BMRA
British Metals Recycling Association

BREF Style Report
Metal Fragmentising Operations
Industrial Emissions Directive

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BREF Style Report - Metal Fragmentising Operations

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1.0 EXECUTIVE SUMMARY

This report provides an analysis and evaluation of the current industrial metals fragmentising processes within the UK, including a consideration of consumption, emissions, and possible future developments within this sector. Its overall objective is to inform the BAT (Best Available Technique) recommendations and decision-making process within the Industrial Emissions Directive (IED), when the relevant technical experts, both domestically and in Europe, consider the metals fragmentiser industry.

The continued development and evolution of the metals fragmentising industry is driven by a need to provide consistently high quality in-feed to consumers; to reduce the amount of waste that is disposed to landfill and; to meet producer responsibility targets. The fragmentising industry is long-established, and the general processing methodology has matured and been optimised since its original development in the early 1960s.

The methods used to research and subsequently analyse this sector include: collecting information through surveys; interviewing manufacturers and operators and; undertaking monitoring and sampling events at fragmentiser installations.

The UK metals recycling industry (MRI) is estimated to be worth around £5.6 billion annually. It comprises an estimated 2,500 businesses, employing 8,000-10,000 people. Annually the industry processes approximately 13 million tonnes of ferrous and non-ferrous metals, with 3-4 million tonnes of this material being processed by fragmentisers, providing valuable secondary raw materials to consumers for melting into new production materials. The MRI can be seen as having a 'pyramid' structure with many small businesses at its base that collect metal and metal-rich wastes that may be sorted, segregated and sold to typically-larger merchants higher-up the pyramid. At the top of the metals recycling 'pyramid' are the largest operators which frequently include those operating metal fragmentisers (and export businesses).

The results of this report's industry survey indicate that there are around 45 such installations within the UK. These installations differ in size and configuration. However, their layout typically comprises:

- A reception area where materials are received, inspected and validated.
- The metals fragmentiser plant. This is used to mechanically fragment and 'shred' the materials in to smaller pieces.
- Post-shredder processing. Fragmentised materials are passed to downstream processing plants that separate metallic from non-metallic materials and produce discrete ferrous and non-ferrous metal outputs. These separation processes typically include air suction and magnetic separation, with some including other processes.

The fragmentation process is one of separation/purification and densification of the metal content ready for it to be melted as a secondary raw material.

The methods used for the milling fall in to either 'damp' or 'dry' processes. Damp processing is the most common method employed within the UK, and involves the controlled injection of water into the mill to reduce and control emissions and to suppress potentially flammable atmospheres. Dry processing typically employs mill extraction, incorporating a wet scrubber to control emissions. Several operators already use certified management systems (for example ISO 14001:2004 and ISO 9001:2008) through which they manage and control their installation's operation. Others employ internal systems to ensure they remain within the requirements of their current Environmental Permit and those regulations enforced by local authorities.

Monitoring events undertaken for this report included measuring and collecting samples of direct and fugitive emissions to air, land and water from four installations. Samples were analysed for particulates, organic and inorganic compounds (including: metals, aliphatic and aromatic hydrocarbons, persistent organics including dioxins, furans and PCBs) and microbiological agents. Dioxins, furans and microbiological agents were either not detected or were present at only trace concentrations. When other potential contaminants were detected, they were typically associated with particulate fractions. These particulates could be found within the air, or within the site drainage waters.

Results from the monitoring events indicated that the installations represent an overall low emission risk. Nevertheless, some emissions may, on a site by site basis, require further control.

The majority of emissions relate to dust/particulates and noise. Without proper controls, these emissions may be considered a nuisance by enforcement agencies but can be easily mitigated by the implementation of management procedures and simple physical upgrades to the installation itself.

Recommendations for BAT conclusions have been made and are summarised in table 1, below. The most significant of these BAT recommendations in terms of greatest benefit, effectiveness and feasibility for implementation are:

- Implementation of certified Environmental Management and Quality Management systems
- Waste acceptance procedures, and radiation screening
- Continual infeed inspection, including detailed risk based inspection plans for bales, CA Scrap and ELVs
- Covering of conveyor belts and some downstream processing operations, and the use of water mist and spray dust suppression
- Undercover storage of process outputs and residues (not including ferrous materials)
- Routine monitoring and measurement of consumption
- Routine monitoring and measurement of emissions

The metals fragmentising sector is investing considerable resources into the development of increasingly sophisticated downstream separation and recovery processes. These include, for example, operations to recover plastics, which can be sorted by polymer for reuse.

More sophisticated metals recovery and purification stages have also been developed, to capture as much of the metal as possible.

The sector is also developing its capacity to deliver energy recovery processes for its non-recoverable/recyclable residues, or processing the non-recyclable materials to a standard suitable for energy recovery. It is possible that many of these new techniques are not located at the site of the fragmentiser installation.

This will allow the sector to offer a complete waste management service that will deliver opportunities to maximise the commercial rates of recycling and recovery for metallic wastes, to assist producers with their responsibility requirements under extended producer responsibility regimes (such as end-of-life vehicles, waste electrical and electronic equipment, and packaging), and to reduce the amount of materials sent to landfill. The industry is working towards achieving its 'zero waste' objectives.

Summary Of Best Available Techniques

Suggested Procedure	Report Section	Fragmentising Method: Dry	Fragmentising Method: Damp	Cost	Effectiveness	Feasibility
Management Procedures						
Certified Environmental Management System	10.1.1	++++	++++	££	●●●	■■■
Certified Quality Management System	10.1.2	++++	++++	££	●●●	■■■
Qualified Staff/training programs	10.6.1	++++	++++	££	●●	■■■
Noise/vibration management plan	10.4.3	++++	++++	££	●●	■■■
Accident/emergency management plan	10.4.1	++++	++++	££	●●	■■■
Site diary	10.4.2	++++	++++	£	●	■■■
Annual Emission Monitoring/Analysis						
Fugitive and depositional dusts	10.5.7	++++	++++	££	●●	■■■
Stack emission (see coments on H&S)	10.5.7	++++	++++	££	●●	(■■■)
Water discharge analysis	10.5.6	++++	++++	£	●●	■■■
Fragmentiser residue	10.3.2	++++	++++	£	●●	■■■
Noise and vibration	10.4.3	++++	++++	££	●●	■■■
Waste Acceptance						
Acceptance Procedure	10.2.2	++++	++++	££	●●●	■■■
Risk Based Inspection and Acceptance	10.2.3	++++	++++	££	●●	■■■
Reception Areas	10.2.5	++++	++++	££	●●	■■■
Inspection Procedures	10.2.5	++++	++++	££	●●	■■■
Radiation Screening	10.2.1	++++	++++	£££	●●●	■■■
Quarantine Areas	10.2.4	++++	++++	££	●	■■
Storage and Movement						
Covered conveyors and conveyor transfer point	10.3.7	++++	++++	£££	●●●	■■■
Covered storage bays	10.3.1	++++	++++	££	●●●	■■■
Water Mist and Sprays	10.5.2	++++	++++	£££	●●	■■■
Screening / Acoustic barriers/walls	10.4.3	++++	++++	££££	●●●	■■
Waste Water Management						
Appropriately Designed Drainage System	10.5.5	++++	++++	££	●●●	■■■
Foul Sewer Discharge	10.5.5	++++	++++	££	●●	■
On site water treatment and reuse	10.5.6	++++	++++	£££	●●	■■■
Sedimentation tanks and oil interceptors	10.5.4	++++	++++	£££	●●	■■■
Water use						
Water use reduction plan	10.5.2	++	+++	££	●	■■■
Metering at areas of use	10.5.2	++++	++++	£££	●●	■■■
Annual water use reporting	10.5.2	++++	++++	££	●	■■■
Calibrated Mill water injection systems	10.5	o	++++	£££	●●●	■■
Processing						
Pre-shredding	10.2.3	++	+	££££	●●	■■
Continual in feed inspection	10.2.1	++++	++++	££	●●●	■■■
Detailed inspection plans for bales	10.2.4	++++	++++	££	●●●	■■■
Detailed inspection plans for ELVs	10.2.4	++++	++++	££	●●●	■■■
Detailed inspection plans for CA scrap	10.2.4	++++	++++	££	●●●	■■■
Recycle wear parts	10.3.5	++++	++++	££	●●	■■
Protection of underlying ground and baseline						
Site investigation/ monitoring	10.7.1	+++	+++	££	●●	■
Appropriate concrete paving	10.7.1	++++	++++	££	●●	■■■
Appropriate liquid storage	10.3.8	++++	++++	££	●	■■■
Power use						
Power use reduction planning	10.5.1	++++	++++	£	●	■■■
Metering at areas of use	10.5.1	++++	++++	££	●	■■■
Metering of separate functions	10.5.1	++++	++++	££	●	■■■
Annual power use reporting	10.5.1	+++	+++	£	●	■■■

Key

Desirability of the BAT recommendation	
Strongly recommended	++++
Recommended	+++
Suggested	++
Desirable	+
Not Applicable	o
Cost Profile - implement and manage	
£100,000s	££££
£10,000s	£££
£1,000s	££
<£1,000	£
Effectiveness of the proposed BAT recommendation	
Will produce some improvement to operations	●
Will result in improvements to operations	●●
Will result in significant improvements to operation:	●●●
Feasibility of the proposal to industry as a whole	
Possible for all installations	■■■
Possible for some installations	■■
Limited application at some installations	■

Table 1: BAT summary

2.0 INTRODUCTORY COMMENTS

The BAT (Best Available Techniques) Reference Document (BREF), entitled 'Waste Treatment Industries' reflected an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive).

The Waste Treatment Industries BREF did not include information on the Metals Fragmentising Industry (MFI) sector. The trade body for the UK metals recycling industry, the British Metals Recycling Association (BMRA), commissioned this report to inform the process of BAT. It is not clear at this stage whether the BREF for Metal Fragmentisers will be added as an addendum, annex, or new chapter within the existing Waste Treatment Industries BREF.

The layout and content has been based upon what would be expected of a full BREF. The report provides background monitoring, research and questionnaire data from the industry. This information is used then to produce BAT recommendations which are provided along with reasoning for the suggestion and the benefit to the operators.

2.1 Scope of this Document

This report is intended to cover the activity of Metals Fragmentising and as described in Section 5 of Annex I of the IPPC Directive, namely 'waste management'. There are already BREF reports covering waste incineration and some thermal waste treatments, such as pyrolysis and gasification (point 5.2 of Annex I of the Directive).

The recovery (R) and Disposal (D) (R/D) codes of Annexes II A and II B of Directive 75/442/EEC which refer to the IPPC Directive changed according to the Commission Decision 93/350/EC. Since this last amendment corresponds to the most recent classification of R/D operation codes, the following outline the type of waste operation codes that are covered in this document.

R4 – Recycling / Reclamation of metals and metal compounds

R5 – Recycling / Reclamation of other inorganic materials

R13 – Storage of wastes pending any of the operations numbered R1 – R12 (excluding temporary storage, pending collection, on the site where it is produced)

D14 – Repackaging prior to submission to any of the operations numbered D1 to D13

A full 'life cycle assessment' applied to a certain waste can consider all the links in the waste chain as well as the impact of the final product/waste on the environment. IPPC is not intended to address these analyses, but focuses instead on installations. For example, minimisation of the amount and/or toxicity of the waste produced at source in industrial installations is intrinsic to IPPC and is covered by each industrial sector BREF.

The scope of this document should not be interpreted as any attempt to interpret the Industrial Emissions Directive or any waste legislation.

General information on the waste treatment sector

The waste treatment sector is highly regulated in the EU. For this reason, there are already many legal definitions of terms commonly used in this sector. In simple terms waste treatment installations contain operations for the recovery/recycling or disposal of waste. These installations are considered to provide services to society, by handling their waste material, and in turn may themselves generate products, secondary raw material and wastes. The information below, suggests there are ~45 metal fragmentiser operations in the UK. The actual number is unclear because of two main factors.

1. The industry may not report the number of shredders due to operational changes (e.g. closure or opening of new facilities), and

2. Some shredders may be of a size that falls below the IED Directive facility threshold.

It is of note that whereas many of the other waste treatment operation covered by BREF and PPC handle hazardous waste, metal fragmentisers (MFs) do not generally process hazardous wastes, and do not have environmental permits to allow the processing of such waste.

