
Guidelines for Bio-medical Waste Incinerator (Revised Draft)



CENTRAL POLLUTION CONTROL BOARD

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Abbreviations

AFHCE	-	Armed Forces Health Care Establishment
APCD	-	Air Pollution Control Device
BMWM Rules	-	Bio-medical Waste Management Rules, 2016
CBWTF	-	Common Bio-medical Waste Treatment Facility
CEMS	-	Continuous Emission Monitoring System
CO	-	Carbon Monoxide
CO ₂	-	Carbon Dioxide
CPCB	-	Central Pollution Control Board
DG	-	Diesel Generator
DGAFMS	-	Director General Armed Forces Medical Services
E (P) Act, 1986	-	Environment (Protection) Act, 1986
FRP	-	Fibre Reinforced Plastic
HCFs	-	Health Care Facilities
HCl	-	Hydrochloric Acid
HOWM & TM Rules	-	Hazardous and Other Waste Management & Transboundary Movement Rules, 2016
LoI	-	Loss on Ignition
MoEF & CC	-	Ministry of Environment, Forest & Climate Change
NO _x	-	Oxides of Nitrogen
O ₂	-	Oxygen
PCC	-	Pollution Control Committee
PLC	-	Programmable Logical Control
SCR	-	Selective Catalytic Reduction
SNCR	-	Selective Non-Catalytic Reduction
SPCB	-	State Pollution Control Board
TOC	-	Total Organic Carbon
UT	-	Union Territory
VOCs	-	Volatile Organic Compounds
WC	-	Water Column

Guidelines for Bio-medical Waste Incinerator

1. Introduction

The Bio-medical Waste Management Rules, 2016 (hereafter referred as BMWM Rules) notified under the Environment (Protection) Act 1986, incineration is one of the treatment and safe disposal of the bio-medical waste generated in the Country. These rules also stipulate emission standards under Schedule-II which include for dioxins and furans. Further, the BMWM Rules, 2016 stipulates that no occupier shall establish on-site treatment and disposal facility, if a service of Common Bio-medical Waste Treatment Facility (CBWTF) is available within distance of seventy-five kilometer. In cases, where service of the CBWTF is not available, the Occupier (s) shall set up requisite biomedical waste treatment equipment including incinerator prior to commencement of its operation, as per the authorisation given by the prescribed authority [(i.e., State Pollution Control Board (SPCB) or Pollution Control Committee (PCC)] in the respective State /Union Territory (UT). Also, Schedule-II of the BMWM Rules, 2016 stipulates revised incinerator stack emission standards which include for residence time of two seconds in secondary chamber as well as dioxins and furans and mercury and its compounds. Simply modification of the secondary chamber to comply with the residence by the existing incinerator would technically hamper the existing APCD as well as ID Fan and would lead to failure of the incinerator to comply with the new emission standards or frequent problems due to inadequate incineration system. Therefore, this would call for replacement of existing incinerator with the new incinerator.

In order to help the occupier or operator of a CBWTF to ensure adoption of properly designed incinerator and also to provide guidance to the manufacturers so as to supply state-of-art-incinerator, in the year 2003, Central Pollution Control Board (CPCB) has issued guidelines entitled 'Design and Construction of Bio-medical Waste Incinerator'. However, these guidelines have not been implemented in some of the States leading to non-compliances to the emission norms stipulated under the BMWM Rules.

To ensure treatment and disposal of bio-medical waste generated from the Health Care Facilities (HCFs), at present (as per Annual Report 2014 submitted by the SPCBs/PCCs), 655 no. of bio-medical waste incinerators are in operation which

include i.e., 440 no. of captive incinerators operated by the Health Care Facilities (HCFs) and 215 no. of incinerators run by the CBWTFs. Also, 82 out of 440 captive incinerators operated by the HCFs are either having single chamber or not fitted with requisite air pollution control devices (APCDs), in violation of the BMWM Rules.

In order to ensure uniformity in manufacturing and supplying of the properly designed incinerator by all the manufactures as well as adoption of the state-of- art- incinerators which can comply to the latest emission norms stipulated under Schedule-II of the BMWM Rules, 2016 (**Annexure-I**) throughout the country, existing guidelines have been revised in consultation with the stakeholders. These guidelines are expected to be followed and complied by all the manufacturers of bio-medical waste incinerators, Occupier (s) and CBWTFs as well as the prescribed authorities.

2. Applicability of the Guidelines

- i. These guidelines shall be applicable to all the existing incinerators undergoing enhancement or upgradation as well as upcoming or new installation of new incinerators as well as the manufacturers of incinerators.
- ii. According to the BMWM Rules, 2016, establishment of an individual captive incineration facility by a health care facility (HCF) as on-site treatment and disposal facility shall not be allowed if a service of a Common Bio-medical Waste Treatment Facility (CBWTF) is available within a distance of seventy five kilometer as prescribed under the BMWM Rules.
- iii. Where service of the Common Bio-medical Waste Treatment Facility (CBWTF) is not available, then in such a case, the Occupier (i.e., HCF) shall be permitted to set up requisite treatment equipment as per the authorisation to be granted under the BMWM Rules, by the prescribed authority i.e., SPCB/PCC State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) or Director General Armed Forces Medical Services (DGAFMS) in case of the Armed Forces Health Care Establishments (AFHCEs). In such a case, the Occupier should install captive treatment facilities in line with the guidelines issued by CPCB from time to time.
- iv. Siting of the incinerator or location of the incinerator should be same as that of the criteria applicable for the common bio-medical waste treatment facilities.

3. About incineration

Incineration and other high temperature waste treatment systems are described as "thermal treatment or destruction processes". Incineration of waste materials converts wastes containing elements of carbon, hydrogen, oxygen alongwith presence of other elements such as nitrogen, sulphur, chlorine and pathogens etc., can be destroyed completely by oxidation process using auxiliary fuel producing benign gases (flue gases) such as carbon dioxide, water, and nitrogen and some acidic gases such as oxides of sulphur, nitrogen, acids and other toxic gases such as heavy metals, Dioxins & Furans etc. as well as solid form of ash, depending upon waste constituents of the waste and performance of incineration system.

When complete combustion occurs, carbon and hydrogen combines with the oxygen of the combustion air to form carbon dioxide (CO₂) and water vapour (H₂O), If incomplete combustion occurs, carbon monoxide (CO) also will be formed. Depending on the type of waste, the organic chlorine in the combustion chamber reacts almost completely to form hydrogen chloride (HCl) and elemental chlorine (Cl₂) which leaves from combustion chamber in vapour phase. Nitrogen enters the combustion chamber as a component of the waste and in the combustion air and produce nitrogen oxides (NO_x). Simplified combustion reactions can be represented by the chemical reactions given below:



Therefore, incinerator is required to be equipped with necessary air pollution control devices (APCD) for removal of pollutants from flue gases to achieve desired level. The flue gases are cleaned for removal of particulate pollutants and gaseous compounds by passing through various air pollution control devices (APCD) before releasing them into the atmosphere through stack.

