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IVC DESIGN PRINCIPLES

Environmental and sustainability solutions provided to
RESOURCE RECYCLING SOLUTIONS LIMITED

WRM-LTD.CO.UK

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1.0 INTRODUCTION

1.1 Context

Walker Resource Management Ltd (WRM) have been commissioned by Resource Recycling Solutions Limited (hereon referred as RRS), to provide a Design Principles report in line with the sites proposed In-Vessel Composting (IVC) development This report will provide an overview and justification for the different aspects of the IVC system.

1.2 Site Description

RRS is a composting site, located at Iron House Farm, primarily composting source segregated green bio-waste in open windrows. Iron House Farm is located off Lancaster Road, in Out Rawcliffe, which is 17km south of Lancaster and 9km west of the M6. The main village of Out Rawcliffe is situated to the southwest at 3km. The site is situated within an area that is of agricultural use with some residential. It is proposed that an IVC system is installed on site to facilitate the treatment of comingled food and green waste to PAS100 standard on site.

1.3 Site Location

Iron House Farm,
Lancaster Road,
Out Rawcliffe,
Preston,
Lancashire,
PR3 6BP

Grid Reference: 341162 (easting), 444756 (northing)

1.4 Site Operational Parameters

The projected throughput of the development is:

- <75,000 tonnes of green wastes / comingled food and green wastes / food wastes only

2.0 LEGISLATIVE FRAMEWORK

The target material and annual throughput have implications upon the regulatory requirements for developing the facility. Specifically in this instance the following regulatory requirements will need consideration in the development of a technology specification and selection criteria:

- Animal By-Products Commission Regulation 142/2011 (2011);
- Industrial Emissions Directive 2010/75/EU (2010) - Best Available Techniques Reference Document For Waste Treatment (BREF) (2018);
- Environment Agency's TGN for composting: How to comply with your environmental permit. Additional technical guidance for composting and aerobic treatment sector.

2.1 Animal By-Products Regulations

The sanitisation process of waste material must comply with Regulation (EU) 142/2011 (OJ: L54/1/2011) implementing Regulation (EC) 1069/2009 laying down health rules regarding animal by-products and products not intended for human consumption. These regulations permit the treatment of Category 3 animal by-product in approved composting plants. Certain Category 2 animal by-products are also permitted to be treated. Higher risk Category 2 material cannot be used as feedstock in composting, except where they have first been rendered to 133ºC for 20 minutes. No Category 1 animal by-products can be used as feedstock in composting.

Animal by-products other than catering waste and some former foodstuffs must be treated to the EU standard set out in Regulation EC142/2011 Annex V, Chapter III, Section 1 which is the treatment of particles in a closed system for;1 hour at >60ºC and being no greater than 12mm in size.

2.2 BREF

The latest BREF for Waste Treatment activities was published in 2018 and this process ensures the Environmental Permit for the Site is in line with the latest set of BAT standards. The BREF for Waste Treatment activities, as well as the Commission Implementing Decision (EU) 2018/1147, have been consulted in order to ensure this BAT Assessment meets the requirements of legislation and to ensure the site meets the required standards of compliance.

3.0 CAPACITY REQUIREMENT

The following section outlines the designed capacity of the In-Vessel Composting (IVC) tunnel system against the proposed annual tonnage allowance for material reception and treatment.

3.1 Waste Reception

All incoming vehicles will enter the via the existing waste facility site entrance and to the weighbridge. The site can receive waste Monday to Saturday. This provides 280 days of waste receipt (excluding Sundays, Bank Holidays and half days on Saturday). However, given that the composting process is continual, material can be held in process for 365 days per annum.

3.2 IVC Design Capacity

Green waste, comingled category 3 ABPR food and green waste or food waste only will be processed through an in-vessel tunnel composting system. The plant has been designed and specified to treat the proposed annual throughput of material.

