ATTACHMENT NUMBER D2

Facility Operation

Contents

Attachment D2.1 Description of Unit Operations

D2.1 DESCRIPTION OF UNIT OPERATIONS

1. INTRODUCTION

The waste management facility at Carranstown will consist of:

- A Community Recycling Park with an estimated throughput of 2,000 tonnes per annum
- A Materials Recycling Facility for non-hazardous waste with an anticipated throughput of 20,000 tonnes per annum
- A Waste to Energy Plant for non-hazardous waste with a nominal capacity of 150,000 tonnes per annum.

Process descriptions for each of the above are presented in Sections 2, 3 and 4. The site layout plan is shown in Attachment D2.2.

1.1 LABORATORY ACTIVITIES

There will be no laboratory facilities required on site.

Continuous monitoring of dust, Total Organic Carbon (TOC), Hydrochloric acid (HCl), Sulphur dioxide (SO_2), Nitrogen oxides (NO_x), Oxygen (O_2), Carbon monoxide (CO), temperature and water content will be carried out at different stages throughout the waste to energy plant. Fixed installed emissions monitoring equipment will be provided at the stack for continuous monitoring of the above emissions.

Continuous sampling of dioxins will also be carried out at the stack. The AMESA dioxin/furan monitoring system, or equivalent, will be installed, which is used for measuring dioxins/furans in other plants that comply with the German Environmental Regulation 17BIm SchV and TA Luft. Further details on the AMESA dioxin/furan monitoring system are included in Attachment J1.2.

1.2 ANCILLARY ACTIVITIES

The water treatment system, electrical systems and utilities that will be provided at the waste management facility are described in Sections 5, 6 and 7 respectively.

1.3 ABATEMENT/TREATMENT/RECOVERY SYSTEMS

There will be a number of abatement, treatment and recovery process steps within the waste management facility. These steps are listed in Table 1.1 below.

Table 1.1 Abatement/Treatment/Recovery Systems within Waste Management Facility

Emission Treatment / Recovery	Abatement /Treatment / Recovery System	Relevant Section
Odour	Primary Air Supply taken from Waste Acceptance Hall	3.1 & 4.2
Litter	Enclosed Waste Acceptance Hall	3.1 & 4.2
Oxides of nitrogen (NO_x)	Injection of Ammonia Solution/Urea into Boiler	4.4
Hydrocarbons (expressed as Total Organic Carbon (TOC))	Furnace	4.4
Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF)	Minimum temperature of 850 °C for 2 seconds in first pass of Boiler	4.5
Energy Recovery	Boiler	4.5
Process Effluent	Evaporating Spray Tower	4.6
Hydrocarbons (expressed as Total Organic Carbon (TOC)), Particulates (Dust), Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF), Heavy Metals	Activated Carbon/Lime Mixture Injection and Baghouse Filter and Tail End Flue Gas Cleaning	4.7 & 4.9
Sulphur Dioxide (SO_2), Hydrogen Chloride (HCl), Hydrogen Fluoride (HF), Heavy Metals	Wet Flue Gas Cleaning	4.8
Plume Abatement	Heat Exchanger	4.10

1.4 DEVELOPMENT AND OPERATIONAL HISTORY

The waste management facility is to be constructed on a greenfield site at Carranstown, Co. Meath about 3 km north east of the village of Duleek. The site was previously in agricultural use and there is no record of any known historical pollution. As part of the environmental impact assessment for the proposed development, a hydrogeological survey of the site was carried out, the results of which are detailed in Attachment 9 of the EIS. The findings of this survey indicate that there is no contamination of soil or groundwater at the site.

2. COMMUNITY RECYCLING PARK

2.1 PROCESS DESCRIPTION

The community recycling park will be located at the front of the facility and will offer as wide a range of recycling opportunities as possible. The Community Recycling Park will be open to the public six days a week. It is anticipated that about 3,500 cars will use the park each month. Based on experience at similar facilities, it is expected that 2,000 tonnes/annum of recyclable domestic waste will be collected by the facility.

The community recycling park will use a small quantity of water for hand washing and toilet facilities and electricity for lighting. A number of different categories of waste will be accepted in order to optimise the recovery and recycling options available. Likely categories of recyclable waste that will be accepted are as follows:

- Cardboard
- Newspaper and magazines
- Glass
- Aluminium drink cans
- Textiles (clothes and blankets, for example)
- Footwear
- Batteries
- Waste oils (kitchen oil and car lubrication oil)
- Wood

Individual waste streams will be deposited into dedicated containers by members of the public. Photographs from typical community recycling parks are shown overleaf. The storage containers will be kept in shelters as necessary, which will be planted with an organic green roof system on the roof to improve the visual appearance of the area from the road. The containers will be emptied as they become full. The layout of the community recycling park is shown in Attachment D2.3.

The creation of the community recycling park is not only environmentally sound, but is in line with National Policy to increase the number of such facilities.

2.2 PROCESS CONTROL

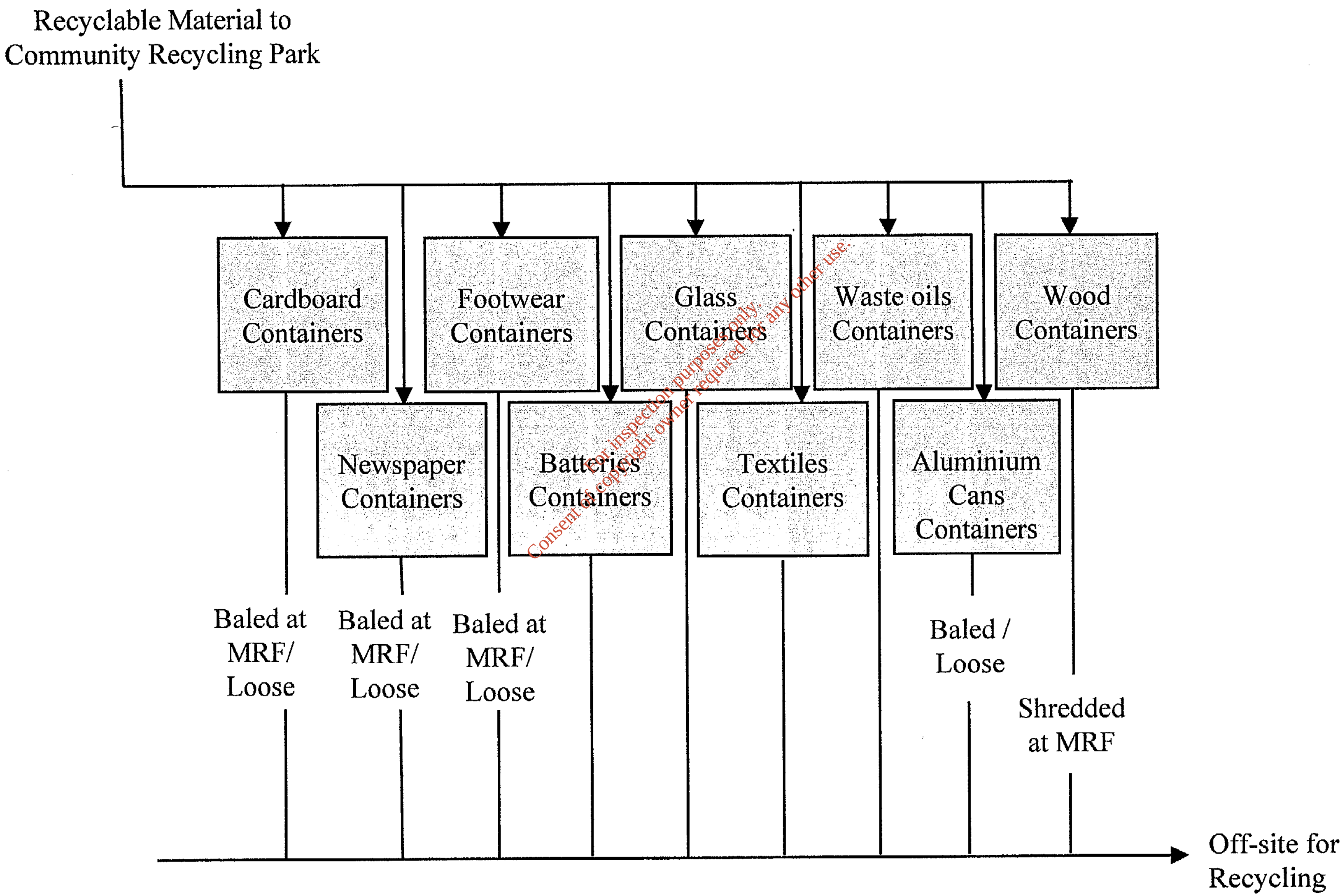
The community recycling park will be staffed continuously during opening hours to monitor deliveries of waste, assist the public in depositing their waste and ensure that no inappropriate waste is delivered. The containers will be emptied as they become full.

