INTERMEDIATE TECHNOLOGY CONSULTANTS

Study Visit to South Africa

Low Cost Solid Waste Incinerator

Project No.	2C98028
Work Package Number	1.1.8
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Date:29th July1999

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Table of Contents

ACKNOWLEDGEMENTS

We would like to especially thank the following public servants for the time taken from their busy schedules during our South Africa visit:

Judy Butcher	Ixopo TLC	Town Clerk
Joyce Hammond	Ixopo Ixopo TLC	Environmental Health Officer
Peter Robins	Himeville TLC	CEO
Allan Haywood	Himeville TLC	Chairman
Anton Henn	Caledon TLC	Health Service

We would like to thank as well all other people that have taken time out of their busy schedules to talk to us during our visit.

EXECUTIVE SUMMARY

This visit was undertaken to investigate the existing small-scale low to medium cost incineration projects at three locations in South Africa: Ixopo and Himeville in KwaZulu Natal Province and Caledon in Cape Province. In addition to investigating the incinerators, discussions were held with a number of organisations, groups and individuals with an interest in incineration, including local authorities, waste management consultants, and an environmental pressure group.

Four South African designed and manufactured incinerators were investigated: a local design built on site at Himeville, a Toxic 400 installed at Ixopo, two recently installed DISA incinerators at Caledon and the Macro Burn 500 (manufacturer's head office is in Johannesburg). The incinerators at Himeville and Ixopo are operational and were seen in operation. It was not possible to see the two incinerators at Caledon or the Macro Burn incinerator in operation, although videos of similar incinerators were shown by their respective manufacturers.

The main characteristics of the incinerators investigated are summarised in Table ES1.

Table ES1: The main characteristics of the incinerators investigated

		Himeville	Ixopo	Caledon	Macro Burn
Population		600	6000 - 10000	-	-
Quantity waste treated	m^3/y	5290	-	2800	-
Incinerator type		Local design	Toxic 400	DISA (x2)	Macro Burn 500
Throughput	kg/h	-	750	250 (combined)	227
Costs: Capital	£	<1,000	85,000	6,500	50,000
Infrastructure	£	Inclusive	85,000	Inclusive	-
O & M	£/y	8,100	30,000	93,881	-
Op. temperature	^oC	assumed <400	850 - 1200	-	850 +
Front end operation		Manual sorting and recycling	Manual sorting and recycling	Manual sorting	Unknown
Back end operation		Landfill residue	Landfill residue	Landfill residue	Landfill residue
Support fuel		None	Recycled fuel oil	None	Fuel oil
Loading		Manual	Automatic	Manual	Automatic
De-ashing		Manual	Manual	Manual	Manual
Control		None	Automatic	None	Automatic

The two incinerators seen in use at Himeville and Ixopo represent the two extremes of the low to medium cost incineration. The Himeville incinerator achieves its primary aim of volume reduction and would be easy to replicate elsewhere using locally available materials and labour. However, its main problem is that of very poor combustion, resulting in an almost continuous cloud of smoke being emitted to atmosphere, which is not acceptable. Modifications could be carried out to improve the Himeville incinerator's performance, but this would increase its cost from £1,000 to an estimated £8,000 without any guarantee of achieving acceptable performance.

In contrast the Ixopo incinerator performs well, operating at temperatures in excess of 850^{o}C. Releases to air have been independently analysed and shown to conform largely to local and national regulations. Replicating the technology elsewhere in Africa may be problematic, as the basic construction requires skills and materials that are not readily available in many low-income countries and also the capital cost may be too high. A first attempt at assessing how the incinerator can be simplified has reduced capital cost form £85,000 to £60,200 and infrastructure costs to £6,000. However, simplification may result in significant loss of performance and the cost may still be too high.

The incinerator in Caledon is simple and cheap but has an (assumed) low throughput and has not been seen in use nor has operational data been provided. The Macro Burn unit on paper is worth considering but like the Caledon unit it has not been seen in operation or independently monitored (with MSW as feedstock) to assess the release to atmosphere.

Of considerable interest is the front-end operation practised at both Himeville and Ixopo. Both recognise the need to sort and separate waste before incineration for two main reasons, firstly to remove materials which are potentially hazardous if burnt (such as PVC) and secondly to remove materials that can be recycled and provide additional revenue for the site operation and work for the local population. Removal of recyclable materials such as glass and metals also helps to maintain combustion as these do not contribute to the combustion process and could inhibit combustion and operation significantly.

These front-end operations are labour intensive which will have relevance in many low income counties and could fit in with recycling that is already carried out by the informal sector. By incorporating this type of front-end operation in an incineration project it may be possible to create new jobs or maintain existing jobs in the recycling sector. It may, where recycling occurs, enable the informal sector to become stakeholders in the project by allowing for sorting and separation on site in an organised manner, taking account of health and safety considerations.

Regulating and enforcing incineration is one of the main problems if impact on the environment is to be minimised and monitored. In South Africa a regulatory framework exists for licensing waste management sites, which includes incineration. Although enforcement is not as stringent as in many high-income countries it does attempt to control waste management processes and their impact on the environment.

The framework includes guidelines for the design, installation and operation of incinerators, which provide data on emissions limits. As part of the permitting process for waste incineration an Environmental Impact Assessment (EIA) is required which includes a Best Practicable Environmental Option (BPEO) study. BPEO enables waste management technology to be evaluated in terms of the environment in which it will operate without imposing a strict set of rules. It is a useful tool enabling all responsible parties to ensure that a waste management process is appropriate to their needs while minimising the impact on the environment. However emission limits and operating guidelines also have their place in ensuring standard performance specifications are realised.

In addition the principle of Integrated Pollution Control (IPC) is presently being developed in South Africa and will probably be applicable to the incineration of waste. IPC is the principle that integrates the regulation and licensing of potentially polluting activities for impacts on all environmental media (land, water, air, noise etc.). There also exist general pollution and public health laws and overarching legislation and policies. The (Draft) White Paper on Environmental Policy for South Africa published in May 1998 (Reference 2.5) and the Environmental Management Act 107 (1998) subscribes to principles including life cycle assessment (i.e. cradle to grave), full cost accounting, polluter pays principle, and waste avoidance and minimisation.

All three sites are operated by or on behalf of their respective local councils who charge for this service through the rates. Himeville makes additional charges for the disposal of garden refuse while Caledon has a range of charges for non-domestic non-hazardous wastes (business, commercial etc.). Ixopo and Himeville also generate additional income from the recovery and recycling of metal, glass and card.

Members of the Ixopo Transitional Local Council (TLC) were satisfied with the performance of the incinerator and indicated that they would endorse similar projects elsewhere in South Africa. Himeville TLC are very aware of the shortcomings of their incinerator and are investigating means of improving its performance.

The work being undertaken in South Africa does indicate that low to medium-cost incineration can be used effectively to treat municipal waste and therefore has implications for the low-cost incinerator project. In terms of developing an incinerator two approaches could be taken.

- Adapt the Ixopo incinerator to suit local conditions in other low-income countries by finding ways to reduce cost and use locally available materials and skills. However, this may have a significant effect on its performance without bringing the cost down to an affordable level.
- Design a new incinerator, taking account of local materials, skills and facilities, and of lessons learnt from the visit to South Africa. A full design specification will be required that would set operating criteria including minimum incineration temperature and maximum release to air.

It will be necessary to provide guidelines for the implementation, design and operation of low cost incinerators so that either of the two options can be measured against pre-determined criteria. If the host country already has guidelines for incineration then these should be used. However, if guidelines do not exist or are not specific to small-scale low cost incineration then the project should, in collaboration with the responsible parties in the host country, develop guidelines based on those used in South Africa. These guidelines can then be used as a working document to show that any incinerator that the project introduces, even as a pilot scheme conforms to and is being evaluated against acceptable criteria.

The lessons learnt from Himeville and Ixopo in sorting and separation of recyclable hazardous materials should form an important part of any incinerator project and be considered at the design stage and not as an add-on. Good sorting can help to minimise releases to air and enhance the combustion characteristics in the incinerator.

The following recommendations were made for consideration by the project team and funders:

- Develop guidelines for implementing the framework for the design and operation of incinerators.
- Develop and test a design for a low cost incinerator and evaluate it against the guidelines.
- Develop monitoring guidelines.
- Develop operation and maintenance procedures.

1 Introduction

This report presents the findings of a study visit to South Africa (from 13th to 20th June 1999) to investigate low to medium cost small-scale municipal waste incineration. The main purpose of the visit was to investigate the small-scale incinerator project based at Ixopo in KwaZulu Natal Province to assess the degree to which it is successful in meeting the waste disposal of the local municipal authority.

Emphasis was placed on evaluating the level of emissions that result from the incineration process

1. Is the Ixopo (or other) plant effective at delivering a satisfactory waste disposal service in terms of economic sustainability and technical performance?
2. Is the current level of emissions at Ixopo acceptable, given the local environment and regulatory framework?
3. What is the cost of constructing a similar plant in other African countries, exploiting low-cost, locally available materials and construction techniques?
4. If the current level of emissions is not acceptable, what is the estimated extra cost of plant needed to achieve acceptable emissions levels?

Although a large amount of information was obtained during the study visit further details (e.g. cost recovery breakdown, emission analysis, waste stream analysis) not readily available at the time were to be sent on to the UK. It was decided that information received after the 9th July 1999 would not be included in this report. However, any additional information will be collated and made available to the project team and DFID.