The IVC building consists of 4No. tunnels, each 4m high (filled to 3.7m), 6m wide and 34m long. Each tunnel can hold up to 377 tonnes of material (using a bulk density of 0.5) which is processed for a typical period of 7 days during which time the critical limits in the tunnels are automatically monitored as part of a SCADA system.

In process, the IVC can therefore hold **1,508 tonnes** of waste material at any one time.

It should be noted that this calculation assumes a straight-line material throughput which in reality would not occur due to seasonality in feedstocks. However, this is considered against the overall capacity of the proposed design specification.

3.3 IVC Capacity Assessment

A calculation is provided below demonstrating the maximum capacity of material that could be treated per annum based upon the overall system design.

1. Holding Capacity: Tunnel capacity (377 tonnes) * Number of tunnels (4) = **1,508t**
2. Process period: Operational days (365) / Maximum process length (7 days) = **52 process periods** per tunnel per annum
3. Design Capacity: Holding capacity (1,508t) * Process period (52) = **78,416 tonnes per annum**.

The overall assessment therefore identifies that the IVC is designed to be able to treat a straight line throughout at maximum capacity throughout a given year of **78,416 tonnes**.

4.0 IVC DESIGN

The treatment specification identifies the requirements as specified by the itemised regulations as well as learning identified by WRM throughout the process of achieving regulatory permissions for the installation of a new IVC facility.

The specification herein, identifies the infrastructural and operational parameters and requirements for the development and operation of an IVC facility utilising tunnel composting technology. The regulatory specifics are cross-referenced throughout, and additional operational understanding is identified where appropriate around specific technology options.

4.1 IVC Building

The building will be constructed of concrete sectional blocks and clad with a corrugated steel sheeting. The building will feature a double pitched roof will be of steel construction and will measure 50m (l) x 45 (w) x 5m (height). All areas of the building that utilise steel as the primary fabric construction material, will be coated with an anticorrosive primer (e.g., epoxy primer) to minimise long-term degradation. The IVC building will comprise of a waste reception area 4No. of IVC tunnels and a corridor running in front of the tunnels linking the two areas. This corridor will be sized appropriately for operational vehicles.

The entrance point to the waste reception area of the building which is located at the northern point on the eastern side, will feature a 2No. of roller shutter doors big enough for Refuse Collection Vehicles (RCV's) to enter and deposit waste. Next to that will be a double roller shutter specifically for a mobile shredder to access the building, that has a dedicated area within the waste reception hall. Finally at the southern portion of the eastern edge another roller shutter door will be in place where the IVC tunnels are located, the primary function will be for non-collection vehicles (e.g., shovel loaders) taking sanitised material out to the OWC area. All roller shutter doors will be manually operated and remain closed when vehicles are not entering/exiting. For pedestrians there will be on 2No. of entrance points. One will be situated next to the waste reception roller shutter door and one situated next to the IVC tunnels roller shutter door. These doors will be airtight and enable safe access away from the delivery vehicles and as an emergency escape during fires. A footbath will also be present next to each door for sterilisation of footwear during ingress & egress.

4.2 Waste Reception Area

The IVC waste reception is to be internally constructed of sectional concrete blocks up the base of the building eaves, these will be sealed with a suitable water-tight compound for the sealant. A concrete floor is to be installed with a similar thickness (c.150mm) and foundation material (recycled aggregates) as the existing OWC concrete pad. The entrance point to the waste reception area will feature a 2No. of roller shutter doors big enough for Refuse Collection Vehicles (RCV's) to enter. As previously mentioned next to that will be double door for the mobile shredder to enter the building, this will have specific zone inside the hall. Within the area dividing bays will be in place for waste to ensure an adequate level of tidiness is maintained and enables a more efficient loading system for the shovel loaders. An area of the waste reception hall will be marked for quarantine, should contrary material be received on site. The area will be clearly segregated from other material and cordoned off. A pressure washer system will be installed as all vehicles will require wash-down prior to leaving the IVC reception hall.

