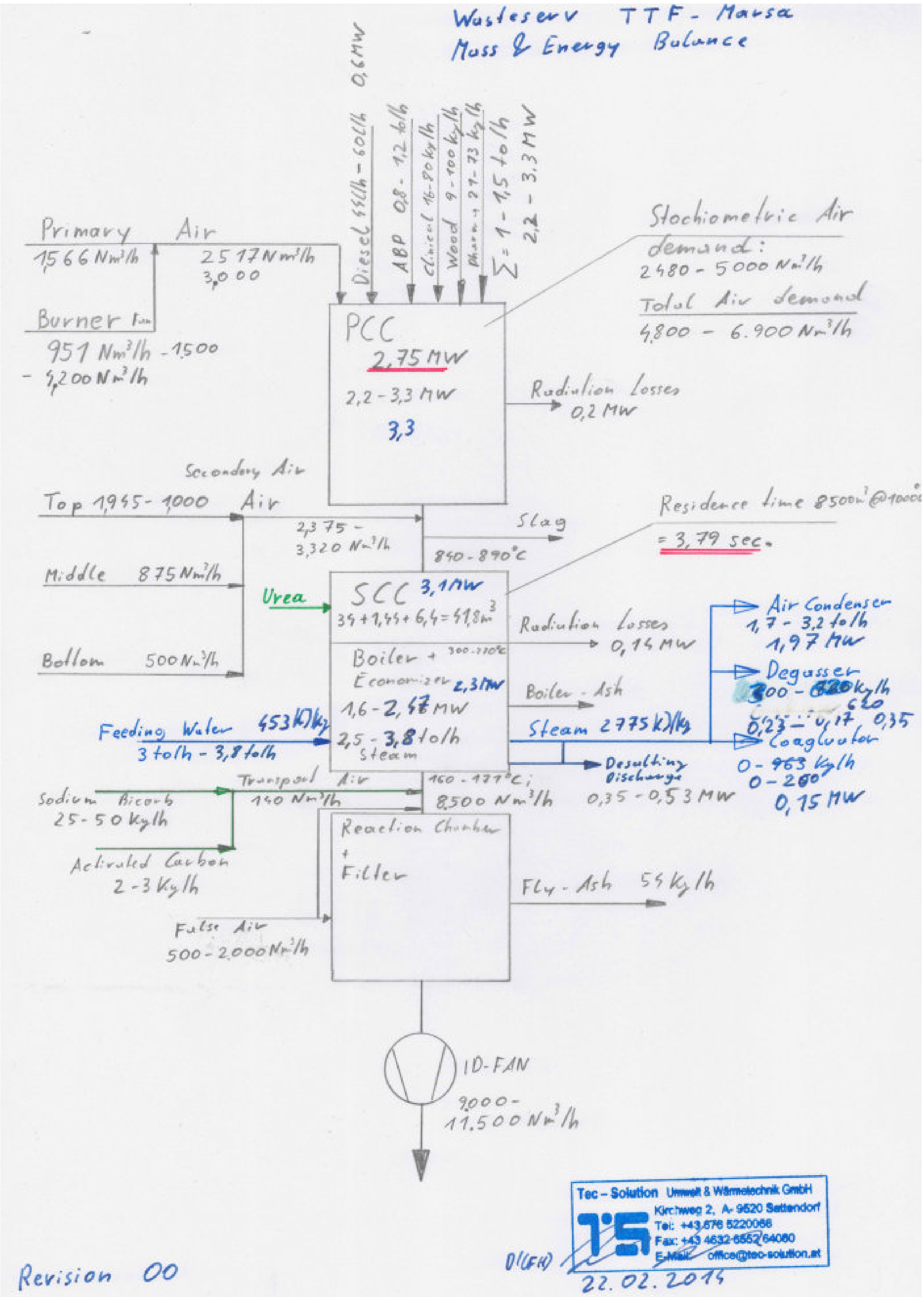
- Analysis carried out by studio ALFA carried out by Dott. Massimo Ferrari
  - Clean gas analysis - report 381/2014 date 28/01/2014. 02-03 December 2013
  - Clean gas analysis - report 1382/2014 from the 28/01/2014. 03-05 December 2013.
- Analysis carried out by CADA di Filippo Giglio & C.
  - Bottom ash analysis – report 2111631-001 date 20/12/2013
  - Filter dust analysis – report 2111631-002 date 20/12/2013
  - Boiler dust analysis – report 2111631-003 date 20/12/2013
  - Raw gas analysis – report 2103653-001 date 19/06/2011
- Head of shift reports:
  - 05/02/2014 Day, HOS Paul Matzhold
  - 08/09/2014 Day, HOS: Ryan and Guido
  - 08/09/2014 Night, HOS Paul Matzhold
- Hazardous Waste Survey Raw Data evaluated by the National Statistics Office in collaboration with WasteServ Ltd. in August 2011 handed over from Daniela Grech.
- Various mails from 19/09 to 27/09/2012 from Combino Pharm, Crystal Pharma, Aminochemicals, Arrowmalta, Actavis, Parmacarepremium and others.
- Measurements carried out by Tec-Solution GmbH in Feb and May 2014 about:
  - Combustion air flow, pressure and temperature to the front plate
  - Combustion air flow, pressure and temperature through the burner
  - Combustion air flow, pressure and temperature through bottom fan
  - Combustion air flow, pressure and temperature opposite the rotary kiln
  - Combustion air flow, pressure and temperature through secondary air nozzles
  - Flue gas flow, pressure and temperature between boiler outlet and economizer entrance
  - Economiser outlet temperature
  - Transport air flow, pressure and temperature, adjustment to 11m/sec. transport air speed
  - Flue gas flow, pressure and temperature post to venturi injector before reaction vessel
  - Flue gas flow, pressure and temperature before fabric filter
  - Flue gas flow, pressure and temperature post to fabric filter
  - Flue gas flow, pressure and temperature at the position of the emission sensor
  - Feeding water flow by level reduction of feeding water tank by time
  - Cooling air flow, pressure and temperature before air condenser
  - Cooling air flow, pressure and temperature post air condenser
  - Steam temperature before air condenser
  - Condensate temperature post air condenser

The accuracy of the elaborated calculation model for the design of the future flue gas scrubbing plant has been checked with the actual operation and analysis data:

- The calculated flue gas amount is in line with the actual fuel input, combustion air measurements and performance figures
- The calculated clean gas concentration figures (based on actual input and residue amounts) are in line with the clean gas analysis of studio ALFA.

- The calculated raw gas concentration figures (based on clean gas analysis values and pollutant quantities in ashes) are in line with the raw gas analysis carried out in 2011 by CADA di Filippo Giglio & C.

Mass and energy flow diagram of the MTTF (current situation, February 2014):



4.2 Findings / Design parameters for upgrading of the flue gas scrubbing system

4.2.1 Waste fuels

Generally, all the types of waste enlisted in chapter 1 can be treated in the rotary kiln with the new flue gas scrubbing system recommended in this study (including recommendations on improvement of incineration).

The theoretically available hazardous waste fractions in Malta have been researched in a waste transfer station study by Daniela Grech, WSM:

Question 1: How many tonnes do you produce each year?

	Not Applicable	Gave Value	Total responses	Total tonnes produced
Sludge	1,100	42	1,142	712.72
Solvent waste	1,027	115	1,142	358.46
Acid Alkaline or saline_waste	1,110	32	1,142	854.59
Electric and electronic equipment waste	1,111	31	1,142	16.41
Batteries and accumulators	1,039	103	1,142	76.31
Other chemical preparation waste	1,101	41	1,142	77.09
Chemical deposits residues and spent chemical catalysts	1,058	84	1,142	415.59
Combustion waste	1,131	11	1,142	11.44
Mineral waste	1,137	5	1,142	2.01
Healthcare waste	1,140	2	1,142	1.12

Waste Stream	Tonnes per annum
Spent solvents	583
Batteries and Accumulators	579
Hazardous Discarded Equipment	3,196
Mixed & Undifferentiated Waste	4
Chemical Preparation Wastes	101
Chemical Deposits and Residues	6,402
Industrial Effluent Sludges	327
Combustion Waste	740
Mineral Waste	9
Acid Alkaline and Saline Waste	131
	12,072

For this study, the waste fractions which are appropriate for the thermal treatment at the MTTF have been chosen out of the above named waste transfer station study.
The waste fractions which are admissible for treatment at the MTTF with the new flue gas scrubbing system are enlisted in the following table.
It has also been evaluated which partial amounts of these figures are realistically available.
A "financial worst case" has been chosen in order to calculate the feasibility if no higher availability and no higher thermal capacity can be achieved.

Actual waste disposal:

revenues and disposal tariffs	to/a	7480	€/to	301
clinical waste 20MJ/kg	421,6		500	
abattoir waste not pre dried 5MJ/kg	6029,4		50	
abattoir waste pre dried 18MJ/kg				
blood pre dried 18MJ/kg	750		50	
shredded plastic waste RDF 16,8 MJ/kg				
shredded wood 13 MJ/kg	41		100	
excavated landfill material 4,4 MJ/kg				
tank oil sludge				
de inking sludge 4,4 MJ/kg	2		500	
pharmaceutical waste 13 MJ/kg	119,2		500	
paint 6 MJ/kg	48,6		500	
waste oils 20MJ/kg	68,2		500	
workshop residue 10MJ/kg			500	

Future waste disposal for the different scenarios:

revenues and disposal tariffs	to/a	4800	€/to	520
clinical waste 20MJ/kg	421,6		500	
abattoir waste not pre dried 5MJ/kg	0		0	
abattoir waste pre dried 18MJ/kg	1205		50	
blood pre dried 18MJ/kg	750		50	
shredded plastic waste RDF 16,8 MJ/kg				
shredded wood 13 MJ/kg	41		100	
excavated landfill material 4,4 MJ/kg				
tank oil sludge				
de inking sludge 4,4 MJ/kg	2		500	
pharmaceutical waste 13 MJ/kg	119,2		500	
paint 6 MJ/kg	48,6		500	
waste oils 20MJ/kg	68,2		500	
workshop residue 10MJ/kg			500	
Solvent 1 28MJ/kg			500	
Solvent 2 24MJ/kg			500	
Solvent 3 20 MJ/kg			500	
Solvent 4 26MJ/kg			500	
combustion waste (boiler dust)	100		500	
industrial effluent sludges	327		500	
chemical deposits	1616,4		500	
chemical preparation waste	101		500	
solvents	0		500	

The annual waste throughput is reduced to 4,800to/a
Only a part of the available waste fractions is recorded as available for treatment.

4.2.2 Performance figures

Parameter	Unit	Permit IP0004/07	Actual figures	Applied data for this study
Max. thermal capacity	MW	5.7	3.3	3.3
Min. thermal capacity	MW	4.3	2.2	2.2
Max. waste throughput	t/h	3.5	1.38	0.79
Max. chlorine content of mixed waste during a half hourly feed rate	%	1	1	1
Maximum PVC content	%	1.9	1.9	1.9
Maximum flue gas volume at stack	Nm^3/h_{wet}	14,700	11,500	14,400
Temperature at stack	°C	160	135-150	135 -155
Max. calorific value of waste mix.	MJ/kg	15	15	15
Average calorific value of waste mix.	MJ/kg	-	6.86	11
Min. calorific value of waste mix	MJ/kg	5	5	5
Steam pressure	bar(abs.)	11	9.5	9.5
Steam temperature	°C	180	177.6	177.6
Max. accumulation of slag	kg/h	205	80	300
Max. accumulation of boiler ash	kg/h	12	10	20
Max. accumulation of fly ash	kg/h	68	56	32
Waste water from plant	l/h	300	4,123	3,400 bins /640 WWTP
Hours of operation	h/a	8760	5616	5616

4.2.3 Raw gas data

4.2.3.1 Actual half hourly raw gas values

Raw gas data at the outlet of economiser / entry of flue gas scrubbing system		
Flue gas volume wet	Nm^3/h wet	5,000-12,000
Temperature	°C	145-220
main gas components		
CO_2	Vol.-% wet	5.0 – 17.4
O_2	Vol.-% wet	1.9 – 12
H_2O	Vol.-% wet	5.0 – 41.2
N_2	Vol.-% wet	29.4 – 88.2
pollutants		
Dust	mg/Nm^3 wet	4
CO	mg/Nm^3 wet	<100 / 109.43 [1)]
TOC	mg/Nm^3 wet	1-10
PCDD/PCDF	$ngTEQ/Nm^3$ wet	0.5-10/ 22.9-828 [2)]
Mercury	mg/Nm^3 wet	0.05-3
Cadmium +Thallium	mg/Nm^3 wet	<5
Other heavy metals (Pb, Sb, As, Cr, Co, Cu,Mn, Ni, V, Sn)	mg/Nm^3 wet	800
NO_x nitrogen oxides,counted as NO_2	mg/Nm^3 wet	max. 350 [3)]
SO_x sulphur compounds, total of SO_2 /SO_3 , counted as SO_2	mg/Nm^3 wet	max. 10,000
Inorganic chlorine compounds (as HCl)	mg/Nm^3 wet	max. 2,000 (1% of fuel)
Inorganic fluorine compounds HF	mg/Nm^3 wet	max. 500
Ammonia as NH_3	mg/Nm^3 wet	20
Sum of heavy metals (mainly Pb und Zn)	in % ash	10
ash content	%	8-20
Average waste heating value	MJ/kg	6.8 - 12

1) TOC levels have been identified between 8 and 109.43 mg/Nm^3 wet [NL 1-10]

2) Dioxine levels have been identified between 22.9 and 828 (spot analysis) $ngTEQ/Nm^3$ [NL 0.5-10].
During the data acquisition, Tec-Solution GmbH found out that the dosing device for activated carbon was not working during the flue gas analysis by Studio Alpha in December 2013. Therefore, the analysis has to be carried out again to get information about the real actual adsorption performance on activated carbon.

3) NOx levels have been identified between 160 and 190 mg/Nm^3 wet with the urea SNCR-System working.

4.2.3.2 Target raw gas values

We advise to improve the incineration process / SNCR system as a primary measure in order to keep the required flue gas scrubbing system simpler (recommendations for improvement of the incineration process: see chapter 5).
After realisation of these improvements, the following half hourly raw gas values (exit of economiser) should improve from the actual values named above in 4.2.3.1 to the following figures:

PCDD/F	half hourly: < 23 ngTEQ/Nm³ wet	daily: < 5-10 ngTEQ/Nm³ wet
NOx	half hourly: < 180 mg/Nm³ wet	daily: < 150 mg/Nm³ wet

4.2.3.3 For comparison: typical raw gas values from existing waste incineration plants

Components	Units	Incineration plants for		
		Municipal waste	Hazardous waste	Industrial sewage sludge (fluidised bed)
Dust	mg/Nm³	1000 – 5000	1000 – 10000	30000 – 200000
Carbon monoxide (CO)	mg/Nm³	5 – 50	<30	5 – 50
TOC	mg/Nm³	1 – 10	1 – 10	1 – 10
PCDD/PCDF	ngTEQ/Nm³	0.5 – 10	0.5 – 10	0.1 – 10
Mercury	mg/Nm³	0.05 – 0.5	0.05 – 3	0.2
Cadmium + thallium	mg/Nm³	<3	<5	2.5
Other heavy metals (Pb, Sb, As, Cr, Co, Cu, Mn, Ni, V, Sn)	mg/Nm³	<50	<100	800
Inorganic chlorine compounds (as HCl)	mg/Nm³	500– 2000	3000 – 100000	
Inorganic fluorine compounds (as HF)	mg/Nm²	5 – 20	50 – 550	
Sulphur compounds, total of SO_2/SO_3, counted as SO_2	mg/Nm³	200 – 1000	1500 – 50000	
Nitrogen oxides, counted as NO_2	mg/Nm³	250 – 500	100 – 1500	<200
Nitrous oxide	mg/Nm³	<40	<20	10 – 150
CO_2	%	5 – 10	5 – 8	
Water steam (H_2O)	%	10 – 20	6 – 20	

Notes:
1. Sewage sludge plants are those for the incineration of industrial sewage sludge
2. The information in this table refers to German plants. The values seen at older plants can be considerably higher, especially in the case of emissions influenced by furnace-technical parameters e.g. CO, TOC, etc.
3. Hazardous waste values refer to mixed HW merchant plants rather than dedicated stream plants.

Table 3.6: Flue-gas concentrations after the boiler (crude flue-gas) at various waste incineration plants (O_2 reference value 11 %)
[1, UBA, 2001], [64, TWGComments, 2003]

[2]

4.2.4 Clean gas data

4.2.4.1 Legal limit / permit values

Emission limit values at the stack (purified flue gas) according to IPPC Permit IP0004/07:

Table 3.1.2.2 – Emission Limit values

Pollutant	Daily	Half Hourly (100%)	Half Hourly (97%)
	mg.Nm-3	mg.Nm-3	mg.Nm-3
Total dust	≤ 5	≤ 20	≤ 5
Gaseous and vapourous organic substances expressed as TOC	≤10	≤ 20	≤ 10
HCl	≤ 8	≤ 50	≤ 8
HF	≤ 2	≤ 2	≤ 2
SO2	≤ 40	≤150	≤ 40
NOX expressed as NO2	≤ 180	≤ 350	≤180
CO ****	30 mg/m^3		100 mg/m^3 (95%)
Cadmium and Thallium and their compounds, expressed as cadmium (Cd) and thallium (tl)	0.05 mg/m^3 *		
Mercury and its compounds, expressed as mercury (Hg)	0.05 mg/m^3 *		
Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V) and their compounds, expressed as their native elements, respectively (TOTAL)	0.5 mg/m^3 *		
Dioxins and furans**	0.1 ng/m^3		
Ammonia as NH3	10 mg/m^3 ***		

Emission limit values at the stack (purified flue gas) according to tender document to this study:
(WSM 081/2013 of 24/09/2013)

The IPPC limits specified in the IPPC permit are as follows:

	Half Hourly (mg/Nm^3)	Daily average (mg/Nm^3)
CO	75	30
TOC	10	10
NOx	180	180
HCL	8	8
SO_2	40	40
NH_3	10	10
Dust	5	5
HF	2	2

➔ The goal of this study is to achieve **50 to 75 % of the permit values** in normal operation.

4.3 Applied main design data

The following three load cases (6500, 8000 and 12000 Nm³/h flue gas amount) have been taken into consideration for the technical design of the different plant configurations (3 scenarios).
For the financial analysis of this study, the average load case (8000 Nm³/h) has been applied.

balance point 1 flue gas on economizer outlet					
parameter	**symbol**	**dimension**			
flue gas amount		[Nm³/h]	6500	8000	12000
flue gas temperature		[°C]	145,00	172,00	220,00
flue gas pressure		mbar	-8,00	-11,35	-15,00
Nitrogen content wet	N2wet	[%]	57,00	56,00	55,00
specific heat capacity nitrogen	cpN2	[kJ/Nm³]	1,31	1,32	1,32
oxygen content wet	O2wet	[%]	8,00	8,00	8,00
specific heat capacity oxygen	cpO2	[kJ/Nm³]	1,34	1,34	1,35
carbon dioxide content wet	CO2wet	[%]	10,00	11,00	12,00
specific heat capacity carbon dioxide	cpCO2	[kJ/Nm³]	1,72	1,74	1,77
water content	H2O	[%]	25,00	25,00	25,00
specific heat capacity water	cpH2O	[kJ/Nm³]	1,52	1,53	1,54
specific heat capacity flue gas	cp	[kJ/Nm³]	1,41	1,42	1,43
verification %		Vol-%	100,00	100,00	100,00
power		MW	0,3689	0,5420	1,0498
Cl-concentration in flue gas		mg/Nm³	1000	1000	1000
Cl- mass flow		kg/h	6,5	8	12
SO2 - concentration in flue gas		mg/Nm³	1500	1500	1500
SO2 - mass flow		kg/h	9,75	12	18
dust concentration		mg/Nm³	4003	4003	4003
dust -mass flow		kg/h	26,020	32,024	48,036

5 Recommendations on the upgrade of the incineration process

The following improvements of the incineration process are required for primary emission reduction and may enable a simpler flue gas scrubbing plant configuration:

1. Installation of **secondary air nozzles** that provide a homogeneous mixture of gases
2. **Sealing of leakages** in the flue gas ducts of the plant
3. replacement of the dry deslagger by a **wet deslagger**
4. provide a **continuous waste fuel feed**
5. installation of new **soot blowers**
6. installation of an automated **combustion performance control system** which regulates the oxygen level, temperatures, pressure levels

<u>Further recommendations (not directly related to simpler flue gas scrubbing plant configuration)</u>

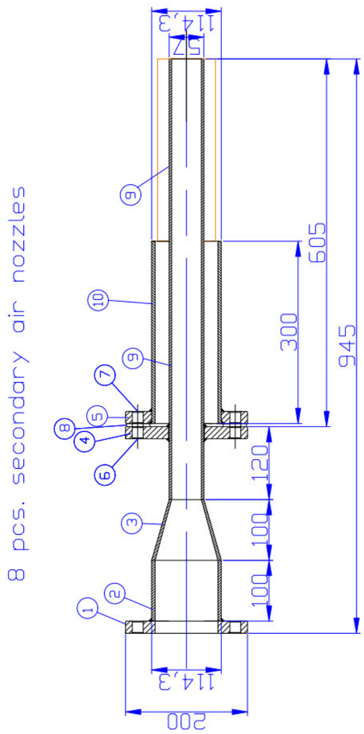
7. installation of a **solvent lance and rack**
8. **Stack and ID fan** improvements
9. Test of **clay minerals and activated carbon** in the existing adsorber

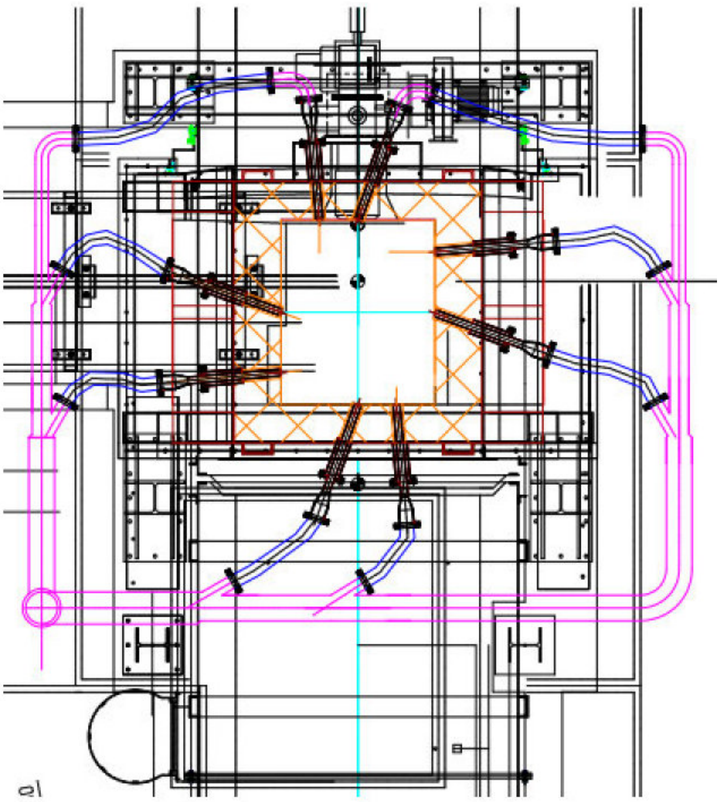
(detailed descriptions below).

5.1 Secondary air nozzles

Cold strains actually form CO and Dioxins in parallel with the formation of NOx. The temperature grid measurement carried out by Tec-Solution in February 2014 shows up 180°C temperature differences
(-> presence of cold strains) before the second combustion chamber. Actually, the air supplied in the post combustion zone is injected at a too low speed – the flue gases and cold strains are not mixed homogeneously – this amplifies the formation of pollutants especially PCCD/F´s.
The installation of secondary air nozzles that provide a homogeneous mixture of gases will reduce the formation of these pollutants.

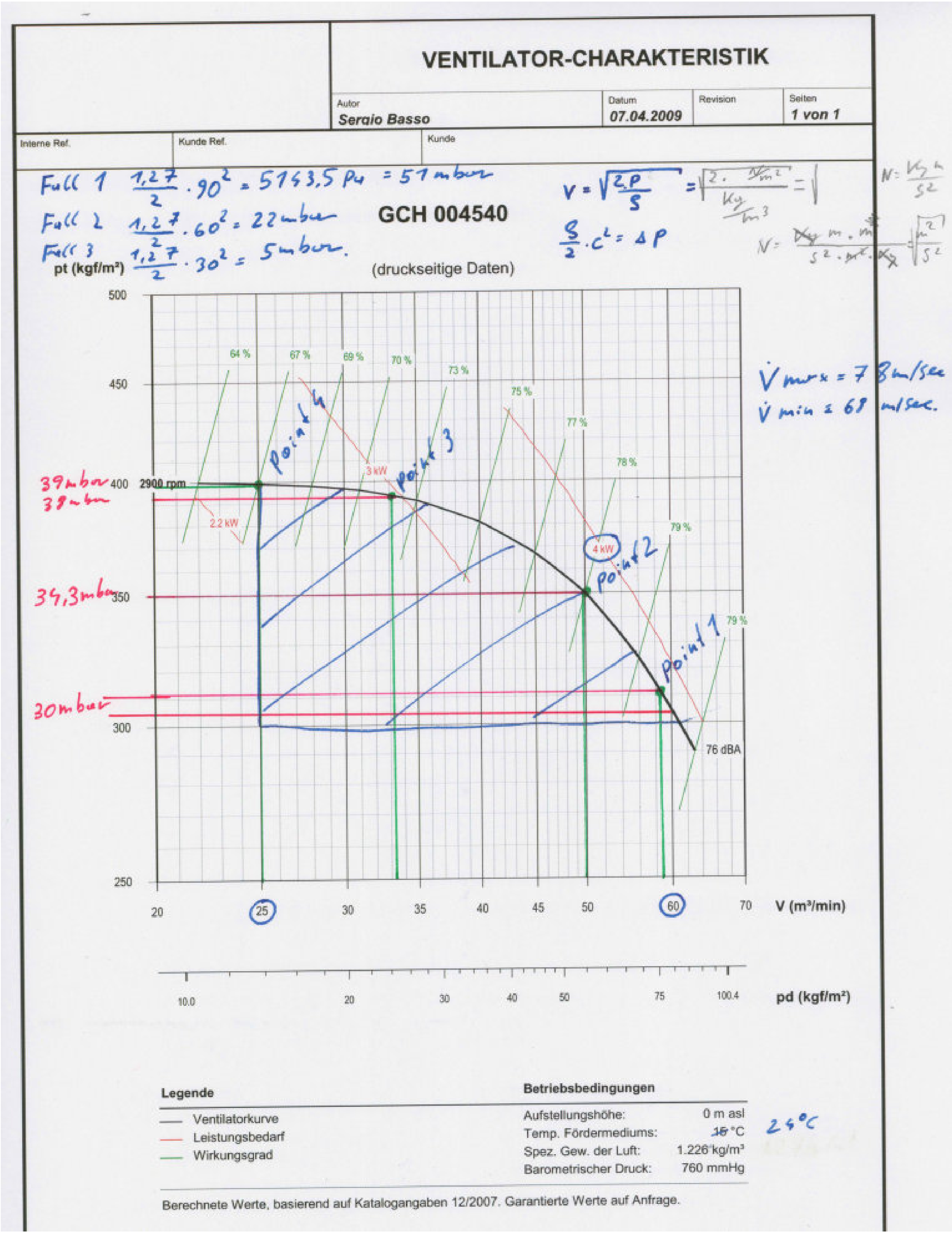
Recommended design (copyright Tec-Solution):





Implementation costs estimated at: 30,000€

Fan diagram of secondary air fan GCH004540 which could be used for the supply of secondary air.



5.2 Sealing of leakages

Cold strains all along the plant result from leakages. These cold strains promote the PCDD/F de novo synthesis. Sealing is required at the

- emergency stack
- manholes
- firedoors
- fabric filter head and other openings (high temperature seal (300°C- 1000°C)
- eliminate dilution air valve

5.3 Wet deslagger

The kiln is actually operated on gasification or pyrolysis - advantage is the avoidance of melted ashes (vital for the existing dry deslagger) - disadvantage is the poor burnout of gases due to the lack of oxygen. Regarding reduction of pollutants, the burnout should be increased. Especially when using the future waste streams, it is likely that the slag will accrue in a melt flow and a wet deslagger will be necessary.
A wet deslagger / wet kiln ash discharging system allows to maintain subpressure in the kiln which is essential to avoid leakage of crude partial burnt flue gases from the kiln into the environment. On the other way, cold air is aspirated through the not tight actual dry deslagger while subpressure is present in the kiln. This triggers the above named cold strains in the furnace.
In fact, the overall air pollutant emission of the plant is actually influenced negatively by these flue gas leakages and cold strains.
The water demand for the wet deslagger is estimated at 75 l/h which are boiled down. This water can be supplied by purified water from the new WWTP (before polishing stage).

A second small burner opposite the drum outlet ("Bärenbrenner") might be necessary to melt down the ashes from the rotary kiln into the wet discharging unit.

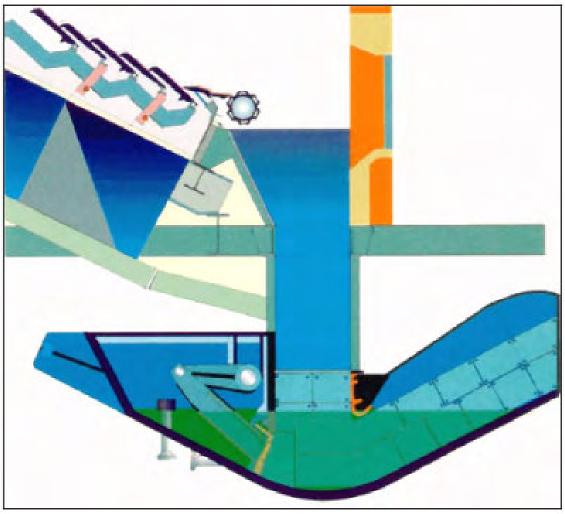
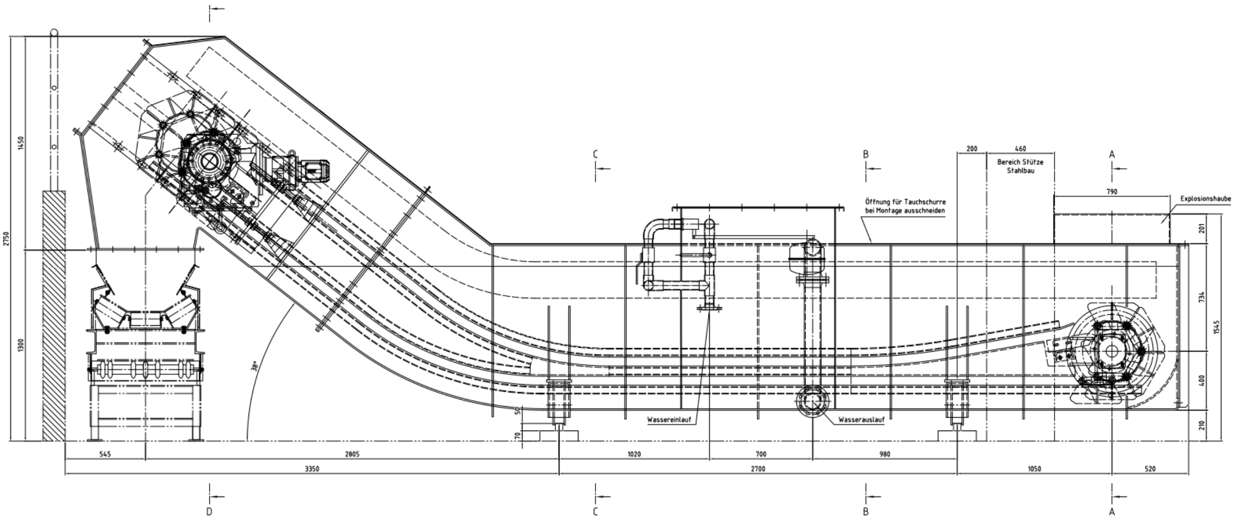
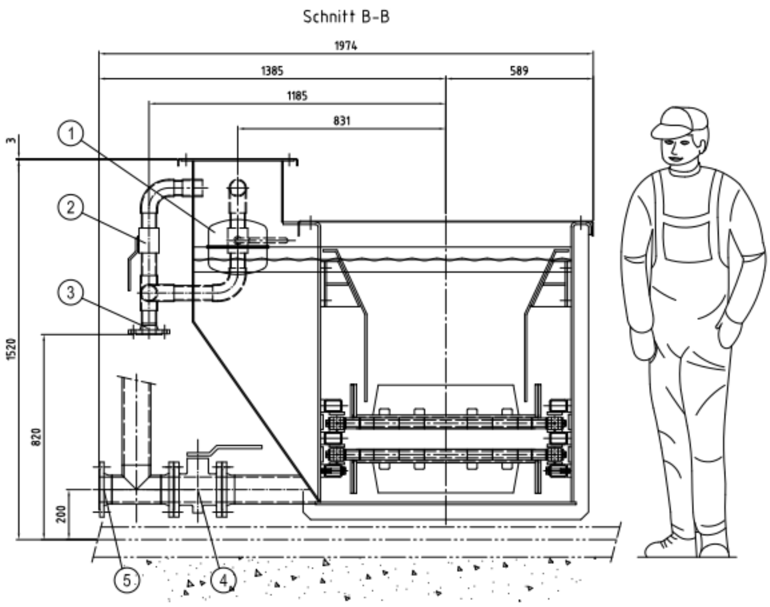


Figure 2.5: Example of a type of ash remover used at a grate incinerator
Source [1, UBA, 2001]

A budget price offer for a wet discharging unit has been requested by the company Loibl Allen-Sherman-Hoff GmbH. The price for the Machine ex factory was specified with 72,000€.