Section 2 provides some background information on the operating environment of the incinerators under investigation, briefly describing how they fit in with local waste management operations, how they are operated, and the quantities and type of waste generated. Section 3 briefly describes the incinerator technology used, providing data, where known, on operating temperatures and front and back end operations.

Section 4 investigates releases to atmosphere giving, where known, independently monitored data on emissions and description of smoke and plume problems observed while visiting the site. Operation and maintenance issues are discussed in section 5, with economic aspects, including cost recovery data, discussed in section 6.

In section 7 a summary of environmental regulations with regards to incineration in South Africa is provided, including guidelines for releases to atmosphere. Section 8 discusses the scope for the various incinerators seen to be replicated elsewhere in Africa and section 9 presents a summary of outcomes of a series of meetings with other interested parties not directly involved with manufacture or operation of incinerators.

Section 10 discusses the findings of the study visit and section 11 makes recommendations for the next phase of the low-cost incinerator (LCI) project.

A photographic record of the sites visited will be complied and issued as an independent annex to this report.

2 OPERATING ENVIRONMENT

2.1 HIMEVILLE

Himeville is situated at the base of the Southern Drakensberg mountain range, approximately 1500 metres above sea level, close to the border of Lesotho. This region is an important tourist area including a nature reserve and is generally of high scenic value. The municipal area covers 3.96km^2 with a population of 600 which is expected to rise to 1300 over the next year due to a new housing development.

Himeville Transitional Local Council (TLC) operates its own waste management site close to the residential area. Originally a landfill, the site is now used for general waste management activities (separation, storage, baling, incineration and landfilling of residuals from incineration). The site also treats the waste from the neighbouring and larger town of Underberg which contributes 66% of all waste being handled by the site.

The local council has developed a waste separation system comprising two stages. The first stage requires each household to separate waste such as glass and metal cans and place them in clear plastic bags, provided by the council, ready for collection. These bags along with other household refuse are collected using a tractor with a tipper type trailer and delivered to the waste disposal site.

At the waste disposal site the waste is deposited on to a sorting floor (a concrete floor covered by a simply supported corrugated steel roof) which extends up to the incinerator loading doors. A team of people (mainly women) then remove the bags containing the glass and cans (second stage separation). The cans are crushed in a dedicated baler and stored on site, the glass containers (3 colours) are separated and stored in bags. A recycling company collects the cans and glass.

Quantities treated on the site are:

Incineration (rest waste & garden waste)	5290 m^3/y	529t/y (0.1t/m^3 assumed)
Scrap metal despatched for recycling		74.88t/y
Glass despatched for recycling		41.82t/y

Reference documents 1.1 to 1.4 were used for the data research.

Data on the waste composition was not available but it is assumed the composition is consistent with a village with a high income socio-economic profile.

2.2 IXOPO

Ixopo is South West of Durban, is approximately 1000 metres above sea level and has a population of between 6000 and 10000. The socio-economic population profile is thought to be typical for KwaZulu-Natal. (Feedback is possible from Ixopo TLC.)

The waste management site is situated on a hillside approximately 1km south of the town. The site consists of a landfill, which is no longer used for untreated municipal waste, and an incinerator. A new landfill for the disposal of incinerator residue is being developed; meanwhile the permission to landfill ash only in the old site has been given.

Current waste management (for household waste) practice consists of:

- collection from households and retail business
- separation and recycling of metals, glass and card (from retail premises only)
- separation of PVC
- incineration
- ash disposal

Compass waste management, under contract to the council, operates the site and waste collection. The local council provides black plastic bags, which are collected on a regular basis by tipper truck. The waste is deposited on a sorting floor situated inside the sorting shed where it is then sorted manually by a team of people (women and men) removing metals, glass, card and PVC. Batteries are not removed but the operators, Ixopo TLC, Johnson Thermal Engineering (the incinerator manufacturer), and the consultants consider it a good idea.

Glass is sorted by colour, bagged and stored close to the site. Metal cans are manually crushed, bagged and also stored close to site. The card is manually baled and stored close to the site. These materials are then collected by a recycling company.

The local council has tried to improve the waste management system by getting households and businesses to separate waste as they generate it. Different coloured plastic bags were provided for different wastes but the scheme did not prove successful. There are plans to reintroduce the scheme at a later date in conjunction with a public education programme.

Medical waste, including sharps, is also incinerated at the same time as the municipal waste. The medical waste, sealed into special boxes and containers by the hospitals, is collected by Compass Waste management and loaded without sorting into the incinerator. Municipal and medical waste streams are co-incinerated in a ratio of approximately three parts municipal and one part medical waste by volume.

Data on the waste composition was not available but it is assumed that it would vary significantly depending on which socio-economic group generated the waste. The waste from those in the middle to high income groups will typically be made up of more packaging materials with some vegetable and other foodstuff. In the waste from the poorer groups we expect a tendency towards less packaging and a higher putrescible fraction.

Based on the waste seen on the day of the visit, the quality is comparable in composition and in calorific value (CV) to European waste. A rough estimate based on experience would place the CV at between 7,000 and 8,000 kJ/kg.

References 2.1 to 2.6 were used for data research.

2.3 CALEDON (DISA TECHNOLOGIES)

Caledon is a small town approximately 100km to the east of Cape Town on the main Cape Town to Port Elizabeth highway. The town is situated on the southern side of the Swartberg mountain at an elevation of between 200 and 315metres above sea level.

Caledon's waste disposal site is located on municipal property approximately 2km north of the town, and has been in operation for 50 years. The site is situated in a north west facing valley (i.e. away from the town) at an altitude of approximately 340 metres above sea level. Neighbouring land includes a nature reserve and in general the region is of outstanding natural beauty and attracts foreign and domestic tourists.

The site is predominately a landfill site; however, an amendment to the site permit was made to allow for controlled incineration. Two cylinder-type incinerators were installed (see section 3 for details) and have been used for the disposal of waste. Glass, metals and plastic are removed before the waste is fed into the incinerator.

The council operates two waste collection vehicles (non-compacting), each with a capacity of 22m^3, averaging a total of 6 trips a day to the site over a five day week. Average waste volumes taken to the site are 2800m^3 per year which includes 710m^3 of domestic waste, 50m^3 of garden refuse, 50m^3 building rubble, 2m^3 medical waste (residue from incineration at the local hospital) and 1900m^3 industrial waste.

Industrial waste comprises 1000m^3 cardboard and plastic, 500m^3 of malt waste and 400m^3 of general industrial waste from business and the hotels. The composition of the domestic, garden refuse, building rubble and medical waste has not been analysed.

References 5.1 to 5.7 were used for data research.

3 TECHNOLOGY

3.1 HIMEVILLE

The incinerator was designed by members of the local council and built by local contractors. It is a simple design consisting of a single updraught combustion chamber built from ordinary building bricks partially lined with refractory bricks (see Annex 4 - Photographs) and fitted with steel loading doors, de-ashing doors and chimney. With the exception of some firebricks around the grate area there is no other refractory or insulation. However, insulation in the form of fire-resistant mineral sheets will be fitted shortly (some preparation work for the fitting of retention studs for the insulation sheets has already been undertaken).

The incinerator is situated at one end of the sorting floor which is approximately 0.5 metres above the incinerator's grate. The loading doors are on the same side (i.e. front of the incinerator) and at the same level as the sorting floor so that waste can be pushed directly into the incinerator. On the opposite side (back) de-ashing doors are fitted at grate level. The grate, made from railway lines, covers the full area of the incinerator and individual grate bars are widely spaced allowing un-burnt and partially burnt waste to fall through.

Combustion air enters the incinerator from below the grate via an opening at the back of the incinerator that is approximately 0.5 metres high (i.e. height of the grate from the ground) by the full width of the incinerator. There is no restriction or control on the flow of air into the combustion chamber so a large amount of air is allowed to enter. There is no provision of secondary air.

The condition of all the steel components including the chimney were good with no evidence of burnout and little oxidation, suggesting that combustion temperatures are low. The planned improvements in insulation may improve combustion characteristics but there is still room for much improvement.

The bailer used for crushing the cans is a hydraulic single-ram horizontal unit exerting up to 15 tonnes of pressure. The cans are ejected from the machine in small easy to handle bales which can withstand transportation without breaking up.

The capital cost of designing and building the incinerator is not known but is not thought to exceed R10,000 (£1,000).

3.2 IXOPO

The incinerator is a Toxic 400 which is the largest standard incinerator made designed and manufactured by Johnson Thermal Engineering. The incinerator is a two chamber unit incorporating a static hearth pyrolitic primary chamber with manual stoking. The hot gases pass from the primary into a vertical secondary chamber before passing into the stack. The residence time for the gases within the secondary combustion chamber is two seconds.

Waste is batch loaded into the incinerator using a hydraulic ram loader at one end of the incinerator and ash is removed manually from the other. Manual stoking through two side doors as well as new waste entering the combustion chamber push the burning waste and ash along the chamber towards the de-ashing doors. De-ashing is carried out manually every morning before start-up.