Applied techniques, emissions and consumptions in the waste treatment sector – Metals Fragmentising

This document provides a summary of the technical and environmental situation of metals fragmentising. It contains a brief technical description of the activities and processes found in the sector and it is complemented by actual emissions and consumption data gathered from current installations. The information in this document describes:

- Commonly-applied techniques such as generic management of installations, reception, acceptance, traceability, quality assurance, storage and handling, energy systems.

- Recovery of materials from the waste, emission abatement treatments to air, waste, water and residues generated in the Waste Treatment (WT) installations.

This document also identifies the key environmental issues for the metals recovery sector. These are related to emissions to air and water and soil contamination. However, due to the nature of the industry, some emissions may be more important for some operators than others. In this document the most significant issues are identified to help the reader to recognise the main environmental issues for installations.

Techniques to consider in the determination of BAT

Techniques are included for consideration in the determination of BAT. Each BAT recommendation is described briefly and includes the achieved environmental benefits, cross media effects, operational data, applicability and, where possible, economics. In some cases, the driving forces for implementation have been explored and examples of metal fragmentising sites using such techniques reported.

This document provides information within different categories. They relate to the techniques for the improvement of the environmental performance of the installation operation itself, or techniques for the prevention of contamination, or the management of the installation. The other categories relate to:

a) techniques for the abatement of air emissions,

b) techniques for the abatement of water emissions,

c) treatment of solid waste residues generated during the treatment process,

d) techniques for the control and prevention of soil contamination.

In some cases it is not possible to confine a technique to one of the above categories.

From the information provided it is clear that the majority of the techniques are related to the improvement of the environmental performance of metal fragmentising process, prevention or management techniques. The rest of the techniques deal with the process generated emission control and abatement. A significant aspect of the techniques considered relate to the inspection, validation and reception of materials for processing.

Best Available Techniques for the waste treatment sector – Metal Fragmentising

This document contains the suggested Best Available Technique (BAT) for the Metals Fragmentising sector. They relate to the most relevant environmental issues and typically relate to emissions from normal operation. In some situations, BAT conclusions following investigations in to emissions from incidents and accidents are also reported.

It should be noted that whilst this document is intended to provide some background to the BAT for the metals fragmentisers, BAT itself will be determined by an EU-appointed Technical Working Group (TWG). The main reason is that the BAT chapter contains a rationale for when the BAT conclusions apply. Consequently, it is essential to consult the entire BAT chapter. BAT conclusions for the metals fragmentising sector will be set out at two levels.

1. The generic BAT conclusions

   i.e. they are generally applicable across the whole waste treatment sector.

2. Sector specific BAT conclusions

   e.g. those for the metals fragmentising installations. These may be a combination of generic elements and the activity specific elements applicable to the particular operation. In some cases other BREF documents can give guidance and then form part of the list of documents that need to be considered when analysing a specific installation.

Some of the BAT conclusions are based upon established technologies or techniques. Such techniques have been highlighted following a similar strategy to that used in the European Union waste list of the Waste Framework Directive in the determination of BAT in this sector; some associated emission levels following the use of BAT have been identified. These relate to the emission of volatile organic compounds (VOCs) and particulate matter to air, and include noise emissions to air, and parameters specific to water including suspended solids, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), oils and hydrocarbons.

2.2 Emerging Techniques

In the general context of the operations, the capital outlay for a fragmentiser and its associated separation processes is significant. This financial entry barrier to an industry which, already has significant capacity, limits the installation of new plant. The overall method of fragmentising, using a hammer mill, is a long-established process. Therefore there is not a significant renew and replacement process/cycle. Mills are subject to the replacement of parts through normal wear and tear, maintenance and modification/upgrade. Due to the significant initial outlay many installations have been processing for many years. Responses to the survey (see Section 5.0) indicate that the average age of mills is 15.3 years, with some mills up to 30 years old. However, with routine replacement of parts and servicing programs, installations will have components significantly younger than the operational age.

Emerging techniques include those methods which have not yet seen widespread acceptance or implementation within the UK. These include the use of foam injection, bag-house filters (a commonly-used mitigation measure in other industries), closed-loop air systems. In addition, significant investment has been made in developing downstream processing and separation techniques to increase the level of material recovery.

2.3 Conclusion

Clearly this document can only provide suggestions for the production of BAT and does not constitute a definitive BREF.

Notwithstanding the above comments, it would appear from the work undertaken that fragmentising is the Best Available Technique (BAT), for the liberation and recovery of metals, plastics and other potentially recoverable materials for recycling and recovery from a mixed metal infeed.

Further work to collect data on the current consumption and emission levels and on the performance of techniques to be considered in the determination of BAT should continue. If this is handled at company level, then we would urge those companies to share the data they collect (anonymously if required) with the BMRA so that the development of BAT conclusions can continue to evolve.

Monitoring programmes were designed to provide some information on sites and the types of emissions which might be expected. Placing sampling equipment and gathering data close to the fragmentiser mill chamber has been very difficult as this area is closely controlled for health and safety reasons

On any site, and in particular on sites of potentially contaminative operational uses, operational conditions can change rapidly over short distances and time periods and there may be differences in operational conditions between monitoring events. No responsibility can therefore be accepted for conditions that have not been revealed by the monitoring investigations or not disclosed in the questionnaires.

Site assessments can range from limited observations to extensive investigations and testing. The degree of uncertainty in interpreting a site's environmental condition will depend upon the budget and scope of work authorised by the client. Some degree of uncertainty will always exist.

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3.0 PREFACE

3.1 Objective of this Document

The objectives of this document are broadly similar to that of a BREF and include:

- to review the current metals fragmentising industry within the UK;
- to identify the general techniques employed in the metal fragmentising industry and the range of possible techniques;
- to provide a framework for the MFI to consider in respect of BAT for their operations;
- to consider the operational management of MFs;
- to detail the types of emissions currently experienced at MFs;

- to detail the types of consumption currently experienced at MFs;
- to provide reference information for the UK National Experts to use in their negotiations with the European Commission when establishing the sector BREF; and
- to provide the industry and domestic permitting authorities with reference information to help shape/influence permit conditions and monitoring requirements

3.2 Status of this Document

Unless otherwise stated, references to 'the Directive' in this document mean Council Directive 2010/75/EU on Industrial Emissions.

This document has been produced in the style of a BREF report using similar formatting and content as a formal BREF document. This is to help feed in to the BREF development process.

This report is based upon research, monitoring of the fragmentiser process and gathered information and opinions from the fragmentiser industry. This report represents a view of the UK fragmentiser operators, their operation and management, and cannot, without input from the rest of the EU Community, provide a full and detailed BREF position.

There will inevitably be gaps and assumptions made about the data provided. Nevertheless, we have endeavoured to provide an overview and opinion on the issues relating to the operation of fragmentisers.

Definitions for terms used have been provided and, where possible, these are based upon those used in the Directive. For this reason, text from the Waste Treatments Industries BREF (WTI) has been used where required. The reader is therefore also referred to the WTI BREF.

3.3 Relevant Legal Obligations of the IED Directive and the Definition of BAT

In order to help the reader understand the legal context in which this document has been prepared, some of the most relevant provisions of the IED Directive, including the definition of the term 'Best Available Techniques', are described in this section. This description is inevitably incomplete and given for information only. It has no legal value and does not in any way alter or prejudice the actual provisions of the Directive.

The purpose of the Directive is to achieve integrated prevention and control of pollution arising from the activities listed in Annex I of the Directive, leading to a high level of protection of the environment as a whole. Its implementation should also take account of the other Community objectives such as the competitiveness of the EU Community's industry, thereby contributing to sustainable development.

The IED provides a permitting system for certain categories of industrial installations requiring both operators and regulators to consider the overall pollution and consumption potential of an installation. The aim of taking an integrated approach must be to improve the management and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle given in Article 3 that "operators should take all appropriate preventative measures against pollution, in particular through the application of BAT".

'Best Available Techniques', Article 2(11) of the Directive, is defined as 'the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical sustainability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.'

Annex IV of the Directive contains a list of 'considerations to be taken into account generally or in specific cases when determining the best available techniques '…bearing in mind the likely costs and the benefits of a measure and the principles of precaution and prevention'.

Competent authorities responsible for issuing permits are required to take account of the general principles set out in Article 3 of the IED Directive, when determining the conditions of a permit. The conditions must include emission limit values, supplemented or replaced where appropriate by equivalent parameters or technical measures. According to Article 9(4) of the Directive, these emission limit values, equivalent parameters and technical measures must, without prejudice to compliance with environmental quality standards, be based on BAT, without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions.

In all circumstances, the conditions of the permit must include provisions on the minimisation of long-distance or transboundary pollution and must ensure a high level of protection for the environment as a whole.

3.4 Information Sources

The document includes information from the MFI, the manufacturers of metal fragmentising equipment, the representative trade body British Metals Recycling Association (BMRA) and, monitoring events held at selected fragmentising sites.

Other sources of information include the Environment Agency (EA), Department for Environment, Farming and Rural Affairs (DEFRA) and other relevant published reports where appropriate.

All contributions to this project are gratefully acknowledged, with particular thanks to those sites that agreed to sampling and monitoring events.

A reference list and information source is provided at the back of this text.

3.5 Understanding and Using this Document

The information provided in this document is intended to be used as an input to the determination of BAT in specific cases. When determining BAT and setting BAT-based permit conditions, account should always be taken of the overall goal to achieve a high level of protection for the environment as a whole.

However, this document does not, nor is it intended to, set emission limit levels.

The establishment of appropriate permit conditions will involve taking account of local, site specific factors, such as the technical characteristics of the plant, geographical location and local environmental conditions.

BAT change over time, and therefore this document should be reviewed and updated as appropriate.

4.0 GENERAL INFORMATION

4.1 Scope

This document is intended to cover the activities involved in the fragmentising of metals and the subsequent separation of materials arising from the fragmentation process.

Figure 1 outlines the operations to be considered in this report.

The document covers only those operations from the point of reception to the point of discharge from the installation process. It is necessary to define the facility so consideration can be given to the specific operations occurring in and around the fragmentising operation. It may therefore be seen that the actual fragmentising is a component of the process as a whole.

The document considers waste materials selected for treatment processes and how these materials are selected by a metals fragmentising facility, but does not deal with the waste's full lifecycle nor issues such as the quality of prior treatment (such as End-of-Life Vehicle depollution prior to fragmentising), other than inspection and acceptance of suitably pre-treated wastes to the fragmentiser.

There is no discussion of the merits or otherwise of the final recycling/recovery operation or disposal of materials from the fragmentising process whether that is by landfill, energy recovery, incineration or melting. Each of these disposal options is covered by its own BREF and therefore techniques relating to them are not covered in this document. This scope was agreed by BMRA and after discussion with the UK regulators.

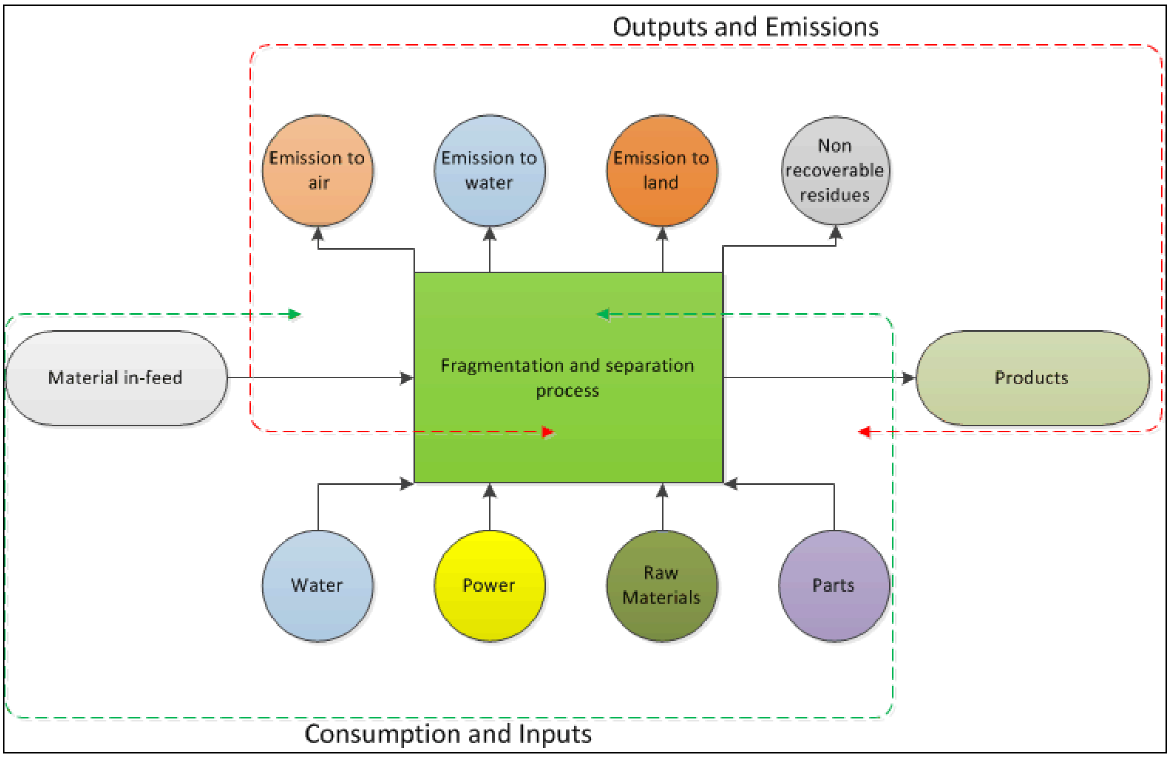


Figure 1: General summary of fragmentiser inputs and outputs

4.2 Definitions

Wherever possible the following definitions have been taken from the Directive; published Commission guidance, and other expert sources.

