Environmental Testing Report Synopsis

MD-1000 Clinical Waste Treatment System

Located at Recycled Waste PLC
Speke, Liverpool U.K.

Prepared for: **Environmental Waste International**
283 Station Street
Ajax
Ontario
Canada

Prepared by: **Precision Analysis (North West) Ltd**
Imex Spaces
Brunswick Dock
Liverpool
Merseyside
L3 4BD

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Introduction

Recycled Waste Limited operates an MD1000 microwave based medical waste processor, manufactured by Environmental Waste International of Ajax, Ontario, Canada. This technology is at the leading edge of current technology available for the effective handling and ultimate disposal of clinical waste and similar organic materials.

The layout, design and selection of the abatement is particularly impressive because it is designed to limit, if not eliminate completely, the formation and therefore environmental impact of the final exhaust gases. It has been known for many years that organic species such as Dioxins are related to the traditional methods of waste incineration. However, by removing the source of oxygen during the volume reduction stages, this system has minimised the risk of such reactions and formations leading to a system that can operate at lower temperatures without the negative impact on the exhaust streams.

The whole operation shows a huge potential for clean organic waste processing that includes the harder to handle materials such as clinical waste. On this occasion, waste meats and old operating theatre items were mixed together to simulate a typical waste stream and this was considered to be representative as it contained a lot of the elements that have shown up in existing streams such as metal implements.

As the processing of organic-based clinical waste falls under the definition of a prescribed material as originally dictated by Environmental Protection (Prescribed Processes & Substances) Regulations 1991 as amended and now covered by Integrated Pollution, Prevention & Control, the systems will need some form of environmental regulation when they become commercially available, even as mobile units. This report will serve as a guide to any potential future users on the level of expected emissions.

The abatement systems on the unit are both wet scrubbing and dry turbine thermal abatement using dual fuel technology (gas & exhaust waste bleed).

In this instance the environmental release of particulate matter, a range of heavy metals, volatile organic compounds, Dioxins (& Furans), acid gases and combustion gases are prescribed substances arising from the operation of a regulated process. Statutory Instruments will undoubtedly apply to the operation of the processes, as will the legal requirements relating to the control of exposure to the operators used engineering controls. Statutory nuisance could also be levelled at the process unless a clear understanding of the discharge profiles are known. This last element extends to environmental noise, which may well be the only issue that needs to be addressed after the issue of this report.

As part of a requirement for compliance monitoring, the microwave waste processing operations were tested over a two-day period during the second week in April 2002. The survey reported here relates to the emissions that arose from the process. This assessment was carried out by S. Lawrence of C√CHEC, part of the affiliate organization of Precision Analysis (NW) Ltd, an experienced and competent environmental analysis and consultancy group that is a member of the Source Testing Association.

Scope of Contract

Representatives of Precision Analysis (NW) Ltd / C√CHEC visited the Merseyside premises where Recycled Waste currently have their Microwave Waste Processing system installed. The objective was to assess the environmental performance of the authorised process with the following objectives:

- To assess operation and condition of abatement and exhaust discharge equipment.
- To determine exhaust gas volumetric flow rate.
- To determine extract gas temperature.
- To calculate appropriate isokinetic sample rate.
- To sample stacks isokinetically to collect and determine particulate concentration (and in turn heavy metals) i.a.w. BS3405: 1983 *Measurement of particulate emission including grit and dust (simplified method).*
- To sample and determine total Volatile Organic Compounds
- To sample and determine the level of Dioxins (& Furans) in exhaust streams
- To sample and determine various acid and exhaust gases
- To sample and analyse the quality of water effluent COD, BOD, VOC's and suspended solids
- To sample and analyse the carbon residue effluent and determine leachates
- To determine the anti-microbial efficacy of the microwave process
- To relate conditions to relevant guidance.
- To provide a full report on the findings.

Microbiology

Testing Laboratory: Precision Analysis (NW) Ltd, Imex Spaces, Brunswick Dock, Liverpool, L3 4BD. 0151-708-6212. UKAS Testing Laboratory No 1763.