One oil fired burner is used to in the primary chamber and two oil fired burners in the secondary chamber (gas and kerosene burners can also be fitted). Primary air is supplied by natural draught but is damper controlled. A dedicated blower supplies secondary combustion air. The incinerator is automatically controlled via the control panel, which incorporates a binary PLC. Temperatures in the primary chamber are maintained at between 700 and 900^{o}C and secondary chamber temperatures between 1000 and 1200^{o}C (for further details see specification in Annex 3). This conforms to South African regulatory guidelines, which state that secondary combustion temperatures must be at least 850^{O}C (see section 7, Environmental Regulations).

The incinerator is a steel construction with the primary chamber, the secondary chamber and the stack fully lined using a castable insulation layer on top of which a high density castable refractory is laid. The primary chamber shell is made from 8mm thick steel plate that is rolled and fully welded with a number of strengthening rings welded around the outside to prevent buckling or deformation occurring during normal operation. The shells for the secondary chamber and stack are also fabricated from steel, the thickness of which was not ascertained. The lifetime of the refractory is approximately 5 years before major repairs need to be undertaken.

The incinerator and sorting floor are situated inside a purpose-designed building consisting of two main areas the incinerator shed and the sorting shed. The sorting floor is higher than the incinerator shed allowing for waste to be dropped directly into loading-ram hopper. Waste from the sorting floor is placed in a wheeled skip, which is pushed by hand to the hopper. A stop on the floor just in front of the hopper enables the skip to be tipped easily when pushed up against it, enabling the waste to enter the hopper.

The building is a steel construction with one metre high wall around its base. The rest of the wall is made up of steel corrugated wall cladding and roof. One wall of the sorting shed is partially clad with transparent corrugated plastic to allowing natural light to illuminate the sorting floor. The entrance for the waste trucks into the sorting area has subsequently been provided with a corrugated steel floor and wall.

The support fuel used by the incinerator is recycled waste oil that has been cleaned and filtered. This is a cheaper alternative than using new fuel oil and seems to work well.

Nominally the throughput for medical waste would be 400kg of waste per hour but this would vary depending on the composition of the waste being incinerated. Typically, with the mixture of medical and municipal waste at Ixopo, throughputs of 750kg per hour are achieved (however, this is not confirmed by weighing).

The cost of the incinerator including loading ram and control panel was approximately R850,000 (£85,000) installed. The capital cost of the complete site including buildings and perimeter fence was approximately R 1,700,000 (Reference 2.1).

3.3 CALEDON

This incinerator, manufactured by DISA, is a very simple design consisting of a vertical stainless steel tube of consistent diameter with the combustion chamber being the first quarter of the tube. A loading door is fitted towards the top of the combustion chamber section and a de-ashing door fitted towards the base and at the rear of this section. The combustion chamber section is lined with a refractory while the rest of the incinerator is unlined. A conical type fixed grate is fitted inside the combustion chamber.

Combustion air comes in from underneath the combustion chamber passing through the grate and the load and into the remaining tube, which becomes the stack. A mesh is fitted to the top of the stack to restrict the flow of particles into the atmosphere. Glass, metals and plastic are removed manually from the waste stream before the residue is incinerated. Sorting tables and bins are provided for this.

The sorting tables are located on a concrete floor, which is covered by a simple corrugated steel roof to provide the operators with shelter from the sun and rain.

The capital cost for the incinerators including installation was R65,000 (£6,500) using council labour. The full cost using contracted labour was estimated at approximately R100,000.00 (£10,000). As this plant was not operating during our visit the above description is based on Dr. Gerrit Mars's (director of DISA) and Anton Henn's (Caledon TLC) accounts and on a video of a comparable plant in operation.

3.4 MACRO BURN

This is a commercial incinerator made in South Africa. It was not possible to see a unit in operation although a video of one in Port Elizabeth was seen (operating with medical waste) and a visit was made to see a modified version at a local crematorium in Johannesburg.

Although primarily used for medical waste incineration the Macro Burn incinerator is based on the LA Retort, designed for municipal waste incineration for use in Los Angeles in the USA during the 1950s. The incinerator is an underfed three-chamber pyrolitic unit using oil, gas or kerosene as the support fuel. The unit has a steel outer shell and is lined with a layer of insulation material on top of which a castable refractory is laid. There are burners for the primary and secondary chambers but not for the tertiary chamber. The stack is not lined and is made from a locally produced low-chrome steel 3CR12 which is similar to an EN59. This type of steel has improved acidic corrosion resistance and higher oxidation temperatures than ordinary mild steel.

Waste is batch loaded using a hydraulic ram loader on to an upward sloping static hearth. The rationale for the sloping floor is that waste entering the combustion chamber will be below the waste already burning and so not disturb it. Waste entering the chamber is therefore pre-heated which helps to maintain good combustion efficiency. At the top of the slope there is a burnout grate to enable complete combustion of the waste and to facilitate ash removal. Ash removal can be either continuous or batch.

The largest standard unit produced is the Macro Burn 500 which has a throughput of 227kg (500lbs) of waste per hour and cost approximately £50,000 ex works.

4 RELEASES TO THE ENVIRONMENT

4.1 HIMEVILLE

Monitoring of the stack emission has not been undertaken and the following notes are based on visual and olfactory observations only.

Throughout the observed incineration period the stack emitted white heavy smoke. The large amount of air that enters the combustion chamber and the good condition of the unlined steel stack suggest that poor combustion occurs which is in keeping with large amounts of smoke being released. The plume grounds within 50m of the stack and the smell nuisance is evident on the site.

The council are very aware of the problem and have received a number of complaints from local residents. To minimise nuisance levels the council is only operating the incinerator for limited periods during the morning. Attempts are being made to improve insulation within the incinerator which it is hoped will help to increase combustion temperatures resulting in reduced smoke levels. Other suggestions made include controlling the rate of air from under and over grate. However, care must be taken when combustion occurs at higher temperatures to preserve the combustion chamber and stack from the resulting higher temperatures.

As far as regulatory compliance is concerned the operations do not possess a Registration Certificate as a waste incineration process and would certainly not comply with the limits and conditions laid down in the Guidelines for Process 39 (see Section 7).

Releases to land is ash of low burn-out quality containing a significant amount of partially and unburned organic materials which are liable to release leachate and gas when disposed of to land.

Releases to water are therefore suspected from the ashes as a leachate. The quality of the leachate has not been analysed to our knowledge and therefore compliance with the Permit in terms of Section 20 of the Environmental Conservation Act cannot be assessed.

4.2 IXOPO

Generally little or no visible smoke can be seen coming from the stack. When smoke does appear it usually corresponds with loading of waste into the incinerator. Opening the loading door allows fresh cold air to enter the combustion chamber, which will have a cooling effect in the combustion process and also provide excess primary combustion air. Both effects may lead to incomplete combustion and hence smoke. However, once the door is closed the situation quickly rectifies itself with good combustion conditions being re-established. Many batch and semi continuous fed incinerators have a tendency to display this characteristic.

Earlier this year emissions from this incinerator were monitored and the results are shown in Table 4.1 below in comparison with South African regulatory guidelines (for details see section 7, Environmental Regulations).

These test results are for municipal waste only (glass, metals, card and PVC separated) without medical waste. Data for heavy metals is still outstanding and little is known about the monitoring methodology used.

With respect to the Registration Certificate in Terms of Atmospheric Pollution Prevention Act, Ixopo TLC and the operators have let a provisional registration certificate expire on 02.08.98 and have not renewed this. However, in the present climate of change to the legal regulatory system this is not deemed to constitute an actual breach of the regulations. Although the results from emission monitoring may not comply for heavy metals (results still awaited), in general, compliance with the Guidance is good.

Table 4.1: Ixopo emission data compare with SA guidelines

	Ixopo incinerator emission data **Measured on 6 May 1999** **Barometric pressure 51.5 kPa**	**South African Guidelines** **Process 39** **Atmospheric Pollution Prevention Act**
O_2	11-11.5 %	11 %
CO_2	10-10.5 %	Not given
CO	58.4 mg/Nm^3	Not given
NO_2	8.6 mg/Nm^3	Not given
SO_2	13.5 mg/Nm^3	< 25 mg/Nm^3
Chloride	7.3 mg/Nm^3	< 30 mg/Nm^3
Particulates	52 mg/Nm^3	<180 mg/Nm^3
Exhaust gas temp.	860^{o}C at stack outlet	Not given

Releases to land consist of the ash raked out of the primary combustion chamber every morning before starting a new burn cycle.

This ash is of a fairly good quality (no analysis available at the moment). Its potential for biological activity and for leaching in general has to be determined by test.

Releases to water may occur at the site due to the practice of storing the ash on the ground outside the plant. Further releases may occur at the landfill site where the ash is deposited.

As far as can be ascertained landfilling of the ashes is carried out at an old existing landfill under the terms of a permit which allows only incinerator ash to be deposited.

The burners seem to perform well using recycled oil as the fuel. They burn effectively and cleanly without any noticeable effect on the emissions and it is assumed that as long as the burners are well maintained and that the recycled oil is of acceptable quality, long term problems should not occur.

4.3 CALEDON

Releases to air have not been measured and observation was not possible as the incinerators were not in operation during the visit. Video evidence was presented by the manufacturer/installer of a similar incinerator at another site. It was not possible to assess the level of smoke emissions to atmosphere from this video.