Incinerators such as (i) Fixed Hearth Furnaces; (ii) Rotary Kiln Incinerators and (iii) Plasma gasification incinerator are in operation across the country. Plasma pyrolysis is a process which reduces materials to their more basic chemical components by means of an intensively hot (thousands of degrees F) gas plasma in the absence of oxygen. Plasma, often referred to as the "fourth state of matter" is a special form of ionized gas that conducts electricity. Typical industrial uses of

thermal plasmas are at temperatures in the range of 5,000 - 10,000°C (9, 000-18, 000°F). Controlled plasma arcs are generated when a steady flow of gas is forced between electrodes with a high electrical current flowing between these electrodes. This now ionized gas generates an intense heat in the form of a plasma arc column or "plume". Plasma arcs create an ultra-high energy environment where the energy density is greater than the bonding energy between the elemental atoms that form molecules. When the molecules that form the waste are fed into the plasma arc, the molecules are dissociated into their basic elemental atomic constituents. This dissociation permanently and totally destroys the molecular compounds and their properties. Some plasma heating system consists of DC-powered graphite electrodes rather than plasma torches, typically marketed by various companies.

Bio-medical waste incinerator is required to be operated by obtaining:

- (i) Environmental Clearance under the item 7 (da) of the schedule listed under the EIA Notification 2006 notified by the Ministry of Environment, Forest and Climate Change (MoEF & CC) vide amendment of SO 1142 (e) dated April 17, 2015, from the respective State Environment Impact Assessment Authority (SEIAA) or MoEF & CC as the case may be prior to any construction work or preparation of land by the projects management for the new projects, expansion and modernisation of the existing treatment capacity without enhancement in existing treatment capacity;
- (ii) Authorisation from the respective SPCB/PCC as required under Rule 10 of the Bio-medical Waste Management Rules, 2016; and
- (iii) Consent to operate from the respective SPCB/PCC as required under the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981.

The emission standards for common bio-medical waste incinerator as prescribed under the BMWM Rules, 2016 as notified by the Govt. of India under the Environment (Protection) Act, 1986, is given at Annexure-I and same is required to be implemented by the respective SPCBs/PCCs.

4. Requirements of the bio-medical waste incinerator

Following design criteria may be adopted for better performance:

- (i) The incinerator shall be designed for through put of more than 50 kg/hr or more (i.e., but not less than 50 kg/hr). Minimum hearth depending on the Thermal Heat Values of the bio-medical waste incinerators is given in **Table 1**.

Table 1. Capacity-wise minimum thermal capacity of the BMW incinerator

S. No	Capacity of the BMW Incinerator in Kg/hour	Thermal Heat Capacity in Kcal/hour	Thermal Capacity of the Incinerator in K.Cal/hour
(1)	50 – 60	100000-120000	235000
(2)	90-100	180000-200000	329000
(3)	140-150	280000-300000	517000
(4)	175	350000	587500
(5)	225 -250	450000-500000	728500
(6)	300	600000	869500

Each incinerator must be installed with a suitable air pollution control devices (APCD) (as specified in the section 4). For higher capacity incinerators (*i.e., 250 kg/hour or more*), incinerators rotary kiln based incinerators are preferred over fixed hearth incinerators. *Rotary Kiln shall be preferred; in case of the total bio-medical waste treated in a batch (8 hour) is exceeding 2.5 to 3 Tonnes.*

- (ii) The Bio-medical Waste incineration shall be designed for primary and secondary combustion systems. Single chamber bio-medical waste incinerator shall not be manufactured by the any manufacturer or adopted by the any occupier (i.e., HCF) or operator of a CBWTF. In case of a rotary kiln, rotational speed of rotary kiln is adjusted so as to give adequate turbulence, residence time minimum of one hour to the bio-medical waste so that the Total Organic Carbon (TOC) content in the slag/bottom ash is less than 3% or their loss on ignition shall be less than 5% of the dry weight as prescribed under the BMW Rules. Inclination and the rotational speed of the rotary kiln is related to ash quality and however, considering the load on thrust bearing, rotary kiln inclination shall not be more

than 3 degrees with horizontal unless the designed technology specification warrants it.

