



**A GUIDANCE NOTE ON THE  
BEST PRACTICABLE MEANS  
FOR  
SPECIFIED PROCESS –  
GAS WORKS  
(CARBONIZATION AND GASIFICATION  
OF PLANT BIOMASS)**

**BPM 8/1 (2019)**

**Environmental Protection Department**

Environmental Compliance Division /  
Air Policy Division

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# 1. INTRODUCTION

1.1 This Note is one of a series issued by the Environmental Protection Department (EPD) to guide the air pollution management of specified processes (SP), to which Part IV of the Air Pollution Control Ordinance (the Ordinance) applies, and the assessment of an application for SP licence. It covers operations for the carbonization and gasification of plant biomass<sup>1</sup>, which are classified as specified process of “Gas Works” as described in Schedule 1 to the Ordinance -

“Works in which coal, coke, oil, carbonaceous material or any mixtures or derivatives of such materials or any waste materials are handled or prepared for carbonization or gasification and in which such materials are carbonized or gasified.”

## Definition

1.2 For the purpose of this Note,

“plant biomass” refers to any organic material that comes from plants and can be burned directly as fuel or converted to biochar, liquid biofuels or biogas fuels<sup>2</sup>;

“oil” includes fossil-derived oil (e.g. engine oil) and biomass-derived fuel (e.g. animal fats and vegetable oil);

“carbonization” means a process by which solid residues with increasing content of the element carbon are formed from organic materials usually by pyrolysis<sup>3</sup> in an inert atmosphere<sup>4</sup>;

“gasification” means the partial combustion process of organic materials at high temperature with the help of a gasification substance (e.g. air or steam) to produce synthesis gases (syngas) that can be used as chemical feedstock (through some reforming processes) or as a fuel<sup>5</sup>; and

“carbonaceous material” refers to any solid material other than an inorganic carbonate which contains carbon or carbon containing compounds<sup>6</sup>.

1.3 Plant biomass is a type of carbonaceous material, which includes fallen trees trunks

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<sup>1</sup> Operations for the carbonization and gasification of coal, coke, oil and carbonaceous material (other than plant biomass) or any mixtures or derivatives of such materials or any waste materials, are covered in another guidance note – BPM 8/2 (2019).

<sup>2</sup> Reference is made to the publication titled *Review of Woodfuel Biomass Production and Utilization in Africa* published by the United Nation Environment Programme. (<https://wedocs.unep.org/handle/20.500.11822/28515>)

<sup>3</sup> Pyrolysis is the thermal degradation of a substance at elevated temperatures in the absence of oxygen.

<sup>4</sup> Reference is made to the definition of “carbonization” from *Compendium of Chemical Terminology* published by International Union of Pure and Applied Chemistry. (<https://goldbook.iupac.org/terms/view/C00840>)

<sup>5</sup> Reference is made to the definition of “gasification” from *Best Available Techniques (BAT) Reference Document for Waste Incineration (Final Draft December 2018)* published by Joint Research Centre of the European Commission. (<https://eippcb.jrc.ec.europa.eu/reference/>)

<sup>6</sup> Reference is made to the definition of “carbonaceous material” from *Consolidated Glossary of the United States Patent and Trademark Office*. (<https://www.uspto.gov/web/patents/classification/glossary/index.htm>).

and branches, sawdust, wood shavings, woodchips, wood offcuts, horse bedding material contaminated with horse urine and/or manure, wooden pallets and bamboo poles from dismantled bamboo scaffolds.

### Best Practicable Means (BPM)

- 1.4 Under section 12 of the Ordinance, the owner of any premises used for the conduct of an SP shall use the BPM for preventing the emission of noxious or offensive emissions from their plants, preventing the discharge of such emissions into the atmosphere and rendering such emissions where discharged harmless and inoffensive. This Note sets out the minimum requirements for the provision and maintenance of the BPM for an individual plant. However, an applicant for an SP licence should recognize that fulfilment of the requirements in this Note does not necessarily lead to the granting of the licence because the decision will also take into account the circumstances of an individual application. In addition, the Authority may impose specific requirements in the licence, if granted, on top of the requirements set out in this Note. The terms and conditions in the SP licence should be the statutory requirements for the environmental management of the SP.