'Installation' – according to Article 3(3) of the IED directive shall mean:

'a stationary technical unit where one or more activities listed in Annex I or Part 1 of Annex VII are carried out, and any other directly associated activities which have technical connection with the activities carried out on that site and which could have an effect on emissions and pollution'.

This definition could be read in two ways in terms of the structural approach. The key issues are what constitutes a Stationary Technical Unit (STU) and whether this is just that part of the installation in which one or more activities listed in Annex I of the Directive are carried out, or with other activities (Directly Associated Activities (DAAs)) also potentially part of the installation despite not being formally part of the STU. The other approach is that the installation as a whole is an STU in which Annex I activities and DAAs occur.

In this document the STU of a metals fragmentiser is assumed to be the inspection area and inspection process, the fragmentising unit (mill) and associated infeed, the output conveyors following the separation processes, and the storage of the material pre- and post-processing. Discussion with the UK regulators indicated that the inspection, reception and validation of the infeed materials should form part of the BREF process.

It is clear that in some cases the outputs from shredding are transported by conveyor directly to a complex, secondary separation and sorting process. In this context these additional separation processes do not constitute DAA. Figure 2 summarises what is considered to constitute an STU.

'Stationary' – in this context the definition of stationary means the technical unit must be stationary to be an installation. In this context, for example, the fragmentising chamber is part of the installation, whereas mobile cranes feeding the fragmentiser are not.

'Technical Unit' – Under the definitions discussed a Technical Unit could include all the equipment, structures, pipe work, machinery, tools, private railway sidings, dock, unloading quays serving the installation, jetties, warehouse or similar structures, and facilities for reception, storage, handling and pre-treatment of process inputs and outputs, and for controlling, monitoring and recording environmental performance. In order to be included in the Technical Unit, such elements must be an integral part of an Annex I activity or a DAA part of the installation. 'Directly associated activities' (DAA) and 'Technical Connection'.

In the context of this document the reception (weighing and screening) and inspection of materials arriving at the installation specifically for fragmentising denote the start of an STU, with the materials once processed through the separation processes and stored, defining the end of the STU.

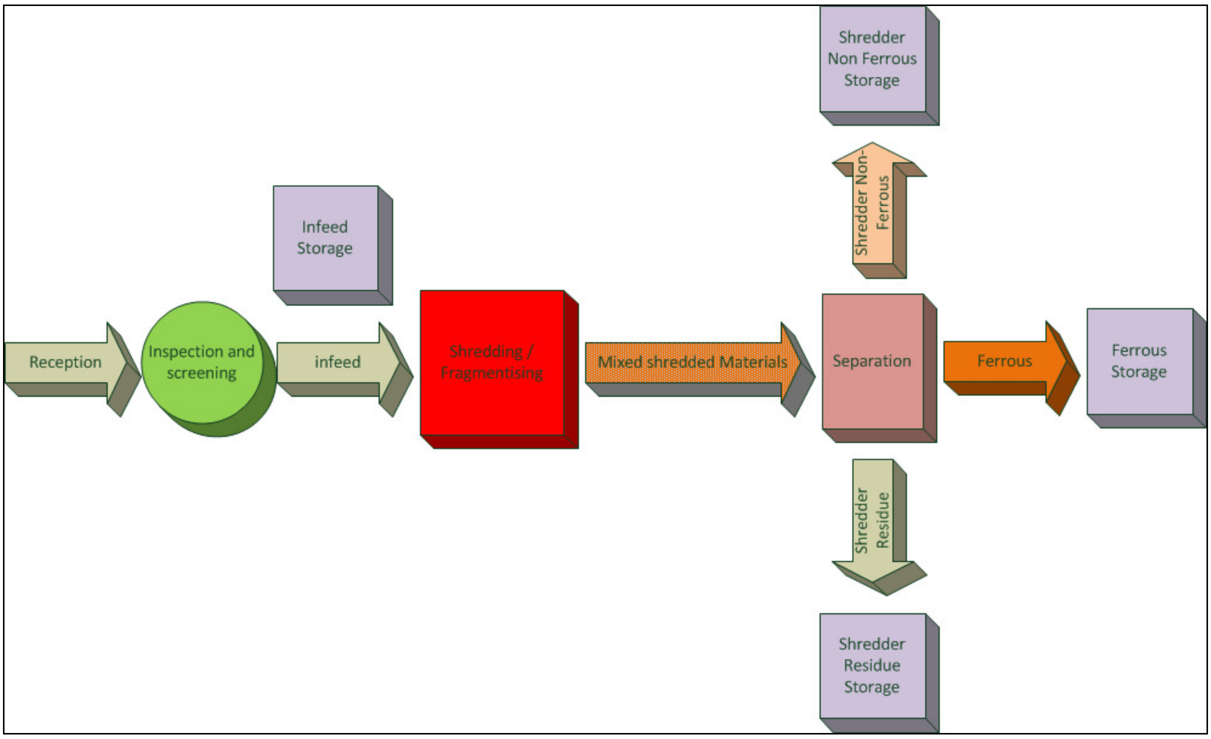


Figure 2: Defined fragmentiser Stationary Technical Unit (STU)

Using this definition of STU, the further processing of fragmentiser residue and non-ferrous fractions to maximise the recovery of non-ferrous metals and plastics would constitute DAA and therefore may not fall under the scope of the Directive.

4.3 The UK Metal Recycling Industry

The UK metals recycling industry (MRI) is estimated to be worth £5.6 billion annually. It processes approximately 13 million tonnes of ferrous and non-ferrous metals, of which 3-4 million tonnes are processed by fragmentising, providing valuable secondary raw materials to consumers for melting into new production materials.

Domestic demand for recycled metals is satisfied with around 40% of the total metals collected by the MRI being supplied to UK steelworks, foundries and smelters. However, with the closure and down scaling of UK steel and metals production, this proportion is declining. The remaining 60% is exported to worldwide destinations. The UK is Europe's largest net exporter of recycled metals (55%) and its total tonnage of exports is only exceeded by countries such as Japan, Russia, and the USA. The metals recycling industry contributes about £3 billion annually to the UK's balance of trade and directly employs around 8,000-10,000 workers. (*BMRA Data*).

The MRI can be seen as having a 'pyramid' structure. At the base of this pyramid there are typically many small, often family-owned businesses, that collect metals and metal-rich wastes that may be sorted, segregated and sold to merchants higher-up the pyramid. These businesses are often larger enterprises that may part- or fully-process these materials, as well as densifying and purifying the metals prior to selling to larger recycling businesses or traders.

At the top of the metals recycling pyramid are the largest operators which frequently includes those operating metal fragmentisers and export businesses supplying high-quality, furnace-ready metals to domestic and international remelters.

4.3.1 The metals recycling industry - Waste Treatment (WT) document

This document considers the issues relating to the reception, inspection, validation, storage and processing, and the intrinsic issues of the fragmentising process, methods, techniques, abatement and management. It therefore considers, in general terms, the fragmentising process and those metals which pass through fragmentiser sites for processing.

4.4 General Information

Treatment of any waste including metals occurs for the following reasons:

- to reduce any hazardous properties to separate waste in to its individual components, some or all to be put to further use or treatment;
- to reduce the amount of waste to be sent for disposal;
- to transform waste materials into a useful form, such as recovered metals suitable for remelting.

Metal-bearing wastes presented for fragmentising should be pre-treated as necessary to ensure they are non-hazardous. For example, ELVs should be fully depolluted by an authorised treatment facility (ATF) prior to processing.

There are agreements in place to permit the processing of certain hazardous wastes, for example ELVs which, for various reasons, it may not be possible to fully depollute. However these materials are batch-processed and the residues segregated and properly characterised and disposed of.

4.5 Residues from Fragmentisation

4.5.1 Fragmentiser residue

Fragmentiser residue: Comprises non-metallic and lower density materials. It is typically drawn off by air suction systems and contains materials such as foam, fabric, carpet, plastics and other materials including dust and fibres. This material is commonly referred to as ‘frag dirt’, ‘fluff’, ‘shredder light fraction’, or ‘light fraction’.

4.5.2 Wet scrubber sludges/waters

Deduster sludge/wet scrubber sludge: Some 'dry' and 'damp' fragmentisers utilise a wet scrubber to clean the cyclone extraction air system.

Both an air vortex and water is used to trap fine particulates before the air is finally emitted. These particles are trapped and separated in a settling tank, which enables the solids to be removed and disposed of.

The waters added to the wet scrubber are re-circulated within the plant through settling tanks to remove the trapped solids before they are reused. The waters are topped up as required, and typically will be discharged and completely replaced from every few weeks to every few months.

4.5.3 Wear parts

Wear parts line the inside of the mill chamber. These are parts specifically designed to 'armour' the interior of the mill, whilst protecting the structure of the mill. Wear parts include hammers, lining plates, anvils and grids. Whilst processing, the mill chamber is heavily abraded. The ability to remove and replace the wear parts inside the chamber protects the mill itself, and enables the mill to be continually refurbished to maintain operational efficiency.

4.6 Fragmentiser Installations

Metal grades are recovered and separated by the use of a fragmentiser installation. The process is a physical one requiring fragmentising, followed by separation using magnets, eddy current magnets, trommels, suction and hand picking to achieve the required level of separation to arrive at an acceptable quality of material for sale. The downstream separation processes may or may not be directly attached to the mill.

There are currently approximately 45 fragmentisers in the UK. They range from less than 1,000 horsepower (hp) to about 10,000hp in output power, and differ in size based upon the volume of the shredding chamber, rotor diameter and infeed chute. They are distributed across the UK, with most clustered around and within large urban areas and close to the point of in-feed arisings. Alternatively, as is the case with the UK larger installations, they are located close to the point of sale, for example docks and ports for ease of over-sea export, or close to steel melters in the UK, (see figure 3 page 24).