- (iii) The size of the opening through which the waste is charged shall be larger than the size of the waste bag to be fed. The volume of the primary chamber shall be at least five times the volume of one batch.
 - (iv) Incinerator chambers shall also be fitted with a suitable provision of pressure gauges for measuring the air supply or flow rate. Combustion air measurement through flow transmitter should be provided and the display shall be in PLC. Further, the double chamber incinerator shall preferably be designed on "controlled-air" incineration principle, as particulate matter emission is low in such incinerator. Air supply in the primary and secondary chamber may be regulated between 30%-80% and 170%-120% of stoichiometric requirement respectively. Primary air shall be admitted near / at the hearth for better contact. Flow meter / suitable flow measurement device shall be provided on the primary & secondary air ducting. The combustion air shall be supplied through a separate forced draft fan after accounting for the air supplied through burners.
 - (v) The pressure in the incineration chambers under all circumstances should be lower than the ambient pressure in the room where the incinerator is installed. A minimum negative draft of 1.27 to 2.54 mm (or rounded to 2 to 3 mm) of WC (Water Column) shall be maintained in the primary chamber to avoid leakage of gaseous emissions from the chamber and for safety reasons. Provision shall be made in the primary chamber to measure the Water Column pressure by means of U-Tube manometer or digital display provision and connected with PLC.
 - (vi) The waste shall be fed into the incinerator in small batches (about 15-20 % of total capacity of the incinerator) after the fixed interval of time in case of fixed hearth incinerator and continuous charging using appropriate feeding mechanism in case of rotary kiln incinerator or as recommended by the manufacturer, depending on the capacity of the incinerator. The size of the hearth i.e. primary chamber shall be designed properly.
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- (vii) The sides and the top portion of the primary and secondary chambers shall preferably have rounded corner from inside to avoid possibility of formation of black or cold pockets/dead zones.
 - (viii) The size of the secondary chamber shall be properly designed so as to facilitate a minimum of two seconds residence time to ensure combustion of the gas flow, unburnt material such as volatiles, smoke and soot. For the estimation of residence time in the secondary chamber its volume shall be calculated starting from the secondary burner tip to the thermocouple.
 - (ix) Incinerator walls shall be protected with insulated fire bricks/refractory system. The refractory lining of the chamber shall be strong enough to sustain thermal shocks i.e., minimum temperature of 1000° C in the primary chamber and 1050 +/- 50 ° C in the secondary chamber. The refractory & insulation bricks shall have suitable thickness each & shall conform to IS: 8-1994 & IS: 2042-2006 respectively. However, in case the bio-medical waste incinerator operator wishes to treat outdated medicines or cytotoxic waste, the refractory lining of the chamber shall be designed suitably in conform to IS Specifications for bricks or refractory to with stand minimum temperature of 1200° C in secondary chamber.
 - (x) The incinerator combustion chamber(s) should be designed for easy maintenance of all internal parts including the refractory and insulation.
 - (xi) The materials used in the individual parts of the incinerator shall be heat resistance and shall with stand against the mechanical properties, oxidation, corrosion, etc. The Incinerator shell shall be made of mild steel plate of adequate thickness (minimum 5 mm thick) & painted externally with heat resistant aluminum paint suitable to withstand temperature of 250°C with proper surface preparation and also the outside surface temperature of the incinerator casing being touched during normal operations should not exceed 45 to 50 °C above ambient temperature and should be provided with a safety measure in the form of a spikes or mesh around hot surface which will prevent direct touch
 - (xii) Refractory lining of all the hot ducts shall be done with refractory castable & insulating castable. Good quality Ceramic wool shall be used at all hot duct flanges & expansion joints.
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- (xiii) The thermocouple sensor location shall be after tip of the burner and before exit of the incinerator chambers as follows:
- (xiv) There shall be a separate burner each for the Primary & Secondary chamber. One or more separate burners each for primary and secondary chambers may be required depending on diameters of the incinerator chambers to maintain desired temperatures in the incinerator chambers. The heat input capacity of each burner shall be sufficient to raise desired temperature in the primary and secondary chambers i.e., minimum of 800 °C and 1050±50°C respectively as prescribed under the BMW Rules, 2016, within maximum of 60 minutes prior to waste charging. However, considering the life of refractory and also to avoid cracks in the refractory, pre-heating and cooling should be done gradually before and after incineration process. Also, the Incinerators (combustion chambers) shall be able to incinerate the waste so as to achieve the Total Organic Carbon (TOC) content in the slag and bottom ashes less than 3% or their Loss on Ignition (LoI) shall be less than 5% of the dry weight. The burners shall have automatic switching "off/on" control to avoid the fluctuations of temperatures beyond the required temperature range.
- (a) Each burner shall be equipped with spark igniter and main burner.
 - (b) Proper flame safeguard provision of the burner shall be installed
 - (c) Burner retracting mechanism in both the chambers to safeguard the burners.
 - (d) Provide projected type of observation or view ports (high-temperature glass with a metal closure provision) to observe visual condition of the burning process and waste/ash accumulation in the combustion chamber. Neither heat, flame, nor particles should be able to pass through the observation or view port.
 - (e) Flame of the primary burner
 - shall be pointing towards the centre of the hearth.
 - shall be having a length such that it touches the waste but does not impinge directly on the refractory floor or wall.
 - The secondary burner shall be positioned in such a way that the flue gas passes through the flame.
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- (xv) There shall not be any manual handling during charging of waste in to the primary chamber of the incinerator. The waste shall be charged in bags through automatic feeding device at the manufacturer's recommended intervals ensuring no direct exposure of furnace atmosphere to the incinerator operator. The device shall prevent leakage of the hot flue gas & any backfire. The waste shall be introduced on the hearth in such a way so as to prevent the heap formation. Suitable raking arrangement shall be provided for uniform spreading of waste on the hearth.
- (xvi) A tamper-proof PLC (Programmable Logic Control) based control system or SCADA in case of all the upcoming new incinerator with higher capacity (i.e., more than 250 Kg/hour) shall be installed to prevent:
- (a) Opening of waste charging door while the incinerator is in operation with burning of waste or while the incinerator chamber is having temperature is less than 750 ° C and if the temperature in primary chamber is higher than 850 ° C. Waste charging in case of any unsafe conditions such as very high temperature in the primary & secondary chambers.
 - (b) failure of the combustion air fan, ID fan, recirculation pumps;
 - (c) low water pressure & high temperature of the flue gas at the outlet of air pollution control device.
- (xvii) The incineration system must have an automatic emergency vent designed with a provision of valves and a compressor. The emergency vent shall remain closed and such provision shall not emit flue gases or leakages during normal operation of the incinerator.
- (xviii) Each incineration system shall have graphic or computer recording devices which shall automatically and continuously monitor and record dates, time of day, batch sequential number and operating parameters such as temperatures in both the chambers as well as stack exit gas.
- (xix) Flue gas parameters such as CO, CO₂, and O₂ as well as other relevant parameters in gaseous emission as prescribed by the prescribed authority shall also be measured during the operation of the incineration using continuous emission monitoring system (CEMS) (pl. refer to protocols for CEMS issued by CPCB).
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- (xx) The possibility of providing heat recovery system/heat exchanger with the incinerator shall also be considered wherever possible or feasible. Pre-heating of combustion air shall be practiced wherever possible.
- (xxi) Structural design of the chimney / stack shall be as per IS: 6533-1989. The chimney/stack shall be lined from inside with natural hard rubber suitable for the duty conditions and shall also conform to IS:4682 Part I-1994 or suitable thickness of Fibre Reinforced Plastic (FRP) lining also be used to avoid corrosion due to oxygen and acids in the flue gas.
- (xxii) The incinerator should have alarm system to alert the incinerator in the event of power failure, non-operation of the APCD, not maintaining adequate temperatures in primary and secondary chambers or in case of any emergency including the following:
- (a) Deviation from permitted range of pH of the scrubbed liquid;
 - (b) Deviation from permitted range of ID Fan Temperature;
 - (c) Low level of diesel;
 - (d) Low temperature of primary chamber at the time of waste feeding;
 - (e) Exceeding of outlet water temperature
 - (f) Fault in chimney lighting arrestor;
 - (g) Failure of water and electricity supply; and
 - (h) Failure of solenoid valve of any of the burners.
 - (i) Relevant operating parameters as per technology provider/design requirement.
- (xxiii) The incinerator should have instruction plate(s) attached in a prominent location on the unit that clearly addresses (i) Cleaning ashes and slag from the combustion chamber(s) and cleaning of combustion air openings before starting the incinerator (where applicable) and (ii) Operating procedures and instructions. These should include proper start-up procedures, normal shut-down procedures, emergency shut-down procedures, and procedures for loading waste (where applicable).
- (xxiv) All the measuring devices attached with the incinerator should have digital display and should have provision of connecting to the recording system, which should include fuel meter and separate energy meter.
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5. Air pollution control devices

It is not possible to comply with the emission limits prescribed under the BMWM Rules, 2016 without requisite Air Pollution Control Device (APCD). A bio-medical waste incinerator shall always be equipped with suitable APCD and no incinerator shall be allowed to operate unless equipped with APCD. Therefore, Pollution control devices attached with the incineration system should be able to comply with prescribed standards especially for particulate matter, HCl, NOX, combustion efficiency, Mercury & its compounds as well as Dioxins and Furans as prescribed under BMWM Rules, 2016.

There are many combinations of treatment equipment (both wet systems and dry systems or in combination) for enhancement of flue gas cleaning and removal of air pollutants, to comply with the standards. Bag house filters/ESPs involve dry operation and have low pressure drop but much higher capital cost as compared to venturi scrubbers. In case of wet system, the material used for the air pollution control systems should be preferably stainless steel to have life and durability of the APCD.

It is required to maintain optimal conditions for combustion of waste in the incinerator followed by adequate pollution control devices to achieve stipulated limits. Different combinations of treatment units can be used for cleaning of flue gases generated after combustion for removal of air pollutants, to comply with the aforesaid notified standards. Flue gas treatment by concept of either dry or wet control systems. However, in both cases, the exist gas from secondary chamber should be reduced to less than 220 ° C in minimum possible time. Effective flue gas treatment can be achieved by means of heat exchanger in dry APCDs or by quenching in wet APCDs.

Suggested air pollution control devices or treatment scheme for the incineration system may comprise of the equipment, in combination, with adequate efficiencies to ensure compliance to the stipulated emission standards as given in schedule-II of the Bo-medical Waste Management Rules, 2016 (Annexure-I).

