Energy from Waste, Combined Heat and Power Facility

North Yard, Devonport

Environmental Permit Application (Application EPR/WP3833FT/A001)

Operational Techniques

June 2011

Prepared for

Revision Schedule

Operational Techniques
June 2011

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01	Feb 2011	Initial Draft	**Andrew Oliver** Consultant	**Angela Graham** Principal	**Mike Nutting** Associate
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Table of Contents

1 Report Context

Scott Wilson Ltd has been commissioned by MVV Environment Devonport Ltd (MVV hereafter) to prepare an application for an environmental permit for an Energy from Waste, Combined Heat and Power Facility located at Devonport Dockyard, Plymouth (Devonport EfW/CHP hereafter).

Within the Site, as defined in planning terms, and the Installation, as defined in permitting terms, the proposed facility will comprise:

- Tipping Hall;
- Waste Bunker Hall with Waste Handling Cranes;
- Bale Store/Baling System;
- Turbine Hall with Steam Turbine Generator;
- Boiler House with Grate, Boiler and Ancillary Systems;
- Flue Gas Cleaning System and Chimney;
- Air Cooled Condensers;
- Water Treatment Plant;
- Bottom Ash Handling System.
- Administration Block; and
- Workshop and Stores

This report has been prepared to support an application for an environmental permit and details the technical operations proposed for the site. The report should be read in conjunction with the other supporting application reports and risk assessments.

2 Introduction

2.1 Structure of Report

This section of the application provides an overview of the in-process controls that are proposed for the installation in line with SGN 5.01 *"Guidance for the Incineration of Waste and Fuel Manufactured From or Including Waste* (Sections 2.1, 2.5 and 2.6)".

The report includes information pertaining to:

- Engineering and infrastructure considerations;
- Waste acceptance management, including the provision of appropriate measurement equipment and waste acceptance procedures;
- Waste storage and baling processes;
- Combustion processes including associated steam generation, electricity production and pollution control systems; and
- Arrangements for the management of treatment residues and recyclable and reusable products.

2.2 Overview of Devonport EfW/CHP Facility

2.2.1 Background

Through a competitive tendering process, MVV Environment Devonport Limited (MVV) has been awarded the South West Devon Waste Partnership's (SWDWP) residual waste treatment contract. The SWDWP is a collaboration that has been established between Plymouth City Council, Torbay Council and Devon County Council to provide a long term solution to deal with waste from the southwest Devon area which is left over after re-use, recycling and composting.

MVV's proposal is to construct and operate an Energy from Waste (EfW) facility, incorporating Combined Heat and Power (CHP) technology, on land currently situated in the north east of Her Majesty's Naval Base (HMNB) Devonport, Plymouth. This EfW CHP facility will, depending on the composition of the waste and therefore its energy content, have capacity to process up to 265,000 tonnes per year of waste although it is expected that 245,000 tonnes per year will be processed. The waste will be combusted and the heat will be used to generate steam. The steam will drive a steam turbine and generate renewable electricity for use at the facility, to supply Devonport Dockyard, and for export to the National Grid. Steam will also be extracted from the turbine and fed into the Devonport Dockyard steam network to be used for space heating.

2.2.2 Technology Choice

MVV have chosen to provide an EfW facility, which will be operated as a combined heat and power (CHP) plant, as it is considered that this offers the best approach in respect of managing residual waste streams with the added benefit of generating energy in the form of electricity and heat.

2.2.3 Purpose of the Facility

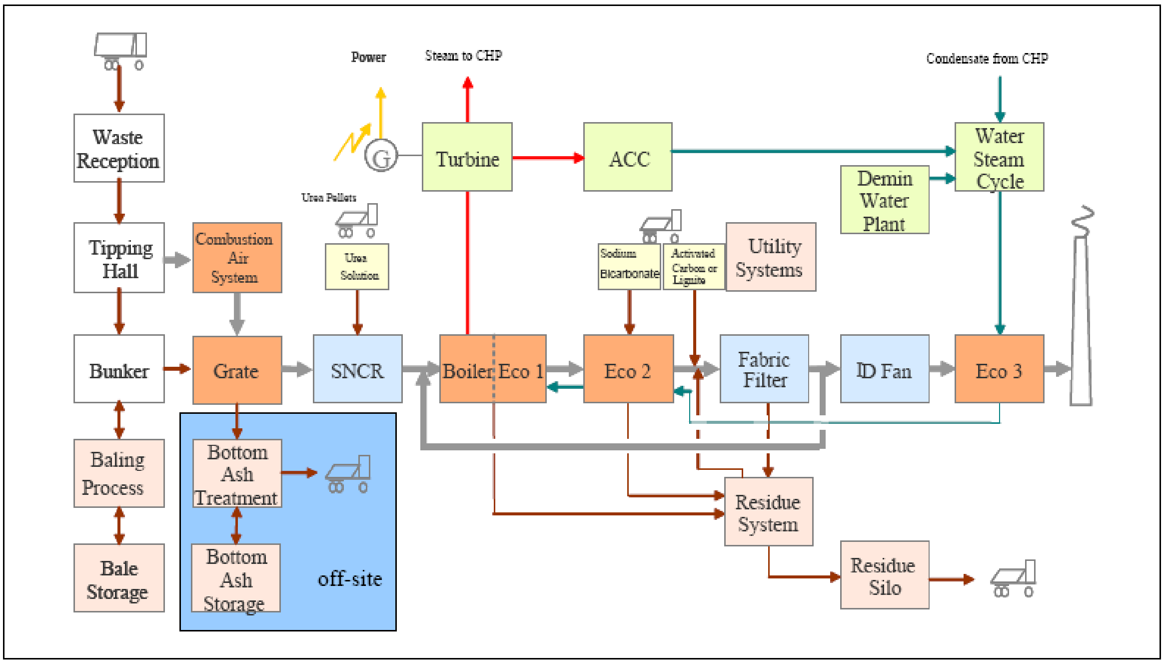
The proposed EfW/CHP facility is designed to manage residual municipal waste streams ('black bag rubbish') and commercial and industrial waste streams of a similar nature that currently go to landfill. The facility, which will create 33 full time equivalent operational posts, uses:

- A mass burn combustion process that enables blending of the incoming wastes to produce a consistent waste fuel feed to the furnace;
- The exhaust gases from the combustion processes to generate electricity and heat via a steam turbine, each of which will be used to operate the process, with the excess being exported ; and will
- Generate further recyclable and reusable materials, including metals and bottom ash.

The facility has a maximum operating capacity of 265,000 tonnes of waste per annum, and is designed to provide the South West Devon Waste Partnership with a 97% diversion of residual waste from landfill.

The schematic of the process is shown in Figure 2.1 below.

Figure 2.1: Plant Schematic



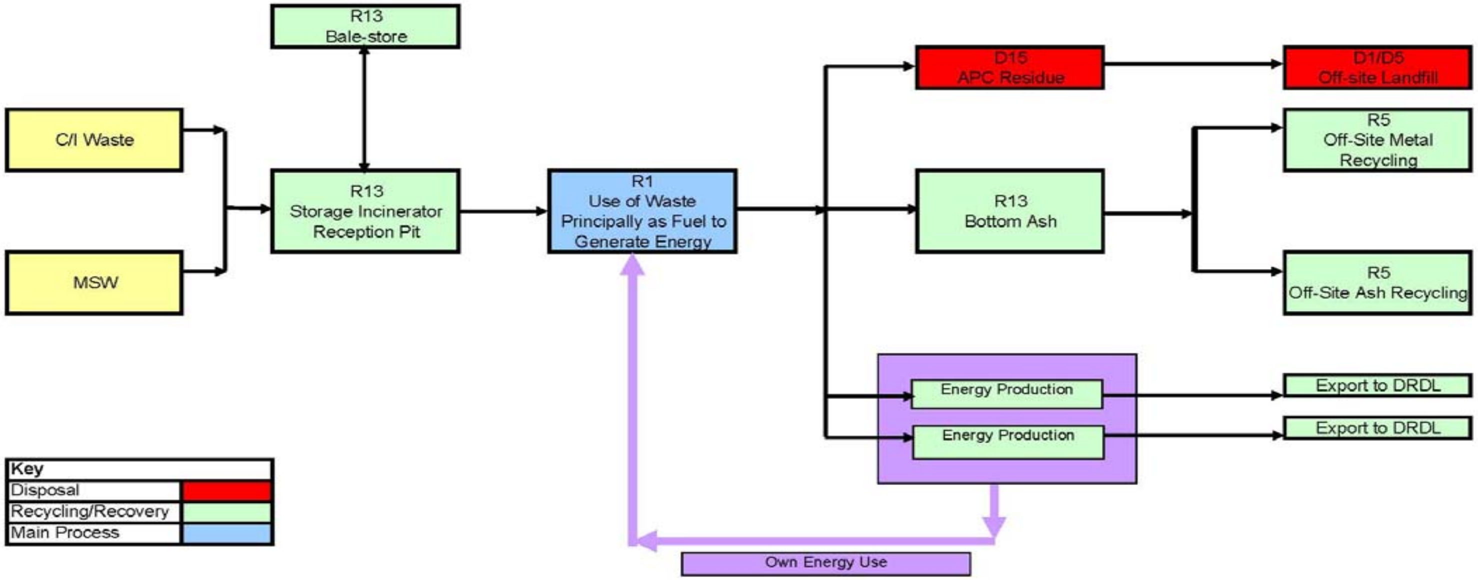
2.2.4 Waste Management Operations

In accordance with Annex II of the Waste Framework Directive, as amended in 1996 (96/350/EC), the waste management operations to be undertaken at the facility are shown in Table 2.1 below and shown on the flowchart in figure 2.2 on the next page.

Table 2.1: Waste Management Operations

Waste Management Operations	
R1	Use of waste principally as a fuel or other means to generate energy
R5	Recycling or recovery of other inorganic materials (e.g. bottom ash)
R13	Storage of metals and bottom ash prior to offsite recovery processes.
D15	Storage of waste prior to transfer to a disposal activity D1 – D14 (e.g. APC residue)

Figure 2.2 Process Flowchart



2.3 Regulatory Context

Waste Management

The main regulations governing waste management activities at the facility are the *Environmental Permitting Regulations (EPR) 2010*. These regulations provide the structure on which the site will be licensed and operated.

With respect to the receipt of waste at the facility and the transfer of residual products off-site for further treatment or disposal, these are governed by related regulations including:

- Environmental Protection (Duty of Care) Regulations 1991 (DOCR);
- Landfill Directive 2000, plus subsequent amendments in 2004 and 2005; and
- Hazardous Waste Regulations 2005.

Water Management

The main regulations governing water management at the facility include:

- Water Resources Act 1991;
- Water Industry Act 1991;
- Groundwater Regulations 1998; and
- The Surface Water Regulations 1997 – various classifications.

These regulations provide the structure on which the site will be regulated for the management of surface waters and wastewaters.

2.4 Demonstration of Best Available Technique

The Environment Agency EPR sector guidance SGN 5.01 *“Guidance for the Incineration of Waste and Fuel Manufactured From or Including Waste”* provides BAT guidance for in-process controls for:

- Waste reception and storage;
- Waste charging;
- Furnace requirements;
- Boiler design; and
- Pollution control.

The proposed technology and control arrangements for the facility will be developed to achieve the standards and requirements of BAT as outlined in the relevant guidance documents (SGN S5.01, Sections 2 and 3).

A statement regarding BAT in relation to the SGN standard has been prepared and is presented in a BAT assessment report (Application Volume 1, Part 13).

3 Site Engineering and Infrastructure

3.1 General Plant Design Principles

MVV is one of the most experienced owners and operators of waste to energy facilities with about 50 years of experience in the design, build and operation of EfW and CHP facilities. The proposed design reflects expert knowledge gained long-term with various types of designs and operational parameters on new and old plants.

MVV have developed a number of special innovative features during their years of expertise and aims to develop one of the most energy efficient facilities of its type in the UK.

The facility layout has been designed to make best use of the site and its topography, whilst taking account of the known geotechnical features of the land, to achieve maximum reuse of excavated material.

Given the proximity of housing the main facility building has been placed in an area of the Site which seeks to minimise the visual impact from the houses in Barne Barton. The main building has been designed with the chimney positioned in the north-east part of the site. The layout is specific to the site and its characteristics and places the administration area facing Barne Barton and the operational side with the more heavily trafficked areas facing the Dockyard.

The facility design takes account as far as practicable the following requirements:

- Statutory requirements;
- Life expectancy;
- Maintenance;
- Health and safety;
- Location of the proposed facility and environment; and
- Sustainability.

These are discussed in more detail in the sections below.

3.2 Site Development and Construction

3.2.1 Sustainable Construction

It is recognised that the proposed facility will be developed on an existing brownfield site, comprising made ground containing a range of materials, plus natural strata. The site therefore presents some opportunities for materials recovery, in accordance with, amongst others, the Institution of Civil Engineers 'Demolition Protocol'.

The overall and detailed design of the facility maintains the considerations of design best practice and the appropriate guidance produced by CABE and DEFRA, and the design will be submitted for review by CABE.

The design will use, where appropriate, materials which will of themselves be fit for purpose in terms of performance and longevity whilst being readily recyclable if and when the facility reaches the end of its operational life. Embodied within this approach is the durability of materials and avoidance of the need for excessive refinishing (for example painting, staining or similar activities) through the operational life of the facility.

The general considerations are:

- The building is orientated so that all public uses (administration buildings, parking, etc) will face the adjacent residential and wildlife areas, whilst the operational activities, tipping hall, condensers, etc. will face the industrial estate /dockyard;
- The position and orientation of the building recognises the relative position and proximity of sensitive receptors to minimise any potential adverse impacts e.g., the positioning of potentially noisy plant as far away from surrounding residential properties as possible, and the orientation of the plant so as to minimise potential noise nuisance;
- Visual impacts and noise impacts, e.g. the positioning of the air-cooled condensing fans;
- The site layout has been developed to minimise the facility's footprint within the site; the approach of applying sustainable design to industrial architecture comes from the understanding that, whilst heavily influenced by its operational requirements, the facility will be designed and constructed to fully embrace sustainable principles as far as is reasonably practical when considering the constraints familiar to process facilities of this nature;
- Materials to be used as part of the development will be sourced to maximise sustainability and the use of re-used or recycled products, where this is compatible with engineering requirements, to include the surfacing of hardstandings and within the fabric of the buildings. Where possible, reference will be made to BRE's Green Guide to specification. For example the main building vertical envelope would be an insulated profiled metal cladding which is rated 'A' (on a scale of A – best to E – worst), and as such represents a high performing construction with very good overall environmental credentials. Hard landscaping, such as parking areas, will be principally constructed from 'A' rated materials, such as asphalt for car parking areas or reinforced concrete over recycled sub-base for heavy-duty parking areas. The perimeter fence will be manufactured from suitable 'A' rated materials such as plastic coated paladin fencing with steel posts. The main building materials will be procured from responsible sources, and the majority of suppliers selected will be those who operate environmental management systems, or who are able to demonstrate their environmental credentials, and responsible sourcing of their materials and products. Insulation used in the development will be formed from materials with relatively low embodied energy, which principally excludes HFC blown extruded polystyrene, and denser forms of glass-wool, as well as mineral-wool, and HFC blown petroleum based products; and
- Further consideration will be given to the internal fit-out of the building in terms of materials choices, for example, wooden desks, which are perceived as being more easily recycled, will be preferred over other less recyclable materials.

3.2.2 Minimising the Use of Virgin Materials

New buildings will be sized appropriately for the facility, ensuring that the layout and design of finished site levels will be completed to achieve a balance between minimising the visual signature of the buildings and establishing the best practical balance of cut and fill.

Where site levels are to be raised, it is intended to re-use as much of the existing excavated site material as possible. In the event that additional materials are required then consideration will be given to the use of imported recycled fill material. Where possible, such material will be derived from local sources to minimise costs and the impact of transport on the environment.

3.2.3 Materials Selection and Procurement

The selection of materials will consider the environmental impact of materials across their entire life cycle, including keeping the use of high-embodied energy materials to a minimum, in order to:

- Ensure the use of harmful or hazardous materials is minimised;
- Where practical, specify materials from renewable and sustainable sources (e.g. timber from FSC or PEFC certificated sustainable forests);
- Where practical, specify the use of recycled materials; and
- Where practical, specify the use of local materials.

3.3 Site Infrastructure

3.3.1 Plant Design Life

The design life of the facility is 30 years, while the life expectancy of the facility as a whole is approximately 40 years. MVV has experience of operating EfW/CHP facilities for periods in excess of individual design lives, for example the Mannheim facility, which has now been operational for more than 45 years.

Individual elements of the facility have shorter lives and will be subject to major overhaul or replacement in accordance with the manufacturer's recommendations. Other aspects, such as the civil engineering elements will have a longer life expectancy.

3.3.2 Main Process Building

The waste treatment process will take place within the Main Building and no waste will be stored or processed outside the building. The maximum height of this building will be 45m and the minimum height 15m. External 'ribs' will project 3m above the height of the main building enclosure. The total length of the building will be 134m and the width will vary between a minimum of 30m and a maximum of 82m.

3.3.3 Building Foundations

An extensive ground investigation has been carried out of the site. The investigation showed made ground on top of alluvium, overlying slate bedrock. Groundwater levels shows tidal influence which has to be taken account of in the construction methodology and the hydrostatic pressures need to be taken account of in the foundation design.

The waste reception bunker will be constructed as a watertight structure by means of diaphragm walling or secant piling, with ground anchors or tension piles to resist floatation forces. The remainder of the foundations will consist of reinforced concrete slabs supported on rotary bored piles founded in the slate bedrock. The foundation design will be further developed during the detailed engineering phase.

3.3.4 Building Finish and Corrosion Protection

An important consideration when designing a building is the need for it to be able to withstand the impacts of elements such as weathering throughout the design life. With the site proposed for the Devonport facility being located adjacent to the coast, this is of even greater importance due to the marine environment and in particular the impact of on the building finishes. All building finishes and material corrosion protection will be specified to achieve the design life without undue levels of life cycle maintenance.

3.3.5 External Roads, Pavements and Kerbing

A design life of 40 years has been specified, subject to periodic maintenance of roadways and heavily used operational areas. Coloured surface finishes will be considered and adopted where appropriate throughout the design to demarcate areas for pedestrian access, traffic flow and parking.

Heavily trafficked operational roadway areas will be constructed as concrete pavements, with a brushed finish, all to BS EN: 13877, parts 1 - 3. All roadway areas will be laid to falls to facilitate adequate drainage of surface water.

All roadways and pavements will be designed to prevent egress of surface derived contaminants into the sub-soil.

3.3.6 Weighbridges

The facility will be equipped with 2 weighbridges positioned to allow weighing in and weighing out of all waste delivery vehicles, vehicles delivering consumables and vehicles transporting products and residues.

MVV will provide 2 power supplies to the weighbridges to provide contingency. In the event of a total power failure the weighbridge system will not be affected as it will also be connected to the UPS (Uninterrupted Power Supply) system of the facility, which is based on a battery and emergency generator supply.

The weighbridges and tipping bays will be compatible with all types of WDA Authorised vehicles including;

- Rear and front end loading RCVs (refuse collection vehicles);
- Bantam RCV;
- De-watered street washing and cleaning vehicles;
- Hook loader (Roll on/off skip loader); and
- Articulated bulk haulage vehicles, including tractor units and ejector trailer (ram and walking floor ejector).

Both ‘in’ and ‘out’ weighing lanes will be equipped with electronic weighbridges calibrated to a tolerance of +/- 20 kgs, measuring 20.0 m x 3.0 m with a 60 tonnes load capacity. The in and out weighbridges will be used to weigh all waste delivered into the facility, whether from the Authority or a Third Party; as well as products, residues and rejected material leaving the facility.

Traffic will be controlled by the use of barriers located across the vehicle entry and exit lanes as well as the by-pass lanes.

3.3.7 Energy

MVV’s process design is already highly efficient in terms of energy recovery from the waste. MVV will further minimise the CO_2 output from building services by adopting low energy design and energy efficient systems and products and the provision of monitoring systems. MVV will implement an Energy Management System in compliance with BS EN 16002:2009, which will enable it to develop and implement a policy and objectives which take into account the legal requirements and information about significant energy aspects. This Energy Management System will be integrated into the Environmental Management System as energy gives rise to environmental impacts such as atmospheric emissions and use of non renewable resources. The standard is based on the Plan-Do-Check-Act methodology, allowing a feedback mechanism to be introduced resulting in continual improvement. MVV's arrangements for minimising energy consumption are as follows:

- Monitoring and target-setting for energy use; a building management system will monitor all of the various forms of energy use within individual buildings, and a strategy for monitoring and review of energy use will form part of the facility's Environmental Management System:
- Use of natural lighting. where appropriate;
- Maximise potential for natural ventilation and adequate cross flow of air to reduce the need for air conditioning and active cooling, whilst avoiding overcooling in winter, all having regard to zoning within the building;
- Incorporation of low energy lighting internally and externally, the later of which will be directed to minimise loss of light to the sky;
- Regular maintenance of all equipment, to ensure it is operating efficiently;
- Using greener fuels for vehicles, as they become available.
- Introducing new, more energy and carbon efficient equipment, in accordance with a planned equipment replacement programme;
- Training of all staff to ensure that they are 'energy aware' and thus switch off equipment when not in use and turn off idling engines;
- All construction materials will be sourced as locally as possible, in line with the proximity principle;
- 'Passive' measures will be employed to ensure that the building designs adopt best practice to minimise its requirement on heating and cooling, with measures to include ensuring that each building is robustly thermally insulated, and that air leakage through the building fabric is minimised; and
- Consideration will be given to zoning of lighting and the incorporation of automated systems in order to reduce operating costs over the life of the installation, where relevant, having regard to health and safety requirements.