A fan will be located at the northern portion of the building's western side. This fan will serve as the main extraction point for the waste reception hall, and there will be a dual air-duct system that connects the fan to the IVC tunnels and biofilter (see Figure 2).

4.3 IVC Tunnel

RRS will utilise a tunnel based IVC system with each tunnel measuring 4m x (high) x 6m (wide) x 35m (long). The tunnels can hold up to 377 tonnes of material which will have a typical processing period of 7 days during which time the critical limits in the tunnels are automatically monitored as part of a SCADA system. The system operates a static composting method, i.e., there is no mechanical agitation while material is in tunnel. Instead, agitation is provided when material is unloaded.

RRS will follow the ABPR two-barrier method. Waste material from the waste reception hall is removed of contaminants (e.g., plastics), shredded and is then loaded into the tunnels(s). The waste shall be sanitised at >60ºC for 48 hours, once complete the waste will be removed by shovel loader and placed in another tunnel. This movement (turn of the material) is to ensure there is a suitable level of agitation. Once deposited in the second tunnel, the 48-hour sanitisation process will be repeated. Proceeding this second sanitisation phase waste material will be removed from the IVC building for Open Windrow stabilisation. As previously mentioned, this two-barrier sanitisation method will be undertaken typically over a 7-day period.

One air injection fan supplies air at the base of each tunnel on the western side of the building (4No. in total for all tunnels). These will be linked by a ducted system that will run externally to the building, drawing air from the primary air extraction fan that is connected to the reception hall. This process of forced aeration of the compost pile will take place through the channels in the tunnel floor which also act as the leachate drainage channels. These channels direct airflow at the base of the material which then flows up through the composting mass into a headspace at the top of the tunnel. Removable reinforced plastic aeration & drainage frame will line the concrete channels. These frames will feature a plastic grated top to prevent debris accumulation. A visual inspection will take place proceeding the sanitisation period and If debris is present the frames will be removed, and pressure washed. The tunnels are loaded from one end (eastern side) and operate in batch mode after the tunnel is fully loaded. The 4No. of IVC tunnel will be used to attain a nearly continuous operation. Air extraction will take place via one extraction fan that is located at the upper portion of each tunnel on the western edge (4No. in total for all tunnels). This will enable air to be drawn up through the waste pile. The tunnel's air extraction fan is linked via an external ducted system that connects to the site's biofilter ducting for odour abatement purposes.

To ensure adequate impermeability in line with the release of leachate from the composting process, a concrete floor is to be installed with a similar thickness (c.150mm) and foundation material (recycled aggregates) as the existing OWC concrete floor. The joints of the pad will feature a suitable water-tight compound for the sealant. The walls of the tunnels will be formed of sealed sectional 25cm concrete blocks to ensure a consistent level of impermeability. A vertically raising steel-framed (coated with epoxy primer) flat screen roof system will be in place to enable suitable clearance for a shovel loader to enter the tunnel when depositing and removing material. Once depositing or removal of material has taken place the roof can retract down to the height of the sectional concrete walls. This roof will be operated via screw jacks located in each corner of the tunnels.

Air containment for the tunnels is managed through the negative air pressure provided by the air extraction fans and, the loose air seal from the tunnel roof fabric. The doors for the tunnels will be removable steel doors (coated with epoxy primer) that can be hooked off by a tele handler. To ensure secure placement there will be grooves either side of the door frames. The reasoning for this choice is to minimise the potential for hydrogen sulphide related corrosion resulting that would be more prevalent with a hinged door system. Adjacent to the tunnel doors on the eastern side of the building a roller shutter door is in place specifically for non-collection vehicles (e.g., shovel loaders) to transport sanitised material to the OWC area. All roller shutter doors will be manually operated and remain closed when vehicles are not entering & exiting.