Typical Community Recycling Park Layout

Newspaper/Magazine Recycling Bin

A process flow diagram for the community recycling park is included overleaf.

COMMUNITY RECYCLING PARK PROCESS FLOW DIAGRAM



2.3 EMISSIONS

There will be no emissions from the community recycling park. As no kitchen waste will be accepted at the park there will not be a problem with odour or vermin. In addition, the area will be kept clean and odour free through good housekeeping practices, i.e. regular washing and sweeping of the area, provision of hand washing facilities for members of the public and monitoring of waste deliveries.

2.4 INPUTS AND OUTPUTS

It is anticipated that the community recycling park will accept approximately 2,000 tonnes of domestic waste per annum. Newspapers, cardboard, cans and wood may be brought to the materials recycling facility, where they will be baled/shredded prior to being sent off site for recycling. Other items, i.e. glass, batteries, will be sent directly off site to recycling outlets.

3. MATERIALS RECYCLING FACILITY

3.1 PROCESS DESCRIPTION

The materials recycling facility (MRF) will be located in a separate section of the waste acceptance hall from the waste to energy plant. This area will be maintained under negative air pressure to prevent any odours that may arise being released to atmosphere thus preventing a public nuisance. This air will be used as combustion air in the incineration process. It is expected that the facility will process 20,000 tonnes of dry recyclable waste material per annum.

The typical types of recyclable wastes arising from the industrial/commercial sector include paper, cardboard, plastic, wood and metals.

Upon arrival at the facility the dry recyclable waste will be discharged from the trucks into a storage area, which is 5m below the level of the waste acceptance hall. The storage area will be capable of holding 2,200 m^3 of waste material. This capacity is sufficient to allow for a maintenance period of seven days when waste would have to be stored. Initial separation of large items, such as bulky pieces of wood or metal, will take place here. Grab operators will identify these items and separate them from the rest of the waste material. These items may then be shredded to reduce their size or may be put directly into containers for transport to a recycling facility.

The main volume of the waste will then be loaded into a hopper using vehicular loading. The material will then be conveyed into a rotating screen, which will be designed to grade the waste stream into size fractions. Using such a system will make the manual sorting of the waste easier.

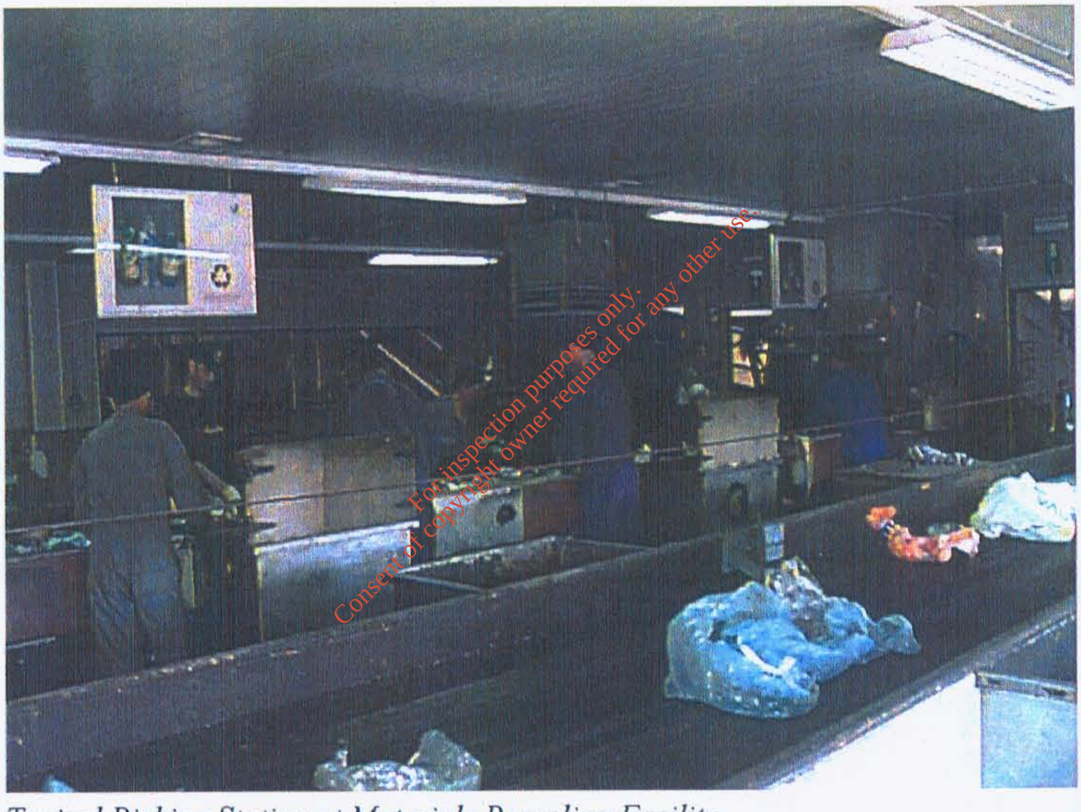
The waste will now be separated into three separate fractions namely;

- Particles (< 25 mm) not suitable for recycling from the material stream. These particles commonly contain sand, minerals, some metals and other small fractions. This fraction will be conveyed to the storage bunker of the incinerator plant for energy recovery.
- Particles (25 – 300 mm) containing paper, cardboard, plastic, wood and metals. These particles are considered too small to be sorted manually with reasonable efficiency. This fraction will pass through a magnetic separator to remove metals. The residual material from this fraction will also be processed for energy recovery.
- Particles (> 300 mm) containing all the above listed materials are easy to remove manually. This fraction will consist of the bulk of the materials to be recovered.

The large fraction (>300mm) i.e. paper, plastic and cardboard leaving the rotating screen will then be conveyed to an enclosed picking station, where manual removal of each material will be carried out. A photograph of a picking station at a similar Indaver facility is shown below. The recovered materials will then be dropped through a chute and be stored in bunkers.

Magnetic separation of metals will be carried out on this stream after the manual sorting is complete. Metals may be baled or loaded directly into containers for recycling at an appropriately off site licensed facility. As this waste stream will arise from the industrial/ commercial sector, aluminium beverage cans are not anticipated to be part of the incoming material. However, should this material become a significant portion of the waste stream the installation of automatic eddy-current techniques will be employed at the facility to remove non-ferrous metal.

The recovered materials will be either baled or placed in containers. Paper, cardboard and plastics are expected to be baled. The decision on whether a material requires baling will depend primarily on its weight and the requirement of the receiving customer. Typical bale sizes used in this industry are 1 m^3 in volume. All recovered materials will be transported to appropriate licensed facilities for recycling.



Typical Picking Station at Materials Recycling Facility

The remaining waste that is not suitable for recycling will continue on the conveyor and will be transferred to the waste bunker for incineration. The total residual material usually represents approximately 20% of the total incoming material weight. This is based on Indaver's experience of operating a similar facility.