Implementation costs estimated at. 150,000€

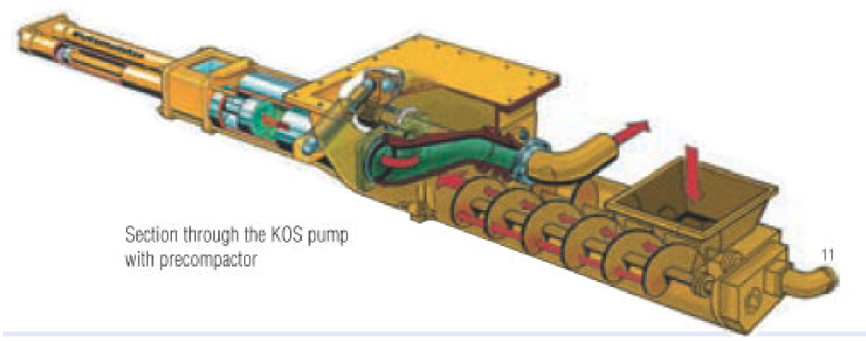
5.4 Continuous waste fuel feed

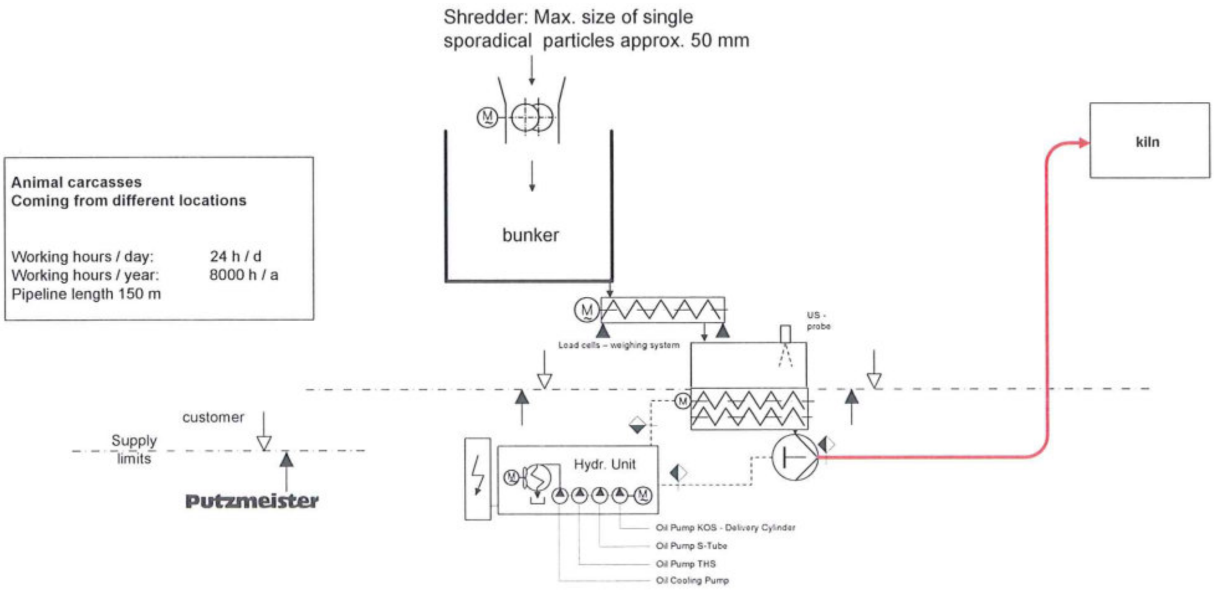
A continuous waste fuel feed (f.ex. by a Putzmeister pump) enables a better utilisation of the incineration capacity – higher revenues, less operation disorder, less auxiliary fuel consumption and less formation of pollutants due to more constant temperatures in the kiln.

Budget Price from Putzmeister in 2010 ex factory 125,000€

Implementation costs estimated at 200,000€

Putzmeister





1 x Hydraulic power pack HA 11 CI-S

For driving the high-density solids pump KOS 1030 and the auger feed device THS 222 in accordance with technical description KS 909149.

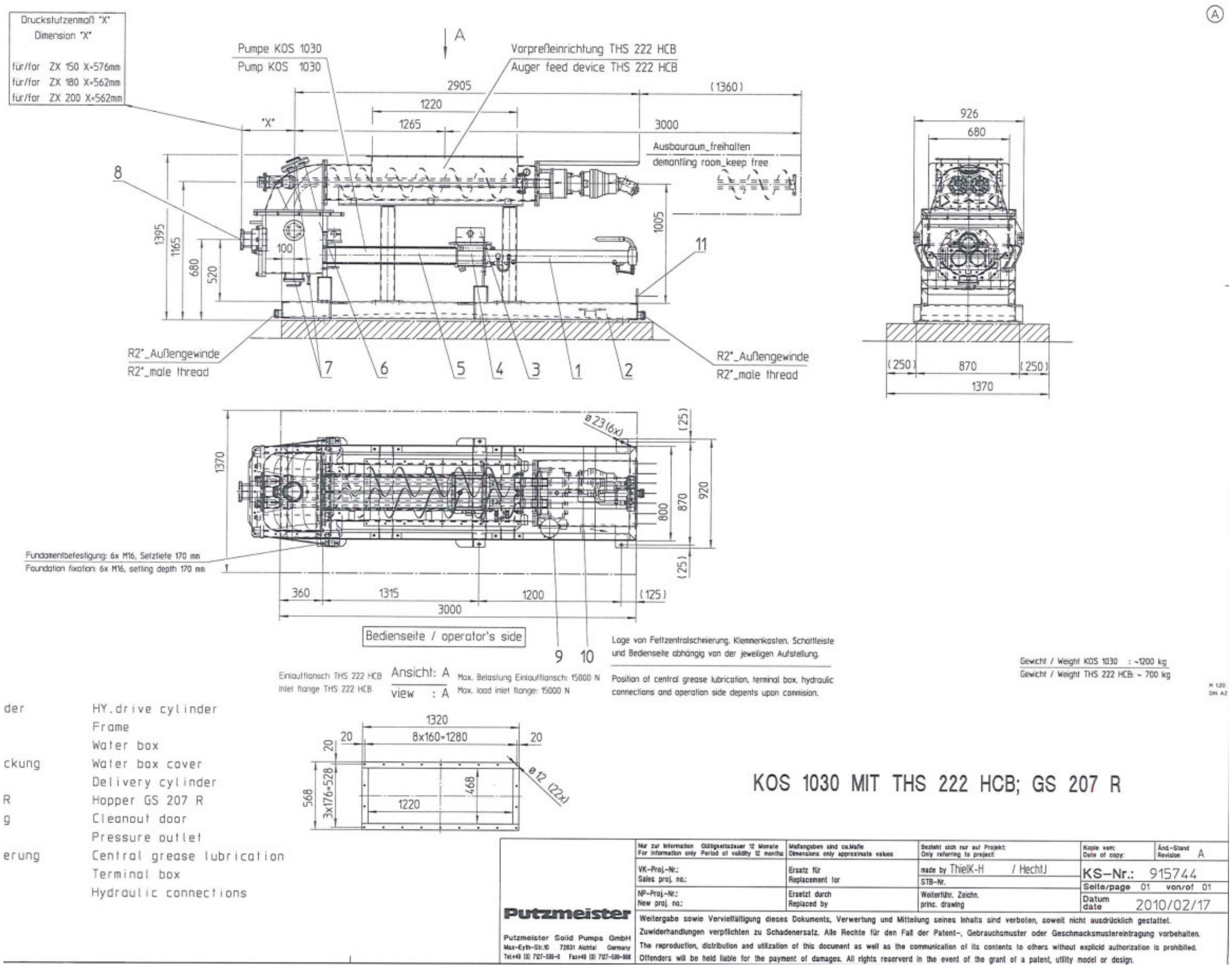
Motor output:	11 kW
Motor speed:	1450 rpm
Voltage:	400 / 50 V/Hz

Quotation drawing (non-binding) KS 910692_01

1 x Control cabinet

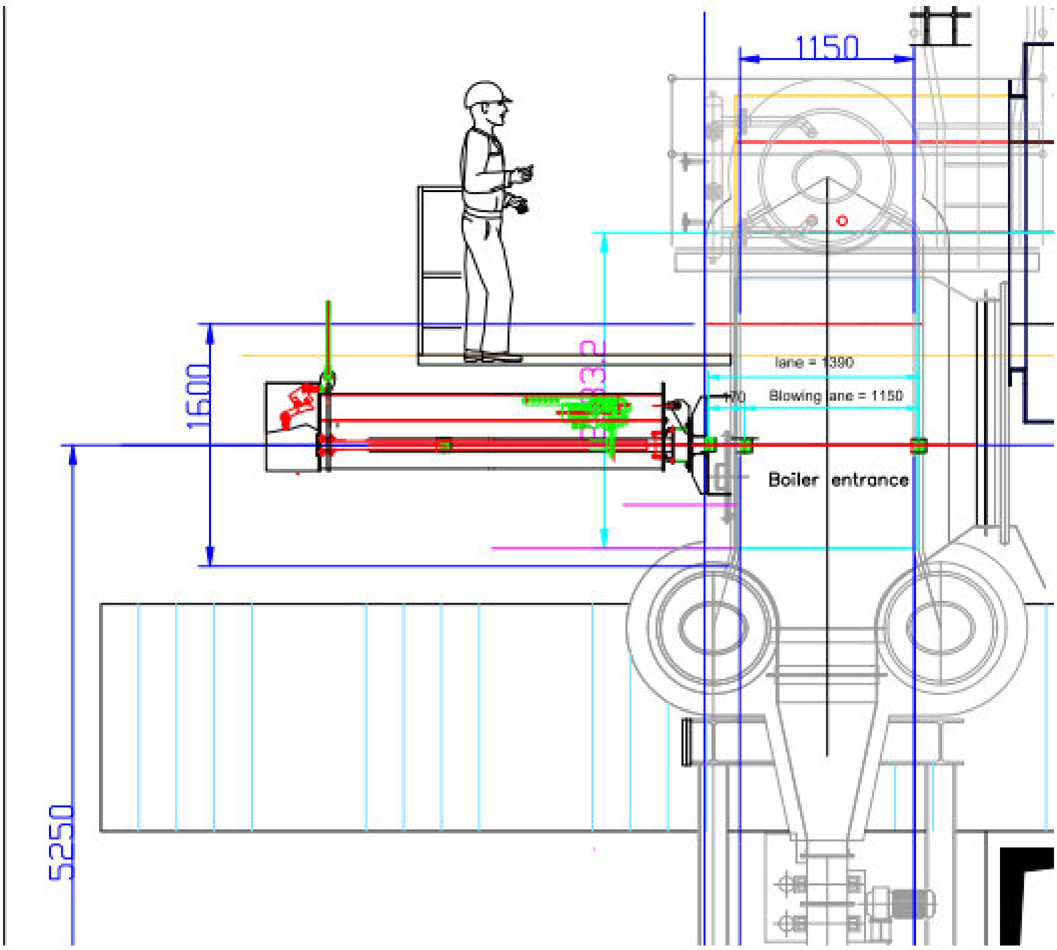
In compliance with the PUTZMEISTER standard, the control cabinet is assembled separately from the hydraulic power pack and in accordance with technical description KS 66238.

Control cabinet, 2-door, with Siemens S 7 - 314 C control. Protection class IP 55.

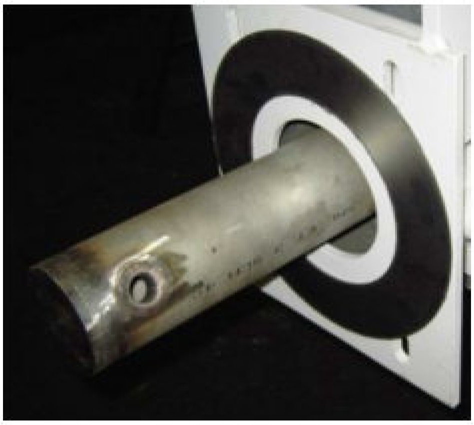


5.5 Soot blower

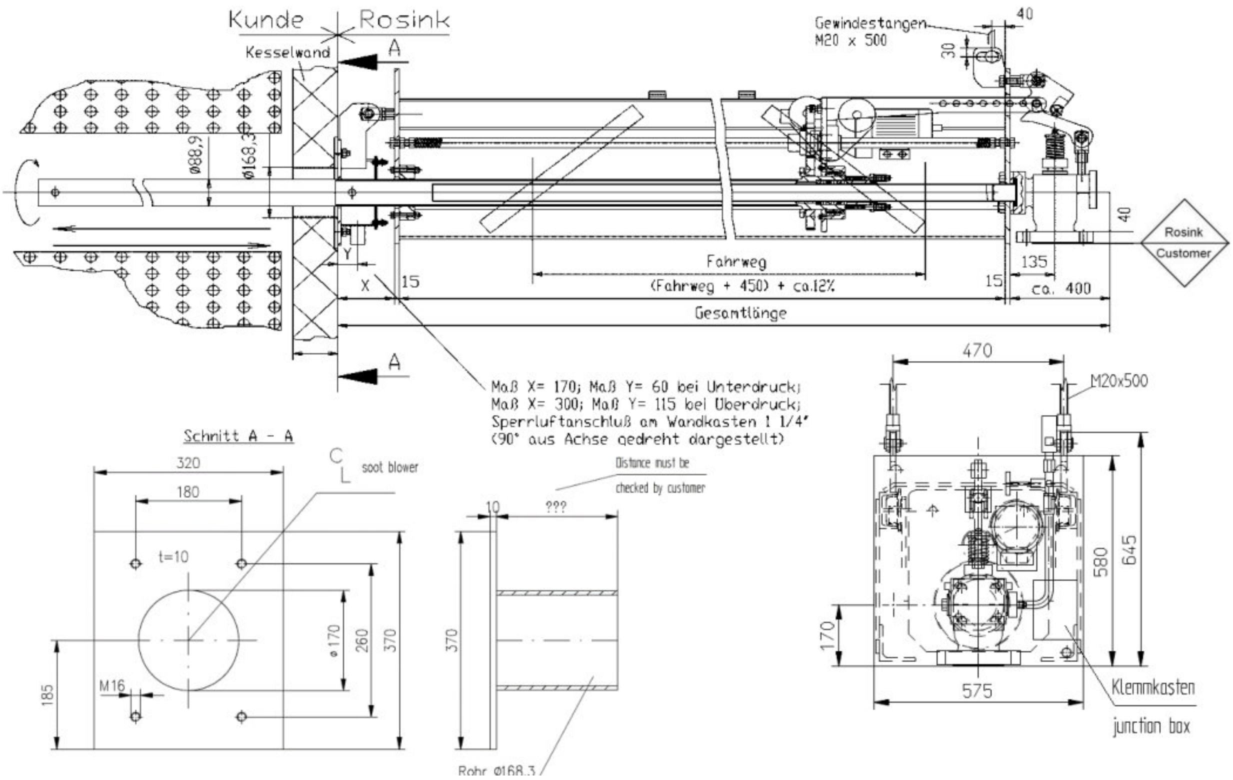
The plant availability can be increased by installation of online cleaning equipment like a soot blower in the front of the boiler, a small modification between the post combustion chamber (SCC) and the entrance of the boiler,that permits the dust to move forward to the discharging hopper.
Further improvements can be achieved by installation of cleaning doors that permit the workers to clean the boiler with compressed air lances from outside meanwhile the plant is in operation.



Soot blower nozzle head



Pos. 200: Lanzenschraubbläser Typ LSB II



Implementation costs estimated at 40,000€

5.6 Incineration control system

An automatic control system for the incineration and for the flue gas scrubbing system should be implemented in order to meet the requirements of the referring BAT-documents concerning energy and consumable efficiency as well as lowest possible residue amounts.

The following improvements may be obtained:

- better bottom and fly ash quality
- less fly ash production
- less formation of pollutants / destruction of pollutants like CO, TOC, PCDD/F, NOx
- transfer of metallic mercury to its dischargeable ionic form
- better energy efficiency
- less operation disorders
    - better utilisation of the capacity – higher revenues
    - higher availability
    - less maintenance costs
- better operation of the flue gas scrubbing system

The actual control of combustion air only respects the oxygen content at the end of SCC by an non precise valve that introduces secondary air at a very low speed. The modulation of the secondary air is between 1945 and 1000 Nm³/h.

The theoretical total air demand of the incinerator would between 4,800 and 6,900 Nm³/h (2.2-3.3 MW).

- 1566 Nm³/h are supplied by primary air nozzles at the front plate with 50 mbar without modulation.
- 951-1500 Nm³/h are supplied by the burner, dependent on the burners performance.

So the actual maximum air flow for combustion in the rotary drum is around 3,000 Nm³/h which is far too low compared to the theoretical air demand of 4,800-6,900 Nm³/h. This limits actually the waste throughput respectively limits the burn out of flue gas pollutants because there is not any more air available for combustion.

A fan is installed at the bottom of the vertical column. This fan was used in the original plant concept to seal the dry discharging unit with air and supply combustion air for a burner that has been decommissioned during the upgrade. This burner should be used for secondary air supply, and the opening should be sealed, because it inserts actually 500 Nm³/h of air that creates cold strains in the combustion and inhibits the complete burn out of TOC and PCCD/F.
Tec-Solution suggests using this fan for the secondary air and connect it to the new secondary air nozzles.

Vis-à-vis of the rotary kiln's end, there has been installed a fan by Wasteserv. This fan supplies the first secondary air level with 875 Nm³/h of air which already improved the burnout of flue gas but still the speed of air injection could be improved by using a higher pressure and speed of injection.

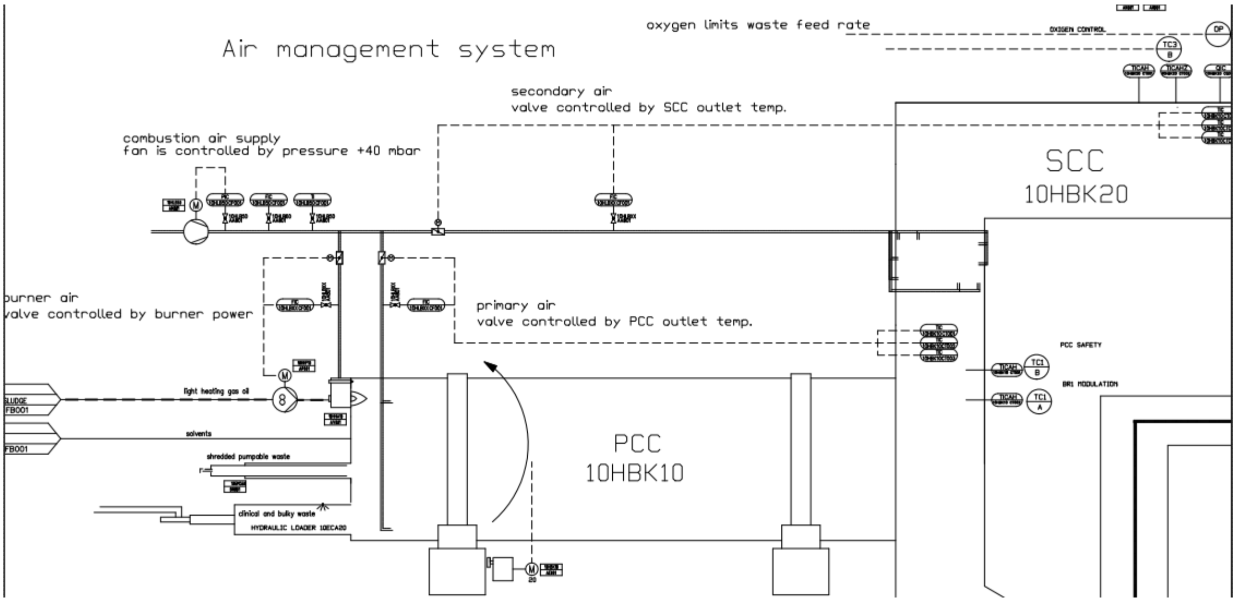
At the top the secondary air fan supplies 1,000-1,945 Nm³/h of combustion air without any pressure => this generates hot and cold strains simultaneously which causes the formation of NOx, CO and PCCD/F at the same time.

<u>Recommendations on the design of the incineration control system:</u>

- Waste feed should be performed in correlation with the air amount available.
- Combustion air demand should be evaluated by actual process parameters and controlled automatically.
- The distribution of the combustion air at the front and the back should be modulated by automatic air control valves. These valves are operated according to the temperatures in the combustion.
- The primary air valve at the front plate should control the temperature in the vertical column at the end of the PCC.
- The secondary air valve to the secondary air level should control the temperature at the end of the SCC
- The actual air amounts should be evaluated permanently by venturi type air flow sensors.
- The burner air fan at the top could be suitable to feed the whole combustion air system and supply a defined pressure. The required air amounts are than taken by the different air control valves to source the nozzles at the different positions of the kiln.

- Constant temperatures in the combustion and sufficient mixing of gases would have a positive effect on CO, NOx, TOC and PCCD/F. The SNCR system would work better as well with constant operation conditions.

The air management system together with a constant dosing of waste should **increase the throughput of the system by at least 20%.**



5.7 Solvent lance

With the future fuel mix (including solvents), it should be feasible to **reduce the use of auxiliary fuels** (diesel) to a minimum (only at start-up, shut-down or during disturbances).

The following availability of solvents could be identified from Daniela Grech's communication with different waste producers:

Producer	Type	Quantity [to/a]	Price [€]
Siegfried-malta	Laboratory waste – liquid waste made up of a number of different liquids. Aqueous based. Approx. 1 – 2 IBCs per month. Currently being exported.	14,76	
Crystal Pharma	Non-Halogenated Organic	360	225 - 595
Medichem	Organic solvent based approximately 95T per year.	95	250-280
Actavis	HPLC waste from lab – this makes up approximately 85% of all the liquid waste and is mostly aqueous solutions with a content of Methanol. This is handled in IBCs.	90	
Arrow Pharma Malta	Lab liquid hazardous waste: approx. 40T / year ⍰ Organic flammable liquids HPLC waste Particle size waste oils Glacial acetic acid waste	40	
	Sum	**600**	**200€/to**

A disposal price of 200 €/to should be achievable and would increase the revenues substantially.

For the introduction of solvents into the kiln, we recommend the installation of a solvent spray lance in the kiln's front plate. Solvents may not be used during start up and shut down (complete burnout of pollutants at lower / changing temperatures not guaranteed).

The lance is supplied by solvents at a pressure of 2 bar (existing Jessberger pump JP 800 could be suitable) and by an atomisation medium (compressed air). The solvents are atomised via the jet nozzle which enables the distribution of solvents all over the combustion zone and a proper burnout.

The following pictures of a suitable spray lance type have been taken during a test with water (left without atomisation, right with atomisation medium):

The following investment costs for the upgrade of the solvent system have been indentified:

Investment cost	price €
combustion control system	100000
solvent lance and rack	56000
solvent pipework valves and other	50000
primary air fan (old burner fan could be reused)	20000
air control valves	22000
air pipework	12000
cabeling pannelboards	40000
failsafe control system	12000
engineering	34000
electrical engineering	24000
transport	20000
assembly start up and comissioning	48000
hazop study with notified Body TÜV	12000
documentation	6000
depriciation [15 years]	456000

This scenario contains the investment for an incineration control system specified in 5.6 as well:

Revenue on 350 to of solvents: 70,000 €/a equals savings on diesel 262000 l/a @ 0,92 € = 241,040 €

Total revenue 311,040 €/a. ROI 1.5 years.

5.8 Improvements of ID-fan and stack

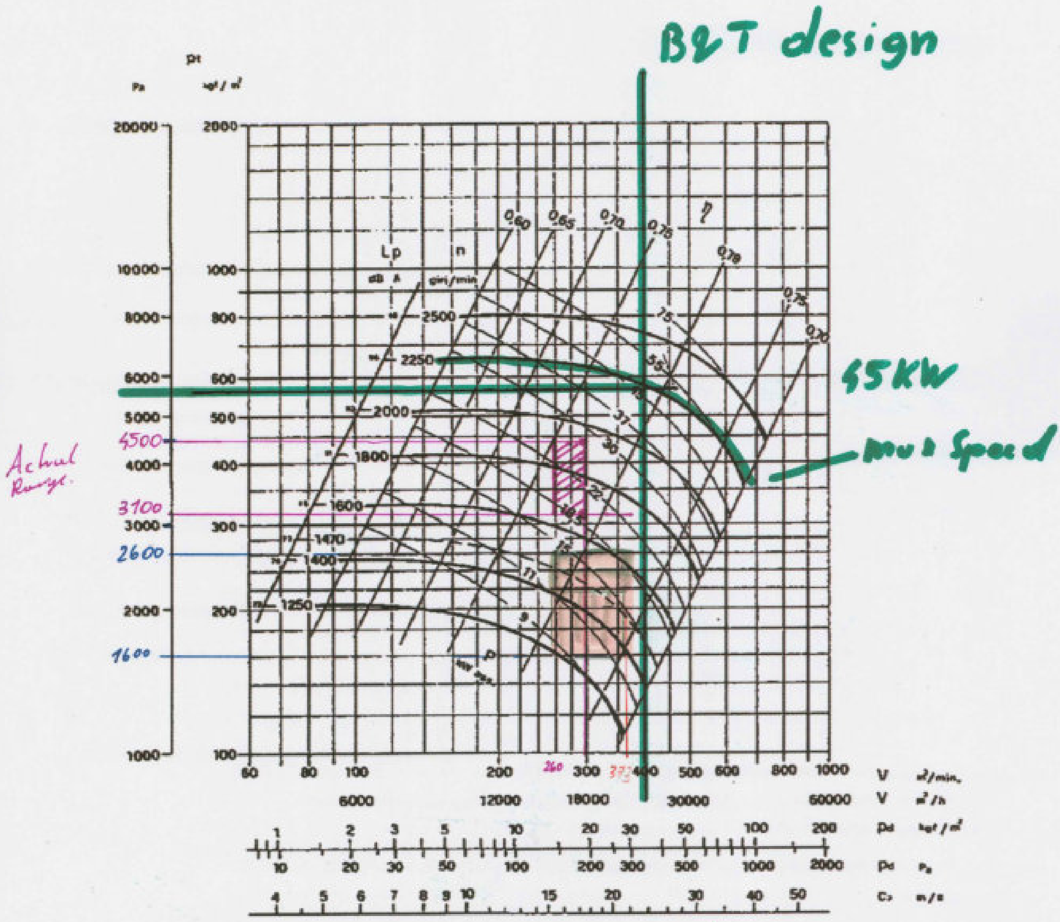
The existing stack has an outlet diameter of 0.63 m. The sampeling point diameter is 0.85 m. This reduction of diameter generates a big pressure loss and limits the flue gas amount to around 18.000 Nm^3/h. The implementation of a silencer before the stack and the reduction of the fluegas outlet speed to 11 m/sec could improve the noise level around the plant and reduce electricity consumption of the ID-fan.

During Tec-Solution's site visit in February 2014, the pressure drop of the stack was figured to roughly 3 mbar by measurement. Theoretically, the pressure drop should only be 0.9 mbar (based on flow volume, pipe and stack diameters). It is likely that **clogging** (condensed pollutants) already reduced the free diameter from originally 630 mm to around 460 mm.
Before cleaning the stack, the emissions sensors must be removed in order to avoid damages.

Actually, the ID-fan is operated at maximum speed @ 60 Hz but does **neither provide the required pressurisation nor the required gas flow**. Theoretically, the ID-fan should consume 25-30 kW (calculated from actually required pressurisation and flow). The actual real consumption should be measured.
We recommend to investigate these discrepancies. Possible problems could be: wrong rotation direction, inappropriate belt pulleys, disturbances in the transmission, aspiration of false air.

The measurement of temperatures before and after the ID fan showed that there was a temperature reduction from 140 to 122 °C – this indicates **leakages** directly before the ID-fan (check of compensator is recommended).

Existing ID-Fan EUMc 801



17773 Bm^3/h = 296 Bm^3/min @ 31 - 45 mbar

Power Consumption between 20 & 28 kW

Reduction of false air

$10.000 \cdot \left(\frac{273 + 140}{273}\right) \cdot \frac{1013}{(1013 - 31)} = 15606\ Bm^3/h$ 260 Bm^3/min @ 31 mbar

future operation range of ID-Fan 15

actual operation range of ID-Fan

Stack diameter Ø 630 mm Speed 17773 Bm^3/h = 16 m/sec = 88 pa

Ø 845 mm Speed 8,8 m/sec. = 26 pa

22 383,25 Bm^3/h Ø 630 mm Speed 19,9 m/sec = 127,3 pa

$S = \frac{14500}{22383,25} = 0,653 \frac{kg}{m^3}$ Ø 845 mm 11 m/sec = 38,9 pa

5.9 Test clay minerals / activated carbon

A clay mineral and activated carbon mix had been requested from Walhalla Kalk to enable higher dosing rates (up to 25 kg/h) than the actual 2 kg/h of activated carbon – this may improve the emission values (f.ex. PCDD/F) substantially at the actual waste mix.

A test could easily be executed by using a sample charge and comparison of separation efficiency.

Please send back to:
Fax: 0941 4025-510

WALHALLA KALK

Plant/address:		WasteServ Malta Ltd.			
		Triq il-Biccerija			
		Marsa MRS 1123			
		Malta			
Speak to:		Ing Ramon Vella, Head of plant and operations engineer			
Telefon number:		+356 23858414			
Telefax number:		+356 23858418			
E-Mail:		ramon.a.vella@wasteservmalta.com			
Flue gas purifying system:		dry ☒ semi dry ☐ wet ☐			
Flue gas	m^3/h N.tr.:			m^3/h N.f.:	6-12000 [9000]
Moisture	Vol% H_2O:			mg H_2O/m^3:	11-16 [12,5]
Added moisture	Vol% H_2O:			t H_2O/h:	0
T before fabric filter	°C:	110-150			
		raw gas		**clean gas**	
		from	**to**	**now**	**like**
				100%	50-75%
SO_2	mg/ m^3:	737-5000		15 [40=Limit]	
HCl	mg/ m^3:	470-1000		1.46 [8=Limit]	
Hg total	µg/m^3:	0.05			
Hg^{++}	µg/m^3:				
PCDD/F	ng TE/m^3:	22.9		0.2 0.1	
Adsorbent	mg/Nm^3:	2734 / 200		typ:	NaHCO3; HOK
Dust before filter	mg/m^3:	3500			
Fabric filter	m^3/m^2 x min.:	0,55			
Filter area total	m^2:	468			
Δ p in fabric filter	mbar:	17-22			
Type of fabric:					
Air permeability	l/m^2 x h:				
Temp. resistance	°C:	240			
Other informations:		DN=125mm; L=2510mm			
		Actual Emission readings:			
		http://statistics.wasteservmalta.com/scadahourly.aspx			
		https://www.wasteservmalta.com/incinerator.aspx			

A budget price offer for the reagent has been handed over that is cheaper than the actually used HOK at the same adsorption efficiency:

CHEMICAL DATA SHEET

WALHALLA KALK

Walhalla-Dioxorb® 759 CA (20)

Adsorbent for purifying flue gases composed of hydrated lime, a special mixture and 20 % activated carbon for the separation of dioxins and furanes.

Chemical analysis:
(without activated carbon)

Loss of ignition			11.0 - 14.0	%
Carbon dioxide	1.0 - 3.0	%		
Water (105 °C)	5.0 - 8.0	%		
CaO			8.0 - 11.0	%
MgO			2.0 - 3.0	%
SiO_2			36.5 - 39.5	%
Fe_2O_3			4.0 - 5.0	%
Al_2O_3			13.0 - 16.0	%
SO_3			0.1 - 0.5	%
Activated carbon			20 ± 1	%
Iodine adsorption activated carbon			> 800	mg/g

Physical properties:

Bulk density according to EN 459-2	about 0.6	kg/dm^3

Riddle analysis:

Residue on test riddle according to DIN ISO 3310	0.1 mm	3 - 6 %
	0.063 mm	9 - 13 %

Walhalla-Dioxorb® reacts absorptively and adsorptively with PCDD/F and heavy metals.

The specified numbers are averages without right to title.

Safety Data Sheet = Walhalla-Dioxorb® - Hazardous Substance Group 2 A.

Date: September 13, 2013

Walhalla Kalk stated that a dioxin quantity of 23 ng/Nm³ could be absorbed on 15 kg/h of this clay mineral and activated carbon mix.

WALHALLA KALK

Walhalla Kalk GmbH & Co. KG · Donaustaufer Str. 207 · 93055 Regensburg

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Your sign/Message from:
Our sign: LWe-CM

Date: June 10, 2014

Offer

Dear Mr. Liebisch,

Thank you very much for your inquiry.

We can offer to you according to our current conditions of sale and delivery of June 2011:

Walhalla-Dioxorb® 759 AK (20) in big bags, ex factory Regensburg	**415,40 €/t**
+ CO_2-additional costs	**0,19 €/t**
Transport costs from Regensburg to M-MARSA, - minimum weight 5 t/delivery (lower quantities not possible due to technical reasons)	**4.590,00 € all inclusive**

Walhalla-Dioxorb® 759 AK (20) is a blend optimized for adsorbing PCDD/F consisting of several clays, 20 % activated carbon with a specific surface > 800 m²/g, and a little lime hydrate. Based on 12.000 m³ of flue gas and 23 ng TE/Nm³/m³ PCDD/F, I calculated an expected dosing rate of approximately 1,25 g/m³ (about 15 kg/h).

Terms of payment: 8 days 2 % discount - 30 days clear

Please note that only written orders can be accepted.

<u>Briefly, the realisation of above named recommendations may enable the following benefits related to this study:</u>

If the incineration process can be improved according to the target raw gas emission levels, compliance with the emission limits shall be reached with a **simpler new flue gas scrubbing system** (scenario 1 or 2 presented below in chapter 6).
However, if the targets (detailed figures: see chapter 4.2.3.2) for the incineration process cannot be reached, an additional catalyst for the reduction of NO_x and PCDD/F should be installed (scenario 3).