(Note: “best practicable means”, where used with respect to the emission from a premises of an air pollutant, has reference not only to the provision and the efficient maintenance of appliances adequate for preventing such emission, but also to the manner in which such appliances are used and to the proper supervision by the owner of the premises of any operation in which such an air pollutant is evolved.)

- 1.5 If an SP licence holder seeks to renew the licence of his existing SP that fails to meet the latest version of this Note at the time of the licence renewal application, the licence holder should provide full justifications for the failure and propose for the Authority’s consideration a practicable plan with reasonable implementation timeframe to upgrade the emission control performance of the plant concerned.

## **2. EMISSION LIMITS**

- 2.1 All emissions to air, other than steam or water vapour, shall be colourless, free from persistent mist or fume, and free from droplets.
- 2.2 Emissions from non-fugitive fixed emission points in the specified process and associated processes covered by this Note shall not:
- (a) exceed the concentration limits set out in Annex I; and
  - (b) appear to be as dark as or darker than Shade 1 on the Ringelmann Chart when compared in the appropriate manner with the Ringelmann Chart or an approved device, if the emission is due to a combustion or pyrolysis process.

### **3. TYPE OF FUEL USED**

- 3.1 All fuels to be used shall comply with the Air Pollution Control (Fuel Restriction) Regulations in force or be approved by the Authority. Clean energy sources and fuels with proven benefits to air pollution reduction (such as electricity, gaseous fuel or pyrolytic gas generated during the carbonization / gasification process) shall be used whenever possible in the process.

### **4. CONTROL OF EMISSIONS**

- 4.1 Emission of air pollutants shall be minimized to prevent:
- (a) harm to the environment, adverse effects to human health, or creation of any nuisance situation (e.g. objectionable odours noticeable outside the premises where the process is carried out);
  - (b) hindrance to the attainment or maintenance of the relevant air quality objectives; and
  - (c) undue constraints on the existing and future development or land use.
- 4.2 To satisfy the emission limits set out in Section 2 of this Note, prevention or reduction of emissions at source should be made. Where the emission cannot be prevented or reduced at source to a sufficient extent to meet these requirements, air pollution control equipment shall be provided to meet the emission limits.

#### Control of feedstocks

- 4.3 Plant biomass used as feedstocks shall be screened and sorted to remove all halogenated compounds and other unwanted materials such as plastics, metals, rubber tyres and debris before being fed into the carbonization or gasification plant. The maximum content of sulphur, chlorine and heavy metals of the feedstock shall comply with the specifications in Annex II. The licensee should prepare a sampling plan to collect representative samples of feedstock for analysis to demonstrate the compliance with the specifications. The sampling plan shall be submitted to the Authority for agreement at least one week before conducting a commissioning trial of the plant according to paragraph 7.1 below.

#### Design of Carbonization / Gasification Plant, Work Process and Plant Equipment

- 4.4 The carbonization or gasification plant (batch-type or continuous-type) shall be suitably designed based on sound and relevant engineering principles, and be installed and operated to ensure safe and effective thermal decomposition of plant biomass into pyrolytic char, oil and/or gas with minimal environmental impacts. The relevant design and operation practices shall make reference to, and be on a par with the international best available technologies and best environmental practices of relevant trades.