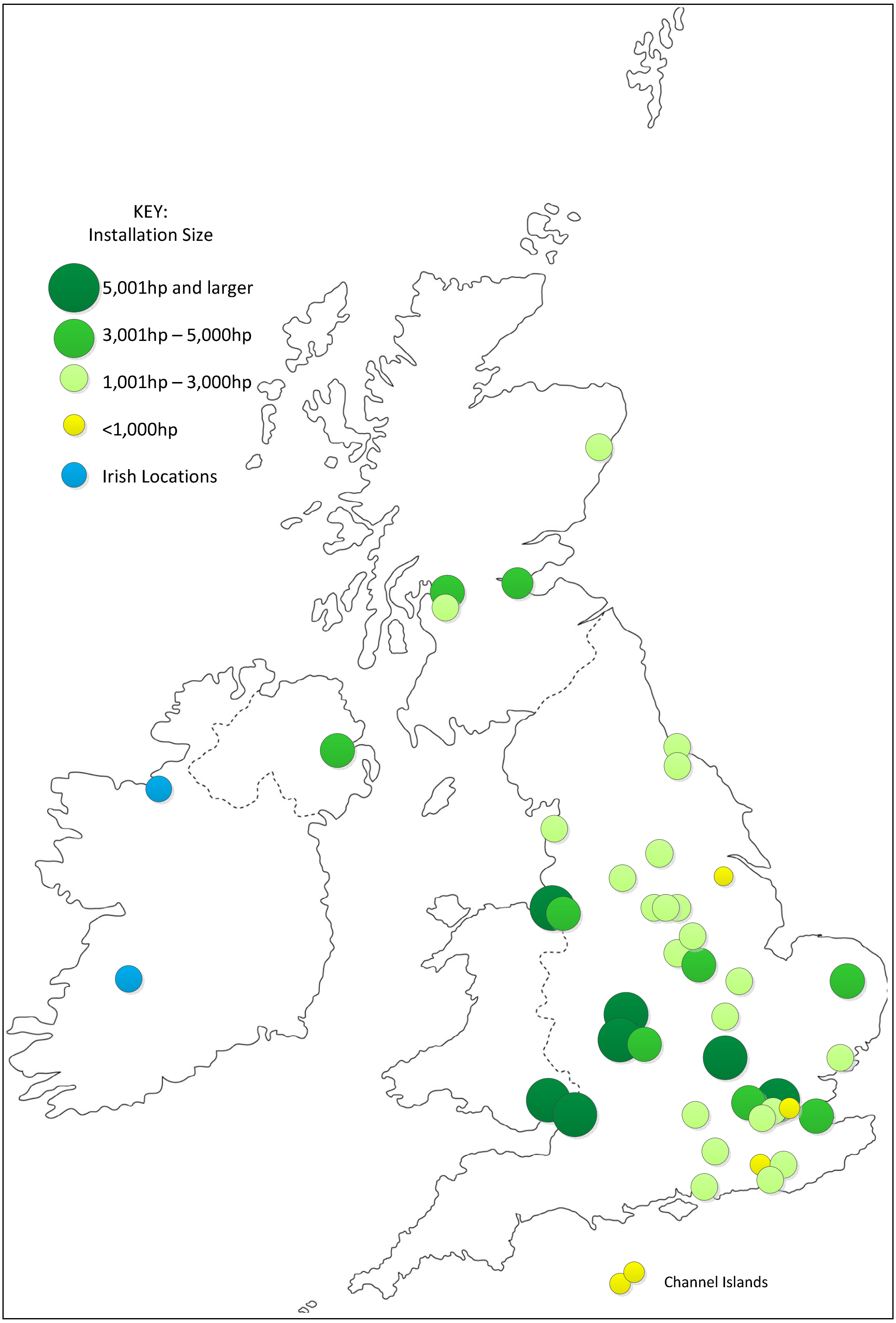


Figure 3: UK Installations: Approximate location and size range (in hp) based upon information collated from questionnaires, operators and equipment suppliers.

However, despite the use of similar separation procedures, and apparently fundamentally similar processes, each fragmentiser is configured differently. It appears that no two are identical. The fragmentising chamber may be similar in operation and structure, but the configuration of the downstream processes can be variable. This is based upon several factors including: available space; the manufacturer; the specific shredding option chosen (see Section 5 for more detail); the preference of the operator at the time of commissioning, the age of the facility and; the extent of repair and replacement of parts over the installation's lifetime.

4.7 Fragmentising Process

Once received materials have been inspected, and those items that are unsuitable for processing (which may cause damage to the mill) along with items that also need to be identified and removed, including sealed containers and undepolluted ELVs, the material is considered ready for processing.

In basic terms, a fragmentiser plant consists of an infeed conveyor or chute which is loaded with the infeed materials. This aspect of the process is arguably the most important as it controls not only the material input density (by for example mixing or alternating bales and loose infeed), but the mixture, feed rate (depth of scrap) and sorting of the infeed. Conveyor loading is normally undertaken to ensure the mill is fed at a constant rate. This ensures the chamber is full, allowing the scrap to shred, fragment and abrade.

Once the materials have passed along the infeed conveyor they normally descend towards the mill. Feed rollers compact and push the scrap materials in to the mill chamber. Once through the rollers the operator has no control over the scrap infeed. The mill chamber contains a heavy rotor (with free pivoted hammers) which revolves at high speed (several rotations per second), the hammers 'grab' the scrap pulling it into the mill, firstly shredding it against an anvil, and then fragmentising it through abrasion and attrition within the mill. The mills are designed to run full so that the chamber is under pressure from the scrap within it. This loading has several effects: it assists with the attrition and fragmentisation of the scrap; and it fills the void space within the mill, helping the materials to be pushed through exit grids.

Subsequent to the fragmentising and once the materials reach a small enough size they are typically ejected through grids in the mill chamber. These mixed fragmented materials then pass on to the downstream separation processes. The downstream operation is installation dependant, ranging from operations with very limited separation and sorting to extensive processing.

The separated ferrous metals typically pass through a picking station. There, workers manually remove items such as copper wound armatures (which have a ferrous component making them magnetic) and other entrained non-metallic materials. This stage serves to ensure the copper content of the ferrous grade is reduced, maximising the non-ferrous yield and improve cost efficiency as other items may also be removed by the pickers at this stage.

4.7.1 Fragmentiser types

Fragmentisers can be classified by size and are typically measured by their power output, which is given in horse-power (hp). However in this document power output is also given in kW (kilowatt) using a conversion factor of 0.7457 kW hp^{-1}.

The power output of a fragmentiser is an indicator of its processing capacity. It is often useful to describe fragmentisers in terms of their relative size.

For the purposes of this report the following 'classification' has been used: small (<1,000hp); medium (1,000 to 3,000hp); large (3,000 to 5,000hp); and mega (>5,000hp).

Numerical designations are used to describe the model type, and refer to the internal dimensions of the shredding chamber. It is therefore possible for fragmentisers of the same power output to be manufactured in different sizes to allow for differing production rates, and different specifications for infeed. Another factor which influences the 'size' of the fragmentiser is the dimensions of the infeed chute and conveyor.

The size and power of a fragmentiser determines the type and/or character of infeed material it is able to process.

4.7.2 Typical fragmentising cycle

The materials to be processed are loaded on to the infeed conveyor or chute by mobile cranes which select materials from a stockpile. Ideally, materials will be loaded to a constant depth and density. At the inlet aperture feed rollers take over from the conveyor, gripping and crushing/compacting the infeed material before presenting the materials to the mill chamber. It is possible for the operator to move these rollers up and down to accommodate materials of larger gauge. The infeed rate is dictated to the operator and by the load on the main motor driving the mill's rotor. The greater the load, the slower the feed and vice versa, thereby ensuring the shredder is at its optimum loading and therefore optimum operational performance.

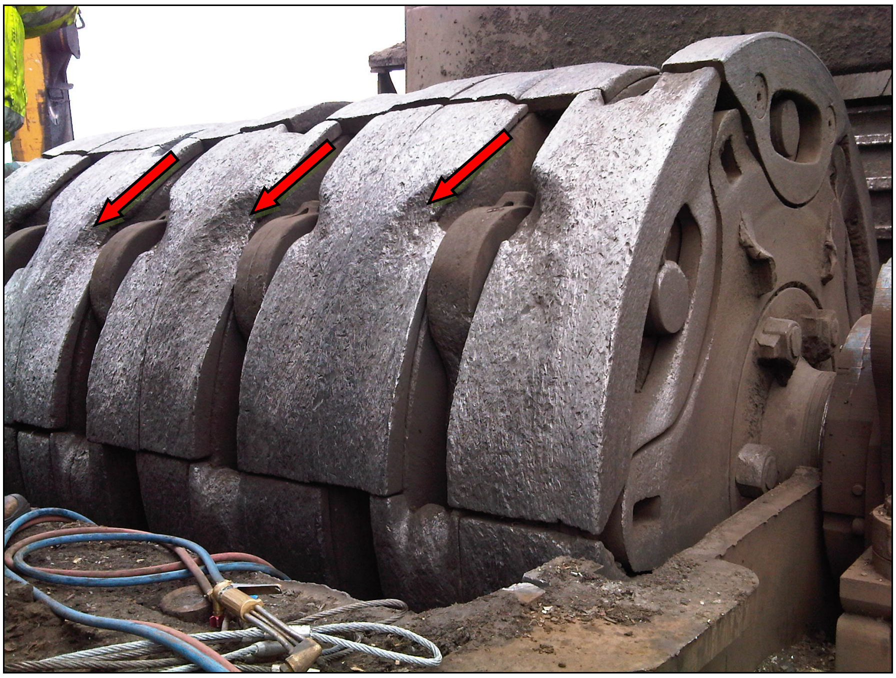
The fragmentation of the infeed is achieved by heavy, free-swinging hammers mounted on a rotor spinning at high speed close to an 'anvil'. The fragments exit the mill chamber via grids. If the fragments are small enough, they will pass out of the mill through the grid for the next stage of the process. If they are not, they will be retained in the fragmentiser, going through repeated cycles of impact and attrition until they are small enough. This may be due to further fragmentisation, or size reduction by deformation and densification.

Within the shredding chamber various parts are designed to wear. They line the interior of the fragmentiser and the exterior of the rotor and are replaced as part of routine maintenance. The hammers are also removed and replaced by sliding the mounting pins out to release them.

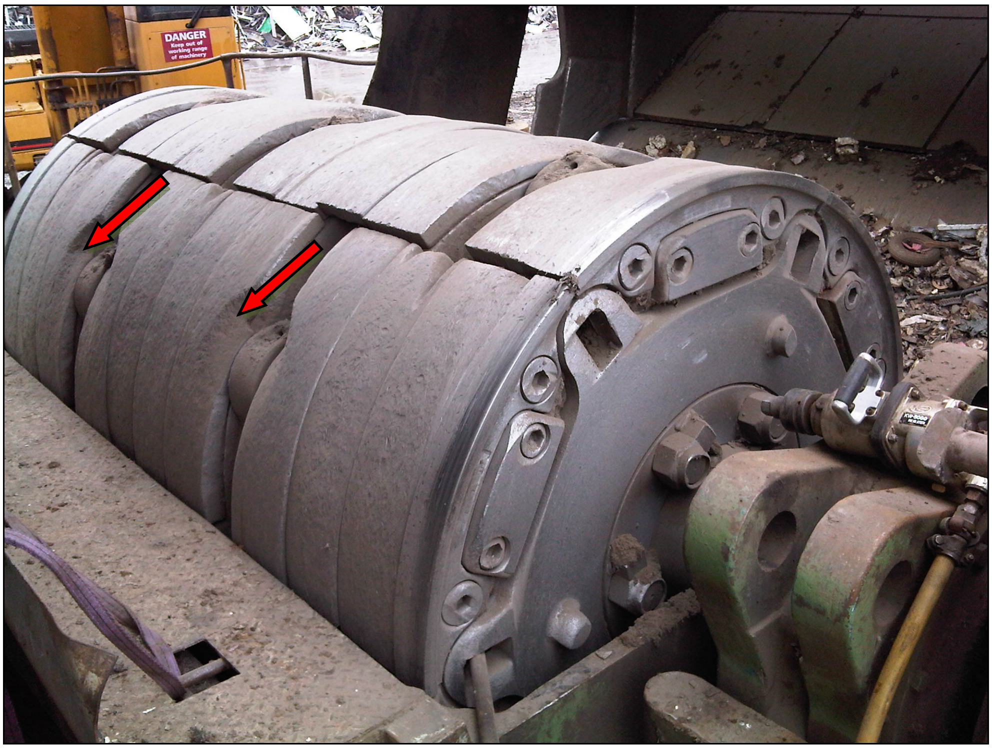
Hammers are typically the most commonly-replaced parts. Due to the abrasive nature of the infeed, they wear quickly, and can, under some circumstances break.

If they become too worn or damaged, the rotor balance can be significantly affected, generating significant vibration. In addition, broken hammer fragments within the mill can cause damage to the mill and other hammers within chamber. It is also common for the hammers to be rotated so that they wear evenly, and for the hammers to be weighed and balanced across the rotor to reduce vibration. The mills are also commonly mounted upon springs or other vibration absorbing/damping material to prevent the transmission to the surroundings.