Regarding economical aspects, the aim should be to **increase the plant availability** from 5,616 to 6,500 – 7,000 h/a. This will be difficult due to the disadvantageous design of the post combustion chamber, but by realisation of the above named recommendations, a substantial improvement can be expected. The increased availability will result in more tons of hazardous waste disposed and will lead to higher revenues.

<u>Further recommendations:</u>

In the course of the Detail Engineering for the new flue gas scrubbing system, **a fire and explosion protection concept** should be elaborated; especially concerning the

- Storage and feeding systems of waste (in particular solvents, diesel)
- Pre-dedusting system (bag filter)
- Flue gas polishing system (storage and use of activated carbon)

6 Recommended scenarios for the flue gas scrubbing system

Three possible scenarios are taken into consideration for further investigation.
These possible plant scenarios have been chosen according to the basic design data and required emission limits cited in chapter 4.

For each scenario, a **short process description, a flow chart and an equipment list** have been elaborated in order to assess the scenarios on their technical and economical feasibility. The main design data for the equipment required are defined in the flow charts and layout drafts.
The short process descriptions are enclosed on the following pages of this document; the process flow charts are enclosed as separated attachments and the equipment lists are integrated in the economical feasibility calculation (calculation sheets are enclosed as separated attachments to this document).
The identified optimum scenario has been described further in a detailed process description (see chapter 8), P&Is and in layout drafts (separate attachments).

Disclaimer:
The below recommended configurations of apparatus and machines in this study serve as a basis for the cost calculation of the feasibility study.
Due to the fact that the author of this study has not got any influence on the chosen equipment and controls, Tec-Solution Umwelt- & Wärmetechnik GmbH cannot take the responsibility of the supplier to asses all assumptions in the basic engineering, and carry out the full engineering.
It is scheduled to tender the process engineering and the delivery of the plant based on the most advantageous scenario succeeding to this study.
The respective supplier is responsible for the full functionality, safety and compliance including regarding the emission limits of the delivered plant.

6.1 Decision making process

As described in the cited BAT-document on Waste Incineration, the flue gas pollutants of hazardous waste incineration plants are likely to occur in peaks which cannot be anticipated as the waste composition may vary widely.

Decision making on the best available flue gas scrubbing system:

Dry and semi dry flue gas scrubbing systems for the reduction of acidic gases have been evaluated in the course of this study, but finally, these technologies are not considered to be suitable for this plant as the dosing system for reagents cannot react fast enough to the varying raw gas emission levels to ensure the compliance with the legal emission values. Furthermore, the consumption of expensive reduction agents is higher compared to wet scrubbing systems and there will emerge higher amounts of hazardous waste from dry and semi-dry flue gas scrubbing systems.
Most of already existing hazardous waste incineration plants in Europe use wet flue gas cleaning systems combined with dry adsorption flue gas polishing systems. The two staged scrubbing system

provides lowest emission levels compared to dry or semi dry systems while reaction agents may be used most efficiently.
The main advantages of the wet scrubbing system are the high reactivity of absorption agents in the wet phase and the provision of a large buffer for agent – peaks of acidic gas emissions can easily be absorbed in the washing water.
The wet scrubbing system requires a **pre-dedusting** unit.

For the final **reduction of PCDD/F** (downstream to the realisation of primary measures), a flue gas polishing system is required. As the existing fabric filter can be used for the flue gas polishing system, a static bed adsorber has not been investigated further. Especially at smaller plant sizes, fabric filter based polishing systems are widely used.

If the minimisation of NOx and PCDD/F in the raw gas cannot be reached by primary measures (incineration process), an appropriate **catalyst** (SCR system with PCDD/F reduction) should be implemented. If the target raw gas values named in chapter 4.2.3.2 can be achieved, the required clean gas values should be achieved with both scenario 1 or 2 without additional catalyst (according to the reagent supplier Walhalla Kalk, a half hourly raw gas value of < 23 ng/Nm³ can be reduced to the emission limit value in the choosen flue gas polishing system of scenario 1 and 2 by their clay mineral / activated carbon based reagents).

6.2 Descriptions of the chosen scenarios

6.2.1 The recommended basic process

The three scenarios investigated further in an investment and operational cost analysis are based on the following basic process (consisting of best available technologies according to source [2], see also chapter 3 of this document).

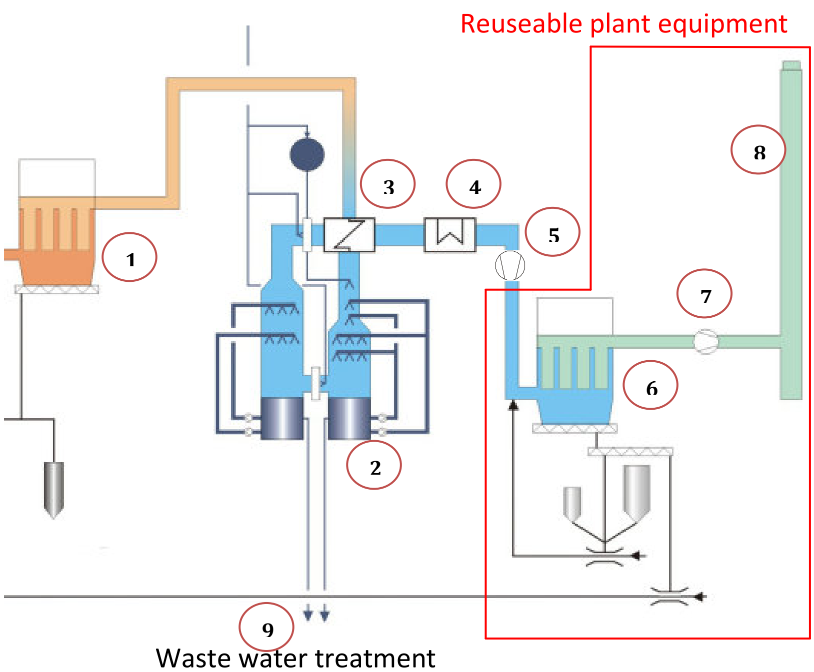


Illustration 1: Basic process for the upgrade of the flue gas treatment plant, based on illustrations of chapter 10.3 of source [2].

The flue gases (due to future waste mix 6,000 – 12,000 Nm³ instead of 8,000 Nm³/h) leave the boiler at a temperature of 145-220 °C. In case of disturbances, the flue gas temperature might also be higher up to 235 °C.
We recommend the installation of the following main components for the upgrade of the flue gas scrubbing system:

1. **New pre-dedusting** system:
   a new fabric filter resistant to peak temperatures of 240 °C for effective dedusting which also helps to improve the deposition of dioxins and fine dust particles. The boiler ash and the filter ash can be collected and deposited together.
2. **New two staged wet scrubbing** system:
   At the entry of the wet scrubbin system, the flue gases are cooled down to ca. 65-80°C by water injection in a teflon quenche.
   The first stage is the HCl scrubber (concurrent flow): HCl, HF and $HgCl_2$ from the flue gases are absorbed at pH 1 into the washing water (no reagent dosing necessary).
   The second stage is the SO_2 scrubber (countercurrent flow), operated at a pH of 8. An alkaline dosing reagent (NaOH or lime milk) is necessary. The scrubber has to be designed depending on the chosen dosing reagent (it is not possible to use either NaOH or lime milk in the same apparatus).
   The mists of the flue gases between the two scrubbing stages and on the exit of the second scrubber are eliminated by rinsed droplet separation stages.
3. **New teflon heat exchanger:**
   As flue gases must be cooled down before entering the not heat resistant scrubber plastic whilst condensation of water from the wet flue gases leaving the scrubber should be avoided, we recommend to transfer the heat from the flue gas entering the wet scrubbers to the flue gas leaving the wet scrubbers in a teflon heat exchanger.
4. **New steam heat exchanger:**
   In order to avoid flue gas condensation in downstream equipment, the humid flue gas should be heated by the use of steam up to 150 °C.
5. **New support ID-Fan:**
   A supporting ID-fan is needed due to the higher flue gas amount (future waste mix and higher vapor content because of wet scrubbing system) and due to the higher pressure drop of the new equipment installed.
6. **Use of the existing dry absorber to a flue gas polishing system**
   The existing fabric filter can be reused. Currently, Na_2CO_3 and activated carbon are used for the deposition of acidic and organic flue gas pollutants.
   In the future, dosing rates for the solid reagents will be much lower than in the current operation manner as acidic gases and a part of Hg will be already deposited in the wet scrubbing stage and dioxins should already be minimised by upstream measures.
   Instead of Na_2CO_3 and activated carbon other agents such as Dioxorb® (based on clay minerals) by Walhalla Kalk may be used (improvements on effectivity and cost reduction possible).
7. **Existing ID-fan**
8. **Existing stack and emission measuring equipment**

9. **New Waste water treatment plant**

   A wet flue gas scrubbing system requires the treatment of aqueous affluents in a waste water treatment plant before discharging to the drainage system or to the sea.
   The configuration of the waste water treatment plant depends on the type of scrubbers used.
   For waste water treatment, we recommend the methods named in chapter 3.3.3.1 (Treatment of the united waters from scrubber 1+2). The emission limit values for discharge to the drainage should be achieved by application of the therein described steps 1-8.

   According to the MEPA (meeting with Dr. Michael J. Sant), the discharge of not further reused treated waste water from wet flue gas scrubbers to the sea is admissible if the limit values (see chapter 6.3 of this document) are respected.

<u>Suggestions on the reduction of water consumption and on the reuse of waste water (minimisation of water discharge to drainage / sea):</u>

- Boiler drain water can be used as water supply for wet scrubbers.
- The waste water from the flue gas scrubbing system can be treated and partly recycled to the wet scrubbing system.
- another part of the treated waste water from scrubbers could be used for cleaning activities on site
- the waste water can be used for feeding a new wet de-slagger which is likely to be needed with the new waste streams to be incinerated.
- some of the waste water is evaporated in the quenche
- purified waste water can be used for lime milk preparation
- purified waste water can be used for preparation of polyelectrolyte solution
- the effluents of a gypsum chamber filter press can be recycled to the HCl scrubber and to the WWTP to increase pH value

6.2.2 Scenario 1 „Sodium Hydroxide Scrubber”

Kindly note the enclosed process flow chart no. 1510MFA001.
Implementation of the basic process as described above.
The second scrubber is a sodium hydroxide type (operated by use of NaOH).

Waste water treatment plant configuration if using a sodium hydroxide scrubber:

Treatment of united effluents from scrubber 1+2

- Collection of scrubber effluents of both scrubbing stages in one tank
- $Ca(OH)_2$ dosing for pH **neutralisation / alkalinisation** and conversion of $Na_2SO_{3/4}$ to gypsum $CaSO_{3/4}$
- TMT15 dosing for the chemical **precipitation** of mercury
- Polyelectrolyte and $FeCl_3$ dosing for **flocculation** of heavy metals
- if needed, further addition of $Ca(OH)_2$ for conversion of sulphites / sulphates to gypsum
- **sedimentation** of heavy metal compounds and gypsum in a tank
- Separation of solids by a **filter press**
  → sludge (gypsum, heavy metals) to landfill
  → water to
    a) re-use (scrubber feed, other internal use)
    b) polishing filters (sand filter, activated carbon), final neutralisation by NaOH if needed
       → effluents for other re-use or to discharge (to drain or sea)

Alternative option: Separate treatment of effluents from scrubber 1+2

This option has not been investigated due to the disadvantage in investment costs by simultaneously higher reagent costs for sodium hydroxide

Advantages of the NaOH scrubber:

+ In the NaOH scrubber, gaseous SO_2 is converted to the water soluable salts $Na_2SO_{3/4}$
  → the NaOH scrubber construction is simpler than the construction for the $Ca(OH)_2$ scrubber
  → lower investment costs for wet scrubbing system
+ The operation and use of a NaOH scrubber is simple

Disadvantages of the NaOH scrubber:

- If the washing water which contains soluable salts ($Na_2SO_{3/4}$) which may not be directly discharged to surface water (which is likely if SO_2 contents in the flue gas are rather high or fluctuant), these salts have to be converted to gypsum ($CaSO_{3/4}$) by addition of $Ca(OH)_2$ in the waste water treatment plant.
  → additional current expenses for the agent NaOH – $Ca(OH)_2$ is needed as well

It has to be considered that NaOH is commonly used at smaller plant sizes respectively if a low SO_2 raw gas concentration and preferably no heavy metals can be expected.
In this case, rather higher and fluctuant SO_2 raw gas concentrations and fluctuant heavy metal concentrations can be expected.

6.2.3 Scenario 2 „Lime milk scrubber"

Kindly note the enclosed process flow chart no. 1510MFA002.
Implementation of the basic process as described above.
The second scrubber is a lime milk type (operated by use of $Ca(OH)_2$).
The agent $Ca(OH)_2$ is recommended for smaller to medium plant sizes whilst $CaCO_3$ is commonly used at large plant sizes. The use of $CaCO_3$ is very cheap and it would be available directly from the island of Malta; however its use requires a well experienced and trained staff as operation will be more difficult compared to using $Ca(OH)_2$. $Ca(OH)_2$ is the more effective agent.
It is also possible to substitute a part of $Ca(OH)_2$ by $CaCO_3$ (no further additional plant equipment is needed) – we recommend to use only $Ca(OH)_2$ in the beginning and to substitute a part of the agent by $CaCO_3$ later to save operational costs. The cost estimation of this feasibility study is based on the exclusive use of $Ca(OH)_2$ (worst case).

Description of the lime milk scrubber and the required waste water treatment plant configuration:
The SO_2 scrubber needs a continuous fresh water feed for rinsing the pumps.
It is necessary to keep a gypsum concentration of roughly 10% in the scrubber circulation water.
Therefore, a continuous flow of the scrubbing water is concentrated in a sedimentation tank. The concentrate is recycled into scrubber 2 to keep the gypsum concentration at 10%, the filtrate is recycled to scrubber 1 replacing a part of the required fresh water feed.

<u>The effluents of scrubber 1 and 2 are treated separately:</u>

- a part of the water of scrubber 2 is discharged to a chamber filter press discontinuously for **de-watering** → gypsum may be discharged at Wasteserv's own landfill site on the island or sold to the local building industry
- The filtrate is collected together with the effluents of scrubber 1 in a tank; $Ca(OH)_2$ dosing for **neutralisation / alkalinisation**
- TMT15 dosing for the chemical **precipitation** of mercury
- Polyelectrolyte and $FeCl_3$ dosing for **flocculation** of heavy metals
- **sedimentation** of heavy metal compounds in a tank
- **De-watering** of the heavy metal sludge by another filter press
  → sludge (mainly heavy metals) to landfill (export required)
  → water to
    a) re-use (scrubber feed, other internal use)
    b) polishing filters (sand filter, activated carbon), final neutralisation by NaOH if needed
       → effluents for other re-use or to discharge (to drain or sea)

Advantages:

+ Lower operational costs
+ Future possibility of replacing a part of the agent $Ca(OH)_2$ by cheap lime stone $CaCO_3$

Disadvantages:

- Higher investment costs, more equipment needed
- Operation not as simple as NaOH scrubber

6.2.4 Scenario 3 „Scrubber and SCR catalyst“

Kindly note the enclosed process flow chart no. 1510MFA003.

If the minimisation of NOx and PCDD/F in the raw gas cannot be reached by primary measures (incineration process / SNCR), an appropriate **catalyst** (SCR system with additional PCDD/F reduction) should be implemented in order to meet the emission limits.

Plant configuration:
The cheaper solution of scenario 1 or 2 with an additional catalyst including heat exchangers:

- The flue gas leaving the polishing filter (roughly 150°C) is heated in a **gas/gas heat exchanger** followed by a **thermo oil heat exchanger** to roughly 220 °C.
  This temperature is necessary for the correct function of the catalyst.
- Dosing of **ammonia** water into the catalyst – **reduction of NOx**
- Additionaly, a further **reduction of PCDD/F** is possible (if needed)
- The hot purified flue gas (220°C) leaving the catalyst is used to heat up the colder flue gas entering the catalyst in the above mentioned **gas/gas heat exchanger**.
- The fumes pass two ducts of the existing economizer to **preheat the feeding water** before passing the ID-Fan and the stack.
- The first part of the economiser must be equipped with a **thermo oil heat exchanger** to transfer the required energy from the raw gas to the gas entering the catalyst. This themo oil cycle can take temperatures >300 °C - therefore it should be save against thermal overload.

6.3 Achievable emission values

The following clean gas values should be achieved with the above named selected scenarios.

We recommend these values to be guaranteed by the supplier of the flue gas scrubbing system:

Pollutants		Achievable half hourly values in operation	BAT
Dust [2]	mg/Nm³ wet	3	0.1-15
CO [1]	mg/Nm³ wet	30	5-100
TOC [1]	mg/Nm³ wet	10	0.1-20
PCDD/PCDF [1,3]	ngTEQ/Nm³	0.1 (without SCR) / 0.05 (SCR)	0.002-0.1
Mercury [2]	mg/Nm³ wet	0.01	0.0003-1
Cadmium +Thallium [2]	mg/Nm³ wet	0.05	0.0002-0.2
Other heavy metals [2] (Pb, Sb, As, Cr, Co, Cu,Mn, Ni, V, Sn)	mg/Nm³ wet	0.4	0.0013-0.5
Nitrogen oxides,counted as NO_2 [1,3]	mg/Nm³ wet	< 150 (without SCR) / <100 (SCR)	50-200
Sulphur compounds, total [2] of SO_2 /SO_3 , counted as SO_2	mg/Nm³ wet	< 35	1-150
Inorganic chlorine compounds (as HCl) [2]	mg/Nm³ wet	< 5	0.1-60
Inorganic fluorine compounds HF [2]	mg/Nm³ wet	< 0.5	0.1-2
Ammonia as NH_3 [1,3]	mg/Nm³ wet	5	1-10

[1] Values are strongly related to the quality of the incineration process.
[2] Values are influenced by equipment chosen in Scenario 1 & 2
[3] Values are influenced by equipment chosen in Scenario 3

Reference: [2] Table 3.2.3.1 Summary data of the emissions to air from HWI

The above listed achievable half hourly values meet the actual emission limits from the plant's permit IP0004/07 – see chapter 4 of this document.

Expected effluents from the waste water treatment plant:

Parameter	Dimension	Emission expected in operation	Typical plant supplier's guarantee values	Maltese LN 378 of 2005 and 426 of 2007 SEWER DISCHARGE CONTROL [S.L.423.15]	BAT example from Austrian Plants Table 81
pH value		7.2	6.5-9.5	6 - 10	6.8-8.5
Temperature	mg/l	<40	40	40°C	< 30
Electric conductivity	mS				<25
Fish toxicity	-				2
Undissolved compounds	ml/l				10 - < 25
Settleable solids	ml/l	10	20 mg/l	20	<0.3
Filterable substances	mg/l	7			7-20
Residue on evaporation	g/l				1.4
Salt content	g/l				35
Suspended solids	mg/l			500	
Total Kjeldahl Nitrogen	mg/l as N			100	
Total Aluminium as Al	mg/l as Al				0.12
Total Arsenic As	mg/l as As	<0.01	0.05	0.05	<0.003 - < 0.05
Silver Ag	mg/l as Ag			5	
Total Boron	mg/l as B			2	
Total Barium	mg/l as Ba				0.19
Total Calcium as Ca	g/l as Ca				< 5
Total Cadmium Cd	mg/l	<0.05	0.05		<0.001 - <0.05
Total Cobalt Co	mg/l as Co		0.5		< 0.05
Chlorides	g/l as Cl		5-10[1]	1	7 < 20
Chlorine (free)	mg/l as Cl			100	<0.05
Chlorine total	mg/l as Cl				<0.05
Cyanides (easy releasable)	mg/l	<0.1	0.1		<0.006 - < 0.1
Hydrocyanic acid and compounds releasing hydrocyanic acid on acidification	mg/L as CN	<0.1		10	
Total Cr	mg/l as Cr	<0.05	0.5	5	<0.05 - < 0.1
Cr (VI)	mg/l as Cr				<0.05
Total Copper Cu	mg/l as Cu	<0.05	0.5	5	<0.05 - < 0.3
Total Fluoride	mg/l as F	<8	10	10	<0.006 - <10
Total Mercury Hg	mg/l as Hg	<0.005	0.01		<0.001 - <0.01
Total Manganese	mg/l as Mn		1		<0.05
Total Ammonium NH_4-N	mg/l	<127	10		<8

[1] Chlorides exist in the discharged water as the water soluble salt $CaCl_2$. Therefore, a high reuse rate of water in the flue gas scrubbing system / WWTP causes higher $CaCl_2$ contents in the discharge water. Based on the advantage of a high reuse rate of water (low fresh water consumption), we suggest to apply for the permit of a higher chloride emission limit value than foreseen in the Maltese LN 378 and 426.

Nitrate (NO_3)	mg/l				<5
Nitrite (NO_2)	mg/l				<8
Total Nickel Ni	mg/l as Ni	<0.06	0.5	5	<0.05 - <0.5
Phosphorous P	mg/l as P				<0.05
Total lead Pb	mg/l as Pb	<0.1	0.1	1	<0.01 - <0.1
PCDD/PCDF´s	ng/l		0.3		
Antimon Sb	mg/l	<0.1	0.2		0.05<0.1
Tin Sn	mg/l as Sn				<0.06
Total Sulphates (SO_4)	mg/l as (SO 4)	1,000-2,000[2]	1,000-2,000[2]	1,000	<1,200
Sulphides and compounds releasing hydrogen sulphide on acidification H_2S	mg/l as S		0.2	10	<0.01 <0.1
Sulfites SO_3^{2-}	mg/l	< 8	20		<1.0 - <8
Total Zinc Zn	mg/l as Zn	<0.5	0.5	10	<0.05 - <0.5
AOX / EOX		<0.1			1.02/<0.1
BTXE					<0.025
COD					<75
Total Hydrocarbon					0.05 - <3
Phenol (Phenolindex)	mg/l	<0.1	0.3		<0.01 - <0.1
TOC extractable organic carbon	mg/l	25	0.1		4.3-25
Tensides	mg/l				<0.02
Volatile chlorinated hydro carbons	mg/l				<0.1
Free and emulsified/saponifable grease	mg/l			200	<4
Total Thallium	mg/l as Tl		0.05		<0.01 - <0.05
Total Vanadium	mg/l as V		0.5		0.01 - < 0.05
Non volatile lipophilic components	mg/l				<20
Total non- ferrous metals	mg/l			30	
Total soluble non-ferrous metals	mg/l			10	

[2]If 1000mg/l cannot be guaranteed by the supplier, a guarantee value of 2000mg/l still should be acceptable as the water should be diluted with other effluents of the site when reusing it for cleaning activities.

The sulphates level of 1000 mg/l should be achieved at the main sewer of the plant.

7 Financial analysis

7.1 Identification of the investment costs for the different scenarios

For the identification of the investment costs a detailed equipment list based on the P&I's of the different scenarios was used.
Budget price offers have been requested from various suppliers for the key components like heat exchangers, fans, pumps, fabric filter, scrubbers and the catalyst.

The price for the electronic equipment and the assembly has been evaluated by the external experts Reinhard Novak and Johannes Schittenhelm which have both more than 10 years of experience in their field of engineering. The costs for building and erection have been evaluated from comparable projects in Austria and Germany.

The normal level of precision of investment cost estimation for a feasibility study is around ± 30%. As budget prices have been requested for all mayor components a precision level of ± 10% should be given at the actual date of publication September 2014.

Table: Detailed Equipment list and estimated investment costs based on budget price

	Scenario 1 NaOH	Scenario 2 Ca(OH)2	Scenario 3 Ca(OH)2 + SCR
Engineering & Supervision	**328.000**	**350.000**	**412.000**
Plant engineering	100.000	120.000	160.000
Electrical engineering	78.000	78.000	88.000
Civil engineering	44.000	44.000	44.000
Assembly supervision	58.000	60.000	60.000
Start up comissioning training	48.000	48.000	60.000
Hardware	**1.161.500**	**1.223.350**	**1.812.250**
fabric filter	177.000	177.000	177.000
fabric filter screw	15.000	15.000	15.000
rotary valve	3.000	3.000	3.000
big bag holder	2.000	2.000	2.000
fabric filter bypass	3.200	3.200	3.200
connecting pipework	83.000	83.000	83.000
teflon heat exchanger	60.000	60.000	60.000
quenche	18.000	18.000	18.000
HCl-Scrubber	38.000	38.000	38.000
HCL-Scrubber pump 1	11.000	11.000	11.000
HCL-Scrubber Pump 2	11.000	11.000	11.000
droplet seperator	7.300	7.300	7.300
SO2 scrubber	63.000	63.000	63.000
SO2-Agitator		6.000	6.000
SO2-Scrubber pump 1	15.000	15.000	15.000
SO2 Scrubber pump 2	15.000	15.000	15.000
nozzles	21.000	21.000	21.000
oxi-fan		4.000	4.000
droplet seperator	9.300	9.300	9.300
steam heat exchanger	110.000	110.000	110.000
support ID fan	28.000	28.000	28.000
lime silo	26.000	26.000	26.000

tomal dosing equipment 1	8.000	8.000	8.000
tomal dosing equipment 2		8.000	
NaOH dosing station	12.000		
lime milk station		7.900	7.900
lime milk pump 1		12.000	12.000
lime milk pump 2		12.000	12.000
polyelektrolyte dosing station	14.000	14.000	14.000
FeCLIII Station	17.000	17.000	17.000
TMT15 Station	15.000	15.000	15.000
sedimentation tank		10.650	10.650
emergency water tank	6.700	6.700	6.700
neutralization tank	3.300	3.300	3.300
precipitation tank	3.300	3.300	3.300
floctuation tank	3.300	3.300	3.300
sedimentation tank	3.300	3.300	3.300
sedimentation pump	3.000	3.000	3.000
clear water tank	3.000	3.000	3.000
clear water pump	2.500	2.500	2.500
sludge storage tank WWTP	3.300	3.300	3.300
sludge storage tank lime milk		3.300	3.300
SO2-Sump	25.000	25.000	25.000
SO2-Sump Pump	15.000	15.000	15.000
other plastic works	40.000	40.000	40.000
chamber filter press- lime milk	72.000	72.000	72.000
chamber filter press WWTP	30.000	30.000	30.000
filtrate tank	8.000	8.000	8.000
filtrate pump	3.000	3.000	3.000
sand bed filter	7.500	7.500	7.500
activated carbon filter	7.500	7.500	7.500
thermal oil heat exchanger 1			85.000
thermal oil heat exchanger 2			85.000
expansion vessel incl. valves			20.000
thermal oil pump group			12.000
3 valves for bypass			9.900
ammonia dosing station for 1000l/IBC			15.000
3 stage catalyst module incl. injection			370.000
valves pipework insulation	140.000	150.000	150.000
Electronic equipment	**287.500**	**293.500**	**361.500**
UPS	1.500	1.500	1.500
Sensors	90.000	90.000	110.000
PLC equipment	35.000	35.000	40.000
Pannelboards	66.000	70.000	100.000
cabeling	65.000	67.000	80.000
Spare	30.000	30.000	30.000
Shipping costs	**110.000**	**120.000**	**180.000**
Assembly costs	**200.000**	**210.000**	**210.000**
Civil works	**401.000**	**401.000**	**417.000**
Steel construction	189.000	189.000	205.000
Concrete Table	100.000	100.000	100.000
Foundations and acid resistant reservoirs	82.000	82.000	82.000
Spare	30.000	30.000	30.000
Investment costs	**2.488.000**	**2.597.850**	**3.392.750**
Investment costs turn key installation	**2.861.200**	**2.987.528**	**3.901.663**

7.2 Financial analysis of the different scenarios

The financial analysis is carried out with a calculation model designed as a forecast of all the amounts of money spent in the plant's lifetime. One of the important factors is that it can be adapted flexibly to project start, building, commissioning and operation start dates and timeframes.

Firstly, the actual financial situation of the installed plant was analysed to set the benchmark regarding the financial effort.

Secondly, the consumption data from the detailed mass and energy balance has been used to identify proportional operations costs on calculated consumptions. Budget prices have been requested for consumables to respect the special situation regarding supply on the island of Malta.

The following worst conditions have been assumed for the estimation of operational costs:

- No increase of plant availability - 5,616h/a
- No reduction of plant shutdowns - 14 stopps/a
- No reduction in heating gas oil consumption - 491,120 l/a @ 0.92 €/l
- No disposal of solvents
- No increase of thermal power - 3.3 MW
- Reduction of throughput proportional according average calorific value from 7,480 to/a@ 6.86-7.9MJ/kg to **0.85 to/h**@(11-12 MJ/kg) = **4,800 to/a**

The illustration framework consists of:

- Assumptions for indexes and availability:
- Revenues
- Various cost categories:
  - Wages
  - Capital cost including the allowance for depriciation
  - Proportional costs
  - Nonpersonnel costs (overhead)
  - Terms of redemption
- Profit and loss statement
- Cash flow

Assumptions for indexes and availability:

- Wage index	3%
- Advance in prices	2%
- Deterioration coefficient (for equipment)	5%
- Consumable price index	2%
- Energy price index	3%
- Disposal price index	2%
- Plant availability	5616 h/a

7.2.1 Revenues

Based on the 2013 figures, the revenues for the **actual disposal activities** have been evaluated:

revenues and disposal tariffs	to/a	7480	€/to
clinical waste 20MJ/kg	421,6		500
abattoir waste not pre dried 5MJ/kg	6029,4		50
abattoir waste pre dried 18MJ/kg			
blood pre dried 18MJ/kg	750		50
shredded plastic waste RDF 16,8 MJ/kg			
shredded wood 13 MJ/kg	41		100
excavated landfill material 4,4 MJ/kg			
tank oil sludge			
de inking sludge 4,4 MJ/kg	2		500
pharmaceutical waste 13 MJ/kg	119,2		500
paint 6 MJ/kg	48,6		500
waste oils 20MJ/kg	68,2		500
workshop residue 10MJ/kg			500

Based on the mass and energy balance for the combustion, the **future waste mix** for all 3 scenarios has been identified:

revenues and disposal tariffs	to/a	4800	€/to
clinical waste 20MJ/kg	421,6		500
abattoir waste not pre dried 5MJ/kg	0		0
abattoir waste pre dried 18MJ/kg	1205		50
blood pre dried 18MJ/kg	750		50
shredded plastic waste RDF 16,8 MJ/kg			
shredded wood 13 MJ/kg	41		100
excavated landfill material 4,4 MJ/kg			
tank oil sludge			
de inking sludge 4,4 MJ/kg	2		500
pharmaceutical waste 13 MJ/kg	119,2		500
paint 6 MJ/kg	48,6		500
waste oils 20MJ/kg	68,2		500
workshop residue 10MJ/kg			500
Solvent 1 28MJ/kg			500
Solvent 2 24MJ/kg			500
Solvent 3 20 MJ/kg			500
Solvent 4 26MJ/kg			500
combustion waste (boiler dust)	100		500
industrial effluent sludges	327		500
chemical deposits	1616,4		500
chemical preparation waste	101		500
solvents	0		500

The available waste fractions respect a share of the evaluated waste amounts from the Hazardous Waste Survey Raw Data evaluated by the National Statistics Office in collaboration with WasteServ Ltd. in August 2011 handed over from Daniela Grech.

7.2.2 Costs

wages			
	salary	number	Index
business leader COO	3000	1	
secretary	800	1	
plant manager	2000	1	
electrician	1200	1	
fitter	1200	4	
lab scientist	1800	1	
supervisors	1100	2	
inspectors	950	2	
store keeper	1100	2	
bin washer	950	4	
head of shift	1500	6	
operators	950	6	
loaders	950	8	
social insurance and tax (% of net wage)			10
total staff number		39	

Costs for labour are based on actual spending by WSM for the year 2013. Data has been handed over by Ramon Vella.

non proportional costs			
maintenance:	Calculation basis		Index
mechanical equipment	7599950		3
refractory	144077		100
electrical equipment	1793500		2
vehicles	0		7,7
building infrastructure	1401000		1
administrative costs			
fire insurance			0,03
machinery breakage insurance			0,4
training	10000		
telefon, fax	6000		
stationary	10000		
advertising expenses	0		
travelling expenses	3000		
tools/ workshop equipment	30000		
advisory	20000		
audits, surveys, analysis	25000		
tax counselling	0		

Non proportional costs are based on actual spending by WSM for the year 2013, and assumptions from Tec-Solution GmbH . A Part of the data has been handed over by Ramon Vella.

proportional costs					
energy					
electricity	0,185	€/kWh/h		314,08	kWh/h
electricity for new plant	0,185			156	kWh/h
heating gas oil for starts	7000	l/stopp		14	stopps/a
heating gas oil for operation	0,92	€/l		70	l/h
consumables					
drinking water	5,5	m³/h		2,3	€/m³
water chemicals BT1040	0,0342	l/h		3,72	€/l
water chemicals BT210T	0,016	l/h		3,05	€/l
disinfectant	0,0342	l/h		2,7	€/l
sodium bicarbonate	0	kg/h		0,34	€/kg
lime hydrate Ca(OH)2	41,47	kg/h		0,27	€/kg
sodium hydroxide	0	kg/h		1,1	€/kg
urea	4,27	kg/h		0,38	€/kg
activated carbon	0	kg/h		1	€/kg
clay minerals with activated carbon	15	kg/h		0,6	€/kg
TMT 15	0,2	kg/h		2,95	€/kg
Fe III Cl	0,23	kg/h		1,8	€/kg
polyelektrolyte	0,07	kg/h		4,3	€/kg
salt for water treatment	0,2	kg/h		8,28	€/kg
disposal					
bottom ash/ slag	0,3	to/h		26	€/to
boiler ash	0,02	to/h		450	€/to
fabric filter dust	0,032	to/h		450	€/to
gipsum	0,032			26	€/to
WWTP Sludge	0,0005			450	€/to
effluents/wastewater	4	m³/h		0	€/m³

Consumption is based on actual consumption data and the calculated values of the mass and energy balance. Chemicals and reagents have been requested from various suppliers prices/ unit are delivered on site.

redemption (long term interest rate)		
loan amount	2988	€
intrest rate	3,5	%
duration of credit	15	a
payments per year	4	
intervall interest	1,00875	
annuity factor	0,0214939	
annuity per quarter	64	
interest 1st quarter		
interest 2nd quarter		
interest 3rd quarter		
interest 4th quarter		
payment 1 term		
payment 2 term		
payment 3 term		
payment 4 term		
residual dept 2 quarter		
residual dept 3 quarter		
residual dept 4 quarter		
residual long term debt at end of year		
debt retirement		

The long term interest rate is calculated based on quarterly payments for the loan.