- 5.1 Particulate matter:** Fine particulates in the flue gases requires specific dust separation technologies such as settling chamber or in series, cyclones (only for pre-cleaning of flue gases), bag house filters, fabric filters coated with catalyst, ceramic filters, electrostatic precipitator or wet scrubbers (venturi scrubber) in
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order to meet flue gas standards. In case of electrostatic precipitators, special care is required to avoid electric sparks due to presence of dust and to avoid reformation of dioxins and adsorption to the fine dust.

- 5.2 Acids :** Conventional alkali dry or wet scrubber (venturi) with hydrated lime or sodium hydroxide injection is used for neutralizing the acid gases (having pH around 7 to 8.5) is permitted.
- 5.3 Oxides of Nitrogen (NO_x):** In general NO_x generally complied by the bio-medical waste incinerator with the conventional air pollution control systems. For control of NO_x , if required, either catalytic reduction with ammonia in a catalytic converter -selective catalytic reduction (SCR) or by a high-temperature reaction with ammonia in the furnace i.e., selective non-catalytic reduction (SNCR) also be used. Urea may be substituted for ammonia as the reducing reagent but must be supplied earlier in the process so that it can hydrolyze into ammonia. Substitution of urea can reduce costs and potential hazards associated with storage of anhydrous ammonia.
- 5.4 Heavy metals including mercury:** If the feeding bio-medical waste contains mercury and its compounds, there is an every chance of these emissions to get air borne. Therefore, requires specific treatment for control of these emissions. Injection of activated carbon or dry scrubbing with chemicals to precipitate mercury. In general, heavy metals are often adsorbed on injected active carbon powder, which is further collected by particle filtration.
- 5.5 Dioxins:** To reduce the precursors essential for formation of Dioxins & Furans, it is required to ensure proper combustion in secondary chamber by maintaining minimum temperature of about 1050 +/- 50°C and a residence time of atleast 2 seconds. Keeping De-novo synthesis in the backdrop, steps must be taken to prevent reformation of dioxins by rapidly lowering the flue gas temperatures, particularly from 500° C to less than 220° C by adopting rapid quench or heat exchanger system. The flue gas may also be treated using adsorption by activated carbon etc. Apart from this different type of wet and dry adsorption methods with mixtures of activated charcoal, open-hearth coke, lime and limestone solutions in fixed bed, moving bed and fluidized bed reactors (Fixed
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bed reactor, adsorption with activated charcoal or open hearth coke, entrained flow or circulating fluidized bed reactor with added activated coke/lime or limestone solutions and subsequent fabric filter or may be used. Also measures should be taken for avoiding particle deposition by soot cleaners, mechanical rappers, sonic blowers, frequent cleaning of sections which are passed by flue gas at the critical temperature range. Considering the volume of flue gas, approximately 0.5 to 1 kg/hr activated carbon is required to be used in the form of a packed column for all cases upto 300 Kg/hr capacity of BMW incinerators. However, in case of the BMW incinerator with wet scrubbing system, this consumption quantity is required to be arrived in the form of dosing.

- 5.6 Mist:** Mist eliminator is needed in case of wet APCDs comprising of venturi and wet scrubber so as to eliminate mist in stack emissions. The rate of mist elimination depends on type of APCDs adopted.

A typical flow diagram of the APCD attached with the incinerator operated by a CBWTF is given in the **Figure-1 to 2**.

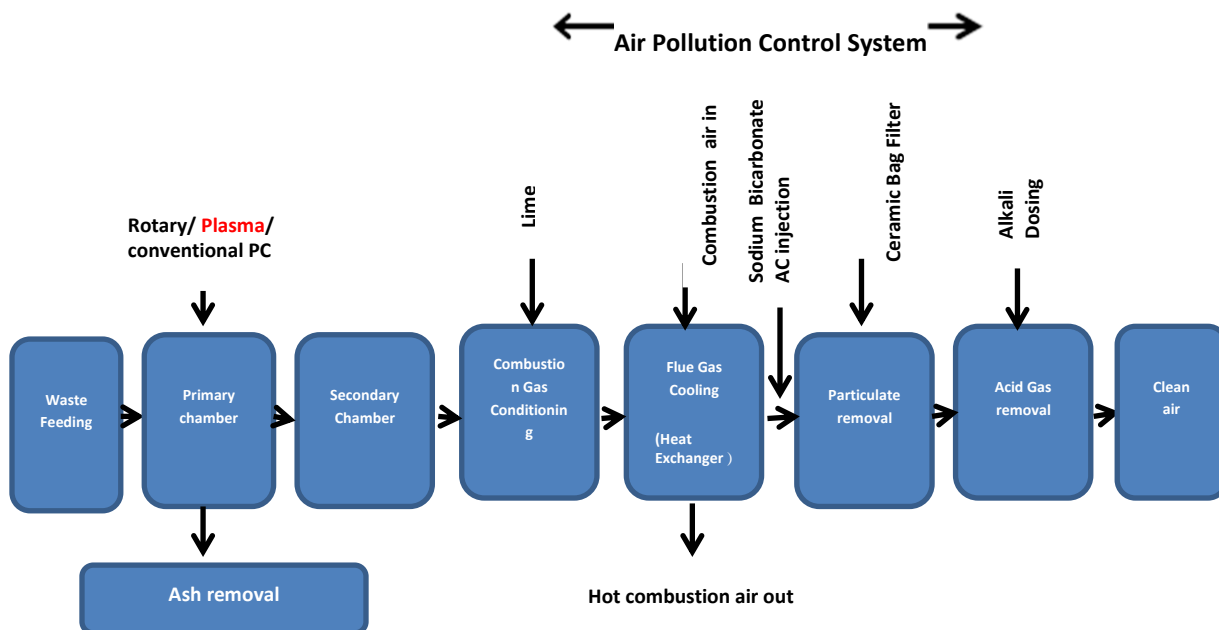


Figure 1. Bio-medical waste incineration with dry air pollution control System

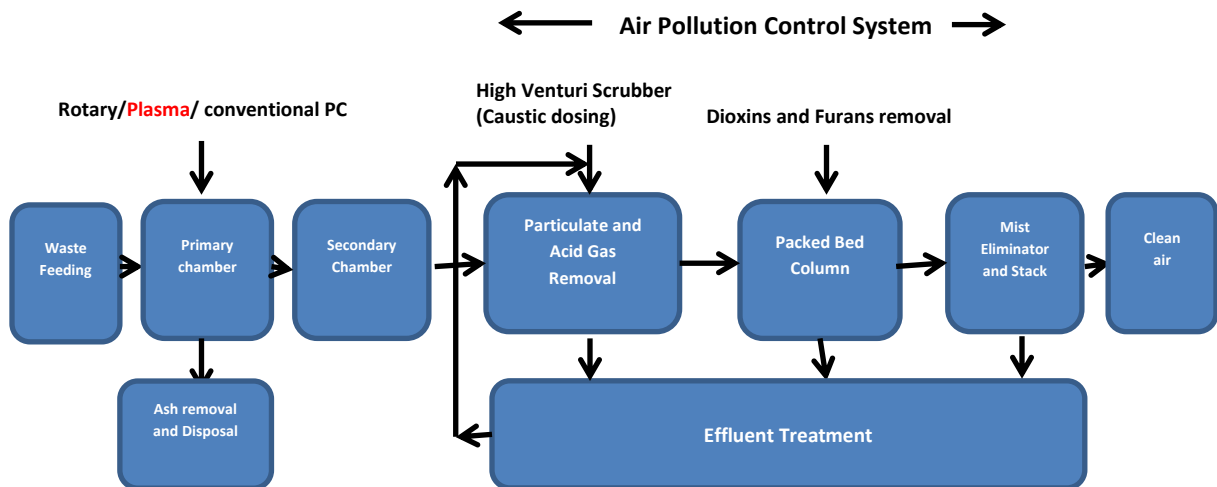


Figure 2. Bio-medical waste incineration with wet air pollution control system

- 5.7 Oxygen correction:** *Oxygen correction to the measured concentrations is to be done only when the measured % oxygen concentration is higher than the standard % oxygen concentration (i.e. 11%).* Correction Formula to calculate the emission concentration at standard percentage of oxygen concentration is as follows:

$$E_s = \frac{(21 - O_s) (E_m)}{(21 - O_m)}$$

Where,

E_s = Calculated emission concentration in % at the standard percentage oxygen concentration in %

E_m = Measured emission concentration in %.