4.4 Material Flow Overview

Figure 1 provides a visual representation of the material flow through the building from material reception, shredding, composting, and removal following the previously mentioned treatment method.

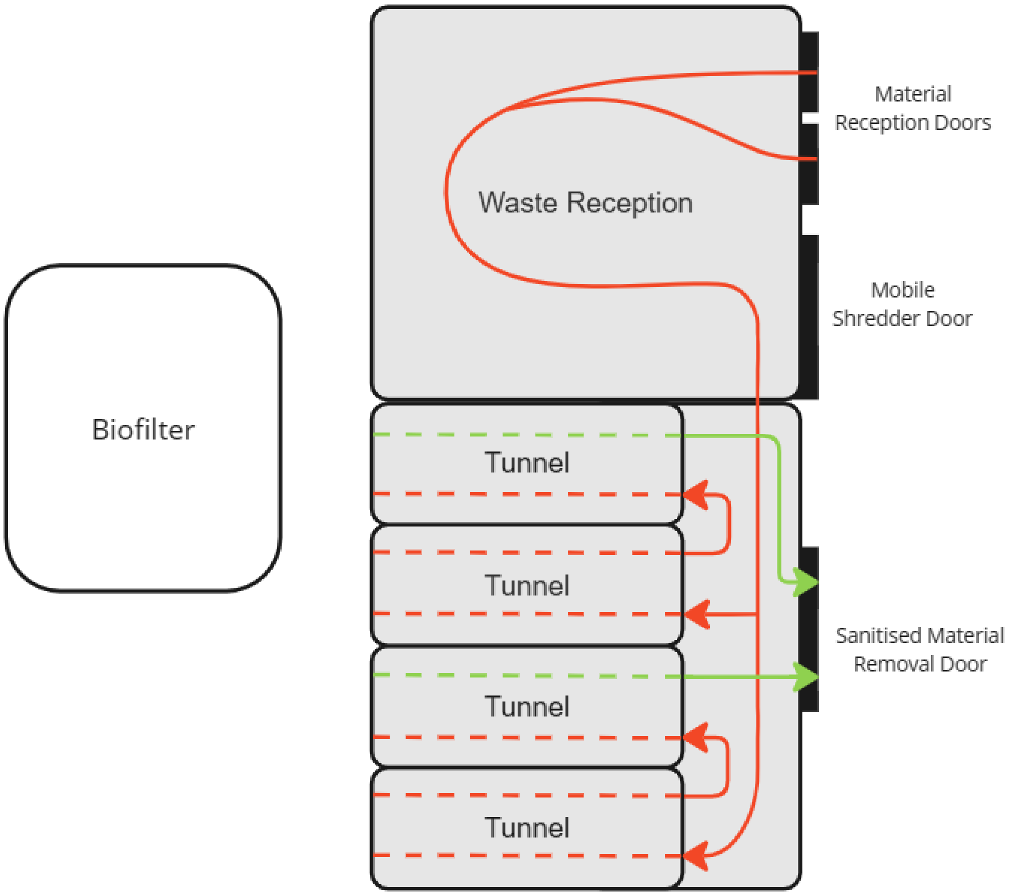

Figure 1 - Material Flow Overview.
(Not to Scale)

4.5 Airflow Overview

Figure 2 provides a visual representation of the air flow associated with the IVC building as a result of the proposed aeration system.

