How to comply with your environmental permit

Additional guidance for:

# Treating waste by thermal desorption (An addendum to S5.06)

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# Contents

# 1 Introduction

This document expands upon the requirements of **IPPC S5.06: Guidance for the recovery and disposal of hazardous and non-hazardous waste** (SGN 5.06), which sets out standards for the design, operation and management of waste facilities subject to environmental permitting under the IPPC Directive[1] and **EPR 1.00 How to comply with your environmental permit**.

This guidance document sets out the additional requirements that we expect regulated facilities to meet for the treatment of waste materials by thermal desorption processes, along with those set out in SGN 5.06. New facilities will normally be expected as a minimum to comply with these requirements from the start of operation. We also expect existing facilities to comply, although where significant improvements are needed we will allow an appropriate length of time to up-grade in order to achieve this[2].

We have also published a generic guidance document relevant to all industrial and commercial premises called "Getting Your Site Right – Industrial and Commercial Pollution Prevention", which provides advice for businesses on minimising waste and pollution risk.

## 1.1 What activities are covered?

This guidance is applicable to installations and mobile plant that undertake thermal desorption as a Part A(1) activity listed in Schedule 1 of the Environmental Permitting Regulations (England & Wales).

Thermal desorption is a treatment process whereby heat is applied to materials, such as waste soils, sediments, slurries and filter cakes, in order to remove (vaporise) volatile contaminants (e.g. oils and solvents). Along with such volatile contaminants, thermal desorption will also vaporise water contained within the material and therefore a thermal desorption plant also functions, and may be referred to, as a "dryer". A schematic of a typical indirect thermal desorption process is summarised in Figure 1 below.

Off-gas arising from the heating process (i.e. the gas given off from the waste during the heating process, containing the vaporised contaminants and water vapour) should be collected and cooled, in order to condense out the contaminants to enable their collection and potential recovery (e.g. by using the recovered oil or solvent as a fuel).

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[1] **DIRECTIVE 2008/1/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL** of 15 January 2008 concerning integrated pollution prevention and control (Codified version)

[2] Appropriate timescales for upgrading and improving existing plant are discussed in Section 1.4 of Sector Guidance Note S5.06

The off-gas will also require filtration to remove particulates, for example using a cyclone, scrubber or fabric filter. Following condensation and filtration, further abatement of the off-gas should be provided to ensure that any small quantities of residual volatiles are removed (e.g. by carbon adsorption) or destroyed (e.g. by thermal oxidation) before it is emitted to air.

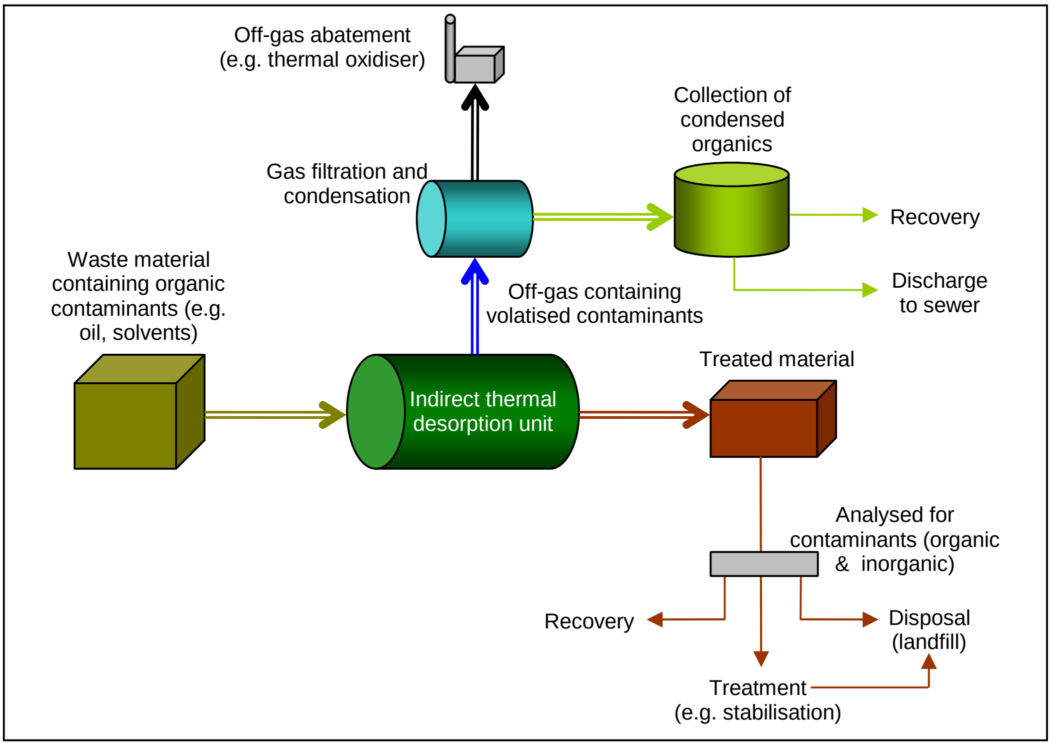



**Figure 1 - Schematic of a typical thermal desorption treatment process**

The treated solid wastes are collected and allowed to cool before being sent for disposal or recovery. As thermal desorption primarily removes organic contaminants, the treated material may still contain high concentrations of inorganic contaminants (metals) and therefore may require further treatment, e.g. stabilisation.

The condensed liquid from the thermal desorption process may require further treatment before discharge to sewer due, for example, to the presence of residual oil, metals and levels of chloride or Chemical Oxygen Demand (COD).

It is important, both from a regulatory and operational perspective, to distinguish between waste thermal desorption processes and waste incineration processes. Thermal desorption is a process that generally operates at lower temperatures than waste incineration (usually below 400°C, although higher temperatures may be required for specific contaminants) and treats the contaminants through a process of thermally-induced physical separation and collection, rather than destruction (through either oxidation or chemical decomposition).

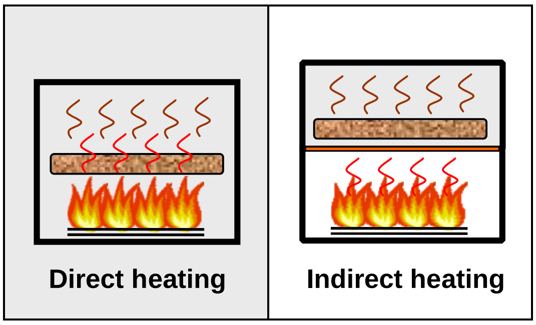
The principal aim of a thermal desorption process is to heat the waste material to a specified temperature (or sequence of temperatures) in order to change the physical state of the volatile contaminants (i.e. from liquid or solid to gas); vaporising them from the material in order to facilitate their removal and subsequent recovery, whilst preventing their destruction. To prevent the destruction of the volatile contaminants or the waste material itself a thermal desorption process should be designed and operated to ensure that the waste is not heated under conditions (i.e. in terms of treatment temperature, pressure and oxygen level) that would result in oxidation (e.g. combustion) or chemical decomposition (e.g. pyrolysis).

Direct and indirect thermal desorption units (TDUs) (see Section 1.2 for an introduction to the types of TDU) that burn the vaporised contaminants (e.g. in the heating chamber of the TDU or in a thermal oxidiser or other associated combustion unit) rather than recovering them (e.g. through a process of condensation or adsorption) are likely to be considered incineration or coincineration plant.

## 1.2 What types of TDU are there?

A wide variety of thermal desorption systems have been used for the treatment of waste materials contaminated with volatile substances, which vary in the method of heating used, the heating source(s) and the mode of operation. The principle system variations are summarised below.

<u>Method of heating:</u>

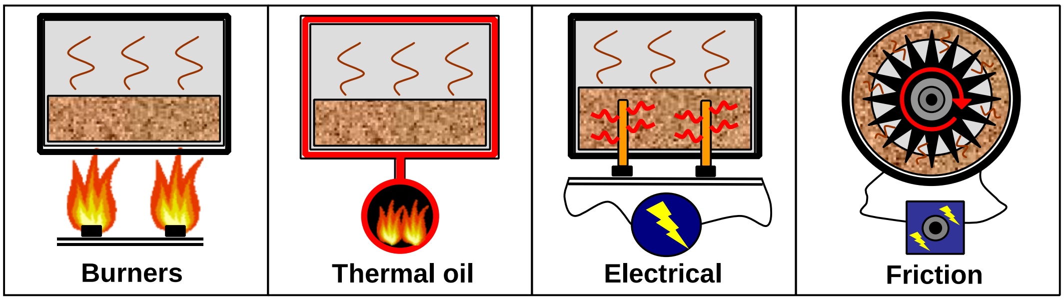



- **Direct**
  Heat is applied directly to the waste material. There is no separation between the combustion gases (e.g. burner gases) and the waste material or the offgases released from it. Direct methods of heating are not considered BAT (Best Available Techniques) and are not covered in this guidance document.