Date of testing: 9th & 10th April 2002

Methodology: Testing was based on recommendations in the Environment Agency's draft document *Technical Guidance on Clinical Waste Management Facilities*, version 2.2 September 2001 based on Level III STAATT guidelines. i.e.:

Precision Analysis

- Alternative Clinical Waste Treatment in the UK should achieve inactivation of **vegetative bacteria (including mycobacteria), fungi, viruses, and parasites** to a 6 log reduction or greater. ***Escherichia coli*** represent bacteria that reside in the gastro-intestinal tract. ***Pseudomonas aeruginosa*** and ***Staphylococcus aureus*** are recognised by STAATT as indicator organisms for all vegetative bacteria.

- Inactivation of ***Bacillus stearothermophilus*** or ***Bacillus subtilis*** spores should take place to a 4 log reduction or greater. Bacterial spores are recognised as the microbial structures most resistant to heat treatment and disinfection.

- To demonstrate the efficacy of the decontamination process, test microorganisms should be exposed to the process in the presence of typical waste load compositions, notably those that may hinder full access of treatment.

- Post-commissioning, microbial inactivation should be demonstrated at a regular frequency using bacterial spores (no less than once weekly is recommended by the EA). A relationship between these microbiological tests and real time parametric treatment monitoring should be verified (i.e. the killing of spores should be linked to external equipment monitoring chamber conditions such as temperature, microwave energy values, pressures, etc).

Method

The first load (day 2) contained 2 uninoculated ham shanks, animal bone (see Figure 1) and various metal (stainless steel, brass and titanium), plastic surgical instruments, laboratory coats (cotton) and general waste. The second load (day 2) contained 3 ham shanks and 2 marrowbones inoculated with test organisms (see Figure 2), stock suspension and syringes complete with their needles which had been used to inoculate the meat and marrowbone were also added to the load (see Figure 3 and 4). Other general waste (plastic, glass, fabric) was also added to the second load.

Building Air Monitoring

Atmospheric monitoring for pathogenic microorganisms was carried out using a centrifugal sampler. Sampling took place before and during the decontamination process, in close proximity to the decontamination equipment.

Effluent Microbial Monitoring

Effluent from the decontamination unit passed into a sealed non-sterile receptacle directly below the unit (auxiliary scrubber). Samples were collected from this vessel, and from the main scrubber overflow before the chlorine dioxide injection point and carbon filter.

Results

All test organisms were in excess of 10^6cfu/ml before they were introduced to the decontamination unit, and most were in excess of 10^8cfu/ml. After the decontamination run, none of the test organisms was detected in the marrowbones or the meat, and none were recovered from any of the six replicate broth cultures placed throughout the load. Prolonged incubation in broth did not permit the test organisms to recover.

Test organisms impregnated in fabric containing horse blood were also not detected after passing through the decontamination unit.

Bacteria were detected at $2.5x10^2$cfu/ml in material collected after the macerator. None of the test organisms was detected in this sample. The organisms detected represented normal air-borne bacteria, and this level of contamination is acceptable as the macerator is not required to function as a sterile unit.

Low levels of bacteria were also detected in the effluent samples (at 22^OC only). None of the bacteria recovered were pathogenic species or any of the test organisms. This result represents normal low-level background contamination not unexpected from a non-sterile site (auxiliary scrubber).

Air monitoring detected a low level of air-borne bacteria, which increased slightly during the decontamination run. This may be due to the increased air turbulence resulting from the operation of the unit. However, all counts were within acceptable limits (<100cfu/m^3) and none of the test organisms was detected during air sampling.