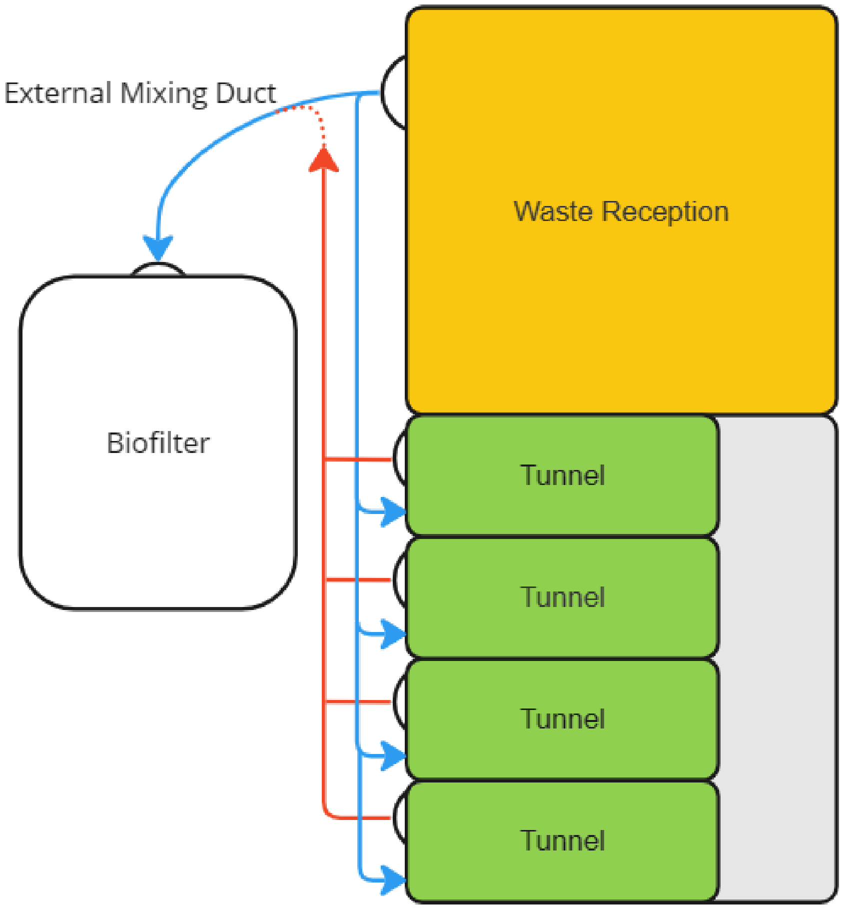

Figure 2 - Airflow Overview for the Aeration System. (Not to Scale)

4.6 Drainage System

All leachate drainage channels for the waste reception will be cut into the concrete floor and will be lined with reinforced plastic with grating to ensure avoidance of cracking from vehicle movement. Grated channels in the waste reception area will direct leachate from south to north & east to west. The concrete floor also features falls ensuring leachate flows into the designated 'dirty area' channel and does not enter the APBR designated 'clean area' corridor that is situated in front of the tunnels. Leachate exits the building at the southern portion of the western edge into an enclosed external drainage channel to maintain ABPR and odour control. This external channel directs leachate to the leachate storage tank, which is located adjacent to the biofilter. The tank will be constructed of concrete and feature a corrugated steel cladding. Collected leachate is to be re-used when moistening of waste material during the batch formation phase within the tunnels.

Within the IVC tunnels a series of drainage channels run along the floor, these were previously mentioned as the reinforced plastic aeration frames. Leachate will flow from west to east up to the point of the tunnel entrance. A singular enclosed drainage channel runs along the front of the tunnel entrance points. This leachate drainage channel runs south to north and then east to west along the northern edge of the waste reception hall, directing leachate into the enclosed external drainage channel on the western edge of the building. Leachate will then flow northward to the leachate storage tank.

The ABPR dirty area (waste reception) and ABPR clean areas (IVC tunnels & corridor) have dedicated drainage channels within the IVC building. This enables separation of processed and unprocessed materials preventing leachate related cross contamination between the area. A formalised clean down procedure of the clean area corridor will also take place each time un-sanitised material has been deposited in the tunnels (e.g., pressure washing of the concrete floor and shovel loaders). The implementation of these measures ensures RRS are adhering to ABPR regulatory requirements (see Figure 3).