- **Indirect**
  Typically, heat is applied to the exterior of the heating chamber and is transferred through the wall of the chamber to the waste material. Neither

the burner flame nor the combustion gases come into contact with the waste material or the off-gases. Indirect TDUs that are not designed or operated with the aim of maximising the recovery of the volatilised contaminants from the offgases are unlikely to be considered BAT (indicative BAT requirements for treatment are detailed in Section 4).

Sources of heat (indirect):




- **Burners** (natural gas or oil fired)
  Multiple burners, fired on natural gas or oil, are used to heat the exterior of the treatment chamber; the heat is transferred through the wall of the chamber to the waste inside.

- **Thermal oil**
  Synthetic oil is heated by a boiler or similar device and pumped to the desorption unit where it is usually circulated through a jacket that surrounds the heating chamber and sometimes through the chamber itself e.g. along a central shaft. The oil acts as a heat transfer fluid that is heated separately from the treatment chamber.

- **Electrical** (e.g. infra-red or microwave)
  Typically, electrical heating elements are inserted into the waste material and the vapour pressure created by the infrared heat drives the volatile contaminants from the soil. The elements should be protected (e.g. by being inside a conductive casing) to ensure that the waste material does not come into direct contact with them. In the case of microwave (dielectric) heating, rather than heating the solid material itself, the microwaves are principally used to heat the contaminants and any water contained within the waste material, causing them to boil and volatilise and also distribute heat through the surrounding material.

- **Friction**
  A motor drives a circular hammermill within the heating chamber, which rotates rapidly within the chamber. As the hammers come into contact with the material in the chamber the resulting friction generates the heat required to increase the temperature of the waste (typically to a temperature between 250°C - 300°C) and desorb the water and volatile contaminants. To date, this heating method has principally been applied to the treatment of oil-contaminated wastes, such as drill cuttings.

Mode of operation:

- **Batch** (e.g. sealed oven design)
  Discrete batches of waste material of a specific quantity (i.e. dependent upon capacity of the heating chamber) are made up and treated, one at a time. A batch of waste will remain sealed within the treatment chamber for the duration of the treatment process. Once finished, the treated batch of material will be removed from the chamber and the next batch of material will be treated.

- **Continuous** (e.g. rotary kiln design)
  The waste material may be pre-treated in discrete batches, however the material is fed into and removed from the unit in a continuous fashion and at a controlled rate. It is vital that the plant is operated in a way that ensures the temperature and waste residence time in the treatment chamber are adequate to fully treat the waste before it exits the system.

## 1.3 How are these treatment activities permitted?

A thermal desorption unit can be operated for the purpose of waste disposal or waste recovery, or both, as long as the installation is permitted for the relevant activity or activities, as defined under Section 5.3 and Section 5.4 of Schedule 1 to the Environmental Permitting Regulations.

Whether a Schedule 1 listed activity (or activities) is relevant to a specific thermal desorption process will depend upon the principal purpose of the waste treatment activity (i.e. waste disposal or recovery), its capacity and the nature of the waste being treated (i.e. whether it is hazardous or non-hazardous).

The Section 5.3 and 5.4 listed activities that a thermal desorption process may be permitted under, and the associated Annex I or Annex II codes (as defined by the 2008 Directive on Waste[2]), are detailed below:

**i) WASTE DISPOSAL ACTIVITIES**

| |
|---|
| **5.3 A(1)(a)**<br>Applicable when the thermal desorption activity:<br>• Involves waste that is classified as hazardous waste<br>• Involves plant which has a capacity of more than 10 tonnes per day and • Is a disposal activity. |

[2] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

→ Relevant Annex IIA/IIB codes: D9 for treatment and D15 for storage.

**5.3 A(1)(c)(iii)**
Applicable when the thermal desorption activity:
• Involves waste which is non-hazardous
• Involves plant which has a capacity of more than 50 tonnes per day and • Is a disposal activity.

Relevant Annex IIA/IIB codes: D9 for treatment and D15 for storage. **ii) WASTE RECOVERY ACTIVITIES**

**5.4A(1)(a)**
Applicable when recovering by distillation any oil or organic solvent.

→ Relevant Annex IIA/IIB codes: R3 (for oil) or R2 (for solvent) for treatment and R13 for storage.

**5.4A(1)(c)**
Unless carried out as part of another Part A activity, applicable when recovering hazardous waste >10t/day, for

**II.** Reclamation/regeneration of solvents
**III.** Recycling/reclamation of inorganic materials other than metals and metal compounds
**V.** Recovery of components used for pollution abatement
**VI.** Recovery of components used for catalysts
**VII.** Oil re-refining or other reuses of oil

→ Relevant Annex IIA/IIB codes: II. = R2; III. = R5; V. = R7; VI. = R8, VII. = R9 and R13 for storage.

## 1.4 What types of waste can be treated?

Thermal desorption is best suited to the treatment of solid/semi-solid waste materials, such as soils, sludge and filter cakes, containing concentrations of organic contaminants that can be readily desorbed and collected. It is not well suited to the treatment of liquid wastes and is unlikely to be appropriate for the treatment of inorganic contaminants. It is possible to use thermal desorption to remove volatile metals from a waste material (i.e. metals with lower boiling points, for example mercury), however such a process would require specific off-gas abatement measures to ensure that the desorbed metals are recovered and not released into the environment.

Different volatile organic contaminants will be desorbed (volatilised) at different temperatures, dependent upon their boiling point and molecular weight. The typical treatment temperature range for the desorption of volatile contaminants, such as petroleum-based fuels, is typically between 200°C to 400°C. However, less volatile contaminants, such as pesticides, dioxins and PCBs, will only be desorbed once higher temperatures have been achieved, e.g. >450°C.

The degree to which a waste can be successfully treated by a thermal desorption process will depend upon the physical and chemical characteristics of the waste material and its contaminants, as well as the design of the treatment plant. For example, thermal desorption is not considered to be effective for the treatment of non-volatile metals, corrosives, inorganic cyanides and reactive oxidisers and reducers. Certain wastes, such as those containing heavy tars and other high molecular weight organic compounds, may cause fouling/plugging to occur inside the treatment chamber (thereby inhibiting heat transfer and the thermal desorption process) and the off-gas treatment equipment (e.g. bag-houses or condenser systems). Other wastes may also be unsuitable for treatment, such as wastes containing asbestos or compounds that may decompose upon heating and release dangerous gases (e.g. oxidising, explosive or toxic gases), or wastes that may polymerise during the treatment process.

Some of the other key physical and chemical characteristics and associated issues that require consideration when assessing the suitability of a waste to treatment by thermal desorption are summarised in Figure 2 below.