O_s = Standard oxygen concentration in %.

O_m = Measured oxygen concentration in %.

6. Requirements of stack to be attached with the bio-medical waste incinerator

6.1 Stack height requirement

Stack height shall not be less than 30 meters above the ground as stipulated under the BMWM Rules, 2016.

6.2 Stack emission monitoring provision

The sampling location and other monitoring specification of porthole, platform ladder (preferably steel scaffolding or spiral stair-case) etc. to collect stack samples from the chimney for monitoring the air pollutants, as and when required shall be as per the CPCBs Guidelines for Stack Emission Monitoring i.e., LATS -80. Stack should also be fitted with the aviation lamp at the top. For monitoring of Dioxins and Furans, the monitoring provision as given in **Annexure-II** is required to be provided by all the BMW Incinerator operators. However, these monitoring provisions may also be used for monitoring of the general parameters.

6.3 Frequency of monitoring

The bio-medical waste incinerator operator shall carry out stack emission monitoring through a laboratory approved under the Environment (Protection) Act, 1986 and record of such analysis results shall be maintained and submitted to the prescribed authority (SPCB/PCC). For all the new and upcoming bio-medical waste incinerator, the stack emissions are required to be monitored as per the frequency suggested in **Table 2** below:

Table 2 Stack emission monitoring frequency as per BMWM Rules, 2016

S. No	Stack emission monitoring parameters	Frequency of monitoring
(i)	Particulate Matter, HCl, NO _x , Hg & compounds and combustion efficiency	<i>once in three months</i>
(ii)	Dioxins and furans	<i>once in a year</i>

Note: All the monitored values shall be corrected to 11% Oxygen on dry basis.

All the Bio-medical waste incinerator operators existing prior to notification of the BMWM Rules, 2016 dated 28.03.2016, are required to take necessary corrective measures for upgradation of the air pollution control systems to comply with the emission standards stipulated under Schedule - II of the BMWM Rules, 2016, within two years (i.e., 27.03.2018) from the date of notification of the BMWM Rules, 2016 i.e., 28.03.2016.

6.4 Continuous emission monitoring system

All the bio-medical waste treatment facility (both captive incinerators operated by HCFs and the incinerators operated by the CBWTFs) operators shall install continuous emission monitoring system for monitoring of the stack emission parameters as stipulated by State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) in authorisation and transmit the data real time to the servers at SPCB or PCC and CPCB as stipulated under the BMWWM Rules, 2016. Complete details of operation & compliance with regulatory requirements need to be made available to the public in the Web-site by all the bio-medical treatment facility operators in compliance to the BMWWM Rules, 2016. However, to have reliability in monitoring results, the Continuous emission monitoring system (CEMS) shall be used only when the incinerator chambers are heated to desired temperatures. For further details protocol to be issued by CPCB for CEMS should also be referred.

6.5 Monitoring of Dioxins and Furans

Dibenzo-p-dioxins and dibenzofurans: Analysis of dioxins and furans as well as reference measurement methods to calibrate automated measurement systems shall be carried out as given by CEN-standards. If CEN-standards are not available, ISO standards, National or International Standards, which will ensure the provision of data of an equivalent scientific quality, shall apply. The total concentration of dioxins and furans is to be calculated by multiplying mass concentrations of following Dibenzo-p-dioxins and dibenzofurans with their toxic equivalence factors, before summing:

Name of Congener		Toxic equivalence factor
2,3,7,8	Tetrachlorodibenzodioxin	1.0
1,2,3,7,8	Pentachlorodibenzodioxin	0.5
1,2,3,4,7,8	Hexachlorodibenzodioxin	0.1
1,2,3,6,7,8	Hexachlorodibenzodioxin	0.1
1,2,3,7,8,9	Hexachlorodibenzodioxin	0.1
1,2,3,4,6,7,8	Heptachlorodibenzodioxin	0.01

	Octachlorodibenzodioxin	0.001
2,3,7,8	Tetrachlorodibenzofuran	0.1
2,3,4,7,8	Pentachlorodibenzofuran	0.5
1,2,3,7,8	Pentachlorodibenzofuran	0.05
1,2,3,4,7,8	Hexachlorodibenzofuran	0.1
1,2,3,6,7,8	Hexachlorodibenzofuran	0.1
1,2,3,7,8,9	Hexachlorodibenzofuran	0.1
2,3,4,6,7,8	Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8	Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9	Heptachlorodibenzofuran	0.01
	Octachlorodibenzofuran	0.001

Note: EPA Test No. i.e., USEPA Method 23 along with USEPA Method 5 shall be followed for measurement of the Dioxins and Furans.

6.6 Quench/scrubber liquid waste management

In case of wet air pollution control system, appropriate treatment to the wastewaters generated from (i) Cleaning of waste storage areas and the facility; (ii) cleaning of exhaust gases shall be provided. Also, the treated wastewater shall conform to the waste water effluent discharge standards prescribed under the BMWM Rules. Operation of the ETP should be inter-connected with the incineration operation so as to ensure only treated water is recirculated (having pH around 8) in the APCD for effective cleaning of incinerator flue gas.

7 Incineration ash management

Incineration ash (ash from incineration of any bio-medical waste) shall be disposed through hazardous waste treatment, storage and disposal facility, if toxic or hazardous constituents are present beyond the prescribed limits as given in the Hazardous Waste and Other Waste (Management, and Transboundary Movement) Rules, 2016 or as revised from time to time.

Note:

APCD suggested under this guideline is only recommendatory and the operator is required to provide suitable APCD to comply with the norms stipulated under schedule II of the BMWM Rules, 2016 and existing incinerator operator are also required to upgrade the requisite APCD as per the stipulated time period to ensure compliance to the new emission standards including residence time of 2 seconds in secondary incinerator chamber as well as dioxins and furans, mercury in stack emission.

8. Incinerator room and waste storage room

- i. The incinerator structure shall be built in a room with proper roofing and cross ventilation. There shall be minimum of 1.5 m clear distance in all the directions from the incinerator structure to the wall of the incinerator room.
- ii. Adjacent to the incinerator room, there shall be a waste storage area. It shall be properly ventilated and washing can be done very easily. The waste storage room shall be washed and chemically disinfected on daily basis.
- iii. The floor and inner wall of the incinerator and storage rooms shall have outer covering of impervious and glazed material so as to avoid retention of moisture and for easy cleaning.
- iv. The incineration ash shall be stored in a closed sturdy container in a masonry room to avoid any pilferage. Finally, the ash shall be disposed off in accordance with the BMWM Rules.