This site does not possess a Registration Certificate as a waste incineration process (in terms of Atmospheric Pollution Prevention). However its Permit allows the incineration of waste on-site (Reference 5.3). It would most probably not comply with the Guidelines for Process 39 (Reference 8.4). We have not witnessed this incineration in operation or had any monitoring report and are therefore not able to comment in any definite way.

Releases to land and water are again difficult to assess as at present the main operations on-site consist of untreated waste landfilling. It is noted that the Motivation Report (Reference 5.2) contains a section on Leachate Management and proposes the construction of a leachate collection point and six-monthly monitoring of the leachate for a number of parameters.

4.4 MACRO BURN

Information on emission monitoring was not available during the visit although a video was shown, by the manufacturers, of the Macro Burn 500 in use in Port Elizabeth incinerating medical waste. The video briefly focused on the stack with no visible smoke emissions. This was supported with anecdotal evidence from the manufacturers, suggesting emissions from the incinerator are at or below those allowed. Without independent monitoring and analysis the video and anecdotal evidence cannot be accepted as typical.

Since the visit stack-monitoring data has been received for a Macro Burn (model unknown) being used at the Rietfontein medical waste incineration facility. This data, part of a risk assessment study, is at least eight years old and does not comply entirely with the Guidelines (Reference 8.4). Also as the feedstock is medical waste the relevance for this study is limited.

5 OPERATION AND MAINTENANCE

5.1 HIMEVILLE

Himeville TLC are fully aware of the shortcomings of their incinerator but feel that it is a first step towards an integrated waste management system and is better than uncontrolled burning at the landfill or elsewhere in the town.

Although the incinerator is not particularly efficient the front end operation is well managed and forms the basis of a good waste management system. The sorting and separating of glass and metals mean that revenues are generated which go towards the operating cost of the waste management site and also reduce the amount of low calorific value waste material that goes through the incinerator. Improvements to the insulation should help to improve combustion efficiency to some extent but a lot of modifications are still required if the incinerator is to perform anything like adequately..

In summary Himeville TLC has made a good attempt at developing a waste management system especially the front-end operation. If the incinerator can be modified to perform to acceptable standards than the TLC would be happy to recommend their system to other villages and towns with a similar socio-economic make up.

5.2 IXOPO

Ixopo TLC expressed satisfaction with the incinerator and felt that it was appropriate to their needs and would be happy to recommend it to any other council of similar size. The front end operation manually sorts and removes glass, metals, card and PVC from the waste stream which, with the exception of the PVC, is sold on for recycling..

The TLC has not reported (at the time of the visit) any concerns raised by the local community about the incinerator.

The main problems associated with its operation were that the burners have failed to fire occasionally, thermocouples have burnt out and during the wet season (i.e. summer) the waste can be difficult to incinerate as it is very wet. The problem with the burners is probably due to the thermocouples burning out. The thermocouples provide feedback to the control system, which regulates the burners. The thermocouples used are standard K type rated for operation at temperatures up to 1300^{o}C therefore for burnout to occur temperatures in excess of this must have been achieved. Under normal operation this should not occur and so there is the possibility that the incinerator has been or could have been operated incorrectly. Further investigation of the operation may be required.

Worries over handling medical waste were expressed by some of the workforce although it is delivered in sealed containers, which are kept intact. Separate compartments for storing the medical waste until it is incinerated were thought to be useful. At present the ash is placed on the ground at the front of the site until it is removed for landfilling. It was suggested that a skip should be provided for storing the ash until it is removed to the landfill. Staff also recognised the importance of being properly trained so that they understand fully the proper operation of the incinerator and the environmental and health consequences of not operating the plant correctly.

To reduce volume metal cans are crushed manually using hammers or metal spikes. The staff responsible for this operation would prefer a mechanical crusher although this could be manually operated rather than hydraulic or electric. This would improve throughput and make their job easier. Ixopo TLC is aware of the problem and would be interested in obtaining low-cost can crushers.

Some investigation has been undertaken by the council and consultants Ray Lombard and Associates into using incineration residue as filler for cement block production. However, the residue has not been analysed to assess its suitability for this application. The main reasons for investigating alternative uses are a mix of environmental concerns and job creation (ref. 2.1)

5.3 CALEDON

Very little hard data is available on the operation of the site. Sorting and separation of glass, metals, card and PVC are intended. Sorting tables are provided for each of the incinerators. The council indicated that the rights to separate and sell glass, metal and card would be sold on to a recycling company. It is estimated that the two incinerators seen at Caledon have a combined capacity not exceeding 250kg/h.

5.4 MACRO BURN

No hard data was made available on the operation and maintenance of the Macro Burn incinerators. Anecdotal information was given and a video of a Macro Burn 500 in operation was shown. The video provided little real operational data and was concerned with the incineration of medical rather than municipal waste, so this information has very little relevance to the low cost incinerator (LCI) project.

6 ECONOMICS

6.1 HIMEVILLE

Waste management is undertaken by Himeville TLC and it has an operating budget of R81,000 (£8,100) per year. Revenues for waste management are raised through the rates and through direct charges for waste management services. Himeville takes waste from the neighbouring town of Underberg and charges their TLC for this service (it is assumed the Underberg TLC raises revenues through a rate). In addition garden refuse is charges at R20 per load and self-dumping is free.

Additional revenues are raised through the selling of the glass and metal separated from the waste stream. The quantities of glass and metal will vary year on year but the latest figures shows that recycled glass raised R740 and metal R2200 which after transportation cost were deducted reduced to R 390 (£39) and R1620 (£1,620) respectively.

This revenue has to pay for seven staff including a site supervisor, a driver, collection staff, sorting staff and the operation and maintenance of the site equipment including tractor and trailer, incinerator and baler.

Wages range from R650/month for the women doing the separation to R3000 for the Site Supervisor. Other operational costs are not known but 100% cost recovery is achieved (i.e. R81,000).

6.2 IXOPO

Waste management is undertaken by Compass Waste Services under contract to Ixopo TLC. Revenues for this service are raised through the rates at R1800 (£180) per annum of which R480 per annum (R40 per month) is for refuse collection services. Compass Waste Services are responsible for all collection, sorting and disposal of waste.

Additional revenue is raised through the sale of recovered glass, metals and card.

The monthly management fees to run the plant are R25,000 (£2,500) or R300,000 (£30,000) per annum. Compass Waste derives an important part of its income from the disposal of the medical waste which amounts to R7,000 (R84,000 per annum). This aspect is therefore important for the overall cost recovery.

6.3 CALEDON

The Caledon TLC are responsible for waste management services and charge for the service through the rates and directly for those using the site. Waste management services have an annual budget of R938,810 (£93,800) per annum which includes collection and disposal. Waste management charges (inclusive of VAT) are shown in Table 6.1 below.

Table 6.1: Waste management charges for Caledon

Waste Type	Charge per month (Rand)	Collection
Domestic	30.21	Once per week
General business (non-food)	60.42	Twice per week
Business (food)	81.51	Three per week
Business (bring own)	399.00	As required
Industrial (non hazardous)	272.46	One truck load per week
Sports	21.00	Once per week

7 ENVIRONMENTAL REGULATIONS

The regulatory framework relevant for a waste incineration process in South Africa is complex. However, as the implementation of an LCI plant will be in a third country there is no need to understand every nuance of this framework. For the purpose of this study it is assumed that no hazardous waste is received or treated. The following simplified legal framework therefore could apply:

7.1 SPECIFIC REQUIREMENTS

1. **Registration Certificate** under the terms of the **Atmospheric Pollution Prevention Act**

The Chief Pollution Officer grants this certificate if s/he is satisfied that Best Practicable Means (BPM) are adopted for preventing or reducing to a minimum releases to the atmosphere. "Guidelines for the Design, Installation and Operation of Incinerators", Process 39 gives operators and regulators guidelines on how to operate/regulate incineration processes. Within the classification used in the Guidelines it is assumed that we are dealing with a Class 2 incinerator (incinerators burning more than 100 kg/h of general waste).

The following is required by the Guidelines (among others):

Emission limits (11% O_2, dry):

Particulates	< 180 mg/Nm^3
Opacity	< 20%
Heavy Metals (Cd, Hg, Tl)	< 0.05 mg/Nm^3
Heavy Metals (Cr, Be, As, Sb, Ba, Pb	
Ag, Co, Cu, Mn, Sn, V & Ni)	< 0.5 mg/Nm^3
Chloride as HCl	< 30 mg/Nm^3
Hydrofluoric acid as HF	< 30 mg/Nm^3
Sulphur dioxide as SO_2	< 25 mg/Nm^3

Minimum combustion temperature	
Secondary combustion temperature	> 850 °C

Other provisions relate to feeding, monitoring, operator training, operating manuals, waste composition etc.

The regulatory authority is the Department of Environmental Affairs & Tourism (DEAT) and day-to-day supervision is carried out from the DEAT provincial office in Durban.

2. **Authorisation** to conduct an activity which may have a substantial detrimental effect on the environment in terms of **Section 21 and 22 of the Environmental Conservation Act 73 of 1989**.

This requirement can be interpreted as a permit to carry out an identified activity which could have an environmental impact. This Authorisation is administered by the Provincial DEAT.

3. **Permit** to operate a disposal site in terms **of Section 20 (1) of the Environmental Conservation Act 73 of 1989.**

Essentially this permit relates to a waste disposal site and has a number of conditions attached to it. These conditions dictate the permissible waste, construction of the site access control, operational regime, monitoring and reporting requirements and rehabilitation after closure.