Depreciation is calculated on investment costs. Due to the fact that the housing of the plant is not a building on it´s own, the whole investment is depriced in a period of 15 years which can be recorded as realistic service life.

figures in 1000€	actual setup	Scenario 1 NaOH	Scenario 2 Ca(OH)2	Scenario 3 Ca(OH)2 + SCR
Investment cost	0	2861	2988	3902
engineering & supervision	0	328	350	412
hardware mechanical	0	1162	1223	1812
electric and electronic equipment	0	288	294	362
shipping costs	0	110	120	180
assembly costs	0	200	210	210
civil works	0	401	401	417
turn key factor/ process quarantee	0	373	390	509
depriciation [15 years]	0	191	199	260

The detailed cost structure is described in Chapter 7.1

The profit and loss statement sheet displays:

Cash flow/ Cash loss is calculated by

Revenues – Cash based expenses which consist of:

- Proportional costs
- Wages
- Non proportional costs
- Long term interest rate for the investment

The EBIT earnings before interest and tax are calculated by Cash flow/Cash loss– allowance for depreciation

compared in year 2017	actual setup	Scenario 1 NaOH	Scenario 2 Ca(OH)2	Scenario 3 Ca(OH)2 + SCR
consumables	223	422	229	241
electricity	367	538	550	619
heating gas oil	463	463	463	463
disposal	193	279	196	196
non proportional costs	550	604	606	630
wages	683	683	683	683
redemption	0	246	257	335
total expenses	2.479,588	3.234,570	2.984,688	3.167,768
revenues	728	1.628	1.628	1.628
CASH-FLOW/ CASH-LOSS	-1.751,252	-1.606,755	-1.356,873	-1.539,953
allowance for depreciation	0	191	199	260
EBIT earnings before interest and tax	-1.751,252	-1.797,501	-1.556,041	-1.800,063

7.3 Result of the financial analysis

Scenario 2 requires a slightly higher investment volume than scenario 1, but pays off in less than two years because of lower operational costs (lower costs for reagents and discharge of residues).
These operational costs can even be lowered additionally by substituting a part of the consumption on lime milk by use of cheaper lime stone – this would even more reduce the pay-off.

loss of money during plant lifetime up to 2031				
figures in 1,000€	actual setup	Scenario 1 NaOH	Scenario 2 Ca(OH)2	Scenario 3 Ca(OH)2 + SCR
debit balance /shortage	-37107	-37360	-33166	-37256

The change over from treatment of animal by-products to hazardous waste would even with the higher investment in a new flue gas cleaning plant bring an advantage in costs of 3,941,000€ over the plant lifetime till 2031.

Due to the low revenues on animal byproducts and the low plant availability combined with fossil fuel costs and no use of the thermal energy, the plant will generate annual cash loss of 1,751,252€/a.

A way out of this difficult situation could be a further reduction of fossil fuel consumption and the acquisition of hazardous waste that can be handled with the actual flue gas cleaning system improved by another dry reagent.

An improvement on the flue gas cleaning plant could easily achieved with the new reagent Dioxorb 759AK(20) without any investment in the equipment.

The aim is to improve the incineration process by the recommendations (investment costs for improvement of incineration estimated at 876,000€ named in chapter 5 in order to avoid higher investment costs for the SCR system (additional requirement estimated 914,000 €+ 79,000€/a higher annual operation costs) and generate a revenue of 311,000€/a (savings of diesel and disposal of solvents). With this investment the flue gas amount from combustion should be increased from 8000 to 12000 Nm^3/h and a 20% higher waste throughput should be possible.

If this step is done, we recommend to improve the flue gas cleaning plant according scenario 2, to turn the plant in a hazardous waste disposal facility that is capable to treat a part of the hazardous wastes that are actually exported for high disposal fees. Furthermore the plant would be independent to the supply of animal byproducts which are low in revenues and could maybe be handed to another disposer in the future as well as the abattoir tendered out the disposal of waste in 2014.

The goal should be to get this installation up to an availability of 7000h/and a disposal capacity of 6000 to of hazardous waste per year. No fossil fuels should be consumed in normal operation.

This could generate enough revenue to reduce the annual cash loss to zero.

8 Detailed Process & installation description of the identified optimum solution

Scenario 2 flue gas scrubbing plant

Please see also the scenario 2 P&I flow charts and the balance point list for detailed process parameters.

Pre-dedusting: Fabric Filter

Efficient pre-dedusting is required to avoid clogging in the wet flue gas cleaning plant.
Flue gases from the economiser [Balance Point 01] enter the fabric filter [10HTE10AT001] which purifies the fumes from dust. Clean gas values of 1-3 mg/Nm³ of dust on the filter's outlet [Balance Point 2] should be achievable.

The filter and hoses are designed to bear 240 to 250°C inlet temperature. State of the art fabric filter suppliers guarantee value for dust < 1 mg/Nm³ and leak air rates of 0.5% of max. flue gas flow amount. The specific filter load per square meter should be around 0.85 m³/(min.m²).
The separated dust is cleaned off pneumatically by puls-jet technology and is transported by the fabric filter screw [10HTE10AF001] to the rotary valve [10HTE11AF101] [Balance Point 14]. The dust is collected in an enclosed big bag or metallic IBC.
To avoid condensation of fumes and corrosion by acids from flue gas, the fabric filter is equipped with a steam trace heating device.

Gas/gas heat exchanger (raw gas)

Succeeding to the dedusting stage the hot gases pass through a gas/gas heat exchanger [10HTB10AC001] [Balance Point 3]. This heat exchanger reduces water consumption of the quench [10HTD10BN001] and steam demand for reheating.
This gas/gas heat exchanger transfers heat from the hot flue gas before entering the wet scrubbers to the colder de-salted flue gas leaving the second wet scrubber [10HTD20BB001]. Because of the high chemical stress from acidic components, the heat exchanger must be coated with teflon to avoid fast corrosion. The tubes should be positioned easily cleanable by power washer. Manholes on each side of the heat exchanger guarantee proper accessibility. The hot raw flue gas should be ducted inside the tubes whilst the colder clean gas should pass the outside of the tubes.

Wet flue gas cleaning plant

The wet flue gas cleaning plant is designed in two stages and performs the reduction of HCl, HF, SO_2, $HgCl_2$, fine dust and aerosols.

Quenche

The flue gas enters the quenche [10HTD10BN001], [Balance Point 3] with an average temperature of 130 °C. The quenche is designed for entry temperatures of 100-173 °C (part load conditions). The quenche cools the fumes to the cooling limit temperature [Balance Point 4] of around 67°C by injection of recycled scrubber water.
Subsequently, the flue gas is saturated with water and already most of the acidic compounds like HCl and HF are discharged from the gaseous state to the liquid phase.

Scrubber 1: Acidic scrubber (HCl-scrubber)

The acidic scrubber [10HTD10BB001] is operated in co-current flow.
The scrubber is operated at a pH value of 1 and provides the following functions:

- Cooling of flue gases to saturation temperature.
- Absorption of halogen compounds (HF, HCl) and ionic mercury (Hg^{2+}) in water

HCl and HF from the flue gas are absorbed on the surface of the acidic water droplets:

$$HF\ (g) + H_2O\ (l) \rightarrow HF\ (l) + H_2O\ (l)$$
$$HCl\ (g) + H_2O\ (l) \rightarrow HCl\ (l) + H_2O\ (l)$$

The halogen compounds lower the pH value in the washing water. In order to keep the pH at a value of 1, a low amount of hydrated lime is added. A part of the absorbed acid ions can react with hydrated lime to their corresponding salts in the washing water.

$$2\ HF\ (l) + Ca(OH)_2\ (s,l) \rightarrow CaF_2\ (l) + 2\ H_2O\ (l)$$
$$2\ HCl\ (l) + Ca(OH)_2\ (s,l) \rightarrow CaCl_2\ (l) + 2\ H_2O\ (l)$$

In the wet scrubber mercury can be well absorbed if bound as $HgCl_2$, $Hg_2Cl_2$and HgO (ionic form Hg^{2+}) whereas metallic mercury (Hg^0) neither can be absorbed nor condensed in the scrubber. In the presence of chlorine from waste fuel and at incineration temperatures above 850 °C, metallic mercury will be oxidised mainly to gaseous $HgCl_2$. Chlorine concentrations of roughly 1 w-% of waste input proved to be sufficient in existing plants.
The mercury salt will be absorbed in the washing water of the acidic scrubber:

$$HgCl_2\ (g) + H_2O\ (l) \rightarrow HgCl_2(l) + H_2O\ (l)$$

In an undesired side reaction, $HgCl_2$ can be reduced to Hg_2Cl_2 by SO_2 and further disproportionate again to metallic mercury. The metallic mercury built by disproportionation evaporates again in the flue gas stream and cannot be discharged via the wet scrubbers anymore – it has to be discharged downstream in the flue gas polishing system.

Reduction $$SO_2(l) + 2\ HgCl_2\ (l) + H_2O \rightarrow SO_3\ (l) + Hg_2Cl_2\ (l) + 2\ HCl$$
Disproportionation $$Hg_2Cl_2\ (l) \rightarrow Hg\ (g,l) + HgCl_2\ (l)$$

The following measures are provided in this plant concept in order to reduce the disproportionation rate:

- low pH value in the first scrubber
- permanent discharge of separated mercury into the waste water treatment plant

Most of the sulphur dioxide (SO_2) already absorbed in scrubber 1 will be converted to sulphate (SO_4^{2-}) so that already the reduction of $HgCl_2$ will be held low.

Furthermore the use of a precipitation agent like f.ex. NETfloc SMF-1 (supplier New Environmental Technology GmbH) may improve the discharge performance of both metallic and ionic mercury in the first scrubber. Field studies on the use of this kind of agent have recently been successfully executed at the waste incineration plant Dürnrohr, Austria.

The water is collected in the sump, two independent scrubber pumps [10HTF11/12AP001] feed the nozzles at the top of the scrubber [Balance Point 23] which atomise the washing water.
The nozzle levels are arranged in such a way that a homogeneous distribution of circulation water in the form of small droplets in the flue gas results.
The major part of droplets directly falls into the bottom of the scrubber, the rest is separated from the flue gas by a droplet separator and also conveyed into the bottom of the scrubber.

The circulation water of scrubber 1 is kept in suitable operation condition by:

- Acidic water is periodically discharged to the waste water treatment plant [Balance Point 33].
- Dosage of hydrated lime
- Supply of fresh water by:
  - the rinsing system of the droplet separator [10HTD10AT001]
  - re-routing of cleaned water from the waste water treatment plant [Balance Point 62]
  - dilution water from hydrated lime
  - clarified water from the SO_2 scrubber (after sedimentation [Balance Point 27]): problems might occur due to residues of gypsum in this water stream - only applicable if the supplier agrees or if successfully tested during the commissiong period. Alternatively, the water amount has to be supplied by cleaned water from the WWTP.
  - if required (level regulation) water may also be supplied via the emergency water nozzles [10HTD10BN001]

A part of this water evaporates in the quenching zone, the rest is withdrawn as waste water and as moisture content of neutralisation sludge.

In the case of a power breakdown, the emergency water nozzles in the quenche are fed by an emergency water tank [10GHA90BB001] that has enough capacity to cool the fumes for about an hour in order to protect the heat sensitive scrubber plastic.

The memory effect of PCDD/F on scrubber plastic is reduced to a minimum by temperature regulation by injection of water in the quenche.

Sources for reaction equations and reaction parameters: [6], [9]

Scrubber 2: Alkaline scrubber based on lime milk (SO_2-scrubber)

The SO_2-scrubber or gypsum scrubber is operated as countercurrent scrubber with two atomisation levels.
The suspension of gypsum is collected in the sump, two independent scrubber pumps [10HTF21/22AP001] feed the nozzles at the top of the scrubber [Balance Point 24] which atomise the reagent.
The nozzle levels are arranged in such a way that a homogeneous distribution of circulation water in the form of small droplets in the flue gas results.
The major part of droplets directly falls into the bottom of the scrubber, the rest is separated from the flue gas by a droplet separator and also conveyed into the bottom of the scrubber.

The pH of the circulation water is adjusted to a slightly acid value by addition of hydrated lime or limestone.
The concentration of solids in the circulation water is held at a certain value by the controlled discharge of gypsum. Discharged gypsum is dewatered by chamber filter press.
Water is withdrawn from the scrubber as filtrate from the dewatering of gypsum and as water content of the discharged gypsum.

<u>Main reactions:</u>

SO_2 is absorbed by the slightly alkaline recirculating water and exists as dissolved SO_2 or as hydrogensulphite which dissociates to some extent into sulphite:

$$SO_2\,(g) + H_2O\,(l) \rightarrow SO_2\,(l) + H_2O\,(l)$$
$$SO_2\,(l) + 2\,H_2O\,(l) \rightarrow H_3O^+\,(l) + HSO_3^-\,(l) \leftrightarrow 2\,H^+\,(l) + SO_3^{2-}\,(l) + H_2O$$

The hydrogensulphite reacts with oxygen to sulphate:

$$HSO_3^- (l) + ½ O_2 (g,l) \quad -> \quad HSO_4^- (l) \quad <-> \quad SO_4^{2-} (l) + H^+ (l)$$

The oxi-air fan [10HTG20AN001] supplies the air for this reaction.

a) Precipitation by lime hydrate:

$$HSO_4^- (l) + Ca(OH)_2 \quad -> \quad CaSO_4 + H_2O + OH^-$$

b) Precipitation by lime stone:

$CaCO_3$ is suspended in water:

$$CaCO_3 (s) + H_2O (l) \quad -> \quad CaCO_3 (l) + H_2O (l)$$

In the slightly acidic scrubber water, $CaCO_3$ dissolves:

$$CaCO_3 (l) + H_3O^+ \quad -> \quad HCO_3^- + Ca^{2+} + H_2O$$
$$SO_4^{2-} + Ca^{2+} \quad -> \quad CaSO_4$$

Water / agent / gypsum balance of scrubber 2:

- Water is supplied to scrubber 2 by
  - the water required for rinsing of the pumps (drinking water) [Balance Point 32]
  - the water required for droplet separators after scrubber 2 (purified water from WWTP) [Balance Point 32]
  - dilution water from hydrated lime / lime stone

    This amount of water would dilute the scrubber’s water so much that the crystallisation process of gypsum would decrease. In order to trigger the crystallisation of gypsum in scrubber 2, the gypsum concentration has to be held at 10%. This is executed by thickening a part of the circulation water in a clarifier (sedimentation tank / hydrocyclone) [10HTM20AT001] continuously and refeed the gypsum concentrate (18% gypsum) to the scrubber [Balance Point 26]. The clean water [Balance Point 27] is used to feed scrubber 1.
- The required pH value is adjusted by the dosage of hydrated lime or lime stone [Balance Point 20] which also supplies the reacting agent for the conversion of SO_2 into gypsum.
- A part of the scrubber water [Balance Point 28] is discharged discontinuously to the chamber filter press [10HTM30AT001] depending on the water level in the scrubber or alternatively after a certain period of time.
  The dewatered gypsum may be landfilled or (if pollutant limits can be held) sold to the building industry. The filtrate is pumped to the neutralisation tank of the WWTP.

Several by passes between the scrubbers and the WWTP are required for start-up and shutdown of the plant.

Sources for reaction equations and reaction parameters: [6], [9]

Gas/gas heat exchanger (clean gas) and reheating of flue gases

The clean gas leaving scrubber 2 at roughly 67 °C [Balance Point 5] is pre-heated by the gas/gas heat exchanger [10HTB10AC001] [Balance Point 6] and heated up further above the acid dew point (> 145 °C) by the steam heated exchanger [10HUA10AC001] [Balance Point 7].
This reheating is required to achieve the appropriate reaction temperature in the flue gas polishing system and to avoid corrosion in the following equipment.
Subsequently, the heated flue gas is aspirated by the assistant ID-fan [Balance Point 8] that maintains the subpressure in the secondary combustion chamber at around -3 mbar.

Flue gas polishing system / dry sorption

The fumes aspirated by the assistant ID-fan pass the existing venture type injector [10HRA20BN001] [Balance Point 9] where a mixture of dry reagents like clay minerals, activated carbon[Balance Point 36], lime hydrate [Balance Point 35] and recirculated dust [Balance Point 43] is injected into the gas stream.
The reagent mixture is capable to absorb remaining traces of HCl, SO_2 and HF and to adsorb metallic and ionic mercury and organic compounds like PCCD/F.
The clay minerals and activated carbon are dosed as a concentrate from the big bag station [10HRJ10BB001] through a dosing mill [10HRJ10AJ001] that enables dosing rates up to 25 kg/h, the lime hydrate is dosed from the big bag station [10HRH10BB001] that can be connected to the lime hydrate silo [10HTJ10BB001].
The existing Tomal dosing gear [10HRH10AF001] can be used to feed via the transport screw [10HRH10AF002] the mill [10HRH10AJ001] and transport air fan [10HRH10AN001] that connects with the dust recirculation system and is linked to the venture type injector.
Fire and explosion risk because of activated carbon is avoided by dilution with inert agents (carbon percentage lower than 10-20%, depending on detailed risk analysis).

The existing dry reactor [10HRD20BB001] increases the residence time between reagents and fumes which are than purified in the existing dry adsorber [10HRA10AT001],[Balance Point 10].
The steam trace heating [10HRA10AC001] heats the filter in the area of the hopper to avoid acidic condensation of the fumes on cold spots.
Fine dust and aerosols are separated by the fibres of the filter bags that are cleaned off pneumatically. Clean dust concentrations of 1-3mg/Nm³ should be technically achievable.

The dust is transported by the 2 filter screws [10HRA10AF001] and [10HRA10AF002] to the rotary valve [10HRA10AF101] that seals the adsorber against leak air from the dust transport system.
Around 25 to 50 kg of dust [Balance Point 41] are transported by screw [10HRA20AF001] to the separation screw [10HRA20AF002] that splits the dust into recirculation by the dosing equipment [10HRA21AF001] and the double caplet valve [10HRA22AF101] that feeds the transport injector [10HRA22BB001] dust to rotary kiln front plate for re-burning [Balance Point 44]. This enables the partial discharge of sulphur already in the drum of the rotary kiln. The released pollutants like PCCD/F are destroyed in the combustion. The sink for mercury compounds is the first scrubber stage / waste water treatment plant.
The recirculated dust is dosed by the injector [10HRA21BB002],[Balance Point 45] into the transport air to the venture type injector [10HRA20BN001].
The transport air [Balance Point 37] is pressurised by the transport air fan [10HLB70AN001] and preheated by the condensate heat exchanger [10HLC70AC001] which uses the energy of the condensates from traces heating and steam heat exchanger. Every condensate stream needs a separate heat exchanger pack. The condensate is transferred to the condensate tank.

ID- Fan

The existing ID fan [10HNC10AN001] has only to cope with the pressure loss of the dry adsorption and the stack. It has to maintain a subpressure of -1 mbar behind the assistant ID fan [10HNU40AN001]. This can release additional capacity of the system due to the fact that it is actually limited by the maximum flue gas amount.

Emission sensor

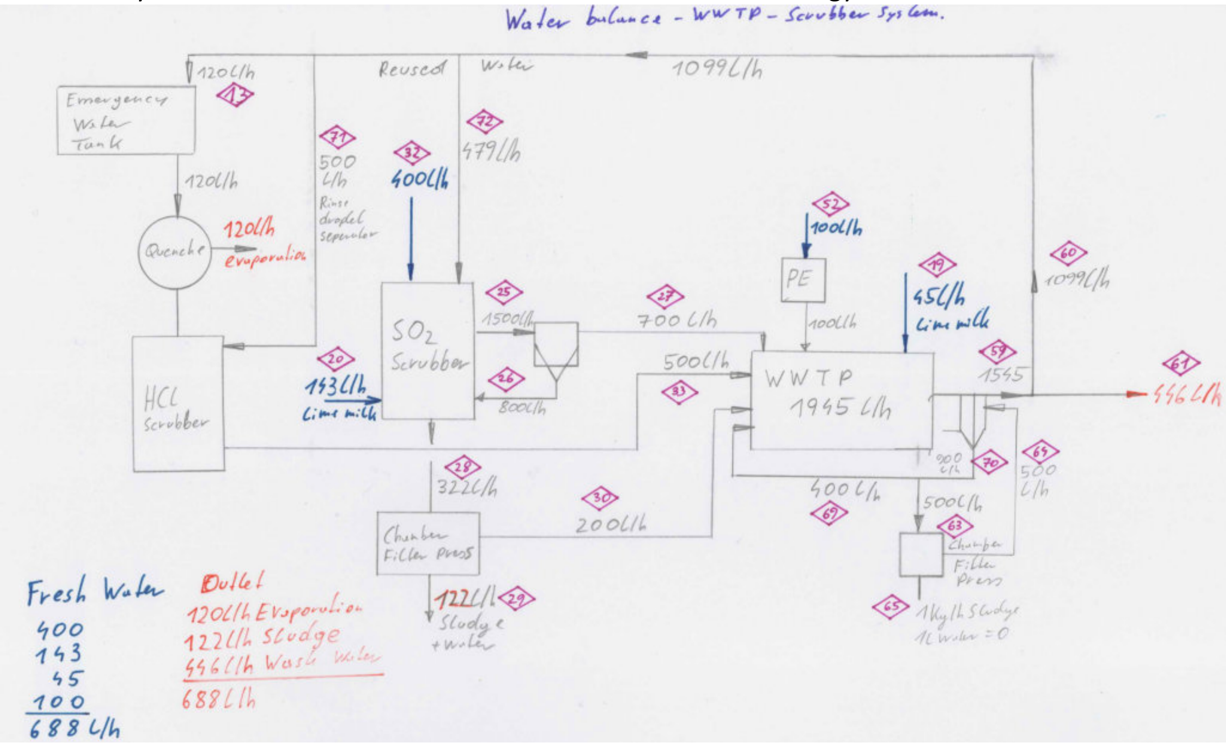
The emission sensors [Balance Point 11] report constantly the pollutant concentrations at the stack. The emission analysis software records the data and publishes on the website:
https://www.wasteservmalta.com/incinerator.aspx
Daily readings and half hourly readings are published on half hourly basis.

Stack

The existing stack [10HNE10BR001] has a height of 26 m and an outlet diameter of 0.63 m.
The sampeling point diameter is 0.85 m. This reduction of diameter generates a big pressure loss and limits the flue gas amount to around 18.000 Nm³/h.
The implementation of a silencer before the stack and the reduction of the fluegas outlet speed to 11 m/sec could improve the noise level around the plant and reduce electricity consumption of the ID-fan.

Waste water treatment plant

The chemical process steps are described in chapter 3.3.3.1 and 6.2.3.
The circuitry of water chosen for the calculation of the mass and energy balance is illustrated below:



→ The waste water amounts up to 446 l/h have to be discharged to drain.
This amount can be reduced to roughly 370 l/h if a new wet deslagging system (boils down 75 l/h) is implemented as recommended in chapter 5. It is sufficient to use the purified water before the polishing state.
The remaining 370 l/h may be used for cleaning activities on site in order to reduce the fresh water need.

9 Estimated time table for the upgrading of the flue gas scrubbing system

The activities listed below require the finalisation of the optimisation of the incineration process as recommended in chapter 4.

- **Milestone project start**
- preparation of the tender, collection of submissions, evaluation of submissions: 4 months
- basic engineering 2 months
- detail engineering 4 months
- purchase of components 1 months
- manufacturing of components 6 months
    - engineering of Building
    - manufacturing of steel structure
- transport to site 2 months
- **Milestone start of erection 1.6 years post to start**
- assembling on site 2 months
- insulation 0.5 months
- electrical installation 2 months loop checks simultaneously
- **Milestone start of commissioning 2 years post to start**
- cold test 1 month
- shut down of plant 0.25 months
- connect new installation 0.25 months
- hot test 0.75 months
- performance test 0.25months

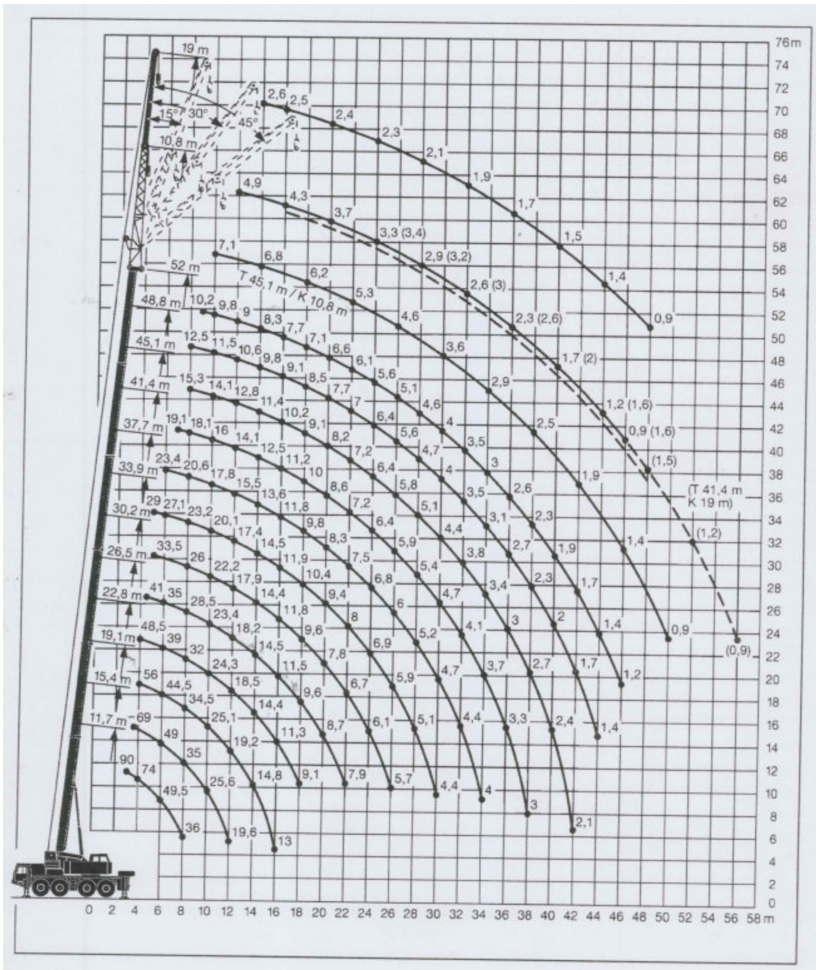
time demand: 28 months => 2.3 years.
2017 is estimated to be the year of commissioning (see financial analysis).
Money demand: 30% in 2015; 50% in 2016; 20% in 2017

10Recommended assembly concept

The location site for the new flue gas cleaning plant respects minimal disturbance of actual operations of the plant. The position for assembling the plant can be one tower crane located between the fuel reservoir and the hoist to assemble the steel structure and minor components. For the bigger lifts a mobile crane can be positioned in front of the workshop building. The room for the switchgear can be located at the same level like the old plant control room in the space available in front of the shredder area. The reception of waste can be performed between the lifts.

Alternative to the existing drawings, parts of the flue gas cleaning plant can be placed on a level of 6 m above the ground level. This enables free access for trucks to the hoist and the cool room area.
A position of 100,000 € (concrete table) has been considered in the investment costs for this construction.

The assembly concept with 2 cranes should enable the assembly timeframe of 2 months.



This picture shows the lifting table of the 90to Liebherr crane from MJK-Transport. Such a crane should be suitable to carry out the big lifts for the assembly.

Attachments

A1. Ash analysis reports of laboratory CADA with hand written evaluations by Dieter Liebisch (filter dust analysis, boiler dust analysis, buttom ash analysis)
(16 sheets)

A2. Calculation sheets (calculation on economical feasibility) for actual situation, scenario 1, 2 and 3
(16 sheets)

A3. Detailed P+I flow sheets for scenario 1, 2 and 3
(19 sheets)

A4. Balance point list (from mass & energy balance) for scenario 2
(10 sheets)

A5. Layout drawings including basic information for the assembly strategy; for scenario 2
(5 sheets)

A6. List of equipment (machines and apparatus) for scenario 2 / scenario 3
(3 sheets)

Annex II: Statutory Consultation Feedback

Annex II: Feedback received following the Statutory Consultation carried out for the application of renewal (application IP0004/07/C) of the Marsa Thermal Treatment Facility (MTTF) carried out between 24 April 2019 – 15 May 2019 and between January 13 2020 and January 27 2020 and 11th May 2020 till 25th May 2020.

Comment received by	Feedback	ERA reply and comment 21.5.19	WasteServ Malta Ltd. reply	Comment received by	ERA reply and comment	WasteServ Malta Ltd. reply	Comment received by consultee:	ERA reply and comment	WasteServ Malta Ltd. reply 27.01.2021
External Consultees Feedback									
Environmental Health Directorate	With reference to request to provide any comments on the contents of such application regarding subject in caption, please be informed that this Directorate would like to submit the following comments/recommendations regarding this proposal: 1. Pest Control Management System is to be included as part of the permit. 2. Unpredicted impacts and nuisances which may arise from this operation and that may have a significant adverse effect on public health are to be immediately addressed by the applicant and the necessary mitigation measures taken; 3. Complaints lodged by the public regarding any adverse impacts/nuisances should be immediately addressed by the applicant. All complaints lodged and actions taken are to be recorded and such records are to be readily available to the Competent Authorities when requested.	Operator to confirm what pest control measures are in place at the facility. On comments, 2 and 3, kindly note that conditions are already included in the permit, which cater for such requirements. [Conditions 2.3.9 – 2.3.11]. Records of incidents and complaints are also included as part of the Annual Environmental Report.	The implemented tender WSM 049/248/2018, covers the pest control services required by Wasteserv. Plans of each rodent control tamper proof station are attached in Annexes 1 and 2.	Kindly be informed that we have no further comments from our end.	Noted.		With reference to request to provide any comments on the contents of such application regarding subject in caption, please be informed that this Directorate would like to submit the following comments/recommendations regarding this proposal: 1. No water runoff or litter is to exit the scheme. 2. As BAT 33. Water collected from rainwater and second-class water MUST NOT be used for human consumption. The overflow of reservoir used for the collection of rainwater must overflow onto the street. Second Class/Rainwater used for washing and cleaning must be treated with Chlorine to prevent microbial growth especially Legionella. Irrigation using rain/grey water should be carried out using drip irrigation to prevent the spread of aerosol in air. 3. A better explanation is needed for the term Cooling Tower (Autoclave) as indicated in Annex I in the MCP forms and Industrial Cooling System identified in Annex IV BAT Conclusions. Will there be water aerosol in direct contact with the stream of air as explained in LN 5 of 2006 for the Control of Legionella Control?	WSM to clarify any outstanding issues	As per instruction given, second class / rain water shall be treated with chlorine. No water is used for irrigation. The Cooling Tower in question is an air cooled condenser. There are no water aerosol involved since this is an air cooled condenser.
Veterinary Regulation Directorate	No feedback provided.			No feedback provided.					/
Malta Resources Authority	No feedback provided.			No feedback provided.					/
Planning Authority	The following discrepancies are noted in the sewage network plan provided: -Final animal fat silos and LPG storage tanks as shown in approved doc PA 2585/13/170A are not shown in sewage network plan; -Layout of approved WC and store is different and office is omitted from sewage network plan; -End product store is not shown on sewage network plan; -Bin washing facility is indicated as enclosed on sewage network plan but	Operator to provide reply.	WSM submitted the drawings available.	No feedback provided.					/

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	this is not shown as being enclosed in approved doc PA 2585/13/170A								
Regulatory for Energy and Water Services	The Regulator for Energy and Water Services (REWS) has no comments as such on the renewal and variation of this IPPC permit. Just a small clarification on page 7 of the Improvement Programme, Reference 17, where it reads "*Authorisation from REWs was received in December 2016…*"We have checked our file and the Authorisation from REWS was issued to the Marsa Thermal Treatment Facility on 12/10/2017.	REWS to note that application pertains only to a renewal of the application. Operator to amend.	Improvement Program pt 17 to be amended accordingly.	The Regulator for Energy and Water Services has no objection to this permit renewal.	Noted.		The Regulator for Energy and Water Services (REWS) notes that this site has an unauthorised Petroleum Filling Station (Commercial Site) at Marsa Thermal Treatment Facility. At this instance we re-notify the operator to come to a decision on the plans Wasteserv had for this particular fuel installation and commit to authorise it or decommission this fuel storage within a reasonable time frame.	WSM to clarify any outstanding issues	As agreed with REWS, Wasteserv shall discontinue the use of the fuel dispenser and shall also decommission it. The towable containers have arrived in Malta. Decommissioning of the (current) fuel dispenser shall take place by end of March 2021.
The Energy & Water Agency	Regarding the IPPC application renewal IP0004/07/C MTTF permit we do not have any comments to add from an Energy and water perspective.	Noted.		No feedback provided.					/
Civil Protection Department	Wasteserv should always update their emergency plan. Make sure that at all time they have good fire brigade access. The private fire hydrant system is regularly maintained, water reservoir is topped with water. Drainage system is able to cope with run off of firefighting water	Operator to reply	Recommendations are already implemented.	No further comments.	Noted.				/
Water Services Corporation	Comments on IPPC renewal as follows: General Comments: 1. Both sites (autoclave and TTF) are still not covered by a Public Sewer Discharge Permit. This requirement should still be reiterated for both sites. 2. IPPC permit should include clear timeframes by when Wasteserv will have to fully comply with the Sewer Discharge Control Regulations. 3. Any culverts (located in non-contaminated areas) exposed to rain water which are connected to sewer shall be redirected to road or public thoroughfare as per BRO Technical Guidance Document F requirements. Improvement Programme Ref #13	General Comments: 1. Operator to provide feedback. 2. Request will be considered. Operator to provide status update on measures being taken to achieve compliance with the Sewer Discharge Control Regulations. 3. Operator to provide feedback. Improvement Programme Ref #13 4. Operator to provide test results as required by WSC.	The WWTP equipment has received a major upgrade to address issues during commissioning in the last quarter of 2019. During the period January – February 2020 it is expected that the aerobic treatment stabilizes following the regeneration of the bacterial activities. WSC shall be asked in March 2020 to carry out tests as a final step prior to the achievement of the sewage discharge permit. This implies that coming March the parameters of the effluent shall be within the legal parameters. The redirection of run-off water at the upper area to the	Taking into consideration Annex II statutory consultation document, 1. WSC positively notes the efforts done by WasteServ to upgrade the WWTP and also to connect the TTF pit to the WWTP. During the interim period until the WWTP is back online it is being presumed that raw untreated waste water is being discharged to sewer. This cannot be tolerated for an indefinite period of time (and is only being allowed due to these exceptional circumstances involving a major upgrade of the WWTP) and thus it	1. Operator to reply. ERA is in agreement with the recommended timeframe. 2. Operator to reply. 3. Operator to reply. 4. Operator to reply.	1. Safeguarding any issues that may not be tackled due to the Covid 19 crisis, the system should be operating optimally by end May 2020. 2. Contingency plan attached as Annex VI. 3. WSM shall continue to liaise with WSC to install the necessary equipment as required. 4. Attached layouts found in Annexes X, XI and XII.	1. In relation to Annex II – Statutory consultation feedback: a. Comment about WasteServ attaining to the May 2020 deadline for obtaining the discharge permit is to be extended by a further and final 2 months (end July 2020) in view of the disruption caused by the Covid-19 crisis. b. Annex XII – MTTF Sewage – drawing to reflect the re-routing of the cesspit to the SBR + any other relevant changes (such as re-routing of storm water culverts to road) to reflect current setup. c. Annex VI – Contingency Plan – this does not give sufficient information on how discharge of non-compliant waste water is prevented in case of a plant malfunction of shutdown. Moreover, more information is to be given on the future plans regarding the backup plant. 2. Annex XVI – TTF_EP08 – Flowchart is missing a step were WasteServ should inform WSC-DPU of any exceeding results (in relation to S.L. 545.08) obtained from testing of the SBR final effluent.	WSM to clarify any outstanding issues	1. a. Wasteserv shall be reinitiating the permitting process and shall be contacting WSC to take a sample from the premises to conduct its tests with a view of attaining the water discharge permit. b. Drawings denoted Annex X and Annex XI are current. Annex XII shall be updated in the coming days. In order not to disrupt the IPPC permitting process, it is being suggested that this item is listed in the improvement programme. c.