9. Electrical safety requirements

All the Electrical appliances attached with the incinerator and other machinery should be provided with suitable and necessary safety devices. All cables and wiring should be of copper with insulation and all cable wiring should be in cable tray. All the workers should be trained properly on electrical safety aspects by the manufacturers and only such trained workers should be engaged for operation of the incinerator. Electrical safety aspects should be maintained as per the Factories Act, 1948.

10. Requirements of operator of the incinerator

- i. A well trained /competent personnel shall be designated to operate and maintain the incinerator. The operator shall be skilled manpower, adequate qualification in relevant subject (having atleast qualification of SSC/ITI), and shall be certified by the incinerator supplier in operation & maintenance of the incinerator.
- ii. There shall be at least one assistant designated at the incinerator plant to keep track of the wastes, records of incinerator operation, cleanliness of the surrounding area and incinerator & waste storage room. They shall also take care of
 - waste charging depending on the designed capacity of the incinerator as per recommendations of the manufacturers,
 - Operation of the incinerator in compliance to the operating standards prescribed under the BMWM Rules;
 - No burning of waste containing chlorinated compounds
 - operation and monitoring of the incinerator by periodic maintenance (i.e., cleaning of combustion chamber, declogging of air inflows and fuel burners)
 - regular and /or continuous measurement of the relevant flue gas parameters such as CO₂, O₂, CO and CE and
 - Incineration ash disposal in accordance with the BMWM Rules.
- iii. All the staff at the incinerator plant shall put on protective gears such as gumboots, gloves, eye glasses, etc. for safety reasons.
- iv. Any accident occurred shall immediately be reported to the facility operator. The facility operator shall have well defined strategies to deal with such accident/emergency.
- v. The incinerator manufacturer should have OSHAS 18001 certification.

11 Requirements of the incinerator manufacturer

The manufacture should permanently mark on the incinerator indicating (i) manufacturer's name or trademark (ii) style, type, model or, date of manufacture of the incinerator (iii) capacity and also in terms of net designed heat release in heat units per timed period (i.e., British Thermal Units per hour,

mega joules per hour, kilocalories per hour). The incinerator should be procured by the occupier or operator from manufacturer having (i) Department of Industry; (ii) Registration with Central Exercise and Service Tax.

Also, the Manufacturer shall have to issue the performance guarantee and also certify that the incinerator system has been designed and commissioned such the system can comply with the stipulated standards along with the latest monitoring results of the system as soon as commissioned.

Note:

- (I) ***In case of plasma pyrolysis, the operating parameters of the plasma pyrolysis and the emission standards should be in line with Schedule II of the BMWM Rules, 2016 as given in Annexure-I of these guidelines.***
- (II) ***The guidelines will help in selection/installation of better Bio-medical waste incinerator system. However, it shall be ensured that the Bio-medical waste incinerator shall comply with the standards stipulated under Schedule II of the Bio-medical Waste Management Rules, 2016 notified under the Environment (Protection) Act, 1986.***

12. Suggested Additional General Conditions for plasma pyrolysis: The design requirement of the plasma gasification need not be similar to conventional two stage incinerator. However, the combustion gases generated from plasma gasifier shall be treated with suitable APCS as required for conventional two stage combustion chamber. The following points shall be considered:

- a) Any CBWTF proposes to use above technology, is required to obtain EC from SEIAA or MoEF & CC as the case may be as well as Consent to Operate under Water (Prevention & Control of Pollution) Act, 1974 /Air (Prevention and Control of Pollution) Act, 1981 followed by Authorization under Bio-medical Waste Management Rules, 2026.
- b) The primary chamber of the 'Plasma Pyrolysis system' shall have 'oxygen starved condition' & free from any leakages whereas the secondary

chamber of the system shall have controlled combustion processing atmosphere for complete combustion of the syn gases emanated from the primary chamber.

- c) The system shall have suitable PLC based Automatic Feeding system with a provision of automatic recording for the parameters like date, time, batch no. operating parameters such as temperatures in primary & secondary chambers, negative draft in the primary chamber, amount of excess air supplied in secondary chamber, air flow rate & resident time for saturated gases, scrubber water temperature, pressure drop in the scrubber etc.
 - d) Digital flow meter / suitable flow measuring devices for measurement of negative draft in the primary chamber shall be mounted on the primary and secondary air ducting.
 - e) A minimum negative draft of 2 to 3 mm of WC (Water Column) shall be maintained in the primary chamber to avoid leakage of gaseous emission from the chamber and for safety reasons.
 - f) The waste shall be fed into the system uniformly in adequate quantities depending on the designed capacity of 'Plasma Pyrolysis system' in fixed interval of time.
 - g) The primary and secondary chambers shall preferably have rounded corner from inside to avoid possibility of formation of black pockets / dead zones.
 - h) There shall be a separate graphite plasma torch each for the primary & secondary chamber. The torch shall have automatic switching "off/on" control to avoid the fluctuations of temperatures beyond the required temperature range. There shall be automatic provision for opening of primary chamber only when the desired temperatures attained in the
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primary and secondary chambers. Also following provisions to be made:

- i). proper flame safeguard of the torch shall be installed.
 - ii). Provide view ports to observe flame of the torch.
 - iii). Torch of the primary burner shall be pointing towards the centre of the feed and length of the torch shall be such that it touches the waste but does not impinge directly on the refractory floor or wall.
 - iv). The secondary torch shall be positioned in such a way that the flue gas passes through the flame.
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- i) The CO, CO₂, and O₂ in source emission shall also be measured daily (at least ½ hour at one minute interval) and records in this regard shall be maintained. Additionally, parameters such as CO, Cl, CH₄ and H₂ shall also be measured in secondary chamber, prior to scrubbing and after scrubbing at least once in a month and records shall be maintained and submitted to CPCB and SPCB/PCC.
 - j) The possibility of providing heat recovery system/ heat exchanger with the system shall also be considered wherever possible, to minimize the cost of treatment and energy consumption.
 - k) Only skilled person shall be designated to operate and maintain the system. The operator shall have adequate qualification in relevant subject and shall be trained and certified by the pyrolysis system supplier in operation & maintenance of the system.
 - l) There shall be at least one assistant designated at the plant to keep track of the wastes, records of system operation, cleanliness of the surrounding area and waste storage room. They shall also take care of waste charging and ash disposal.
 - m) All the staff at the plant shall put on protective gears such as gumboots, gloves, eye glasses, etc. for reasons.
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- n) Any accident occurred shall immediately be reported to the facility operator. The facility operator shall have well defined strategies to deal with such accident/emergency.
 - o) The provision of feeder cycle of the system shall start only when the pre-heating temperature in the primary chamber is attained. Provision of proper suction arrangement as well as tangential loading of the material shall be provided in feeder section to avoid fugitive emissions during loading.
 - p) Suitable and adequate insulation shall be provided for the system externally to avoid thermal radiation in the work zone area.
 - q) The system shall be attached with the required stack monitoring provision as per requirement of the Dioxins/Furans monitoring given under **Annexure-II**.
 - r) The operator of a Plasma Pyrolysis shall comply with all the provisions of the Bio-medical Waste Management Rules, 2016 for collection, storage, transportation, treatment and disposal of bio-medical waste.
 - s) The design and construction requirement outlined in this guideline for conventional Bio-medical waste incinerator is also applicable to Plasma Pyrolysis. Any other conditions if necessary that may be imposed by CPCB/SPCB/PCC/MoEF & CC in future if required.
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Annexure-I**Schedule-II of the BMW Rules, 2016: Incinerator Standards for Treatment and Disposal of Bio-medical Waste****1. STANDARDS FOR INCINERATION.-**

All incinerators shall meet the following operating and emission standards-

A. Operating Standards

(j) Combustion efficiency (CE) shall be at least 99.00%.