As the IVC building will feature a double pitched roof rainwater will flow to either a central or perimeter roof gully. These gullies are connected to series of drainpipes that are located around the perimeter of the building. The drainpipes will be connected to a drainage channel that directs the liquid to a plastic self-bunded rainwater collection tank adjacent to the biofilter. This tank is in place for recirculation purposes to moisten the biofilter when necessary, as captured leachate cannot be used due to the potential to inhibit the abatement performance of the biofilter system. It will also be used to re-moisten material proceeding the batch formation phase, to avoid reinoculation that occur through the use of captured leachate.

4.7 Leachate Drainage System Overview

Figure 3 provides a visual representation of the leachate flow through the IVC building, with reference ABPR clean (green) and dirty area (red).

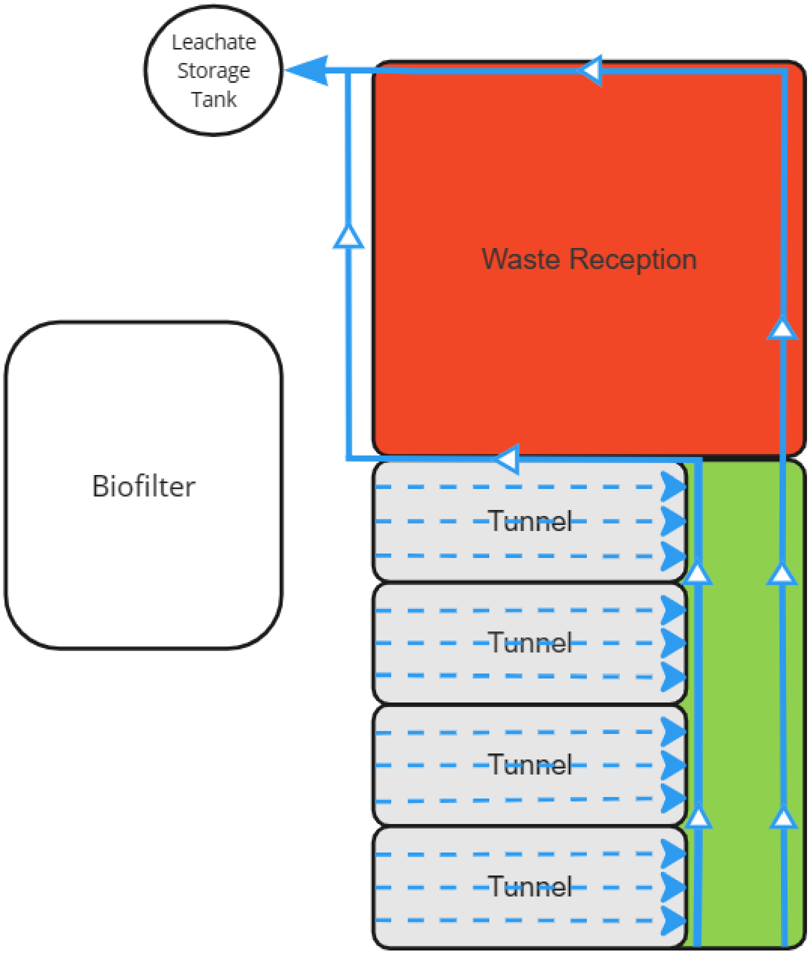

Figure 3 - Leachate Drainage System Overview. (Not to Scale)

4.8 Air Treatment System

External Mixing Duct

Optimal systems employ a method for mixing process air (exhaust air from the tunnels) with reception hall air. As not all air drawn from the reception hall will be required 100% of the time to be blown through the tunnels, an excess of air can bypass the tunnels. This air has a lower concentration than the exhaust air from the tunnels and when mixed together can act to dilute the air that then goes to the air treatment system. This has the benefit of producing a more stable airflow quality preventing surges in concentration which can prevent effective treatment in the designed biofiltration system.