It is intended that one sorting line will be installed initially. After observation of the composition and volumes of the waste stream and prior to reaching full capacity, the second sorting line will be installed. The second line, and means of separating waste between the two lines, will then be optimised to sort the type of waste arriving.

The materials recycling facility will operate on a single shift system. A process flow diagram for the facility is included overleaf. A schematic of the materials recycling facility is also provided in Attachment D2.4. The layout of the main plant, including the materials recycling facility, is shown in Attachment D2.5.

3.2 PROCESS CONTROL

Due to the high degree of manual handling, this process will be controlled at local level throughout. The rate of feed into the process will be governed by the operators of the loading machinery and will be overseen by a process supervisor.

An important aspect to the control of the system will be the installation of emergency stop switches that will be located in close proximity to process operators so that they can be easily accessed. There will be two types of stop switch available to operators:

- Emergency Stop Switches will be located throughout the process and will have the capability to stop all items of plant associated with the process including conveyors, balers and compactors. These will be used in emergency situations only. Resetting of such switches will only be allowed by the Process Supervisor when he/she is satisfied that the emergency situation has been cleared.
- Conveyor Stop Switches will be located within the manual sorting area. The purpose of these switches will be to temporarily stop a conveyor to allow removal of large volumes of material from the conveyor line. These switches will not stop any other items of plant associated with the process. The conveyor will automatically restart following an audible alarm and a period of approximately 20 seconds.

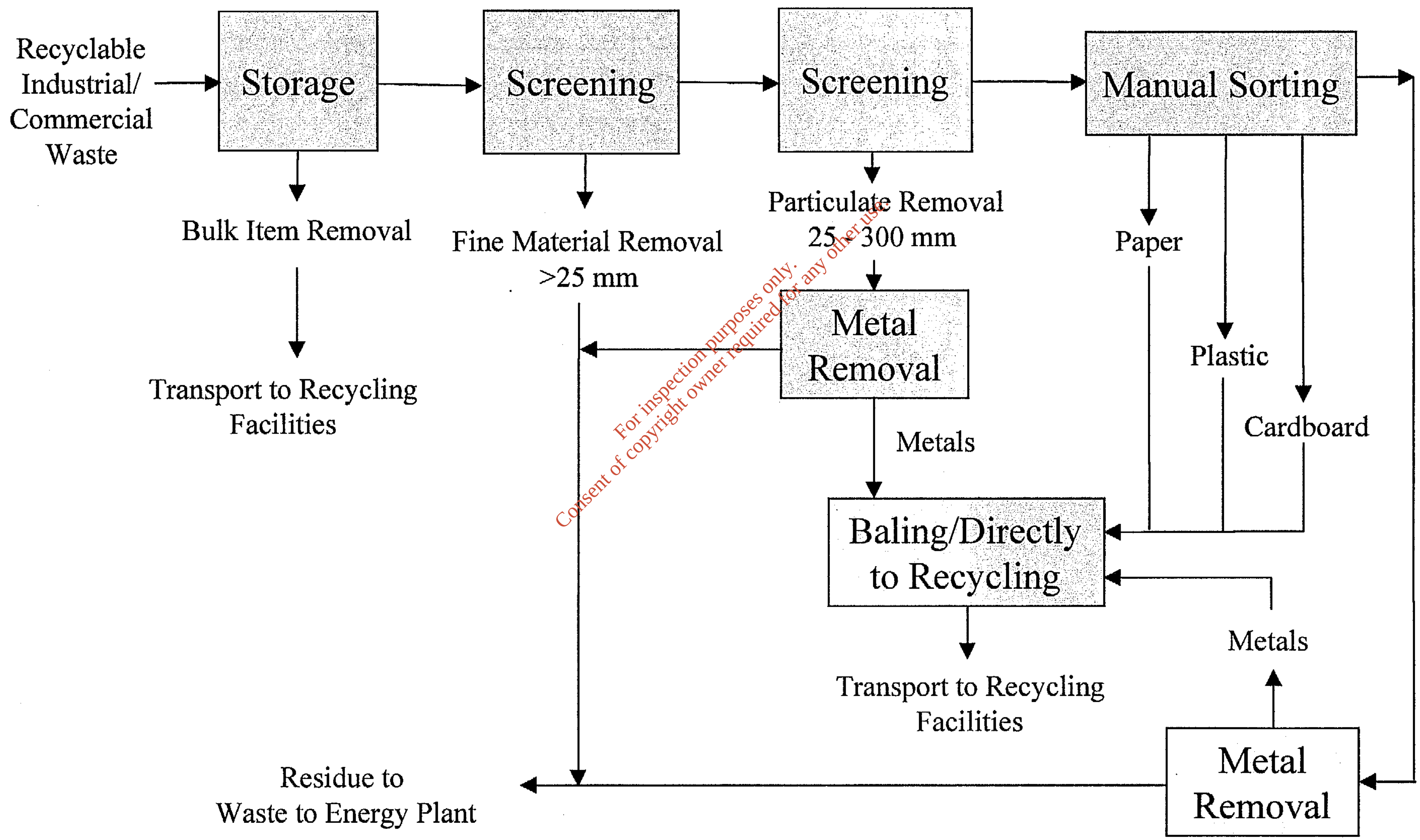
3.3 EMISSIONS

As the sorting plant will accept only dry waste and will be operated under negative pressure there will be no potential odours. As the area will be within an enclosed building there will be no potential for windblown waste. The machinery in the sorting plant (conveyors and bailers) will produce noise. However, as these sources will be located within the building, they will not contribute significantly to external noise levels. Ear protection will be provided for all personnel operating in areas of high noise.

3.4 INPUTS AND OUTPUTS

The plant will have a nominal input capacity of up to 20,000 tonnes of waste per annum. Depending on the nature and composition of the waste accepted it is expected that some 16,000 tonnes per annum will be sorted for recycling with some 4,000 tonnes per annum of residual waste remaining for incineration.

MATERIALS RECYCLING FACILITY PROCESS FLOW DIAGRAM



4. WASTE TO ENERGY PLANT

4.1 INTRODUCTION

The proposed plant is based on conventional grate incineration technology. This technology is proven and reliable and has been widely used in many countries world-wide. The facility will have a nominal capacity of 150,000 tonnes/annum. The facility will have a potential maximum design capacity of 180,000 tonnes/annum, depending on the calorific value of the waste and operating efficiency of the plant.

In summary, the incineration process will involve the solid waste material firstly being tipped into a bunker prior to being fed into the furnace. In the furnace the waste will be incinerated, producing heat, ash and combustion gases. The flue gases will then be cooled, filtered, passed through scrubbers and reheated prior to discharge via the stack. The waste liquids produced by the scrubbers will be used in the cooling process and a solid waste produced, rather than an aqueous liquid, thereby eliminating any process effluent from the facility. The heat produced by the combustion of the waste will be used to generate steam, which will be used to drive a steam turbine and electrical generator. The plant will produce approximately 14MW of electricity, approximately 11MW of which will be exported to the ESB distribution network, which is equivalent to supplying electricity to approximately 16,000 homes.

The incineration process will consist of a number of individual process steps, as follows:

1. Waste Storage and Handling
2. Furnace
3. Boiler
4. Energy Recovery
5. Flue Gas Cooling
6. Activated Carbon/Lime Mixture Injection and Baghouse Filter
7. Wet Flue Gas Cleaning
8. Tail End Flue Gas Cleaning
9. Plume Abatement and Discharge (Stack)
10. Ash Handling

Each of these process steps are described in Sections 4.2 to 4.11 under the following headings:

- Process Description
- Process Control
- Emissions

- Inputs and Outputs
- Abnormal Situations

Steps 5 to 9 above involve the treatment or abatement of the combustion gases produced during the combustion of waste and therefore are considered treatment/abatement systems. The boiler process step, Step 3, also involves abatement of the oxides of nitrogen, which are by-products of the incineration process.