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	4. Tests performed on Autoclave STP effluent in 2017 indicated exceedances in COD, FOG & TKN. Recent tests confirmed exceedances in COD & TKN – full test results are yet to be issued. 5. Test performed on TTF pit confirmed exceedances in TSS, COD, TKN and FOG – full test results are yet to be issued. 6. Wasteserv is to commit with a fixed deadline to treating the waste water from the TTF pit either through a separate treatment plant or by diverting the waste water to the autoclave STP. Final result must be that no untreated waste water is to be discharged to sewer from the MTTF/Autoclave site. 7. Wasteserv to compile and/or update their contingency plan in the event of an STP shut down and how will discharge of untreated waste water be prevented and also including mandatory communication with DPU in the event of a plant malfunction/problem and/or deterioration of final effluent water quality. 8. Wasteserv to look into the possibility of installing on-line final effluent monitoring equipment. Improvement Programme Ref#20 9. Voluntary undertaking is no longer being considered given the fact that only the Autoclave waste water is being treated whilst the waste water from the TTF is still being discharged 'raw'. WSC will be, for the time being, considering the two sites separately. Follow-up to feedback provided by PA on the discrepancies noted in sewer network plan. 10. Wasteserv are to update their drawing as detailed by the PA.	5. Operator to provide test results as required by WSC. 6. Operator to provide feedback. 7. Operator to provide feedback 8. Operator to provide feedback Improvement Programme Ref#20 9. Operator to provide feedback Follow-up to feedback provided by PA on the discrepancies noted in sewer network plan. 10. Operator to provide feedback as requested above.	WWTP are also at an advanced stage and the contractor is waiting for the necessary components to arrive to proceed with the necessary works.	would only make sense to construe WasteServ to obtain their discharge permit within a certain period of time in order to make sure that the process is expediated. WSC suggests by end May 2020. 2. WSC has requested WasteServ a number of times to submit the contingency plan relating to WWTP shutdowns and how will the raw sewage be stored and/or transported to another location to prevent the discharge of untreated waste water. 3. Wasteserv to install online waste water monitoring equipment on the WWTP outlet reservoir to monitor quality prior to discharge to sewer. 4. WasteServ to submit an updated internal drains layout to reflect changes made.					The contingency plan sheds light on rapid fault finding and intervention. In light of the announced new plant ECOHIVE Hygienics, plans related to the backup plant have changed. 2. Procedure TTF EP08 is being updated to include notification to WSC in case of exceedances.

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MCCAA				No feedback			There are no comments from our end.	N/A	/
Occupational Health and Safety Authority	OHSA has no objection to the renewal of the MTTF permit.	Noted.		Following my previous email dated 17/05/2019, a follow up inspection was carried out in July 2019. The plant was seen in operation and the issues identified during the previous inspection were addressed. OHSA has no objection to the renewal of the MTTF permit provided that the employer abides by all applicable OHS legislation.	Noted		From the information supplied by the applicant, the quantities of dangerous substances stored at MTTF do not classify this site as a COMAH establishment under the L.N. 179/2015. Kindly note that it is the obligation of the employer to ensure that occupational health and safety legislation is adhered to. OHSA finds no objection to the renewal of the permit as long as the operator/employer conforms to all applicable OHS regulations	N/A	/
Internal Consultees Feedback									
Environmental Assessment Unit	No additional comments from our end as long as the activities, listed under Section 1 of the document referred, remain within the parameters assessed in the EIS carried out for the said development.	Noted.		No comments.	Noted.		No comments.		/
Biodiversity & Water Unit	No feedback provided.			No feedback provided			The submissions related to renewal to this IPPC permit have been noted. Noting that there are no emissions to surface waters, and that facility is equipped with a wastewater treatment plant and related discharges are linked to the sewer system, we have no comments to add.		/
Air quality & Waste Unit **Air Quality Team**	In order to aid in the compilation of the inventory, the AER template in the permit will need to be amended so to include: 1. Reporting of the waste gas flow normalised to the conditions at which the pollutant concentrations are reported 2. Reporting of the total loads emitted in kg or tons for all the pollutants they are required to measure by the permit.	Noted, Operator to provide reply.	WSM carries out the necessary testing depending on the waste steam inputs at the plant. Furthermore any upgrades depend on the availability of the technology locally and the possibility to capture enough information given the age of the plant.	The Operator is to confirm as to whether the required data can be provided. Kindly note that such data will need be collected in order for the facility to be compliant with the various environmental acquis and BAT conclusions of the IED on waste incineration.	Operator to reply.	WSM shall be undertaking further studies to evaluate the feasibility and technical viability of executing the required modifications to meet the latest BAT's requirements. The main issues that arise are: a. The possibility of stopping the incineration process until the necessary installation, testing, tweaking and commissioning process is done. b. The need to retrofit advanced technologies that are compatible with obsolete systems. c. The ability to adopt the old technologies to new systems without affecting	No feedback provided		/

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						the integrity of the process.			
Air quality & Waste Unit **Waste Management Team**	1. In Annex 1 (Improvement Programme), Reference No. 16, it is stated that a report on the study of bottom ash treatment was sent to ERA in May 2017. In this regard, it is to be noted that the Waste Team was consulted on the said report and feedback was provided last year indicating the following: • The applicant was requested to provide ERA with an HP criteria assessment of the compositional analysis of the bottom ash in accordance with Schedule 3 of S.L.549.63 – the Waste Regulations in order to determine whether or not the waste is hazardous, and hence the determine the classification of the waste; and • It was highlighted that some of the samples analysed showed values that exceed the thresholds laid down in the Council Decision 2003/33/EC for both non-hazardous and hazardous landfills. In addition, recently, the Waste Team also provided guidance on the procedure to follow for the purposes of carrying out such tests. (Refer to attached emails). In this context, we are still pending results from WSM.	Noted.		Waste Team are of the opinion that, based on the current technical specifications of the MTTF as laid down in the current permit, any waste containing PCBs, particularly the following EWC codes should be removed from Schedule 3 of the IPPC MTTF Permit (i.e. shall not be accepted at the MTTF): ▪ 13 01 01* hydraulic oils, containing PCBs; and ▪ 13 03 01* insulating or heat transmission oils containing PCBs	Operator to reply. It is to be noted that the aforementioned EWC codes will be removed from the permit.	Kindly refer to Annex XVII for a description of waste streams acceptable at the facility.	1. It was noted that the EWC codes previously recommended for removal from the permit (13 01 01* hydraulic oils, containing PCBs; and 13 03 01* insulating or heat transmission oils containing PCBs) are still being listed in *Annex XVII - Acceptable wastestreams*. In view that in previous consultations the normal incinerating temperature was indicated to be approximately 900°C, and in view that PCBs require a temperature of 1200°C for their dissociation, the waste team would like clarifications from EPU on whether such waste will be removed from their permit or otherwise; 2. BAT 1.3: The operator was requested to indicate date and method statement by when the mandatory monitoring of ash content would be implemented, and the reply makes reference to Annex II. However Annex II (Statutory Consultation feedback) does not indicate such information. Applicant is requested to provide these details; and 3. The Document *TTF QP 04 Incineration Procedure Testing* indicates that the bottom ash will be landfilled. Characterisation of the bottom ash is required to ensure that the waste falls within the acceptance criteria of hazardous or non-hazardous landfills, as laid down in Council Decision 2003/33/EC, before disposal of such material can take place	WSM to clarify any outstanding issues, and pending requirements will be included as part of the permit.	1. This was an oversight. EWC Codes indicated are to be removed. 2. Bottom ash is being tested on a monthly basis. In case of exceedances, weekly samples (previously collected) are analysed / investigated. Methodology for bottom ash characterisation is attached as Annex XXII. Furthermore, a trail is being conducted to assess effect of waste type (specifically pharmaceutical waste) with bottom ash results (specifically chromium content / level). 3. Methodology for bottom ash characterisation is attached as Annex XXII.
Air quality & Waste Unit **Noise Team**	Comments on the Nosie survey which was last updated in April 2017 and the method statement of which was submitted in May 2019 In particular, it is to be ensured that not just the measurement procedure but also the assessment methodology is in line with BS 4142:2014, in particular section 11. Thus, ensuring that the noise levels emitted from the installation at all operational times shall not exceed the background noise level by 5dB (clause 2.2.9.3). The background levels are to be taken from the baseline study report (Ecoserv Report Reference: 128-16_R2.).	Operator to take note	ERA approved the method statement on 17th June 2019.	No further comments from a noise perspective on the available documents.	Noted		No further comments from a noise perspective on the referred documents.		/
Compliance & Enforcement Directorate	Further to the feedback submitted on the Improvement Programme items, CED also wishes to clarify	Operator to provide reply	The report has been submitted. Action	1. With reference to Annex 8 “Waste incineration and	1. Operator to reply by means of a	Refer to Annex XV. Full documentation of all the processes		WSM to clarify any outstanding issues, update the	

<table>
<tr><th>Comment received by</th><th>Feedback</th><th>ERA reply and comment
21.5.19</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by consultee:</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply
27.01.2021</th></tr>
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<td>that the compliance status of a site cannot be determined on the basis of the latest inspection report alone, as recurring issues may not always be readily apparent during every inspection.

The site has significant problems in terms of odour management, an issue which seems to have intensified in the past year or so. Besides the long-standing odour issues at the incinerator building and fridge, as well as the issue of carcasses and animal tissue waste regularly being left outside prior to treatment; there also appears to be more recent odour issues arising from components of the Autoclave Plant. While Wasteserv has commissioned an independent consultant to identify the odour sources and come up with potential solutions, this report itself is still pending, let alone the application of any mitigation measures which may be suggested.

The odour issues at this plant need to be taken seriously and concrete measures to control these odours need to be presented and implemented by the operator.</td>
<td></td>
<td>plan details are found in Annex 2.</td>
<td>segregation” – In the procedures laid out for the Heads of Shift for both day and night, there should be further clarification on how waste is ‘prepared for incineration’. Thawing of waste in the open is not acceptable.

2. With reference to Annex 2 “Odour Reduction Action Plan”, CED is corresponding with Wasteserv separately on this matter. However as a general observation, the timeframes proposed on some of the key items to reduce odour are too far in the future. Furthermore, interim measures to reduce odour should be in place until such time as the longer-term solutions are implemented.</td>
<td>process flow diagram.

2. Operator to note replies provide Annex I.</td>
<td>at the TTF may be found in Annex XVI.

Wasteserv has engaged a consultant to devise a method that respects the permit conditions.</td>
<td>
<table>
<tr><th>IP item</th><th>Requirement</th><th>CEDs feedback</th></tr>
<tr><td>2</td><td>Submission of monitoring data from plant acceptance tests related to solvent storage and solvent line.</td><td>Noted</td></tr>
<tr><td>11</td><td>Submission of air emissions improvement plan. This shall include:

a) Details as to how waste loads shall be managed so as to prevent exceedences of air emissions
b) Details of additional abatement required</td><td>Noted.</td></tr>
<tr><td>12</td><td>Implementation of approved air emissions improvement plan</td><td>Noted.</td></tr>
<tr><td>13</td><td>Submission of the following details regarding the waste water treatment plant,:
(a) Associated emission levels, and comparison against the limits in Legal Notice 139 of 2002 as amended, and the requirements of the Water Services Corporation;
(b) Comparison against BAT, in particular BAT on treatment of waste water as specified in section 5.1.5 of the BREF for Slaughterhouses and Animal By-products Industries;
(c) Maintenance programme;
(d) Training programme for staff;
(e) Monitoring proposal;</td><td>It seems that only 13c is being addressed in Annex XIX.

Part of this IP item is also being addressed in Annex II.</td></tr>
</table>
</td>
<td>requested documents. Any necessary requirements that the Authority deems necessary will be included in the permit.</td>
<td>13a
2nd Class Waste Water Readings presented in Annex XXVI.

13b
Refer to Annex XXIII.

13d
As per Competency Matrix (Controlled Document 142), personnel of interest</td>
</tr>
</table>

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								(f) Certification of impermeability by an independent warranted civil engineer or engineer.			are trained on procedures TTF EP08 and TTF EP11. 13e Refer to procedure TTF EP08. 13f Refer to Annex XXIV.
							14	Submission of a land and groundwater risk assessment, and if required, a monitoring strategy and baseline report in line with European Commission and MEPA guidance pursuant to Regulations 9(3) and 16(2) of the Industrial Emissions (IPPC) Regulations, and condition.	Noted.		
							15	Certification from a competent company or engineer that the relevant fire safety procedures and equipment are in place, including emergency firefighting water supplies for use by the Civil Protection Department.	No further comments		
							16	Submission of proposals for treatment of bottom ash prior to landfilling.	Email was sent on 27.01.20 by CED. No feedback from WS has been provided yet.		16 Please refer to the methodology for bottom ash characterisation specified in Annex XXII.
							17	Authorisation from the Regulator for Energy and Water Services (REWS) for operations and for the storage of fuels, oils and other liquids not mentioned in Regulation 2 of LN 53 of 2010.	No further comments		
							18	Certification by an independent warranted civil engineer or engineer that the engineered site containment, cesspit and drainage systems on site are leak-proof and resistant to physical, mechanical and chemical stresses to which they may be subjected.	No further comments		
							19	Certification by an independent warranted engineer that the pipes, pumps, valves and flanges forming part of the diesel transfer system are leakproof	No further comments		
							20	Implementation of conditions imposed by Water Services Corporation in 'no objection' letter dated 13th August 2015 (as	WSC to provide feedback		

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	found in Schedule 7 of the permit) and the related Voluntary Undertaking agreement	
21	Submission of an updated plan of the sewage system of the installation	WSC to provide feedback
22	To compile ozone depleting substances equipment registration form in Schedule 5 and submit it to the Authority. This shall include any fixed or mobile refrigeration equipment (including refrigerated containers leased from third parties which is located on site for a period exceeding 6 months)	Email sent to EPU on 13.04.20 that no feedback was provided from MCCAA
23	Submission of maintenance programme for all plant in the installation	No further comments
24	Submission of an update to the noise report submitted in May 2012, to reflect the operations implemented on site	No further comments
25	Submission of updated list of delegate TCPs and their CVs and contact details	No further comments

Section C: Other issues:

	Issue	CEDs feedback
1	Autoclave commissioning	No further comments
2	Registration of Medium combustion plants	No further comments
3	Odour Issues on site	OK072/19 is still active

Statutory Consultations reply:

Comment received by	WasteServ Malta Ltd. reply	CED comments 25.05.2020

<table>
<tr><th>Comment received by</th><th>Feedback</th><th>ERA reply and comment
21.5.19</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by consultee:</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply
27.01.2021</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>Compliance & Enforcement Directorate</td><td>Refer to Annex XV. Full documentation of all the processes at the TTF may be found in Annex XVI.

Wasteserv has engaged a consultant to devise a method that respects the permit conditions.</td><td>QP03 Waste Storage procedure process flow diagram in page 4 shows thawing to be taking place outside. CED is reiterating this is not acceptable and a short-term, interim measure should be proposed prior to the implementation of any longer term upgrades being envisaged. Furthermore, Document QP07 makes no mention of the fallen animals received at night being put into cold storage.

Noted. Kindly advise when report/recommendations are expected to be available.</td></tr>
</table>
<table>
<tr><th><u>BAT</u></th><th>CED comments 07.02.2020</th><th>WS Reply</th><th>CED comments 25.05.2020</th></tr>
<tr><td><u>BAT 10 - Bottom Ash</u></td><td>The current practice of directing this to landfill without pre treatment is in breach of Landfill Directive. According to the Bottom Ash report submitted to ERA in May 2017 indicated that in certain instances the leaching test results of the bottom ash showed values exceeding thresholds laid down in Council Decision 2003/33/EC for non-hazardous landfills. Therefore reply related to feasibility is not acceptable as it is a legal requirement.</td><td>See BAT 9. (further cross referencing is made to Annex II AQW comment replies)</td><td>No further comments</td></tr>
<tr><td>BAT 11 – Waste Acceptance</td><td>CED feels that relying solely on information provided by waste producers in all instances is insufficient and periodic checks</td><td>WSM carries out regular monitoring and tests as required. Details of current procedures are found in Annex XV.</td><td>No further comments</td></tr>
</table>
</td><td></td><td>As specified in Annex XXI, Wasteserv is endeavouring to improve odour abatement infrastructure. To note that a shed shall be erected to enclose the Waste Marshalling Area. Thus bin temporary storage and/or queuing shall take place inside. Air from the Shredder Room, Main Refrigerator and Marshalling Area shall be directed and treated using a Chemical Scrubber. Ref QP07, the fallen animals in question are pets and horses. Pets are incinerated immediately. Fallen horses amount to few cases thus odour for potential is minimal. In the future, such fallen animals can be queued in the Waste Marshalling Area which shall be enclosed and its air directed for treatment.

Refer to Annex XXI.</td></tr>
</table>

<table>
<tr><th>Comment received by</th><th>Feedback</th><th>ERA reply and comment
21.5.19</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply</th><th>Comment received by consultee:</th><th>ERA reply and comment</th><th>WasteServ Malta Ltd. reply
27.01.2021</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>through sampling and analysis by Wasteserv should be standard practice.</td><td></td><td></td></tr>
</table>

<u>BAT 1.5 Emissions to air</u>
<table>
<tr><th><u>1.5.1 Diffuse emissions</u></th><th>CED comments 07.02.2020</th><th>WS Reply</th><th>CED comments 25.05.2020</th></tr>
<tr><td><u>Odour emissions</u></td><td>Operator did not provided feedback on the measures being implemented on site.

However, waste as described under BAT 21 is accepted/present at the facility. CED requests the operator to indicate actions to be implemented.</td><td>WSM is currently studying the rerouting of air from the scrubber, Abattoir and Clinical Waste are stored in refrigerated chambers at 5 Degrees Celcius Maximum. WSM is working on installing an exgtraction system for the shredding room and bottom ash chamber.</td><td>WSM is to advise projected timeframes for these</td></tr>
<tr><td><u>BAT 22 – Direct feeding of odorous waste</u></td><td>The operator indicated that they do not handle liquid or gaseous waste.

Despite stating the above, it is to note the presence of liquid blood, tallow, and tallow vapour generated from the autoclave process were not taken into account by the operator.
Considering that the tallow storage tanks are located outside the autoclave building, and thus any odorous and gaseous emissions are not captured through the scrubbing system. Operator is to indicate how such emissions can be redirected to the furnace.</td><td>All vents protruding from the tallow tanks shall be connected together and rerouted back to the Autoclave plant so that fumes/odours can be captured by the air scrubbing system.</td><td>A timeframe for implementation shall be provided. Please note that in view of frequent complaints regarding odours generated in this area, WSM should give this upgrade priority.</td></tr>
<tr><td><u>BAT 23 – Techniques to reduce diffuse dust emissions to air from the treatment of slags and bottom ashes.</u></td><td>Operator indicated that slag and bottom ashes are not treated on site.

No further comments from CED</td><td></td><td>N/A</td></tr>
</table>
</td><td></td><td>Refer to Annex XXI.

Emissions from the tallow tanks shall be directed to the Autoclave Shed. The air inside the Autoclave shed shall be treated via a Chemical Scrubber and RTO. Refer to Annex XXI.</td></tr>
</table>

Comment received by	Feedback	ERA reply and comment 21.5.19	WasteServ Malta Ltd. reply	Comment received by	ERA reply and comment	WasteServ Malta Ltd. reply	Comment received by consultee:	ERA reply and comment	WasteServ Malta Ltd. reply 27.01.2021
							(see nested tables below)		

BAT 24 – Further techniques to reduce diffuse dust emissions to air from the treatment of slags and bottom ashes.	N/A. No further comments from CED		N/A

	CED comments 07.02.2020	WS Reply	CED comments 25.05.2020
1.5.2.3 – Emissions of NOx, N2O, CO and NH3			
BAT 29 – Air emissions abatement techniques for NOx, N2O, CO and NH3	Operator indicated that only the following are applicable - Optimisation of incineration process - Catalytic filter bags		N/A
BAT-associated emission levels (BAT-AELs) for channelled NOX and CO emissions to air from the incineration of waste and for channelled NH3 emissions to air from the use of SNCR and/or SCR	Data at CED's end shows that emissions (monthly averages are below the stipulated thresholds) No further comments from CED Operator indicated that this is not applicable.		N/A
BAT 30 Air emissions abatement techniques (PCDD/F and PCBs)	Reduction of channelled emissions to air of organic compounds from incineration of waste CED insists that Wasteserv should include the technique as requested and not just its applicability, and the reason for its applicability or lack there-of		

1.6 – Emissions to Water			
BAT 32 - Segregation of	WasteServ failed to provide an exhaustive list of		

Comment received by	Feedback	ERA reply and comment 21.5.19	WasteServ Malta Ltd. reply	Comment received by	ERA reply and comment	WasteServ Malta Ltd. reply	Comment received by consultee:				ERA reply and comment	WasteServ Malta Ltd. reply 27.01.2021
							waste water streams	waste water streams, details of treatment and/ or disposal mechanisms in place. CED feels that answer provided that all waste water streams are treated is not sufficient.				
							BAT 33 - Reducation of water usage and generation of waste water	Refer to final comment regarding the AER data and Sewer Discharges below.	WSM carried a rigorous exercise to seal all drains and intersections with high quality material to avoid potential future leakages.	This answer is in reply to our comments on BAT 34 not BAT 33, however the reply is noted.		
							BAT 34 - Reduction of emissions to water from storage and treatment of slags and bottom ashes	Operator to indicate applicability of measures in place to reduce water usage and prevent/reduce generation of waste water – CED is of the opinion that WasteServ is to provide more detailed reply and not simply yes or not applicable replies WasteServ only stated that since the FGC is a dry proves, there is no emissions to water since both slag and bottom ash are stored in chambers with no access to water Furthermore, no concentrations have been provided for any of the parameters vis a vis direct emissions to water bodies. No concentrations have been provided for any of the parameters vis a vis indirect emissions to water bodies. Although in the application process, the operator stated		See comment above on BAT 33. Noted.		

Comment received by	Feedback	ERA reply and comment 21.5.19	WasteServ Malta Ltd. reply	Comment received by	ERA reply and comment	WasteServ Malta Ltd. reply	Comment received by consultee:	ERA reply and comment	WasteServ Malta Ltd. reply 27.01.2021
							that there are no direct discharges a water body, in view of a recent episode of effluent run off to port facility, CED feels that a more rigorous exercise to determine possible emissions to water is to be carried out and answers forwarded to ERA. From TTF AER data, CED confirms that the concentrations of parameters tested for discharges to sewer, have proved to be much higher than the limit value. CED contacted WSC, who have been made aware of the situation who informed that at present, MTTF are not permitted to discharge to sewer, however WSC are aware of the situation including the exceedances. A recent update confirmed that MTTF redirected all effluent to the WWTP, however WSC are awaiting further testing.		

Annex IV: BAT Conclusions

IPPC BAT Conclusions

Best available techniques (BAT) conclusions for waste incineration , under Directive 2010/75/EU of the European Parliament and of the Council

In accordance with Article 14,3 of the Directive on Industrial Emissions 2010/75/EU (IED) ***"BAT conclusions shall be the reference for setting the licence conditions".***

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR WASTE INCINERATION

SCOPE

These BAT conclusions concern the following activities specified in Annex I to Directive 2010/75/EU, namely:

5.1 Disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving the treatment of slags and/or bottom ashes from the incineration of waste.

5.2 Disposal or recovery of waste in waste incineration plants:

a) for non-hazardous waste with a capacity exceeding 3 tonnes per hour;
b) For hazardous waste with a capacity exceeding 10 tonnes per day.

5.2 Disposal or recovery of waste in waste co-incineration plants:

a) for non-hazardous waste with a capacity exceeding 3 tonnes per hour;
b) for hazardous waste with a capacity exceeding 10 tonnes per day;

Whose main purpose is not the production of material products and where at least one of the following conditions is fulfilled:

- only waste, other than waste defined in Article 3(31)(b) of Directive 2010/75/EU, is combusted;
- more than 40 % of the resulting heat release comes from hazardous waste;
- Mixed municipal waste is combusted.

5.3 (a) Disposal of non-hazardous waste with a capacity exceeding 50 tonnes per day involving the treatment of slags and/or bottom ashes from the incineration of waste.

(b) Recovery, or a mix of recovery and disposal, of non-hazardous waste with a capacity exceeding 75 tonnes per day involving the treatment of slags and/or bottom ashes from the incineration of waste.

5.4 Disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving the treatment of slags and/or bottom ashes from the incineration of waste.

These BAT conclusions do not address the following:

- Pre-treatment of waste prior to incineration. This may be covered by the BAT conclusions for Waste Treatment (WT).
- Treatment of incineration fly ashes and other residues resulting from flue-gas cleaning (FGC). This may be covered by the BAT conclusions for Waste Treatment (WT).
- Incineration or co-incineration of exclusively gaseous waste, other than that resulting from the thermal treatment of waste.
- Treatment of waste in plants covered by Article 42(2) of Directive 2010/75/EU.

Other BAT conclusions and reference documents which could be relevant for the activities covered by these BAT conclusions are the following:

- Waste Treatment (WT);
- Economics and Cross-Media Effects (ECM);
- Emissions from Storage (EFS);
- Energy Efficiency (ENE);
- Industrial Cooling Systems (ICS);
- Monitoring of Emissions to Air and Water from IED Installations (ROM);
- Large Combustion Plants (LCP);
- Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW).

General Considerations:

Best Available Techniques

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection. Unless otherwise stated, the BAT conclusions are generally applicable.

Emission levels associated with the best available techniques (BAT-AELs) for emissions to air

Emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to concentrations, expressed as mass of emitted substances per volume of flue-gas or of extracted air under the following standard conditions: dry gas at a temperature of 273.15 K and a pressure of 101.3 kPa, and expressed in mg/Nm^3, $\mu g/Nm^3$, ng $I\text{-}TEQ/Nm^3$ or ng $WHO\text{-}TEQ/Nm^3$.

The reference oxygen levels used to express BAT-AELs in this document are shown in the table below.

Activity	Reference oxygen level (OR)
Incineration of waste	11 dry vol-%
Bottom ash treatment	No correction for the oxygen level

The equation for calculating the emission concentration at the reference oxygen level is:

$$E_R = \frac{21 - O_R}{21 - O_M} \times E_M$$

Where:

E_R: emission concentration at the reference oxygen level O_R;
O_R: reference oxygen level in vol-%;
E_M: measured emission concentration;
O_M: measured oxygen level in vol-%.

For averaging periods of BAT-AELs for emissions to air, the following definitions apply.

Type of measurement	Averaging period	Definition
Continuous	Half-hourly average	Average value over a period of 30 minutes
	Daily average	Average over a period of one day based on valid half-hourly averages
Periodic	Average over the sampling period	Average value of three consecutive measurements of at least 30 minutes each ([1])
	Long-term sampling period	Value over a sampling period of 2 to 4 weeks
([1]) For any parameter where, due to sampling or analytical limitations, 30-minute sampling/measurement and/or an average of three consecutive measurements is inappropriate, a more suitable procedure may be employed. For PCDD/F and dioxin-like PCBs, one sampling period of 6 to 8 hours is used in the case of short-term sampling.		

When waste is co-incinerated together with non-waste fuels, the BAT-AELs for emissions to air given in these BAT conclusions apply to the entire flue-gas volume generated.

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste water), expressed in mg/l or ng I-TEQ/l.

For waste water from FGC, the BAT-AELs refer either to spot sampling (for TSS only) or to daily averages, i.e. 24-hour flow-proportional composite samples. Time-proportional composite sampling can be used provided that sufficient flow stability is demonstrated.

For waste water from bottom ash treatment, the BAT-AELs refer to either of the following two cases:

- In the case of continuous discharges, daily average values, i.e. 24-hour flow-proportional composite samples;
- In the case of batch discharges, average values over the release duration taken as flow-proportional composite samples, or, provided that the effluent is appropriately mixed and homogeneous, a spot sample taken before discharge.

The BAT-AELs for emissions to water apply at the point where the emission leaves the installation.

Energy efficiency levels associated with the best available techniques (BAT-AEELs)

The BAT-AEELs given in these BAT conclusions for the incineration of non-hazardous waste other than sewage sludge and of hazardous wood waste are expressed as:

- gross electrical efficiency in the case of an incineration plant or part of an incineration plant that produces electricity using a condensing turbine;
- gross energy efficiency in the case of an incineration plant or part of an incineration plant that:
  - Produces only heat, or
  - Produces electricity using a back-pressure turbine and heat with the steam leaving the turbine.

This is expressed as follows:

Gross electrical efficiency	$\eta_e = \frac{W_e}{Q_{th}} \times (Q_b/(Q_b - Q_i))$
Gross energy efficiency	$\eta_h = \frac{W_e + Q_{he} + Q_{de} + Q_i}{Q_{th}}$

Where:

- W_e: electrical power generated, in MW;
- Q_{he}: thermal power supplied to the heat exchangers on the primary side, in MW;
- Q_{de}: directly exported thermal power (as steam or hot water) less the thermal power of the return flow, in MW;
- Q_b: thermal power produced by the boiler, in MW;
- Q_i: thermal power (as steam or hot water) that is used internally (e.g. for flue-gas reheating), in MW;
- Q_{th}: thermal input to the thermal treatment units (e.g. furnaces), including the waste and auxiliary fuels that are used continuously (excluding for example for start-up), in MW_{th} expressed as the lower heating value.

The BAT-AEELs given in these BAT conclusions for the incineration of sewage sludge and of hazardous waste other than hazardous wood waste are expressed as boiler efficiency.

BAT-AEELs are expressed as a percentage.

The monitoring associated with the BAT-AEELs is given in 0.

Content of unburnt substances in bottom ashes/slags

The content of unburnt substances in the slags and/or bottom ashes is expressed as a percentage of the dry weight, either as the loss on ignition or as the TOC mass fraction.

General BAT conclusion

<table>
<tr><th colspan="2">1.1 Environmental management systems</th><th></th><th>ERA reply</th><th>ERA reply</th><th>ERA reply</th></tr>
<tr>
<td>BAT 1

Environment management system (EMS)</td>
<td>BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features:

i. commitment, leadership and accountability of the management, including senior management, for the implementation of an effective EMS;
ii. an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment (or human health) as well as of the applicable legal requirements relating to the environment;
iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
v. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);
viii. internal and external communication;
ix. fostering employee involvement in good environmental management practices;
x. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
xi. effective operational planning and process control;
xii. implementation of appropriate maintenance programmes;
xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;
xv. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;
xvi. application of sectoral benchmarking on a regular basis;
xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
xx. following and taking into account the development of cleaner techniques.