As part of this Permit a 6 - monthly audit is conducted at Ixopo covering all major areas of environmental impact.

They are issued and regulated by the provincial office of the Department of Water Affairs and Forestry (DWAF).

Draft "Minimum Requirements for Waste Disposal by Landfill" have been issued for consultation (we have a copy of 2nd edition, 24.06.98). Provisions from this document can be incorporated into the waste disposal permit and so become binding. (The Minimum Requirements document is not in itself binding).

4. **Other legal provisions** and their regulators are:

–	Major Hazard Installation	Department of Labour
–	Hazardous Chemical Substances Act in terms of Occupational Health & Safety Act (OSHA)	Department of Labour
–	Sewage Disposal Permit	According to local by-laws
–	Planning & Zoning issues	Local Authority
–	Human Tissues Act 65 of 1983 (Relating to the handling & disposal of clinical waste)	Department of Health

It is also noted that the principle of Integrated Pollution Control (IPC) is presently being developed in South Africa and will probably be applicable to the incineration of waste. IPC is the principle which integrates the regulatory and licensing ….. for impacts on all environmental media (land, water, air, noise etc.).

7.2 OVERARCHING LEGISLATION

In addition to the above specific regulatory provisions there exist general pollution and public health laws and overarching legislation and policies.

The (Draft) White Paper on Environmental Policy for South Africa published in May 1998 (Reference 2.5) and the Environmental Management Act 107 (1998) subscribes to principles including:

Cradle to grave assessment of activities in the sense of a lifecycle

Full cost accounting requires decisions to be based on full social and environmental cost of activities

Polluter pays principle

Waste avoidance and minimisation, encouraging waste re-cycling, separation at source and safe disposal of unavoidable waste.

7.3 Permitting Process and Best Practicable Environmental Option (BPEO)

Flow chart 7.1 gives an outline of the permitting process for a waste incineration process similar to Ixopo (Reference 4.5).

The Environmental Impact Assessment is the main vehicle by which the impact of a process is assessed and compliance is demonstrated.

In addition to and as part of the EIA a Best Practicable Environmental Option (BPEO) study is concluded to demonstrate that the process used will cause a minimum of environmental harm while delivering the process result.

The flow chart suggests that permits, certificates and authorisations are issued at one point in the procedures. This is a simplification for the purpose of this report; in fact permits etc. are issued at different points in time (provisional, final).

The Environmental Impact Assessment is the main vehicle by which the impact of a process is assessed and compliance is demonstrated.

In addition to and as part of the EIA a Best Practicable Environmental Option (BPEO) study is concluded to demonstrate that the process used will cause a minimum of environmental harm while delivering the process result..

BPEO as a concept can be considered as follows:

> *A BPEO is the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air, and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or the least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term.*
>
> Susan Wolf & Anna White, *Principles of Environmental Law (2nd Ed),* Cavendish Publishing Ltd, 1997

The essential feature of BPEO is that regard is required for the overall effect of a polluting process on all environmental media (i.e. water, air, land etc.) and it is therefore clear that a degree of compromise will be required. For example an increase in air pollution created by incinerating municipal waste may be more than offset by a reduction in water pollution caused by uncontrolled dumping or using poorly engineered landfill.

Enforcement of existing regulations is not vigorous in South Africa's waste management culture, partly due to the lack of alternative sites and processes and partly due to the continuous changes to the political and legislative background.

This explains why of three plants/operations surveyed none has an up to date Registration Certificate in terms of atmospheric pollution prevention.

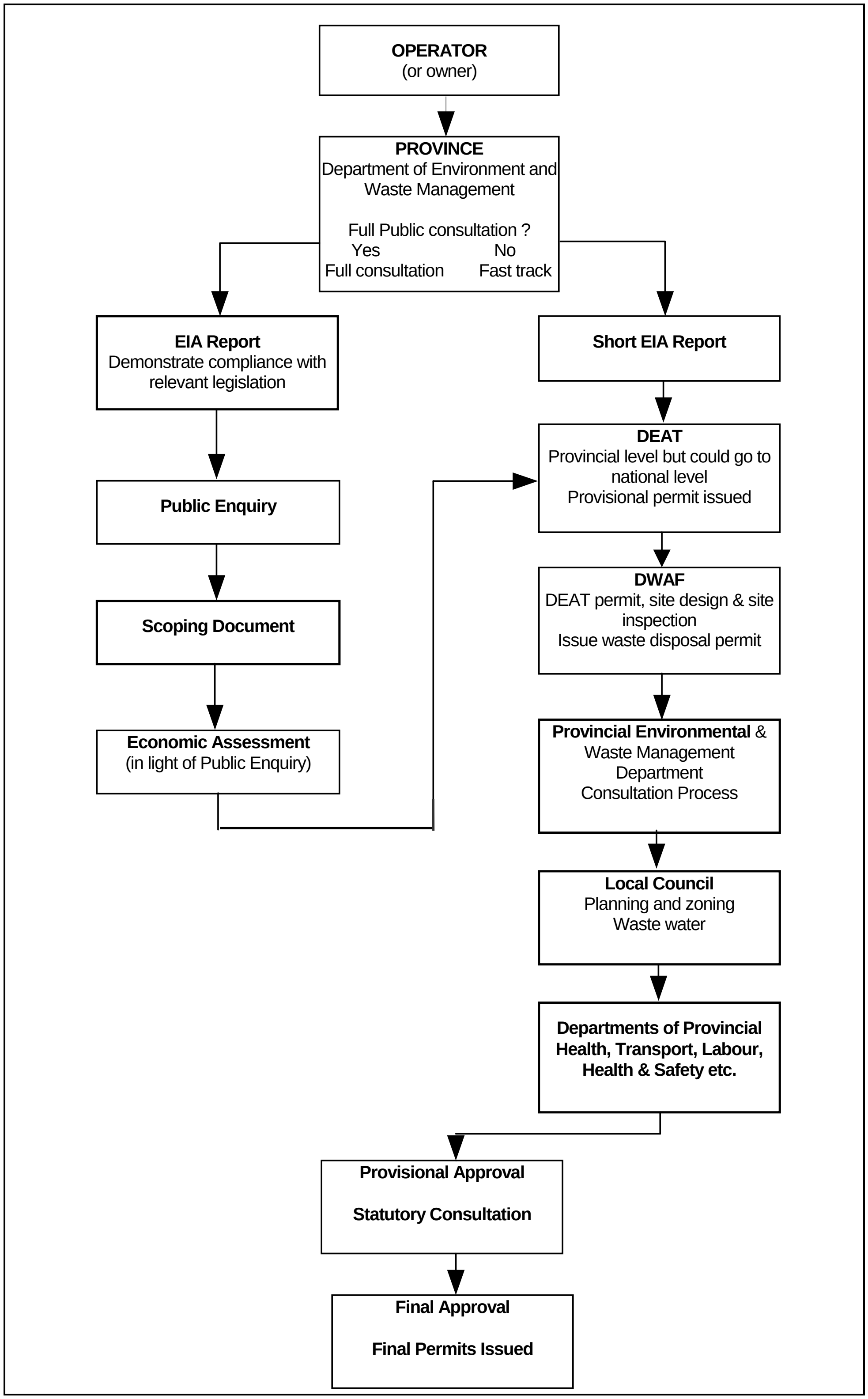

Figure 7.1: Permitting Flowchart

7.3 CONCLUSIONS FOR LOW COST INCINERATOR PROJECT

It is probable that the host country for this project does not operate a detailed environmental regulatory system.

The South African model, as described above, includes the most important aspects of such a system and can be used as a checklist to identify gaps in the country's own regulatory system.

Likewise the permitting process and tools (EIA, BPEO) can be borrowed if such instruments are not recommended by national legislation.

8 SCOPE FOR REPLICATION

8.1 HIMEVILLE

This design of incinerator will be very easy to replicate elsewhere in Africa with very few modifications to the basic materials used. However, it is not particularly efficient and improvements will be needed before it could be considered for use elsewhere. Planned improvements to the insulation at the Himeville site are expected to make a marginal difference to its overall performance. Table 8.1 attempts to assess the costs incurred improving the performance of the incinerator.

Table 8.1: Possible improvements to the Himeville incinerator

	Description	Acceptable	Current cost £	Revision	Revised cost £
Feeding	Manual batch feed and stoking	✔	0	None	0
Primary Chamber	Brick structure with refractory brick lining,; steel loading & de-ashing doors, steel grate	✘	1,000	Modification to combustion chamber and grate size, better insualtion.	3,000
Stack	Steel no refractory lining	✘		Locally fabricated, line chimney	1,000
Controls	None	✘	0	Manual control of air flow	0
De-ashing	Manual through door	✔	0	None	0
Assembly & erection	Brick structure made on site, steel work assembled on site	✘	included in capital cost	Lower labour cost	included in capital cost
Commission & Training	On site	✔	0	Commission on site and train operators	1,000
		Plant Capital cost	**1,000**	**Revised plant capital cost**	**5,000**
Site	Simple fence around landfill site which includes incinerator site.	✔	0	Simple fence	1,000
Sorting	Small concrete floor with simple roof no sides	✔	included in plant capital cost	Concrete floor covered by simple corrugated iron roof with wire mesh sides	4,000
Civil costs			**0**		**5,000**

	Description	Acceptable	Current cost £	Revision	Revised cost £
		Total capital cost	**1,000**	**Total revised capital cost**	**10,000**

Any measures introduced to improve incineration temperatures may have implications on other materials used in constructing the incinerator especially the steel stack. Modifications needed to improve the incinerator performance significantly include changing the grate size, limiting the amount of air entering the combustion chamber and changes to the combustion volume to match the amount of waste being incinerated. In other words a major redesign would be required.