(ii) The Combustion efficiency is computed as follows:

$$\text{C.E.} = \frac{\% \text{CO}_2}{\% \text{CO}_2 + \% \text{CO}} \times 100$$

(iii) The temperature of the primary chamber shall be a minimum of 800 °C and the secondary chamber shall be minimum of 1050°C + or - 50°C.

(iv) The secondary chamber gas residence time shall be at least two seconds.

B. Emission Standards

Sl. No.	Parameter	Standards	
(1)	(2)	(3)	(4)
		Limiting concentration in mg/Nm³ unless stated	Sampling Duration in minutes, unless stated
1.	Particulate matter	50	30 or 1NM ³ of sample volume, whichever is more
2.	Nitrogen Oxides NO and NO ₂ expressed asNO ₂	400	30 for online sampling or grab sample

3.	HCl	50	30 or 1NM ³ of sample volume, whichever is more
4.	Total Dioxins and Furans	0.1ngTEQ/Nm ³ (at 11% O ₂)	8 hours or 5NM ³ of sample volume, whichever is more
5.	Hg and its compounds	0.05	2 hours or 1NM ³ of sample volume, whichever is more

C. Stack Height: Minimum stack height shall be 30 meters above the ground and shall be attached with the necessary monitoring facilities as per requirement of monitoring of 'general parameters' as notified under the Environment (Protection) Act, 1986 and in accordance with the Central Pollution Control Board Guidelines of Emission Regulation Part-III.

Note:

- (a) The existing incinerators shall comply with the above within a period of two years from the date of the notification.
- (b) The existing incinerators shall comply with the standards for Dioxins and Furans of 0.1ngTEQ/Nm³, as given below within two years from the date of commencement of these rules.
- (c) All upcoming common bio-medical waste treatment facilities having incineration facility or captive incinerator shall comply with standards for Dioxins and Furans.
- (d) The existing secondary combustion chambers of the incinerator and the pollution control devices shall be suitably retrofitted, if necessary, to achieve the emission limits.
- (e) Wastes to be incinerated shall not be chemically treated with any chlorinated disinfectants.
- (e) Ash from incineration of biomedical waste shall be disposed of at common hazardous waste treatment and disposal facility. However, it may be disposed of in municipal landfill, if the toxic metals in incineration ash are within the regulatory quantities as defined under the Hazardous Waste (Management and Handling and Transboundary Movement) Rules, 2008 as amended from time to time.

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- (f) Only low Sulphur fuel like Light Diesel Oil or Low Sulphur Heavy Stock or Diesel, Compressed Natural Gas, Liquefied Natural Gas or Liquefied Petroleum Gas shall be used as fuel in the incinerator.
 - (g) The occupier or operator of a common bio-medical waste treatment facility shall monitor the stack gaseous emissions (under optimum capacity of the incinerator) once in three months through a laboratory approved under the Environment (Protection) Act, 1986 and record of such analysis results shall be maintained and submitted to the prescribed authority. In case of dioxins and furans, monitoring should be done once in a year.
 - (h) The occupier or operator of the common bio-medical waste treatment facility shall install continuous emission monitoring system for the parameters as stipulated by State Pollution Control Board or Pollution Control Committees in authorisation and transmit the data real time to the servers at State Pollution Control Board or Pollution Control Committees and Central Pollution Control Board.
 - (i) All monitored values shall be corrected to 11% Oxygen on dry basis.
 - (j) Incinerators (combustion chambers) shall be operated with such temperature, retention time and turbulence, as to achieve Total Organic Carbon content in the slag and bottom ashes less than 3% or their loss on ignition shall be less than 5% of the dry weight.
 - (k) The occupier or operator of a common bio-medical waste incinerator shall use combustion gas analyzer to measure CO₂, CO and O₂.

2. Operating and Emission Standards for Disposal by Plasma Pyrolysis or Gasification:

A. Operating Standards:

All the operators of the **Plasma Pyrolysis or Gasification** shall meet the following operating and emission standards:

(k) Combustion Efficiency (CE) shall be at least 99.99%.

(ii) The Combustion Efficiency is computed as follows.

$$\text{C.E} = \frac{\% \text{CO}_2}{(\% \text{CO}_2 + \% \text{CO})} \times 100$$

(iii) The temperature of the combustion chamber after plasma gasification shall be $1050 \pm 50^\circ \text{C}$ with gas residence time of at least 2(two) second, with minimum 3 % Oxygen in the stack gas.

(iv) The Stack height should be minimum of 30 m above ground level and shall be attached with the necessary monitoring facilities as per requirement of monitoring of 'general parameters' as notified under the Environment (Protection) Act, 1986 and in accordance with the CPCB Guidelines of Emission Regulation Part-III.

B. Air Emission Standards and Air Pollution Control Measures

(i) Emission standards for incinerator, notified at SI No.1 above in this Schedule, and revised from time to time, shall be applicable for the Plasma Pyrolysis or Gasification also.

(ii) Suitably designed air pollution control devices shall be installed or retrofitted with the 'Plasma Pyrolysis or Gasification to achieve the above emission limits, if necessary.

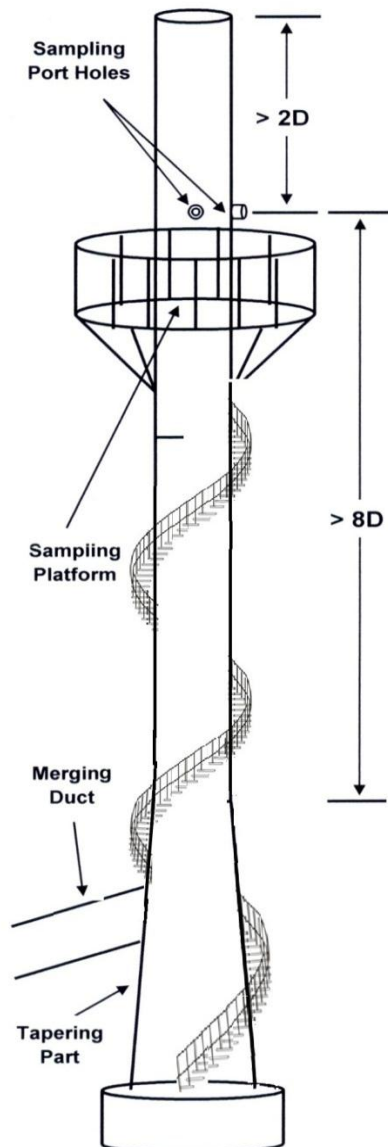
(iii) Wastes to be treated using Plasma Pyrolysis or Gasification shall not be chemically treated with any chlorinated disinfectants and chlorinated plastics shall not be treated in the system.