Specifically for incineration plants and, where relevant, bottom ash treatment plants, BAT is also to incorporate the following features in the EMS:

xxi. for incineration plants, waste stream management (BAT 9);

xxii. for bottom ash treatment plants, output quality management (BAT 10);

xxiii. a residues management plan including measures aiming to:

a. minimise the generation of residues;

b. optimise the reuse, regeneration, recycling of, and/or energy recovery from the residues;

c. ensure the proper disposal of residues;

xxiv. for incineration plants, an OTNOC management plan (BAT 18);

xxv. for incineration plants, an accident management plan (Section 2.4);

xxvi. for bottom ash treatment plants, diffuse dust emissions management (BAT 23);

xxvii. an odour management plan where an odour nuisance at sensitive receptors is expected and/or has been substantiated(Section 2.4);

xxviii. A noise management plan (also BAT 37Error! Reference source not found.) where a noise nuisance at sensitive receptors is expected and/or has been substantiated (Section 2.4).</td>
<td>Is an Environmental Management System (EMS) being implemented as part of the installation process?

If yes, does it incorporate the aforementioned features? (Ex: commitment of the management, planning and establishing the necessary procedures in conjunction with investment and financial planning etc.) If certain features are not incorporated in the current EMS kindly indicate a timeframe by when the EMS shall be updated to include all missing features (as may be applicable to your operations).

Operator to confirm whether the following elements are included in the EMS;

<table>
<tr><th>Feature</th><th>Yes/No</th></tr>
<tr><td>i</td><td>Yes</td></tr>
<tr><td>ii</td><td>Yes</td></tr>
<tr><td>iii</td><td>Yes</td></tr>
<tr><td>iv</td><td>Yes</td></tr>
<tr><td>v</td><td>Yes</td></tr>
<tr><td>vi</td><td>Yes</td></tr>
<tr><td>vii</td><td>Yes</td></tr>
<tr><td>ix</td><td>Yes</td></tr>
<tr><td>x</td><td>Yes</td></tr>
<tr><td>xi</td><td>Yes</td></tr>
<tr><td>xii</td><td>Yes</td></tr>
<tr><td>xiii</td><td>Yes</td></tr>
<tr><td>xiv</td><td>Yes</td></tr>
<tr><td>xv</td><td>Yes</td></tr>
<tr><td>xvi</td><td>Yes</td></tr>
<tr><td>xvii</td><td>Yes</td></tr>
<tr><td>xviii</td><td>Yes</td></tr>
<tr><td>xix</td><td>Yes</td></tr>
<tr><td>xx</td><td>Yes</td></tr>
<tr><td>xxi</td><td>Yes</td></tr>
<tr><td>xxii</td><td>Yes</td></tr>
<tr><td>xxiii</td><td>Yes</td></tr>
<tr><td>xxiv</td><td>Yes</td></tr>
<tr><td>xxv</td><td>Yes</td></tr>
<tr><td>xxvi</td><td>Yes</td></tr>
<tr><td>xxvii</td><td>Yes</td></tr>
<tr><td>xxviii</td><td>Yes</td></tr>
</table></td>
<td></td>
<td>A) Operator to submit all EMS documentation in relation to the features listed in BAT 1.

Full documentation is found in Annex XVI.</td>
<td>Noted.</td>
</tr>
</table>

	Note Regulation (EC) No 1221/2009 establishes the European Union eco-management and audit scheme (EMAS), which is an example of an EMS consistent with this BAT.				
1.2 Monitoring					
BAT 2 **Gross electricial efficiency**	BAT is to determine either the gross electrical efficiency, the gross energy efficiency, or the boiler efficiency of the incineration plant as a whole or of all the relevant parts of the incineration plant. N.B In the case of a new incineration plant or after each modification of an existing incineration plant that could significantly affect the energy efficiency, the gross electrical efficiency, the gross energy efficiency, or the boiler efficiency is determined by carrying out a performance test at full load. In the case of an existing incineration plant that has not carried out a performance test, or where a performance test at full load cannot be carried out for technical reasons, the gross electrical efficiency, the gross energy efficiency, or the boiler efficiency can be determined taking into account the design values at performance test conditions. For the performance test, no EN standard is available for the determination of the boiler efficiency of incineration plants. For grate-fired incineration plants, the FDBR guideline RL 7 may be used.	The incinerator does not produce electrical energy. Infact the original plant design did not consider a waste to energy plant.		Non-applicability not accepted. Operator is to to be provide the requested information. **The economizer is recovering 6800kg/h of steam – that is equivalent to 7.93kW.**	Noted, kindly provide the gross electrical efficiency, the gross energy efficiency, or the boiler efficiency of the incineration plant as a whole or of all the relevant parts of the incineration plant. Details on the results of any performance tests are to be considered and provided. **Energy Flux computed and presented in Annex XXV.** **Steam produced in boiler is condensed and recirculated in boiler. Given that this water is still hot, efficiency is improved as energy required to heat up ingress water is minimal. Apart from this aspect, there is no industrial use for the heat generated / recuperated.**
BAT 3 **Monitoring of key parameters of air emissions and water emissions**	**BAT is to monitor key process parameters relevant for emissions to air and water including those given below.**	**Operator to confirm whether continous monitoring for the parameteres is in line with BAT 3** **Flue gas and bottom ash are dry processes**		The operator to confirm whether flow will be measured. **Affirmative - confirmed**	Noted, permit will be updated accordingly.

Stream/Location	Parameter(s)	Monitoring
Flue-gas from the incineration of waste	Flow, oxygen content, temperature, pressure, water vapour content	Continuous measurement
Combustion chamber	Temperature	
Waste water from wet FGC	Flow, pH, temperature	
Waste water from bottom ash treatment plants	Flow, pH, conductivity	

Flue-gas from the incineration of waste	Flow	**YES**
	Oxygen content	**YES**
	temperature	**YES**
	pressure	**YES**
	Water vapour content	**YES**
Combustion chamber	Temperature	**YES**
Waste water from wet FGC	Flow	**N/A**
	pH	**N/A**
	Temperature	**N/A**
Waste water from bottom ash treatment plants	Flow	**N/A**
	pH	**N/A**
	conductivity	**N/A**

BAT 4 **EN standards for monitoring**	**BAT is to monitor channelled emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.**	**Operator to populate table**			
	(table below)	(table below)	*Should any of the parameters indicated are not currently monitored kindly provide a timeframe and proposal for the inclusion of such monitoring.* **All parameters are being monitored as per current IPPC conditions. Any amendments shall be incorporated into a new EMP tender documents as specified by the Authorities.**		Noted, permit will be updated accordingly.

Substance/ Parameter	Process	Standard(s) (1)	Minimum monitoring frequency (2)	Monitoring associated with
NO_X	Incineration of waste	Generic EN standards	Continuous	BAT 29
NH_3	Incineration of waste when SNCR and/or SCR is used	Generic EN standards	Continuous	BAT 29
N_2O	Incineration of waste in fluidised bed furnace Incineration of waste when SNCR is operated with urea	EN 21258 (3)	Once every year	BAT 29
CO	Incineration of waste	Generic EN standards	Continuous	BAT 27
SO_2	Incineration of waste	Generic EN standards	Continuous	BAT 29
HCl	Incineration of waste	Generic EN standards	Continuous	BAT 27

Substance/ Parameter	Process	Standard(s)	monitoring frequency implemented
NO_X	Incineration of waste	**Generic EN standards DM 25/08/2000 SO GU nº223 del 23/09/2000All.1**	**Continuous**
NH_3	Incineration of waste when SNCR and/or SCR is used	**Generic EN standards**	**Continuous**
N_2O	Incineration of waste in fluidised bed furnace Incineration of waste when SNCR is	**EN 21258 (3)**	**N/A**

HF	Incineration of waste	Generic EN standards	Continuous (4)	BAT 27
Dust	Bottom ash treatment	EN 13284-1	Once every year	BAT 26
	Incineration of waste	Generic EN standards and EN 13284-2	Continuous	BAT 25
Metals and metalloids except mercury (As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sb, Tl, V)	Incineration of waste	EN 14385	Once every six months	BAT 25
Hg	Incineration of waste	Generic EN standards and EN 14884	Continuous (5)	BAT 31
TVOC	Incineration of waste	Generic EN standards	Continuous	BAT 30
PBDD/F	Incineration of waste (6)	No EN standard available	Once every six months	BAT 30
PCDD/F	Incineration of waste	EN 1948-1, EN 1948-2, EN 1948-3	Once every six months for short-term sampling	BAT 30**Error! Reference source not found.**
		No EN standard available for long-term sampling, EN 1948-2, EN 1948-3	Once every month for long-term sampling (7)	BAT 30**Error! Reference source not found.**
Dioxin-like PCBs	Incineration of waste	EN 1948-1, EN 1948-2, EN 1948-4	Once every six months for short-term sampling (8)	BAT 30
		No EN standard available for long-term sampling, EN 1948-2, EN 1948-4	Once every month for long-term sampling (7)(8)	BAT 30
Benzo[*a*]pyrene	Incineration of waste	No EN standard available	Once every year	BAT 30

(1) Generic EN standards for continuous measurements are EN 15267-1, EN 15267-2, EN 15267-3 and EN 14181. EN standards for periodic measurements are given in the table or in the footnotes.
(2) For periodic monitoring, the monitoring frequency does not apply where plant operation would be for the sole purpose of performing an emission measurement.
(3) If continuous monitoring of N_2O is applied, the generic EN standards for continuous measurements apply.
(4) The continuous measurement of HF may be replaced by periodic measurements with a minimum frequency of once every six months if the HCl emission levels are proven to be sufficiently stable. No EN standard is available for the periodic measurement of HF.
(5) For plants incinerating wastes with a proven low and stable mercury content (e.g. mono-streams of waste of a controlled composition), the continuous monitoring of emissions may be replaced by long-term sampling (no EN standard is available for long-term sampling of Hg [to check before publication if an EN standard has become available]) or periodic measurements with a minimum frequency of once every six months. In the latter case the relevant standard is EN 13211.
(6) The monitoring only applies to the incineration of waste containing brominated flame retardants or to plants using 0 d with continuous injection of bromine.
(7) The monitoring does not apply if the emission levels are proven to be sufficiently stable.
(8) The monitoring does not apply where the emissions of dioxin-like PCBs are proven to be less than 0.01 ng WHO-TEQ/Nm³.

	operated with urea		
CO	Incineration of waste	**Generic EN standards**	**Continuous**
SO_2	Incineration of waste	**Generic EN standards**	**Continuous**
HCl	Incineration of waste	**Generic EN standards**	**Continuous**
HF	Incineration of waste	**Generic EN standards**	**Continuous (4)**
Dust	Bottom ash treatment	**EN 13284-1**	**N/A**
	Incineration of waste	**Generic EN standards and EN 13284-2**	**Continuous -**
Metals and metalloids except mercury (As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sb, Tl, V)	Incineration of waste	**EN 14385**	**Once every six months**
Hg	Incineration of waste	**Generic EN standards and EN 14884**	**Once every 6 months**
TVOC	Incineration of waste	**Generic EN standards**	**Continuous**
PBDD/F	Incineration of waste (6)	**No EN standard available**	**N/A**
PCDD/F	Incineration of waste	**EN 1948-1, EN 1948-2, EN 1948-3**	**Once every six months for short-term sampling, method used was EN 1948-2/3**
		No EN standard available for long-term sampling, EN 1948-2, EN 1948-3	**N/A**
Dioxin-like PCBs	Incineration of waste	**EN 1948-1, EN 1948-2, EN 1948-4**	**Once every six months for short-term sampling (8)**
		No EN standard available for long-term sampling, EN 1948-2, EN 1948-4	**Report method used was EN 1948-4**
Benzo[*a*]pyrene	Incineration of waste	**No EN standard available**	**Bi-anually as Polyaromatic Hydrocarbons (PAH) testing according to ISO 11338-1**

BAT 5	BAT is to appropriately monitor channelled emissions to air from the incineration plant during Other Than Normal Operating Conditions (OTNOC) **Description:**	**Operations in OTNOC have been less than 15 hours/year** **Refer to Annex 4**		Operator to provide clarification as to whether the only OTNOC scenario being considered in the reply is when the	Noted.

Air emission monitoring during OTNOC	The monitoring can be carried out by direct emission measurements (e.g. for the pollutants that are monitored continuously) or by monitoring of surrogate parameters if this proves to be of equivalent or better scientific quality than direct emission measurements. Emissions during start-up and shutdown while no waste is being incinerated, including emissions of PCDD/F, are estimated based on measurement campaigns, e.g. every three years, carried out during planned start-up/shutdown operations.			emeregency stack is utilised. It is to be noted that during emergency stack use, emissions are calculated. In what other OTNOC scenerios are the emissions calculated? To include but not limited to: 1. Non-planned start-up & shut down when waste is burning **These are constantly monitored as part of the normal operations.** 2. Leaks **These are constantly monitored as part of the normal operations.** 3. Malfucntions – **constantly monitored unless ERS is triggered, at which point Annex 4 is used.** 4. Breakdown **constantly monitored unless ERS is triggered, at which point Annex 4 is used.** 5. Bypassing of abatments systems **These are constantly monitored as part of the normal operations.** 6. Other exceptional conditions – **not envisaged.**	
BAT 6 **Emission to water from FGC and/or bottom ash treatment**	To monitor emissions to water from FGC and/or bottom ash treatment with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	Operator to populate table if applicable: **N/A Processes are dry**		Non-applicability declaration noted.	

Substance/Parameter	Process	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Total organic carbon (TOC)	FGC	EN 1484	Once every month	BAT 34
	Bottom ash treatment		Once every month ([1])	
Total suspended solids (TSS)	FGC	EN 872	Once every day ([2])	
	Bottom ash treatment		Once every month ([1])	
As	FGC	Various EN standards available (e.g. EN ISO 11885, EN ISO 15586 or EN ISO 17294-2)	Once every month	
Cd	FGC			
Cr	FGC			
Cu	FGC			
Mo	FGC			
Ni	FGC			
Pb	FGC		Once every month	
	Bottom ash treatment		Once every month ([1])	
Sb	FGC		Once every month	
Tl	FGC			
Zn	FGC			
Hg	FGC	Various EN standards available (e.g. EN ISO 12846 or EN ISO 17852)		
Ammonium-nitrogen (NH_4-N)	Bottom ash treatment	Various EN standards available (e.g. EN ISO 11732, EN ISO 14911)	Once every month ([1])	
Chloride (Cl^-)	Bottom ash treatment	Various EN standards available (e.g. EN ISO 10304-1, EN ISO 15682)		
Sulphate (SO_4^{2-})	Bottom ash treatment	EN ISO 10304-1		
PCDD/F	FGC	No EN standard available	Once every month ([1])	
	Bottom ash treatment		Once every six months	

([1]) The monitoring frequency may be at least once every six months if the emissions are proven to be sufficiently stable.

([2]) The daily 24-hour flow-proportional composite sampling measurements may be substituted by daily spot sample measurements.

Substance/Parameter	Process	Standard(s) being utilised	monitoring frequency being implemented
Total organic carbon (TOC)	FGC		
	Bottom ash treatment		
Total suspended solids (TSS)	FGC		
	Bottom ash treatment		
As	FGC		
Cd	FGC		
Cr	FGC		
Cu	FGC		
Mo	FGC		
Ni	FGC		
Pb	FGC		
	Bottom ash treatment		
Sb	FGC		
Tl	FGC		
Zn	FGC		
Hg	FGC		
Ammonium-nitrogen (NH_4-N)	Bottom ash treatment		
Chloride (Cl^-)	Bottom ash treatment		
Sulphate (SO_4^{2-})	Bottom ash treatment		
PCDD/F	FGC		
	Bottom ash treatment		

<table>
<tr>
<td>BAT 7

Ash monitoring: content of unburnt substances in slags and bottom ashes</td>
<td>BAT is to monitor the content of unburnt substances in slags and bottom ashes at the incineration plant with at least the frequency given below and in accordance with EN standards.
<table>
<tr><th>Parameter</th><th>Standard(s)</th><th>Minimum monitoring frequency</th><th>Monitoring associated with</th></tr>
<tr><td>Loss on ignition ([1])</td><td>EN 14899 and either EN 15169 or EN 15935</td><td rowspan="2">Once every three months</td><td rowspan="2">BAT 14Error! Reference source not found.</td></tr>
<tr><td>Total organic carbon ([1]) ([2])</td><td>EN 14899 and either EN 13137 or EN 15936</td></tr>
<tr><td colspan="4">([1]) Either the loss on ignition or the total organic carbon is monitored.

([2]) Elemental carbon (e.g. determined according to DIN 19539) may be subtracted from the measurement result.</td></tr>
</table></td>
<td>Kindly provide required details pertaining to unburnt substances in slags and bottom ashes:
Average for the period:
<table>
<tr><th>Parameter</th><th>monitoring frequency</th></tr>
<tr><td>Loss on ignition ([1])</td><td>Bottom ash: once a month – weekly samples tested in case exceedance noted for the monthly analysis

SLAGS (filter cake and boiler dust) – test carried out every 6 months on one sample of each</td></tr>
<tr><td>Total organic carbon ([1]) ([2])</td><td>Bottom ash: once a month – weekly samples tested in case exceedance noted for the monthly analysis

SLAGS (filter cake and boiler dust) – test carried out every 6 months on one sample of each</td></tr>
</table></td>
<td></td>
<td>Monitoring requirement for SLAGS is be increased to the frequency prescribed by the BAT conclusion.

Noted. To be included in future tenders of EMPs.</td>
<td>Noted, item will be reflected in updated permit.</td>
</tr>
<tr>
<td>BAT 8

POP content in output streams</td>
<td>For the incineration of hazardous waste containing POPs, BAT is to determine the POP content in the output streams (e.g. slags and bottom ashes, flue-gas, waste water) after the commissioning of the incineration plant and after each change that may significantly affect the POP content in the output streams.

Description

The POP content in the output streams is determined by direct measurements or by indirect methods (e.g. the cumulated quantity of POPs in the fly ashes, dry FGC residues, waste water from FGC and related waste water treatment sludge may be determined by monitoring the POP contents in the flue-gas before and after the FGC system) or based on studies representative of the plant.

Applicability

Only applicable for plants that:
• incinerate hazardous waste with POP levels prior to incineration exceeding the concentration limits defined in Annex IV to Regulation (EC) No 850/2004 and amendments; and
• Do not meet the process description specifications of Chapter IV.G.2 point (g) of the UNEP technical guidelines UNEP/CHW.13/6/Add.1/Rev.1.</td>
<td>Kindly indicate whether a POP assessment in the output streams has been carried out.
<table>
<tr><th>Output stream</th><th>POP assessment
POPS considered: dioxins, furans, PCBs (and PAHs)</th></tr>
<tr><td>Slags and bottom ashes</td><td>Bottom ash: tested once a month for Total content of Dioxins and Furans (PCDD + PcDF I-TEQ)– weekly samples tested in case exceedance noted for the monthly analysis

SLAGS (filter cake and boiler dust) – tested every 6 months for Total content of Dioxins and Furans (PCDD + PcDF I-TEQ)– carried out every 6 months on one sample of each</td></tr>
<tr><td>Flue-gas</td><td>Monitored once every 6 months for PCBs, dioxins and furans, and PAHs</td></tr>
<tr><td>Waste water</td><td>No equipment to test water sample in-house for any POPs mentioned</td></tr>
</table></td>
<td></td>
<td>Noted.</td>
<td></td>
</tr>
<tr>
<td colspan="2">1.3. General environmental and combustion performance</td>
<td></td><td></td><td></td><td></td>
</tr>
<tr>
<td>BAT 9</td>
<td>In order to improve the overall environmental performance of the incineration plant by waste stream management, BAT is to use all of the techniques (a) to (c) given below, and, where relevant, also techniques (d), (e) and (f).</td>
<td></td><td></td><td></td><td></td>
</tr>
</table>

<table>
<tr>
<td>Waste stream management</td>
<td></td>
<td>
<table>
<tr><th></th><th>Technique</th><th>Description</th></tr>
<tr><td>a.</td><td>Determination of the types of waste that can be incinerated</td><td>Based on the characteristics of the incineration plant, identification of the types of waste which can be incinerated in terms of, for example, the physical state, the chemical characteristics, the hazardous properties, and the acceptable ranges of calorific value, humidity, ash content and size.</td></tr>
<tr><td>b.</td><td>Set-up and implementation of waste characterisation and pre-acceptance procedures</td><td>These procedures aim to ensure the technical (and legal) suitability of waste treatment operations for a particular waste prior to the arrival of the waste at the plant. They include procedures to collect information about the waste input and may include waste sampling and characterisation to achieve sufficient knowledge of the waste composition. Waste pre-acceptance procedures are risk-based considering, for example, the hazardous properties of the waste, the risks posed by the waste in terms of process safety, occupational safety and environmental impact, as well as the information provided by the previous waste holder(s).</td></tr>
<tr><td>c.</td><td>Set-up and implementation of waste acceptance procedures</td><td>Acceptance procedures aim to confirm the characteristics of the waste, as identified at the pre-acceptance stage. These procedures define the elements to be verified upon the delivery of the waste at the plant as well as the waste acceptance and rejection criteria. They may include waste sampling, inspection and analysis. Waste acceptance procedures are risk-based considering, for example, the hazardous properties of the waste, the risks posed by the waste in terms of process safety, occupational safety and environmental impact, as well as the information provided by the previous waste holder(s). The elements to be monitored for each type of waste are detailed in BAT 11.</td></tr>
<tr><td>d.</td><td>Set-up and implementation of a waste tracking system and inventory</td><td>A waste tracking system and inventory aims to track the location and quantity of waste in the plant. It holds all the information generated during waste pre-acceptance procedures (e.g. date of arrival at the plant and unique reference number of the waste, information on the previous waste holder(s), pre-acceptance and acceptance analysis results, nature and quantity of waste held on site including all identified hazards), acceptance, storage, treatment and/or transfer off site. The waste tracking system is risk-based considering, for example, the hazardous properties of the waste, the risks posed by the waste in terms of process safety, occupational safety and environmental impact, as well as the information provided by the previous waste holder(s).

The waste tracking system includes clear labelling of wastes that are stored in places other than the waste bunker or sludge storage tank (e.g. in containers, drums, bales or other forms of packaging) such that they can be identified at all times.</td></tr>
<tr><td>e.</td><td>Waste segregation</td><td>Wastes are kept separated depending on their properties in order to enable easier and environmentally safer storage and incineration. Waste segregation relies on the physical separation of different wastes and on procedures that identify when and where wastes are stored.</td></tr>
<tr><td>f.</td><td>Verification of waste compatibility prior to the mixing or blending of hazardous wastes</td><td>Compatibility is ensured by a set of verification measures and tests in order to detect any unwanted and/or potentially dangerous chemical reactions between wastes (e.g. polymerisation, gas evolution, exothermal reaction, decomposition) upon mixing or blending. The compatibility tests are risk-based considering, for example, the hazardous properties of the waste, the risks posed by the waste in terms of process safety, occupational safety and environmental impact, as well as the information provided by the previous waste holder(s).</td></tr>
</table>
</td>
<td>
<table>
<tr><td rowspan="8">Mandatory</td><td rowspan="6">a)</td><td rowspan="6">waste characterization</td><td>Physical state</td><td>YES</td></tr>
<tr><td>Chemical characterisatics</td><td>YES</td></tr>
<tr><td>Hazardous ranges of calorific value</td><td>YES</td></tr>
<tr><td>Humidity</td><td>YES</td></tr>
<tr><td>Ash content</td><td>NO</td></tr>
<tr><td>Size</td><td>YES</td></tr>
<tr><td></td><td colspan="3">Kindly attach the waste acceptance criteria</td></tr>
<tr><td>b)</td><td colspan="3">Refer to Annexes 5 and 6</td></tr>
<tr><td></td><td>c)</td><td colspan="3">Refer to Annexes 5 and 6</td></tr>
<tr><td rowspan="3">Where applicable</td><td>d)</td><td colspan="3">Refer to Annexes 7</td></tr>
<tr><td>e)</td><td colspan="3">Refer to Annexes 8</td></tr>
<tr><td>f)</td><td colspan="3">Refer to Annexes 5</td></tr>
</table>
</td>
<td></td>
<td>1. Operator to indicate date and method statement by when the mandatory montiroing of ash content will be implemented.
Refer to Annex II - Air quality & Waste Unit

2. In relation to Annex 5, Annex 6 and Annex 7 operator complete documentation as opposed to the schematic in the SOP.

TTF EP09 – Testing and Monitoring of Samples- This procedure sets the standard for the testing of hazardous material prior to acceptance for incineration at the Thermal Treatment Facility (TTF). It is only applicable for new material which was never accepted beforehand and limited information is provided.
TTF QP01 – Waste Enquiry Procedure- This procedure documents the method by which waste enquiries from third parties are forwarded by the Waste Acceptance department and processed at the Thermal Treatment Facility (TTF) by the scientist. Procedure provides guidelines on what needs to be checked prior to waste acceptance at TTF.
TTF QP05 – Monitoring of Ground Emissions- This procedure sets the standard for the monitoring of ground emissions (Boiler Dust, Bottom Ash and Filter Cake) generated at the Thermal Treatment Facility (TTF) as per IPPC Permit IP0004/07.

3. Annex 8 – kindly also provide reference documents listed in the provided SOP. In the event that such documentation is confidential, such documentation will not be put in the public domain.

Full documentations has been provided in Annex XV1</td>
<td>1.
Requirement remains unaddressed, timeframes will be required as an improvement programme items.

Routine tests are being performed. Methodology for bottom ash characterisation is attached as Annex XXII.

Furthermore, a trail is being conducted to assess effect of waste type (specifically pharmaceutical waste) with bottom ash results (specifically chromium content / level).

2.
Submisisons are noted, but will required further discussions with WSM.

3.
Noted.</td>
</tr>
<tr>
<td>BAT 10

Bottom ash treatment</td>
<td colspan="2">In order to improve the overall environmental performance of the bottom ash treatment plant, BAT is to include output quality management features in the EMS (BAT 1).

Description
Output quality management features are included in the EMS, so as to ensure that the output of the bottom ash treatment is in line with expectations, using existing EN standards where available. This also allows the performance of the bottom ash treatment to be monitored and optimised.</td>
<td>There is no bottom ash treatment plant as the rendered volumes make any treatment unfeasible.</td>
<td></td>
<td>The current practice of directing this to landfill without pre treatment is in breach of Landfill Directive. According to the Bottom Ash report submitted to ERA in May 2017 indicated that in certain instances the leaching test results of the bottom ash showed values exceeding thresholds laid down in Council Decision 2003/33/EC for non-hazardous landfills. Therefore reply related to feasibility is not acceptable as it is a legal requirement.

See BAT 9.</td>
<td>See comments in statutory consultation.</td>
</tr>
</table>

<table>
<tr>
<td>BAT 11

Waste acceptance procedures</td>
<td>In order to improve the overall environmental performance of the incineration plant, BAT is to monitor the waste deliveries as part of the waste acceptance procedures (BAT 9c) including, depending on the risk posed by the incoming waste, the elements given below.
<table>
<tr><td>Waste type</td><td>Waste delivery monitoring</td></tr>
<tr><td>Municipal solid waste and other non-hazardous waste</td><td>
• Radioactivity detection
• Weighing of the waste deliveries
• Visual inspection
• Periodic sampling of waste deliveries and analysis of key properties/substances (e.g. calorific value, content of halogens and metals/metalloids). For municipal solid waste, this involves separate unloading.</td></tr>
<tr><td>Sewage sludge</td><td>
• Weighing of the waste deliveries (or measuring the flow if the sewage sludge is delivered via pipeline)
• Visual inspection, as far as technically possible
• Periodic sampling and analysis of key properties/substances (e.g. calorific value, content of water, ash and mercury)</td></tr>
<tr><td>Hazardous waste other than clinical waste</td><td>
• Radioactivity detection
• Weighing of the waste deliveries
• Visual inspection, as far as technically possible
• Control and comparison of individual waste deliveries with the declaration of the waste producer
• Sampling of the content of:
o all bulk tankers and trailers
o packed waste (e.g. in drums, intermediate bulk containers (IBCs) or smaller packaging)
and analysis of:
o combustion parameters (including calorific value and flashpoint)
o waste compatibility, to detect possible hazardous reactions upon blending or mixing of wastes, prior to storage (BAT 9 f)
o key substances including POPs, halogens and sulphur, metals/metalloids</td></tr>
<tr><td>Clinical waste</td><td>
• Radioactivity detection
• Weighing of the waste deliveries
• Visual inspection of the packaging integrity</td></tr>
</table></td>
<td>Operator to elaborate on whether the below elements are included as part of the waste acceptance procedures:
<table>
<tr><td>Waste type</td><td>Waste delivery monitoring</td><td>WSM reply</td></tr>
<tr><td>Municipal solid waste and other non-hazardous waste</td><td>Radioactivity detection</td><td>Yes</td></tr>
<tr><td></td><td>Weighing of the waste deliveries</td><td>Yes</td></tr>
<tr><td></td><td>Visual inspection</td><td>Yes</td></tr>
<tr><td></td><td>Periodic sampling of waste deliveries and analysis of key properties/substances (e.g. calorific value, content of halogens and metals/metalloids). For municipal solid waste, this involves separate unloading.</td><td>No since information about hazardous waste is being provided by the waste producer or concerned authority</td></tr>
<tr><td>Sewage sludge</td><td>Weighing of the waste deliveries (or measuring the flow if the sewage sludge is delivered via pipeline)</td><td>N/A</td></tr>
<tr><td></td><td>Visual inspection, as far as technically possible</td><td>N/A</td></tr>
<tr><td></td><td>Periodic sampling and analysis of key properties/substances (e.g. calorific value, content of water, ash and mercury)</td><td>N/A</td></tr>
<tr><td>Hazardous waste other than clinical waste</td><td>Radioactivity detection</td><td>Yes</td></tr>
<tr><td></td><td>Weighing of the waste deliveries</td><td>Yes</td></tr>
<tr><td></td><td>Visual inspection, as far as technically possible</td><td>Yes</td></tr>
<tr><td></td><td>Control and comparison of individual waste deliveries with the declaration of the waste producer</td><td>Yes</td></tr>
<tr><td></td><td>Sampling of the content of:
• all bulk tankers and trailers
• packed waste (e.g. in drums, intermediate bulk containers (IBCs) or smaller packaging)
and analysis of:
• combustion parameters (including calorific value and flashpoint)
• waste compatibility, to detect possible hazardous reactions upon blending or mixing of wastes, prior to storage (BAT 9 f)
• key substances including POPs, halogens and sulphur, metals/metalloids</td><td>No since information about hazardous waste is being provided by the waste producer</td></tr>
<tr><td>Clinical waste</td><td>Radioactivity detection</td><td>Yes</td></tr>
<tr><td></td><td>Weighing of the waste deliveries</td><td>Yes</td></tr>
<tr><td></td><td>Visual inspection of the packaging integrity</td><td>Yes</td></tr>
</table></td>
<td></td>
<td>1. On the periodic sampling, Operator to confirm whether no testing is carried out on the waste that is declared as non-hazardous . It is also to be clarified as to whether WSM relies solely on the declaration provided by the waste producer for its waste acceptance procedures.
2. On the periodic sampling, Operator to confirm whether no testing is carried out on waste that is declared as hazardous waste and WSM rrelies solely on the declaration provided by the waste procuder for its waste acceptance procedures.

ERA feels that relying solely on information provided by waste producers in all instances is insufficient and periodic checks through sampling and analysis by Wasteserv should be standard practice.

WSM carries out regular monitoring and tests as required. Details of current procedures are found in Annex XV.</td>
<td>Noted.</td>
</tr>
</table>

BAT 12

Waste storage practices

In order to reduce the environmental risks associated with the reception, handling and storage of waste, BAT is to use both of the techniques given below.

	Technique	Description
a.	Impermeable surfaces with an adequate drainage infrastructure	Depending on the risks posed by the waste in terms of soil or water contamination, the surface of the waste reception, handling and storage areas is made impermeable to the liquids concerned and fitted with an adequate drainage infrastructure (BAT 32). The integrity of this surface is periodically verified, as far as technically possible.
b.	Adequate waste storage capacity	Measures are taken to avoid accumulation of waste, such as: • the maximum waste storage capacity is clearly established and not exceeded, taking into account the characteristics of the wastes (e.g. regarding the risk of fire) and the treatment capacity; • the quantity of waste stored is regularly monitored against the maximum allowed storage capacity; • for wastes that are not mixed during storage (e.g. clinical waste, packed waste), the maximum residence time is clearly established.

Technique	Measures being implemned
Impermeable surfaces with an adequate drainage infrastructure	**All waste liquid is contained in areas with impermeable** **surface and is directed to leak proof cesspits**
Adequate waste storage capacity	**Yes**

- **Is impermeability recertified periodically? Yes**
- **Is the maximum waste storage capacacity for each category of waste established? Yes, maximum volumes established**
- **Is the quantity of waste stored is regularly monitored against the maximum allowed storage capacity? Yes,**
- **Is a miximum residence time established for each category of waste? The plant includes refrigeration section to house any waste material that is not incinerated upon acceptance. Waste stored in reefers at -18 deg celcuis has a maximum storage period of 4 weeks.**

1. With respect to the impermeability certification, kindly provide details. It is to be noted that the LGW risk assessment (NOV 2016) provided states that the integrity of the containment systems have not been tested. Operator to providedetails on method and frequency of recertification.
   Certification attached as Annex V. Re-certification shall be carried out once every four years or at a shorter term if the requirement arises.
2. Kindly indicate the maximum waste storage capacity for each waste category (by EWC). Maximum volumes are to be provided. Such details will be included in the permit.
   Refer to Annex XX.
3. Kindly provide an exhaustive list of maximum storage or holding period for each waste category acceptance on site (not stored in reefers).
   Refer to Annex XX.