There will be two lines within the waste to energy plant, each of which will incorporate a furnace, boiler, flue gas cooling system and Activated Carbon/Lime Mixture injection and baghouse filter system. This is to facilitate the maintenance and overhaul of any of these systems without interrupting the plant's capacity to accept waste. The wet scrubbing and the tail end flue gas cleaning will be combined for both lines.

An overall process flow diagram for the incineration process in included overleaf. A schematic of the waste to energy plant process is also provided in Attachment D2.6. The layout of the main plant, including the waste to energy plant, is shown in Attachment D2.5.

4.2 WASTE STORAGE AND HANDLING

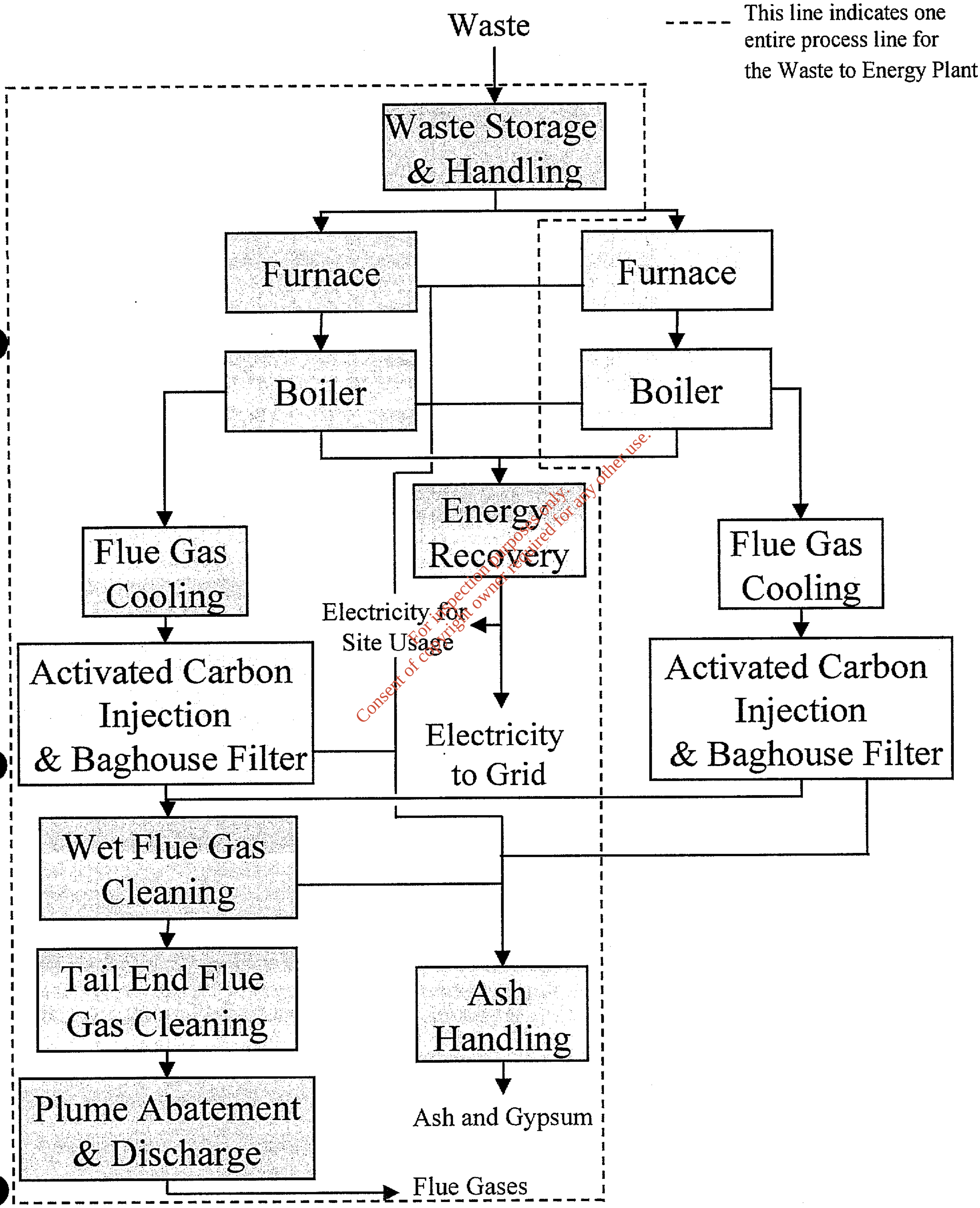
4.2.1 Process Description

The facilities for the waste handling and storage operation will include a waste reception hall, a crane in the reception hall, a 12,000 m^3 waste bunker, semi-automatic grab cranes and waste hoppers feeding the furnace.

The covered waste delivery trucks will drive into the supervised waste acceptance hall on arrival. Each truck will then discharge the waste into the bunker through one of five waste discharge chutes. A photograph of a truck unloading in a reception hall at a similar Indaver facility is shown overleaf. Any bulky waste will be shredded to reduce its size prior to discharge into the bunker. This shredder will be located in the waste acceptance hall and will be used for both the materials recycling facility and the waste to energy plant. A crane will be located in the acceptance hall for the purpose of removing material from the bunker should the need arise. The waste acceptance hall will be maintained under negative pressure, allowing air to be continually drawn through the doors of the hall to be used as an air supply for the furnace. This will prevent odours from the waste escaping from the building.

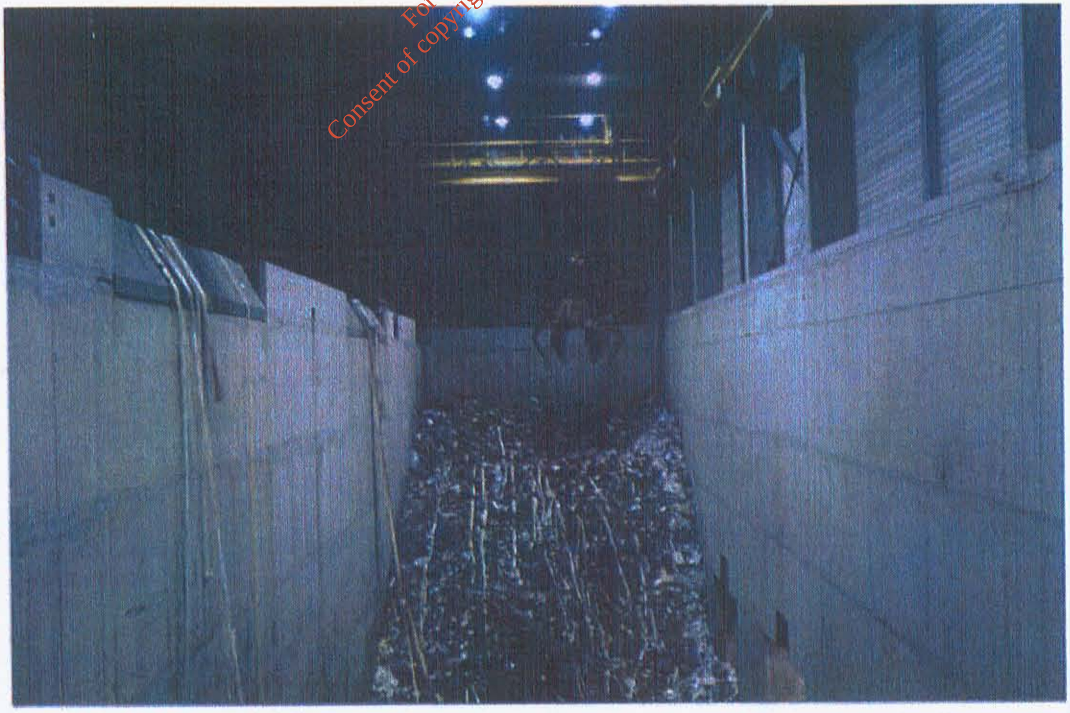
The bunker capacity of 12,000 m^3 has been designed to allow the plant to accept waste during periods of shut down for maintenance and therefore will be able to continue operating over prolonged periods (e.g. long weekends) without deliveries. The bunker has a depth of 5 metres beneath ground level (10m below floor level of the waste acceptance hall). In order for the bunker to be filled to it's 12,000 m^3 capacity, two of the discharge chutes would need to be closed. With all the discharge chutes open, the capacity of the bunker is some 9,000 m^3. Mixed waste (non-hazardous municipal/commercial/industrial) of the type expected at the plant typically has a density of 0.3-0.4 tonnes/m^3, giving an approximate bunker capacity of up to 4,800 tonnes, or equivalent to 10 days operation of the plant.