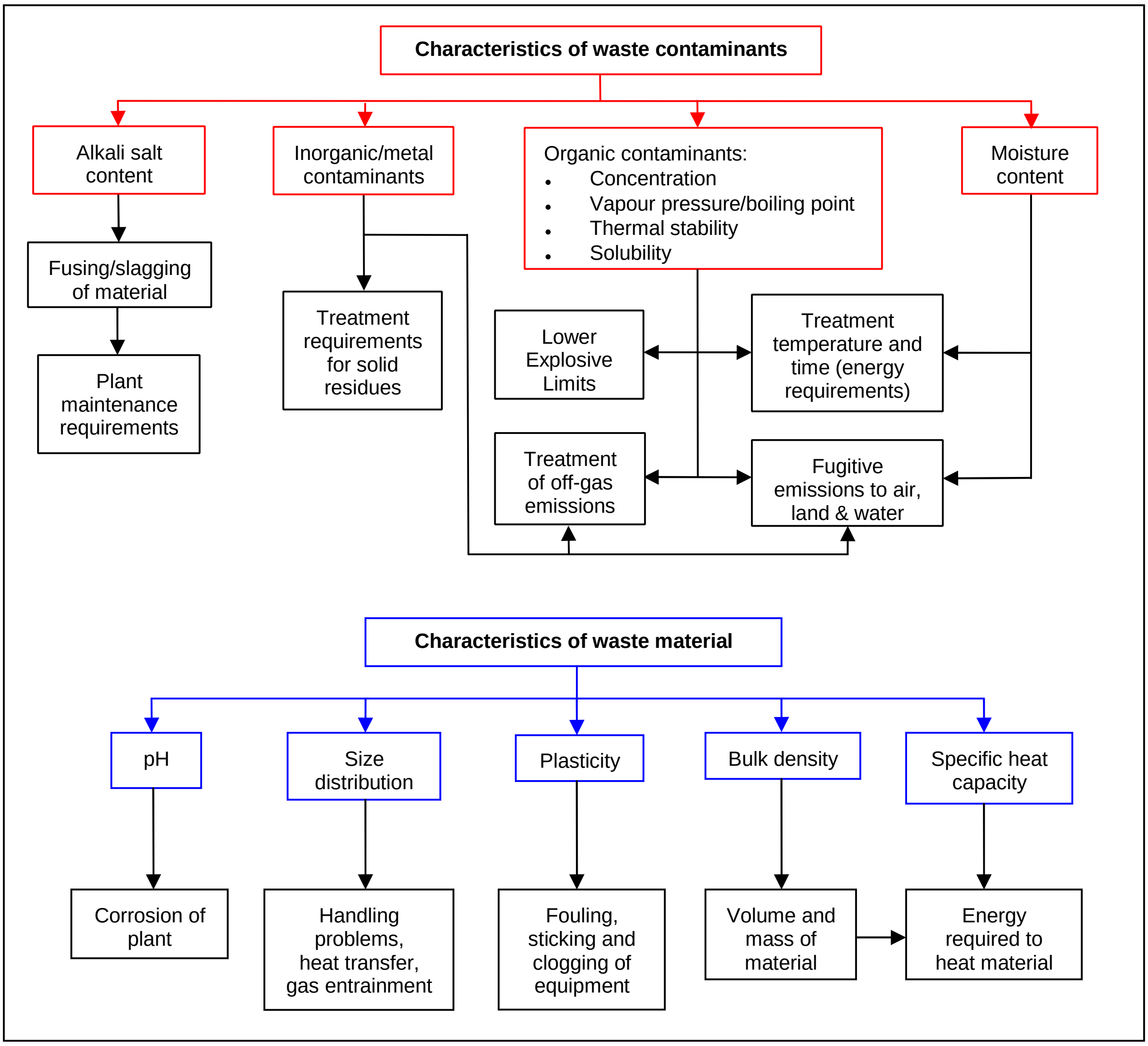



**Figure 2 - Key treatment considerations relating to the composition and characteristics of a waste (adapted from Anderson, 1993)**

# 1.5 What are the key issues?

This section identifies the key issues that are covered by this guidance document for the treatment of waste by thermal desorption. The key issues are identified below and links are provided to the corresponding sections of this guidance document, which set out the relevant indicative BAT requirements:

1. Waste characterisation
   *See Section 2 on Waste characterisation*

2. Storage and handling of wastes and residues
   *See Section 3 on waste storage and Sections 5.3 & 5.4 on (fugitive) emissions control*

3. Process testing, monitoring and control
   *See Section 4 on waste treatment and Section 6 on process efficiency*

4. Off-gas management
   *See Sections 4 on waste treatment and Section 5.1 on (point-source) emissions control*.

We expect Operators to address these key issues through the selection and demonstration of Best Available Techniques during the design and operation of the regulated facility, as set out in the indicative BAT requirements of this guidance document and SGN S5.06.

# 2 Waste characterisation

The performance of a thermal desorption process and behaviour of the waste treated can be understood and predicted, as long as the contaminated waste is adequately characterised. Because waste materials are often variable in their physical and chemical characteristics, the ability to accurately describe the characteristics of the waste, taking into account its variability, is crucial to the safe, reliable and efficient operation of the process. If a waste stream is relatively consistent in its nature and composition it may be possible to treat it as a regular arising.

Along with establishing the suitability of the waste material for treatment by thermal desorption, appropriate waste characterisation will enable the Operator to determine:

- what (if any) pre-treatment is required;
- how the treatment process is set-up to treat the waste, e.g. in terms of treatment temperature and residence time;
- how the treated material and collected residues are handled and stored on site;
- what disposal or recovery options are available for the treated material and collected residues; and,
- what the management and abatement requirements are for the off-gases.

**Indicative BAT Requirements**

The Operator must comply with the relevant indicative requirements for waste pre-acceptance and acceptance of S5.06, as set out in Section 2.1.1 and Section 2.1.2 of SGN 5.06 respectively, and the following appropriate measures:

1. The technical capability of a facility must be pre-determined in terms of the nature and quantities of waste materials that can be treated at the facility, taking into account the available pre-treatment provisions, storage capacity

and infrastructure, treatment capability and capacity, material handling provisions, and effectiveness of the off-gas treatment systems.

2. The facility must have clearly defined acceptance and rejection criteria for waste that can be safely stored on-site and treated by the thermal desorption process, including consideration of factors such as:
    - Concentration, boiling point and flash point of volatile organic contaminants
    - Water content, pH and physical characteristics of waste material
    - Presence of inorganic contaminants, chlorinated compounds and odorous materials

3. A system should be in place to inform customers and site operatives of the type of waste that the facility is permitted to accept for storage and/or treatment, specifically considering the nature and quantity of the material and it's contaminants (organic and inorganic, volatile and non-volatile).

4. Waste should only be accepted for treatment if the material and its contaminants can be effectively treated by the thermal desorption process. Waste materials that do not contain contaminants that will be effectively treated (i.e. desorbed during treatment) should not be accepted for treatment in isolation or in combination with other wastes, unless the contaminants are below relevant hazardous waste thresholds and it is demonstrated that they will assist the treatment process.

5. Representative samples must be taken and analysed in order to characterise the waste material and identify contaminants. The samples collected need to be as fully representative of the whole to be characterised as possible. Sample size and number should be large enough to adequately represent the range of waste characteristics and contaminants contained in the waste material. Waste materials that are not known to be homogenous may need to be pre-treated or sampled in a way that ensures variability is taken into account, for example, by pre-mixing the waste before sampling or by using a coring tool.

6. Sampling highly volatile organics may require the use of specialised sampling techniques and equipment to ensure that, as far as possible, the volatile substances are not lost from the sample. Where necessary, precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes before analysis. The container holding the sample should be securely sealed to prevent the loss or separation of volatile components (e.g. moisture or solvents) between the time of sample collection and analysis.

7. Lab-scale studies should be carried out to characterise and quantify the separate solid, oil/solvent and water fractions of the waste material, for example using retort apparatus.

8. Waste samples should be taken and analysed for a full range of contaminants, (organic/inorganic, volatile/non-volatile) for example:
    - BTEX compounds (benzene, toluene, ethylbenzene and xylenes),
    - Total and speciated hydrocarbons,
    - Metals (e.g. arsenic, cadmium, chromium, copper, lead, mercury and nickel)
    - Base/Neutral/Acid compounds
    - Polycyclic aromatic hydrocarbons
    - Halogenated compounds (e.g. PCBs or compounds containing chlorine)

9. The characterised waste should be assessed (for example, through documented literature studies, lab-scale tests, trials) to confirm whether or not it is suitable for storage and treatment by thermal desorption and to identify any potentially problematic contaminants. If confirmed suitable, treatment criteria required should be determined (i.e. in terms of pre-treatment requirement, treatment temperature and duration) to ensure that the waste will be fully treated and that the process is operated in an efficient and safe manner.
10. Wastes containing PCBs and other chlorinated substances should only be accepted for treatment by thermal desorption if specific measures are in place in order to prevent the release of PCBs to atmosphere and the formation and release of dioxins and furans.

11. Waste samples should also be analysed for a full range of inorganic contaminants, which may remain in the waste material following thermal treatment or become volatised during the treatment process (e.g. for volatile metals such as mercury).

12. Where significant concentrations of volatile metals are detected in a sample the corresponding waste material should only accepted for treatment by the thermal desorption unit if the treatment temperature will be sufficiently below the boiling point of the metal (in order to prevent evaporation of the metal), unless it has been assessed that the metal will not cause unacceptable contamination of the condensate and suitable off-gas abatement systems are in place, which will ensure that any volatilised metals are fully removed from the gas before it is discharged to atmosphere.