1. Noted.

2. Annex XX not submitted kindly resubmit.
Attached.

3. Annex XX not submitted kindly resubmit.
Attached.

BAT 13

Storage practices Clinical waste

In order to reduce the environmental risk associated with the storage and handling of clinical waste, BAT is to use a combination of the techniques given below

	Technique	Description
a.	Automated or semi-automated waste handling	Clinical wastes are unloaded from the truck to the storage area using an automated or manual system depending on the risk posed by this operation. From the storage area the clinical wastes are fed into the furnace by an automated feeding system.
b.	Incineration of non-reusable sealed containers, if used	Clinical waste is delivered in sealed and robust combustible containers that are never opened throughout storage and handling operations. If needles and sharps are disposed of in them, the containers are puncture-proof as well.

Which of the following techniques are utilised to reduce the risk associated with the storage and handling of clinical waste?

	Technique	Measures/methods implemented
a.	Automated or semi-automated waste handling	**No, waste is moved manually, as per original plant design.**
b.	Incineration of non-reusable sealed containers, if used	**Yes**
c.	Cleaning and disinfection of reusable containers, if used	**No, containers are incinerated, as per original plant design.**

a) WSM to indicate whether there is any plan to automate or semi-automate the waste Handling of clinical waste. If so kindly provide timeframes. **Under the existing setup the possibility of semi automating the handling system is unachievable since this setup would required additional space that is unavailable.**
b) Noted
c) Noted

Applicant to confirm whether all containers utilised for clinical waste are incinerated.

Yellow bins and IBCs are not disposable hence they are reused accordingly.

c.	Cleaning and disinfection of reusable containers, if used	Reusable waste containers are cleaned in a designated cleaning area and disinfected in a facility specifically designed for disinfection. Any leftovers from the cleaning operations are incinerated.

BAT 14

Optimisation techniques to improve the overall environmental performance of the incineration of waste

In order to improve the overall environmental performance of the incineration of waste, to reduce the content of unburnt substances in slags and bottom ashes, and to reduce emissions to air from the incineration of waste, BAT is to use an appropriate combination of the techniques given below.

Kindly provide details as to whether one or more of the following techniques is being implemented

Noted.

	Technique	Description	Applicability
a.	Waste blending and mixing	Waste blending and mixing prior to incineration includes for example the following operations: • bunker crane mixing; • using a feed equalisation system; • blending of compatible liquid and pasty wastes. In some cases, solid wastes are shredded prior to mixing.	Not applicable where direct furnace feeding is required due to safety considerations or waste characteristics (e.g. infectious clinical waste, odorous wastes, or wastes that are prone to releasing volatile substances). Not applicable where undesired reactions may occur between different types of waste (BAT 9).
b.	Advanced control system	Section 2.1	Generally applicable.
c.	Optimisation of the incineration process	Section 2.1	Optimisation of the design is not applicable to existing furnaces.

Technique	Yes/No
Waste blending and mixing	**Yes**
Advanced control system	**No**
Optimisation of the incineration process	**N/A**

Operator to provide justification as to why an advanced control system is not being considered in view of the past environmental performance.

The incineration system is currently reaching its end of lifetime cycle. Replacing the control system would involve heavy investment that would amount to 50% of replacing the existing equipment. Not withstanding this all operators are being trained to ameliorate current practices.

Applicant is to provide details on how the training shall amelioerate current practice.

Through training, Head of Shifts learn to operate the plant with the least resulting emissions.

Table 1: BAT-associated environmental performance levels for unburnt substances in slags and bottom ashes from the incineration of waste

Parameter	Unit	BAT-AEPL
TOC content in slags and bottom ashes (1)	Dry wt-%	1–3 (2)
Loss on ignition of slags and bottom ashes (1)	Dry wt-%	1–5 (2)

(1) Either the BAT-AEPL for TOC content or the BAT-AEPL for the loss on ignition applies.

(2) The lower end of the BAT-AEPL range can be achieved when using fluidised bed furnaces or rotary kilns operated in slagging mode.

The associated monitoring is in BAT 7

Kindly indicate test results for slags and bottom ashes:

Parameter	Dry wt-%							
	Jan '19	**Feb '19**	**Mar '19**	**Apr '19**	**May '19**	**Jul '19**	**Aug**	**Sept '19**
TOC content in bottom ashes	**0.974**	**0.28**	**0.845**	**0.171**	**<0.1**	**<0.1**	**<0.1**	**0.19**
Loss on ignition of bottom ashes	**1.31**	**0.13**	**0.41**	**<0.1**	**3.1**	**3.4**	**5.4**	**0.12**

Parameter	Dry wt-%			
	July - #1	**July- #2**	**July - #3**	**July - #4**
TOC content in bottom ashes	**<0.1**	**<0.1**	**<0.1**	**<0.1**
Loss on ignition of bottom ashes	**<0.1**	**0.2**	**0.2**	**<0.1**

Parameter	Dry wt-%			
	Mar 19 – filter cake	**Mar 19 – boiler dust**	**Sept 19 – filter cake**	**Sept 19 – boiler dust**
TOC content in slags	**N/A**	**N/A**	**N/A**	**N/A**
Loss on ignition of slags	**N/A**	**N/A**	**N/A**	**N/A**

Noted.

BAT 15

Automated control systems

In order to improve the overall environmental performance of the incineration plant and to reduce emissions to air, BAT is to set up and implement procedures for the adjustment of the plant's settings, e.g. through the advanced control system (Section 2.1), as and when needed and practicable, based on the characterisation and control of the waste (BAT 11).

What measures are in place to ascertain adherance to air emissions ELVs?
O2 control with drum revolution control loading enables PCC to operate at 1000 and SCC to operate at 920-1000 Deg. Celcius.
Control air speed between 30 and 90 m/s to ensure proper mixing

Operator to provide justification as to why an advanced control system is not being considered in view of the past environmental performance
Refer to Bat 14.

See reply above.

BAT 16 **Shutdown and Start-up practices**	In order to improve the overall environmental performance of the incineration plant and to reduce emissions to air, BAT is to set up and implement operational procedures (e.g. organisation of the supply chain, continuous rather than batch operation) to limit as far as practicable shutdown and start-up operations.	Operator is to indicate what measures are being carried out to actively reduce shutdown and start-up operations. **Redesign of burnout air system to ensure homogeneous air temperature** **Upgrades on plant to delay clogging of bottle neck areas: such as retractable soot blower in boiler entrance. This enabled the plant to run for an extra 2-3weeks before getting clogged.**		Operator to clarify whether such improvements have been carried already. Operator to provide tangible proof that such measures will reduce the frequency of shutdown and start-up operations. **Upgrades on the plant have been carried out. A retractable soot blower system has been installed in Nov-Dec 2016 increasing the operational period from 4-5 weeks to 7-8 weeks. The burnout air system it is currently being projected. Due to Covid 19 works are moving slowly.**	Noted.
BAT 17 **Operation of FGC systems and waste water treatment system**	In order to reduce emissions to air and, where relevant, to water from the incineration plant, BAT is to ensure that the FGC system and the waste water treatment plant are appropriately designed (e.g. considering the maximum flow rate and pollutant concentrations), operated within their design range, and maintained so as to ensure optimal availability.	The temperatures in the incinerator are controlled to ensure the lack of formation of NO_xs , furans, etc. **A WWTP is installed on site and is able to meet the limits indicated in SL 545.08.** **FGC system is not applicable to the plant**		Comments from Water Services Corporation in the statuorty consultation are referred. ERA is in disagreement with such a statement. Comment on FGC is noted. **WSM has completed the WWTP upgrade and is currently awaiting for the bacteria to fully proliferate. It is expected that the plant shall return to full operations by the end of the month.**	Noted, matter be dfiscussed further with WSC and WSM.
BAT 18 **Other Than Normal Operating Conditions**	In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air and, where relevant, to water from the incineration plant during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the environmental management system (BAT 1) that includes all of the following elements: • Identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences, and regular review and update of the list of identified OTNOC following the periodic assessment below; • Appropriate design of critical equipment (e.g. compartmentalisation of the bag filter, techniques to heat up the flue-gas and obviate the need to bypass the bag filter during start-up and shutdown, etc.); • Set-up and implementation of a preventive maintenance plan for critical equipment (**Error! Reference source not found.** xii); • Monitoring and recording of emissions during OTNOC and associated circumstances (BAT 5); • Periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary.	**Emissions are being monitored and recorded on a half hourly basis; hence emission control is conducted continuously.** **Preventive maintenance is carried out as per schedule. During shutdowns, which happen every 6-9 weeks, all major preventives are performed limiting potential failures leading to OTNOC are repaired immediately.**		Kindly clarify whether an OTNOC management plan is in place. **This management plant is fully in place as described elsewhere in this document.**	Noted.
1.4 Energy efficiency					
BAT 20 **Energy efficiency techniques**	**In order to increase the energy efficiency of the incineration plant, BAT is to use an appropriate combination of the techniques given below.**	**Operator to indicate what is the overall status in terms of energy efficiency. And to indicate whether the below techniques are being implemented. The Operator is also to indicate what plans are there to improve energy efficiency (if applicable).**			

	Technique	Description	Applicability
a.	Drying of sewage sludge	After mechanical dewatering, sewage sludge is further dried, using for example low-grade heat, before it is fed to the furnace. The extent to which sludge can be dried depends on the furnace feeding system.	Applicable within the constraints associated with the availability of low-grade heat.
b.	Reduction of the flue-gas flow	The flue-gas flow is reduced through, e.g.: • improving the primary and secondary combustion air distribution; • flue-gas recirculation (Section 2.2). A smaller flue-gas flow reduces the energy demand of the plant (e.g. for induced draught fans).	For existing plants, the applicability of flue-gas recirculation may be limited due to technical constraints (e.g. pollutant load in the flue-gas, incineration conditions).
c.	Minimisation of heat losses	Heat losses are minimised through, e.g.: • use of integral furnace-boilers, allowing for heat to also be recovered from the furnace sides; • thermal insulation of furnaces and boilers; • flue-gas recirculation (Section 2.2); • recovery of heat from the cooling of slags and bottom ashes (BAT 20 i).	Integral furnace-boilers are not applicable to rotary kilns or to other furnaces dedicated to the high-temperature incineration of hazardous waste.
d.	Optimisation of the boiler design	The heat transfer in the boiler is improved by optimising, for example, the: • flue-gas velocity and distribution; • water/steam circulation; • convection bundles; • on-line and off-line boiler cleaning systems in order to minimise the fouling of the convection bundles.	Applicable to new plants and to major retrofits of existing plants.
e.	Low-temperature flue-gas heat exchangers	Special corrosion-resistant heat exchangers are used to recover additional energy from the flue-gas at the boiler exit, after an ESP, or after a dry sorbent injection system.	Applicable within the constraints of the operating temperature profile of the FGC system. In the case of existing plants, the applicability may be limited by a lack of space.
f.	High steam conditions	The higher the steam conditions (temperature and pressure), the higher the electricity conversion efficiency allowed by the steam cycle. Working at high steam conditions (e.g. above 45 bar, 400 °C) requires the use of special steel alloys or refractory cladding to protect the boiler sections that are exposed to the highest temperatures.	Applicable to new plants and to major retrofits of existing plants, where the plant is mainly oriented towards the generation of electricity. The applicability may be limited by: • the stickiness of the fly ashes;

	Technique	Applicability
a	Drying of sewage sludge	**N/A**
b	Reduction of the flue-gas flow	**Yes**
c	Minimisation of heat losses	**Yes**
d	Optimisation of the boiler design	**Yes, through economiser**
e	Low-temperature flue-gas heat exchangers	**Yes**
f	High steam conditions	**No need for high steam conditions to power other systems**
g	Cogeneration	**No**
h	Flue-gas condenser	**Yes**
i	Dry bottom ash handling	**Yes**

Operator to indicate what plans are in place to improve energy efficiency.

There are a number of initiatives to improve efficiency, namely:

a. **Optimization on the waste classification to use its calorific value and reduce fuel consumed**
b. **Upgrading the refrigeration systems to reduce energy consumption**
c. **Constant monitoring on the auxiliary boilers / economizers to utilize heat dissipated to heat incoming water supply**

Noted.

	Technique	Description	Applicability
			• the corrosiveness of the flue-gas.
g.	Cogeneration	Cogeneration of heat and electricity where the heat (mainly from the steam that leaves the turbine) is used for producing hot water/steam to be used in industrial processes/activities or in a district heating/cooling network.	Applicable within the constraints associated with the local heat and power demand and/or availability of networks.
h.	Flue-gas condenser	A heat exchanger or a scrubber with a heat exchanger, where the water vapour contained in the flue-gas condenses, transferring the latent heat to water at a sufficiently low temperature (e.g. return flow of a district heating network). The flue-gas condenser also provides co-benefits by reducing emissions to air (e.g. of dust and acid gases). The use of heat pumps can increase the amount of energy recovered from flue-gas condensation.	Applicable within the constraints associated with the demand for low-temperature heat, e.g. by the availability of a district heating network with a sufficiently low return temperature.
i.	Dry bottom ash handling	Dry, hot bottom ash falls from the grate onto a transport system and is cooled down by ambient air. Energy is recovered by using the cooling air for combustion.	Only applicable to grate furnaces. There may be technical restrictions that prevent retrofitting to existing furnaces.

Table 2: BAT-associated energy efficiency levels (BAT-AEELs) for the incineration of waste

Plant	BAT-AEEL (%)			
	Municipal solid waste, other non-hazardous waste and hazardous wood waste		**Hazardous waste other than hazardous wood waste ([1])**	**Sewage sludge**
	Gross electrical efficiency ([2]) ([3])	**Gross energy efficiency ([4])**	**Boiler efficiency**	
New plant	25–35	72–91 ([5])	60–80	60–70 ([6])
Existing plant	20–35			

([1]) The BAT-AEEL only applies where a heat recovery boiler is applicable.

([2]) The BAT-AEELs for gross electrical efficiency only apply to plants or parts of plants producing electricity using a condensing turbine.

([3]) The higher end of the BAT-AEEL range can be achieved when using BAT 20 f.

([4]) The BAT-AEELs for gross energy efficiency only apply to plants or parts of plants producing only heat or producing electricity using a back-pressure turbine and heat with the steam leaving the turbine.

([5]) A gross energy efficiency exceeding the higher end of the BAT-AEEL range (even above 100 %) can be achieved where a flue-gas condenser is used.

([6]) For the incineration of sewage sludge, the boiler efficiency is highly dependent on the water content of the sewage sludge as fed into the furnace.

The associated monitoring is in 0.

BAT-AEEL (%)			
Municipal solid waste, other non-hazardous waste and hazardous wood waste		**Hazardous waste other than hazardous wood waste ([1])**	**Sewage sludge**
Gross electrical efficiency ([2]) ([3])	**Gross energy efficiency ([4])**	**Boiler efficiency**	

Note: Incinerator is not designed for Waste to Energy

Kindly provide requested information

Kindly provide requested information since this BAT is not exclusively related to waste to energy plants.

Energy Flux computed and presented in Annex XXV.

1.5 Emissions to air

1.5.1 Diffuse emissions

BAT 21	In order to prevent or reduce diffuse emissions from the incineration plant, including odour emissions, BAT is to:				Timeframes are to be provided for the

<table>
<tr><td>Odour emissions</td><td>(a) store solid and bulk pasty wastes that are odorous and/or prone to releasing volatile substances in enclosed buildings under controlled subatmospheric pressure and use the extracted air as combustion air for incineration or send it to another suitable abatement system in the case of a risk of explosion;
(b) store liquid wastes in tanks under appropriate controlled pressure and duct the tank vents to the combustion air feed or to another suitable abatement system;
(c) control the risk of odour during complete shutdown periods when no incineration capacity is available, e.g. by:
a. sending the vented or extracted air to an alternative abatement system, e.g. a wet scrubber, a fixed adsorption bed;
(d) minimising the amount of waste in storage, e.g. by interrupting, reducing or transferring waste deliveries, as a part of waste stream management (BAT 9);
(e) storing waste in properly sealed bales</td><td><table><tr><td></td><td>Operator to indicate which of the indicated measures are being implemented</td></tr><tr><td>a</td><td>Being implemented</td></tr><tr><td>b</td><td>Liquid waste is not accepted</td></tr><tr><td>c</td><td>Waste stored at -18 deg celc</td></tr><tr><td>d</td><td>Scheduling of feed stock deliveries</td></tr><tr><td>e</td><td>Stored in sealed IBCs</td></tr></table></td><td></td><td>Operator to provide reply on the measures being implemented on site.

WSM is currently studying the rerouting of air from the scrubber, Abattoir and Clinical Waste are stored in refrigerated chambers at 5 Degrees Celcius Maximum. WSM is working on installing an extraction system for the shredding room and bottom ash chamber.</td><td>implementation of the wet scrubber system.

Refer to Annex XXI.</td></tr>
<tr><td>BAT 22

Direct feeding of odorous waste</td><td>In order to prevent diffuse emissions of volatile compounds from the handling of gaseous and liquid wastes that are odorous and/or prone to releasing volatile substances at incineration plants, BAT is to introduce them into the furnace by direct feeding.</td><td>Operator to indicate applicability.

Facility does not handle liquid and gaseous waste.</td><td></td><td>The operator indicated that they do not handle liquid or gaseous waste.

Despite stating the above, it is to note the presence of liquid blood, tallow, and tallow vapour generated from the autoclave process were not taken into account by the operator. Considering that the tallow storage tanks are located outside the autoclave building, and thus any odorous and gaseous emissions are not captured through the scrubbing system. Operator is to indicate how such emissions can be redirected to the furnace.
All vents protruding from the tallow tanks shall be connected together and rerouted back to the Autoclave plant so that fumes/odours can be captured by the air scrubbing system.</td><td>Noted.

Emissions from the tallow tanks shall be directed to the autoclave shed. The air inside the Autoclave shed shall be treated via a Chemical Scrubber and RTO. Refer to Annex XXI.</td></tr>
<tr><td>BAT 23

Techniques to reduce diffuse dust emissions to air from the treatment of slags and bottom ashes</td><td>In order to prevent or reduce diffuse dust emissions to air from the treatment of slags and bottom ashes, BAT is to include in the environmental management system (BAT 1) the following diffuse dust emissions management features:

• identification of the most relevant diffuse dust emission sources (e.g. using EN 15445);

• Definition and implementation of appropriate actions and techniques to prevent or reduce diffuse emissions over a given time frame.</td><td>If treatment of slags and bottom ashes are treated on site, Operator to indicate what measures are in place to prevent and/or reduce diffuse dust emissions.

Slags and bottom ashes are not treated on site.</td><td></td><td>Non-applicabiility statement noted.</td><td></td></tr>
<tr><td rowspan="2">BAT 24

Further techniques to reduce diffuse dust emissions to air from the treatment of slags and bottom ashes</td><td>In order to prevent or reduce diffuse dust emissions to air from the treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below.</td><td>If treatment of slags and bottom ashes are treated on site, Operator to indicate which of the below techniques are being utilized.
N/A no treatment is done on site. However enclosures and covers are included throughout the entire process. Stockpiles are stored safely.</td><td></td><td></td><td>Noted.</td></tr>
<tr><td><table><tr><td></td><td>Technique</td><td>Description</td><td>Applicability</td></tr><tr><td>a.</td><td>Enclose and cover equipment</td><td>Enclose/encapsulate potentially dusty operations (such as grinding, screening) and/or cover conveyors and elevators.

Enclosure can also be accomplished by installing all of the equipment in a closed building.</td><td>Installing the equipment in a closed building may not be applicable to mobile treatment devices.</td></tr><tr><td>b.</td><td>Limit height of discharge</td><td>Match the discharge height to the varying height of the heap, automatically if possible (e.g. conveyor belts with adjustable heights).</td><td>Generally applicable.</td></tr><tr><td>c.</td><td>Protect stockpiles against prevailing winds</td><td>Protect bulk storage areas or stockpiles with covers or wind barriers such as screening, walling or vertical greenery, as well as correctly orienting the stockpiles in relation to the prevailing wind.</td><td>Generally applicable.</td></tr><tr><td>d.</td><td>Use water sprays</td><td>Install water spray systems at the main sources of diffuse dust emissions. The humidification of dust particles aids dust agglomeration and settling.</td><td>Generally applicable.</td></tr></table></td><td><table><tr><td></td><td>Technique</td><td>Method</td></tr><tr><td>a.</td><td>Enclose and cover equipment</td><td>Yes</td></tr><tr><td>b.</td><td>Limit height of discharge</td><td>Yes</td></tr><tr><td>c.</td><td>Protect stockpiles against prevailing winds</td><td>Yes</td></tr><tr><td>d.</td><td>Use water sprays</td><td>No as stockpiling is limit</td></tr><tr><td>e.</td><td>Optimise moisture content</td><td>No</td></tr></table></td><td></td><td>Noted.</td><td></td></tr>
</table>

	Technique	Description	Applicability
		Diffuse dust emissions at stockpiles are reduced by ensuring appropriate humidification of the charging and discharging points, or of the stockpiles themselves.	
e.	Optimise moisture content	Optimise the moisture content of the slags/bottom ashes to the level required for efficient recovery of metals and mineral materials while minimising the dust release.	Generally applicable.
f.	Operate under subatmospheric pressure	Carry out the treatment of slags and bottom ashes in enclosed equipment or buildings (see technique a) under subatmospheric pressure to enable treatment of the extracted air with an abatement technique (BAT 26) as channelled emissions.	Only applicable to dry-discharged and other low-moisture bottom ashes.

	Technique	Applicability
f.	Operate under subatmospheric pressure	No

1.5.2 Channelled emissions

1.5.2.1 Emissions of dust, metals and metalloids

BAT 25

Air emissions abatement techniques (Particulate matter, metals, metalloids)

In order to reduce channelled emissions to air of dust, metals and metalloids from the incineration of waste, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a.	Bag filter	Section 2.2	Generally applicable to new plants. Applicable to existing plants within the constraints associated with the operating temperature profile of the FGC system.
b.	Electrostatic precipitator	Section 2.2	Generally applicable.
c.	Dry sorbent injection	Section 2.2 Not relevant for the reduction of dust emissions. Adsorption of metals by injection of activated carbon or other reagents in combination with a dry sorbent injection system or a semi-wet absorber that is used to reduce acid gas emissions.	Generally applicable.
d.	Wet scrubber	Section 2.2 Wet scrubbing systems are not used to remove the main dust load but, installed after other abatement techniques, to further reduce the concentrations of dust, metals and metalloids in the flue-gas.	There may be applicability restrictions due to low water availability, e.g. in arid areas.
e.	Fixed- or moving-bed adsorption	Section 2.2. The system is used mainly to adsorb mercury and other metals and metalloids as well as organic compounds including PCDD/F, but also acts as an effective polishing filter for dust.	The applicability may be limited by the overall pressure drop associated with the FGC system configuration. In the case of existing plants, the applicability may be limited by a lack of space.

Operator to indicate applicability:

	Technique	Applicability
a.	Bag filter	Yes
b.	Electrostatic precipitator	**No as bag house filter was sufficient in original plant design**
c.	Dry sorbent injection	Yes
d.	Wet scrubber	No
e.	Fixed- or moving-bed adsorption	No

No further comments from ERA as air emissions for dust emissions (monthly average data from 2019) were below the stipulated thresholds

Table 3: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, metals and metalloids from the incineration of waste

Parameter	BAT-AEL (mg/Nm³)	Averaging period

Parameter	**Average concentration (mg/Nm³) According to complete Flue gas**	Averaging period

For dust please provide daily averages for the purposes of comparibility with BAT requirements

Refer to Annex XIII

Noted.

Dust	< 2–5 ([1])	Daily average
Cd+Tl	0.005–0.02	Average over the sampling period
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	0.01–0.3	Average over the sampling period

([1]) For existing plants dedicated to the incineration of hazardous waste and for which a bag filter is not applicable, the higher end of the BAT-AEL range is 7 mg/Nm³.

The associated monitoring is in BAT 4.

	analysis carried out in July 2019	
Dust	6.1 mg/Nm3	Average over the sampling period
Cd	0.0007 mg/Nm3	Average over the sampling period
Tl	<0.0001 mg/Nm3	Average over the sampling period
Sb	0.0001 mg/Nm3	Average over the sampling period
As	0.0001 mg/Nm3	Average over the sampling period
Pb	0.008 mg/Nm3	Average over the sampling period
Cr	0.009 mg/Nm3	Average over the sampling period
Co	0.0002 mg/Nm3	Average over the sampling period
Cu	0.004 mg/Nm3	Average over the sampling period
Mn	0.006 mg/Nm3	Average over the sampling period
Ni	0.012 mg/Nm3	Average over the sampling period
V	0.0002 mg/Nm3	Average over the sampling period

BAT 26

Particulate matter from the enclosed treatment of slags and bottom ashes

In order to reduce channelled **dust emissions to air from the enclosed treatment of slags and bottom ashes** with extraction of air (**BAT 24 f), BAT is to treat the extracted air with a bag filter (Section 2.2).**

Table 4: BAT-associated emission levels (BAT-AELs) for channelled dust emissions to air from the enclosed treatment of slags and bottom ashes with extraction of air

Parameter	BAT-AEL (mg/Nm³)	Averaging period
Dust	2–5	Average over the sampling period

The associated monitoring is in **Error! Reference source not found.**.

N/A There is no treatment in the facility for slags and bottom ashes

Parameter	Monitoring result (mg/Nm³)
Dust	

Non-applicability is noted.

1.5.2.2 Emissions of HCl, HF and SO_2

BAT 27

Air emissions abatement techniques (HF/HCL/SO_2)

In order to reduce channelled peak emissions of HCl, HF and SO_2 to air from the incineration of waste while limiting the consumption of reagents and the amount of residues generated from dry sorbent injection and semi-wet absorbers, BAT is to use technique (a) or both of the techniques given below.

	Technique	Description	Applicability
a.	Wet scrubber	Section 2.2	There may be applicability restrictions due to low water availability, e.g. in arid areas.
b.	Semi-wet absorber	Section 2.2	Generally applicable.
c.	Dry sorbent injection	Section 2.2	Generally applicable.

Kindly specify which technique(s) shall be implemented to reduce emissions of HCl, HF, and SO_2.

	Technique	Applicability
a.	Wet scrubber	No
b.	Semi-wet absorber	No as the process is dry
c.	Dry sorbent injection	Yes
d.	Direct desulphurisation	No as it is not a fluidised bed

No further comments from ERA as monthly averages for HCl, HF & SO_2 emissions for 2019 were below the thresholds.

	Technique	Description	Applicability
d.	Direct desulphurisation	Section 2.2 Used for partial abatement of acid gas emissions upstream of other techniques.	Only applicable to fluidised bed furnaces.
e.	Boiler sorbent injection	Section 2.2 Used for partial abatement of acid gas emissions upstream of other techniques.	Generally applicable.

e.	Boiler sorbent injection	**No because a dry sorbent injection was found to be sufficient as per original plant design.**

BAT 28

Further air emissions abatement techniques (HF/HCL/SO$_2$)

In order to reduce channelled peak emissions of HCl, HF and SO$_2$ to air from the incineration of waste while limiting the consumption of reagents and the amount of residues generated from dry sorbent injection and semi-wet absorbers, BAT is to use technique (a) or both of the techniques given below.

	Technique	Description	Applicability
a.	Optimised and automated reagent dosage	The use of continuous HCl and/or SO$_2$ measurements (and/or of other parameters that may prove useful for this purpose) upstream and/or downstream of the FGC system for the optimisation of the automated reagent dosage.	Generally applicable.
b.	Recirculation of reagents	The recirculation of a proportion of the collected FGC solids to reduce the amount of unreacted reagent(s) in the residues. The technique is particularly relevant in the case of FGC techniques operating with a high stoichiometric excess.	Generally applicable to new plants. Applicable to existing plants within the constraints of the size of the bag filter.

Kindly specify which technique(s) shall be/are implemented to reduce emissions of HCl, HF, and SO$_2$.

	Technique	Applicability
a.	Optimised and automated reagent dosage	**The flow is calibrated upon test carried out by plant specialist based on plant performance. Emissions are monitored regularly and within limits. Feasibility study on the operation of the scrubber sysem is attached in Annex 9.**
b.	Recirculation of reagents	**No**

a) Operator to provide necessary documentation or SOPs in place.

Refer to Annexes XIV & XV

b) Noted

Emission data from 2019 shows that overall, average monthly emissions are within the stipulated thresholds. Data from the AERs shows that monthly averages are below the thresholds. That being said, the data at ERA's end is not sufficient to conclude whether the operators are in line with the emissions limit values stipulated in the permit. The permit will be amended so that the reporting requirement are in line with S.L. 549.81

Noted

Noted.

Table 5: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of HCl, HF and SO$_2$ from the incineration of waste

Parameter	BAT-AEL (mg/Nm^3)		Averaging period
	New plant	Existing plant	
HCl	< 2–6 (1)	< 2–8 (1)	Daily average
HF	< 1	< 1	Daily average or average over the sampling period
SO$_2$	5–30	5–40	Daily average

(1) The lower end of the BAT-AEL range can be achieved when using a wet scrubber; the higher end of the range may be associated with the use of dry sorbent injection.

The associated monitoring is in BAT 4.

Parameter	Existing plant Average concentration (mg/Nm^3) According to complete Flue gas analysis carried out in July 2019	Averaging period (Frequency – once every 6 motnhs)
HCl	**1.4 mg/Nm3**	**Average over the sampling period**
HF	**<0.1 mg/Nm3**	**Average over the sampling period**
SO$_2$	**<1 mg/Nm3**	**Average over the sampling period**

Operator to reclarify monitoring frequency of listed parameters whether its once every six months or the frequecy stipulated in BAT 4. It is noted that the monitoring reuquirements including frequency are to be as indicoated in BAT 4.

Monitoring of these parameters (HCl, HF and SO2 – together with NH3, NOx, THC, and CO) is done CONTINUOUSLY. However, for reporting purposes, half-hourly average readings are submitted.

Noted.

1.5.2.3 **Emissions of NO$_X$, N$_2$O, CO and NH$_3$**

BAT 29

Air emissions abatement techniques (NO$_x$/ CO/ N$_2$O/ NH$_3$)

In order to reduce channelled NO$_X$ emissions to air while limiting the emissions of CO and N$_2$O from the incineration of waste and the emissions of NH$_3$ from the use of SNCR and/or SCR, BAT is to use an appropriate combination of the techniques given below.

	Technique	Description	Applicability
a.	Optimisation of the incineration process	Section 2.1	Generally applicable.
b.	Flue-gas recirculation	Section 2.2	For existing plants, the applicability may be limited due to technical constraints (e.g. pollutant load in the flue-gas, incineration conditions).

Kindly specify which technique(s) shall be implemented to reduce emissions of NO$_x$, CO, N$_2$O and NH$_3$.

	Technique	Applicability
a.	Optimisation of the incineration process	**Yes**
b.	Flue-gas recirculation	**No**
c.	Selective non-catalytic reduction (SNCR)	**No**

Data from AERS shows that emissions (monthly averages are below the stipulated thresholds) No further comments.

	Technique	Description	Applicability
c.	Selective non-catalytic reduction (SNCR)	Section 2.2	Generally applicable.
d.	Selective catalytic reduction (SCR)	Section 2.2	In the case of existing plants, the applicability may be limited by a lack of space.
e.	Catalytic filter bags	Section 2.2	Only applicable to plants fitted with a bag filter.
f.	Optimisation of the SNCR/SCR design and operation	Optimisation of the reagent to NO_X ratio over the cross-section of the furnace or duct, of the size of the reagent drops and of the temperature window in which the reagent is injected.	Only applicable where SNCR and/or SCR is used for the reduction of NO_X emissions.
g.	Wet scrubber	Section 2.2 Where a wet scrubber is used for acid gas abatement, and in particular with SNCR, unreacted ammonia is absorbed by the scrubbing liquor and, once stripped, can be recycled as SNCR or SCR reagent.	There may be applicability restrictions due to low water availability, e.g. in arid areas.

	Technique	Applicability
d.	Selective catalytic reduction (SCR)	**No**
e.	Catalytic filter bags	**Yes**
f.	Optimisation of the SNCR/SCR design and operation	**No**
g.	Wet scrubber	**No**

Table 6: BAT-associated emission levels (BAT-AELs) for channelled NO_X and CO emissions to air from the incineration of waste and for channelled NH_3 emissions to air from the use of SNCR and/or SCR

Parameter	BAT-AEL (mg/Nm^3)		Averaging period
	New plant	Existing plant	
NO_X	50–120 (1)	50–150 (1) (2)	Daily average
CO	10–50	10–50	
NH_3	2–10 (1)	2–10 (1) (3)	

(1) The lower end of the BAT-AEL range can be achieved when using SCR. The lower end of the BAT-AEL range may not be achievable when incinerating waste with a high nitrogen content (e.g. residues from the production of organic nitrogen compounds).

(2) The higher end of the BAT-AEL range is 180 mg/Nm^3 where SCR is not applicable.

(3) For existing plants fitted with SNCR without wet abatement techniques, the higher end of the BAT-AEL range is 15 mg/Nm^3.

Not applicable

Parameter	Average concentration (mg/Nm^3)	Averaging period
NO_X		
CO		
NH_3		

Noted.

The associated monitoring is in BAT 4.

BAT 30

Air emissions abatement techniques (PCDD/F and PCBs)

In order to reduce channelled emissions to air of organic compounds including PCDD/F and PCBs from the incineration of waste, BAT is to use techniques (a), (b), (c), (d), and one or a combination of techniques (e) to (i) given below.

	Technique	Description	Applicability

Kindly specify which technique(s) shall be implemented to reduce emissions of PCDD/F and PCBs.