3.3.8 Water Resources

All water services will comply with the requirements of the Water Regulations 1999 and will be designed and installed in accordance with BS 6700.

Mains cold water will be distributed around the buildings to serve all drinking water connections as close to the rising main as practicable, with connections being provided to the domestic cold water storage tanks. Where small loads are required, consideration has been given to local water heating rather than centralised production and storage.

The following low water use appliances will be installed where it is economic to do so:

- Spray taps;
- Dual flush toilets;

- Infra red detection proximity urinals;
- Low flow showers – aerated heads;
- Consumption monitoring will be undertaken;
- Maximum use of rainwater harvesting for landscape irrigation, dust suppression (in the tipping area and site roads if required), although systems will still be connected to the mains supply to ensure that water is always available, even at times of low rainfall;
- In line with EA guidance, flood risk associated with climate change factors will be carefully addressed as part of the design and layout;
- Dry landscaping or low water use/drought resistant planting will be incorporated, where appropriate, to reduce water demands for this element of the development; and
- Where possible, water will be recycled and reused within the process, thus limiting the amount of fresh water required.

3.3.9 Surface Water Management

It is proposed to provide a drainage system to drain the run-off roof and wall rain water to an infiltration system. It is intended that the main building roof and wall surfaces will be drained to an infiltration basin whereas the workshop and stores building, due to its size, will be drained to an infiltration trench.

The design of the drainage system will be based on the following performance criteria:

- Design return period of 1 in 30 years: No surcharge in the system is allowed;
- Design return period of 1 in 30 years including an allowance of 20% for climate change:
- Surcharge of pipe work is allowed but no surcharge of the manhole and no flood risk;
- Design return period of 1 in 100 years including an allowance of 20% for climate change:
- Surcharge of the manhole is allowed and flooding is allowed locally.

A copy of the proposed drainage plan is provided in Drawing D123356/EP/004 Drainage Layout Plan in Volume 1, Section 12.

The surface water will pass through a Class 1 bypass petrol interceptor prior to being discharged to the tidal estuary of the river Tamar. An outfall structure complete with adequate flow calming measures and scour protection will be provided at the point of discharge. This new outfall structure will be located within the foot print of the site, the invert level of the outfall pipe at the point of discharge will be set such that it is above the maximum tidal water level for a 1 in 200 years return period (i.e 4.48 m AOD - note that this level already includes an allowance for climate change and a 300 mm freeboard). Consequently the design of the surface water system will be based on free discharge flow conditions.

Please note that it is intended to provide an emergency cut-off valve immediately upstream of the outfall such as to prevent any water discharging to the environment in the event of an accidental spill on site.

3.3.10 Foul Water, Trade Effluent and Contaminated Water Management

Foul Water Drainage

The foul sewer connection for the management of foul water from the site will be made to a rising main section of the existing internal dockyard network. The route of the foul connection is approximately 275 metres distant, and will include a new 20,000 litre packaged pumping station, with valve chamber and type D access chamber.

Process Water Drainage

There will be no routine discharge of process water from the site during normal plant operations.

During periods of plant shutdown, or when periods of increased steam off-take with high condensate losses by the MOD leads to increased waste water from the water treatment plant, there may be a need to arrange for disposal of process water from the facility. To facilitate the management of process water during these periods, a neutralisation tank will be provided which will enable water quality testing to ensure that any discharge would comply with the requirements of the foul sewer discharge consent for the facility. Arrangements to remove water would then be made either via sewer discharge or by tanker.

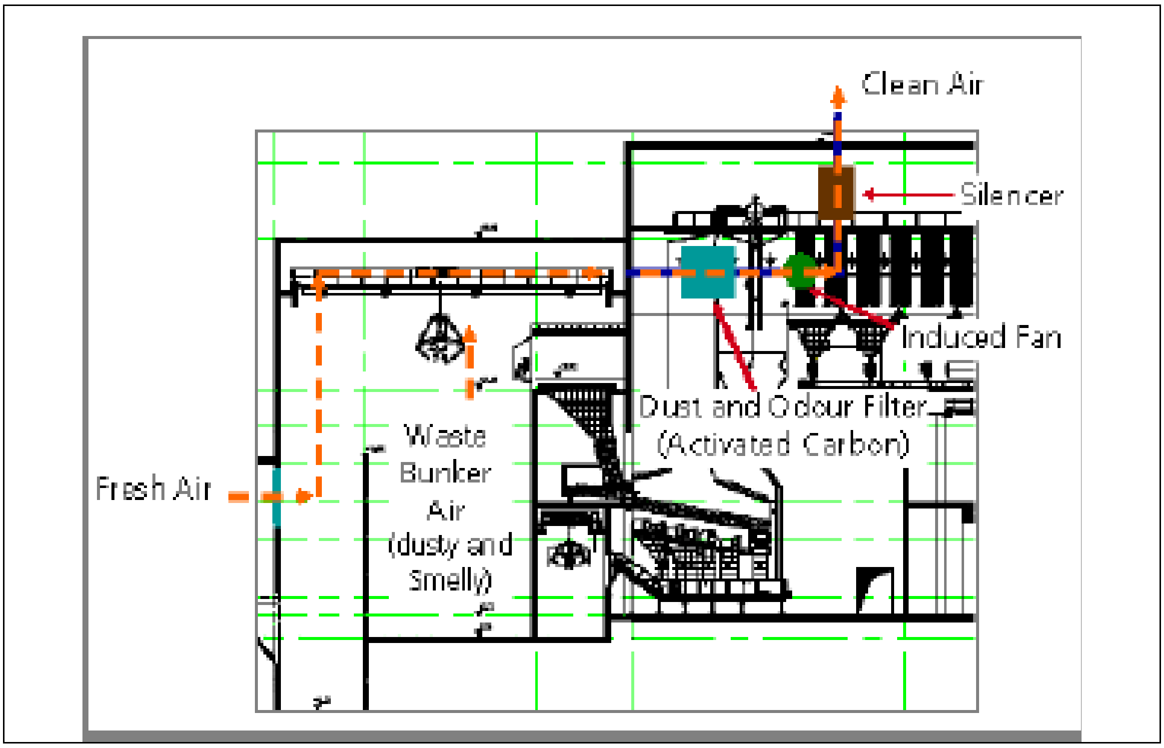
Fire Water Management

Firewater generated will be retained within the appropriate building and will be sampled prior to manual discharge to the foul sewer, if found acceptable. If firewater quality not suitable for discharge to sewer, alternative arrangements to remove from site to a suitable treatment facility (eg via tanker) will be made.

3.3.11 Ventilation and Extraction

The ventilation of the tipping hall, the waste bunker and bale-store via the primary air system or the shut-down exhaust system, and the ventilation of the boiler house via the secondary air system combustion air fans, is normal practice within the EfW/CHP facilities operated by MVV. The additional extraction and filtering unit or “shut down exhaust system” serves the tipping hall and the combined waste bunker and bale-store building during a plant outage.

Figure 3.1: Shut Down Exhaust System Schematic



3.3.12 Power Supply

The power supply system is a standard arrangement in which the switchgear units are set up separately for each process part. There are appropriate cross connections to create the necessary redundancies.

11 kV is the standard voltage level for electricity produced by a generator at this type of facility. The power required for the facility's own use is taken from service transformers. The power to be fed into the local grid is transformed to the required voltage by a step-up transformer. An emergency diesel powered generator is provided which ensures safe shut-down of the incineration plant if needed in the case of grid connection failure. The fire-fighting systems, feed water pumps, grate hydraulic system and the emergency drive of the induced draught fan are the main consumers fed from the emergency power supply. In addition, an 11kV stand-by power supply is provided to supply the plant's parasitic load in the case that the 33kV main power connection of the plant fails. This will enable the facility to be restarted and operated in 'island' mode, so that waste processing can continue.

3.3.13 Fencing and Security

Security and emergency procedures will be established as integral parts of the IMS. The main security provisions will be:

- Access points to the facility will be protected by lockable steel security gates, and an adjacent notice board will clearly display the opening hours of the site – the main access gate will be secured outside of opening, i.e. waste delivery, hours;
- Site boundaries will be protected by 2.4m high security fencing and will be inspected on a weekly basis – any defects identified will be made secure immediately, and permanent repairs will be undertaken as soon as practicable;
- Where appropriate, all building doors will be closed and secured outside of facility opening hours. The facility will continue to be operated and supervised 24 hours per day. The site will be monitored at all times from the control room by strategically placed CCTV cameras. This will help prevent unauthorised access to the operational areas.
- Access to operational areas of the building will be controlled by means of an electronic key card system
- In the event that evidence of unauthorised access and/or vandalism is identified, the matter will be reported to the Technically Competent Person responsible for the site who will then take the appropriate action; and
- All visitors will have to sign a visitor's book at the weighbridge when they arrive on-site.

3.3.14 Water Conservation

Key design parameters are as follows:

- Provide leak detection systems and/or water meters to all main supplies;
- Specify low consumption fixtures and fittings e.g. spray taps and dual flush toilets;
- Set water consumption targets for the completed building (m3 per person per year); and
- Consider the use of proximity detection shut off of water supply to urinals and WCs.

3.4 Fire Prevention and Control

3.4.1 Fire Risk Assessment

MVV will carry out a detailed fire risk assessment of the facility, as well as of individual operations on-site, at the design stage, taking into account all health, safety and welfare issues, protection of the environment and the requirement for business continuity. This will include reviewing best-practice and recommendations from fire investigations on similar facilities, and other related best practice industry guidance. This fire assessment will cover both the construction and subsequent phases. This assessment will be undertaken prior to the Works commencing in order to minimise the risk of delay to the facility arising from construction fires. MVV will discuss the requirements of the local fire department and these will be incorporated, alongside the outputs from the detailed fire assessment, into the subsequent design fire strategy in order to minimise both the cause of fire occurring and the subsequent impact of any fire.

3.4.2 Fire Prevention and Control

The design and construction of the Plant will comply with the following requirements in respect of Fire Protection & Fire Fighting systems:

- The design will follow the guidance of Building Regulations Approved Document B ‘Fire Safety’, and the Regulatory Reform (Fire Safety) Order – RRO 2005;
- All fire protection and detection products, systems and services will be provided by suppliers and contractors included on the Loss Prevention Certification Board's List of Approved Fire and Security Products and Services. Their design, manufacture and installation will be carried out by companies having achieved the LPCB Quality systems certification;
- Fire protection systems will be designed and installed generally in accordance with National Fire Protection Association (NFPA) 850 – Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, and in particular Chapter 9 - Alternative Fuels; BS EN 671 ‘fire precautions, extinguishing systems’; BS 5306 and BS 558 ‘fire precautions in the design and construction of buildings’ and BS EN 14604 ‘smoke detection’;
- All fire alarm and detection systems will be installed in accordance with BS 5839, Part 1 - 2002 and subsequent amendments to give level P1 coverage in accordance with the Loss Prevention Council (LPC) Rules for Automatic Fire Detection and Alarm Installations for the Protection of Property;
- The fire detection, protection and alarm systems will also comply with the Building Control, Fire Officer’s and the Insurer's reasonable requirements;
- All construction materials including insulation will be non-combustible, in line with the insurer’s requirements. MVV will ensure that all workmanship and manufacture swill meet or surpass all relevant British, European or equivalent International industry recognised standards and guidance;

3.4.3 Specific Design Measures

The following information provides an overview of the particular design features that have been incorporated into MVV’s design of the facility with regards to mitigating the risk of fire and managing any fire that might occur.

The design will allow for the quarantine, management and treatment of vehicles arriving on-site with a smouldering load or vehicle fire.

Special features of MVV's approach are:

- Infra red detection camera continuously scanning the waste bunker surface to provide early identification of hot spots;
- Water Deluge system for the waste bunker and bale-store to rapidly extinguish hot spots/fires that may develop in the bunker.
- Nitrogen blanketing system for the fabric filter; and
- Inert gas extinguishing system to reduce the oxygen content down to 10% (without danger to personnel) inside the electrical switchgear building.

3.4.4 Fire Compartments

Subject to the location of key equipment, the facility will be segregated into fire compartments. For example, certain specific Fire Compartments, such as the waste bunker and the boiler house, will be separated from each other by fire barriers with a minimum of 2-hour fire resistance rating, by spatial separation or by other approved means. Fire compartments include, but are not limited to, the following areas/ buildings of the plant:

- Waste tipping hall, waste bunker, and bale-store, including shredder and baling machinery;
- Boiler house, including residue silos and fabric filter;
- Turbine hall (including lubricating oil storage, pumping and filter units);
- Electrical / Switchgear building;
- Water treatment building;
- Stair towers;
- 11/33 kV Oil Transformer station;
- Urea storage and pumps;
- Fuel oil storage and pumps;
- Workshop and Store;
- Flammable liquid storage;
- Emergency diesel generator container;
- Fire pump room with foam storage;
- Administrative and visitor building; and
- Weighbridge office.

For each of these fire compartments, a fire risk assessment will be carried out by MVV to identify appropriate fire detection and protection systems, in association with appropriate civil work design principles, to control risk of fire propagation, spread of fumes and smoke and fire water flooding. In addition, it will serve to maintain the integrity of dedicated fire partition walls in the event of fire. 2 hour fire protection will be provided to all buildings, rooms and structures around the waste bunker, bale-store and tipping hall.

3.4.5 Fire Protection

The complete fire alarm system will include a fire detection system and a central control panel, which will be located in the central control room. The central control panel will report, as a minimum, the status of all fire pumps, the designated fire in the furnace and the fire detection and protection systems. The central control panel will allow a rapid identification of the location of any fire, with the alarm initiation device and location displayed at the control panel. The central control panel will allow print-outs of alarm listings, plans with fire brigade access routes, hazard points, etc.

Fire detectors will be fitted throughout the plant in sufficient numbers to cover all areas of risk and a fire detection and protection system will also be fitted above the diesel fire pump. MVV will use VESDA (very early warning fire detection) air sampling systems, which will be utilised where appropriate in the plant. The plant will have sufficient audible alarm units installed so that in the event of an evacuation being required they can be heard in all areas, the sound level of the units being set at least 5dB above the ambient levels. Hose stations designed in accordance with BS 9990 Standard for the Installation of Standpipe, Private Hydrants, and Hose Systems, will be provided at strategic positions within the plant for fire fighting in fire risk areas.

3.4.6 Fire Protection in Waste Bunker, Tipping Hall and Bale-store

These areas are at greater fire risk and protection measures are detailed below:

- All partition walls and floors around the tipping hall and the baling hall will be 2 hour fire rated;
- Smoke and heat ventilation systems will include natural ventilation at the roof;
- Fire detection will be provided by infra-red detection and by heat detectors to avoid issues due to excessive dust and moisture levels; and
- Fire fighting measures in accordance with NFPA 850 will include:
    a. Automatic water spray system;
    b. Water cannons (Figure 3.2) connected to foam reagent system for waste bunker area that can be controlled remotely from the control room or via local manual operation from a mobile control panel;
    c. Water spray system above the waste feed hoppers;
    d. Manual fire hoses;
    e. Fire water reservoir and fire pump system located beneath the tipping hall; and
    f. Foam tank beside the tipping hall.

Figure 3.2: Water Cannon in Waste Bunker, Remotely Operated

4 Waste Reception

4.1 Introduction

This section provides evidence of the existence of relevant in-process controls for the management of waste reception operations that have sufficient capacity to allow the effective management and control of the installation to the standard indicated by the Environment Agency *"Guidance for the Incineration of Waste and Fuel Manufactured From or Including Waste*" (SGN S5.01, Section 2.1.1).

4.2 Plant Capacity

The EfW CHP facility is designed to treat 245,000 tonnes of waste per annum at the thermal design point of 82.1 Megawatts thermal (MWth) (hourly throughput of 31.1 tonnes per hour (tph) with a Calorific Value (CV) of 9.5 Megajoules per kilogram (MJ/kg) and an availability of 90% (equal to 7,884 full load operational hours per year). Under low CV and high availability conditions the mechanical throughput could be as high as 265,000 tonnes of waste per annum.

4.3 Waste Types

Wastes to be accepted at the facility include:

- Household Residual Waste;
- Household Bulky Items;
- Commercial Waste collected under Section 45(2) Environmental Protection Act 1990;
- HWRC Waste;
- Litter and Refuse from public Highway;
- Road Channel debris;
- Fly tipped waste;
- Tyres;
- Waste collected by Authority from charities, schools etc;
- Waste from household clearances;
- Animal carcass from road or marine kills;
- Faeces and sex litter;
- Waste contaminants and residues from bio composting;
- Other wastes that may be collected by the WDA; and
- Other similar waste from commercial and industrial sources.

4.4 General Arrangements For Waste Receipt

The general arrangements for receiving waste materials arriving at the site include:

- Weigh at the "In" weighbridge; operatives will direct the vehicle to the appropriate tipping bay, based on acceptability of waste;
- Waste will be tipped into the bunker within the Waste Tipping Hall, from where it will be moved, by gantry cranes, to the feed hopper;

- The feed hopper will direct waste to the grate for incineration;
- Should oversized material be delivered to site then this will be fed through the shredder used during waste baling, to ensure satisfactory combustion;
- In the event that hazardous and / or unacceptable material is identified after discharge into the waste bunker, it will be set aside in the transfer area of the reception hall and directed for treatment / disposal as appropriate.

4.4.1 Waste Deliveries

The access roads, tipping hall and waste bunker are designed to accommodate the full range of anticipated waste types to be received from the WDA, and commercial and industrial sources. The waste reception area has been sized to enable flexibility in respect of various delivery vehicle types and for fluctuations in delivery rates, including the accommodation of occasional “out of specification” vehicle types.

A mechanism for vehicle recognition will be employed at the site to assist with waste acceptance protocols. Operators of vehicles that will utilise the facility (i.e. RVCs and bulk transport) will provide vehicle details to the operator for pre-registration into the site Vehicle Information System.

Vehicles entering the site that are not registered will be held at the gatehouse, where appropriate information will be presented and recorded. This information will be verified with the producer (i.e. WCA) and details entered in the information system before the vehicle will be allowed to enter the facility. Vehicles that cannot be verified will be turned away.

Waste deliveries take place during normal daytime operating hours, and are received at the weighbridge where the weighing and registration of incoming and outgoing vehicles takes place. This process is manually operated, but is also equipped to allow for more automation in future. During normal daytime opening hours, the gatehouse is manned with weighbridge personnel, while outside these periods, vehicle registration can be carried out by operating staff specially delegated to the gate house.

Weighbridge Maintenance and inspection plans

The Operator will ensure that both the in and out weighbridges are serviced and maintained by the supplier under an agreed maintenance contract. This contract will typically include:

- Routine services every 6 months;
- Calibration visits annually with calibration certificates;
- Electronic parts provision and fitting;
- Load cell testing and replacement;
- Technical advice and support; and

Additionally, in-house routine maintenance of the weighbridges will consist of a weekly inspection for damage and cleaning by mechanical sweeper as and when required, but at least weekly.

4.4.2 Tipping Hall

The waste reception area (tipping hall) is specifically sized with a length of 40 meters to facilitate the manoeuvring of articulated vehicles. There are 5 tipping bays, each 4.9m wide, which is sufficient to handle the maximum anticipated throughput of the facility.

Both the tipping hall and the tipping bays have been specifically designed to be larger than is normally proposed in order to increase flexibility of the waste reception area to potential future changes in delivery vehicles. For example, if vehicles decrease in number but increase in size, in order to meet more stringent legislative requirements with regard to emissions from waste transportation, then the facility will be equipped to accommodate this.