# 3 Waste handling & storage

Appropriate measures for the handling and storage of untreated and treated waste materials must be implemented at the installation in order to:

→ Prevent the cross-contamination and dilution of contaminants between different batches/loads of wastes and between treated and untreated wastes.

→ Prevent fugitive emissions to air, land and water.

→ Maximise the availability and efficiency of the systems used to convey and treat the waste material.

**Indicative BAT Requirements**

The Operator must comply with the relevant indicative BAT requirements for waste storage as set out in Section 2.1.3 of S5.06 and the following appropriate measures:

1. Untreated and treated waste material should be held in contained (bunded/kerbed) storage areas that are provided with impermeable hardstanding and sealed drainage designed to collect any liquids released from the waste material during storage. Waste material should be stored under cover or in covered containers to prevent the generation of contaminated surface waters/leachate and fugitive emissions to air and water (including dust).

2. Waste storage areas should be provided with adequate ventilation and, where necessary, air extraction systems with abatement. Specifically, if untreated waste is stored in a confined/sheltered location, consideration should be given to the potential generation and accumulation of volatile gases and the formation of potentially flammable/hazardous atmospheres (see Section 7).

3. As far as it is practical to do so, organic and inorganic hazardous wastes and wastes that contain different contaminants that are at concentrations above the Hazardous Waste thresholds and will not be (or have not been) fully treated by the thermal desorption process should be stored, handled and treated separately. There are a number of reasons for this including:

   - both the **hazardous waste strategy** and **hazardous waste hierarchy guidance** documents require that inorganic and organic wastes should be kept separate
   - treatment by dilution is not acceptable
   - the recovery of treated materials may be compromised

   Where mixing of wastes is required (e.g. for pre-treatment or co-treatment purposes) there must be a recorded assessment of the mixing process, which explains why it is necessary and demonstrates that the wastes are compatible, that dilution would not be used to change the classification of the waste (i.e. from hazardous to non-hazardous) and that the quality of the treated waste material would not be negatively affected.

4. Potentially dusty materials (e.g. treated/dried waste) should remain covered/contained at all times, provided with wind protection and, where necessary, water spray should be used to prevent dust generation. However the application of water should be controlled in order to prevent the leaching or dilution of contaminants and surface run-off. Further treatment of recovered water may be necessary prior to its application as a dust control measure due to potentially odorous characteristics of recovered water.

5. Individual storage tanks/vessels or bays should be provided in order to:
   - separate batches of untreated and treated waste and avoid cross-contamination.
   - separate batches of wastes that contain different contaminants, unless they are being treated together (subject to point 3 above).
   - isolate treated batches of waste if they contain high concentrations of a specific substance for recovery – e.g. if a high metal waste is received.

6. The separate storage areas and bays provided in accordance with point 5 above should be physically contained and segregated from each other, and provided with separate sealed drainage systems.

7. At sites where waste material may require pre-treatment (i.e. to improve its handling or treatment), adequate storage infrastructure and capacity should be available at the installation to allow for the storage of waste material before and after pre-treatment, whilst preventing cross contamination of batches and fugitive emissions to air, land and water.

8. The selection of appropriate waste handling and conveyance systems should take into account the physical form/nature of the waste that will be accepted for treatment at the facility and of the material following treatment (i.e. taking into account how factors such as material moisture content, abrasiveness, plasticity and particle size may affect ease of handling), to ensure that they are capable of transporting it in an efficient and reliable manner. For example, screw conveyors may be more appropriate for wastes that are high in moisture than belt-conveyors, which may be better suited to dry materials, and grabs may be more appropriate for handling highly abrasive waste materials.

9. Waste conveyance systems should be contained in order to prevent the generation of fugitive emissions (e.g. dust, steam), loss of material/spillage and odour. Where use can be justified, machinery (tractors / loading shovels) must be fit for purpose and regularly inspected and maintained.

10. Adequate vehicular access should be provided where required, providing clearly marked routes for vehicle movements, which are kept clear of waste material and free from obstacles, surface water drainage systems and unprotected pipework. Measures should be provided to protect plant, buildings and storage infrastructure from vehicle movements (driving and lifting actions) i.e. through the provision of bollards, signs, adequate clearance.

11. Internal and external operational areas should be well lit to minimise the risk of spillage and to ease detection and clean-up of any dropped material.

12. Treated material should be allowed to cool sufficiently before it is removed from the treatment plant and transported to a storage/disposal area. Systems used to handle, transfer and hold the treated material whilst it is cooling should be designed to minimise the double-handling of material and prevent potential fugitive emissions (e.g. of dust, steam and any residual volatile or odorous compounds that may be released whilst the material is still hot), preferably using an enclosed system that is integral to the treatment plant.

13. Liquid residues recovered from the treatment process should be held in appropriate tanks/bulk storage vessels resistant to the material being stored, provided with appropriate containment measures (i.e. fully bunded and located on an impervious surface) and high level alarms. The vents on tanks that contain potentially volatile liquids (i.e. recovered oils and solvents) should be linked to suitable scrubbing and abatement systems. Tanks used for the storage of recovered liquids should also meet the requirements set out in PPG2 and HSG176, as appropriate[3].

14. Where necessary, compatibility testing must be carried out and recorded before different batches of wastes or collected residues are bulked up.

15. Where it is assessed that there is the potential for cross-contamination of material or possible waste compatibility issues (e.g. between treated and untreated material or between materials that contain different contaminants), measures should be in place to ensure that waste handling equipment/plant are cleaned between batches/waste streams and, where possible, separate equipment/plant should be used for handling untreated and treated material.

16. Pipework and storage tanks should be located above-ground to aid their inspection and maintenance and ensure any leakage or spillage is identified and addressed as soon as possible.

17. Pipework, and associated taps, valves and pumps, should:

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[3] PPG2 - Pollution Prevention Guideline, Above Ground Oil Storage Tanks

HSG176 - Storage of flammable liquids in tanks

- be resistant to the liquids they carry or come into contact with;
- where appropriate, resistant to heat;
- be above ground, or if below ground in lined inspection channels, and readily available for inspection and maintenance;
- where appropriate, be labelled as to their contents;
- have the minimum number of connections;
- be located away from main road ways or suitably protected from impact damage;
- be located on impermeable surfaces with suitable containment and segregated away from surface water drains, soakaways and sumps.

# 4 Waste treatment

The key principle of waste treatment by thermal desorption is achieving the optimal removal of volatile organic contaminants through accurate monitoring and control of the treatment temperature.

Achieving this in an efficient and safe manner is reliant upon a thorough understanding of how the vapour pressure of a contaminant varies as a function of temperature and how its treatment is affected by other factors, such as the physical properties of the material, interactions between contaminants and the material, moisture content and contamination concentration.

It is also dependent upon the thermal desorption unit being provided with accurate real-time temperature monitoring and control systems, to ensure that it operates at the required treatment temperature(s), for the required duration, throughout the treatment cycle.

**Indicative BAT requirements**

The Operator must comply with relevant indicative BAT requirements for waste treatment as set out in Section 2.1.4 of S5.06 and the following appropriate measures:

## 4.1 Pre-treatment processing

1. Waste materials with more consistent physical and chemical properties will generally result in more predictable and reliable waste treatment and plant operation and measures should be taken to ensure appropriate waste homogeneity prior to treatment. A variety of pre-treatment processes may be employed and some examples are provided below:

    a) Physical pre-treatment measures, such as crushing and screening, can be used to remove clumped masses and rocks etc, which can help improve material heat transfer during treatment and prevent jamming of feed conveyors or damage to the desorption plant.

b) Fouling/plugging/caking of the plant may be prevented by pre-treating waste to improve the consistency of the material (e.g. reducing its plasticity). If the material contains an excessive amount of moisture, it may require pre-treatment to reduce moisture levels and thereby aid waste handling and improve the thermal efficiency of the treatment process. Air drying, dewatering (e.g. by filter-press), and mixing with drier waste material (subject to the requirements of Point 2 below) are pre-treatment processes that may help ensure that the untreated material has the desired moisture content.

c) High concentrations of volatile contaminants, such as petroleum products, can result in high waste heating values, which could potentially result in over-heating and damage to the desorption plant. Subject to the requirements of Point 2 below, waste material containing excessive concentrations of volatile contaminants are sometimes pre-treated/mixed with treated waste material or waste with lower volatile contaminant concentrations in order to reduce the concentrations to an acceptable level.

d) In order to limit equipment corrosion, it may be necessary to pre-treat highly acidic waste with lime or, subject to the requirements of Point 2 below, other alkaline waste, in order to maintain a more neutral pH. Similarly, a highly alkaline waste may also require pre-treatment.