WASTE TO ENERGY PLANT OVERALL PROCESS FLOW DIAGRAM



Truck unloading into Waste Bunker

Operators will use travelling grab cranes positioned over the bunker to blend the waste in the pit, so that despite the variety within the waste loads delivered (i.e. non-hazardous municipal/commercial/industrial) the feed to the furnace will be relatively uniform. A photograph of a typical waste bunker at a similar Indaver facility is shown overleaf. The average retention time of the waste in the bunker will be three days.



Grab Crane over Waste Bunker

A process flow diagram for the waste storage and handling unit operation is included overleaf.

4.2.2 Process Control

The discharge and mixing of waste in the bunker will be controlled manually. The bunker will be continuously monitored by the operator of the grab crane, who will ensure that there is adequate mixing of waste.

4.2.3 Emissions

Potential emissions from the waste bunker will include odours and windblown waste. To prevent the egress of odours the waste acceptance hall will be maintained under negative pressure, (i.e. air will be drawn in through any opening rather than escaping out). This will be effected by drawing some of the air for combustion from the waste bunker. Therefore as waste will be stored in a contained area and under negative pressure, this will ensure that no odours will emanate from the building.

The waste acceptance hall, being an enclosed area, will also prevent any windborne litter from leaving the facility. All vehicles transporting waste to the site will be required to be covered. "Litter patrols" will be operated by Indaver staff within the facility, around the site and on local approach roads to ensure that litter will not cause a problem.

If for any reason both lines of the waste to energy plant are shut down, typically for 1or 2 days per year, the fans will be kept on-line for as long as possible to maintain the bunker under negative pressure. Any odours will then be discharged via the 40m stack. During these brief periods the waste in the bunker may be sprayed with odour suppressing chemicals to minimise odours. The exact details of the chemicals that may be used to suppress odours are not confirmed at this time. Approval will be sought from the Agency prior to use of any such chemicals.

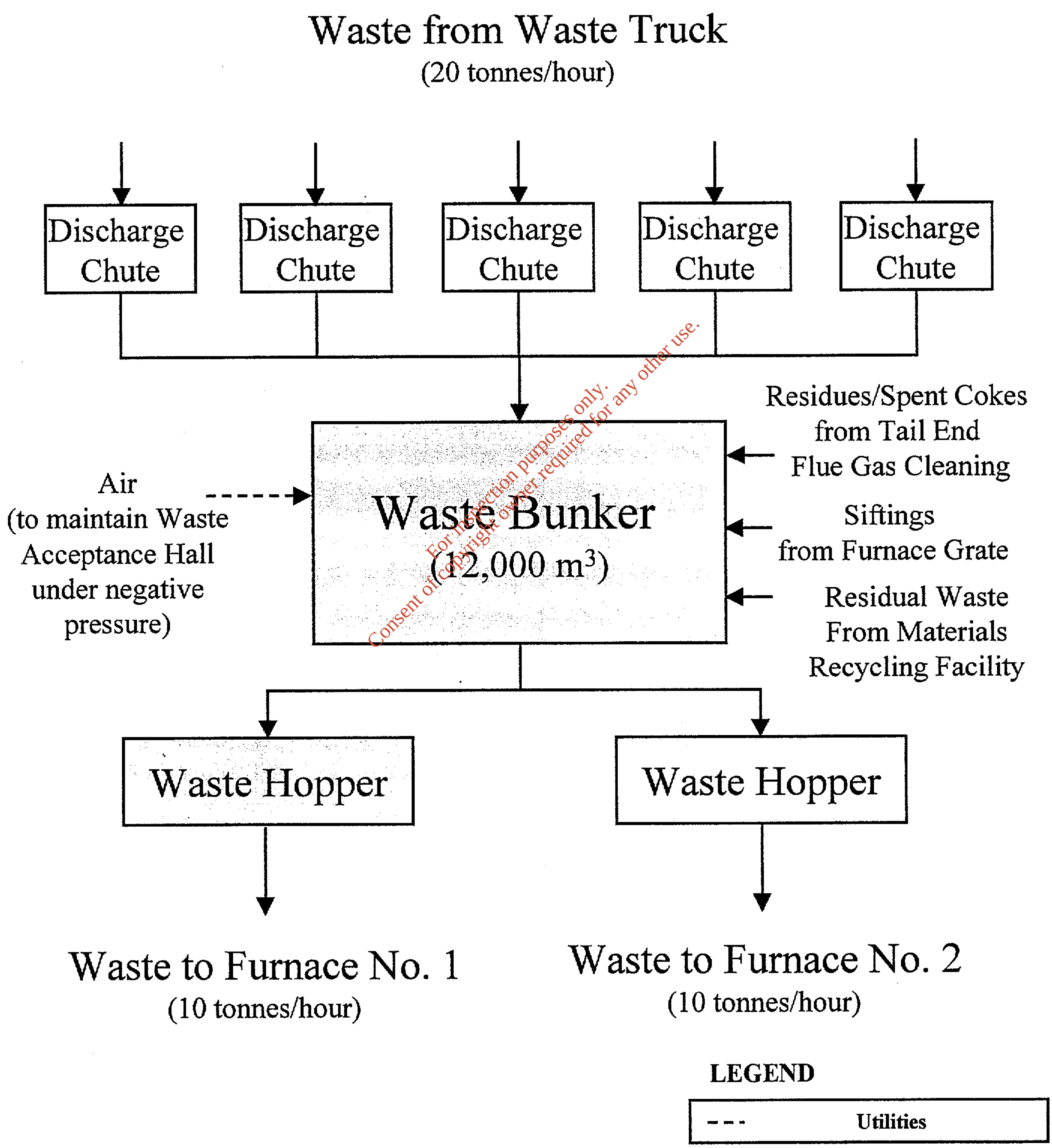
4.2.4 Inputs and Outputs

The waste handling and storage system has been designed to cater for an annual plant throughput of 150,000 tonnes, with the potential to process a maximum of 180,000 tonnes/annum if required depending on plant availability and calorific value of the waste.

4.2.5 Abnormal Situations

A fire could occur in the waste bunker, due to localised heating because of decomposition of organic material or as a result of hot ash in the waste leading to isolated fires. Decomposition of waste can raise the temperature of the waste to 75 °C, drying the waste and causing it to smoulder. Incoming ashes from domestic fires wrapped in other waste can retain their heat. When waste in the bunker is moved these ashes could be exposed to air and could start to smoulder.

WASTE STORAGE & HANDLING PROCESS FLOW DIAGRAM



As the waste bunker will be permanently monitored by the grab crane operator, smouldering of waste as described above will be detected at an early stage. The grab crane operator will simply lift the smouldering waste into the hoppers from where it will enter the furnace. This waste will then be covered by placing another layer of waste into the hopper.