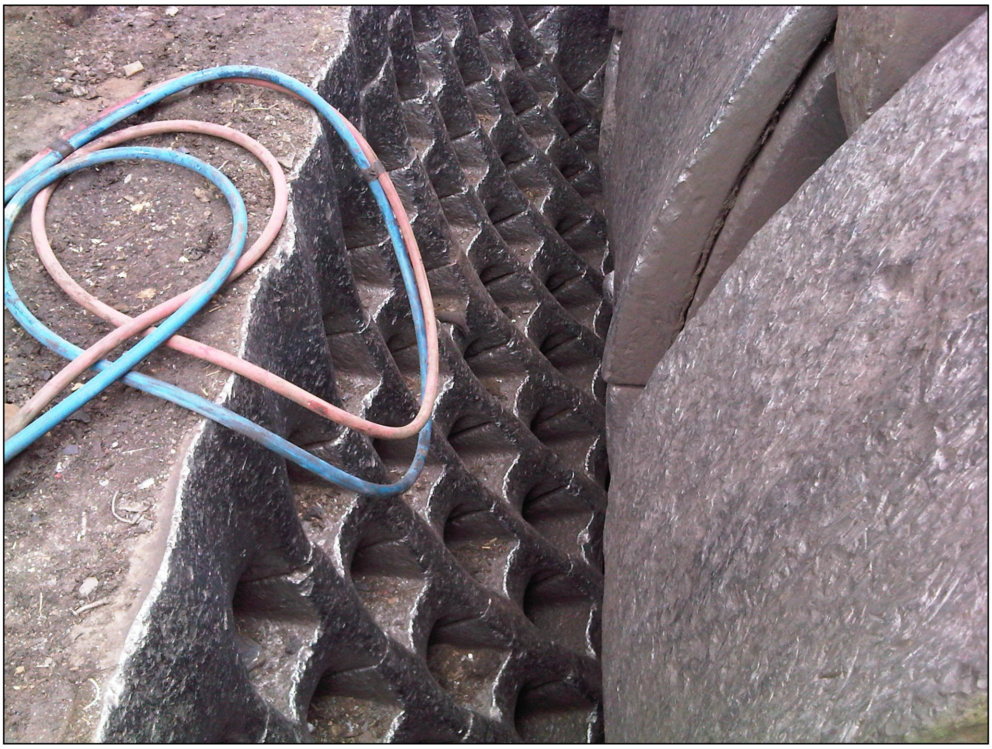
The fragmentiser chamber design is typically a clam shell structure. The whole top section is hinged so it can be lifted clear to gain access for maintenance and repair.



Picture 1 – Large diameter rotor and large hammers. In this case, 20 hammers each weighing ~330kg are mounted on the rotor giving a combined hammer weight of 6.6 tonnes. A wear pattern can be seen clearly on the rotor wear plates close to the hammer mountings.



Picture 2 – Smaller fragmentiser rotor - these hammers are smaller, weighing ~ 100kg each with 16 mounted on the rotor giving a combined hammer weight of ~ 1.6 tonnes. A wear pattern can be seen clearly on the rotor wear plates close to the hammer mountings.



Picture 3 - Example of bottom grids through which fragmentised scrap is forced. The uneven surface of the grid is due to material wear abrasion.

5.0 UK METAL FRAGMENTISER SURVEY

To understand the size and scope of the UK metal fragmentising industry, operators were invited to take part in a survey of their activities. The questionnaire, designed and produced with the support of BMRA fragmentiser operators, was based loosely around current EU guidance regarding data gathering for BREF projects and the type and scope of questions to be answered. The questionnaire was issued to all UK operators of fragmentisers that BMRA believed could be subject to the provisions of the IED.

Based on a survey undertaken in March 2011, the number of fragmentisers operating within the UK in operation in 2010 was 45. This number will undoubtedly change over time, as new installations are commissioned and or as installations close.

	Company Name	Location	Type of Shredder
1	Sims Metal Management	Avonmouth	Lindemann 6,000Hp
2	Ampthill Metals	Bedford	Lindemann 1,250 Hp
3	Clearway	Belfast	LYNXS 2,500 Hp
4	Clearway	Belfast	LYNXS 4,000 Hp
5	Charles Muddle	Billinghurst	American Pulverizer 1,200Hp
6	EMR	Birmingham	MLT (Lindemann Copy) 6,000Hp
7	Hawkswood	Birmingham	American Pulverizer 4,000Hp
8	Sims Metal Management	Birmingham	LYNXS 6,000 Hp
9	B W Riddle Engine Recycling	Bourne	LYNXS 1,600 Hp (Diesel)
10	B W Riddle Engine Recycling	Bourne	LYNXS 1,600 Hp (Diesel)
11	Van Dalen	Dagenham	Lindemann 1,250 Hp
12	EMR	East Tilbury	Lindemann 6,000Hp
13	EMR	Erith (London)	Newell 3,000 Hp
14	J R Adam & Son Limited	Glasgow	LYNXS 4,000 Hp
15	H Ripley	Hailsham	American Pulverizer 1,000Hp
16	EMR	Hartlepool	Cantium (LYNXS) 2,000Hp (Lindemann)
17	Metal & Waste (Hitchin) Limited	Hitchin	LYNXS 6,000 Hp
18	Ward Recycling	Ilkeston	Lindemann 3,000Hp
19	R M Supplies	Inverkeithing	Lindemann 5,000Hp
20	Sackers Recycling	Ipswich	LYNXS 1,250 Hp
21	EMR	Leeds	Lindemann 3,000Hp
22	MDJ Light Bros Limited	Lewes	LYNXS 800 Hp
23	S. Norton & Sons	Liverpool	Lindemann 5,000Hp
24	EMR	Liverpool	Lindemann 10,000Hp
25	S. Norton & Sons	Manchester	Lindemann 2,000 Hp
26	John Lawrie (Aberdeen) Limited	Montrose	Cantium (LYNXS) 2,000 Hp
27	Morecambe Metals	Morecambe	Lindemann 1,250 Hp
28	Briggs Metals	Newark	Lindemann (Diesel) 1,200 Hp
29	EMR	Newhaven	Lindemann 1,250 Hp
30	Sims Metal Management	Newport, Wales	LYNXS 9,000 Hp
31	SITA	Norwich	Hammermill 4,000 Hp
32	Sims Metal Management	Nottingham	Texas Shredder 4,000 Hp
33	EMR	Portsmouth	Lindemann 1,400 Hp
34	Christie & Son	Renfrew (Scotland)	Lindemann 1,250 Hp
35	EMR	Ridham (Kent)	Hammermill Type 5,000Hp
36	C F Booth	Rotherham	American Pulverizer 1,000Hp
37	City Scrap	Scunthorpe	BJD 666
38	Van Dalen	Sheffield	Lindemann 1,250 Hp
39	E L G Haniel	Sheffield	Lindemann 3,000Hp
40	Bishopsgate Metals	Silvertown (London)	BJD 668 800 Hp
41	T J Thompson	Stockton on Tees	Lindemann Kondirator 2,000 Hp
42	EMR	Willesden (London)	Lindemann 5,000Hp
43	Sims Metal Management	Yateley	Metpro Hammermill 3,000Hp
44	Picott & Rouille Ltd	Jersey	Unknown
45	Guernsey Recycling	Guernsey	Unknown

Table 2: List of fragmentisers in the UK, with operator, location, model and power and manufacturer, assumed to be operating within in the UK at the time of writing.

Questionnaires were sent to those installations identified in Table 2. 24 replies were received and used to compile a summary sheet of operations in order to understand the industry in more detail (Table 3). Due to the commercially-sensitive nature of some of the questions not all operators were comfortable disseminating information regarding their business. As a result the author has made certain assumptions and observations of activities in relation to some operations. Where assumptions have been made, this is clearly stated.

The questionnaires were also used to help select installations for detailed monitoring events and to look in detail at the processes and management procedures employed by operators.

Monitoring events were intended to assist in the understanding of the fragmentiser and its operations. The selection process and scope of the monitoring events is discussed in detail in Chapter 7.

Site 43 is now known to be mothballed and is not currently processing. Site 44 is also thought to be closing/stopping production, reducing the current number of installation sites to 43.

Table 3 : see over page

Fragmentiser Questionaire Summary Sheet

All Data Based Upon 2010

Responder Number	Make	Specification	Estimated Size (hp)	Estimated Size (Kw)	Power use Kwh $tonne^{-1}$	Water Consumption $m^3 tonne^{-1}$	Fragmentising method	Total Operating Hours	EMS ISO14001	QMS ISO9001	Surface Water Discharge	Surface water/oil Interceptor	Radiation Screening	No of radiactive sources stored	Number of flame/ audible events $tonne^{-1}$	Number of flame/ audible events prevented $tonne^{-1}$	Routine Air Monitoring	Routine Noise Monitoring	Estimated 2010 Production Calculated from hp and operating hours (tonnes)
11	Lynx	270 x 270	4000	2982.8	25	np	Dp	877	yes	yes	np	yes	yes	0	0.00036	0.00049	no	yes	87700
51	Lynx	270 x 270	6000	4474.2	25	0.0428	Dp	1400	yes	yes	FS	yes	yes	0	0.0005	np	yes	yes	224000
71	Lynx	225 x 270	4000	2982.8	25	0.05	Dp	np	yes	yes	CW	yes	yes	0	0.001	np	no	no	
72	Lynx	225 x 270	2500	1864.25	25	0.05	Dp	np	no	no	CW	yes	yes	0	NR	NR	no	no	
73	Newell	80 x 104	np	np	25	0.05	np	np	no	no	CW	yes	no	na	NR	NR	no	no	
111	Metso	250x286	6000	4474.2	25	0.01	Dp	2400	no	no	FS	yes	yes	0	0.0002	NR	yes	no	312000
112	Metso	250x286	6000	4474.2	32	0.01	Dp	2600	no	no	CW	yes	yes	0	0.00011	0.0004	no	no	416000
113	Metso	250x286	5000	3728.5	30	0.01	Dp	2000	no	no	FS	yes	yes	0	0.00011	0.0005	no	no	320000
118	Metso	300x300	10000	7457	28	0.005	Dp	3000	no	no	FS	yes	yes	0	0.00023	NR	no	no	900000
131	Lynx	nk	1250	932.125	np	np	np	2000	no	no	FS	yes	no	na	0.0005	0.0006	no	yes	80000
171	Lynx	nk	2000	1491.4	34.27	0.119	Dp	962	no	no	FS	yes	yes	0	0.00012	0	no	yes	48100
181	Henchel	nk	np	np	np	np	np	np	np	yes	np	np	no	np	np	np	np	np	
191	Hammermill	Diesel	3000	2237.1	diesel	0.006	Dr	1588	yes	yes	FS + CW	yes	yes	0	0.09	0.0013	no	yes	127040
192	Lynx	325 x 300	9000	6711.3	21	np	Dp	833	yes	yes	CW	yes	yes	0	0.1	0.1	no	no	249900
193	Lindermann	270 x 270	6000	4474.2	25	0.12	Dp	2400	yes	yes	CW	yes	yes	17	0	0.00007	no	no	384000
194	Texas	98 x 104	4000	2982.8	26	0.001	Dp	1701	yes	yes	CW	yes	yes	2	0.0004	0.002	no	no	170100
201	Lindermann	175 x 260	1250	932.125	34	0.008	Dr	1630	no	yes	N	yes	no	na	0.0007	0.002	yes	yes	57050
231	Lindermann	250 x 260	5000	3728.5	25	0.0049	Dp	1305	yes	yes	FS	yes	yes	0	0.000271	0.000623	no	no	169650
232	Lindermann	210 x 260	2000	1491.4	30	0.0048	Dr	1662	yes	yes	FS	yes	yes	0	0.000403	0.001222	no	no	83100
241	Lindermann	np	np	np	np	np	np	np	np	np	np	np	np	np	np	np	np	np	
251	Lindermann	Diesel	1200	894.84	diesel	np	Dp	np	no	no	np	np	no	na	0	NR	no	no	
311	Lindermann	175 x 260	1250	932.125	nk	nk	Dp	1500	no	no	FS	yes	yes	0	0.0004	NR	yes	no	52500
341	Lindermann	225 x 260	3000	2237.1	nk	nk	np	2112	no	yes	FS	yes	yes	50	NR	NR	np	no	168960
271	Hammermill	60 x 60	np	np	np	np	Dr	np	no	no	np	np	yes	0	0	0	no	yes	

Key

np	Not provided - by the operator
na	Not Applicable
nk	Not known - by the operator
NR	Not recorded - by the operator
(light green)	Operator willing to allow monitoring
(pink)	Operator not willing to allow monitoring
(striped pink)	Operator maybe willing to allow monitoring
Dp	Damp processing
Dr	Dry processing
CW	Controlled Water
FS	Foul Sewer
FS + CW	Combined Sewer
N	Neither
yes	Yes: The installation operator does impliment
no	No: The installation operator does not impliment

The questionnaire was based around the operational year 2010. Some of the returned questionnaires do not provide sufficient data for a full summary of the operation or the evidence to be interpreted.