- 4.5 A suitably designed thermal oxidizer or other type of control equipment acceptable to the Authority shall be provided to ensure complete destruction of unwanted combustible substances in the waste gas emitted from the carbonization or gasification kiln / chamber.
- 4.6 The operating temperature of the thermal oxidizer shall be kept at 500°C or above at all time during operation. Otherwise, auxiliary burner(s) shall be incorporated and operated to maintain the temperature at 500°C or above which shall be measured near the inner wall of the combustion chamber or at another representative point of the thermal oxidizer acceptable to the Authority.
- 4.7 If the operation of the carbonization or gasification plant including, but not limited to, the loading of feedstocks into or unloading of products/by-products/wastes from the carbonization or gasification plant may lead to release of air pollutants (including particulates, fumes and odourous air) into the atmosphere, the plant shall be placed and operated inside an enclosure structure as far as practicable. For saw dust or similar fugitive materials, appropriate air pollution mitigation measures (e.g. installation of suitable dust abatement equipment, adoption of air-tight design of the equipment or proper enclosure of the plant) shall be adopted during the operation.
- 4.8 If enclosure structure is required, it shall be designed to prevent the uncontrolled escape of air pollutant emissions including particulates, fumes and odourous air from the plant. Typical air pollutant abatement measures may include maintaining a reasonable negative pressure and fitting self-closing doors at workplace to contain air pollutant emission. Relevant emissions shall be adequately collected by local exhaust, and vented to suitable abatement equipment for proper treatment before being discharged to the atmosphere. Enclosed process chamber, casings, ductwork and ancillary equipment shall be maintained as gas-tight as far as practicable.
- 4.9 Any waste heat generated by the carbonization or gasification process should be recovered as far as practicable.

#### Design of chimney

- 4.10 Chimney include vents, structures and openings of any kind from or through which air pollutants may be emitted. They shall be properly located and designed so as to satisfy the requirements set out in paragraph 4.1 above.
- 4.11 The height of the chimney connected to the thermal oxidizer shall be determined by mathematical or physical dispersion modelling techniques acceptable to the Authority. The exit temperature of the exhaust gas from the chimney shall not be less than 80 °C at full load condition with efflux velocity not less than 7 m/s, or any other value as agreed by the Authority.
- 4.12 For hot emissions, chimney flues and ductwork leading to the chimney shall be adequately insulated with environmental-friendly materials to minimize the cooling of waste gas and prevent liquid condensation on internal surfaces. The design of the chimney shall allow for regular internal cleaning of the chimney flues and ductwork.

## 5. FUGITIVE EMISSION CONTROL

### Engineering Design/Technical Requirement

5.1 The Authority will prescribe the requirements in consideration of the circumstances of individual SP plant. As a general guidance, the loading, unloading, handling and storage of fuel, feedstocks, products, wastes or by-products should be carried out in a manner acceptable to the Authority so as to prevent the release of:

- (a) visible dust emission; and/or
- (b) other noxious or offensive emissions.

5.2 Without prejudice to the generality of the above general requirements, the following control measures shall be implemented:

### Shredding and Crushing Operations

5.3 If shredders and/or crushers or similar machinery are used to break and reduce the size of the feedstocks, products, wastes or by-products onsite, then the shredding and/or crushing operations shall be carried out as far as practicable inside an enclosure structure enclosed on the top and the 3 sides, and its front opening shall be completely covered with self-closing door(s) or flexible curtain(s) when no loading or unloading activity takes place so as to prevent fugitive emission. Where necessary, the ventilation outlet of the enclosure structure shall be ducted to an effective dust extraction and collection system with dust removal efficiency not less than 99.9% (“dust collector”) such as a fabric filter. If the sizes of the feedstocks, products, wastes or by-products are sufficient large so that the risk of becoming airborne is relatively low, appropriate dust suppression measures such as enclosure of the 3-sides and water sprayers shall be applied for the operations as far as practicable. The enclosure shall be taller than the piles of feedstocks, products, wastes or by-products kept inside the enclosure to prevent fugitive emissions caused by wind erosion.

5.4 If the shredding and/or crushing operations are to be carried out in open air, water or a dust suppression chemical shall be sprayed on the feedstock, products, wastes or by-products with a frequency that can effectively suppress dust emissions, unless the shredding and/or crushing processes are accompanied by the operation of an effective dust collector to collect fugitive dust before being discharged to the atmosphere.

5.5 If the feeding process of the shredders and/or crushers may cause excessive emissions, effective dust preventing measures such as enclosing the inlet hoppers of the shredders and/or crushers or installing water sprayers at suitable locations near the inlet hoppers shall be applied.

5.6 Where necessary, water sprayers shall be installed and operated in strategic locations at or near the inlet hoppers of the shredders and/or crushers to suppress dust emission.