2. Pre-mixing of waste(s) should only be carried out if it is in accordance with the requirements of Point 3, Section 3.

3. Pre-treatment should be carried out using purpose built plant and machinery, located in designated area(s) of the installation, provided with appropriate measures to prevent and control fugitive emissions to air, land and water, and employing appropriate techniques to control potential noise, vibration and odour.

4. Following mixing, batches of mixed waste should be re-assessed to confirm:
    - the nature and concentration of the contaminants present and the characteristics of the waste material itself (i.e. pH, moisture content),
    - relevant treatment criteria (e.g. treatment temperature(s) and duration).
    - Suitability of the material for treatment in the installations thermal desorption unit (and whether any further pre-treatment is required).

## 4.2 Pre-treatment trials

1. Lab-scale bench tests and plant trials are required for each waste stream unless it is demonstrated through waste characterisation that a specific waste material has suitably comparable characteristics and contaminant compounds and concentrations to a batch of waste that has already been

successfully trialled and treated using the installation's thermal desorption plant and results of these trial and treatment cycles have been documented and are available for reference.

2. The Operator should pre-determine and optimise the specific operating criteria (max / min temperature range and duration) of the treatment cycle required for fully treating the identified volatile contaminants contained in the waste material. The treatment temperature range should be determined based upon a combination of literature reviews and/or the results of previous documented treatment trials or cycles, and evaluated using a test plant that is representative of the thermal desorption unit. The results of the studies and trials used to establish and confirm the treatment temperatures should be recorded and kept for future reference.

3. The scaling of the test plant is very important, as it should ensure that conditions are representative of, and replicable in, the installation's thermal desorption unit. The temperature profile of a smaller test plant will be significantly different from that of a full-scale treatment plant unless the amount of material used in the test plant and the heating process is scaled to reflect variation in the heat transfer properties of the two plant. For example, typically, the smaller test plant will require a higher fill fraction than the full-scale plant if the heating process is to be representative.

4. If the thermal desorption unit is designed operate under vacuum or negative pressure conditions a boiling point calculator can be used to take into account the effect of pressure on the heating temperature required to volatilise the identified contaminants during the treatment cycle.

## 4.3 Treatment

Plant design and operation

1. Treatment process parameters should be tailored to the specific properties and contaminants of the waste material, therefore the thermal desorption unit will require an appropriate level of system flexibility if potentially variable waste materials are to be treated. The treatment cycle should be operated in accordance with the optimum operating criteria (e.g. for maximum and minimum temperature range, waste feed rate and residence time and air flow) determined by waste-specific studies and trials.

2. As far as possible and practical to do so, the thermal treatment process should be carried out in a sealed chamber in order to minimise air ingress and to prevent the release of fugitive emissions. Vacuum or low oxygen conditions (e.g. using steam or a nitrogen sweep gas) should be maintained to help prevent combustion of the waste material or volatile off-gases. Due to the nature of their operation, the treatment chambers of continuous feed units do not operate as closed systems and measures should be

implemented to minimise air ingress, for example by having an automated damper arrangement on the waste charging system (e.g. on the waste delivery hopper or chute) and/or by using the waste material in the charging/outlet system to form a seal. To maintain a high level of control over air ingress in such a system it is important that waste input is continuously monitored and controlled in order to provide a consistent and continuous feed level.

3. The thermal treatment process should subject the waste to a gradual or staged heating process. Employing low heating rates will help to avoid significant chemical changes to the waste material whilst promoting the evaporation and recovery of the full range of identified contaminants (ranging from those with the lowest boiling point to those with the highest) and avoiding the combustion of those with the highest volatility. Initially, the waste will heat up to a lower temperature (e.g. 90-100°C) at which the water content of the material will be evaporated, before heating to higher temperatures required to volatilise the identified contaminants (e.g. oil-based contaminants will start to be volatilised as the temperature of the waste reaches approximately 200°C).

4. A process for mixing the waste in the treatment chamber will aid the transfer and distribution of heat within the waste material, helping to ensure even and consistent treatment, and the release of the desorbed gases. Mixing processes may also help to break up clumps of solid material in the treatment chamber and prevent the settlement/stratification of the waste and the potential formation of pockets of trapped gases. This is particularly relevant to oven-type TDUs, where the waste may remain in the treatment chamber for long periods of time, possibly in excess of 24 hours. The treatment chambers of rotary kiln TDUs are usually provided with helical flights, which help to mix and move the waste material through the treatment chamber, and oven-type TDUs are often provided with internal paddles or stirrers.

   Where an integral mixing processes is provided, it should be designed and operated in a way that minimises the amount of particulate material that may be drawn out of the treatment chamber with the hot off-gases (i.e. an overly aggressive mixing process could result in a large quantity of material becoming entrained in the off-gas, which would require removal in the off-gas abatement system). Where mixers are not included in the design of the TDU, additional pre-treatment may be required to ensure appropriate waste homogeneity (see Section 4.1.1).

5. A comprehensive inspection and maintenance programme is essential for maintaining system availability and efficiency, particularly if treating high molecular weight, viscous or adhesive materials. In rotary systems, it should be ensured that the material is able to move freely in the heating chamber and does not agglomerate or stick to the sides of the chamber. Oven systems should be designed so that waste material can be easily removed

from the thermal desorption unit following treatment. Inspection and cleaning procedures are particularly important in batch oven units where waste material may remain for a longer period of time.

6. Thermal desorption represents a relatively new and novel process for treating hazardous waste in the UK. Therefore it is important that appropriate systems are in place to promote and maintain technical resilience through the documentation and sharing of internal technical experience and expertise, avoiding reliance upon external expertise or the knowledge and experience of one individual.

Process monitoring and control

7. Appropriate automated process monitoring and control measures must be in place to ensure that the waste is heated to the requisite temperature(s), and for the required duration, to ensure the full and effective desorption of the identified volatile contaminants, whilst preventing combustion of the contaminants or waste material.

8. Time-at-temperature data should be recorded for the waste material treated in the TDU, and concentrations of the target contaminants should be measured in the solid waste material both before and after treatment, using representative samples taken from the waste material to demonstrate treatment efficacy.
9. Thermocouples may be installed in the TDU to allow the temperature of the solid waste material and gas streams to be measured and recorded. Where thermocouples are used, careful consideration should be paid to the temperature and conditions the probes are designed to operate under, and the number and location of the probes to ensure that the readings taken are accurate and representative.

10. The key operating parameters of the TDU should be automatically monitored and recorded in real-time to provide an accurate record of the completed treatment cycle and relevant operating conditions. Advanced process control and monitoring/data-logging systems should be employed at the facility (e.g. systems that employ SCADA (supervisory control and data acquisition), PLCs (programmable logic controllers) and HMI (human machine interface)). Key operating parameters should include some or all of the following variables:

    - treatment temperatures (e.g. of thermal oil, burner or heating element; gas temperatures, solid waste temperatures);
    - treatment chamber pressure, oxygen levels, lower explosive limit (LEL);
    - waste residence time;
    - kiln/chamber rotation speed;
    - sweep gas/off-gas flow rate;
    - thermal oxidiser/boiler temperature;

- condenser operating temperature and process water temperature and flow;
- exit temperature of solid waste, gases and liquids;
- flow and pH of scrubber liquor.
- waste charging/discharging.

11. Records should be kept documenting the effectiveness and efficiency of the thermal desorption process for treating different waste materials and different contaminants. The records should report the efficiency achieved for different components successfully desorbed from waste and also for those that have not been affected by the process. Assessment of treatment efficacy should be based upon mass balance calculations carried out for the relevant contaminants. These records should be used to feedback and inform the waste acceptance criteria for the thermal desorption process.

12. The thermal desorption unit should be provided with automated, controlled and enclosed mechanical feed and discharge systems, interlocked with relevant parameters of plant operation to ensure that it operates safely and effectively (for example, ensuring that waste feed can not take place unless the TDU is operating correctly, waste can not be discharged from the unit until the treatment process has been completed and the waste has cooled sufficiently or, in the case of a continuous rotary kiln unit, the level of waste in the inlet/outlet hoppers are sufficient to prevent excessive air entering the treatment chamber).

13. Automatic system alarms and/or trips should be set for relevant operating parameters such as temperature, pressure, thermal oxidiser temperature, fan/air flow failure, waste feed, scrubber failure, quench/condenser failure.