Should the grab crane operator fail to detect smouldering waste and it develops into a flame and hence becomes a fire, the smoke detection system will activate an alarm in the control room to alert plant operators to the situation. The fire will then be put out using either one of two water cannons located above the bunker. The grab crane operators will be trained in fire fighting techniques. The capacity of each water cannon will be approximately 300 m^3/hr. The water used to extinguish a fire will be absorbed into the waste. If the volume of water used to extinguish the fire is large and cannot be absorbed, the concrete construction of the bunker will provide water retention until it is pumped out and disposed of at a licensed treatment facility.

A lower explosive limit (LEL) detector will also be installed in the waste bunker to monitor hydrocarbon levels and will provide an alarm to alert plant operators in the event of levels deviating from set limits. The ID fan will then ramp up to increase air flow through the bunker, thereby removing any possibility of explosive atmospheric conditions.

4.3 FURNACE

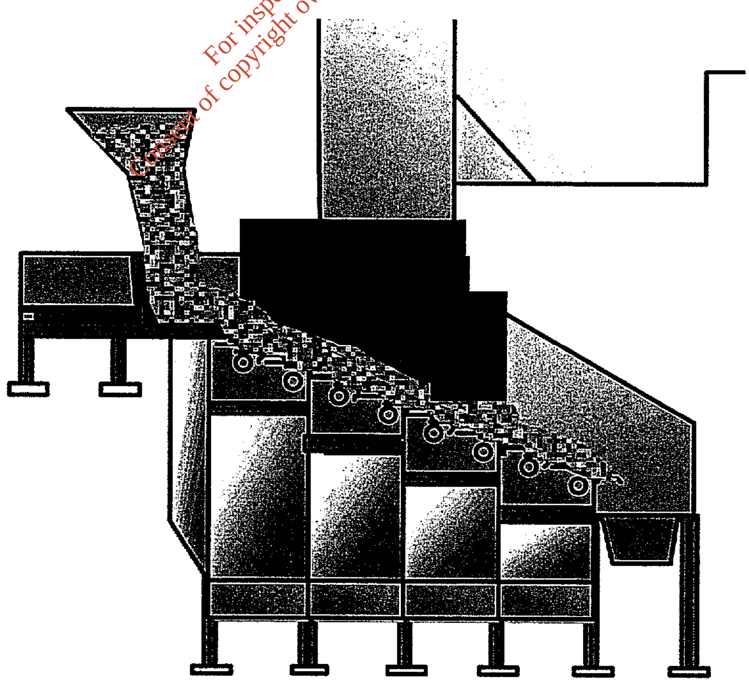
4.3.1 Process Description

The furnace will be the "Grate" type and will be fitted with steel tiles that will gradually push the waste forward on the grate causing a slow and continuous movement. The tiles are designed to allow air to pass up through the waste to ensure complete combustion. The waste will be incinerated in the furnace and the hot combustion gases produced will be used to generate steam in the boiler.

The grab cranes will be used for feeding the blended waste material from the bunker pit into the furnace hoppers (one hopper per furnace). The discharge of waste from the crane into the hoppers is automatic, avoiding any spillages of waste. The grab crane is designed to fit into a hopper and therefore can be used to break any bridges or blockages that may occur in the hopper. Each hopper will contain approximately 50 m^3 of waste at any one time. The waste will then be moved forward from the hopper and into the furnace using a ram mechanism. The feeding hopper and feeding rams will provide the seal between the high temperature furnace and the bunker. The waste itself will act as a plug between the bunker and furnace. The volume of waste moved forward by the ram can be altered. Should the level of waste in the hopper drop to a low level, an alarm will sound in the control room to alert the operator of the grab crane to this fact.

The grate transport mechanism serves to transport the waste slowly from the feed point to the ash discharge. A schematic of a typical grate configuration is shown overleaf. The rate at which the waste will travel through the furnace will be controlled to optimise the combustion. The residence time for waste in the furnace will be approximately one hour. Hoppers will be situated beneath the furnace to collect siftings (small-sized pieces of waste that pass through the grate tiles), which will account for approximately 1% of the input volume. These siftings will be cooled using primary air for the furnace and returned by means of a conveyor system to the bunker.

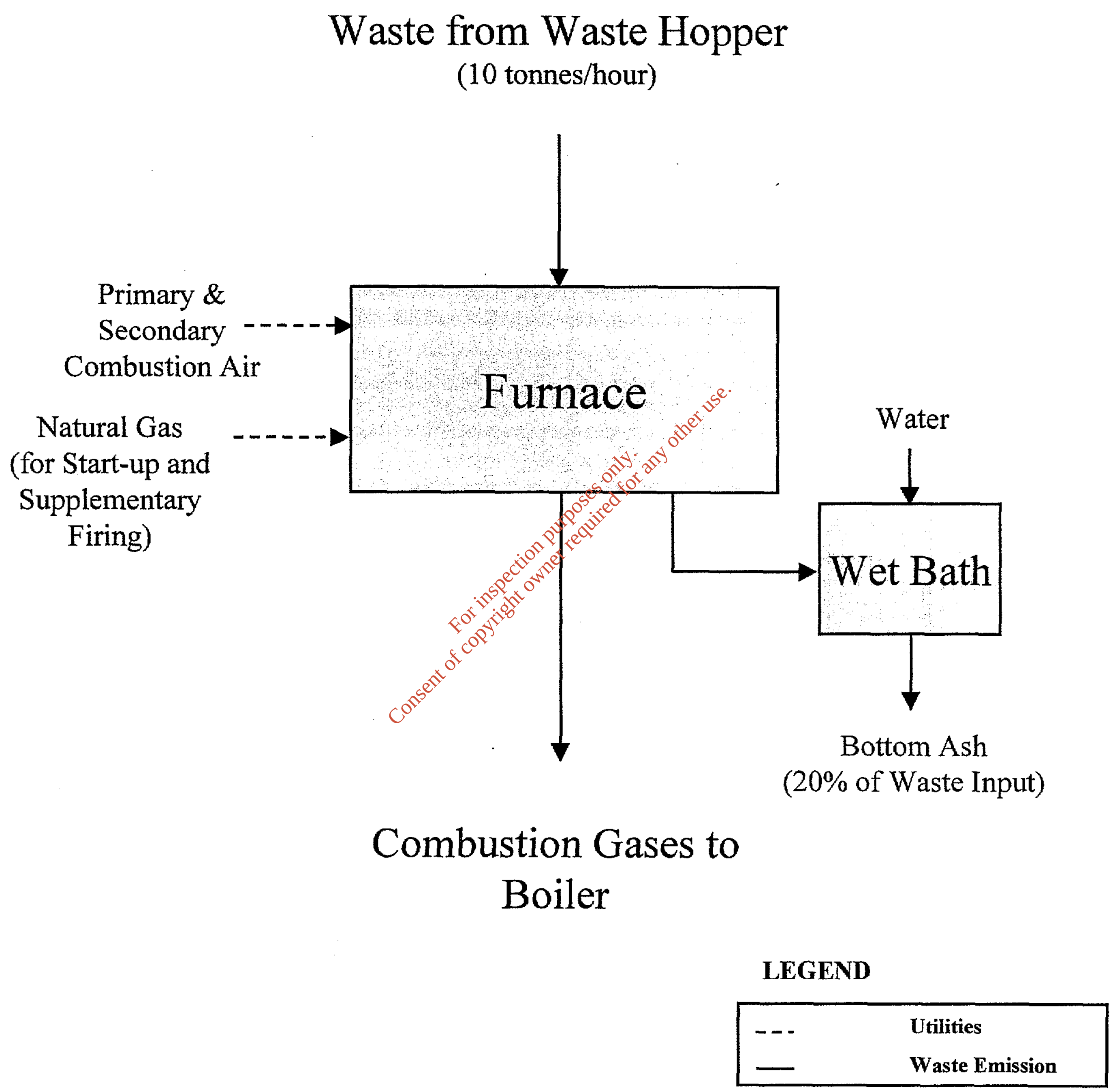
As the waste enters the hot furnace, the material will be heated due to contact with the hot combustion gases and radiated heat from the walls of the incinerator. This initial heat will drive off any moisture from the waste and will take place in the temperature range of 50-100 °C. The moisture content of municipal solid waste (M.S.W.) can vary between 25 and 50%. The next stage in the combustion phase will see the waste undergo a volatilisation stage. Here the combustible gases and vapours are driven off. The volatilisation stage will take place in the temperature range of 200- 750°C with the main release of volatiles between 425 and 550°C. The volatile components of organic material of M.S.W. typically account for 70 to 90%, and are produced in the form of hydrogen, carbon monoxide, methane and ethane. The combustion of volatiles will take place immediately above the surface of the waste and in the combustion chamber above the grate. The volatile gases and vapours released will immediately ignite in the furnace due to the furnace gas temperature of between 750 and 1200 °C. Typical mean residence times of the gases and vapours in the combustion chamber will be 2 to 4 seconds, which compares to typical burnout times for volatile gases of milliseconds. The final section of the grate is the burnout section where the char will be held for sufficient time to ensure complete combustion of the solid matter. The grate will then discharge the resultant ash into a water bath called a "wet bath" to cool the ashes. The ash, known as bottom ash, will represent approximately 20% (dry weight) of the total weight input to the furnace. Metal (approximately 2,100 tonnes/annum) will be recovered from the bottom ash using magnets.