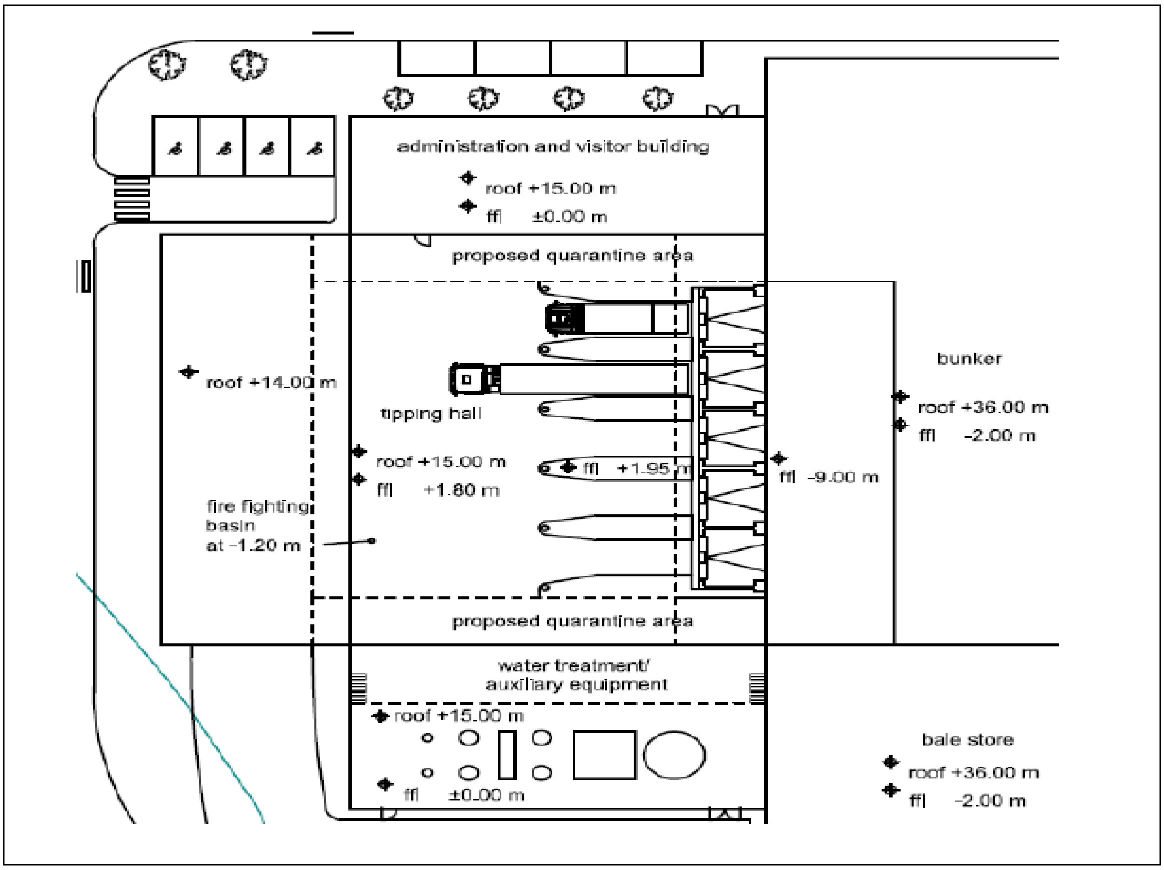
The tipping hall is provided with areas clear of the tipping bays, where waste not suitable for treatment or contaminated waste can be deposited/quarantined in containers or as single items in clearly marked areas, 150 sqm each, as seen on the diagram below) to the left and to the right of the tipping bays prior to disposal. An additional storage area is provided on the 21.6 m level inside the waste bunker for bulky items which were already tipped into the waste bunker, and which cannot be treated by the shredder situated on the same level. These items can be back-loaded into containers by the waste bunker cranes, during off-peak periods.

The tipping hall serves as an enclosure during the tipping of waste into the waste bunker, and ensures that fumes and noise are kept away from the outside environment. This is assisted by the intake of air from outside of the tipping hall, which then flows through the tipping hall into the waste bunker and finally into the combustion chamber, via the primary air system.

For health and safety reasons, the tipping bays are equipped with roller shutter doors which will be closed when no tipping is in progress. In the case that the tipping hall door and / or the tipping bay roller shutter doors are closed, the tipping hall facade and the wall between the tipping hall and the waste bunker are equipped with louvres to ensure the necessary air flow.

The general layout of the tipping hall is shown in figure 4.2 below.

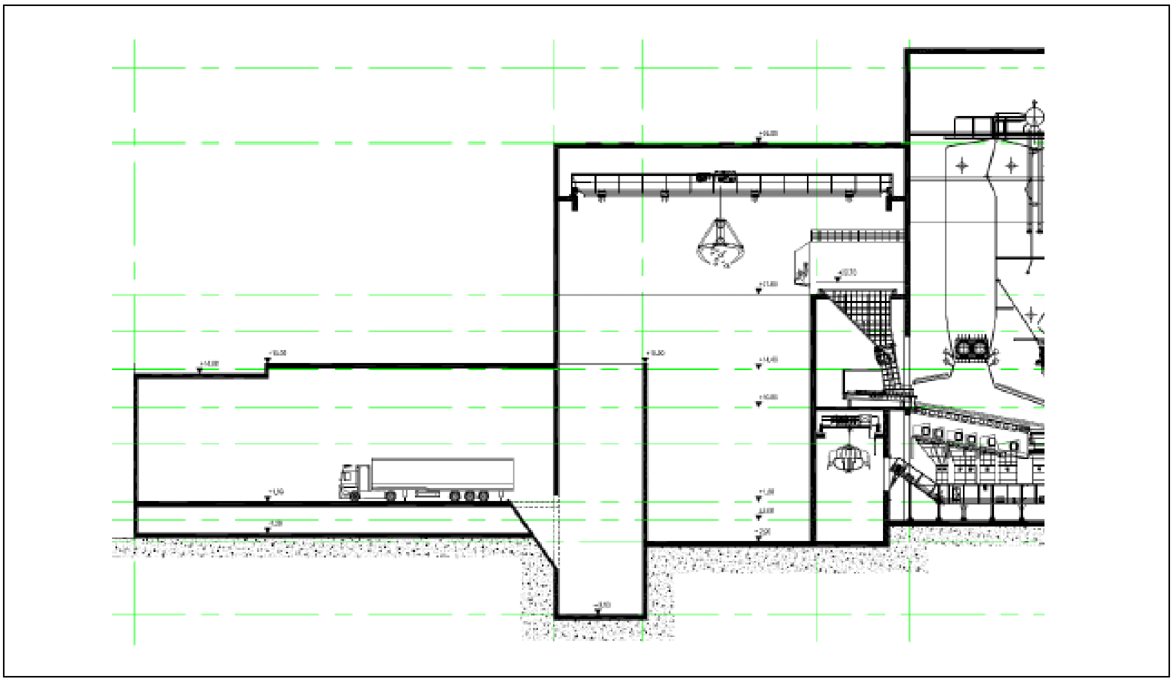
Figure 4.2: Tipping Hall Arrangement



4.4.3 Waste Bunker

To provide the guaranteed high level of diversion, the facility is provided with a waste bunker with a large storage capacity, together with a system for baling and storing waste. The storage capacity available with the combination of waste bunker and bale-storage is sufficient to accommodate all normally anticipated planned maintenance outages, as well as providing additional capacity for shutdowns of a duration up to twice that of a normal planned maintenance outage which may occur as a result of unforeseen circumstances.

Figure 4.3: Cross Section of the Waste Bunker



The bunker is divided into two distinct areas; the tipping area being the deeper part adjacent to the tipping floor and connected by the tipping chutes; and the storage section, which is shallower and separated from the tipping section by a full height wall. The tipping chutes are provided with automatically operated doors activated by reversing vehicles; the doors are closed when vehicles are not discharging. A traffic light system directs vehicles to the correct tipping bay.

The tipping area depth is calculated to ensure vehicles can discharge their full load without waste backing up in the chute. Waste will be continuously cleared from the tipping section by the waste crane and transferred to the storage section to keep the tipping area clear for the discharge of vehicles. Under normal operation, the waste will be mixed within the storage area by the waste cranes to ensure homogeneity and minimise fluctuations in calorific value. The mixed waste will then be fed by the waste crane directly in to the furnace feed hopper.

4.5 Waste Acceptance Procedures

The facility's requirements for the waste acceptance will be defined in a written procedure, and associated site records generated will be retained for a minimum of 6 years. The procedure will be developed to comply with the requirements specified in SGN S5.01, and will be subject to ongoing review and revision as appropriate. The current version will be held available at the facility for inspection.

The general aspects of waste acceptance at the facility are detailed below.

4.5.1 Pre-acceptance Procedures

Materials being accepted at the facility will be primarily generated as a result of WCA statutory collection arrangements and as such the WCA will provide the base analysis.

In respect of other commercial and industrial waste streams it is proposed that appropriate analysis will be undertaken on initial acceptance of waste from a new waste producer and then on a periodic basis to ensure ongoing compliance.

4.5.2 Acceptance Procedures

Loads will be accepted at the facility in accordance with an outline delivery schedule primarily based on the WCA collection regimes to ensure there is sufficient storage capacity to receive waste.

Loads will be only be accepted from registered and verified vehicles, RCVs, other WCA collection vehicles, or another haulage fleet in accordance with arrangements outlined in Sections 4.4.1 and 4.4.2 above.

As vehicles pull onto the 'In' weighbridge, an automated screen will ask the driver to confirm that the vehicle details are correct and will request confirmation of the payload. At this point the driver will be asked to confirm that the information that he has supplied is correct and that he is only carrying WCA Contract Waste.

Discrepancies in respect of the registered vehicles will be logged and the EA advised if the load is to be rejected or clarification required on permission to accept the material.

Waste records will be maintained detailing the volume and type of waste accepted along with any verification checks that are completed.

4.5.3 Waste Rejection and Quarantine

It is anticipated that some types of contract waste will contain large or bulky items (typically HWRC waste). The dimensions of the waste feed hopper are large as a result of the use of a single combustion line, and are therefore generally capable of accepting items up to a length of 1.5m in one dimension. However, there may be certain wastes which MVV considers would be better reduced in size prior to treatment to ensure better burn out and/or to avoid blockages and in these cases the items will be fed into the shredder that is provided as part of the baling system. The shredded material will be returned by a reversing conveyor system directly into the bunker for mixing with the 'normal' waste.

In the event that a contract waste delivery is found to contain a significant quantity of large or bulky items, then these will be directed to discharge in a specific tipping bay at the end of the bunker adjacent to the shredder from where the items can be quickly and easily fed into the shredder in bulk.

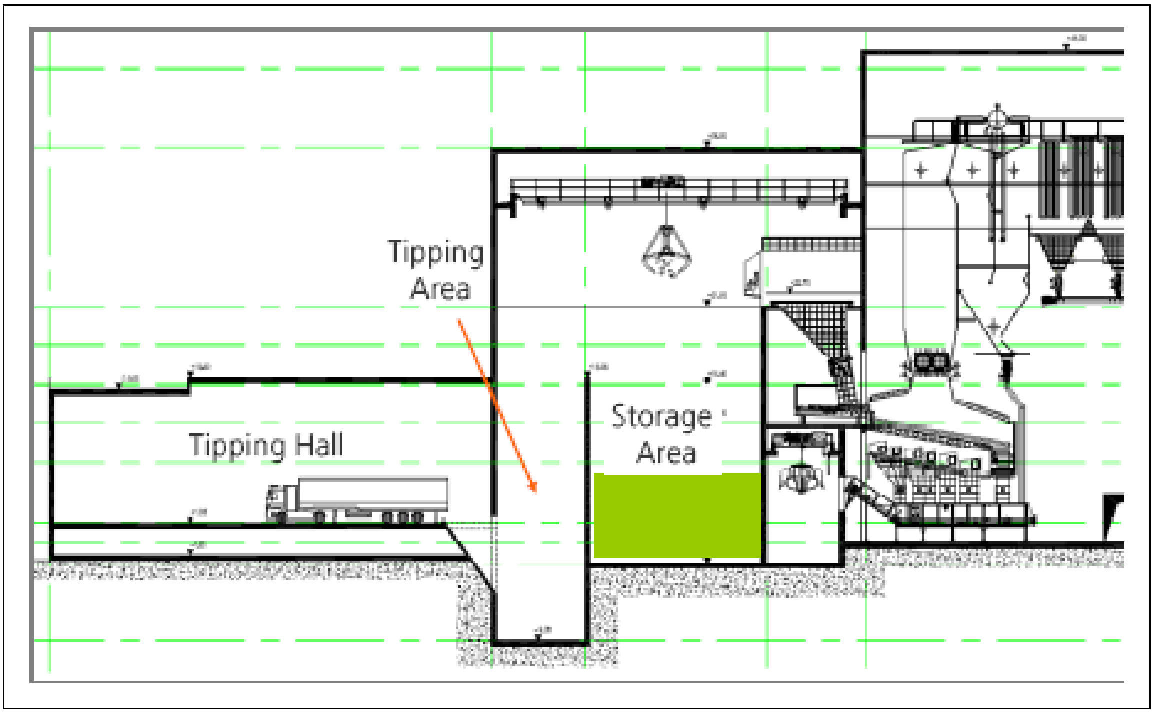
4.6 Waste Storage

4.6.1 General Storage Arrangements

The waste bunker will be sized to contain up to 10 days of waste (7,321 tonnes) at average delivery rates. In normal operation waste will be retained for about 3-5 days of average waste delivery rate in order to cover short periods of non-delivery of waste (e.g. bank holiday periods) and to ensure the necessary feedstock of waste to allow for sufficient mixing of the waste to achieve a homogeneous waste fuel.

For periods of planned shutdowns, the facility has been designed to enable continued waste acceptance using a baling system. The waste will be compacted and wrapped in polyethylene sheeting inside the bunker building, and the bales will then be stored in the dedicated bale-store compartment of the waste bunker which has been sized for 18 days waste (13,179 tonnes). At the end of the shutdown period, the bales will be fed back into the regular waste bunker using a special crane grab and opening device. The major advantage of this mid-term storage system, combining a waste bunker and a bale-store via an integrated baling process, is that there will be no need for a change in the logistics for the WCA/WDA waste delivery fleet. During normal shut-downs, the waste will be delivered as usual and will be tipped into the waste bunker. No rerouting to other facilities or landfills during normal shut-down periods will be necessary. The baling process is a very robust and effective feature of MVV's EfW/CHP facility in Leuna, and keeps the logistics for the clients very simple.

Figure 4.4: Waste Bunker Layout



4.6.2 Waste Bunker Cranes

Two waste cranes, of identical design, will be employed to handle the waste in the bunker. The cranes have hydraulic grabs which require less maintenance and are more reliable than rope grabs. Adequate sizing of the crane capacity is provided to ensure that the tipping areas in the bunker can be cleared during peak delivery hours. Both waste cranes are designed to be fully redundant. This means that the performance of one crane is sufficient to clear the tipping area of the bunker, feed the feed hopper of the boiler and achieve the minimum required mixing of the waste in the waste storage bunker.

Each crane is able to serve the majority of the entire waste bunker and bale-store area, and each is able to reach its parking position on the narrow side of the bunker. For maintenance, the crane grabs can be placed on the feed hopper floor and, where necessary, the grabs can also be lowered down to ground level through an opening in the floor. An auxiliary crane is provided to carry out repair works in the bunker, as well as for clearing blockages in the feed hoppers.

In normal operation, the cranes are operated in a duty and standby mode, although it is possible to operate both waste cranes simultaneously should it be necessary, and in this mode the cranes are provided with an anti-collision system to ensure safe operation. Due to the use of a single process line with a large feed hopper, the cranes are equipped with 12m3 capacity grab, meaning that fewer crane cycles than normal are needed to maintain the required level in the feed hopper. The waste cranes can be operated in manual, semi-automatic or fully automatic mode. During waste delivery periods, operation will normally be in manual or semi-automatic mode, as the crane driver has an important role in directing vehicles to the correct tipping bay, monitoring the waste delivered for untreatable waste and contaminants, clearing the tipping area of the bunker, ensuring adequate mixing and distribution of the waste in the storage section of the bunker and ultimately maintaining a continuous feed to the furnace.

The crane operator monitors the bunker and tipping hall both visually and by means of appropriately placed CCTV cameras, and is also provided with a monitor screen displaying the operating parameters of the furnace and boiler so that the crane operator is able to adjust the handling and feeding of waste to maintain the steady state operation of the process. The tipping floor and waste bunker area will be designed in accordance with all the necessary fire regulations which will include infrared supervision, water canons and a spray deluge system. This infrared camera system will also be used to detect any smouldering loads being delivered to the facility and ensure that these are prioritised by the crane operators and transferred straight in to the feed hopper for treatment.

Figure 4.5: Crane Operator and Hydraulic Crane Grab in Action

Figure 4.6: Typical Bunker View

4.6.3 Waste Storage Periods

The anticipated storage periods are detailed in Table 4.2.

Table 4.2: Average Waste Storage Periods

Process Step	Residence Time
Incoming Waste Streams	
Waste Bunker during normal operating conditions	3 – 5 Days
Hermetically sealed Baled Waste in the enclosed Bale Store under normal operating conditions	3-6 Months
Maximum residence time of hermetically sealed Baled Waste in the Bale Store	Up to 1 year
Waste During Treatment	
Waste on the firing grate during normal operating conditions	60 minutes
Process Outputs	
IBA in the IBA bunker on site,	5 Days
APC residues on site.	5 Days

4.6.4 Management of Waste Storage Areas

Waste storage areas will be inspected daily for:

- Spillage around internal storage areas; and
- Odour, dust and litter release from external storage areas.

Site inspections will be recorded in the site operational log, and any issues logged will addressed as soon as practicable (i.e. same day for external issues) and the action taken will also be recorded.

5 Combustion Process

5.1 Introduction

This section provides evidence of the existence of relevant in-process controls for the management of waste reception operations that have sufficient capacity to allow the effective management and control of the installation to the standard indicated by the Environment Agency *"Guidance for the Incineration of Waste and Fuel Manufactured From or Including Waste*" (SGN S5.01, Section 2.1.1).

5.2 Design Principles

The EfW/CHP facility will be designed to meet all legislative requirements, standards and best practice, and will be robustly constructed and easy to maintain with access platforms to all critical parts of the plant.

MVV is one of the most experienced owners and operators of waste to energy facilities with more than 45 years of experience in building and operating EfW and CHP facilities. The proposed design for the Devonport EfW/CHP facility reflects expert knowledge gained long-term with various types of designs and operational parameters and with new and old plants under diverse boundary conditions.

The proposed design offers a number of key benefits that result from MVV's expertise and are different to those found on the majority of typical EfW/CHP facilities. The features provided are to some extent innovative but any additional risk has been mitigated through the reliable and proven standard design of the individual components and quality standards specified by MVV. The key benefits of the design are discussed in more detail below.

5.2.1 Reliability and Plant Lifetime

Reliability and the operating lifetime of the plant is dependant on design parameters and material choices specifically in respect of the boiler. Boiler fouling and boiler wear govern facility performance, while the other components are usually operated under less stress and are therefore more reliable.

The following are the design parameters that will be implemented to optimise boiler reliability and lifetime:

- The flue gas velocities inside the boiler will be very low, resulting in low fly ash content and minimised erosion of heating surfaces;
- The tube bundle heating surfaces areas will be generously dimensioned, such that they operate at low specific heat load, resulting in long operational lifetime;
- The tube pitch of the bundles will be widely spaced, which prevents clogging by ash particles and facilitates cleaning of the tubes by the online boiler cleaning systems; and
- The boiler will have extensive 'Inconel' cladding, which is superior in performance to normal refractory lining in terms of durability and corrosion resistance.

The dimensioning of the other major equipment components will be based on the same principles, which ensure high availability, durability and long plant service life even under adverse operating conditions.

5.2.2 Flexibility

Both short and long-term changes in the combustion properties of the fuel may cause restrictions regarding the operational equipment load or the facility availability and the facility will therefore include the following equipment and design features, which within reasonable limits will accommodate irregular waste types or new waste types that may be received in the future:

- Separately adjustable pre-heating of both the primary and secondary air will ensure the ignition process is achieved on the required grate zone even if the water content is high or other waste properties require such adjustment; the adjustable flue gas recirculation system serves the same purpose;
- Generous design margins including tube wall thicknesses and redundancies cover effects which may arise from abnormal waste;
- The air pollution control system is capable of accommodating rapid changes in the inlet concentrations of pollutants, achieved by the type of reagent chosen;
- The bunker is not only a storage or buffer facility, but it is specifically needed for the homogenisation of the waste as a feed-stock; long storage duration enables moisture in the waste to distribute more evenly by itself, and the substantial bunker area provides the necessary space for mixing different types of waste using the waste cranes; and
- In addition, the advanced combustion control system provides additional flexibility, since it compensates automatically for process changes.

5.2.3 Air Pollution Control

Four characteristics are included in the design of the air pollution control system to ensure control of emissions under all foreseeable day-to-day operating conditions; which are:

- Sodium bicarbonate, the main reagent, reacts rapidly with the acidic pollutants, which ensures a quick response to changes in inlet conditions and in this respect is superior to lime as a reagent; the use of sodium bicarbonate also results in a reduction in amount of APC residues produced on a like for like comparison of inlet conditions;
- Activated carbon is used to control emissions of mercury, dioxins and furans;
- The effectiveness and efficiency of reagent use is enhanced by the recirculation of APC residue; and
- Each reagent (sodium bicarbonate and activated carbon) is injected at a different location in the system, where the flue gas temperature corresponds to the respective optimum reaction temperature.

5.2.4 Waste Acceptance Key Benefits

The facility's function, as far as receiving of waste is concerned, is characterised by the available storage capacity, which is significantly greater than in most other similar facilities. The quantity of waste that can be stored is sufficient to cover the outage for a complete boiler overhaul, meaning that the waste deliveries can continue without any restriction during the longest foreseeable facility downtime; no diversion of waste to landfills, other EfW/CHP plants or other changes in delivery logistics are necessary.

The main features of the waste storage arrangements are:

- Four weeks of continuous full load plant operation is the basis of design of the total waste storage capacity; this capacity allows a significant margin for the major planned shutdowns which are of two to three weeks duration on average;
- Baling of the waste and enclosed storage provides for intermediate storage with odour control;
- A flow of fresh air through the tipping hall into the waste bunker is defined to ensure that no odour from the waste tipping and storage processes is released to the environment; and
- The bunker is equipped with an off-line ventilation facility, the 'shut-down exhaust system', which provides an air change rate of up to 2/h relative to the filling level of the waste bunker and bale-store; the air is cleaned by a separate activated carbon and dust filter to ensure no odour or dust release to the environment during shutdowns of the plant.