14. The extraction of off-gases from the treatment chamber should be carefully designed and controlled in order to prevent and minimise carry-over of fine particulates/solids in to the off-gas. Mixing of the gas and solid material in the treatment chamber is desirable as it can aid heat distribution, however too vigorous mixing may increase the carry-over of particulates into the off-gas filtration system.

15. An appropriate sweep gas (e.g. an inert or low-oxygen gas) may be used in the treatment chamber to help draw the desorbed volatile gases through to the offgas management and abatement system. The use of a sweep gas and gas extraction should be adequately monitored and controlled in order to prevent the formation of an explosive atmosphere, keeping concentrations of volatile gases in the treatment chamber at a concentration safely below the relevant LEL if not operated in an inert or low oxygen atmosphere.

16. The following records should be maintained on site or at other approved location:
    - Waste treatment verification results

- Operating logs
- Shutdown events
- Monitoring process parameters
- Emission monitoring results
- Failed batches and their re-treatment

## 4.4 Post-treatment

Post-treatment consists of:

- Management of off-gases (collection, cooling, condensing and abating),
- Management of solid material (quenching, stabilisation, disposal), and
- Management of recovered liquids (in-process reuse, water treatment, organic liquid treatment and disposal).

Managing the off-gas in order to minimise the emissions discharged from the plant is an essential aspect of TDU design and operation, and a key operating principle that sets thermal desorption apart from waste incineration is based upon the optimised recovery of the desorbed contaminants from the gas rather than their destruction (i.e. combustion).

<u>Management of off-gases</u>

1. The off-gas management system must be designed and operated to ensure optimal recovery of the volatised organics, which should be based upon an efficient and effective method of cooling and condensing the gases. The system must have the capacity and resilience to reliably handle the potential volume of off-gas and concentrations of desorbed contaminants generated by the TDU under the full range of operating conditions, which will be determined by the characterisation and quantity of the wastes accepted for treatment.

2. The performance of the system used to cool and condense the off-gases and collect the desorbed contaminants must be monitored and maintained in order to ensure it continues to operate efficiently and effectively. Systems must be in place to detect failure or loss in the efficiency/effectiveness of the system, which should be interlocked with plant operation, so that the TDU cannot operate unless the cooling system is working effectively and efficiently.

3. As well as the condensable volatile contaminants, the design and operation of the off-gas management system should take into account the requirements for handling the potential volumes of water that will be desorbed from the treated waste materials. If wet wastes are treated a considerable quantity of water may be evaporated and recovered by the

thermal desorption system. The off-gas treatment system must be capable of safely and effectively managing the desorbed water along with the volatile organic contaminants.

4. Following removal of the condensable fractions, the uncondensed components of the off-gases will require further abatement before the gases can be emitted to air. Requirements for the abatement of point-source emissions to air are covered in Section 5.1.

Management of solid material

5. The treated material should be adequately cooled before being discharged from a contained system in order to prevent fugitive releases (e.g. steam) and to ensure the temperature of the material is safely below the auto-ignition temperature of any potential residual volatile contaminants.

6. Treated solid material should be representatively sampled and analysed for residual contaminants and other potential compounds of concern, including treated volatile contaminants and inorganic contaminants (e.g. heavy metals). It is important to determine the speciation of the metal contaminant, as certain compounds of the metal may be more toxic and harmful to the environment than others. If possible, sampling of the waste should be carried out before any water is added to the material.

7. Post-treatment of the solid waste material typically entails water quenching in order to help cool the solid, control dust and aid handling. Water should be applied to the treated material in a gradual and controlled manner in order to achieve an appropriate consistency whilst preventing the leaching of residual contaminants and the generation of contaminated surface water. If the material is too hot the addition of water may produce significant quantities of steam, which, in an enclosed system, could result in over-pressurisation. In certain circumstances, for example when an immiscible solid is produced by the thermal desorption process (i.e. a solid that will not mix with water), it may be necessary to apply an appropriate additive to the quench water to improve the mixing process.
8. Subsequent treatment of the thermally treated waste material on site (i.e. prior to recovery or disposal) should be carried out in accordance with the indicative BAT requirements set out in S5.06.

Management of recovered liquids

9. Condensed organic contaminants should be sent for further treatment and recovery as appropriate.

10. To enhance their recovery, where possible, recovered liquids are often treated on site to separate the water and solvent/oil fractions of the condensed liquids (e.g. as a minimum using a gravity separation process). Such treatment activities should be carried out using appropriate

tanks/vessels that are resistant to the material contained, fully bunded and located on an impervious surface, and provided with high level alarms. Appropriate tanks/bulk vessels should similarly be provided for the storage of the separated fractions.

# 5 Emissions control

Emission control measures must be designed and operated in order to provide a high level of protection for the environment as a whole. This may be achieved by using a combination of several of the techniques described in this section. Furthermore, the selection of a particular control measure must be justified on the basis of the performance of the installation as a whole i.e. the operator should set out a number of alternative system options and designs and compare their overall performance using the Horizontal Guidance Note H1 Environmental Risk Assessment (H1)4.

## 5.1 Point source emissions to air

Requirements regarding the treatment of off-gases for the purpose of recovering the desorbed contaminants are detailed in Section 4.4 of this document. This section covers the control of point source emissions to air that occur following this recovery process (i.e. emissions of the residual (uncondensed) volatile contaminants, particulate matter, combustion gases and metals).

Emissions to air from thermal desorption systems are influenced by the waste characteristics, the desorption process applied, and the emissions control equipment used. Point-source emissions to air from a typical thermal desorption unit come from two principal sources:

- Gases from the desorption chamber, typically released via a thermal oxidiser, combustion engine or carbon adsorption unit.
- Gases from the process heating system (e.g. boiler or burners).

The principal emissions released from these emission points are likely to be combustion gases from the heating system (i.e. sulphur dioxide ($SO_2$), oxides of nitrogen ($NO_x$), carbon monoxide (CO) and carbon dioxide ($CO_2$)) and Volatile Organic Compounds (VOCs) and particulates from the treatment chamber. The off-gas from a thermal desorption process could also contain concentrations of metals (in particulate and/or volatilised form) and, potentially, persistent organic compounds, such as PCBs, dioxins and furans (depending on the operating temperature of the TDU chamber).

In indirect thermal desorption units, the two gases (those from the desorption chamber and those from the heating system) are usually kept separate and therefore are often emitted from two separate emission points. However, this is not always the case, as hot combustion gases may be re-circulated back into the treatment chamber of the TDU and subsequently managed with the off-gas. Alternatively, the off-gas from the TDU, having passed through a process of

[4] For further guidance on the assessment of candidate techniques refer to IPPC H1 -Environmental Assessment and Appraisal of BAT

quenching/scrubbing (to recover the desorbed contaminants and remove any particulates), may be directed back to the heating system (e.g. boiler) and emitted with the combustion gases. In either case, appropriate measures must be taken to ensure that all process emissions are controlled, minimised and, where necessary, abated.

Relevant air pollutants, along with their potential source(s) and common methods of control, are summarised in Table 1.

| **Air pollutants** | **Potential sources** | **Emission controls options** |
|---|---|---|
| Combustion gases (e.g. $NO_X$, CO, $SO_2$) | Heating system exhaust (e.g. boilers, burners etc) | Design of plant (e.g. low-NOx burners)<br>Choice of fuel (e.g. electricity or natural gas)<br>System efficiency<br>Combustion control<br>Selective catalytic/non-catalytic reduction |
| Acid gases (e.g. $H_2S$) | Treatment of wastes containing sulphur | Neutralisation – e.g. using wet or dry scrubber |
| VOC's & odour (e.g. mercaptans and other organosulphur compounds) | Volatile contaminants desorbed from waste material into off-gas | Condensers<br>Thermal oxidisers/afterburners Catalytic oxidisers<br>Combustion in boiler or engine<br>Carbon adsorption |
| Particulates | Carried over into off-gas by air extraction system (e.g. ID fan)<br><br>Boiler plant combustion | Cyclones<br>Scrubbers<br>Fabric filters/bag-filters<br>HEPA filters<br>Choice of fuel (e.g. electricity or natural gas) |
| Metals (low volatility) | Carried over into off-gas with particulates | Carbon adsorption<br>Particulate abatement – see above |
| Dioxins & furans PCBs | Treatment of chlorinated wastes leading to formation in off-gas | Waste acceptance analysis<br>Particulate abatement<br>Carbon adsorption<br>Operating temperatures |
| Volatilised metals (e.g. mercury) | Volatile contaminants desorbed from waste material into off-gas | Waste acceptance analysis<br>Carbon adsorption]<br>Operating temperatures |

**Table 1: Sources and emission control options for potential air pollutants produced by the thermal desorption of waste**

Figure 4 below shows the design of a typical abatement system used to remove the principal off-gas pollutants produced by a thermal desorption unit.