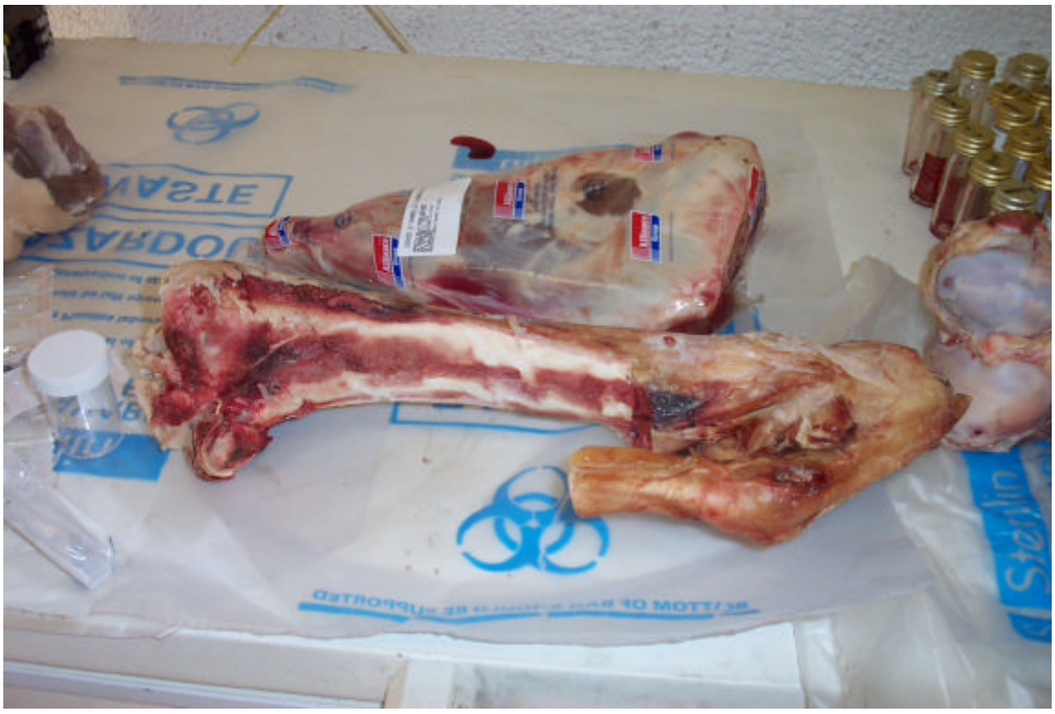

Figure 1

Uninoculated Ham Shank and Animal Bone

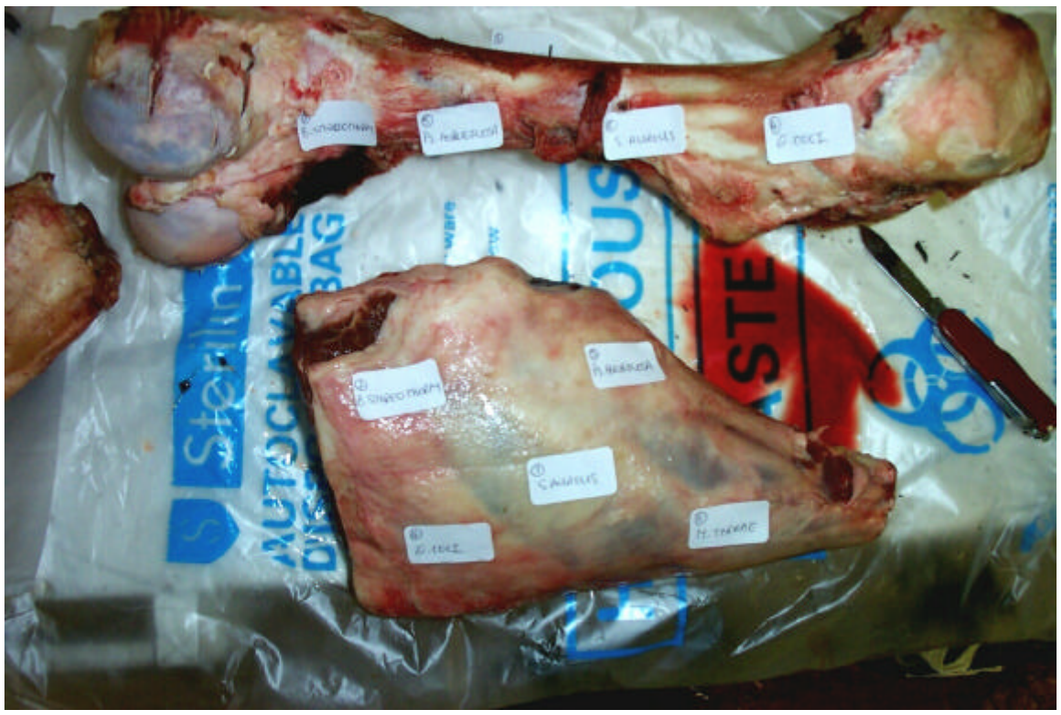

Figure 2

Ham Shank and Animal Bone Inoculated with Test Organisms (Labelled)