Typical "Hopper and Grate" type Furnace

A process flow diagram for this unit operation is included overleaf.

FURNACE PROCESS FLOW DIAGRAM



The addition of combustion air to the furnace will be controlled to ensure optimum combustion conditions. This air will take the form of primary air, fed from below the grate, and secondary air fed over the grate. The secondary air will be provided to assist in burning and for mixing of the flue gases. This will ensure complete combustion of the volatile gases driven off. Sufficient combustion air will be added to ensure effective combustion of the waste. The induced air movement through the furnace and the waste plug in the hopper will prevent the possibility of "fire-back" in the hopper. Air will also be used as a cooling source for the grate.

4.3.2 Process Control

A number of control parameters will be monitored to optimise the conditions in the furnace as follows:

- Waste feed
- Burnout of waste in the furnace
- Temperature
- Percentage oxygen (% O_2) in the combustion gases

The bunker will be continuously monitored by the operator of the grab crane, who will ensure that adequate waste is fed into the hoppers to feed the furnace and maintain the plug. There will also be low level detectors on the hoppers. The rate of feed into the furnace will be controlled by feeding rams to maintain constant steam production at the desired temperature and pressure.

The burnout of waste in the furnace will be controlled by visual inspection of the flame front via cameras and monitors, and by automatic monitoring of the temperature in the last section of the furnace. The temperature may be controlled by either increasing or decreasing the feed of waste to the furnace. The rate of feed through the furnace must also be correct to ensure that the percentage of total organic carbon content in the ash is less than 3% in accordance with the EU Directive on Waste Incineration (2000/76/EC).

The % O_2, percentage carbon monoxide (% CO) and the temperature in the furnace are all inter-related to an extent, and will be dependent on the rate at which combustion air is supplied to the furnace. The CO levels will be used to indicate any level of incomplete combustion in the furnace. By monitoring these parameters, the combustion air input will be optimised to ensure efficient and effective combustion.

4.3.3 Emissions

The only emission from the furnace itself will be bottom ash. Approximately 20% (on the basis of dry weight) or 30,000 tonnes/annum of bottom ash will be produced based on a nominal throughput of 150,000 tonnes/annum.

4.3.4 Inputs and Outputs

The main inputs into the furnace will be waste and combustion air. Each furnace will have a nominal design capacity of 10 tonnes per hour, but could be operated effectively over a range from 6 to 12 tonnes per hour.

The outputs from the furnace will include combustion gases and bottom ash, as described above. At the nominal design load of 10 tonnes/hour, each furnace will produce about 63,000 Nm^3/hr of combustion gases (dry gas, 11% O_2).

4.3.5 Abnormal Situations

The furnace will normally be maintained under negative pressure. There are a number of reasons that there might be an excessive air pressure in the furnace. One reason would be a blockage downstream of the furnace while another would be the sudden increase in the calorific value of the waste. Pressure sensors in the furnace will detect the high pressure. This will result in increasing the speed of the ID fan and thus reducing the pressure in the furnace. If the fan reaches its full capacity without a corresponding drop in pressure in the furnace, the plant will automatically initiate an emergency shutdown sequence, which is described in detail in Section 4.12.3.

Another abnormal situation that could occur in the furnace would be due to the presence of a large gas cylinder or pressurised object in the waste feed to the furnace, which could cause an explosion, which might result in refractory brick damage. The furnace will be designed to withstand such incidents and continuous monitoring of the condition of the tiles will be provided. Monitoring of the interior of the furnace will be carried out from the control room using CCTV cameras.

There will be a number of interlocks on the furnace, which will initiate a plant shutdown:

- If the low level alarm on the hopper to the furnace is activated and waste is not added to the hopper within a specified time period
- If the flame detector on one of the burners detects that the pilot flame or main flame fails to start or stops, an alarm is raised if the flame has not ignited or re-ignited within a specified time period.
- If excessive CO levels occur in the furnace, this could cause an explosion. An interlock will be provided to ensure that oxygen levels in the furnace are greater than 6% which will reduce CO levels and eliminate the risk of explosion.

4.4 BOILER

4.4.1 Process Description

The purpose of the waste heat boiler is to use the heat of the flue gases coming out of the furnace to generate steam at a pressure of 41 bar absolute and a temperature of 400 °C.

The boiler will consist of three empty passes and a final pass with water tube banks. The large empty first pass, which is directly above the furnace, will allow sufficient time at high temperature to complete combustion. The lower part of the first pass will be refractory lined with silicon carbide or aluminium oxide to avoid corrosion and to provide thermal insulation in the area of the grate. The refractory lined part of the first pass of the boiler will be designed to ensure that the specified minimum residence time of 2 seconds at 850 °C after the last air/fuel injection is maintained. This will ensure compliance with the EU Directive on Incineration of Waste (2000/76/EC). The flue gases will leave this section of the boiler at no less than 800 °C, although the temperature just above the grate can reach 1,200 °C. This temperature ensures the destruction of any dioxins in the incoming waste.

Natural gas will be used to bring the combustion gases in the boiler up to the specified temperature of 850 °C prior to addition of the waste feed to the furnace.

Due to the greater cross-sectional area in this large empty first pass, the velocity of the gases will reduce and some of the ash entrained in the combustion gases will fall out. This ash, referred to as boiler ash, will be collected in hoppers beneath the boiler and removed by conveyor and collected into the boiler ash silo.

The empty passes will be constructed from membrane walls (water-lined walls) and will allow heat transfer from flue gases to the evaporating water in the membrane walls mainly by radiation. This heat transfer process will reduce the flue gas temperature to below 650 °C. There will be no water tube banks in these first three passes of the boiler due to the sticky nature of the fly ash which at these high temperatures would deposit on and foul the surface causing the tube banks to be become blocked. Ensuring that the flue gas temperature is below 650 °C prior to the final pass of the boiler (water tube banks) will also reduce the erosion/corrosion of these banks.

Either ammonia or urea will be injected into the first pass of the boiler (urea would break down to form ammonia and water). The ammonia will react with the oxides of nitrogen (NO_x) produced in the furnace to form nitrogen and water. The reactions that will take place are as follows:

$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$

$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$

$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$

The injection of ammonia or urea into the first pass of the boiler will ensure that NO_x emissions from the waste to energy plant will operate below the EU limit of 200 mg/m^3 for NO_2 (as set down in the EU Directive on Waste Incineration (2000/76/EC)), and indeed it is expected that emissions from the plant will be approximately 150mg/m^3. For further details on ammonia or urea, see Table 1.10 in Attachment E5.2.