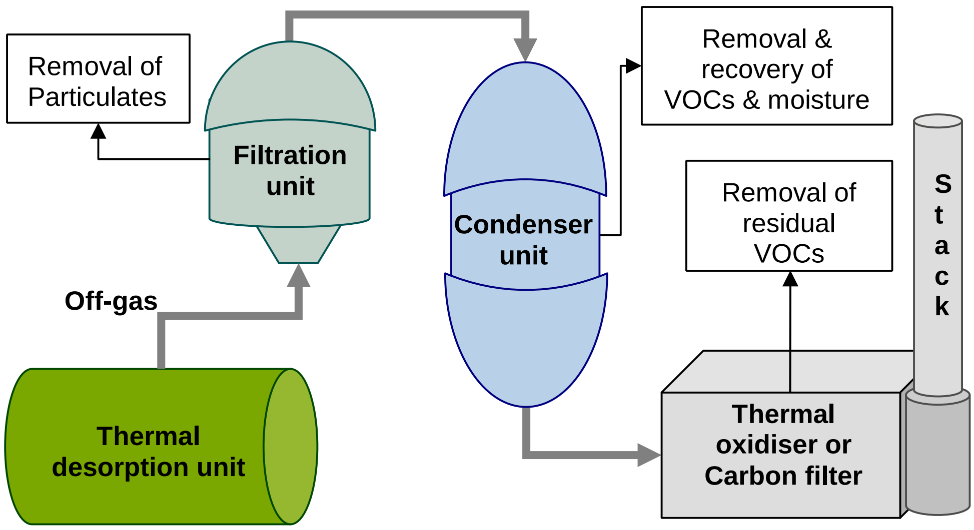


**Figure 4: Example of a TDU off-gas abatement system**

## Indicative BAT requirements

The Operator must comply with the indicative BAT requirements for point source emissions to air, as set out in Section 2.2.1 of S5.06 and the following appropriate measures:

General

1. Emissions to air and associated emission control measures (including stack/vent heights) should be assessed following the methodology set out in Section 4.1 of S5.06 to ensure that releases are prevented, abated and dispersed in accordance with BAT. The assessment should be used to justify whether or not abatement is required, and if required which technique(s) represents BAT for the installation, taking into account the likely emissions, energy and raw material use, global warming potential and waste resulting from the candidate techniques.

2. As a minimum, point source emissions to air should meet the Benchmark Emission Values contained in Section 3.2 of S5.06.

3. The facility should be designed and operated to prevent and minimise the release of visible emissions, including emissions of condensed water or particulates, and odour from the process.

Uncondensed volatile compounds (organic and inorganic)

4. The Operator should only accept wastes that contain volatile contaminants that can be treated effectively by the plant, which includes the effective removal of the contaminants from the gas stream following desorption.

5. The Operator should fully characterise emissions to air from the TDU by carrying out VOC speciation, for a representative range of operating

conditions and wastes, in order to identify and quantify chemical constituents.

6. It is likely that low concentrations of residual uncondensed volatile compounds will remain in the off-gas following its treatment (i.e. cooling/condensing), which will require abatement prior to discharge to atmosphere. Abatement must be provided which will efficiently remove or destroy the potential pollutants (including odorous compounds) from the gas stream before it is emitted to air (e.g. destruction by oxidation/combustion or removal by carbon adsorption).

7. The performance (i.e. destruction/removal efficiency (DRE)) of the emission abatement system should be assessed and maintained on a regular basis and key parameters that determine DRE (e.g. thermal oxidiser temperature, condenser temperature) should be monitored continuously, alarmed and, where practical, interlocked with TDU operation.

Further information on the control of emissions of VOCs is available in Natural Resources Wales guidance document EPR4.02 Speciality organic chemicals sector and Technical Guidance Note (Abatement) A2, Pollution abatement technology for the reduction of solvent vapour emissions, 1994.

Particulates

8. The pressure within the treatment chamber and the rate that gas is drawn out of it should be managed in a way that minimises the amount of particulate material that is carried over into the off-gas, whilst ensuring safe and effective treatment of the waste material and removal of the desorbed contaminants.

9. Wet scrubbers give rise to liquid effluent, which, if not recycled into the process, requires treatment and disposal. This should be considered in the H1 environmental assessment / BAT assessment of the installation.

10. The prevention and minimisation of emissions should be a factor in the selection of the fuels used at the facility. The use of natural gas can reduce potential emissions of particulates compared to other fuels (i.e. oil or coal).

Combustion gases

11. Combustion gases should be controlled through the selection of fuel (e.g. selection of low-sulphur fuels or use of electric drives for continuous rotary systems) and the design of the combustion plant (e.g. through the use of lowNOx burners or selective catalytic reduction).

12. Combustion control systems and a regular programme of plant maintenance should be implemented to optimise and maintain plant efficiency and associated combustion conditions.

## 5.2 Point source emissions to water

**Indicative BAT requirements**

The Operator should comply with the relevant indicative BAT requirements for point source emissions to surface water and sewer, as set out in Section 2.2.2 of S5.06 and the following appropriate measures:

1. Emissions to water and sewer from the treatment process should be minimal. Where possible, recovered water should be reused in the treatment process or other on-site processes, and condensed organic liquors should be sent for recovery (i.e. oil or solvent recovery processes).

2. Potential sources of waste waters include the water fraction of collected condensate, storm water runoff, cooling water and waste stockpile leachate. All such waste waters should be collected and treated as necessary, before being either re-used or discharged.

## 5.3 Fugitive emissions to air (including odour)

**Indicative BAT requirements**

The Operator must comply with the indicative BAT requirements for fugitive emissions to air and odour as set out in Sections 2.2.4 and 2.2.6 of S5.06 and the following appropriate measures:

1. Highly volatile contaminants may evaporate into the air during storage, therefore it is important that storage areas/bays holding wastes that contain such contaminants are provided with appropriate abated extractive ventilation and that containers holding such waste remain closed until the material is transferred for treatment.

2. Waste material should be stored within suitable physical enclosures provided with appropriate dust/vapour control measures to prevent and minimise potential fugitive emissions. Dust curtains can be used to contain potential fugitive releases, preventing their release outside of the waste treatment/storage building(s).

3. Appropriate measures should be taken to prevent fugitive releases to air (e.g. dust, odour) from buildings used for the storage and treatment of waste, for example by keeping buildings under internal negative pressure and/or providing automatic shutter doors, which are kept shut when not in use.

4. The thermal desorption plant should be closed to prevent uncontrolled ingress of air and fugitive emissions. Operating the plant under a slight

negative pressure can also help to prevent fugitive emissions, with the gases drawn to an appropriate abatement system.

5. Post-treatment handling and cooling of the hot waste material should be carried out in process units that are fully enclosed and, where possible, integral to the TDU.

6. If held outdoors, treated waste material should be stored under cover or in covered containers.

7. A programme of site inspection and monitoring should be carried out to ensure that unacceptable levels of dust generated from the movement and handling of waste are not released.

8. A Leak Detection and Repair (LDAR) programme should be implemented at the facility for the control of potential fugitive releases.

## 5.4 Fugitive emissions to water and land

**Indicative BAT requirements**

The Operator must comply with the indicative BAT requirements for waste fugitive emissions to surface water, sewer and groundwater as set out in Section 2.2.5 of S5.06 and the following appropriate measures:

1. All waste material (treated and untreated) should be stored under cover or in covered containers, on impermeable hardstanding with sealed drainage.

2. Waste material should be held in tanks, closed containers or, for solids, suitable bays, capable of holding any free liquid generated during storage, and within an area of the installation provided with appropriate secondary containment measures.

3. If the waste material can not be held in containers/skips it should be held in enclosed or shielded bays of suitable and robust construction that provide the material with adequate shelter and containment to prevent the loss of material and liquid residues.

4. Where ever feasible, material should be held and handled in enclosed systems.

5. Water used for material dampening should be applied at a controlled and calculated rate and not to an extent that could promote leaching or the generation of contaminated run-off.