5.2.5 Combined Heat and Power (CHP)

The combined heat and power (CHP) process is by far the most effective way of utilising combustion heat. In principle, the steam is used first for power generation, and is then also used to produce heat for use in the Dockyard's existing steam network.

Under the current design the EfW CHP facility will have a net overall efficiency of 39% on average, rising to 49% in the winter months when steam demand is highest. This compares to a normal "electricity only net efficiency" of about 27.4% which might occur in the summer months when there is no steam demand from the dockyard. Other electricity only EfW facilities in the UK typically only achieve an efficiency of around 23%.

When comparing the proposed EfW CHP facility to other energy from waste schemes recently built or planned in the UK the proposed scheme will be almost unique. Of the 10 or more schemes under active consideration or built in the last five years in the UK there are only two others that can claim to have CHP from the outset; the Sheffield facility, which was a replacement for an earlier, older facility from the 1970s, and the Runcorn facility which will supply process steam to the large chemical plant operated by Ineos Chlor. Existing schemes with CHP include the Eastcroft facility which supplies steam to a separate company owned by the City of Nottingham, which then generates electricity and sends hot water around a city centre district heating scheme. The Eastcroft facility does not achieve the Good Quality CHP benchmark.

Known potential facilities recently awarded planning permission include an energy from waste CHP facility at Kemsley, Kent, that would, if built, provide steam and electricity to a an adjacent paper mill. Almost all new energy from waste projects are built with the ability to supply steam, and almost all claim to have the intention of doing so, but most do not. A notable example is the South East London Combined Heat and Power (SELCHP) facility which despite having CHP in its title has not yet supplied steam or hot water to the local area of London in which it sits. No new energy from waste schemes that have the same real potential as this scheme to provide CHP or DH have been proposed. Indeed, the proposed EfW CHP scheme is more comparable to the higher levels of CHP commonly seen in continental Europe, in countries such as Denmark and Germany.

5.2.6 Energy Efficiency

The characteristic feature of the facility in this respect is the combination of air pollution control system and boiler system components, which enables recovery of the heat in the flue gases without the adverse effects of quenching by water injection.

In addition the power consumption of the facility (parasitic load) is reduced to an level that is far less than that achieved on normal plants, this is achieved by:

- Electric motors specified as EFF 1 class, or, if not classified under the EFF1 classification, to provide at least a minimum efficiency of 95% which is significantly above the current industrial standard in EfW/CHP processes;
- Systems providing a variable control function during normal operation use motors fitted with frequency control rather than a throttling device (valve or damper) to avoid energy losses;
- Natural convection is used as an integral feature of the aeration and de-aeration systems where applicable;
- The use of “ring main” pipelines, which are often used in normal EfW/CHP processes, produce pump losses and are replaced in MVV´s design by individually controlled direct feeds;
- Lighting, inside and outside the facility, is based on the use of high-efficiency luminaries; and
- Piping and ducting is designed for the minimum feasible pressure loss by avoidance of unnecessary changes of direction and selection of optimal pipe velocities.

By the above means, the parasitic load of the plant will be limited to only 10 % of the normal generator output during full load operation in full condensing mode at the design point.

5.3 Overall Process

The proposed combustion treatment process for the facility is based on a single line plant, with a nominal fuel processing capacity of 31.1tph and an aggregate nominal boiler capacity of 82.1 MW_{th}.

The main process elements are:

- Waste bunker and transport system;
- Combustion Furnace;
- Boiler;
- Steam turbine and air-cooled condenser;
- Flue-gas cleaning system;
- Flue gas fan and chimney; and
- Control and monitoring system.

5.4 Waste Charging

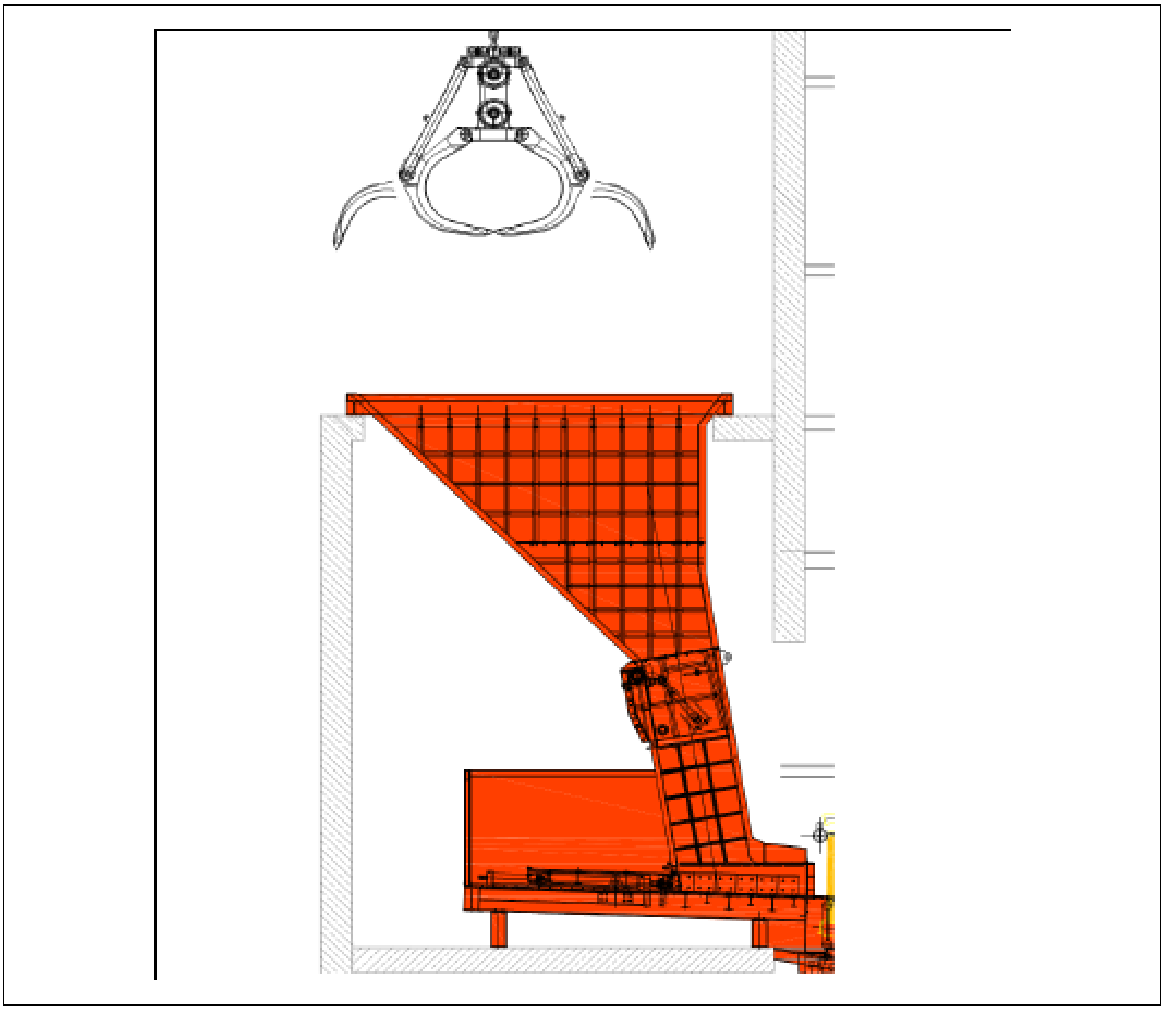
Material will be removed from the waste storage bunkers using the Bunker Cranes. The cranes will have hydraulic grabs which require less operational maintenance and therefore are more reliable than rope grabs.

The waste will be loaded into the feed hopper using the crane. The feed chute is arranged beneath the hopper. A flap gate is positioned between the hopper and chute to provide a method of isolation during start up / shut down and any maintenance periods. Sensors are positioned to monitor the level of waste within the feed hopper, which will trigger an alarm in the crane drivers cab and in the control room should the trigger level be reached. The system incorporates three level of alarms connected to the automated crane control system.

The feed chute between the hopper and the grate widens in the waste flow direction to ensure that material will not clog the shaft. The lower part of the chute is double-walled and water cooled to minimise the risk of back-fires within the waste and to prevent over heating. There is also a fire protection system based on water injection if required.

At the end of the feed chute, the waste meets the feed table. From here it is conveyed to the grate surface using a hydraulic ram, which will ensure a semi-continuous feed. The Combustion Control System will ensure that the fuel is fed evenly into the grate, and at the correct rate according to the load set point. Each grate run has its own feed ram and is shown in Figure 5.1 below.

Figure 5.1: Longitudinal section of waste feed, showing hopper, isolation damper, feed chute, hydraulically driven feed ram on feed table



5.5 Furnace System

5.5.1 Overall System

The combustion technology will incorporate an inclined, reciprocating grate. Waste will be fed via a waste feed hopper and a set of feed rams onto an advanced moving grate with a drying zone, a combustion zone and a burn-out zone. The combustion air will be primarily fed from beneath the grate, and will be drawn from above the waste bunker to facilitate the control of odours and fumes in the bunker and tipping halls.

The overall system is represented by Figures 5.2a, 5.2b and 5.2c below, and descriptions of the individual elements are provided in subsequent sections.

Figure 5.2a: Longitudinal Section of Grate and Boiler with first, second and third vertical passes

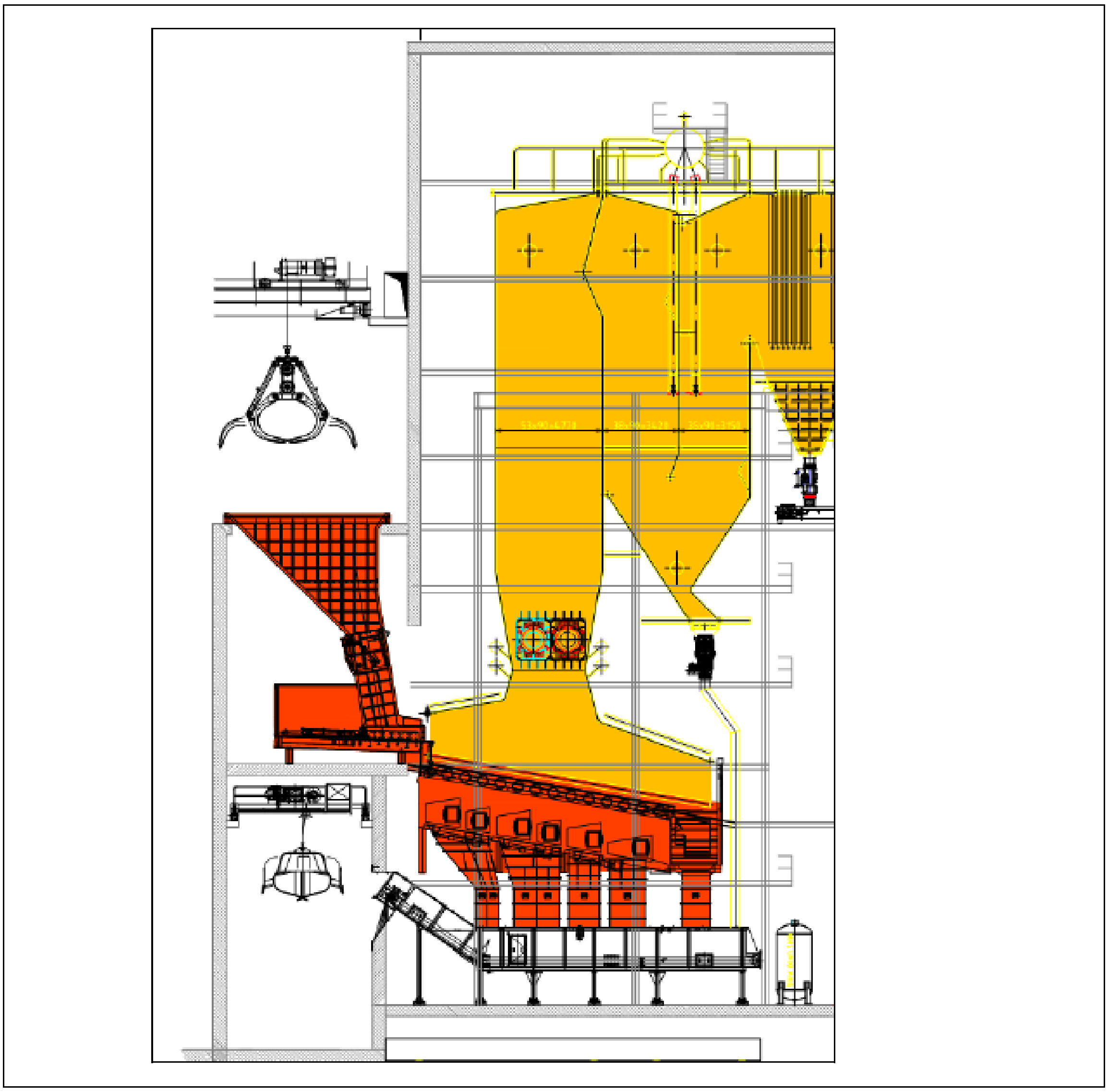


Figure 5.2b: Longitudinal Section Continued with Fourth pass including pre-evaporator, super-heater, fifth vertical pass with economizer 1 followed by sixth pass with economiser 2

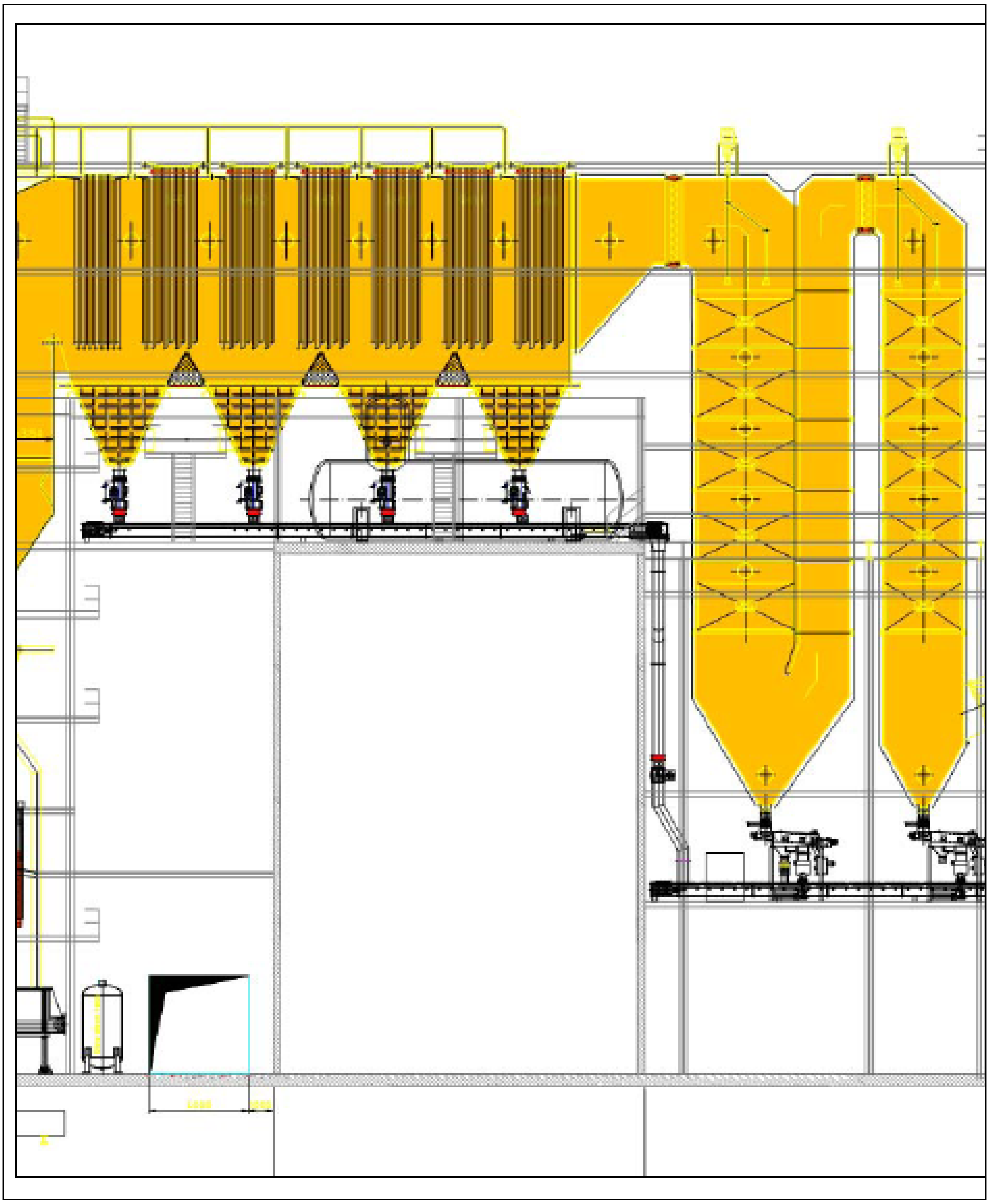
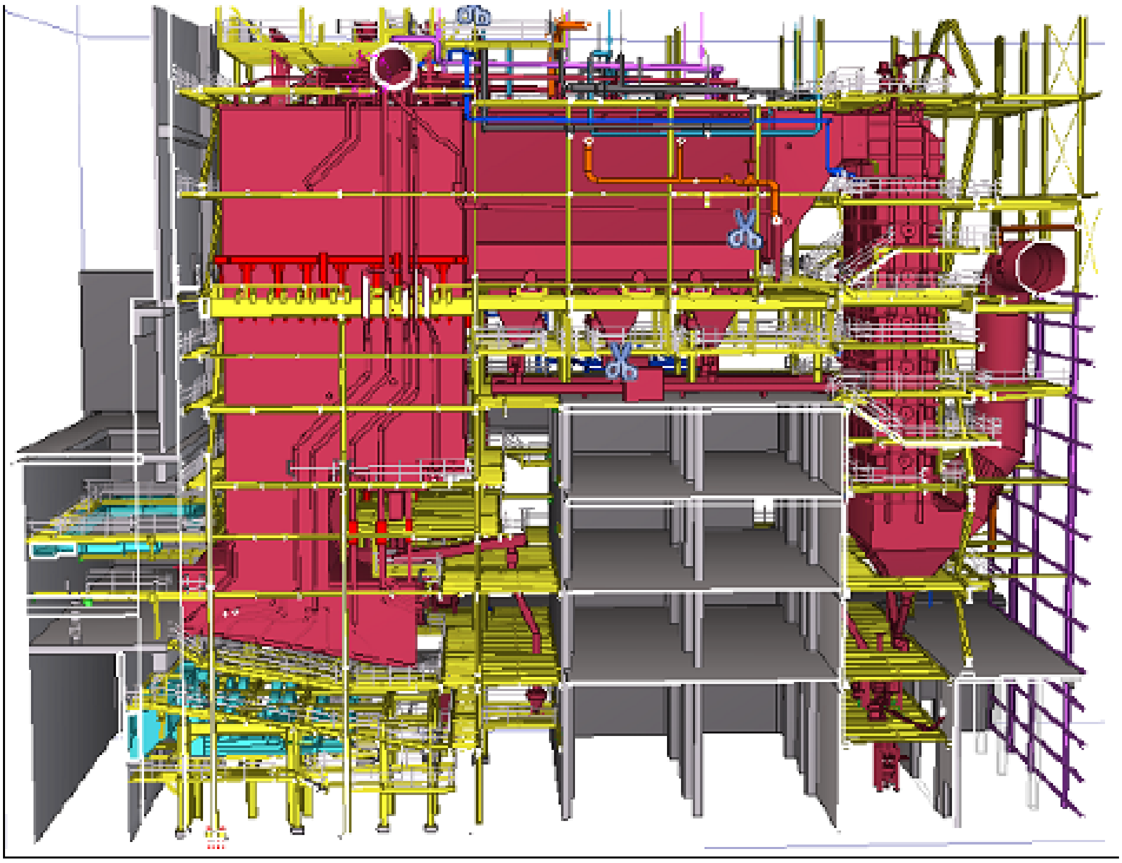


Figure 5.2c: Typical Three-Dimensional Boiler View with Five Pass Design



5.5.2 The Grate

The reciprocating grate is of modular design, with three grate runs in parallel, which facilitates waste drying, followed by the degasification, gasification and complete burnout of the waste. The grate elements are made from a high-chromium cast material, and are air cooled to maintain the surface temperature of the elements at below 400 °C. The grate bars are arranged as alternate rows of movable and fixed bars that are connected on a movable frame driven by hydraulic cylinders.