Notes on the questionnaire discussion: The percentage of operators referred to in the sections below refer to the percentage of respondents and not to the overall percentage of installations. Where the percentages discussed do not add up to 100%, one or more of the respondents has either not provided the data, does not know or does not record the required parameter. Where a company may have more than one site/installation, we have assumed that each site/installation responder is a single entity.

To help with the summary of the data provided, the processes/stages have been broken down into general operations, (see figure 2, page 21).

5.1.1 Questionnaire summary

Of the 24 respondents, it was possible to estimate that 20 of them represented a total of 82,450 hp (out of an estimated total of 134,716 hp taken from table 2). 17 of the 24 also provided operating hours. These 17 shredders processed for a total of 29,970 hours, with a range from 833 hours to 3,000 hours operating period, an average of 1,762 hours per fragmentiser for 2010. It should be noted that the size of the fragmentiser will influence production rate as well as production time. Larger fragmentisers process much larger volumes of material per hour than the smaller operators.

Of the 17 fragmentisers from which it was possible to estimate both hp and operating time, a total maximum possible production of 3.8 million tonnes was estimated for 2010. This information was not provided by the operators directly, but estimated by the author based upon hp, operating hours and an assumed production rate per hp, based upon an average production rate per unit size. The estimates assume a processing rate of between 35t hr^{-1} for ~1200hp mills up to 300t hr^{-1} for 10,000hp mills.

9001:2008 Quality Management System (QMS)

50% of respondents use a certified QMS at their operation.

ISO 14001:2004 Environmental Management System (EMS)

37% of respondents have an EMS in place, 54% did not, and 9% did not provide the information. It is not clear from the responses whether the EMSs are site specific, multi-site or company specific (i.e. covering the entire business). There are advantages to both uses/applications of the EMS system.

Reception, Inspection and Validation of Waste

All operators that responded implement some form of inspection procedure for the materials arriving at their facility to ensure their compliance with the Duty of Care and their installation's relevant permit conditions.

Radiation screening:

70% of respondents screen materials for radiation as they enter the site, before/as the delivery vehicle moves on to the weighbridge. The remaining 30% (one of which did not provide information) use screening at alternative points in the process. For example use of handheld detectors, and screening at the export location or at the steel works.

EU ferrous specifications state that for materials delivered to steel works:

'*All grades shall be checked, within the limits of accessibility and in strict compliance with appropriate deduction equipment for radioactivity, to identify materials presenting radioactivity in excess of the ambient level of radioactivity and radioactive material in sealed containers even if no significant exterior radioactivity is detectable due to shielding or due to the position of the sealed source in the scrap delivery.*'

Screening is also a requirement for materials to meet the 'end-of-waste' criteria under EU Regulation 333/2011.

Gas cylinders, sealed containers and other contaminating materials

The discovery of prohibited materials at the tipping stage may result in the items being reloaded on to the originating vehicle for return to the supplier (this is discussed further in the BAT recommendations). If, for example, gas bottles are discovered some time after the tipping, they might be described as an 'orphan item'. These orphan items are typically stored on site in dedicated storage areas for removal/return to the owner at a later date

Gas cylinders and other sealed containers are a primary source of flame/audible events when they are inadvertently included with the infeed material and processed. These events can lead to environmental problems including pulsed emissions, noise and associated nuisance.

Gas cylinders, beer kegs and roll cages also remain the property of the producer/user of the item and should not enter the general waste stream without prior authorisation.

Monitoring of Flame Events

The issue of flame/audible events are often, inaccurately, referred to as 'explosions' and are discussed in more detail in section 6.3.

Of the 24 responders, 54% routinely record 'prevented' flame events. These are incidents which, had they gone unnoticed, could have resulted in the production of a flame/audible event within the mill. These events include the discovery of, for example, pressurised cylinders or other sealed containers and items prior to processing. The remaining responders, 17% did not provide information and 29% do not record the discovery of such items.

In addition, 79% of operators also record flame events within the mill, 13% do not record them and 8% did not provide information. The majority of the respondents record both prevented and actual flame/audible events during their operations.

The materials leading to the greatest number of flame and audible events when processed are Bales, ELVs and scrap metals arising from CA sites.

Monitoring of Air and Noise Emissions

Routine monitoring of air and noise emissions is undertaken by 17% of the respondents with 12% not providing information. A total of 71% of responders do not undertake air monitoring. This includes the monitoring of emissions from the air vent stack, fugitive and/or depositional dust.

In respect of noise monitoring: 29% of respondents monitor noise, 63% do not and 8% did not provide information.

Discussions with operators suggest that monitoring for emissions to air is often undertaken only as a response to complaints from neighbours or requests from regulators, and not as a routine measurement of the installation's performance.

Surface Water Run-Off

Of the respondents providing answers relating to the surface water run-off, 42% discharge to foul sewer, 29% to a controlled water and 4% to a combined sewer. 21% provided no information and 4% indicated they do not have a discharge consent. In the case of the single respondent with no discharge consent, it is assumed that they have a sealed sump which is emptied and the accumulated fluids tankered off site for disposal.

All companies providing information on surface run-off water discharge had an oil/water interceptor through which the waters drained. In addition, grit traps where also incorporated in to the drainage system. The inspection and management of the drainage system was not investigated.

It is also understood that the routine sampling and monitoring of the drainage discharge from site is not undertaken at all locations. Again discussions and experience indicates that sampling and testing of waters discharged from site is undertaken largely as a response to potential non-compliance.

Consumption

Power:
67% of the respondents provided power consumption figures (per tonne of material processed, kwh t^{-1}). 8% used diesel driven mill, 17% did not provide information and 7% did not know. Based upon the 67%, the average power consumption was 27.2 kwh t^{-1} with a range of 21 kwh t^{-1} to 34.7 kwh t^{-1}.

Water:
63% of responders provided water consumption rate (per tonne of material processed, m^3t^{-1}). 29% did not provide information and 8% did not know.

Based upon the 63%, the average rate of water consumption was 0.032 m^3 t^{-1} with a range of 0.001 m^3 t^{-1} to 0.12 m^3 t^{-1}.

6.0 APPLIED PROCESSES AND TECHNIQUES

6.1 Fragmentiser Process and Techniques

The general fragmentising process described in section 4.7 is relatively standard for most fragmentisers. The differences relate to the scale and processing capacity for the fragmentiser based upon its size, and the 'method' of fragmentising separation and suppression and whether mill extraction is required.

There are two processing methodologies recorded within the UK. These are 'damp' and 'dry' fragmentising. It is understood that in the UK it is 'damp' fragmentising that appears to be the dominant methodology. Whereas 'dry' fragmentising is the most commonly applied methodology in the EU and in other parts of the world. In the USA, with the largest proportion of fragmentisers, a large proportion are understood to use 'damp' processing. Results of the questionnaire indicate that 63% of operators employ 'damp' fragmentising, 17% 'dry' and 21% did not provide information on the method used.

The main advantages and disadvantages associated with each method are considered further.

6.1.1 Damp fragmentiser

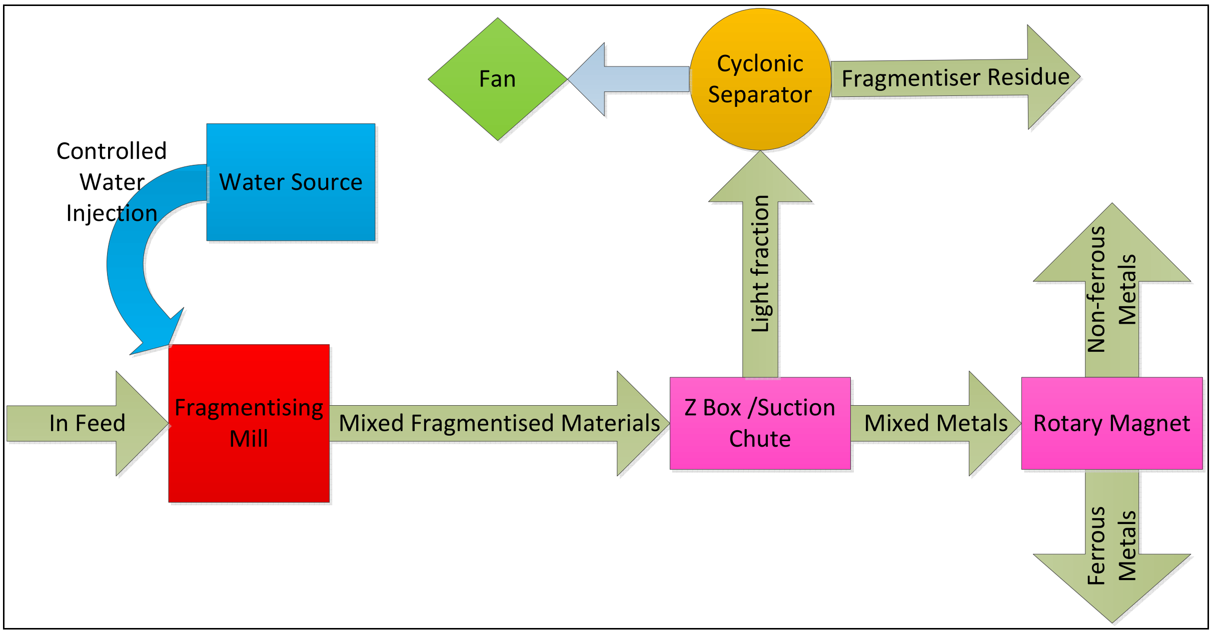


Figure 4: Example of a damp fragmentising configuration

The 'damp' fragmentiser (Figure 4) uses aspects of the 'dry' fragmentiser. Water is injected in to the mill chamber under carefully controlled conditions so that it does not drench the chamber or the fragmented materials or flow from the chamber. The quantity of water added is controlled to ensure it turns to vapour within the mill, producing a damp atmosphere. This is used to control the mill temperature, suppress dusts and vapours and to suppress the generation of potentially flammable atmospheres within the chamber.

The materials passing out from the mill are therefore damp and not wet (maintaining the density differential between metals and non-metals), enabling the use of cyclone separation to draw off the light fragmentiser residue fraction. However, the addition of too much water in an uncontrolled way will cause the accumulation of moisture within the fragmentiser residue increasing its density and reducing the creation of the steamy damp conditions within the mill. Poorly controlled damp processing may potentially reduce separation efficiency (due to density differential) and increase disposal costs.

Damp fragmentisers, because there is no mill extraction, often produce a water vapour cloud generated by the water injection system. It is difficult to measure and quantify emissions from the mill chamber which are fugitive in nature. There is an aspect of reduced visibility at the infeed roller due to the steam, although this has been largely overcome by the introduction of infra-red cameras.