Biofilter

There is a single biofilter for the treatment of air from the reception hall and 4 No. compost tunnels. The internal dimensions of the biofilter housing are 10m x 27.3m (l * w) with a maximum air volume/min of 557.6m^3 and total biofilter volume of 418.2m^3, therefore it will be capable of processing 122.6m^3/m^2/hr. The biofilter is built with a spigot floor, for an optimal air distribution. An air injection fan will be attached to the biofilter to draw air from external mixing duct into the biofilter (see Figure 2). The biofilter media itself will be constructed of coarse shredded untreated wood and will be filled to 1.53m of media per m^2 of biofilter housing. The biofilter will have the recommended minimum airflow residency period of ≥45 seconds. The fan, ventilation system and bio-filter construction materials should minimise the effects of corrosive waste gas, excess condensate, dust and sludge build up within the IVC building and IVC tunnels. See below the calculation for the relevant biofilter sizing:

- Airflow Residency Period: 45 seconds
- Air volume/minute: 33,456m^3/hr (total treatment air consumption) ÷ 60 = 557.6m^3/min
- Biofilter Volume: (557.60m^3/min x 45 seconds) ÷ 60 = 418.2m^3
- Biofilter Area: 27.3m (l) x 10m (w) = 273m^2
- Biofilter Depth: 418.2m^3 ÷ 273m^2 = 1.53m
- Biofilter Air Demand: 33,456m^3/hr ÷ 273m^2 = 122.55m^3/m^2/hr

The moisture balance is critical, and the relative humidity of the filter material should be below 60% to avoid clogging. The sprinkling system connected to the rainwater collection tank used for the moistening biofilter, will be protected against freezing where external temperatures fall considerably below 0°C are an issue. Monitoring of moisture content of the biofilter will be undertaken via the use of a visual observation. For application to warm waste gas streams extracted from the tunnels (>35ºC), cooling will be provided by mixing with air from the waste reception hall. Temperature monitoring is undertaken within the biofilter media through the use of a temperature probe, and any temperature above 35ºC triggers the system to ventilate the biofilters to cool them down. In the plenum chamber, pressure and energy uptake are measured. These parameters help running the facility at its maximum efficiency.

Over time biofilter material losses its coarseness, this is identified by visual inspection of the biofilter media and backpressure (backpressure limit: 2.5Pa). Once the media has been identified as requiring replacement, appropriate wood chip material is brought in and the spent biofilter media composted. During media replacement, a quantity of the existing media will be incorporated into the replacement media to ensure rapid establishment of a suitable microbial population.

When working at maximum capacity the biofilter system will require regular inspection, monitoring and maintenance to ensure optimal performance and therefore the following monitoring will be conducted: A daily visual inspection of the biofilter media condition shall be conducted by a trained operative, to identify areas of drying, weed growth, siltation, shrinkage of the bed, cracks and fissures, etc. The results will be recorded on the Site Diary and any remedial action taken as necessary. There shall be continuous monitoring of temperature and daily monitoring of moisture levels for the biofilter. The back pressure of the biofilter will be monitored daily with an annual calibration. Results for all monitoring aspect will be recorded on the Site Diary. The efficacy of the biofilter will be reviewed at least biannually in line with requirements of the permit.

4.9 Air Flow Calculation

The waste reception hall is one open space with a high point in the apex of between 7.5m & 8m and 5m on the side of the IVC building. See calculations below for the relevant volumes of IVC building.