Therefore a major re-design would be required to improve the performance of the incinerator. This would probably result in increasing the cost of the incinerator without any guarantee of achieving acceptable environmental performance. However, the principles of separation by the householder, the front end operation of sorting and recycling does have potential for replication elsewhere and could be used as a basis for developing an incinerator based waste management system.

8.2 IXOPO

Replication of the incinerator outside of South Africa should be possible but may be difficult to achieve. The shell of the primary chamber, secondary chamber and stack are large fabrications made from 6 and 8mm steel plate and will require very good quality workshop and skill level to reproduce. The refractory linings could be carried out on site but require equipment and skills that may not be readily available in low income countries. Components such as the control panel and the loader could be made in other countries with a reasonable manufacturing base.

However, the high quality of combustion demonstrated with the Ixopo plant should serve as an aim for the LCI Project. It is therefore suggested that the manufacturing processes involved be analysed in more detail and the skills and machinery available in the chosen host country investigated in order to better assess the potential for replication in a lower income country.

Simplification of the process, as well as the use of modified materials/processes, should be investigated in more detail. It may be possible to use cheaper castable refractories, which could be applied on site rather than in a factory helping to reduce labour costs. It may also be possible replace automatic loading with manual but this may have an adverse effect on the performance of the incinerator resulting in lower incineration temperature and increased emissions to atmosphere. Making the outer shell from a number of circular sections that could be bolted or welded together on site may reduce manufacturing costs enabling it to be made in small workshops closer to the site it will be used.

Replicating the infrastructure of the site is much less difficult and could undertaken at a much lower cost. The sorting area and the incinerator shed does not need to be as elaborate as that used at Ixopo. A simple concrete floor covered with a steel roof would be sufficient. Instead of using brick and steel cladding steel mesh fencing could be used to provide security around the incinerator shed and sorting area preventing unauthorised persons, animals and birds from entering.

It should be pointed out however, that any departure from the current design or materials used could result an incinerator that does not perform to the standard of that seen in Ixopo. It is therefore suggested that any work undertaken to simplify the incinerator design should be carried out in collaboration with designer/manufacturer of the Ixopo incinerator, Peter Johnson. Table 8.2 is an initial attempts to show where possible modifications can be made to the Ixopo incinerator design and cost savings be made.

Table 8.2: Possible simplifications and cost reductions for the Ixopo incinerator.

	Description	Acceptable	Current cost £	Revision	Revised cost £
Feeding	Batch using automatic hydraulic ram	✔	4,000	Manual feed and stoking[1]	0
Primary Chamber	Steel horizontal refractory lined cylinder, 1 burner, 2 stoking ports,1 ash door	✔	28,000	Locally fabricated, use of vermiculite with cement binder in place, cast refractory on site, lower labour costs	20,000
Secondary Chamber	Steel shell refractory lined vertical cylinder, 2 burners, secondary air injection	✔	20,000	Locally fabricated, refractory cast o site	15,000
Burner & Blowers	3 burners and 1 blower	✔	4,000	None	4,000
Stack	Steel shell refractory lined 16m high	✔	7,000	Locally fabricated	5,000
Controls	1 binary plc & 2 analogue controllers; 2 temperature sensors	✔	1,000	Manual controls[1]	200
De-ashing	Manual through door	✔	0	None	0
Assembly & erection	Assembled on site, cane needed	✔	11,000	Lower labour cost	6,000
Commission & Training	On site	✔	10,000	None (in long term through local people)	10,000
		Plant capital cost	**85,000**	**Revised plant capital cost**	**60,200**
Site	Perimeter fence	✔	10,000	Simple fence	1,000
Sorting	Concrete floor in enclosed building	✔	75,000	Concrete floor covered by simple corrugated iron roof with wire mesh sides	10,000
		Civil capital costs	**85,000**	**Revised civil capital cost**	**11,000**
		Total capital cost	**170,000**	**Total revised capital cost**	**71,200**
O & M Internal	Staff	✔	30,000	Lower labour cost	15,000
O & M External	Materials, spares, fuel, lubricants, external labour	✔	1,000	None	1,000
O & M costs			**31,000**		**16,000**

Note: 1. Changes to incinerator design and materials may result in lower incinerating temperatures and higher releases to air.

8.3 CALEDON

Easily replicated in low-income countries as the incinerator is made from a single tube fabricated from stainless steel. Any good workshop as found in most cities and towns should be able to fabricate the main tube. Refractory brick could be used to line the combustion chamber instead of castable refractory.

The main problem is obtaining the stainless, which in some countries would have to be imported specially. It would be possible to fabricate the incinerator from steel rather than stainless but it would reduce the life of the machine.

8.4 MACRO BURN

The Macro Burn was not seen in use but it can be assumed that modifications could be made to make it more appropriate for manufacture in low income countries. However, without seeing it operation it is difficult to assess where modifications to its design or materials could be made. From discussion with the manufactures many of the materials used are similar to those used by the Ixopo incinerator and so some savings could be made although quantifying them would be difficult without further operational details.

9 OTHER INVESTIGATIONS: PRESSURE GROUPS, DFID SA AND IWM SA

A brief visit was made to a landfill site at Richmond which is on the main road between Ixopo and Pietermaritzburg (Provincial Capital for KwaZulu-Natal). A fire was underway at the landfill site and the local fire brigade were attempting to bring it under control. Fires are common at this site and often require the assistance of the fire brigade to bring them under control. Personnel at both Himeville TLC and Ixopo TLC have indicated that uncontrolled fires are common at many landfill sites in the KwaZulu-Natal province. These fires are both a nuisance to the operators and cause a great deal of air pollution locally. The landfill site is about 1 km from Richmond so complaints from the town are few. However, smoke from the fire often blows across the main road which runs within a few hundred meters of the site creating a potential hazard to those using the road.

In addition to visiting a number of sites, meeting manufacturers and seeking clarification on the environmental regulation side, discussions were held with a number of people not directly concerned with the incineration of waste in South Africa. This was in order to gain insight into opposition to incineration and to the general social and cultural background relating to waste and re-cycling. (See appended Itinerary for meetings with Bobby Peek, Dougie Brew (DFID SA) and Piet Theron (IWM SA).

These meetings followed a similar agenda agreed verbally at the beginning of the meetings. After briefly presenting the LCI project a general discussion took place enabling all sides to have inputs and present and clarify their views.

There exists a vocal opposition to waste incineration in South Africa. For instance the Environmental Justice Network Forum (EJNF) put in a representation to the National Waste Management Strategy and Action Plan (NWMS) version B, Annex 1, detailing their arguments against waste incineration. These relate to health risks, environmental hazard, high costs, low job creation potential, intrinsic competition with avoidance, minimisation, re-cycling and the need for aggressive regulation and enforcement. In addition alternative waste management options are given; however, these seem not to be appropriate for the South African situation.

Bobby Peek (former member of EJN) and **Linda Ambler** raised the following concerns and suggestions during the meeting:

- The project partners need to be aware of host country's waste management and environmental strategy – the LCI has to fit into an existing strategy and not forced into it.
- Has the host country/region got the financial and human resources to monitor and enforce the process so that it operates within the given performance limits?

– Money needs to be put into waste separation and recycling, which is cheaper and more easily implemented (and not into incineration).

– Stakeholders in the host countries need to be informed of the risks and options available.

Piet Theron of the South Africa IWM believes that waste incineration will have a place in future waste management strategies in South Africa. He also thought that energy recovery in the form of hot water should be explored. He thought that distribution from the plant could be done by the informal sector.

Dougie Brew of DFID SA was informed about the LCI Project. He welcome the research and recommended an integrated approach. Much expertise is available and a lot of work has been done with respect to clean water and sanitation. He also said that solid waste management needed to be addressed with the objective of improving people's lives.

10 DISCUSSION

10.1 SUMMARY OF MAIN INCINERATOR CHARACTERISTICS

Waste management in South Africa is recognised as a problem by the TLC's, consultants, and others with whom discussions took place during the visit. All three of the TLCs visited have chosen incineration as the main disposal route for municipal waste with recycling as an important part of operations. The choice of incinerator technology used and the scale of the front end operation varied between the different TLCs and to an extent were dependant on the size of the population served. Table 10.1 summaries the main characteristics of the incinerators investigated and the sites visited.