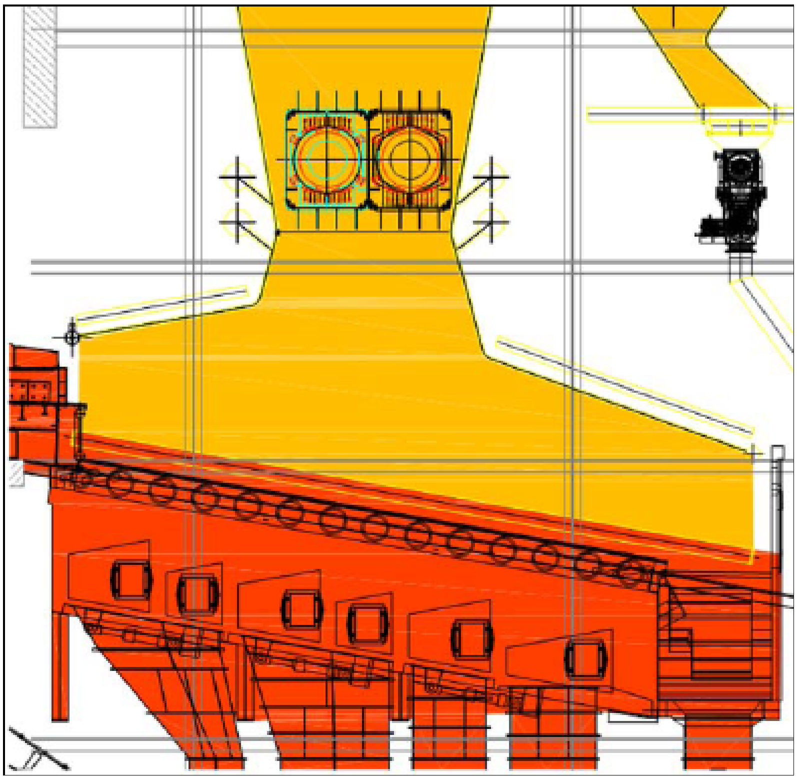
In the longitudinal direction, each grate run is divided into drive and air distribution zones. The moving rows of grate bars of each of the three drive zones are operated by hydraulic cylinders. By changing the drive stroke frequency and the conveying speed the thickness of the fuel bed on the grate can be controlled. The residence time of the fuel on the grate is normally about 45 to 60 minutes.

The four air distribution zones are separate from the drive zones, and each is fed with primary air, which can be regulated according to the requirements of the stages of the incineration process, which are drying and ignition followed by combustion and cooling of the ash. The first two air zones are supplied with pre-heated primary air necessary for drying and ignition.

Under each grate zone ash hoppers are arranged in order to pick up the small ash particles that fall through the grate. From the end of the grate the ash is discharged into the bottom ash conveying system.

The grate system is shown below in Figure 5.3.

Figure 5.3: Longitudinal section of grate: from left: feed table drop-off, grate surface with primary air supply from below and combustion chamber including auxiliary burners above, bottom ash discharge chute



5.5.3 Grate Ash Management

Ash generated during combustion will drop off the end of the grate directly into a water bath equipped with a mechanical ash discharge conveyor. This acts to quench the hot ash and act as an air seal to prevent uncontrolled ingress of air into the primary combustion chamber.

The bottom ash drains in the bunker. Water is lost from the ash discharger due to evaporation and so water from the ash bunker and other process waste water is recirculated to the ash discharger to maintain a water seal. The vapours and fumes are extracted by the secondary air fan from the bottom ash conveying system and therefore do not escape into the open.

The bottom ash is stored in the bottom ash bunker prior to removal off-site by truck. It is handled by a crane which operates fully automatically to distribute the ash in the bunker. Vehicle loading is carried out by manual operation of the crane. The crane is fitted with a clam shell bucket grab.

5.5.4 Auxiliary Burners

There will be auxiliary burners fired by low sulphur, light fuel oil used during;

- Furnace system pre-heating during system start-up – a temperature controller will adjust both burner outputs to achieve a set point temperature in the combustion chamber of 850^{O}C over a time period, before waste fuel feed can be commenced to the primary incineration chamber;

- Reflecting WID requirements, the temperature in the “2 second zone of the combustion chamber” must be maintained above 850^{O}C – during normal operation a controller will start one of the burners when the temperature is falling and approaches a set point typically at 870^{O}C, which ensures that the temperature remains above 850^{O}C at all times when waste is being fed into the incinerator; and
- When the temperature rises above the set point temperature and burner heat is not needed, the burner will be shut down and temperature control is transferred back to the main control system.

5.5.5 Combustion Chamber

The walls of the combustion chamber will be a welded membrane tube wall design, and will be water cooled and refractory lined. The membrane walls will be supplied complete with upper and lower header connections for the attachment of the water walls. The headers will be of fusion-welded construction, and stress relieved in accordance with the relevant code of construction. They also will have connections for supply, collection and drain systems.

The height of the furnace is designed to reach the prescribed residence time to ensure complete combustion. Access doors are installed in the sidewalls of the boiler (upper part) and the rear wall of the combustion chamber. In addition inspection ports are provided in the front and rear wall of the furnace.

Fluctuations in the combustion chamber pressure are absorbed through back-stays which encircle the pressure parts at several levels. The back-stays have been designed to withstand both positive and negative pressures, and the system is designed to accommodate thermal expansion.

5.5.6 Combustion Process

The waste feed rate and the supply of primary and secondary combustion air as well as the grate speed will be regulated by an advanced combustion control system which measures the steam flow rate, flue gas oxygen content and combustion temperature and controls the plant to keep the rate of steam generation constant.

The amount of heat released by the waste will vary according to its net calorific value (NCV). This is the amount of thermal energy released during the complete combustion of a given quantity of the waste, which due to the inconsistent nature of municipal solid waste, constantly varies. The automatic control system will respond to this variation by modifying the waste feed rate and the grate speed to maintain a constant heat release from combustion and hence a constant steam flow rate. The crane operator will mix the waste in the bunker to homogenise the NCV of the waste fed to the boiler

In addition to conventional combustion control (e.g. with conventional temperature sensors) MVV will also provide an acoustic temperature measurement system for monitoring and controlling the temperature profile in the combustion chamber.

The combustion process generates oxides of nitrogen (NOx). In order not to exceed the emission limit for these substances, the secondary combustion chamber will be equipped with a NOx reduction system. The oxides of nitrogen will be reduced to nitrogen and water vapour by injecting urea solution into the secondary combustion chamber. As the reaction is sensitive to temperature, the injection nozzles will be installed at several levels within the combustion chamber to enable the injection of urea solution to be precisely adjusted to the temperature conditions within the chamber. The selection of the injection level is controlled by the acoustic temperature measurement system.

Urea acts as a reducing agent which decomposes during injection in the hot flue gas stream, primarily to ammonia. The hydrogen in the ammonia reacts with the oxygen in the oxides of nitrogen to produce molecules of water vapour and nitrogen. This is a selective non catalytic reduction process (SNCR), which is optimised at temperatures of between 850°C and 1000°C.

The gases will pass through a combination of water-cooled radiant chambers and evaporator screens which will reduce the temperature of the gases to around 650°C before coming into contact with the steam super-heaters. This serves to minimise corrosion and also to ensure that the majority of the small ash particles entrained in the combustion gases are below their melting point and are therefore less likely to adhere to the heat transfer surfaces.

The geometry of the furnace and boiler has been designed to minimise areas where excessive corrosion could occur. In areas which cannot be protected by refractory lining the membrane walls of the boiler will be protected by layers of a highly corrosion resistant alloy metal called Inconel which is applied under carefully controlled conditions to ensure full bonding between the parent metal and the alloy up into the second pass of the boiler. The Contractor will use its extensive experience together with the results of CFD-Modelling to provide a boiler which is designed in flow optimized configuration in order to reduce corrosion and pressure drop.

5.5.7 Combustion Process Optimisation

The combustion diagram (Figure 5.4) depicts the thermal capacity of the grate which in turn determines the capacity of the steam generator, the air pollution control system and the power generation system. The combustion diagram is based on the following parameters:

- Total waste throughput 265,000 t/a (tonnes per annum);
- Design calorific value (CV) of waste 9.5 MJ/kg (heat content per kilogram)
- Number of incineration lines 1
- 7,884 h/a availability which corresponds to 90% full load availability

Please note that full load availability does not just include the time when the plant is available for operation, the definition of full load availability correlates the availability time with the thermal full load performance. The resulting nominal throughput of the plant is thus:

- 245,000 t/a: 7,884 h/a : 1 lines = 31.1 t/h.

The gross thermal input is calculated with the calorific value as follows:

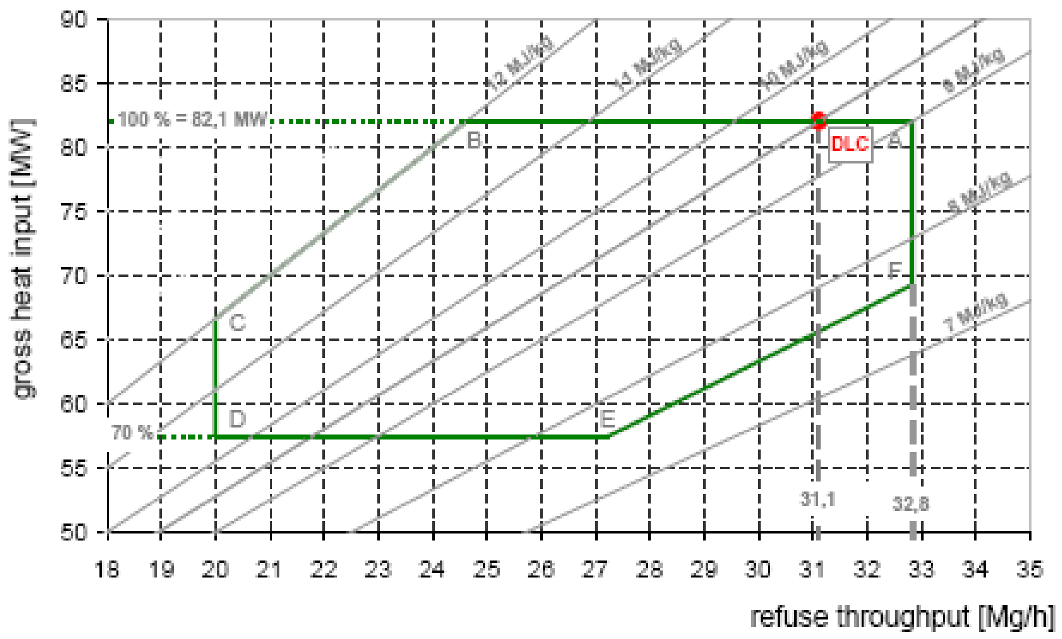
- 31.1 t/h x 9.5 MJ/kg x 1 h/3,600 s = 82.1 MWth.

This represents 100% thermal capacity of the boiler and it is to be noted that the throughput is a function of the calorific value. A lower CV will result in a higher throughput whilst the gross heat input remains unchanged. However there is also a technical limit on the mechanical throughput of the grate.

In the event that the waste has a lower than anticipated CV and the availability of the plant is optimised a maximum throughput of 265,000 t/a could be achieved without exceeding the 100% thermal load of the boiler.

The resulting firing diagram is illustrated in Figure 5.4 below. As well as the Design Load Case (DLC) which represents the nominal heat input from waste, it identifies the flexibility with regard to the supplied waste. Acceptable maximum and minimum figures for the thermal input, the mechanical throughput and the calorific values are shown by the envelope A, B, C, D, E & F marked in green.

Figure 5.4: Firing Diagram Based on Design Load



In normal operation, the incineration process is set to 100% thermal load, which does not depend on the current calorific value of the waste. Rather the resulting steam flow is measured and serves as the controlled variable for the fully automatic combustion control. Keeping the steam flow constant stabilises the combustion process, independent of short and long-term changes in the fuel characteristics. The usual control peaks are allowed for, so the figures in the firing diagram represent the computed average. The design of the plant components throughout includes sufficient margins to cater for short-term peaks of at least +10%, which is required in everyday plant operation because of the variable nature of the fuel.

Operation at partial load, down to 70% of the nominal value, is possible whilst meeting all relevant incineration criteria such as combustion temperatures and completeness of the combustion process. However, the steam temperature may be marginally reduced, to a level that can be tolerated by the turbine. Above 80% load, this is not the case. Operation below 70% load is very unlikely and a lower figure for the partial load capability would require additional heating surfaces that would be superfluous for normal operation.

The use of fossil-fuelled auxiliary burners is not anticipated under normal operations within the limits of the combustion diagram. These burners will be used for pre-heating while starting up and shutting down, and for maintaining minimum temperatures in the combustion chamber during disturbances.

5.5.8 Combustion Air

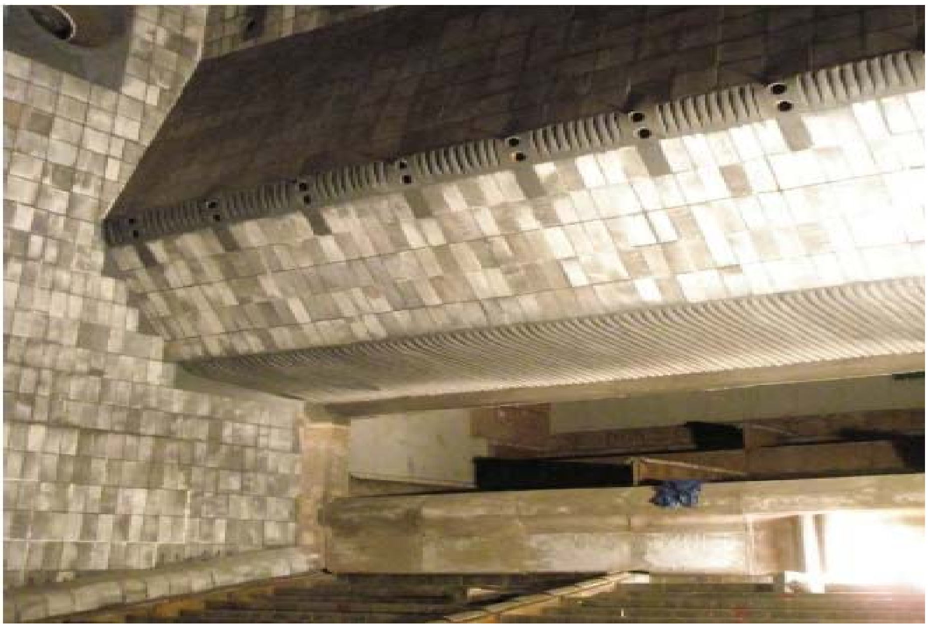
In addition to primary air distributed under the grate, secondary air is fed to the combustion chamber above the grate by means of a separate fan. All fans are speed controlled by frequency converter and are designed with margins to allow for an increase in the volumetric flow rate of 20% and the pressure by 10%.

The primary air is extracted from the waste bunker. In the event of a bunker fire, the air intake is switched over to extract from inside the boiler house. Both the primary and secondary air are pre-heated by steam that enables air temperatures up to 150°C to be achieved; the pre-heat temperature is adjustable. Pre-heating is included because it stabilises the combustion process, and the steam production when waste properties fluctuate, and it also increases the plant efficiency. When burning waste with very stable characteristics, the pre-heating may be turned off in favour of extra throughput and improved power generation capacity.

The primary air is distributed by suitable ducts into the hoppers under the grate. The grate air system consists of 6 air zones per grate line. The inlets to the air zones are provided with motor driven control flaps and measurement of air flow. The air-flow in particular grate zones are calculated relative to the boiler output, and the correcting data will come from the combustion control system.

The secondary air ensures complete burn out of combustion gases in the upper part of the combustion chamber, and is introduced by nozzles that are arranged opposite to each other in the front and rear wall. The secondary air intake is positioned at the top floor level inside the boiler house, which assists with boiler house ventilation, and simultaneously provides some indirect air pre-heating. Ideally, the secondary air injection provides a constant temperature and flow profile in the gases leaving the combustion chamber. The so called plug-flow frees the boiler from locally concentrated fouling and corrosion, and is the prerequisite for low combustion related emissions. An example of the secondary air feed system in the combustion chamber is shown in Figure 5.5 below.

Figure 5.5: Combustion Chamber Showing Principal Arrangement of Secondary Combustion Air Nozzles



Flue gas recirculation serves the same purpose, and is set up in a similar way to the secondary air. It also replaces secondary air with regard to the mixing function, so providing the low total excess air that is desirable in achieving high efficiency and protecting the environment. The flue gas for recirculation is extracted downstream of the fabric filter, which minimises fouling and corrosion in the system.

5.5.9 Combustion Control

Within the operating range of the combustion diagram, any set load is controlled fully and automatically by the combustion control system. The parameters controlled include the steam flow and the O_2 content of the flue gas. Any changes to the respective set points are made by the control system without further manual intervention. The controlled variables are the feed rate linked to the grate speed, and the combustion air flow as a minimum. Additional control circuits control the combustion temperature, the ratio of primary air to secondary air, the distribution of primary air across the zones, the feed rate/grate speed ratio, the primary air temperature.

Combustion control has a direct impact on the operation of the facility due to the potential for large fluctuations in operating conditions resulting in high costs arising from boiler wear and corrosion. Operating costs also increase, because of the corresponding overdosing of reagents. In addition, fluctuations in control hinder the proper utilisation of the built-in design margins for short or mid-term overload operation.

The main criteria for judging performance of the control system is the variation in the live steam flow. It can be directly measured and evaluated, and it is normally kept within a range of ±5%.

5.5.10 Validation of Combustion Conditions

The combustion calculation is based on the firing diagram (figure 5.4 above) with an operational oxygen content in the flue gas downstream of the boiler of 6% wet by volume. This will be verified based on the results of generic CFD modelling data during detailed design and validated at the time of plant commissioning. The respective excess air provides sufficient oxygen for complete combustion even during peak demand. If the figure for the excess air is set too low, this increases the hazard of boiler corrosion, while if the figure is too high, it reduces the efficiency of the boiler and results in higher costs for the air pollution control system. With the oxygen content chosen, a standard value is determined which, with flue gas re-circulation, will guarantee a sufficiently low adiabatic incineration temperature. Flue gas recirculation also decreases the flow of gases to the ID fan and ultimately to the environment.

The combustion calculation determines the various air flows and the resulting flue gas flow that is used as a basis for dimensioning the boiler and the air pollution control systems. From these parameters the steam output of the boiler is determined, and ultimately the power generated by the steam turbine..

A copy of a typical CFD model from the equipment supplier is provided in Appendix B.

5.6 Control System

5.6.1 Reaction Chemistry

Thermal conversion takes place as the waste is combusted in excess air to produced carbon dioxide, water vapour and ash. The general chemical reaction is:

$$C_{20}H_{32}O_{10} \quad + \quad 23O_2 \quad \rightarrow \quad 20CO_2 \quad + \quad 16H_2O$$

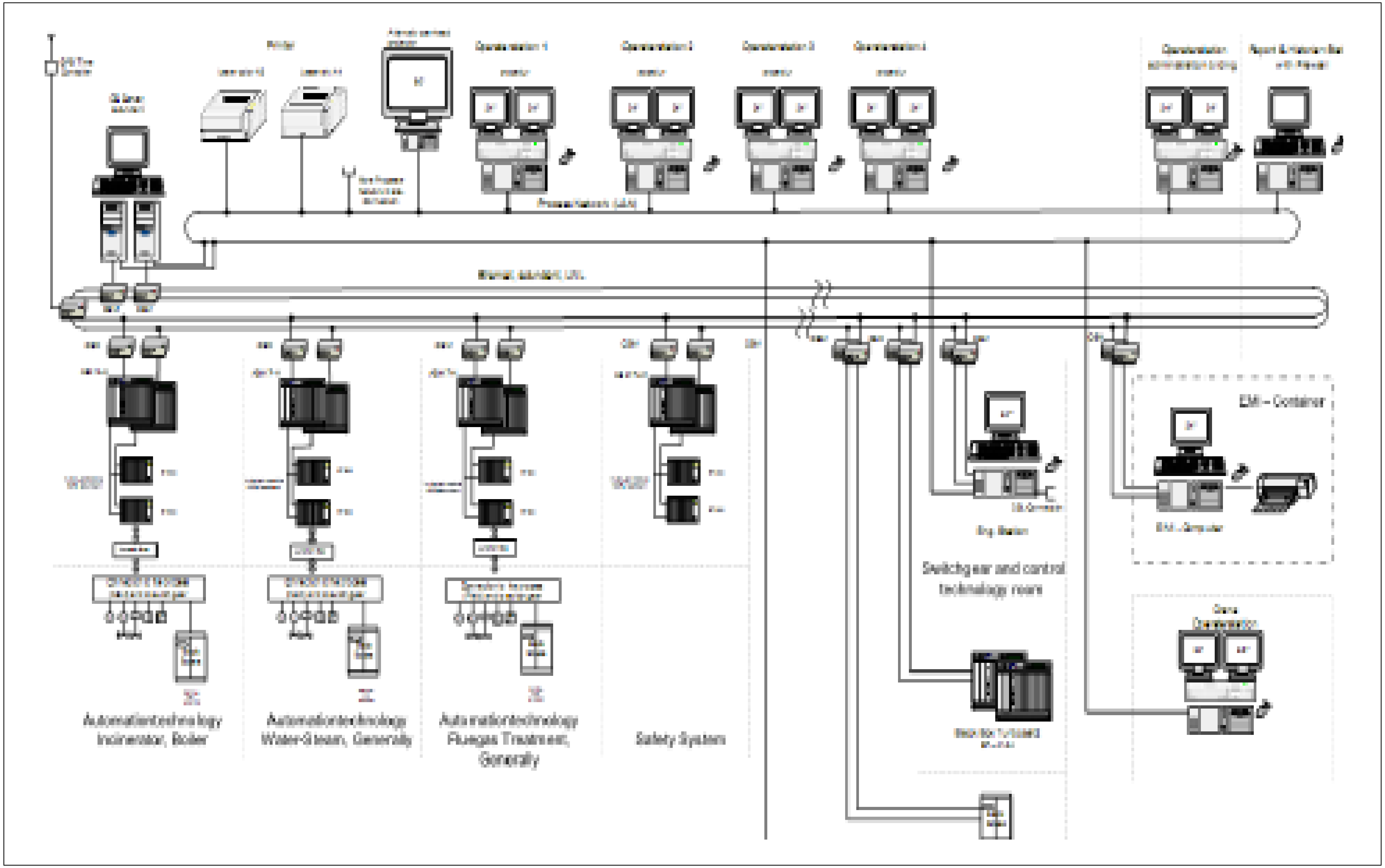
5.6.2 Control System Philosophy

A digital process control system with touch screens is provided for operation and monitoring of the facility and its control systems. The facility is operated and monitored entirely from the central control room. The layout ensures high availability of the whole facility. For reasons of safety, a backup level is included which makes it possible to operate the most important facility components even without the remote bus, process operator interface or visual display units. The backup also enables emergency shut-down of the facility.