	Technique	Applicability
a.	Optimisation of the incineration process	**Yes**
b.	Control of the waste feed	**Yes**
c.	On-line and off-line boiler cleaning	**Yes**
d.	Rapid flue-gas cooling	**Yes**
e.	Dry sorbent injection	**Yes**

Noted.

	a.	Optimisation of the incineration process	Section 2.1 Optimisation of incineration parameters to promote the oxidation of organic compounds including PCDD/F and PCBs present in the waste, and to prevent their and their precursors' (re)formation.	Generally applicable.					
	b.	Control of the waste feed	Knowledge and control of the combustion characteristics of the waste being fed into the furnace, to ensure optimal and, as far as possible, homogeneous and stable incineration conditions.	Not applicable to clinical waste or to municipal solid waste.					
	c.	On-line and off-line boiler cleaning	Efficient cleaning of the boiler bundles to reduce the dust residence time and accumulation in the boiler, thus reducing PCDD/F formation in the boiler. A combination of on-line and off-line boiler cleaning techniques is used.	Generally applicable.					
	d.	Rapid flue-gas cooling	Rapid cooling of the flue-gas from temperatures above 400 °C to below 250 °C before dust abatement to prevent the *de novo* synthesis of PCDD/F. This is achieved by appropriate design of the boiler and/or with the use of a quench system. The latter option limits the amount of energy that can be recovered from the flue-gas and is used in particular in the case of incinerating hazardous wastes with a high halogen content.	Generally applicable.					
	e.	Dry sorbent injection	Section 2.2 Adsorption by injection of activated carbon or other reagents, generally combined with a bag filter where a reaction layer is created in the filter cake and the solids generated are removed.	Generally applicable.					
	f.	Fixed- or moving-bed adsorption	Section 2.2	The applicability may be limited by the overall pressure drop associated with the FGC system. In the case of existing plants, the applicability may be limited by a lack of space.					
	g.	SCR	Section 2.2 Where SCR is used for NO_X abatement, the adequate catalyst surface of the SCR system also provides for the partial reduction of the emissions of PCDD/F and PCBs. The technique is generally used in combination with technique (e), (f) or (i).	In the case of existing plants, the applicability may be limited by a lack of space.					
	h.	Catalytic filter bags	Section 2.2	Only applicable to plants fitted with a bag filter.					
	i.	Carbon sorbent in a wet scrubber	PCDD/F and PCBs are adsorbed by carbon sorbent added to the wet scrubber, either in the scrubbing liquor or in the form of impregnated packing elements. The technique is used for the removal of PCDD/F in general, and also to prevent and/or reduce the re-emission of PCDD/F accumulated in the scrubber (the so-called	Only applicable to plants fitted with a wet scrubber.					

f.	Fixed- or moving-bed adsorption	**No**
g.	SCR	**No**
h.	Catalytic filter bags	**Yes**
i.	Carbon sorbent in a wet scrubber	**No**

	memory effect) occurring especially during shutdown and start-up periods.		

Table 7: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of TVOC, PCDD/F and dioxin-like PCBs from the incineration of waste

Parameter	Unit	BAT-AEL		Averaging period
		New plant	Existing plant	
TVOC	mg/Nm^3	< 3–10	< 3–10	Daily average
PCDD/F (1)	ng I-TEQ/Nm^3	< 0.01–0.04	< 0.01–0.06	Average over the sampling period
		< 0.01–0.06	< 0.01–0.08	Long-term sampling period (2)
PCDD/F + dioxin-like PCBs (1)	ng WHO-TEQ/Nm^3	< 0.01–0.06	< 0.01–0.08	Average over the sampling period
		< 0.01–0.08	< 0.01–0.1	Long-term sampling period (2)

(1) Either the BAT-AEL for PCDD/F or the BAT-AEL for PCDD/F + dioxin-like PCBs applies.

(2) The BAT-AEL does not apply if the emission levels are proven to be sufficiently stable.

The associated monitoring is in BAT 4

Parameter	Existing plant Average concentration According to complete Flue gas analysis carried out in July 2019	Averaging period: (Frequency – once every 6 motnhs)
TVOC mg/Nm^3	3.95 mg/Nm3 (enlisted as TOC)	Average over the sampling period
PCDD/F (1) ng I-TEQ/Nm^3	0.026 ng I-TEQs/Nm3 (enlisted as dioxins and furans)	Average over the sampling period
	Long term sampling not conducted	
PCDD/F + dioxin-like PCBs (1) ng WHO-TEQ/Nm^3	<0.01 ng/Nm3 (enlisted as PCBs)	Average over the sampling period
	Long term sampling not conducted	

1.5.2.5 Emissions of mercury

BAT 31

Air emissions abatement techniques (Mercury)

In order to reduce channelled mercury emissions to air (including mercury emission peaks) from the incineration of waste, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a.	Wet scrubber (low pH)	Section 2.2 A wet scrubber operated at a pH value around 1. The mercury removal rate of the technique can be enhanced by adding reagents and/or adsorbents to the scrubbing liquor, e.g.: • oxidants such as hydrogen peroxide to transform elemental mercury to a water-soluble oxidised form; • sulphur compounds to form stable complexes or salts with mercury; • carbon sorbent to adsorb mercury, including elemental mercury. When designed for a sufficiently high buffer capacity for mercury capture, the technique effectively prevents the occurrence of mercury emission peaks.	There may be applicability restrictions due to low water availability, e.g. in arid areas.
b.	Dry sorbent injection	Section 2.2 Adsorption by injection of activated carbon or other reagents, generally combined with a bag filter where a reaction layer is created in the filter cake and the solids generated are removed.	Generally applicable.
c.	Injection of special, highly reactive activated carbon	Injection of highly reactive activated carbon doped with sulphur or other reagents to enhance the reactivity with mercury. Usually, the injection of this special activated carbon is not continuous but only takes place when a mercury peak is detected. For this purpose, the technique can be used in combination with the continuous monitoring of mercury in the raw flue-gas.	May not be applicable to plants dedicated to the incineration of sewage sludge.

	Technique	Applicability
a.	Wet scrubber (low pH)	No
b.	Dry sorbent injection	Yes
c.	Injection of special, highly reactive activated carbon	Yes
d.	Boiler bromine addition	No since the cominination of the above techniques are considered to be adequate.
e.	Fixed- or moving-bed adsorption	No

Noted

d.	Boiler bromine addition	Bromide added to the waste or injected into the furnace is converted at high temperatures to elemental bromine, which oxidises elemental mercury to the water-soluble and highly adsorbable $HgBr_2$. The technique is used in combination with a downstream abatement technique such as a wet scrubber or an activated carbon injection system. Usually, the injection of bromide is not continuous but only takes place when a mercury peak is detected. For this purpose, the technique can be used in combination with the continuous monitoring of mercury in the raw flue-gas.	Generally applicable.
e.	Fixed- or moving-bed adsorption	Section 2.2 When designed for a sufficiently high adsorption capacity, the technique effectively prevents the occurrence of mercury emission peaks.	The applicability may be limited by the overall pressure drop associated with the FGC system. In the case of existing plants, the applicability may be limited by a lack of space.

Table 8: BAT-associated emission levels (BAT-AELs) for channelled mercury emissions to air from the incineration of waste

Parameter	BAT-AEL (µg/Nm³) (1)		Averaging period
	New plant	Existing plant	
Hg	< 5–20 (2)	< 5–20 (2)	Daily average or average over the sampling period
	1–10	1–10	Long-term sampling period

(1) Either the BAT-AEL for daily average or average over the sampling period or the BAT-AEL for long-term sampling period applies. The BAT-AEL for long-term sampling may apply in the case of plants incinerating waste with a proven low and stable mercury content (e.g. mono-streams of waste of a controlled composition).

(2) The lower end of the BAT-AEL ranges may be achieved when:

- incinerating wastes with a proven low and stable mercury content (e.g. mono-streams of waste of a controlled composition), or
- using specific techniques to prevent or reduce the occurrence of mercury peak emissions while incinerating non-hazardous waste.

The higher end of the BAT-AEL ranges may be associated with the use of dry sorbent injection.

As an indication, the half-hourly average mercury emission levels will generally be:

- < 15–40 µg/Nm³ for existing plants;
- < 15–35 µg/Nm³ for new plants.

The associated monitoring is in BAT 4

Parameter	Average concentration (mg/Nm³) According to complete Flue gas analysis carried out in July 2019	Averaging period
Hg	<0.0001 mg/Nm3	Average over the sampling period
	Long term sampling not conducted Testing for Mercury Emissions from 2016 onwards has always resulted less than <0.0001 mg/Nm3	

1.6 Emissions to water

BAT 32 **Segregation of waste water streams**	**In order to prevent the contamination of uncontaminated water, to reduce emissions to water, and to increase resource efficiency, BAT is to segregate waste water streams and to treat them separately, depending on their characteristics.**	Kindly provide an exhaustive list of waste water streams and provide details of treatment and or disposal mechanisms in place. **All waste water streams are treated in the WWTP**		Operator to provide requested details. Although in the application process, the operator stated that there are no direct discharges a water body, in view of a recent episode of effluent run off to port facility, CED feels that a more rigorous exercise to determine possible emissions to water is to be carried out and answers forwarded to ERA. WSM carried a rigorous exercise to seal all drains and intersections with high quality material to avoid potential future leakages.	Noted.

BAT 33 **Reducation of water usage and generation of waste water**	**In order to reduce water usage and to prevent or reduce the generation of waste water from the incineration plant, BAT is to use one or a combination of the techniques given below.**	Operator to indicate applicability of measures in place to reduce water usage and prevent/reduce generation of waste water			
	(see table BAT 33 techniques)	(see table BAT 33 operator applicability)		Point C is still applicable to MTTF please provide requested details. Operator to indicate applicability of measures in place to reduce water usage and prevent/reduce generation of waste water. WasteServ is to provide more detailed reply Final treated effluent from WWTP is being re-used as 2nd class water for washing and cleaning purposes in Autoclave. Rain water from Autoclave is collected and used to fill up TTF water reservoirs.	Noted.
BAT 34 **Reduction of emissions to water from storage and treatment of slags and bottom ashes**	**In order to reduce emissions to water from FGC and/or from the storage and treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below, and to use secondary techniques as close as possible to the source in order to avoid dilution.**	Kindly indicate which of the below techniques are applicable if flue-gas recirculation and/or from the storage and treatment of slags and bottom ashes is carried out on site. **Since our FGC process is dry, no emissions to water could be generated. Also, both slags and bottom ashes are stored in contained storage chambers with no access to waters (such as rain water).**		Noted.	

BAT 33 techniques:

	Technique	Description	Applicability
a.	Waste-water-free FGC techniques	Use of FGC techniques that do not generate waste water (e.g. dry sorbent injection or semi-wet absorber, Section 2.2).	May not be applicable to the incineration of hazardous waste with a high halogen content.
b.	Injection of waste water from FGC	Waste water from FGC is injected into the hotter parts of the FGC system.	Only applicable to the incineration of municipal solid waste.
c.	Water reuse/recycling	Residual aqueous streams are reused or recycled. The degree of reuse/recycling is limited by the quality requirements of the process to which the water is directed.	Generally applicable.
d.	Dry bottom ash handling	Dry, hot bottom ash falls from the grate onto a transport system and is cooled down by ambient air. No water is used in the process.	Only applicable to grate furnaces. There may be technical restrictions that prevent retrofitting to existing incineration plants.

BAT 33 operator applicability:

	Technique	Applicability
a.	Waste-water-free FGC techniques	N/A
b.	Injection of waste water from FGC	N/A
c.	Water reuse/recycling	N/A
d.	Dry bottom ash handling	Yes

BAT 34 techniques:

	Technique	Typical pollutants targeted
	Primary techniques	
a.	Optimisation of the incineration process (BAT 14) and/or of the FGC system (e.g. SNCR/SCR, BAT 29 (f))	Organic compounds including PCDD/F, ammonia/ammonium
	Secondary techniques ([1])	
Preliminary and primary treatment		
b.	Equalisation	All pollutants
c.	Neutralisation	Acids, alkalis
d.	Physical separation, e.g. screens, sieves, grit separators, primary settlement tanks	Gross solids, suspended solids
Physico-chemical treatment		
e.	Adsorption on activated carbon	Organic compounds including PCDD/F, mercury
f.	Precipitation	Dissolved metals/metalloids, sulphate
g.	Oxidation	Sulphide, sulphite, organic compounds
h.	Ion exchange	Dissolved metals/metalloids
i.	Stripping	Purgeable pollutants (e.g. ammonia/ammonium)
j.	Reverse osmosis	Ammonia/ammonium, metals/metalloids, sulphate, chloride, organic compounds

BAT 34 operator applicability:

	Technique	Applicability
a.	Optimisation of the incineration process and/or of the FGC system	
b.	Equalisation	
c.	Neutralisation	
d.	Physical separation, e.g. screens, sieves, grit separators, primary settlement tanks	
e.	Adsorption on activated carbon	
f.	Precipitation	
g.	Oxidation	
h.	Ion exchange	
i.	Stripping	
j.	Reverse osmosis	
k.	Coagulation and flocculation	
l.	Sedimentation	
m.	Filtration	

Final solids removal		
k.	Coagulation and flocculation	Suspended solids, particulate-bound metals/metalloids
l.	Sedimentation	
m.	Filtration	
n.	Flotation	
([1]) The descriptions of the techniques are given in Section 2.3		

n.	Flotation	

Table 9: BAT-AELs for direct emissions to a receiving water body

Parameter		Process	Unit	BAT-AEL ([1])
Total suspended solids (TSS)		FGC Bottom ash treatment	mg/l	10–30
Total organic carbon (TOC)		FGC Bottom ash treatment		15–40
Metals and metalloids	As	FGC		0.01–0.05
	Cd	FGC		0.005–0.03
	Cr	FGC		0.01–0.1
	Cu	FGC		0.03–0.15
	Hg	FGC		0.001–0.01
	Ni	FGC		0.03–0.15
	Pb	FGC Bottom ash treatment		0.02–0.06
	Sb	FGC		0.02–0.9
	Tl	FGC		0.005–0.03
	Zn	FGC		0.01–0.5
Ammonium-nitrogen (NH_4-N)		Bottom ash treatment		10–30
Sulphate (SO_4^{2-})		Bottom ash treatment		400–1 000
PCDD/F		FGC	ng I-TEQ/l	0.01–0.05

([1]) The averaging periods are defined in the General considerations.

The associated monitoring is in BAT 6

Kindly indicate expected or concentrations being achieved for direct emissions to water bodies.

Parameter		Unit	concentration
Total suspended solids (TSS)		mg/l	
Total organic carbon (TOC)			
Metals and metalloids	As		
	Cd		
	Cr		
	Cu		
	Hg		
	Ni		
	Pb		
	Sb		
	Tl		
	Zn		
Ammonium-nitrogen (NH_4-N)			
Sulphate (SO_4^{2-})			
PCDD/F		ng I-TEQ/l	

Non-applicability is noted

Table 10: BAT-AELs for indirect emissions to a receiving water body

Parameter		Process	Unit	BAT-AEL ([1]) ([2])
Metals and metalloids	As	FGC	mg/l	0.01–0.05
	Cd	FGC		0.005–0.03
	Cr	FGC		0.01–0.1
	Cu	FGC		0.03–0.15
	Hg	FGC		0.001–0.01
	Ni	FGC		0.03–0.15
	Pb	FGC Bottom ash treatment		0.02–0.06

Kindly indicate expected or concentrations being achieved for indirect emissions to water bodies.

Parameter		Unit	concentration
Metals and metalloids	As	mg/l	
	Cd		
	Cr		
	Cu		
	Hg		
	Ni		
	Pb		
	Sb		

Non-applicability is noted

	Sb	FGC		0.02–0.9
	Tl	FGC		0.005–0.03
	Zn	FGC		0.01–0.5
PCDD/F		FGC	ng I-TEQ/l	0.01–0.05

([1]) The averaging periods are defined in the General considerations.

([2]) The BAT-AELs may not apply if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned, provided this does not lead to a higher level of pollution in the environment.

The associated monitoring is in BAT 6.

	Tl		
	Zn		
PCDD/F		ng I-TEQ/l	

1.7 Material efficiency

BAT 33

Separate treatment of bottom ashes from FGC residues

In order to increase resource efficiency, BAT is to handle and treat bottom ashes separately from FGC residues.

Operator to indicate applicability

N/A The processes of FGC and bottom ash are handled and treated separately

Noted.

BAT 34

Treatment of slags and bottom ashes

In order to increase resource efficiency for the treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below based on a risk assessment depending on the hazardous properties of the slags and bottom ashes.

	Technique	Description	Applicability
a.	Screening and sieving	Oscillating screens, vibrating screens and rotary screens are used for an initial classification of the bottom ashes by size before further treatment.	Generally applicable.
b.	Crushing	Mechanical treatment operations intended to prepare materials for the recovery of metals or for the subsequent use of those materials, e.g. in road and earthworks construction.	Generally applicable.
c.	Aeraulic separation	Aeraulic separation is used to sort the light, unburnt fractions commingled in the bottom ashes by blowing off light fragments. A vibrating table is used to transport the bottom ashes to a chute, where the material falls through an air stream that blows uncombusted light materials, such as wood, paper or plastic, onto a removal belt or into a container, so that they can be returned to incineration.	Generally applicable.
d.	Recovery of ferrous and non-ferrous metals	Different techniques are used, including: • magnetic separation for ferrous metals; • eddy current separation for non-ferrous metals; • induction all-metal separation.	Generally applicable.
e.	Ageing	The ageing process stabilises the mineral fraction of the bottom ashes by uptake of atmospheric CO_2 (carbonation), draining of excess water and oxidation. Bottom ashes, after the recovery of metals, are stored in the open air or in covered buildings for several weeks, generally on an impermeable floor allowing for drainage and run-off water to be collected for treatment.	Generally applicable.

	Technique	Applicability
a.	Screening and sieving	**N/A**
b.	Crushing	**N/A**
c.	Aeraulic separation	**N/A**
d.	Recovery of ferrous and non-ferrous metals	**N/A**
e.	Ageing	**N/A**
f.	Washing	**N/A**

The volumes generated do not justify any form of treatment as concluded in the feasibility study report attached in Annex 9.

Noted.

		The stockpiles may be wetted to optimise the moisture content to favour the leaching of salts and the carbonation process. The wetting of bottom ashes also helps prevent dust emissions.	
f.	Washing	The washing of bottom ashes enables the production of a material for recycling with minimal leachability of soluble substances (e.g. salts).	Generally applicable.

1.8	**NOISE**				
BAT 35 **Techniques to reduce noise emissions**	**In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.**				

	Technique	Description	Applicability
a.	Appropriate location of equipment and buildings	Noise levels can be reduced by increasing the distance between the emitter and the receiver and by using buildings as noise screens.	In the case of existing plants, the relocation of equipment may be restricted by a lack of space or by excessive costs.
b.	Operational measures	These include: • improved inspection and maintenance of equipment; • closing of doors and windows of enclosed areas, if possible; • operation of equipment by experienced staff; • avoidance of noisy activities at night, if possible; • provisions for noise control during maintenance activities.	Generally applicable.
c.	Low-noise equipment	This includes low-noise compressors, pumps and fans.	Generally applicable when existing equipment is replaced or new equipment is installed.
d.	Noise attenuation	Noise propagation can be reduced by inserting obstacles between the emitter and the receiver. Appropriate obstacles include protection walls, embankments and buildings.	In the case of existing plants, the insertion of obstacles may be restricted by a lack of space.
e.	Noise-control equipment/ infrastructure	This includes: • noise-reducers; • equipment insulation; • enclosure of noisy equipment; • soundproofing of buildings.	In the case of existing plants, the applicability may be limited by a lack of space.

	Technique	Applicability
a.	Appropriate location of equipment and buildings	Yes
b.	Operational measures	Yes
c.	Low-noise equipment	Yes
d.	Noise attenuation	Yes
e.	Noise-control equipment/ infrastructure	Yes

Noted.

Descriptions of techniques

General techniques

Technique	Description
Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring of operating parameters and of emissions.
Optimisation of the incineration process	Optimisation of the waste feed rate and composition, of the temperature, and of the flow rates and points of injection of the primary and secondary combustion air to effectively oxidise the organic compounds while reducing the generation of NO_X. Optimisation of the design and operation of the furnace (e.g. flue-gas temperature and turbulence, flue-gas and waste residence time, oxygen level, waste agitation).

Techniques to reduce emissions to air

Technique	Description
Bag filter	Bag or fabric filters are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a bag filter requires the selection of a fabric suitable for the characteristics of the flue-gas and the maximum operating temperature.
Boiler sorbent injection	The injection of magnesium- or calcium-based absorbents at a high temperature in the boiler post-combustion area, to achieve partial abatement of acid gases. The technique is highly effective for the removal of SO_X and HF, and provides additional benefits in terms of flattening emission peaks.
Catalytic filter bags	Filter bags are either impregnated with a catalyst or the catalyst is directly mixed with organic material in the production of the fibres used for the filter medium. Such filters can be used to reduce PCDD/F emissions as well as, in combination with a source of NH_3, to reduce NO_X emissions.
Direct desulphurisation	The addition of magnesium- or calcium-based absorbents to the bed of a fluidised bed furnace.
Dry sorbent injection	The injection and dispersion of sorbent in the form of a dry powder in the flue-gas stream. Alkaline sorbents (e.g. sodium bicarbonate, hydrated lime) are injected to react with acid gases (HCl, HF and SO_X). Activated carbon is injected or co-injected to adsorb in particular PCDD/F and mercury. The resulting solids are removed, most often with a bag filter. The excess reactive agents may be recirculated to decrease their consumption, possibly after reactivation by maturation or steam injection (BAT 28 b).
Electrostatic precipitator	Electrostatic precipitators (ESPs) operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. The abatement efficiency may depend on the number of fields, residence time (size), and upstream particle removal devices. They generally include between two and five fields. Electrostatic precipitators can be of the dry or of the wet type depending on the technique used to collect the dust from the electrodes. Wet ESPs are typically used at the polishing stage to remove residual dust and droplets after wet scrubbing.
Fixed- or moving-bed adsorption	The flue-gas is passed through a fixed- or a moving-bed filter where an adsorbent (e.g. activated coke, activated lignite or a carbon-impregnated polymer) is used to adsorb pollutants.

Technique	Description
Flue-gas recirculation	Recirculation of a part of the flue-gas to the furnace to replace a part of the fresh combustion air, with the dual effect of cooling the temperature and limiting the O_2 content for nitrogen oxidation, thus limiting the NO_X generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame. This technique also reduces the flue-gas energy losses. Energy savings are also achieved when the recirculated flue-gas is extracted before FGC, by reducing the gas flow though the FGC system and the size of the required FGC system.
Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NO_X to nitrogen in a catalytic bed by reaction with ammonia at an optimum operating temperature that is typically around 200–450 °C for the high-dust type and 170–250 °C for the tail-end type. In general, ammonia is injected as an aqueous solution; the ammonia source can also be anhydrous ammonia or a urea solution. Several layers of catalyst may be applied. A higher NO_X reduction is achieved with the use of a larger catalyst surface, installed as one or more layers. 'In-duct' or 'slip' SCR combines SNCR with downstream SCR which reduces the ammonia slip from SNCR.
Selective non-catalytic reduction (SNCR)	Selective reduction of nitrogen oxides to nitrogen with ammonia or urea at high temperatures and without catalyst. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction. The performance of the SNCR system can be increased by controlling the injection of the reagent from multiple lances with the support of a (fast-reacting) acoustic or infrared temperature measurement system so as to ensure that the reagent is injected in the optimum temperature zone at all times.
Semi-wet absorber	Also called semi-dry absorber. An alkaline aqueous solution or suspension (e.g. milk of lime) is added to the flue-gas stream to capture the acid gases. The water evaporates and the reaction products are dry. The resulting solids may be recirculated to reduce reagent consumption (BAT 28 b). This technique includes a range of different designs, including *flash-dry* processes which consist of injecting water (providing for fast gas cooling) and reagent at the filter inlet.
Wet scrubber	Use of a liquid, typically water or an aqueous solution/suspension, to capture pollutants from the flue-gas by absorption, in particular acid gases, as well as other soluble compounds and solids. To adsorb mercury and/or PCDD/F, carbon sorbent (as a slurry or as carbon-impregnated plastic packing) can be added to the wet scrubber. Different types of scrubber designs are used, e.g. jet scrubbers, rotation scrubbers, Venturi scrubbers, spray scrubbers and packed tower scrubbers.

Techniques to reduce emissions to water

Technique	Description
Adsorption on activated carbon	The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (the adsorbent). Activated carbon is typically used for the adsorption of organic compounds and mercury.
Precipitation	The conversion of dissolved pollutants into insoluble compounds by adding precipitants. The solid precipitates formed are subsequently separated by sedimentation, flotation or filtration. Typical chemicals used for metal precipitation are lime, dolomite, sodium hydroxide, sodium carbonate, sodium sulphide and organosulphides. Calcium salts (other than lime) are used to precipitate sulphate or fluoride.
Coagulation and flocculation	Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants (e.g. ferric chloride) with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond thereby producing larger flocs. The flocs formed are subsequently separated by sedimentation, air flotation or filtration.
Equalisation	Balancing of flows and pollutant loads by using tanks or other management techniques.
Filtration	The separation of solids from waste water by passing it through a porous medium. It includes different types of techniques, e.g. sand filtration, microfiltration and ultrafiltration.
Flotation	The separation of solid or liquid particles from waste water by attaching them to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.
Ion exchange	The retention of ionic pollutants from waste water and their replacement by more acceptable ions using an ion exchange resin. The pollutants are temporarily retained and afterwards released into a regeneration or backwashing liquid.
Neutralisation	The adjustment of the pH of the waste water to a neutral value (approximately 7) by the addition of chemicals. Sodium hydroxide ($NaOH$) or calcium hydroxide ($Ca(OH)_2$) is generally used to increase the pH whereas sulphuric acid (H_2SO_4), hydrochloric acid (HCl) or carbon dioxide (CO_2) is used to decrease the pH. The precipitation of some substances may occur during neutralisation.
Oxidation	The conversion of pollutants by chemical oxidising agents to similar compounds that are less hazardous and/or easier to abate. In the case of waste water from the use of wet scrubbers, air may be used to oxidise sulphite (SO_3^{2-}) to sulphate (SO_4^{2-}).
Reverse osmosis	A membrane process in which a pressure difference applied between the compartments separated by the membrane causes water to flow from the more concentrated solution to the less concentrated one.
Sedimentation	The separation of suspended solids by gravitational settling.
Stripping	The removal of purgeable pollutants (e.g. ammonia) from waste water by contact with a high flow of a gas current in order to transfer them to the gas phase. The pollutants are subsequently recovered (e.g. by condensation) for further use or disposal. The removal efficiency may be enhanced by increasing the temperature or reducing the pressure.

Management techniques

Technique	Description
Odour management plan	The odour management plan is part of the EMS (BAT 1) and includes: a) A protocol for conducting odour monitoring in accordance with EN standards (e.g. dynamic olfactometry according to EN 13725 to determine the odour concentration); it may be complemented by measurement/estimation of odour exposure (e.g. according to EN 16841-1 or EN 16841-2) or estimation of odour impact; b) A protocol for response to identified odour incidents, e.g. complaints; c) An odour prevention and reduction programme designed to identify the source(s), to characterise the contributions of the sources, and to implement prevention and/or reduction measures.
Noise management plan	The noise management plan is part of the EMS (BAT 1) and includes: a) A protocol for conducting noise monitoring; b) A protocol for response to identified noise incidents, e.g. complaints; c) A noise reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the source(s) and to implement prevention and/or reduction measures.
Accident management plan	An accident management plan is part of the EMS (BAT 1) and identifies hazards posed by the installation and the associated risks and defines measures to address these risks. It considers the inventory of pollutants present or likely to be present which could have environmental consequences if they escape. It can be drawn up using for example FMEA (Failure Mode and Effects Analysis) and/or FMECA (Failure Mode, Effects and Criticality Analysis). The accident management plan includes the setting up and implementation of a fire prevention, detection and control plan, which is risk-based and includes the use of automatic fire detection and warning systems, and of manual and/or automatic fire intervention and control systems. The fire prevention, detection and control plan is relevant in particular for: • waste storage and pre-treatment areas; • furnace loading areas; • electrical control systems; • bag filters; • fixed adsorption beds. • The accident management plan also includes, in particular in the case of installations where hazardous wastes are received, personnel training programmes regarding: • explosion and fire prevention; • fire extinguishing; • knowledge of chemical risks (labelling, carcinogenic substances, toxicity, corrosion, fire).

DEFINITIONS

For the purposes of these BAT conclusions, the following **definitions** apply:

Term used	Definition
General terms	
Boiler efficiency	Ratio between the energy produced at the boiler output (e.g. steam, hot water) and the waste's and auxiliary fuel's energy input to the furnace (as lower heating values).
Bottom ash treatment plant	Plant treating slags and/or bottom ashes from the incineration of waste in order to separate and recover the valuable fraction and to allow the beneficial use of the remaining fraction. This does not include the sole separation of coarse metals at the incineration plant.
Clinical waste	Infectious or otherwise hazardous waste arising from healthcare institutions (e.g. hospitals).

Channelled emissions	Emissions of pollutants into the environment through any kind of duct, pipe, stack, etc. This also includes emissions from open-top biofilters.
Continuous measurement	Measurement using an 'automated measuring system' permanently installed on site.
Diffuse emissions	Non-channelled emissions (e.g. of dust, organic compounds, odour) which can result from 'area' sources (e.g. tanks) or 'point' sources (e.g. pipe flanges). This also includes emissions from open-air windrow composting.
Existing plant	A plant that is not a new plant.
Fly ashes	Particles from the combustion chamber or formed within the flue-gas stream, that are transported in the flue-gas.
Fugitive emissions	Diffuse emissions from 'point' sources.
Hazardous waste	Hazardous waste as defined in point 2 of Article 3 of Directive 2008/98/EC.
Incineration of waste	The combustion of waste, either alone or in combination with fuels, in an incineration plant.
Incineration plant	Either a waste incineration plant as defined in Article 3(40) of Directive 2010/75/EU or a waste co-incineration plant as defined in Article 3(41) of Directive 2010/75/EU, covered by the scope of these BAT conclusions.
Major plant upgrade	A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement technique(s) and associated equipment.
Municipal solid waste	Solid waste from households (mixed or separately collected) as well as solid waste from other sources that is comparable to household waste in nature and composition.
New plant	A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
Other non-hazardous waste	Non-hazardous waste that is neither municipal solid waste nor sewage sludge.
Part of an incineration plant	For the purposes of determining the gross electrical efficiency or the gross energy efficiency of an incineration plant, a part of it may refer for example to: an incineration line and its steam system in isolation; a part of the steam system, connected to one or more boilers, routed to a condensing turbine; the rest of the same steam system that is used for a different purpose, e.g. the steam is directly exported.
Periodic measurement	Measurement at specified time intervals using manual or automated methods.
Residues	Any liquid or solid waste which is generated by an incineration plant or by a bottom ash treatment plant.
Sensitive receptor	Area which needs special protection, such as: residential areas; areas where human activities are carried out (e.g. neighbouring workplaces, schools, daycare centres, recreational areas, hospitals or nursing homes).
Sewage sludge	Residual sludge from the storage, handling and treatment of domestic, urban or industrial waste water. For the purposes of these BAT conclusions, residual sludges constituting hazardous waste are excluded.
Slags and/or bottom ashes	Solid residues removed from the furnace once wastes have been incinerated.
Valid half-hourly average	A half-hourly average is considered valid when there is no maintenance or malfunction of the automated measuring system.
Pollutants/parameters	
As	The sum of arsenic and its compounds, expressed as As.
Cd	The sum of cadmium and its compounds, expressed as Cd.
Cd+Tl	The sum of cadmium, thallium and their compounds, expressed as Cd+Tl.

CO	Carbon monoxide.
Cr	The sum of chromium and its compounds, expressed as Cr.
Cu	The sum of copper and its compounds, expressed as Cu.
Dioxin-like PCBs	PCBs showing a similar toxicity to the 2,3,7,8-substituted PCDD/PCDF according to the World Health Organization (WHO).
Dust	Total particulate matter (in air).
HCl	Hydrogen chloride.
HF	Hydrogen fluoride.
Hg	The sum of mercury and its compounds, expressed as Hg.
Loss on ignition	Change in mass as a result of heating a sample under specified conditions.
N_2O	Dinitrogen monoxide (nitrous oxide).
NH_3	Ammonia.
NH_4-N	Ammonium nitrogen, expressed as N, includes free ammonia (NH_3) and ammonium (NH_4^+).
Ni	The sum of nickel and its compounds, expressed as Ni.
NO_X	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2.
Pb	The sum of lead and its compounds, expressed as Pb.
PBDD/F	Polybrominated dibenzo-*p*-dioxins and –furans.
PCBs	Polychlorinated biphenyls.
PCDD/F	Polychlorinated dibenzo-*p*-dioxins and -furans.
POPs	Persistent Organic Pollutants as listed in Annex IV to Regulation (EC) No 850/2004 of the European Parliament and of the Council and its amendments.
Sb	The sum of antimony and its compounds, expressed as Sb.
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	The sum of antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium and their compounds, expressed as Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V.
SO_2	Sulphur dioxide.
Sulphate (SO_4^{2-})	Dissolved sulphate, expressed as SO_4^{2-}.
TOC	Total organic carbon, expressed as C (in water); includes all organic compounds.
TOC content (in solid residues)	Total organic carbon content. The quantity of carbon that is converted into carbon dioxide by combustion and which is not liberated as carbon dioxide by acid treatment.
TSS	Total suspended solids. Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry.
Tl	The sum of thallium and its compounds, expressed as Tl.

TVOC	Total volatile organic carbon, expressed as C (in air).
Zn	The sum of zinc and its compounds, expressed as Zn.

Acronyms

For the purposes of these BAT conclusions, the following acronyms apply:

Acronym	Definition
EMS	Environmental management system
FDBR	Fachverband Anlagenbau (from the previous name of the organisation: Fachverband Dampfkessel-, Behälter- und Rohrleitungsbau)
FGC	Flue-gas cleaning
OTNOC	Other than normal operating conditions
SCR	Selective catalytic reduction
SNCR	Selective non-catalytic reduction
I-TEQ	International toxic equivalent according to the North Atlantic Treaty Organization (NATO) schemes
WHO-TEQ	Toxic equivalent according to the World Health Organization (WHO) schemes