- Volume of base of reception hall: 50m x 45m x 5m (l * w * h) = 11,250m^3
- Volume of tunnels: 6 x 4 x 34 = 816m^3 per tunnel or 3,264m^3 total
- Volume of eaves reception hall eaves: 0.5 x (20m x 50m x 2.5m) + 0.5 x (25m x 50m x 3.5m) = 3,125m^3
- Total volume of reception hall: 11,250m^3 + 3,125 m^3 = 14,375m^3
- Volume of reception hall - volume of tunnels: 14,375m^3 – 3,264m^3 = 11,111m^3

The waste reception hall is continually vented as the source of air for aerating the compost tunnels. During normal composting operations (including cool-down) on average a tunnel will consume 41m^3 of air per m^2 of tunnel per hour. This means an average air consumption of 8,364m^3/h/tunnel, or a total air consumption of 33,456m^3/h. Therefore, the reception hall is ventilated by 3.01ae/h (air exchanges per hour). The fan system will have a suitable airflow capacity to the meet the required demand. If in the case all the tunnels are not in operation this would not meet the required 3ae/h, meaning air extraction would also need to take place from waste reception hall straight to the air abatement system rather than solely via the tunnels to meet the required 3ae/h.

4.10 Biofilter Treatment

A study undertaken by the Environment Agency[1] relating to biofilter performance demonstrated that a five-vessel IVC site (35,000 tonnes capacity of green and food waste per year) utilised a biofilter as the primary odour mitigation method, the site did not have in place a pre-scrubber and was able to ensure ammonia was below the 20mg/m^3 threshold. RRS will therefore operate in this manner. The wood chip (e.g., virgin pine) used within the biofilter will be sequentially inoculated with selected strains of microorganisms (e.g., Acinetobacter sp, Pseudomonas strains, Thiobacillus sp and Paracoccus versutus) and to further improve abatement performance fertilisers will be applied to the biofilters to stimulate the necessary nutrient growth of the biofilm. RRS will also periodically re-seed the biofilters to prevent potential high emission rates as recommended by Defra[2]. Biofilter media health is to be maintained at the following optimal conditions presented Table 1. If the media health aligns with the intermediate - negative condition RRS will consider reseeding of the biofilter. The below parameters have been determined by SEPA[3].

Table 1 - Criteria for Assessing Biofilter Media Health.

Parameter	Indication of the quality of the biofilter media		
	Optimal	Intermediate	Negative
EC (µS/cm)	<1000	1000 – 3000	> 3000
NH_4^+-NO_x-N	0.25 – 3.5	3.5 – 5 and 0.15 – 0.25	> 5 and < 0.15
$SO_4$2-	<1000 mg/kg	N/A	>1000 mg/kg
Moist Cont (%)	60 - 75	75 - 80 and 50 - 60	> 50 and < 80

An emissions monitoring exercise will be undertaken once operation of the IVC has commenced by an MCERTS accredited monitoring organisation to accurately confirm that ammonia levels are within the 5-40mg/Nm^3 threshold stated in the Best Available Techniques (BAT) Reference Document for Wast Treatment 2018 (BREF)[4].

[1] Biofilter performance and operation as related to commercial composting, Environment Agency
[2] Good Practice and Regulator Guidance on Composting and Odour Controls for Local Authorities, Defra
[3] SEPA Technical Guidance – BAT for Composting
[4] Best Available Technique Reference Documents

APPENDIX A - EMISSION CONTROL

Emission control at an IVC facility will primarily concern odorous emissions and the control of leachate waters. These emissions control systems were identified through regulatory requirements covered by the Industrial Emissions Directive (IED). WRM also provided guidance on which type of systems are preferable as identified from industry experience.

- Negative aeration within the reception hall should be designed with a minimum of 3 air exchanges per hour.
- 6-Monthly 1000 ouE/Nm^3 or for NH_3 20mg/Nm^3.
- Additional regular monitoring parameters should be identified to ensure performance against the design specification.
- Biofilter media should be replaced in line with monitoring outcomes.
- The biofilter media should be constructed from clean wood or other such suitable biofilter media specific product.
- Residency period within the biofilter should be ≥45 seconds.
- Temperature should be regularly monitored within the biofilter media.
- Monitoring of moisture content within the biofilter should be undertaken regularly.
- Air entering the biofilter should contain <45mg NH_3/m_{-3}.

APPENDX B - SITE LAYOUT