6.1.2 Dry fragmentiser

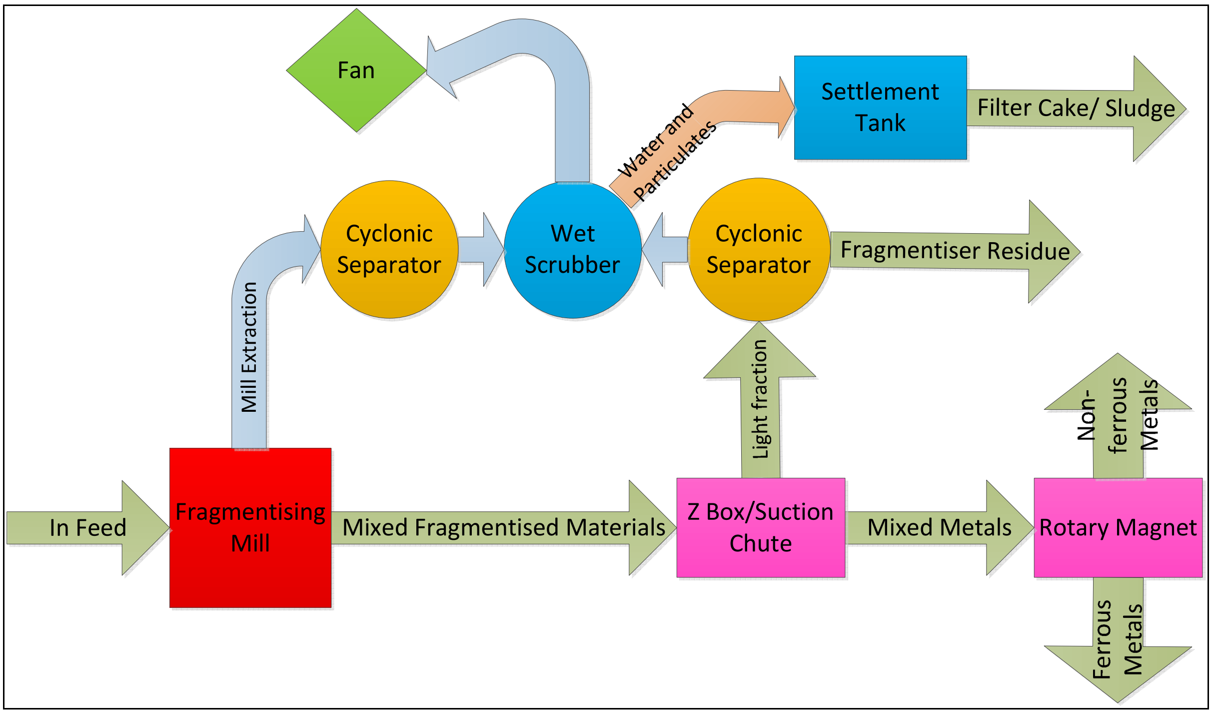


Figure 5: Example of a dry fragmentiser configuration

In the configuration shown in Figure 5, typically less water than a damp process is consumed in the process. No water is added in to the mill and therefore mill extraction is required to extract dusts and vapours from the mill chamber. Cyclones are used to clean and remove dusts and particulates from the extraction air. A wet scrubber/deduster may also be employed to remove some of the fines from the air separation cyclones to reduce dust to atmosphere.

There are fugitive emissions from the mill, although the mill extraction draws out the airborne material released within the mill. Emissions to air could therefore be monitored or measured at the vents/exhaust point sources.

As the mill is not shrouded in steam there is good visibility at the infeed, although some dust can be produced.

The system does allow for the removal of light particulate from the output streams. The lack of added water does have advantages in respect of downstream separation processes: the dry materials are lighter and more friable making them easier to draw off with suction. Downstream processes also use density differences to facilitate separation: the addition of water reduces the density differential, which could reduce separation efficiency. Disposal costs for the dry shredder residue may be lower than those which have added water. However, the increased work required of the fans is likely to increase the power consumption.

The materials are typically drier and therefore lighter so costing less to transport and dispose of than for example damp processing.

However, because they are dry and light they are more friable and prone to generating wind-blown dust. In addition, there may be a de-duster sludge/filter cake or filter sludge derived from the extracted fines to dispose of.

In addition, the lack of a cooling effect, derived from the addition of water during damp processing, means that the mill temperature may reach temperatures greater than that of a damp process. The evaporation of injected waters may carry heat away from the fragmentiser. This may have implications for the volatilisation of materials and the emissions from the process. Higher temperatures will result in driving off more potentially volatile materials to air, than might be expected at lower temperatures.

There is also a higher flame event risk in a dry fragmentiser. Since no water is added, there is nothing to suppress the formation of a flammable vapour, gas or dust atmosphere within the mill chamber, and less water to suppress sources of ignition. Therefore a flame event within the mill chamber of a dry fragmentiser would be more likely, and potentially more energetic than expected within a damp fragmentiser, and result in the discharge of expanding gases along with dusts, fume and other airborne materials from the mill via the mill extraction system.

Typically the mill extraction is fitted with vent flaps to enable combustion gases to safely expand rather than become confined, preventing pressure build up. A flame event may also bypass or overwhelm the usual emission abatement processes, and eject a pulse of dust, debris and combustion product from the fragmentiser. It may also result in the liberation of material which has already been trapped, retained or accumulated within the mill extraction during normal operations.

During a flame event the emission of materials via the mill extraction is possible. It is designed to deal with materials under normal operating conditions. The extraction system may by design, draw the flammable materials in to it, carrying them away from the mill. Even on a dry fragmentiser, there is a facility to flood the mill with water to extinguish a fire and quench the materials within it.

Typically, a dry process will have a wet scrubber, which uses water within the air cyclone system to wash fine particulate materials from the final air emissions. These waters are re-circulated and reused for a period before discharge and replacement. The collected solids are typically removed with the fragmentiser residue for off-site disposal or further processing.

6.1.3 Fragmentiser method summary

There are advantages and disadvantages to both methods described, although the most commonly used method in the UK is ‘damp’ processing.

Cross-media effects are those effects which result from an action designed to deal with another issue. For example, the use of water sprayed on to the site to suppress dust will result in an increased use of water which may become contaminated.

The action is dust suppression, the cross media effect is the increased use of water and the potential contamination of that water. It is possible that the cross-media effect could significantly outweigh the benefit provided by the initial action.

Once a fragmentiser has been built and configured to use one or the other of the methods discussed above, it is not a simple task to retrofit and change to another method, or to use methods of emission control from one design on another. For example, adding a water injection system on to a dry shredder to improve performance, whilst still expecting the mill extraction to deal with the particulates, this is likely to result in material accumulation and blockages. Damp dusts are sticky and these materials result in clogging of the mill extraction cyclones. It is possible in some configurations to turn off the mill extraction, so enabling operators to chose dry or damp processing.

The damp system enables reduced water consumption over a wet processing system, but mitigates the likelihood and severity of flame events within the mill, when compared to dry shredding. It also produces less dust and fewer fugitive air emissions than dry shredding, but does not provide for emission extraction on the mill itself.

Damp water injection systems are available which measure the loading on the mill motor (the loading relates to the mill chamber loading) and introduces water accordingly to ensure a water flow proportional to the amount of material within the mill being processed. This ensures water use matches the mill production requirements. However, if for example there is a flame event in the mill, the water injection can be increased to quench a fire.

In some cases, controlled water injection has been developed to use foam injection in place of injected water. Nevertheless, foam injection is intended to reduce the amount of water introduced (and used overall) in to the mill chamber by filling it with a foam (filling voids and suppressing the volume of air within the mill) as well as producing a water vapour. The foam is created by the addition of a surfactant to the injected water and forced with compressed air through a cylinder designed to create as much turbulence as possible.

Both water and foam injection systems introduce additional capital, operational and maintenance costs, over and above those for dry processing. In the case of the foam injection system, the compressor and the use of surfactant add further cost, albeit balanced in part by the reduced water consumption.

The mill extraction used on dry fragmentisers does not work well when fitted on to damp fragmentisers. Problems include, for example, a lower degree of separation, clogging, and increased cleaning and maintenance. Discussions with manufacturers, operators and experts in the industry indicate that the majority of the mitigation aspects are mutually exclusive to either dry or damp processing.

6.1.4 Pre -shredding

Pre-shredding is a method used to produce a more homogenous mixture of material for the infeed to the main fragmentiser and to reduce flame events with the main mill. However, the use of pre-shredding does not remove the need for controlled inspection procedures for the reception of materials. The process breaks open and loosens infeed, including bales, ELVs or general light iron, generating an infeed of even density. The process typically uses a high-torque slow-rotating mill with toothed rotors which tear and pull the material apart.

This process breaks open and loosens denser material, exposing items such as gas bottles and LPG tanks in ELVs. These materials are broken open or damaged in the process to release the pressure and gases within them before entry in to the mill. This reduces the likelihood of flame events in the main mill. Flame events may still occur in the pre-shredder but they will be much less energetic.

Materials that are too heavy, large or dense to be pre-shredded are identified by the pre-shredder, and prevented from entering in to the main fragmentiser to cause damage.

In addition to possible environmental benefits there are also some economic savings. The reduction in pulsed loading to the mill, reduces wear on the mill and wear parts, and smoothes out the power use. An even density of materials fed to the mill allows the rotor to maintain a constant speed, not slowing and speeding up to deal with changing density and infeed rates. This smoother processing profile reduces the need for the motor to constantly draw power to maintain rotor speed.

The main issue with the use of pre-shredding is the ability of the plant to process sufficient quantities of material to keep pace with the fragmentiser. On larger fragmentisers processing rates of 200-280 tonnes per hour are expected. The larger pre-shredders process at 50–80 tonnes per hour. This means that several pre-shredders would be required to provide the required infeed rate. On most sites the use of several pre-shredders would not, on the basis of space and logistics, be possible.

There are capital expenditure and running costs to be considered and, these would have to be balanced against the potential gains/savings in respect of power use, wear parts and mitigating environmental emissions.

6.2 Separation Process Summary

These measures and operations fall under 'downstream processing'. The configuration of installations is varied and optional for the installation, so not all will have the separation processes discussed below.

6.2.1 Cyclonic cleaning

Cyclonic cleaning is required as a result of using air suction to assist in the separation of the fragmentised materials. The air suction is used to draw off the lighter materials, including foam, carpet/fabric, dust, paper and wood within the mixed fragmentised output from the mill. This may occur either before or after the magnetic drum is used to remove ferrous materials. In the typical UK configuration, this process is often located before the magnetic drum.

The waste materials, once captured by the air stream, are then drawn in to the cyclonic cleaning system. The air used for the suction is under negative pressure and moving at speeds sufficiently high to carry the solid materials; the air flow therefore needs to be processed to reduce the solid loading before emission. This is achieved by passing the air and collected materials through the cyclone system.

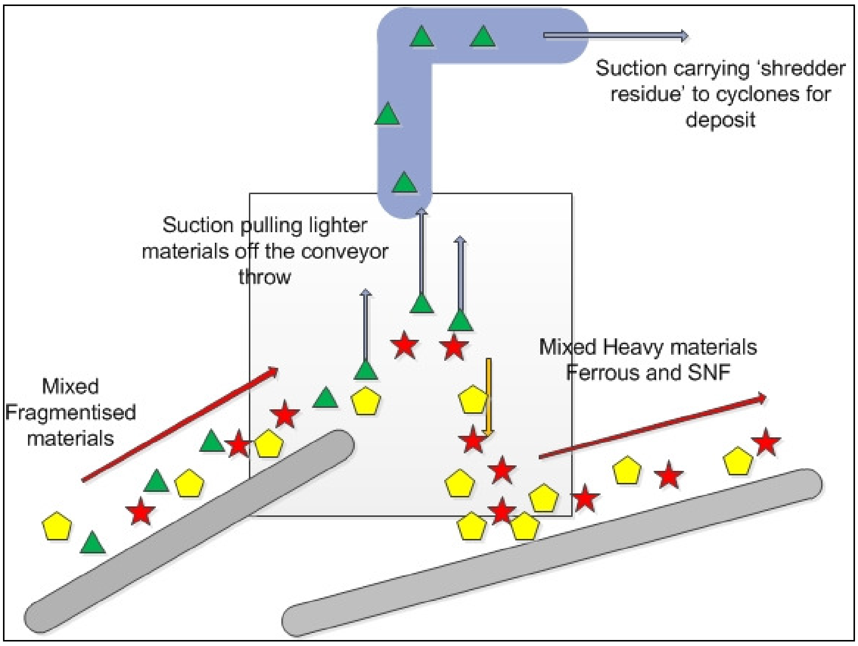


Figure 6: the air separation/suction system uses the conveyor to 'throw' the mixed fragmentised materials in to the suction. This enhances the liberation of shredder residue from the other heavier mixed materials.

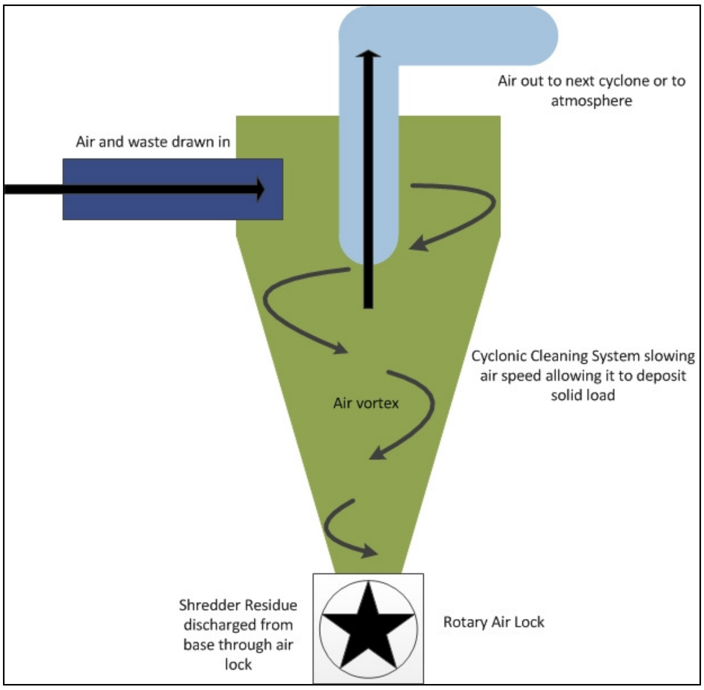


Figure 7: The cyclones are used to reduce the rotational radius of the air increasing its speed; this forces the heavier, denser particles to be thrown against the inside of the cyclone and out of the air flow, from where they fall to the base of the narrow cone. The rotary air lock allows the accumulating materials to pass out of the cyclone base, whilst maintaining an air seal.