### Loading, Unloading and Transfer of Dusty Materials

- 5.7 All receiving hoppers for unloading dusty materials (including feedstocks, products, wastes or by-products, etc. which may give rise to dust emissions) shall be enclosed on the 3 sides with adequate height above the unloading point. In no case shall these hoppers be used as regular storage devices for the feedstocks, products, waste or by-products.
- 5.8 The unloading of dusty materials to the receiving hoppers shall be carried out without substantial spillage of dust. The surface of the dusty materials shall be prevented from drying out during transportation by keeping the dusty material in properly covered container or by maintaining its moisture content adequately.
- 5.9 Unless the moisture content of the dusty materials is a matter of concern, all dusty material shall be sprayed with water or a dust suppression chemical immediately prior to any loading, unloading or transfer operation so as to maintain the dusty materials wet.

### Conveyors

- 5.10 The conveyors for loading, unloading, handling, transfer or storage of fuel, feedstocks, products, wastes or by-products which may generate excessive emissions, should be properly enclosed on the top and the 2 sides with suitable material at the bottom to eliminate any dust emission due to wind-whipping effect. Other design of enclosure will also be considered by the Authority if it can demonstrate that the proposed design has the same performance.
- 5.11 All conveyor transfer points shall be totally enclosed. Openings on the enclosure structure housing the shredders and/or crushers for the passage of conveyors shall be fitted with effective flexible seals to prevent dust emission. All materials collected by dust collector shall be transferred in enclosed system and properly stored inside bins or enclosures.
- 5.12 An effective belt scrapers or an equivalent device shall be provided at the turning points of all belt-type conveyors to remove dust adhered to the belt surface.

### Storage piles and bins

- 5.13 Where practicable, free falling transfer points from conveyors to stockpiles shall be fitted with chute(s) or flexible curtain to minimize dust emission due to wind-whipping effect and water sprays shall also be used where required.
- 5.14 Bulk storage areas or stockpiles shall be enclosed on the top and the 3 sides and the front opening of the enclosure structure shall be completely covered with self-closing door(s) or flexible curtain(s) when no loading or unloading activity takes place so as to prevent fugitive emission. If the sizes of the feedstocks, products, wastes or by-products are sufficiently large so that the risk of becoming airborne is relatively low, the bulk storage areas or stockpiles can be enclosed on the 3 sides provided that the enclosure shall be tall enough to prevent fugitive emissions caused by wind erosion.

Cleaning of vehicles leaving the premises

- 5.15 Suitable and practicable measures shall be taken to prevent or minimize the dust emission caused by vehicle movement within the premises.
- 5.16 Access and route roads within the premises should be paved and adequately wetted when necessary unless other alternative measures to the satisfaction of the Authority are implemented.
- 5.17 If any of the feedstocks, products, wastes or by-products is in a form that could become airborne easily and adhere to the bodies and/or wheels of the vehicles operating within the premises, then effective vehicle cleaning facilities and/or arrangement, such as installation of adequate number of pressurized water spray nozzles, shall be provided at the site exit of the premises and used to clean the bodies and/or wheels of the vehicles before leaving the premises.
- 5.18 Where vehicle cleaning facilities are required, there shall be no visible run-off of sediment-laden water from them to areas outside the premises.
- 5.19 As different arrangements of vehicle cleaning facilities may be used to meet specific site conditions, the applicant for a new licence, variation of a licence or renewal of a licence shall provide detailed information on vehicles cleaning facilities if they are required for agreement by the Authority.

Housekeeping

- 5.20 A high standard of housekeeping shall be maintained in all plant areas. Adequate provisions shall be made for the containment of liquid and solid spillages from the carbonization or gasification process and associated processes. All spillages shall be cleared as soon as possible by a cleaning method acceptable to the Authority and discarded in close containers for disposal or reuse. Any dumping of dusty materials at open area shall be prohibited.
- 5.21 Emissions from the wastewater treatment plant, if provided, shall be minimized and properly controlled to prevent nuisance.