Figure 3

Microorganism Stock Suspensions, Inoculated Meat and Animal Bone Samples and General Waste.

Figure 4

Microorganism Stock Suspensions, Inoculated Meat and Animal Bone Samples and General Waste.

Figure 5

Post Decontamination Meat and Animal Bone

Air Emissions

Introduction

On the days of the assessment, the plant operators made up batches of material consisting of solid waste from typical hospital waste streams including metal implements. These were diluted by large amounts of waste meat sourced by members of the Precision Analysis / C√CHEC team. Sample ports were fitted following a pre-survey visit a few weeks earlier and the final abatement discharge point was clear of any major restrictions.

Overall stack condition was satisfactory. Only one sampling port was installed in a straight section of the exhaust ducts, however these were not appropriate for isokinetic sampling probes and were therefore not used. The actual point of discharge was vertical to a height that will allow effective dilution and dispersion of any traces of pollutants and allows the heat to dissipate.

Temperature profile was determined along the sampling axis of each exhaust. In general, conditions were stable and conditions of satisfactory flow and temperature profile measurements were maintained in accordance with 6.3.2 of the standard, BS3405, although the monitoring access point must be noted as a deviation from the method but this is not considered to have any significance on the eventual pollutant determinations.

Particulate & Dioxin sample integrity was maintained during all sampling runs. The initial flow measurements were comparable with the profiles recorded during the actual sampling stages. This initial flow estimate is called for as part of the standard, BS3405.

No visible discharges were made from any of the stacks at start-up or at any time during testing. A vertical, permanently secured external ladder to secure scaffolding was provided and safe conditions were maintained at all times.

Reference was made to the Secretary of State's Guidance PG5/1 that relates to clinical waste incineration, the closest guidance to the emerging technology being assessed on this occasion. In addition, consideration was also given to the applicable elements of BS4142 for the rating of industrial noise emissions, which is now covered in IPPC and regulated by the same regulator as exhaust emissions. The findings of the noise survey will be included in a separate report that includes other site specific details and data not relevant to the operation and selection of the actual equipment being tested for this report. The noise findings are related to the distance to the boundary of the site, which in this case was very close to the exhaust stacks.

Results from the testing of the exhaust gases suggest that the evaluations were, for the most part, very satisfactory with concentrations of all pollutants well below any guidance value for the components tested. The actual performance of the unit itself and its ability to destroy the microbiological elements of the waste without generating an exhaust gas problem was confirmed.

Air Sampling Methodology

The sampling requirements included a range of components:

- Total particulate matter including heavy metal fractions *sampled* in accordance with *BS 3405:1983, Measurement of particulate emissions including grit and dust (simplified method)*
- Dioxins & Furans *sampled* in accordance with *NSPS TEST METHOD 23,*
- Total Volatiles *sampled* in accordance with *NSPS TEST METHOD 25A-DETERMINATION OF TOTAL GASEOUS ORGANIC CONCENTRATION USING A FLAME IONISATION ANALYSER,*
- Combustion gases and Acid Gases *sampled* in accordance with *NSPS TEST Method 26A-Determination of Hydrogen Halide and Halogen Emissions.*

To carry out this evaluation, the preliminary measurements of stack gas temperature and efflux velocity were also required. In all cases, the test periods were such that a sufficient volume of gas was sampled to provide satisfactory limits of detection in relation to the authorisation levels.

Stack Emission Results

A summary of the data obtained after metal items of various types were added is as follows:

Average exhaust duct temperature, 0C	274
Barometric pressure. mb	1020
Velocity @ exhaust conditions, dry, m/s	37.0
Flow Rate @ 273K & 101.3kPa, m^3 / min	0.20

The following results are all corrected to the reference conditions of 273K, 101.3kPa, but not to a specific Oxygen value, unless otherwise stated.