A typical control situation is shown in Figure 5.6a, and a typical schematic of the control system shown in Figure 5.6b on the next page.

Figure 5.6a: Typical Control Room Situation

Figure 5.6b: Schematic of Control System



The combustion processes will be governed by a control system based on programmable logic controllers (PLCs), as is outlined in Table 5.1.

Table 5.1: Basic Control and Monitoring System

Plant Item	Automatic PLC Control and Monitor	Monitor Only
Waste Bunker Crane	✓	
Waste Fuel Feed	✓	
Primary Air	✓	
Secondary Air	✓	
Auxiliary Burners	✓	
Grate Action	✓	
Combustion Process	✓	
Flue Gas Extraction	✓	
Flue Gas Scrubbing	✓	
Boiler Feedwater	✓	
Boiler Outlet Steam	✓	
Ash Discharge	✓	
Ash Conveyors	✓	
Surface Cleaning	✓	✓
Emission Monitoring	✓	✓
Emergency Shut-down	✓	
Common Services	**Automatic PLC Control and Monitor**	**Monitor Only**
Steam Distribution	✓	
Condensate & Feedwater	✓	
Blowdown	✓	
Water Cooled Condensers	✓	
De-aerator	✓	
Activated Carbon	✓	
Support Fuel	✓	
Air compressor	✓	
Water Treatment		✓
Turbine Generator	✓	
Electrical Distribution		✓
Chemical Dosing		✓
Fire Water		✓
Residue Discharge		✓

The control system feeds into the alarm centre which is the permanently manned control room of the EfW/CHP. It receives alarms triggered by operating systems as well as emergency telephone calls. The control room possesses all the communication facilities required to alert and inform the internal and external auxiliary personnel.

5.6.3 Protection during Abnormal Operation

Process Alarms and Event System

The PLC system will monitor a number of process parameters and in the event the system operation goes outside preset criteria, an alarm will sound. The types of alarms that may be generated include:

- Basic alarms – these are generated by detecting deviations on single process measurements or on single items of equipment; and
- Aggregated alarms – these are generated from a process section and indicate a plant operational issue (e.g. burner stopped, ash transport stopped, shot cleaning stopped).

Signal filtering is used to prevent the generation of repeated, unnecessary alarms and all alarm events are logged and time-stamped in the PLC.

The alarms inform the operator of operational deviations outside the control criteria and will either:

- Require operator intervention; or
- Automatically shut down the plant if not acted upon by the operator.

Alarms will have separate parameters that define the conditions for the alarm being active or not, and these can be acted upon from the operator control console. Operators will be required to record a short note in an operational log outlining the reason for the alarm sounding and any subsequent action taken.

MVV will develop an alarm plan for the EfW/CHP facility, which is an internal instruction for plant operators, and it will describe how alerts and information are to be issued in emergency situations.

5.7 Boiler System

5.7.1 Overview

A six-pass boiler with natural circulation is used for steam generation. The corrosion critical super-heater, the evaporator and the economiser tube bundles are housed in the horizontal pass. These bundles, in particular the first super-heater bundles, can be installed and removed with a mobile crane through the top of the boiler. Removable roof sections are provided in the boiler house roof and the boiler pipework routing is arranged to facilitate removal and installation.

The convective part of the boiler starts with what is called a protective evaporator, the tube bundles of which are integrated in the evaporator circuit. Its purpose is to limit the flue gas temperature before entry into the final superheater and to distribute the gas flow evenly across the gas passage.

The final superheater is divided into two bundles to ensure that the critical tube-rows are easily accessible. The final super-heater operates in direct-flow in order to reduce the tube wall temperatures. Two water injection de-superheaters are provided to control the steam parameters with sufficient accuracy at all load conditions. Generous tube pitch of the bundle heating surfaces in the horizontal pass prevents clogging, which can otherwise easily occur between closely spaced tubes.

The tube diaphragm walls of the first pass run right down to the grate. The second and third, as well as horizontal, passes of the boiler are also formed by diaphragm walls. Only the vertical passes with the economiser bundles have plain walls. Waste may have chlorine concentrations in excess of 1%, and at this level could cause high temperature corrosion of the boiler. The entire first pass is therefore protected with refractory lining at the lower levels and Inconel cladding in the upper level.

To minimise dust entrainment from the combustion chamber into the downstream boiler passes, and to minimise the flue gas fly ash concentrations, low gas velocities are chosen. In the second and third pass, the geometry serves to separate the entrained dust particles, reducing fouling of the downstream heating surfaces. A horizontal boiler layout is preferred to a vertical design, as the vertical boiler requires soot blowers for online cleaning. These consume steam and eventually cause boiler tube wear by erosion. The horizontal type utilises a mechanical ‘rapping’ system, which has no such disadvantages.

5.7.2 Steam Generation

Steam at high pressure and temperature will be created by the evaporation of the water which circulates by natural buoyancy through the evaporator sections and the water tube-walls of the combustion chambers. The steam from the evaporators is saturated, that is to say that it is in equilibrium with the water and will condense immediately heat is removed. In order to minimise condensation of steam within the steam turbine, and to maximise its efficiency, the saturated steam will be further heated in the super-heaters.

The combustion gases will cool rapidly as they pass over the super-heaters located in the horizontal pass and the economiser tubes, which are arranged in subsequent vertical passes to minimise ash deposition and facilitate easy removal of deposits by ‘rapping’. This will maintain heat transfer efficiency, minimise erosion and also minimise the presence of ash deposits on the tubes. The economiser sections will reduce the gas exit temperature to the optimum required by the flue gas treatment process and preheat the boiler water for increased efficiency. The rapid cooling, coupled with minimal ash deposits, will help minimise the reformation of dioxins and furans.

Typical steam parameters in waste incineration plants are 400°C and 40 bar, whereas for this facility, the steam parameters are increased slightly to improve the energy efficiency. These are set at 420 °C and 60 bar, which significantly contribute to increased energy efficiency, but are proven to be feasible whilst satisfying the highest reliability and availability standards.

In essence, an elevated steam temperature entails higher boiler wear rates, but by applying special measures, any adverse effect on the plant production capacity is eliminated. The extra efforts are worthwhile, even more so in consideration of the rising power prices and revenues that may be expected in the future.

5.7.3 Superheater

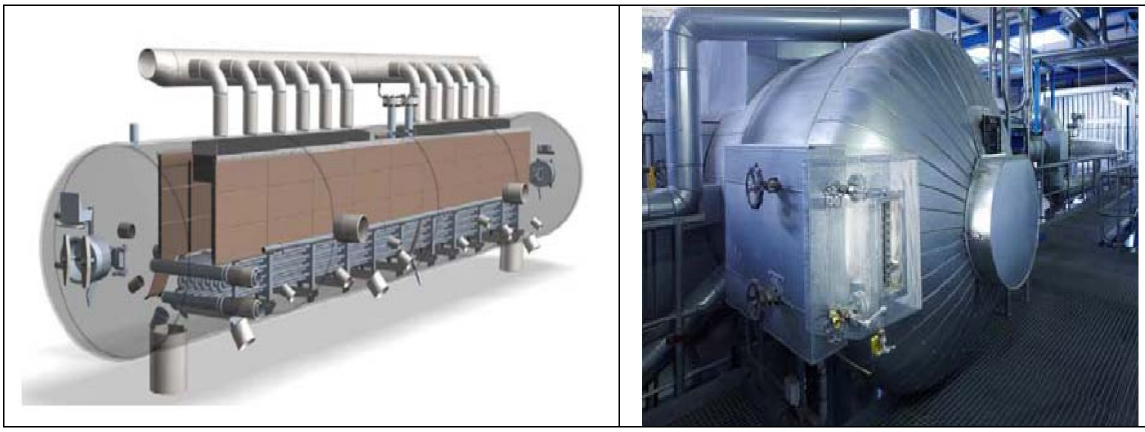
The boiler will incorporate a superheater system, of multi-stage design. The superheater surfaces are designed in the form of “harps” with lower and upper headers. An inter-stage attemperator will be provided between the super-heater stages. Stable steam temperature control will be achieved when burning the specified fuel within the operating range of the combustion diagram. Inspection doors will be provided to facilitate easy access between the superheater stages for inspection, cleaning and repair when necessary. The superheater is shown in Figure 5.7.

Figure 5.7: Superheater

5.7.4 Steam Drum

The steam drum will be provided with a complete set of baffles and mesh screens (demister) to ensure high steam purity. Feed water will be fed into the drum through an internal pipe which is designed for efficient water distribution. Nozzles will be provided on the drum to connect the required level gauges, transmitters, and other necessary instrumentation. These will be welded to the drum. Manholes, for access into the drum, will be fitted. The steam drum is shown in Figures 5.8a and 5.8b below.

Figure 5.8a and 5.8b: Steam Drum



5.7.5 External Economiser

An external economiser operating in counter-flow mode will be used. The economiser heating surfaces are designed in form of bundles, with inlet and outlet headers. The economiser bundles will be installed in a mild-steel plate casing provided with supports to locate the economiser elements, which will be of welded construction to ensure gas tightness. The economiser is shown in Figure 5.9.

Figure 5.9: External Economiser Section

5.7.6 Boiler Valves and Mounting

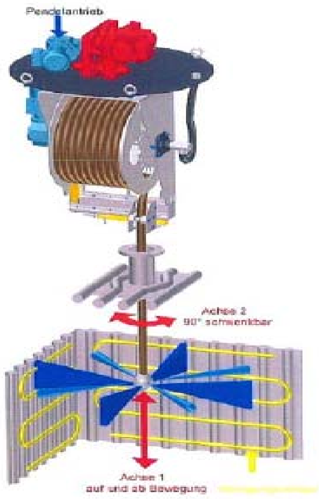
The boiler will incorporate a full compliment of valves, mountings and pipework required to safely operate it. In general, valves are weld on type except safety valves, blow-down valves and control valves, which will be flanged to allow rapid removal and replacement should the need arise. The integral and circulating pipe-work includes feeders to the water wall manifolds, the safety valve vent pipework, steam/water and drain connections to the drum mountings and pipework from the boiler feed water control valve to the economiser, and from the economiser to the drum.

5.7.7 Boiler Heating Surface Cleaning Devices

Shower Cleaning System (SCS)

This system is provided for cleaning of membrane walls of the 2nd and 3rd vertical boiler passes. During operation, a special flexible hose, with a nozzle lance, is introduced into the top of the boiler. This nozzle lance cleans the heating surfaces of the radiation passes with high pressure water jets. This ensures the heat transfer efficiency is maintained in the relevant temperature ranges of the boiler. The SCS arrangements are shown in Figures 5.10a and 5.10b below.

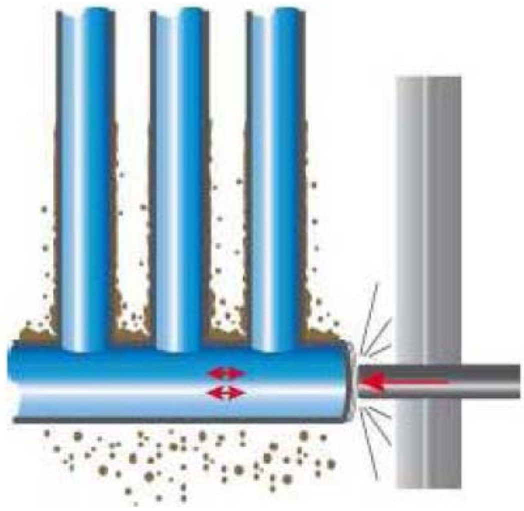
Figure 5.10a and 5.10b: SCS Systems



Mechanical Rapping Device

This is installed on both sides at the horizontal boiler pass for cleaning the convective heating surfaces of the super heater and evaporator. A rapping device is a special device for cleaning waste fired boilers. By rapping the convection heating surfaces, the tubes are made to vibrate so that the deposited combustion residues fall off. Cleaning takes place by means of mechanical hammers. The mechanical rapping device is shown in Figures 5.11a and 5.11b.

Figure 5.11a and 5.11b: Mechanical Rapping Systems

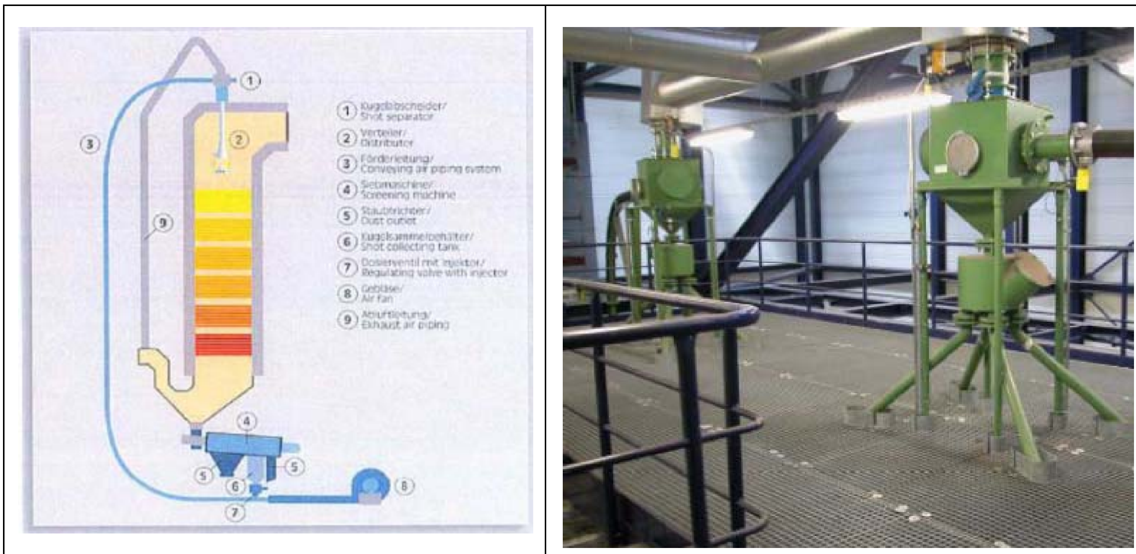


Ball-shot cleaning device

A ball-shot cleaning device is provided for cleaning the heating surface of the vertical economiser. Soft steel balls will be transported via a pneumatic conveyor (fan) to the top of the vertical economiser, where they will be uniformly distributed across the economizer heating surface via a special distribution system. Under gravity, the balls fall downwards through the economiser, impacting on the heating surfaces, causing any material adhering to them to be dislodged by impact. Underneath the hopper of the economiser, the balls will be separated from the ash, and transported to the storage vessel. When the cleaning cycle is repeated, the steel balls will again be transported to the top of the economiser. The ash from the economiser will be conveyed, together with the ash from other boiler passes, to the boiler ash silo located close to the flue gas treatment system.

The ball shot cleaning device is shown in Figures 5.12a and 5.12b.

Figure 5.12a and 5.12b: Ball Shot Cleaning System



5.7.8 Boiler Refractory

So as to protect the membrane walls within the furnace area from aggressive and unburned flue-gas, and to meet the required (WID_dependent) residence time of the flue-gas (2s; >850°C), the walls are lined with refractory materials. Components which are not directly cooled, such as certain boiler hoppers, are also lined with refractory materials so as to protect them against high temperatures. The boiler refractory layout is shown in Figure 5.13.

Figure 5.13: Boiler Refractory

5.7.9 Cladding 'Inconel 625'

The walls surrounding the furnace area above the standard refractory material will be clad with Inconel 625.. The cladding starts with an overlapping to the refractory lining of approximately 200mm, and covers the entire upper part and roof of the first and second boiler passes. In addition, the screen tubes between the first and the second pass will be clad with Inconel.

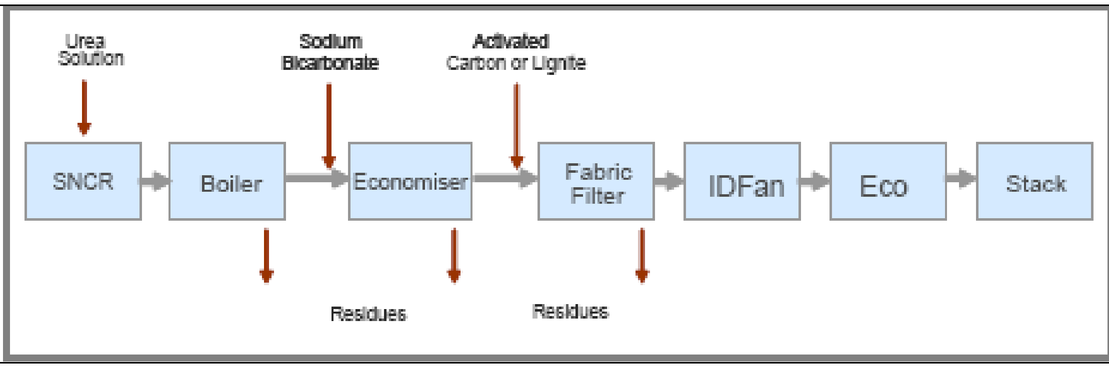
5.7.10 Thermal Insulation

The boiler unit and all hot ancillary components will be suitably insulated, using mineral wool, in order to achieve a cold face temperature of < 50°C above a design ambient temperature of 20°C.

5.8 Air Pollution Control

The air pollution control system (APC) is arranged as illustrated in Figure 5.14.

Figure 5.14: Air Pollution Control System (APC)



NOx removal takes place in the boiler by selective non-catalytic reduction (SNCR), which operates on the basis of urea injection into the flue gas. The reaction temperature at the top of the first boiler pass is slightly lower than the combustion temperature, and is at the optimum for the reaction between the urea solution and NOx. The flue gas then is cooled by the boiler and enters the economiser.

The acid gas constituents of the flue gas are removed in the vertical economizer pass area, by injection of sodium bicarbonate. This provides both an optimum reaction temperature and sufficient residence time for the reaction. On this basis, no dedicated reactor vessel is needed.

Activated carbon or lignite is also injected into the flue gas, downstream of the economiser, because of the lower temperature. Again, this temperature represents the optimum regarding the adsorption of dioxins, furans and mercury.

The reaction products, together with the fly-ash from the boiler, are then separated in the fabric filter. The ID fan downstream of the filter conveys the cleaned flue gas into Economiser 3 for recovery of residual flue gas heat. The flue gases are then released to atmosphere through the chimney. As there is no addition of water in the air pollution control system, the visible plume is minimised.

To enhance the reactions, a certain portion of the filter residue is re-circulated; this ensures maximum utilisation of the reagents. Air pollution control residue, which is a mixture of reaction products and fly-ash, is collected in twin silos, from which it is discharged into vehicles for transport to the final disposal point.

The design of the pollution control system is based on the typical composition of the raw gas entering the system, and includes generous margins to ensure control of emissions under all anticipated operating conditions.

Further description of the individual aspects of the pollution control system is given below, and in the Emissions Management Report (Application Volume 1, Part 7).

5.8.1 NOx Removal

The SNCR process is used in many modern incineration facilities, where the injection process uses compressed air for atomisation of a urea solution produced from urea pellets dissolved in demineralised water for injection and distribution into the combustion chamber. Two injection levels are provided, corresponding to the optimum temperature level at the various load conditions. Figure 5.15 below shows a typical arrangement of injection nozzles at the boiler wall.

Figure 5.15: SNCR Injection Nozzles

To ensure the optimum function of the SNCR process and to monitor the combustion closely, acoustic measurement of the flue gas temperature is provided, The injection is distributed to the respective level according to the temperature measured.