**6. OPERATION AND MAINTENANCE**

- 6.1 BPM requirements include the proper operation and maintenance of equipment, its supervision when in use and the training and supervision of qualified staff. Specific operation and maintenance requirements may be specified by the Authority for individual equipment.
- 6.2 All control and monitoring equipment should be operational and functioning properly when the carbonization or gasification process and associated processes are in operation.
- 6.3 Operating staff shall be properly trained in their duties relating to control of the process and emissions to air. Particular emphasis shall be given to training for



start-up, shut down and abnormal conditions.

- 6.4 Malfunctioning and breakdown of the process or air pollution control equipment, which would cause exceedance of the emission limits or breaches of other air pollution control requirements, shall be reported to the Authority without delay. Moreover, all practicable means (including refraining from using the defective equipment) shall be taken to minimize the abnormal emission.

## **7. COMMISSIONING**

- 7.1 Commissioning trial of the plant, to be witnessed by the Authority whenever appropriate, should be conducted to demonstrate the effectiveness of the air pollution control measures and the compliance with the emission limits. A report shall be submitted to the Authority within 1 month after the completion of the commissioning trial.
- 7.2 The commissioning trial referred to in paragraph 7.1 above shall be conducted in such manner and format agreed by the Authority. Upon satisfactory demonstration to meet the emission limits in the commissioning trial, the Authority will consider the commissioning trial results in setting monitoring requirements of the plant, including the list of parameters to be monitored and the monitoring frequency.

## **8. MONITORING REQUIREMENTS**

- 8.1 The monitoring requirements (e.g. equipment and techniques used) shall be able to demonstrate that the process is properly operated and the emissions can be minimized to comply with the relevant emission limits in Annex I and properties of feedstocks used in the process can comply with the specifications in Annex II. The scope, manner and frequency of the monitoring shall be sufficient for this purpose and will be determined by the Authority based on the processing capacity, types of feedstocks used and sampling results of the commissioning trials.
- 8.2 Monitoring results shall be recorded and submitted to the Authority in such manner specified by the Authority. The record shall be retained at the premises for a minimum of two years, or other period specified by the Authority, after the date of last entry and made available for examination as and when required by the Authority.
- 8.3 The following operating parameters of the carbonization / gasification plant shall be monitored and recorded continuously or periodically as far as practicable to ensure the plant is operated properly.
- (a) Temperature and oxygen content (where applicable) of the gas at the appropriate location(s) in the combustion chamber of the thermal oxidizer; and
  - (b) Temperature and flow rate of the gas at the appropriate location(s) in the chimney.

8.4 Submission of Monitoring Data

The monitoring data referred to in paragraphs 8.3 (a) and (b) above shall be submitted to the Authority in such manner and format agreed with the Authority.

8.5 Process Monitoring

Monthly total of feedstock input, product output and material stock, and other essential operating parameter(s) which may significantly affect the emission of air pollutants shall be submitted to the Authority in such manner and format agreed with the Authority.

8.6 Ambient monitoring

Ambient monitoring shall be conducted if required by the Authority, in such a manner and at such locations and frequency specified by the Authority.

<p>At site boundary and/or any other locations outside the premises acceptable to the Authority:</p>	<p>(i) Respirable suspended particulates (at least one 24-hour sample per 6 calendar days)</p> <p>(ii) Odour patrols along or beyond the site boundary when the plant is in operation [Odour patrols to be conducted by the plant environmental personnel or operator, who shall be free from any respiratory diseases at the time of patrolling, to detect any odour at least two times per day/shift (preferably one in the morning and one in the afternoon), or at frequency to be determined by the Authority.]</p>
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8.7 The following Boundary Ambient Standards set for triggering investigations by the licensee

<p>Respirable suspended particulates :</p>	<p>The prevailing 24-hour Air Quality Objective of respirable suspended particulates</p>
<p>Odour :</p>	<p>Objectionable odour noticeable at the site boundary and/or outside the premises</p>

8.8 Should any ambient monitoring result exceeds the Boundary Ambient Standards, the licensee shall take action according to the Event and Action Plan at Annex III.

**ANNEX I CONCENTRATION LIMITS FOR EMISSIONS FROM CARBONIZATION AND GASIFICATION PLANT**

I.1 Air pollutant emissions from the carbonization/gasification process shall not exceed the concentration limits tabulated in the following table. The air pollutant concentration is expressed at reference conditions of 0°C temperature, 101.325 kPa pressure, dry and 11% oxygen content conditions.