C. Disposal of Ash Vitrified Material: The ash or vitrified material generated from the 'Plasma Pyrolysis or Gasification shall be disposed off in accordance with the Hazardous and Other Waste (Management and Transboundary Movement) Rules 2016 and revisions made thereafter in case the constituents exceed the limits prescribed under Schedule II of the said Rules or else in accordance with the provisions of the Environment (Protection) Act, 1986, whichever is applicable.

Annexure-II

STATIONARY SOURCE EMISSION MONITORING

MODIFICATIONS TO BE MADE TO SAMPLING PLATFORM AND SAMPLING PORT HOLE



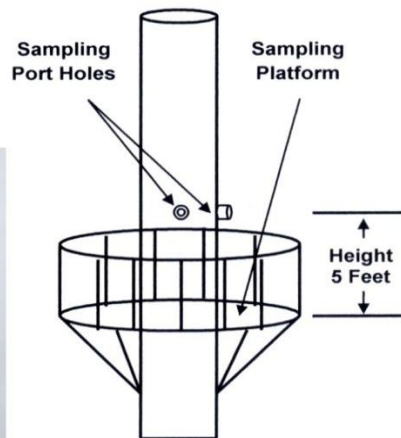
Number of Port Holes : Minimum two numbers of Port Holes at 90° apart from each other at a horizontal plane.

Location of Port Holes : Minimum 8 times of Internal Diameters of Stack downstream (upward direction of stack) from any duct confluence, bends and tapering & minimum 2 times of Internal Diameters of Stack upstream (downward direction of stack) from stack exit.

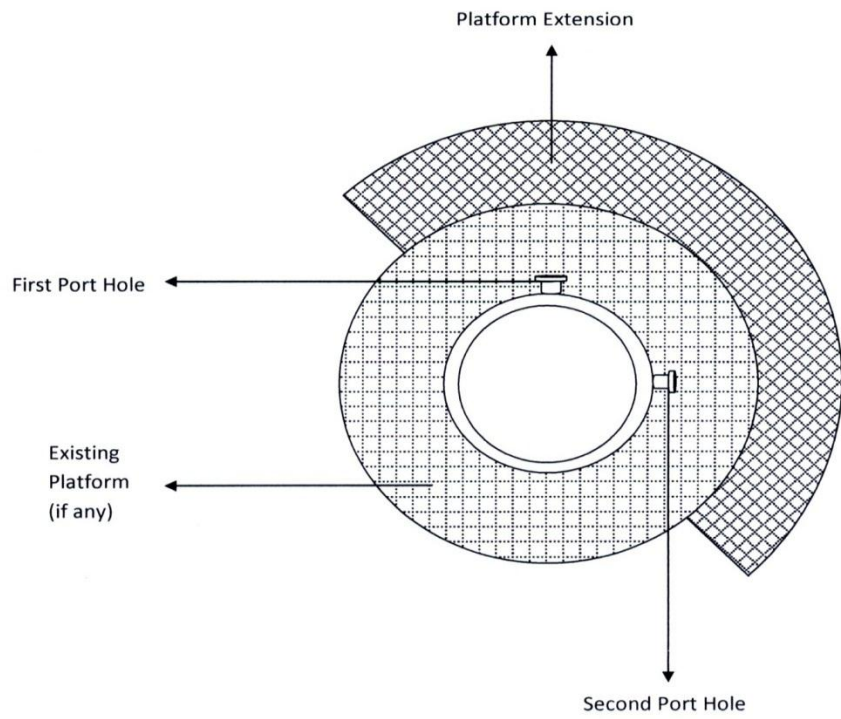
Location of Sampling Platform : 5 feet upstream (downward direction of stack) from the Port Hole as determined above.

Port Hole Flange : If the internal diameter of the flange is 4 inch or more then there is no need to change, if it is less than 4 inch than it has to be replaced with 4 inch flange. The flange should not protrude out more than 6 inches from the outer wall of the stack (it shall be kept as less as possible).

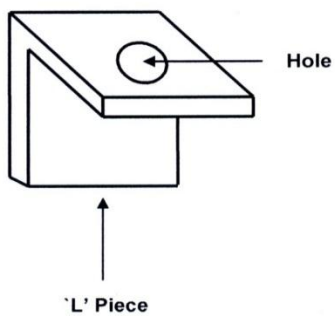
Sampling Platform Modification : A semi-circular extension of the existing platform (width extending outward by 6 feet from outside wall of the stack and covering at least one third of the circumference) may be provided for access to both the Port Holes. This area can be extended from the existing Platform and if deemed necessary for safety of the personnel a counter extension in opposite direction may also be provided. The extended Platform shall be strengthened with requisite support from the stack.



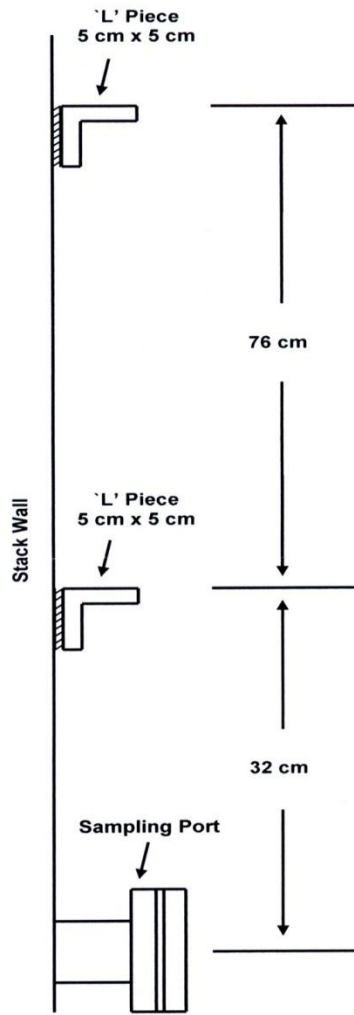
Note: Alternatively, safe access to monitoring platform may be provided with separate scaffolding-cum-staircase arrangement



Sampling Platform Modification / Extension



Fixing of 'L' Pieces on the stack wall : Two 'L' shaped pieces are to be fixed on the stack wall for mounting the Mono-Rail & Chain (part of the Sampling Kit for movement of sampling Train in & out through the Sampling Port Hole). The 'L' pieces shall be made of approximately 6 mm thick galvanized iron to have 5 cm long arms. One arm of the 'L' piece shall be welded on the stack wall and another arm shall have a hole of 14 mm diameter near the open end. Both the 'L' Pieces shall be welded on the stack wall at specified distances (as shown in the diagram on the next page) from the centre of Sampling Port Hole (in a vertical axis on the Stack Wall).



Fixing of 'L' Pieces on the Stack Wall

REFERENCES

1. Bio-medical Waste Management Rules, 2016.
2. CPCB Guidelines for BMW Incinerators (2003).
3. Annual Report 2014 submitted to CPCB by the SPCBs/PCCs.
4. Stationary Source Emission Monitoring –Modifications to be made to the Sampling Platform and Sampling Port Hole issued by National Reference Trace Organics Laboratory (NRTOL), CPCB.

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