Table 10.1: The main characteristics of the incinerators investigated

		Himeville	Ixopo	Caledon	Macro Burn
Population		600	6000 - 10000	-	-
Quantity waste treated	m^3/y	5290	-	2800	-
Incinerator type		Local design	Toxic 400	DISA (x2)	Macro Burn 500
Throughput	Kg/h	-	750	250 (combined)	227
Costs: Capital	£	<1,000	85,000	6,500	50,000
Infrastructure	£	Inclusive	85,000	Inclusive	-
O & M	£/y	8,100	30,000	93,881	-
Op. temperature	^oC	assumed <400	850 - 1200	-	850 +
Front end operation		Manual sorting	Manual sorting	Manual sorting	unknown
Back end operation		Landfill residue	Landfill residue	Landfill residue	Landfill residue
Support fuel		None	recycled fuel oil	none	fuel oil
Loading		Manual	Automatic	Manual	Automatic
De-ashing		Manual	Manual	Manual	Manual
Control		None	Automatic	None	Automatic

10.2 PROJECTS AND TECHNOLOGY

Table 10.2 assesses the acceptability, affordability and replicability of the incinerators investigated in terms of their relevance to the low cost incinerator (LCI) project. A score has been given for this category with 1 representing the least and 5 the most relevant.

Table 10.2. Assessment of relevance for each incinerator to the LCI project

Incinerator	Acceptable		Affordable	Replicable	
	Emissions	Throughput		Technology	Cost recovery
Himeville	1	3	5	5	1
Ixopo	5	4	3	3	2
Caledon	2	2	5	4	1
Macroburn	3	3	3	3	2

The two incinerators seen in use at Himeville and Ixopo represent the two extremes of the low to medium cost incineration. The Himeville incinerator is very basic and achieves its primary aim of volume reduction. It would be easy to replicate elsewhere using locally available materials and labour. However, its main problem is that of very poor combustion resulting in an almost continuous cloud of smoke being emitted to atmosphere, which is not acceptable.

Modifications to the Himeville incinerator could be carried out to improve its performance but this would increase its cost from £1,000 to an estimated £8,000 without any guarantee of achieving acceptable performance (see Table 8.1).

In contrast the Ixopo incinerator performs well, operating at temperatures in excess of 850^{o}C. Releases to air have been independently analysed and shown to conform largely to local and national regulations. Replicating the technology elsewhere in Africa may be problematic, as the basic construction requires skills and materials that are not readily available in many low-income countries.

The high performance demonstrated in Ixopo however warrants an effort to investigate further the scope for replication in a host country looking at ways in which simplifications to its construction and reduce costs. A first attempt at assessing how the incinerator can be simplified (see Table 8.2) has reduced capital cost form £85,000 to £60,200 and infrastructure costs to £6,000.

Of considerable interest is the front end operation practised at both Himeville and Ixopo. Both recognise the need to sort and separate waste before incineration for two main reasons, firstly to remove potentially hazardous materials and secondly to remove materials that can be recycled and provide additional revenue for the site operation and work for the local population. Removal of recyclable materials such as glass and metals also helps to maintain combustion as these do not contribute to the combustion process and could inhibit combustion and operation significantly.

These front end operations are labour intensive which will have relevance in many low income countries and could fit in with recycling that is already carried out by the informal sector. By incorporating this type of front-end operation in an incineration project it may be possible to create new jobs or maintain existing jobs in the recycling sector. It may, where recycling occurs, enable the informal sector to become stakeholders in the project by allowing for sorting and separation on site in an organised manner, taking account of health and safety considerations.

10.3 REGULATION AND ENFORCEMENT

Regulating and enforcing incineration is one of the main problems if impact on the environment is to be minimised and monitored. In South Africa a regulatory framework exists for licensing waste management sites which includes incineration. Although enforcement is not as stringent as in many high income countries it does attempt to control waste management processes and their impact on the environment. With regards to the LCI project there are two main points of interest: the use of Best Practicable Environmental Option (BPEO) and the permitting flow chart.

BPEO enables waste management technology to be evaluated in terms of the local environment in which it will operate without imposing a strict set of rules. It is a useful tool enabling all responsible parities to ensure that a waste management process is appropriate to their needs while minimising the impact on the environment. However emission limits and operating guidelines also have their place in ensuring standard performance specifications are realised.

The flow chart shown in figure 8.1 for permitting can be used as a checklist when implementing the LCI in the host country to evaluate which legislation framework exists already and which step in the permitting/authorisation process needs to be formalised by other means.

The Guidelines for Process 39 should be taken as a basis to specify emissions from an LCI; a detailed scrutiny of this document is recommended and may result in a number of amendments.

10.4 ENVIRONMENTAL PRESSURE GROUPS AND OTHER FINDINGS

The case of EJNF against incineration raises a number of points we should take on board for the LCI Project implementation in a host country.

– Ensure the host country/region has sufficient human and financial resources to enforce the environmental standards required.
– Study the host country's existing/emerging waste management strategy and ensure the LCI Project fits into this.
– Inform stakeholders in-country of the risks of the LCI Project.

It is noted that the present project encourages recycling and waste separation of some components of the waste stream, which when left in the waste compromise the operations. Moreover the use of used, filtered and cleaned engine oil in Ixopo is consistent with the use of secondary materials.

10.5 IMPLICATIONS FOR THE LOW COST INCINERATOR PROJECT

The Ixopo incinerator is the only incinerator, of those seen, that performed to an acceptable level in terms of releases to air, throughput and incineration temperature although its cost is high. It would seem that there are two ways forward, firstly adapt the Ixopo incinerator, investigating ways in which its capital cost can be reduced. This would involve modifying the incineration to suit local skill, materials and facilities of the host country. However, it is likely that modifying the incinerator in this way mean a trade off in performance. Therefore it will be necessary to assess what level of performance would be acceptable and whether an appropriately modified Ixopo incinerator would conform. As already suggested (see Projects and Technology above) undertaking modifications in collaboration with the designer of the Ixopo incinerator should help to ensure that minimum possible de-rating of its performance.

Secondly design a new incinerator taking account of local materials, skills, facilities and of lessons learnt from the visit to South Africa. A full design specification will be required that would set operating criteria including minimum incineration temperature and maximum release to air.

Therefore, it will be necessary to provide guidelines for the Implementation, design and operation of low cost incinerators so that either of the two options can be measured against a pre-determined criteria. If the host country already has guidelines for incineration then these should be used. However, if guidelines do not exist or are not specific to small-scale low cost incineration then the LCI project should, in collaboration the responsible parties in the host country, develop guidelines based on those used in South Africa. These guidelines can then be used as a working document to show that any incinerator that the project introduces, even as a pilot scheme, conforms to and is being evaluated against acceptable criteria.

The lessons learnt from Himeville and Ixopo in sorting and separation of recyclable and hazardous materials should form an important part of any incinerator project and be considered at the design stage and not as an add-on. Good sorting can help to minimise releases to air and enhance combustion characteristic in the incinerator.

11 RECOMMENDATIONS

11.1 DEVELOP GUIDELINES FOR IMPLIMENTING THE FRAMEWORK FOR THE DESIGN AND OPERATION OF INCINERATORS

Guidelines for the incineration should be developed as part of the design phase of the project. These guidelines will then be used to develop the design specification for the incinerator. They should be based on those developed in South Africa which, while less stringent than those used in the UK and Europe, are well structured and appropriate to the needs of South Africa where controlled municipal waste incineration is still in its infancy.

The guidelines should include an Environmental Impact Assessment (EIA) which will enable value judgements to be made about the appropriateness of a particular process at a given location. The guidelines should give specifications for emissions levels, incineration temperature and residence times, waste quality and quantity, and information on front end and back end operations.

These guidelines should be developed in collaboration with stakeholders in the host country and in line with the location to ensure that they are appropriate and reflect the real situation rather than the theoretical one.

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11.2 DEVELOP AND TEST A DESIGN FOR A LOW COST INCINERATOR AND EVALUATE IT AGAINST THE GUIDELINES (PHASE 2)

Two options should be considered (also see figure 11.1):

1. Investigate further the possibilities of reducing the cost of the Ixopo incinerator design for manufacture in the host country. This will include assessing whether their are appropriate skills and facilities available to manufacture incinerator and if not identifying needs and developing a suitable training programme. If it is possible to reduce the cost of the incinerator to an acceptable level without seriously undermining its performance then a pilot project should be undertaken to test and evaluated it under real operational conditions in the host country.

The main implications of simplifying the Ixopo design is that its performance may fall below that observed in South Africa which could include incomplete combustion of the waste occurring, lower incineration temperatures and higher releases to air. To help minimise the effect on performance, simplification work should be undertaken in collaboration with the designer/manufacturer, Peter Johnson.

2. Draw up a design specification for a low cost incinerator using the guidelines developed for the design and operation of an incinerator. A number of conceptual designs should be developed and evaluated against the guidelines. The most appropriate design should be developed into a test-bed prototype with instrumentation arranged for comprehensive testing.

   The test results will be analysed and where necessary modifications and redesigns to the prototype will be made to ensure that the specified operating conditions are achieved. Data from the testing will be used to develop a model that can be used as a design aid for developing similar incinerators for different capacities and operating requirements.

   After successfully completing test phase the test-bed prototype should be developed into a fully operational incinerator for testing under real operational conditions in the host country.

11.3 DEVELOP FRONT AND BACK END OPERATIONS FOR INCINERATION

Front and back end operations should be developed as an integral part of the project rather than as an add-on at a later date. Low-cost and effective systems should be developed for use with the incinerator to minimise the possibility of harmful materials (e.g. batteries, PVC) and recyclable materials (e.g. metals, glass) being incinerated. The markets and outlets for removed materials need to be identified. Also methods for low cost disposal of the residue from incineration should be explored and developed.