Air Pollutant	Concentration Limit (mg / m <sup>3</sup> )	
	Half-hourly Average	Daily Average
Particulates	30	10
Gaseous and vaporous organic substances, expressed as total organic carbon	20	10
Nitrogen oxides, expressed as nitrogen dioxide (NO <sub>2</sub> )	400	200
Carbon monoxide (CO)	100	50

## ANNEX II SPECIFICATIONS OF FEEDSTOCK

II.1 Compositions of sulphur, chlorine and heavy metals of plant biomass to be used as feedstock for the carbonization and gasification processes covered by this Note shall comply with the limits tabulated in the following table. Alternate methods approved by the Authority may also be used to confirm the specifications of feedstock.

<b>Parameters</b>	<b>Unit</b>	<b>Limit</b>	<b>Testing Standard</b>
Sulfur (S)	Wt-%	$\leq 0.05$	ISO 16994
Chlorine (Cl)	Wt-%	$\leq 0.03$	ISO 16994
Arsenic (As)	mg/Kg	$\leq 1$	ISO 16968
Cadmium (Cd)	mg/Kg	$\leq 0.5$	ISO 16968
Chromium (Cr)	mg/Kg	$\leq 10$	ISO 16968
Copper (Cu)	mg/Kg	$\leq 10$	ISO 16968
Lead (Pb)	mg/Kg	$\leq 10$	ISO 16968
Mercury (Hg)	mg/Kg	$\leq 0.1$	ISO 16968
Nickel (Ni)	mg/Kg	$\leq 10$	ISO 16968
Zinc (Zn)	mg/Kg	$\leq 100$	ISO 16968

### ANNEX III EVENT AND ACTION PLAN

<p>Parameter: Respirable Suspended Particulates (RSP) (24 hour average)          Monitoring frequency: At least one 24-hour sample per 6 calendar days          Action level: The prevailing 24-hour Air Quality Objective (AQO) of RSP</p>	
Plant Environmental Personnel	Licensee
<ol style="list-style-type: none"> <li>1. Identify the source, investigate the causes and propose remedial measures. (<i>Exceedance of action level may be caused by malfunction of sampler and its operation, high level of background concentration, failure of air pollution control equipment, mishandling of materials, etc.</i>)</li> <li>2. Discuss with the operator for remedial actions required.</li> <li>3. Carry out corrective actions.</li> <li>4. Check the effectiveness of actions.</li> <li>5. Repeat measurement and increase monitoring frequency if necessary.</li> </ol>	<ol style="list-style-type: none"> <li>1. Notify the Authority for events with concentration equal or above the latest 24-hour AQO of RSP.</li> <li>2. Rectify any unacceptable practice by Licensee.</li> <li>3. Amend working methods if appropriate.</li> <li>4. Report details of the findings (together with the daily inspection records in the past six days before the event) to the Authority.</li> </ol>
<p>Parameter: Objectionable Odour          Monitoring frequency and detecting method: To be determined by the Authority          Action level: Objectionable odour noticeable at the site boundary and/or any other locations outside the premises acceptable to the Authority</p>	
Plant Environmental Personnel	Licensee
<ol style="list-style-type: none"> <li>1. Identify the source, investigate the causes and propose remedial measures. (<i>An odour patrols along or beyond the site boundary should be made at least two times per day/shift by the plant environmental personnel when the plant is in operation. The time, location and result of these checks, along with weather conditions such as indicative wind direction and strength, should be recorded to help identify the source.</i>)</li> <li>2. Discuss with the operator for remedial actions required.</li> <li>3. Carry out corrective actions.</li> <li>4. Check the effectiveness of actions.</li> <li>5. Repeat odour patrols and increase patrol frequency if necessary.</li> </ol>	<ol style="list-style-type: none"> <li>1. Notify the Authority for events with emissions detected with objectionable odour.</li> <li>2. Rectify any unacceptable practice by Licensee.</li> <li>3. Amend working methods if appropriate.</li> <li>4. Report details of the findings to the Authority.</li> </ol>