Particulate matter	11.4 mg/m^3
Total heavy metals[1]	0.22 mg/ m^3
HCl	<0.50 mg/m^3
SO2	<1.0 %
Volatile organic carbon	<1.0 mg/m^3
Carbon Monoxide	11.0 ppm
Carbon Dioxide	1.8 %
Oxides of Nitrogen	1.0 ppm
Dioxin / Furan (TEQ)	0.17 ng/m^3
Oxygen	18.0 %

1 See appendix 1 for to see anticipated regulatory limits.

Water Effluent

Testing methodology

Samples of liquid were asceptically taken from the scrubber unit after the two runs were complete. These were analysed to determine specific chemical/microbiological parameters for disposal purposes. Analysis was performed by standard methodology using both classical chemical and modern instrumental techniques (see below).

Results

Specification for disposal to mains is site specific and is determined by the local authority. However, the recorded results are considered low and should not pose problems regarding disposal.

Solids Residue

Sampling Methodology

The remaining residue was removed from the microwave chamber after undergoing a substantial volume reduction and analysed to determine the level of carbonization as well as inorganic residues such as heavy metals. This utilized two distinct analytical techniques; the carbon was determined by furnace elemental analyser and the heavy metals atomic absorption spectroscopy and atomic fluorescence spectroscopy. The solids residue was also tested for leachability of metals using the above analytical techniques.

Results

Initial metallic testing indicated that further testing for the leachability of the metals was required. The results of this testing where found to be within the guidelines for landfill use as indicated in the Interim Guidance on the Disposal of Contaminated Soils, Environment Agency Publication, 2nd Edition, 1997.

Overall Conclusions

None of the test bacteria impregnated in bone, meat, fabric, and present in meat enriched bacterial broth cultures, were detected after passing through the decontamination unit. Therefore, the **required 6-log reduction was exceeded** for all test organisms during this decontamination run.

There was no evidence of microbial environmental contamination arising from the unit, as confirmed by air and effluent sampling.

The operator has made a considerable effort to prepare the site and optimise the process within the limits of the present equipment. The abatement is very comprehensive and appears to deal with all expected pollutant forms and the operational design of the microwave unit itself actually stops the more significant pollutants forming in the first place.

From an environmental stand-point, the system offers what appears to be among the cleanest and most effective method of dealing with clinical waste while ensuring any pollutants that could potentially be

present in the exhaust gas are dealt with before they have any chance of causing a significant environment impact.

As far as pollutant exhaust gases emissions are concerned, all the pollutant species determined fell comfortably below the PG Guidance limits confirming the “clean” image the system is trying to portray. (See appendix 1 for anticipated limits to ‘Alternative to Incineration’ technologies).

The “metallics added” residue might have been classified as a controlled waste and as such, not be accepted at a traditional landfill site, but since the leachable metal concentrations are within the Environment Agency specification for Contamination Classification Threshold for Disposal, the disposal of the material will likely not be problematic.

It is obvious to anyone that visits the plant and then reviews the actual pollutant discharges, that this technology has a huge potential and certainly offers the best environmental option we have seen for dealing with clinical waste.

Appendix 1

EXPECTED LEGISLATIVE LIMITS FOR 'ALTERNATIVE TO INCINERATION' TECHNOLOGIES

EMISSION	CONCENTRATION
Hydrogen chloride (excluding particulate matter)	30mg/m³
Total particulate matter	30mg/m³
Carbon monoxide	50mg/m³
Sulphur dioxide	300mg/m³
Organic compounds expressed as total carbon	20mg/m³
Dioxins and furans	1ng/m³ TEQ
Cadmium and its compounds (expressed as cadmium)	0.1mg/m³
Mercury and its compounds (expressed as mercury)	0.1mg/m³
Other heavy metals and their compounds (total of arsenic, lead, chromium, nickel, copper, tin and manganese) expressed as metal	1mg/m³