The final pass of the boiler will include banks of water tubes. The outer wall will be constructed as a membrane wall in the hotter part and a steel plate for the colder part. Heat in the final pass will be mainly transferred by convection. The tube banks will consist of - from hot to cold:

- Protective evaporator
- Two or more superheaters
- One or more economisers

The protective evaporator will guarantee that the flue gas temperature is below 650 °C before entering the superheaters. In the evaporator tubes water will be converted to steam. In the superheaters the saturated steam (45 bar, 267 °C) will be further heated (41 bar, 400 °C) in two or more steps. In the first superheater bank after the protective evaporator, steam will flow co-currently with the flue gases, while in the other superheater bank steam will flow counter-currently with the flue gases. This arrangement will ensure that maximum heat transfer will take place without the metal temperature of the tubes exceeding a temperature whereby corrosion by chlorine would become excessive.

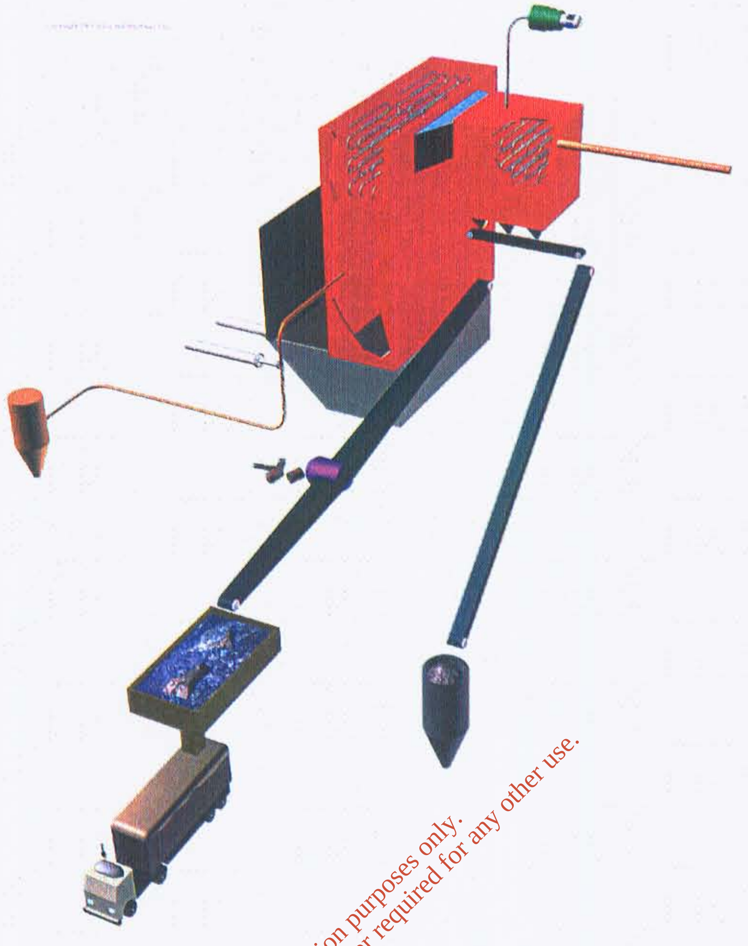
The lower end (exit end) of the final pass will contain the economiser bundles, which will cool the flue gases to approximately 230 °C before leaving the boiler.

During the cooling in these latter stages of the boiler, dioxins may be partially reformed particularly over the temperature range 400ºC to 200ºC. In order to minimise the formation of dioxins the following design measures will be implemented:

- Regular cleaning of heat transfer surfaces. The formation of dioxins is catalysed (speeded up) by the presence of metals, and copper in particular. Regular cleaning of surfaces will reduce the amount of copper present to act as a catalyst. The surfaces will be kept clean using a hammering and vibration mechanism which will cause any particles to fall from the walls of the boiler and will be collected as part of the boiler ash.
- Rapid cooling over the range 400ºC to 200ºC. This will be effected by increasing the velocity of the combustion gases through the narrower section of the boiler where this cooling occurs. This increase in velocity will accelerate heat transfer and cool the combustion gases more rapidly. The total time that the gases will spend in the boiler is approximately 30 seconds.

A schematic of the boiler is included overleaf. This sketch shows the following:

- Boiler and water tubes
- Turbo-alternator (coloured green)
- Ammonia solution/urea injection
- Bottom ash with metal recovery and removal by covered truck from the ash bunker
- Boiler ash silo



Boiler Schematic

Water/ Steam Circuit

Boiler feed-water will enter the lower end of the economiser and pass through it in counter-current flow before being fed to the steam drum mounted on the boiler roof which will operate at the boiler operating pressure (a maximum of 45 bar).

Demineralised water will be used as boiler feedwater. The purpose of the boiler feed-water tank is to provide a pressurised feedwater buffer. The boiler feedwater tank will be equipped with a heating system to heat condensate to about 140 °C at 3.7 bar pressure. Anti-corrosion chemicals will be dosed to the boiler feedwater either via the boiler feedwater tank or directly into the line to prevent fouling occurring in the water tubes. For further details on the boiler feedwater additives, see Table 1.10 in Attachment E5.2. As solubility is lower at higher temperature the dissolved gases will be removed in a de-aerator, which will operate slightly above atmospheric pressure. From the de-aerator, the boiler feedwater will be pumped via the economiser into the steam drum.

The water will be circulated from the steam drum through the evaporator panels and tube banks back to the steam drum by natural circulation (thermosiphon).

The steam leaving the steam drum will pass through the superheaters. A spray injection cooler will be located between the superheater stages for controlling the steam temperature.

In order to maintain the high level of purity required for boiler water, a small quantity of water will be constantly purged from the system and replaced with fresh make-up. This purge is often referred to as boiler blowdown. This blowdown will be recycled for use in the evaporating spray tower.

A process flow diagram for this unit operation is included overleaf.

4.4.2 Process Control

Temperature control will be critical in the boiler to ensure that a minimum residence time of 2 seconds at 850 °C is achieved in the first pass of the boiler. Waste will not be added to the furnace until the temperature in the boiler has reached the specified temperature of 850 °C.

The concentration of NO_x in the combustion gases will be continuously monitored and the rate of ammonia/urea injection into the first pass of the boiler will be set to ensure that the NOx concentration is well below the EU limits discussed above.

4.4.3 Emissions

The only emission from the boiler will be boiler ash. Approximately 1-2% (on the basis of dry weight) or 1,500 to 3,000 tonnes/annum of boiler ash will be produced based on a nominal throughput of 150,000 tonnes/annum.

4.4.4 Inputs and Outputs

The inputs into the boiler will be hot combustion gases, cold boiler feedwater along with boiler feedwater additives. Urea or ammonia will also be injected into the first pass of the boiler to control NO_x emissions.

Outputs will include cooler combustion gases, superheated steam to the turbine. Other outputs will include boiler ash described above and boiler blowdown which will be recycled to the evaporating tower.

4.4.5 Abnormal Situations

As with the furnace, the boiler passes will normally be maintained under negative pressure. The reasons for excessive pressure in the boiler are the same as for the furnace, as described in Section 4.3.5, as are the controls.

Another abnormal situation that could occur in the boiler would be a boiler tube leak which would result in boiler feedwater leaking into the flue gases. In the event of a major boiler tube leak, an emergency shutdown will occur, which is described in detail in Section 4.12.3. A boiler tube leak will be detected by a significant increase in the water vapour content of the flue gases and the level in the demineralisation tank dropping faster than expected. Use of anti-corrosion chemicals in the boiler feedwater and preventative maintenance of the boiler tubes should reduce the occurrence of boiler tube leaks.

BOILER PROCESS FLOW DIAGRAM