## 5.5 Emission Monitoring requirements

**Indicative BAT requirements**

The Operator must, as a minimum, comply with the indicative BAT requirements for emissions monitoring as set out in Section 2.10 of S5.06. Where continuous emission monitoring is not proposed or provided for the plant's point source emissions to air specific justification must be provided to demonstrate that the proposed measures represent BAT taking into account BAT points 2, 3 and 4 of Section 2.10.1 of S5.06.

# 6 Process efficiency

The Operator should ensure that the facility is designed and operated in a way that maximises process efficiency, in terms of raw materials and energy use, in order to minimise its indirect environmental impact and promote the sustainable use of resources (e.g. in terms of its carbon footprint and use of virgin raw materials), whilst maintaining safe and effective standards of operation.

## 6.1 Energy efficiency

Fuels should be combusted and electricity used as efficiently as possible, and heat generated should be transferred efficiently to the waste material. In addition to heat transfer design, further system efficiency improvements may be made through the use of heat recovery systems.

**Indicative BAT requirements**

The Operator must comply with the indicative BAT requirements for energy as set out in Section 2.7 of S5.06 and the following appropriate measures:

1. Energy efficiency should be considered during the selection/design and operation of the TDU. The method and plant used to heat the waste will contribute significantly to the overall energy efficiency of the facility, and different systems are likely to have different efficiencies. Only indirect heating methods should be considered.

2. Appropriate measures should be taken to identify and optimise the treatment temperature(s) and duration of operation at the treatment temperature(s) in order to maximise the energy efficiency of the treatment process (e.g. through thorough waste characterisation, pilot trials, process monitoring and control measures).

3. It is important that the water content of the untreated waste material is assessed and, where necessary, controlled prior to treatment (i.e. through

an appropriate pre-treatment process). If pre-treatment is required, a balance will usually need to be made between the energy required to reduce the moisture content of waste and the increase in the efficiency of the heating process gained from the removal of the water. It may also be advantageous to have a certain minimum amount of moisture in the untreated waste material to aid handling. The removal of volatile organic compounds can be helped by there being a moderate level of moisture in the waste material (typically between 1020%).

4. The potential for energy recovery should be considered during the design of the TDU and reviewed on an on-going basis once operational. Potential opportunities for energy recovery include the recovery of heat from hot gases (e.g. combustion exhaust gases, thermal oxidiser gases) to pre-heat sweep gases, re-heat off-gases or reduce the water content of untreated waste.

## 6.2 Efficient use of raw materials and water

An important technique for controlling direct releases (e.g. emissions and waste), as well as indirect environmental impacts (e.g. from the off-site manufacture/preparation of materials), is to minimise and regulate inputs at source through the efficient use of raw materials and water.

**Indicative BAT requirements**

The Operator must comply with the indicative BAT requirements for raw materials as set out in Section 2.4 of S5.06 and the following appropriate measures:

1. Process consumption of raw materials and water should be considered during the design of the TDU and should be reviewed on an on-going basis during operation. For example, during the comparison of waste cooling systems (requirements for use of refrigerants/coolants/treatment chemicals etc) and emission abatement systems (requirements for use of catalysts, filter material etc).

2. If carbon filters are used on-site for abatement purposes, spent activated carbon should be sent for recovery and re-use where possible.

3. It may be possible to reuse dried treated material to condition wetter untreated material in order to improve its properties for handling and/or treatment. However, any mixing process must be carried out in a way that meets the requirements of BAT, as set out in this document and S5.06.

4. Wherever possible, cooling waters used at the facility should be re-circulated and re-used.

5. Water added to treated waste material (i.e. in order to dampen it and prevent fugitive dust emissions) must be applied in a controlled manner.

## 6.3 Waste minimisation

Various residuals are always generated as part of the thermal desorption process, regardless of the type. Some of these are non-hazardous whereas others are likely to be hazardous i.e. the condensed, concentrated liquid form of the desorbed contaminants. Other typical wastes resulting from thermal desorption processes include over-sized materials, spent carbon, condensed water, process water, treated solid waste material, dusts from particulate control systems, used filters and catalysts.

**Indicative BAT requirements**

The Operator must comply with the indicative BAT requirements for waste minimisation as set out in Section 2.4.2 and 2.6 of S5.06 and the following appropriate measures:

1. Some of the waste streams produced by the treatment process may be suitable for recycling or reuse in the process. For example, if suitable, recovered water could be re-used on-site, primarily to suppress dust emitted from the treated waste material before or after it exits the treatment plant. Opportunities for recycling/reusing waste on-site should be considered during plant design, and should be reviewed on an on-going basis during plant operation.

2. The condensed desorbed contaminants should be stored on-site before being sent for further treatment and recovery (for example, as a recovered fuel oil/processed fuel oil or Cemfuel).

3. Where suitable, and appropriate measures are in place to prevent potential fugitive emissions, fine material collected from the off-gas by the particulate abatement system may be mixed with the contaminated feedstock for reprocessing / re-conditioning.

4. Spent carbon filter material should be sent for reactivation and reuse i.e. to the original supplier or other processor.

5. Where possible, consideration should be given to the use of processed fuel oil as a source for the heating/drive energy generation.

# 7 Accident Management

In order to protect human health and the environment as a whole, it is important that all appropriate measures are in place for the identification, assessment and management of the potential hazards and associated risks posed by the activities carried out on site, both under normal and abnormal scenarios of operation.

## Indicative BAT requirements

The Operator must comply with the indicative BAT requirements for accident management as set out in Section 2.8 of S5.06 and the following appropriate measures:

1. Process control systems should be designed to include provisions for a safe shut-down with minimum emissions (point-source and fugitive) from the plant. Measures should be in place to ensure that waste feed supply is controlled or terminated, as appropriate, followed, where necessary, by a pre-programmed and automated sequence of plant shut-down, which is designed to ensure that the treatment process is controlled in a safe manner and potential emissions are minimised.

2. Where necessary, an uninterrupted power supply should be guaranteed for key process plant and other plant designed to fail to safe in the event of power failure.

3. Appropriate precautions should be taken to minimise the risk of fire or explosion and to minimise the environmental consequences should a fire occur. Volatile gases released/desorbed from the waste material may have the potential to form explosive atmospheres. Areas of the site where flammable or explosive atmospheres may occur (e.g. waste storage, handling and processing areas) should be assessed and, where appropriate, classified into hazardous zones, in accordance with the requirements of DSEAR. For further guidance on DSEAR and hazardous area classification see the HSE's DSEAR Approved code of practice and guidance (L138).

4. The Operator should produce emergency response plans for the potential accidents identified and assessed by the facility's accident management plan. Emergency plans should provide information on the layout of premises, type, quantity and hazards of materials onsite, location and type of fire fighting equipment, the name of contacts in case of emergency and, where possible, be drawn up in consultation with the local fire service.

5. Procedures and training should be in place to manage identified risks and ensure the rapid initiation of the emergency plan should an accident occur. Where possible, the Operator should involve the emergency services in relevant emergency training activities.

6. The design and operation of sealed batch-operated TDUs, and other plant / equipment that operate under pressure (e.g. vessels, pressurised storage containers, heat exchangers, shell and water tube boilers, pipework, safety devices and pressure accessories) may be subject to the requirements of the Pressure Systems Safety Regulations (PSSR). For further guidance on PSSR see the HSE's PSSR Approved Code of Practice (L122).

7. At sites where combustible fine dusts are generated, handled or processed the design and operation of the facility should take into consideration the potential for dust explosion hazards. Further guidance on the prevention of such explosions (e.g. through appropriate dust control measures and explosion relief) can be found in the HSE's guidance note Safe handling of combustible dusts: Precautions against explosions (HSG 103).

# List of abbreviations

| | | |
|---|---|---|
| BAT | – | Best Available Technique(s) |
| DRE | – | Destruction/Removal Efficiency |
| HIM | – | Human Interface Module |
| LDAR | – | Leak Detection And Repair |
| LEL | – | Lower Explosive Limit |
| PCB(s) | – | Polychlorinated Biphenyl(s) |
| PLC | – | Programmable Logic Controller |
| SCADA | – | Supervisory Control And Data Acquisition |
| TDU | – | Thermal Desorption Unit |
| VOC(s) | – | Volatile Organic Compound(s) |
| WID | – | Waste Incineration Directive (Directive 2000/76/EC) |

# References


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