5.8.2 Dry Sorption

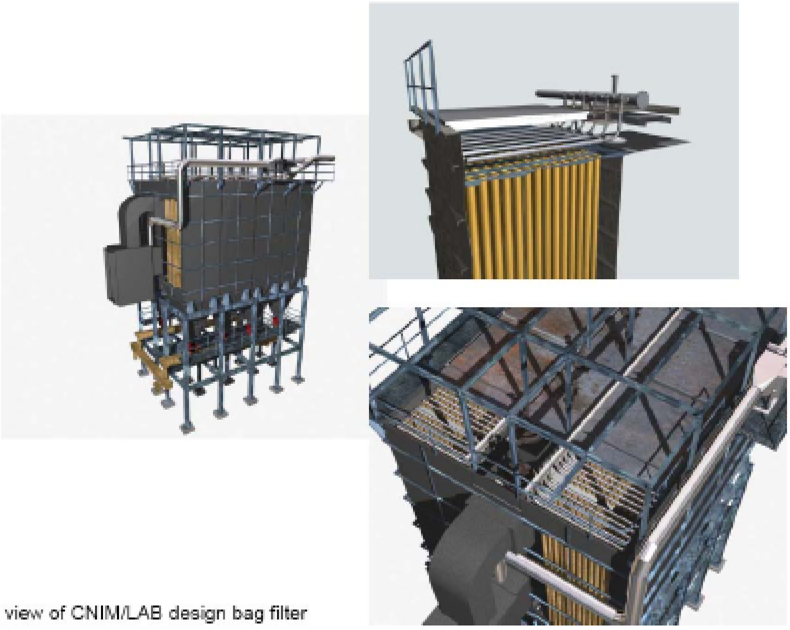
The bicarbonate process is used for dry sorption, which serves to remove sulphur dioxide, hydrogen chloride and hydrogen fluoride from the flue gases, a process which functions best at temperatures of between 200 and 240 °C. The injection point into the system is located to provide this gas temperature throughout the entire period between service intervals.

The second stage of the air pollution control system uses activated carbon, and a temperature of approximately 160 °C is suitable for final cleaning at optimum temperatures. The activated carbon injection is therefore located downstream of the economiser outlet and upstream of the fabric filter.

5.8.3 Fabric Filter

The fabric filter has six chambers. These are sized so that one chamber can be isolated under continuous full load operation, allowing for online inspection and repair work such as replacement of the bags. PTFE-coated material is used for the filter bags. Typical details are illustrated in Figure 5.16.

Figure 5.16: Fabric Filter



Typical view of CNIM/LAB design bag filter

5.9 Flue Gas Management

5.9.1 Flue Gas Ducts and Fan

All components upstream of the ID fan operate at negative pressure. The design margin of the fan is sufficient to comply with all anticipated operational variations in the incinerator. The emissions are measured at an appropriate platform around the chimney.

5.9.2 Flue Gas Recirculation

The design of the facility utilises flue gas recirculation to improve the thermal efficiency of the process, and is in line with BAT. This will also contribute to the control of NOx emissions.

5.9.3 Chimney

A single chimney of 95 metres height will be installed at the end of the process line.

5.10 Dump Stacks and Bypasses

There are no dump stacks or bypasses on the system.

5.11 Cooling System

The superheated steam from the boiler will be expanded in a steam turbine. The expansion of the steam will deliver energy in the form of shaft power which, in turn, will be used to drive an electrical generator. Provision will be made in the design of the steam turbine for steam extraction to provide steam to the existing Dockyard network.

The facility will use a high-efficiency, single shaft condensing steam turbine. The turbine will drive a water cooled synchronous generator via a reduction gearbox. The system will be complete with all necessary auxiliary water steam system equipment, valves, pipework and fittings. The turbine will be provided with oil systems for lubricating the turbine, reduction gearbox and generator main and subsidiary bearings, and for the high pressure hydraulic operation and servo control of the governing and emergency shut-off valves. The oil systems will have main, secondary and emergency pumps, as well as filtration and cooling systems. The facility will use a finned-tube, air-cooled condenser (ACC), to condense the exhaust steam from the steam turbine. In the ACC, the steam will be condensed under vacuum to extract the maximum practical mechanical energy from the expansion in the steam turbine.

The ACC will consist of several sections, as follows:

- Tube bundles in carbon steel with aluminium fins;
- A cooling fan system including adjustable blade pitch, frequency regulated electric motors, and direct drive reduction gear;
- Screening of the air intake and exit openings to reduce visual impact; and
- A steel support structure.

5.12 Power Generation

5.12.1 Overview

The energy recovered from the combustion process in the form of steam is utilised in the water/steam cycle. The steam produces not only electricity, but also is intended to supply heat to the Dockyard steam network. Medium-pressure steam is extracted from the turbine, at the appropriate pressure, for this purpose. As the Dockyard steam demand is seasonal, during the summer period the steam will be used mainly to generate power.

Air-cooled condensing is used for the turbine exhaust steam. The condensate is returned from the air cooled condenser to the boiler feed water system to form a closed loop system. The turbine or the water and steam system provides the live steam system pressure control, and controls the boiler pressure. Any fluctuation of the boiler steam generation is accommodated by the turbine while maintaining the upstream pressure with help of the turbine inlet control valves.

Operational power generation modes include power supply to the Dockyard network and public grid, which is based on the turbine set to inlet steam pressure control and network and grid synchronised. The other mode is ‘island’ operation, i.e. without the Dockyard/Grid connection, in which the turbine supplies only the facility’s internal demand. In this mode, the turbine operates in speed control and the surplus steam is condensed via the turbine bypass.

5.12.2 Turbine Generator

An extraction condensing turbine is used for power generation, which is rated for the relevant live steam peak flow. The turbine bypass avoids shut-down of the entire facility in case of a turbine failure. Also, during regular maintenance of the turbine, the facility can still process waste by importing power from the public grid.

Approximately 10% of the power produced by the generator in full-condensing mode under design-conditions provides the plant’s parasitic load. The balance of 90% is fed into the Dockyard electrical network via a step-up transformer. Any power generated in excess of the Dockyard demand is exported to the Grid.

Figure 5.17: Typical Turbine without Insulation or Sound Protection

5.12.3 Heat Supply

The plant systems include the steam supply to the Dockyard steam network, the condensate return from the Dockyard network is pumped back to the plant. The turbine extractions or bleeds also provide steam for plant internal heating services, such as combustion air preheating. The plant is fully operable with or without the external consumption of steam. In case of external steam or condensate losses, the plant is able to internally produce the demineralised water needed as replacement.

5.12.4 Air Cooled Condenser

The turbine dedicated air cooled condenser is based on the normal A-shape configuration, with seven cooling fans in a single row. The ACC is of a very low noise design, and is equipped with sound optimised, slow-running fans. The design capacity of the ACC is 100% of the design steam production. This means, that in the case of a turbine outage, the steam can completely bypass the turbine and be condensed in the ACC, so the plant can still operate at full load waste throughput.

5.12.5 Condensate and Steam Systems

Condensate and feed-water are handled by centralised systems serving the entire facility. The condensate returning from the air-cooled condenser, the external steam network or any other heater is ultimately collected in the boiler feed water tank. The tank capacity serves as the system buffer upstream of the boiler feed pumps.

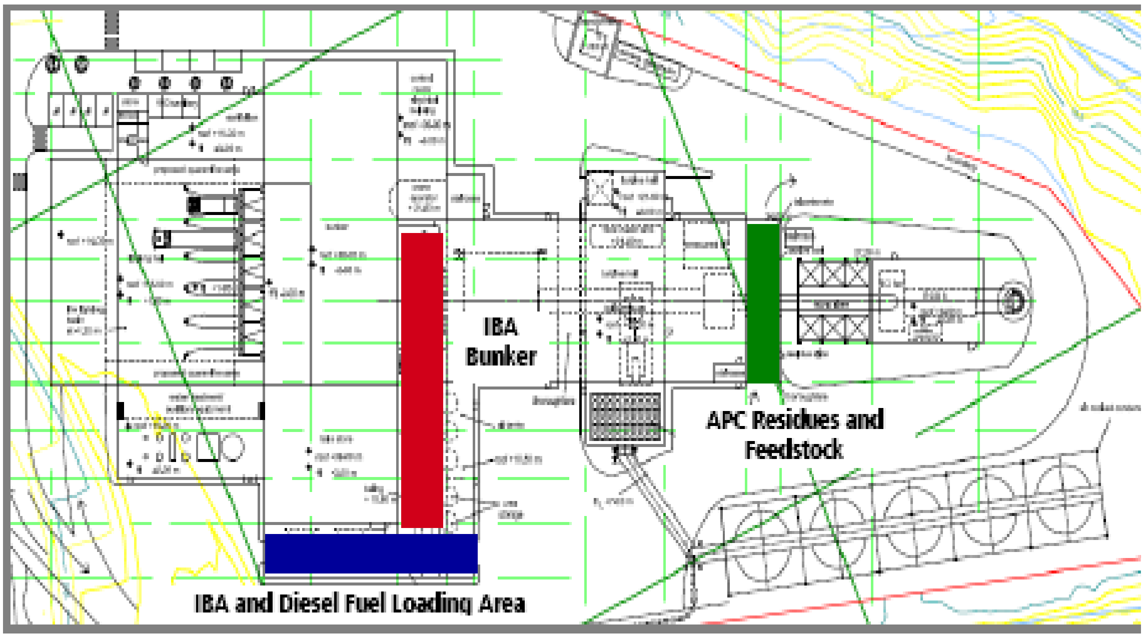
Redundant, electrically-driven, boiler feed water pumps are provided with 3 x 50% of maximum load. The boiler feed pumps are fitted with frequency converters to optimise the overall energy efficiency of the plant. The live steam system includes the main header for distributing the live steam generated by the boiler to the turbine at all load conditions. The medium pressure steam header is fed with steam from a turbine extraction for distribution to steam heaters. With the turbine offline, a valve feeds the header directly from the live steam system.

5.13 Auxiliary Systems

5.13.1 Storage of Reagents and Residues

The facility's equipment includes storage silos with capacities sufficient for seven days of plant operation. There are 4 storage silos; one each for sodium bicarbonate and activated carbon/lignite, and two for air pollution control residues. Transportation to and from the plant is carried out using enclosed road-tankers, which are loaded and unloaded by enclosed systems. Figure 5.18 shows the location of the loading areas for the main reagents and residues.

Figure 5.18: Reagent and Residue Loading Areas



5.13.2 Facility Utilities

Facility utilities, such as compressed air, cooling water and process water, will be provided by centralised plant systems. This provides for design and service redundancy.

6 Residual Materials Management

6.1 Introduction

This section provides evidence of the existence of relevant in-process controls for the management of residual materials produced from the waste treatment processes that have sufficient capacity to allow the effective management and control of the installation to the standard indicated by the Environment Agency *"Guidance For The Incineration of Waste and Fuel Manufactured From or Including Waste*" (SGN S5.01, Sections 2.5 and 2.6).

6.2 Residual Treatment Products

Residual waste treatment products generated from the facility are summarised in Table 7.1.

Table 7.1: Typical Residual Treatment Products Based on 245,000tpa Waste

Waste	Annual Tonnes	Source
Bottom Ash	58,800	• The bottom ash will be produced as a result of the combustion process, and will be passed into the ash discharger where it is quenched with recycled water. • Quenched ash will then be transported by conveyor to a concrete ash bunker contained inside the process building. • Ash removed from site will be transported in a covered rigid tipper lorry. • Ash will be processed off-site to recover metals and aggregate product
APC Residue	8,675	• APC residue is the combination of reaction products from the air pollution control system and fly ash from the boiler extracted from the flue gas by the bag filter. • Extracted APC residue will be conveyed to one of 2 storage silos, (185m^3 capacity) which is equipped with its own dust filter. • APC residue will be discharged into dry powder bulk tankers for transfer from site for landfill disposal.
Oil Wastes	<10	• These will mainly be generated from maintenance activities or from plant leaks, and any such material will be segregated and sent offsite for recovery/reuse.

6.3 Waste Minimisation

A waste minimisation audit will be undertaken during construction, during the first 12 months of operation, and then repeated every two years in accordance with SGN guidance. Minimisation techniques that will be employed at the facility will include:

- Routine inspections for early detection of leakage and other emission issues – this will be followed by prompt action to address any issues noted; and
- Maintenance of high standard of housekeeping across the Site; while
- The aim of the operation as a whole is to reduce the overall volume of the waste material going to landfill.

6.4 Waste Handling

6.4.1 General Storage Arrangements

Facility infrastructure arrangements for storage have been designed to satisfy the requirements of relevant EA guidance, and the general principles employed are to:

- Ensure that watercourses, including those connected directly to ground-water, are protected through the use of a self-contained drainage system, while no open topped tanks or vessels will be utilised for the storage or treatment of liquid wastes;
- Minimise the double-handling of waste materials, enabling the development of transport routes to provide for the direct transfer of material between process stages and to final storage arrangements;
- Ensure that there is no uncontrolled venting to atmosphere at the facility with relevant controls having been put in place, as follows:
  a. Storage vessels are equipped with relevant level monitors such that overflow pipes connected to storage vessels can be directed to the appropriate containment area; and
  b. Bicarbonate, activated carbon and APC residue silos are equipped with level monitoring and dust abatement in the form of a filter.
- Ensure in all spillages due to infrastructure deterioration (e.g. leaks, etc), system overfilling, equipment failure, or other accidental releases being logged, investigated and appropriate corrective action taken – to assist with spillage management, relevant spill response equipment will be situated at various locations around the site, designed for the particular hazard characteristics of the waste materials present;
- Specify areas that have been identified for discharge operations, ensuring the safe unloading and discharge of accepted wastes – the majority of discharge is undertaken within an enclosed reception facility;
- Produce a fire risk assessment, which will be developed throughout the design process and will specify appropriate arrangements for alarms and dealing with fires. This will be audited routinely to ensure continued effectiveness in relation to activities which present a defined fire risk (e.g. welding, grinding, etc). Such activities may be required during plant maintenance and operation and as such an appropriate assessment will be undertaken at the time of the work, and a 'permit to work' raised when appropriate controls have been put in place; and
- Manage vehicle and pedestrian access at the Site, such that:
  a. The whole site will be monitored by CCTV;
  b. Access is only through a secure entrance requiring reporting to site reception;
  c. All non-waste vehicles are required to be parked in a designated car park situated away from waste storage areas;
  d. Process areas are designated as "restricted access" as necessary; and
  e. Pedestrian and vehicle routes within the site are reviewed as part of a total traffic management plan currently in progress.

6.4.2 Residual Waste Storage and Handling

Residual materials will be stored as detailed in Table 7.2.

Table 7.2: Residual Material Storage

Waste	Annual Tonnes	Site Storage
Bottom Ash	58,800	• Concrete bunker inside processing building (size 1540m^3)
APC Residue	8,575	• Storage silos (185m^3 x 2)
Oil Wastes	<1	• Secure drum containers

6.5 Waste Recovery

6.5.1 Ash Recovery Options

The IBA remaining after combustion equates to approximately 24% by weight of the input waste, this equates to approximately 58,800 tonnes annually. Bottom ash, including commingled metals, will be discharged from the end of the combustion grate directly into the ash quench bath. From there, the ash will be transferred by means of an ash extraction conveyor into the ash bunker. The bunker will have a sloping floor so that surplus quench water runs back into a collection sump and can be returned to the quench bath from time to time. The ash retains about 20% by weight of the water from the quench bath. The bottom ash will be loaded by means of an automatic travelling overhead grab crane into a collection vehicle. The vehicle will be sheeted before leaving the ash loading station.

The IBA will be processed at an off site facility situated at Whitecleave Quarry in Devon, owned by Sam Gilpin Demolition Ltd. MVV will submit a planning application and construct the plant, which will be operated by Gilpin, to utilise a significant proportion of bottom ash as a secondary aggregate.

The mechanical processing will include screening and removal of ferrous and non-ferrous metals. At least 95% of the output IBA (target 99%) will be reprocessed as a secondary aggregate with the remainder sent to an appropriately licensed landfill site – possibly at Heathfield or New England Quarry which are both nearby – as inactive waste attracting the inert waste landfill tax. The treated IBA can be used in highway works, pavement concrete, landfill engineering projects, quarry restoration and brownfield remediation projects.

IBA will be sampled and analysed in accordance with the ESA Ash Sampling Protocol to confirm that it is non-hazardous and can be used for aggregate production.

6.5.2 Ferrous & Non-Ferrous Metal Recovery

Ferrous and non-ferrous metals will be recovered from the Incinerator Bottom Ash (IBA) during processing at an off site IBA processing centre. The levels of ferrous and non-ferrous metals remaining in the IBA is a function of the input waste composition which is in turn is largely dependent on the levels of recycling achieved by Waste Collection Authorities and commercial and industrial waste collectors. Metals might typically represent approximately 3.5%, by weight. At least 90% of the metals received under the waste contract will be recovered during this process. Gilpin will make arrangements with metal merchants to collect and recycle the ferrous and non-ferrous metals recovered from the IBA thus avoiding landfill and achieving high diversion rates.

6.6 Waste Disposal

6.6.1 Residuals when EfW Facility is not Available

The provision of additional storage capacity in the bale-store for incoming waste streams means that waste can continue to be accepted throughout planned major shutdowns. As such it is not expected that incoming waste streams will need to be diverted to landfill or alternative treatment facilities.

6.6.2 Bottom Ash

Around 5% of the IBA produced will not be suitable for aggregate production and arrangements will be made to dispose of this material at a suitable landfill.

6.6.3 APC Residues

APC residues, which are hazardous in nature, will be transported to Waste Recycling Group's, Knostrop Works, in Leeds, for pre-treatment, and then on to the Winterton Landfill, Scunthorpe, for final disposal. Vehicles transporting APC from the facility will exit the facility onto the A3064, and from there access the A38 and head north using the motorway network.

APC residue will be sampled and analysed in accordance with the ESA Sampling Protocol to confirm if it is hazardous. A typical APC residue analysis is shown in Table 7.4.

Table 7.4: Typical Chemical Content of APC Residues

Parameter	Unit	Value
Fly ash	%	39.40
Sodium Chloride (NaCl)	%	30.17
Sodium Sulphate (Na_2SO_4)	%	19.30
Sodium Sulphite (Na_2SO_3)	%	0.00
Sodium Fluoride (NaF)	%	0.30
Sodium Carbonate (Na_2CO_3)	%	8.42
Mercury II Hydroxide ($Hg(OH)_2$)	%	0.01
Cadmium Hydroxide ($Cd(OH)_2$)	%	0.03
Activated Lignite	%	2.37
Total	**%**	100

7 Plant Commissioning

7.1 Timetable for Plant Development

The proposed timetable for the development is shown in Appendix C and completion in the indicated timeframe is dependant on planning.

7.2 Commissioning and Acceptance

Following the construction of the facility, a series of tests will be undertaken to ensure that all operations within it function correctly.

Initially the plant will undergo cold commissioning, which is the period in which individual plant items, electrical, control and instrumentation systems are tested and proved. Activities such as boiler cleaning, pipework cleaning, and cleaning of tank internals are carried out. Test sheets will be developed by the technology sub-contractors and will be submitted to MVV within two weeks of the completion of cold commissioning process.

Once all the cold commissioning has been undertaken and verified, a certificate of completion will be issued, which indicates that the plant is ready to undergo the hot commissioning process.

The hot commissioning processes are defined as those activities which require heat application, initially by the application of oil burners, then subsequently by the treatment of waste. Substantial amounts of equipment will be operated jointly, simulating operational conditions at the facility. Hot commissioning activities will include curing refractories, steam purging of pipework and the optimisation of process controls.

During the hot commissioning process the readiness tests will be undertaken prior to the first delivery of waste. and the acceptance tests following the delivery of waste

The readiness and acceptance tests will be monitored by an independent certifier, and within 15 days of the completion of commissioning, the technology sub-contractor(s) will submit a commissioning report confirming the works undertaken and any adjustments which were necessary. The report will include all measurements, settings and adjustments, and will include pipework spring settings, alarm settings, valve adjustments and similar data.

The commissioning report will be included within the final Operation and Maintenance Manuals.

The reliability test and trial operation will be carried out so that the construction sub-contractor can demonstrate to MVV that the facility can perform under all stable and transient operating conditions. The reliability test will commence on the same date as the acceptance tests, will be carried out concurrently with the acceptance tests and will be of 15 days duration. The intention of the reliability test is to demonstrate that the facility is ready to proceed with the trial operation.

On satisfactory completion of the reliability test, the trial operation period will commence and continue for a period of 28 days of continuous operation to demonstrate that the facility can perform under all stable and transient operating conditions required for its normal operation. This will include tests to show that the:

a) Facility may be started up and shut-down, in a well-controlled manner, using the methods described in the construction sub-contractor's draft instruction manuals, without the use of any special or unusual skills on the part of the operators and without imposing any stress or loading on any plant or equipment item beyond that for which it is designed;

b) Facility may be shutdown satisfactorily under emergency conditions using the methods described in the construction sub-contractor's draft instruction manuals;

c) Facility may be run in a stable manner at the extremes of the firing diagram under automatic control;

d) Turbine/generator can process the steam flow at Maximum Continuous Rating;

e) Facility can automatically switch over to and operate in Island mode; and

f) Performance guarantees are achieved in all respects.

If any failure or interruption occurs in any portion of the facility due to, or arising from, faulty design, materials or workmanship (but not otherwise) sufficient to prevent full use of the facility, the trial operation period will recommence in accordance with the EPC Contract after the construction sub-contractor has remedied the cause of the defect. Minor defects, such as instrument faults or equipment faults requiring the operation of standby systems, will not constitute a failure of the trial operation, provided that the overall facility continues to operate satisfactorily and that the faults are rectified and are not persistent.