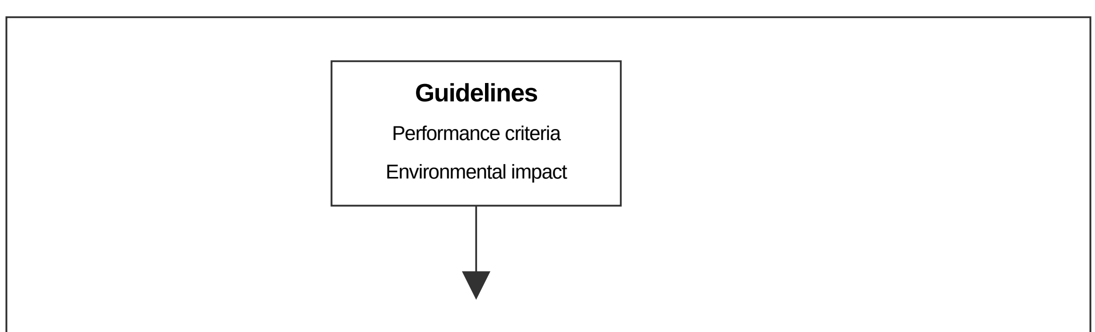
11.4 DEVELOP MONITORING GUIDELINES

Develop a set of monitoring guidelines for use with low-cost incinerators, which can be used by local authorities or other responsible parties to monitor the performance of the incinerator.

A regular site audit modelled on the South Africa Permit (under Section 20 of the Environment Conservation Act 77, 1989) should be envisaged.

11.5 DEVELOP OPERATION AND MAINTENANCE PROCEDURE

Parallel to the design, a set of operational and maintenance manuals should be developed, which also satisfy the requirements of the guidelines and specifications.



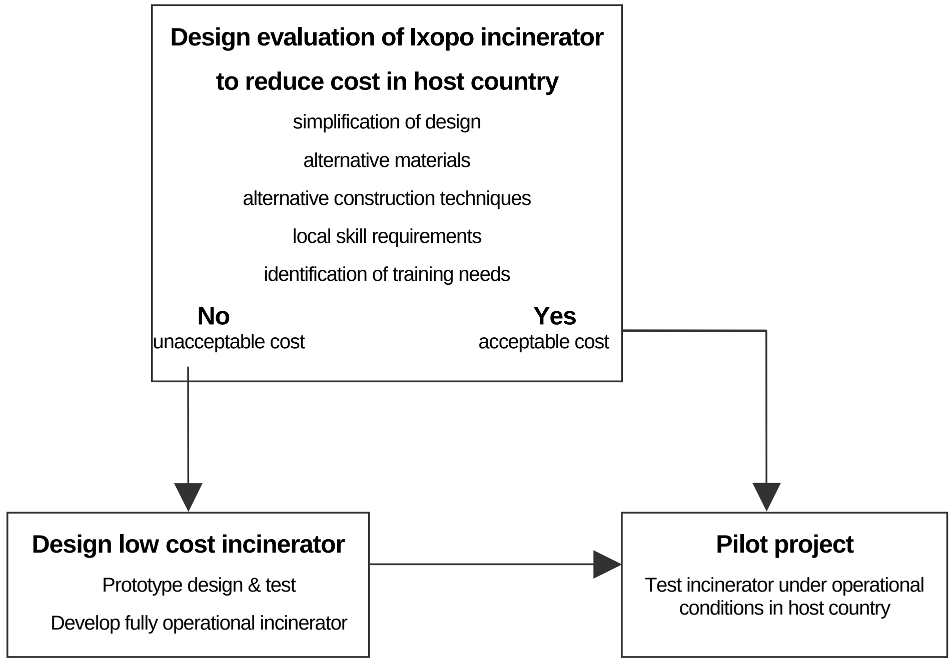


Figure 11.1: Flow diagram representing recommendation 11.2

Reference list for South Africa visit

1. Himeville

1.1 Questionnaire

1.2 Town map and site marked

1.3 Executive Leadership Prop. Policy Proposal 01.05.93

1.4 LF site permit Section 20, Environment Conservation 1989 Permit 16/2/7/U100/D1/21/P269, 03.07.97

2. Ixopo

2.1 Questionnaire

2.2 Leaflet TOXIC waste

2.3 K2N Focus (local free paper)

2.4 Ch. 19 Solid Waste (in SA 1994)

2.5 Environmental legal audit for Compass Waste Services (no date)

2.6 Specification for Static Hearth Pyrolitic incinerator (March 96)

Further information expected:

- Further information on planning/zoning
- Waste composition (JH), Ixopo
- Cost breakdown of operations Ix (JB)

3. Bobby Peak & Piet Theron & Dougie Brew

3.1 Questionnaire – 3-off

Refer to NWS Appendix 1 for EJNF opinion on incineration (Reference 8.3)

3.2 Voice from the Ground, EJNF, 1998 (received Dougie Brew)

3.3 Waste Management in South Africa, Piet Theron, IWM (no date but after 1997)

3.4 Article Engineering News, small scale incineration – a roaring success, June 4 – 10, 1999. Molope/Littergone

3.5 A recent government policy on legislation

3.6 Additional notes Piet Theron

3.7 Domestic waste composition, 1 page referring to township, received from Dougie Brew, 1999

3.8 Urban Governance, Partnership & Poverty in Johannesburg, Volume 1 (no date, after 1998), 2 pages 78 & 79 on waste policy

4. CSIR

4.1 Questionnaire

4.2 Pamphlet on CSIR FB technology

4.3 Pamphlet on general capabilities

4.4 Visitors map

4.5 Flowchart (by hand) of permitting process for MSW incineration

4.6 Regulations and documents (see under 8.)

Further information expected:

2 – 5 kg/h incinerator trial results (end of July)

5. DISA Technologies and Caledon MSW Site

5.1 Questionnaire and additional notes

5.2 Motivation report for permit for waste management

5.3 Waste disposal permit Reference 16/2/7/6406/D4/P259 (30.01.97)

Further information expected:

Copy of emissions results, waste analysis etc.

6. Safurnco (Macro Burn)

6.1 Questionnaire

6.2 Macroburn incinerator sizing guide

6.3 Brochure on incineration

6.4 Report on performance data (fax. 24.06.99)

7. General Notes

8. Policy and Regulations

8.1 National Waste Management Strategy & Action Plans South Africa – condensed version B January 14 1999. Draft Report

8.2 Ditto full version A (April 1999)

8.3 Ditto but only Appendix 1 EJNF submission for version B (10.03.98)

8.4 Guidelines for the design, installation and operation of incinerators, section process 39 (no date)

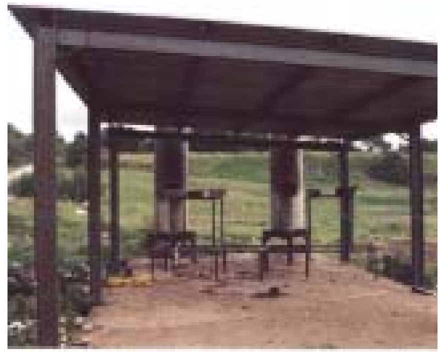
8.5 Minimum requirements for waste disposal by LF (DWAF 2nd edition) 24.06.98

8.6 Minimum requirements for handling, classification and disposal of hazardous wastes (DWAF 2nd edition) 24.06.98

Annex 4 – Site Photographs

Waste incinerator Caledon

- showing loading trays and covered loading area.



Waste incinerator Caledon

Waste incinerator Caledon

- showing particulate mesh screen.

Waste incinerator Caledon

- view of site and open buring of waste

Waste incinerator Caledon

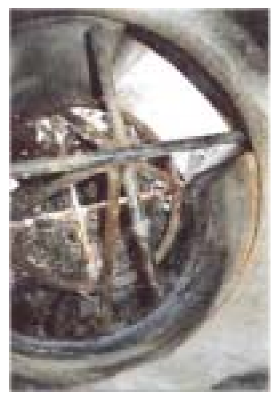
- view of site and open buring of waste

Waste incinerator Caledon

- view of site and open burning of waste with fire department in attendance

Waste incinerator Caledon

- internal view of combustion chamber and conical grate



Waste incinerator Himeville

- loading of fire chamber from loading floor

Waste incinerator Himeville

- hydraulic aluminium bailer machine

Waste incinerator Himeville

- external view showing superstructure

Waste incinerator Himeville

- external view showing grate and manual de-ashing

Waste incinerator Himeville

- external view showing cover sorting floor

Waste incinerator Himeville

- manual pre sorting to remove recyclable materials

Waste incinerator Himeville

- Emission from stack (note particulates)

Waste incinerator Himeville

- Emission from stack

Waste incinerator Himeville

- delivery of waste to sorting floor

Waste incinerator Ixopo

- external view showing stack and waste-oil, support fuel storage tank.

Waste incinerator Ixopo

- external view showing recyclables stored and awaiting collection

Waste incinerator Ixopo

- view showing feed via hydraulic ram

Waste incinerator Ixopo

- manual crushing of aluminium cans

Waste incinerator Ixopo

- manual sorting

Waste incinerator Ixopo

- manual stoking

Waste incinerator Ixopo

- manual stoking

Waste incinerator Ixopo

- loading of ram feed using tipper cart