Guaranteed performance tests will be carried out during the trial operation period so that the construction sub-contractor can demonstrate to MVV that the facility meets the guarantee performance standards required by the construction sub-contract. All such tests shall be witnessed by the independent certifier in accordance with the project agreement. As a minimum the following performance values will be continuously measured and recorded while the facility is working at MCR and control stability has been reached:

a) Throughput of Waste;

b) The boiler flue gas exhaust temperature;

c) Steam production and steam conditions;

d) The amount of electricity produced and electricity exported;

e) Chimney flue gas mass flow rate and composition; and

f) Compliance with any relevant consents.

A simplified heat balance method, with assumed heat loss values, will be agreed with the construction sub-contractor prior to the test which will be used to determine the effective lower heating value (LHV) of the waste which, together with measured throughput, is required to verify the performance. During these tests, the following will be verified: an initial check of consumption rates and measurements of parameters mentioned as reference design values will confirm that the facility is performing acceptably. In principle these checks will be made using normal available facility measuring equipment only.

The guarantee performance tests will be carried out by an independent testing agency. MVV will agree with the construction sub-contractor, a detailed guarantee performance tests programme and procedure at least 60 days prior to the date of commencement of the programme, covering the testing to be undertaken and the methods to be employed. The tests will be conducted in accordance with the detailed procedures prepared by the testing agency on behalf of sub-contractor, and approved by MVV.

The guarantee performance tests procedure will also detail areas of responsibility and the items that specifically require preparation and agreement before the tests can be carried out. During each test, the measured values will be recorded and evaluated jointly by the construction sub-contractor and principle contractor. After completion of the guarantee performance test, the result sheets will be signed and copies distributed to each party.

All test instruments will be supplied with up to date calibration certificates issued by an independent testing laboratory. The difference between the certification date and the actual guarantee performance test start date will not be greater than three months. Where the installed facility instrumentation is used for the tests, calibration checks will be conducted immediately prior to the tests and will be witnessed by MVV.

The calibration of all instruments used for guarantee measurements will be re-checked within one month after the guarantee performance test. If significant errors are found, MVV may call for the appropriate test to be repeated after such errors have been corrected. MVV may provide additional check instruments, with certified calibrations, as a back up to the permanent instrumentation. The tests will be carried out in accordance with the following conditions:

a) During the period of any test, the operating conditions will be held as steady as possible, compatible with safe and effective operation, or as stated by the relevant testing code;

b) If the construction sub-contractor so desires, the facility may be run for a reasonable time at any load up to that which the test is to be made, immediately before the test is taken; a request for this run, stating duration and load must be made in writing to MVV before the official test;

c) If the construction sub-contractor considers it necessary to carry out maintenance procedures or cleaning, prior to performance testing then he will be so entitled providing:

    - No manual cleaning of boiler heating surfaces is allowed prior to the guarantee performance tests;
    - The construction sub-contractor will provide all parts, materials, consumables and supervisory labour;
    - All parts so replaced and materials used will remain in situ; and
    - The parts and materials so used will not be deducted from the contractual spare parts and materials to be provided under the construction sub-contract.

d) All margins required for instrument inaccuracies and for all other reasons will be in accordance with the relevant codes and will be deemed to be included in the guarantee figures; no other tolerances will be allowed;

e) Should the measured value be in accordance with the guaranteed value, the construction sub-contractor will be given the opportunity of making adjustments after which the test is to be repeated;

f) All auxiliary systems necessary to support the Works in a safe condition during normal operation will be required to run throughout the guarantee performance tests; the power absorbed by the auxiliaries in the course of the tests will be measured and recorded;

g) The results of the tests will be correlated to the specified conditions by pre-determined correction factors, which will be defined by means of correction curves developed by the construction sub-contractor and approved by MVV; copies of these curves will be included in the facility's Operating and Maintenance manuals;

h) The tests will be carried out in compliance with code IEC 953 – 2 for gross power output and the VGB-R 131- first edition 1997 for air-cooled condenser capacity in bypass operation and the FDBR Guideline "Acceptance Testing of Waste Incineration Plants with Grate Firing Systems";

i) Air-cooled condenser exchange surfaces will be inspected by MVV before the beginning of the tests, and if necessary surface(s) will be cleaned by maintenance staff under the supervision of MVV;

j) The guarantee performance tests will also include, but not be restricted to, those tests necessary to demonstrate that an acceptable working environment is provided with respect to:

- Ambient temperatures and ventilation within equipment areas;
- Noise levels within buildings, offices etc.;
- Control of fugitive emissions;
- Noise levels at sensitive receptors as required by any authorisations;
- Surface temperatures; and
- Health and safety requirements.

During all tests, the calorific value of the waste, averaged over each test period, will be checked using weighed inputs (from the crane measurement system) and the equipment instrumentation to ensure that waste LHV is within the range of permitted calorific values for the operation of the facility at MCR and over the full design range shown in the firing diagram included in the construction sub-contract. The construction sub-contractor will provide all necessary permanent instrumentation, calibrated to the necessary degree of accuracy to facilitate this assessment.

Subject to the submission by the construction sub-contractor of calculations confirming the thermal losses due to radiation, convection, heat losses in the ash, fly ash, flue gas and other losses, the LHV of the Waste may be calculated using the equipment instrumentation. If in doubt about the validity of this procedure, MVV will have the right to insist on the sampling of waste and the measurement of the calorific value of the sample.

The construction sub-contractor will provide permanent facilities within the plant for measuring the rate of consumption of reagents, water, power, fuel and other consumables subject to the performance guarantees. The consumption of consumables will be determined over a continuous period of not less than two weeks duration coincident with the guarantee performance tests for the facility.

Guarantee performance tests that require operation at conditions other than at MCR for the consumption of consumables will be carried out either before the start or after the completion of the two week period.

The construction sub-contractor will demonstrate that the required maximum consumption values are not exceeded by determining the daily mean values of the respective guaranteed value. The values being determined will be corrected to the guarantee conditions by considering the actual operational parameters, if this is appropriate and agreed by MVV. The corrections will be made by means of the correction curves and formulae provided by the construction sub-contractor.

Measurement of the maximum noise levels will be carried out during the guarantee performance tests when the facility is operating, and all equipment areas will be assessed to measure compliance with the guaranteed performance levels.

For the measurement of the noise levels required by any planning condition and/or the Environmental Permit, as appropriate, measurements will be taken before the facility is operational to determine background levels and with the facility in operation.. All tests will be carried out in accordance with BS4142.

The results of the guarantee performance tests will be evaluated by the independent testing agency and compiled into a report.

Following satisfactory completion of the guarantee performance tests as demonstrated by the report issued by the independent testing agency MVV will issue the take over certificate to the construction sub-contractor.

8 Plant Maintenance

8.1 Installation Maintenance – Strategic Overview

The key objectives of MVV's maintenance strategy are to:

- Extend the period of uninterrupted operation;
- Minimise outages durations; and
- Minimise the outage frequency

The EfW/CHP facility will be operated and maintained by MVV Devonport Limited, using staff transferred from MVV O&M in Germany, and locally employed staff. All of the practices outlined are based on the proven practices and experience of MVV in Germany.

8.2 Planned Maintenance

8.2.1 Maintenance Strategy

The aim is to keep the facility operating at the optimum level of efficiency in terms of waste throughput, consumables (additional fuel, operating resources, and electricity), energy output and wear and tear. To support the achievement of this, MVV will coordinate the operations and maintenance of the EfW/CHP facility and share best practice information between its operations and maintenance functions.

MVV will monitor the condition of components and fuel quality and shall aim to standardise plant control systems, components and recurring activities to support continuous improvement in the availability of the EfW/CHP facility. A schedule of Programmed Maintenance will be developed prior to the plant becoming operational and this will be implemented in each subsequent year. The main elements of the maintenance strategy will include:

- Key components of the EfW/CHP facility shall be subject to major overhaul or replacement in accordance with the manufacturer's recommendations;
- MVV will keep all major parts critical to availability in stock to enable it to react quickly, flexibly and independently to unforeseen events and outages;
- Where activities are not carried out by MVV staff, MVV will develop long term partnerships with reliable third party companies to support the smooth operation of the EfW/CHP facility and reduce the likelihood of unavailability;
- MVV will maintain the EfW/CHP facility in accordance with its established systems based on a company wide knowledge exchange, and in doing so will support the principle of continuous improvement, where appropriate; and
- Intensive equipment overhauls and major repairs will be performed by suppliers and outside contractors, and MVV will establish relationships with sources of local labour for additional support; the in-plant maintenance group will focus on development activities, minor repairs to keep the equipment on-line, the efficient return of equipment for servicing, planning of scheduled maintenance, and the supervision of outside contractors.

8.2.2 Maintenance Organisation

Maintenance functions will be directed by the maintenance engineer, in close coordination with the operations department. The maintenance engineer will implement preventive and predictive maintenance programs, direct routine and corrective maintenance, plan and schedule all major maintenance outages, and manage the activities of vendors and subcontractors performing maintenance tasks.

Maintenance technicians will perform corrective maintenance, as required, including emergency repairs to return the facility or a piece of equipment to service as quickly as possible after a failure. During outages, and at other times as necessary, mechanical and electrical maintenance technicians will supervise and assist in the activities of contract personnel and operations staff members performing maintenance duties.

The maintenance group will be responsible for communications, data entry associated with the computerised maintenance management system, warehouse activities, including receiving and shipping, the preparation of requisitions, and other duties as required.

8.2.3 Maintenance Duties

The duties and responsibilities of the maintenance department of the facility will include:

- All necessary maintenance, repair and testing;
- Planning, organising and managing maintenance, repair and testing services, and carrying out scheduled inspections, overhauls and all breakdown repairs including major repairs;
- Maintaining the facility so as to keep it in substantially the same condition as at the commissioning phase except for fair wear and tear;
- Routine periodic and occasional testing, including non-destructive testing;
- Maintenance records for the generating equipment, and control and protective equipment, maintaining a register of all equipment subject to statutory inspection and inspection in accordance with the standing instructions, including recording all test dates and results;
- Maintaining a plant status report, which will be updated at regular intervals, in which the current condition of all major items of equipment will be recorded, together with proposals and timing for major repair work and cost estimates;
- Maintaining stores and spares inventory, as required;
- Maintaining sub-contractor control and supervision;
- Mark up of material changes to as-built drawings, resulting from work carried out on the facility or any part thereof by the operator or sub-contractors engaged by or on its behalf;
- Ensuring the retention of key plant knowledge within the respective maintenance departments, MVV O&M technicians will supervise and assist in the activities of contract personnel and operations staff performing maintenance duties within their speciality; and
- Ensuring that the maintenance department works in close cooperation with the operations department, to carry out continuous evaluation of facility systems and maintenance/availability improvement opportunities, including improvements in efficiency, reductions in cost, and increases in reliability.

8.2.4 Plant or Equipment Availability

The anticipated EfW/CHP facility availability will be more than 90% or 7,884 hours per year. A bale-store, with provision for 28 days storage, will be provided to facilitate ongoing acceptance of waste during plant shutdowns.

During shutdowns, the cranes will continue operating, mixing and clearing the incoming waste from the tipping area and feeding the baling system instead of feeding the combustion chamber. The baled waste will be immediately transported to the bale-store. Therefore there is no adverse external visual impact on the site during outages or baling campaigns. In general the planning of the main maintenance shutdown of the year will be synchronised with the normal annual downward fluctuation in waste arisings. Additionally, the waste flows are managed so that stored waste is maintained at a minimum.

8.3 Reactive Maintenance

Reactive maintenance personnel will be available seven days a week. Outside normal working hours this will be provided by UK based emergency teams on call, to ensure maximum availability of the facility.

In order to be able to react flexibly and independently to unforeseen events, MVV will keep major parts critical to availability in stock in order to be able to take quick action and minimise disruption.

In cases of serious breakdowns, an expert team from within MVV's existing facilities will be flown in to support the local staff. Furthermore, operating engineers from MVV's existing facilities can guide the operating staff by connecting via secure internet to the plant monitoring system.

In case of a fault that materially affects the operational efficiency and represents an emergency situation causing environmental nuisance, MVV will notify the EA within 60 minutes of becoming aware of the fault.

8.4 Maintenance Programmes

8.4.1 Scheduled Maintenance

Once the maintenance requirements have been defined in accordance with manufacturer's recommendation, industry best practice and MVV's internal best practice, scheduled maintenance activities will take place as follows:

- Daily;
- Weekly;
- Fortnightly;
- Monthly; and
- Quarterly.

8.4.2 Annual Shutdowns

Annual preventive maintenance and repair work will be scheduled over longer time periods, may involve modifications to the facility and shall be prepared and implemented with the assistance/support of external companies. The frequency of scheduled annual shutdowns will generally be minimised to one short time shutdown of 7 days and one revision of approximately 21 days per annum.

In the event of an annual shutdown the maintenance department will be responsible for:

- Scheduling;

- Technical monitoring;
- Inspection and feedback;
- Quality monitoring; and
- Supervision of teams.

8.4.3 Preventative Maintenance

Each item of equipment relevant to the availability of the facility will be monitored by means of a log. Anomalies, breakdowns and servicing shall be recorded. Preparation and analysis shall be used to enable preventive maintenance procedures to be developed according to manufacturers' recommendations. These actions will enable a full preventive maintenance plan to be scheduled. The status of all equipment will be supervised daily, weekly and monthly and the following operating criteria of the facility shall be monitored and analysed:

- Number of hours of operation;
- Temperature of the mechanical components;
- Vibration data; and
- Equipment voltage and current etc.

This scheduled maintenance programme will be used by MVV to minimise maintenance costs.

8.4.4 Responsive Maintenance

Responsive maintenance will be available seven days a week. Outside normal working hours, this will be provided by emergency teams on call, to ensure maximum availability of the facility. In order to be able to react flexibly and independently to unforeseen events we shall keep all parts relevant to availability on stock in order to be able to take quick action and minimise disruption. In cases of serious breakdowns, an expert team from within our existing network of facilities will be flown in to support the local staff.

8.4.5 Maintenance Reporting

To support the ongoing improvement of maintenance procedures, reductions in maintenance costs and higher efficiency, detailed reporting and assessment of maintenance works carried out shall be undertaken. This assessment will look at breakdowns as well as reviewing major maintenance works and annual shutdowns.

MVV will use a process monitoring system to conduct breakdown analyses. Conclusions and suggestions for improvements will be extracted and used in regular peer reviews within the operations and maintenance network. In advance of a planned shutdown, a detailed maintenance program will be provided, the necessary equipment ordered and staff engaged. The detailed maintenance program will be compiled each year individually by actual issues of the operation and updated on a monthly and annual basis.

8.4.6 Spare Part Management

Arrangements will be made with each of the equipment suppliers for critical spares, which cannot kept on site, to be delivered to the site on a 24 hours per day/7 days per week basis. The maintenance department will be responsible for the supervision and management of spare parts stock, and will be supported by a computerized SAP inventory system which retains a digital record of the inventory.

The procurement of spare parts will also be supported by the SAP system; purchase requests will be automatically initiated and will be evaluated by the maintenance engineer to ensure that the spare parts supply is always available. Spare parts for major scheduled maintenance works will be procured in advance according to the maintenance plan and the time schedule.

In order to be able to react flexibly, and independently, to unforeseen events and outages, the philosophy implemented at MVV is to keep all parts relevant to availability in stock in order to be able to quickly take action during any availability disruption. With regards to the activities not carried out by MVV staff themselves, long-term partnerships with reliable local companies will be established. MVV's experience shows that this is proven to be a factor for success. These long-term partnerships with local companies are based on mutual reliance and annually reviewed contract agreements.

Appendix A List of Wastes To Be Accepted

EWC Code	Waste Description
02	**WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING & FISHING FOOD PREPARATION & PROCESSING**
02 01	**Wastes from agriculture, horticulture, aquaculture, forestry, hunting & fishing**
02 01 02	animal-tissue waste
02 01 03	Plant-tissue waste
02 01 04	Waste plastics (except packaging)
02 01 06	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
02 01 07	Wastes from forestry
02 01 09	Agrochemical waste other than those mentioned in 02 01 08
02 02	**Wastes from the preparation and processing of meat, fish & other foods of animal origin**
02 02 02	animal-tissue waste
02 02 03	Materials unsuitable for consumption or processing
02 03	**Wastes from fruit, vegetables, cereals edible oils, cocoa, coffee, tea and tobacco preparation & processing; conserve production; yeast & yeast extract production, molasses preparation & fermentation**
02 03 04	Materials unsuitable for consumption or processing
02 05	**Wastes from the dairy products industry**
02 05 01	Materials unsuitable for consumption or processing
02 06	**Wastes from the baking and confectionery industry**
02 06 01	Materials unsuitable for consumption or processing
02 06 02	Wastes from preserving agents
02 07	**Wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea & cocoa)**
02 07 01	Wastes from washing, cleaning and mechanical reduction of raw materials
02 07 02	Wastes from spirits distillation
02 07 04	Materials unsuitable for consumption or processing
03	**WASTES FROM WOOD PROCESSING AND THE PRODUCTION OF PANELS AND FURNITURE, PULP, PAPER AND CARDBOARD**
03 01	**wastes from wood processing and the production of panels and furniture**
03 01 01	waste bark and cork
03 01 05	sawdust, shavings, cuttings, wood, particle board and veneer other than those mentioned in 03 01 04
03 03	**wastes from pulp, paper and cardboard production and processing**
03 03 01	waste bark and wood
03 03 07	mechanically separated rejects from pulping of waste paper and cardboard
03 03 08	wastes from sorting of paper and cardboard destined for recycling
04	**WASTES FROM THE LEATHER, FUR AND TEXTILE INDUSTRIES**
04 01	Wastes from the leather and fur industry
04 01 08	Waste tanned leather (blue sheetings, shavings, cuttings, buffing dust) containing chromium
04 01 09	Wastes from dressing and finishing
04 02	**Wastes from the textile industry**
04 02 09	wastes from composite materials (impregnated textile, elastomer, plastomer)
04 02 10	organic matter from natural products (for example grease, wax)
04 02 21	Wastes from unprocessed textile fibres
04 02 22	Wastes from processed textile fibres
09	**WASTES FROM THE PHOTOGRAPHIC INDUSTRY**
09 01	**wastes from the photographic industry**
09 01 07	photographic film and paper containing silver or silver compounds
09 01 08	photographic film and paper free of silver or silver compounds
15	**WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED**
15 01	**Packaging (including separately collected municipal packaging waste)**
15 01 01	Paper and cardboard packaging
15 01 02	Plastic packaging
15 01 03	Wooden packaging
15 01 04	Metallic packaging
15 01 05	Composite packaging

EWC Code	Waste Description
15 01 06	Mixed packaging
15 01 07	Glass packaging
15 01 09	Textile packaging
15 02	**Absorbents, filter materials, wiping cloths and protective clothing**
15 02 03	Absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02
17	**CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)**
17 02	**Wood, glass and plastic**
17 02 01	Wood
17 02 03	Plastic
17 09	**Other construction and demolition wastes**
17 09 04	Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03
19	**WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS & PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION/INDUSTRIAL USE**
19 02	**Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)**
19 02 03	Premixed wastes composed only of non-hazardous wastes
19 02 10	Combustible wastes other than those mentioned in 19 02 08 and 19 02 09
19 04	**Vitrified waste and wastes from vitrification**
19 04 01	Vitrified waste
19 05	**Wastes from aerobic treatment of solid wastes**
19 05 01	Non-composted fraction of municipal and similar wastes
19 05 02	Non-composted fraction of animal and vegetable waste
19 05 03	Off-specification compost
19 06	**wastes from anaerobic treatment of waste**
19 06 04	digestate from anaerobic treatment of municipal waste
19 06 06	digestate from anaerobic treatment of animal and vegetable waste
19 08	**wastes from waste water treatment plants not otherwise specified**
19 08 01	screenings
19 10	**wastes from shredding of metal-containing wastes**
19 10 04	fluff-light fraction and dust other than those mentioned in 19 10 03
19 12	**Wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified**
19 12 01	Paper and cardboard
19 12 02	Ferrous metal
19 12 03	Non-ferrous metal
19 12 04	Plastic and rubber
19 12 07	Wood other than that mentioned in 19 12 06
19 12 08	Textiles
19 12 09	Minerals (for example sand, stones)
19 12 10	Combustible waste (refuse derived fuel)
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11
20	**MUNICIPAL WASTES (HOUSEHOLD AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS**
20 01	**Separately collected fractions (except 15 01)**
20 01 01	Paper and cardboard
20 01 08	Biodegradable food waste
20 01 10	Clothes
20 01 11	Textiles
20 01 25	edible oil and fat
20 01 37*	Wood containing dangerous substances
20 01 38	Wood other than that mentioned in 20 01 37
20 01 39	Plastics
20 01 99	Other fractions not otherwise specified
20 02	**Garden and park wastes (including cemetery waste)**
20 02 01	Biodegradable waste
20 02 03	Other non-biodegradable wastes

EWC Code	Waste Description
20 03	**Other municipal wastes**
20 03 01	Mixed municipal waste
20 03 02	Waste from markets
20 03 03	Street-cleaning residues
20 03 04	Septic tank sludge
20 03 06	waste from sewage cleaning
20 03 07	Bulky-waste
20 03 99	Municipal wastes not otherwise specified

Appendix B Typical CFD Model

Appendix C Plant Development Programme