The number and size of the cyclones employed at an installation is dependent upon the size of the mill and the volume of material processing throughput and therefore the amount of suction required to separate the material. It should be noted that dry shredders also employ cyclone cleaning systems on the mill extraction, thereby small shredders in these configurations may still require at least two cyclones. The mill extraction cyclone does not reduce gases or fume concentrations, due to the physical/mechanical nature of the separation process.

The downstream separation processes are typically calibrated and their operation fixed for an ideal processing rate and material type.

All of the systems described below require balancing and maintenance to ensure efficiency is maintained. The pressure of the air circulating within the system should be consistent with the designed configuration. Furthermore, the rotary air lock requires regular inspection. If the seal is breached, the efficiency of the cyclone is compromised and this may lead to increased particulate emission or an increase in power consumption by the fan required to overcome the leak.

It should also be noted that the abrasive nature of the high speed particulates can wear holes in the cyclone walls. These holes compromise the efficiency of the cleaning system and increase the particulate emissions.

The cyclonic cleaning systems may be configured in one of three fundamental ways:

- Open circuit
- Closed circuit with air bleed
- Closed circuit no air bleed

Open circuit

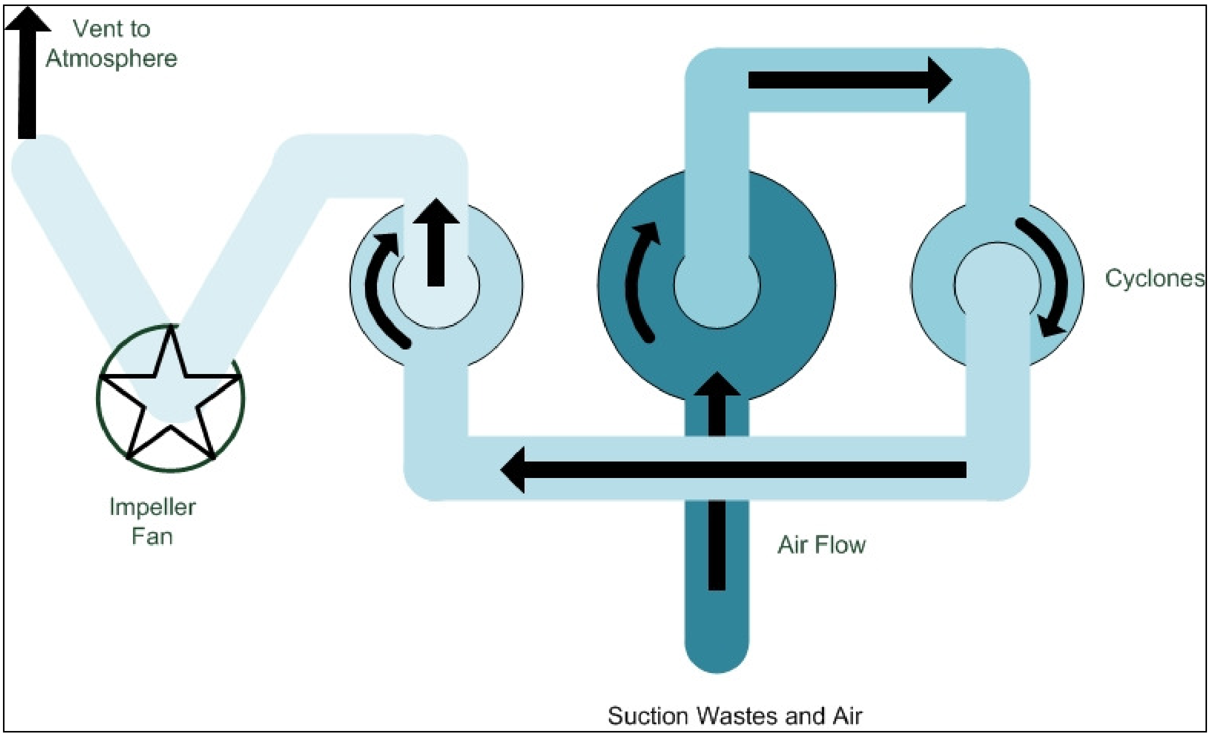


Figure 8: Schematic of the open circuit cyclonic cleaning system. The initial cyclone removes the larger particles and then subsequent cyclones provide a stepwise improvement in air quality.

The air and wastes pass through a single or multiple cyclone system. Each cyclone provides a cleaning stage targeted at a particular fraction of solids. The suspended solid load is reduced as it passes through each cyclone. At the end of the system the air is finally vented to atmosphere. The open system vents all of the air to atmosphere once it has passed through the cyclones.

Manufacturers supply most cyclonic cleaning equipment with an emission limit of ~20mg m^{-3}.

Closed circuit with air bleed

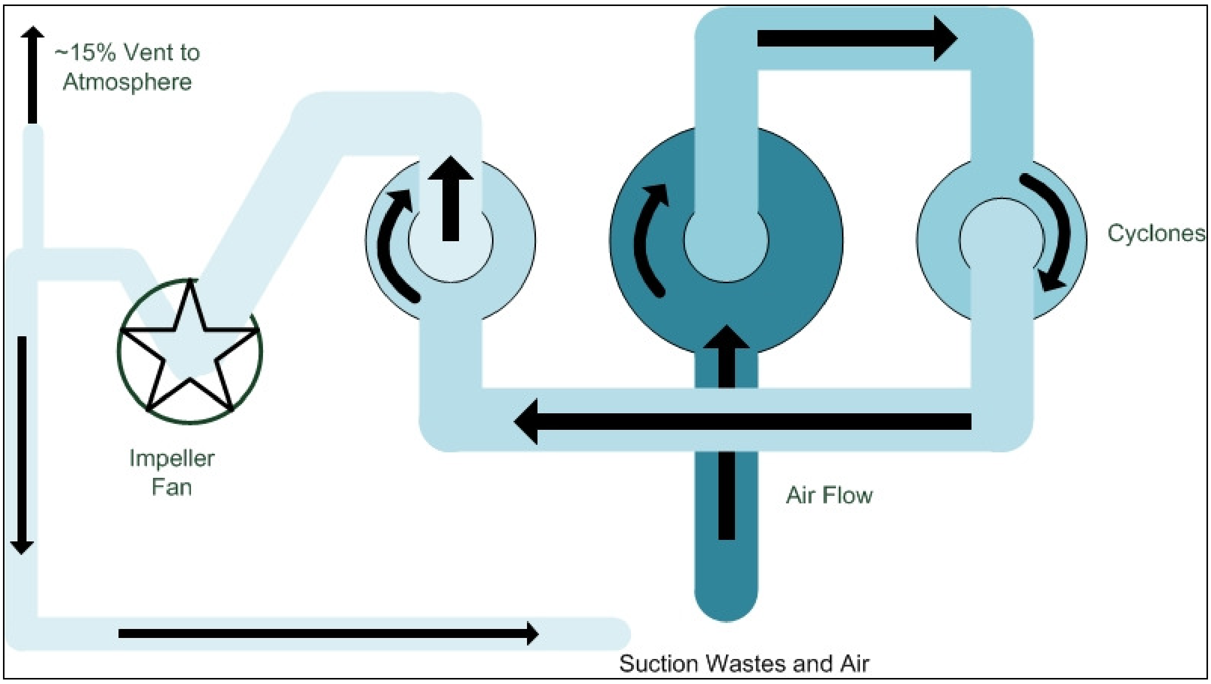


Figure 9: The closed circuit cyclonic cleaning system with air bleed is similar to the open circuit system. However, there is reduced venting volume to atmosphere, achieved by directing some of the exhaust air back to the point of waste suction.

This configuration is similar to the open circuit, but with some of the cyclone air redirected to the point at which it is used for separation. Therefore a quantity of air re-circulates within the cyclonic cleaning system, with only about 15% of this air actually vented.

Due to the smaller volume of air passing thought the vent to atmosphere, bag house filters have, in some circumstances, been fitted to the outlet. The vented air passes through the bag house before final emission. Bag houses are not fitted to the dry processing mill extraction cyclones due to operational issues and fire risk.

Typically in the UK the vented air does not pass through additional processing/filtration.

Closed system

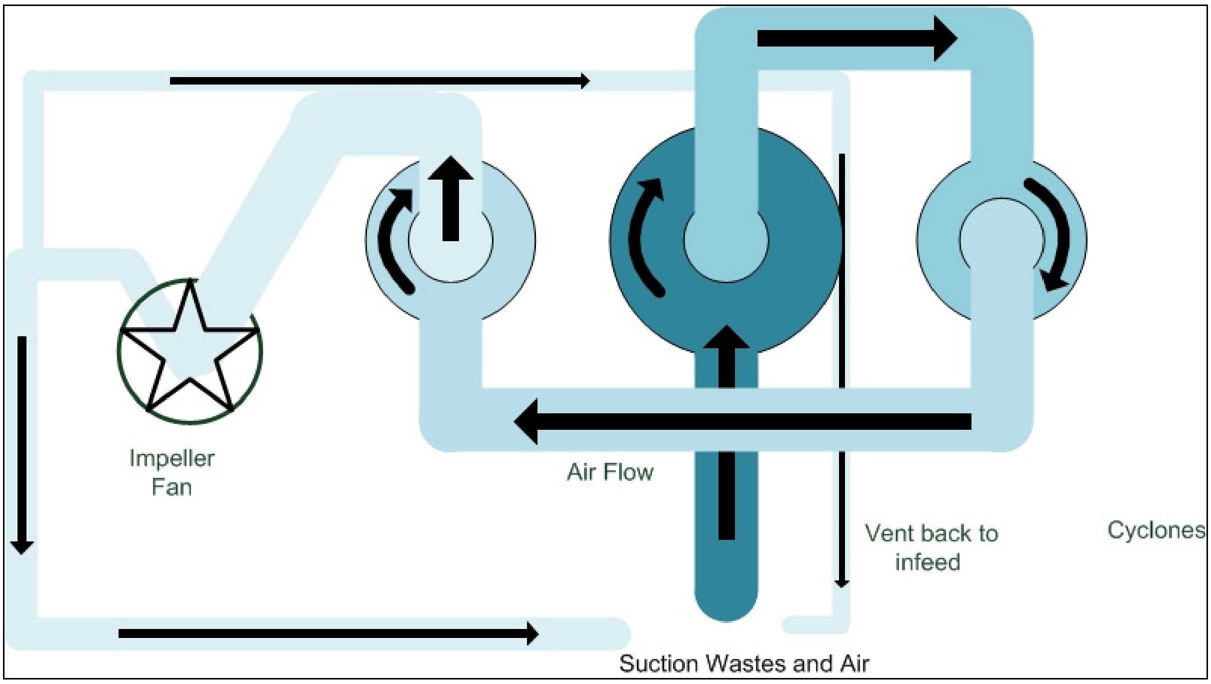


Figure 10: In a closed circuit cyclonic cleaning system all of the vents are redirected to the suction chute along with the other drawn air. To maintain effective separation, the system requires careful balancing so pressure differences throughout the system do not result in uncontrolled emissions or a reduction in separation efficiency.

In this system air is not intentionally vented to the atmosphere. It is a system similar to the 'closed system with air bleed', but in this case the air bleed is redirected to the fragmentised material suction point. This is not common in the UK or Europe but it is used in the US.

6.2.2 Wet scrubbers/de-dusters

These systems employ the same cyclonic cleaning system as the methods above but also utilise water to trap and entrain dusts and particulates from the air stream before it is vented to air. Water may be added as a spray, or flow, which acts as a trap to airborne particulates within the system, flushing them out at the cyclone's base. The process of adding water can assist the aggregation process or increase the particle density, forcing them to drop out of suspension sooner than the rotational force alone. The water is typically reused after removing the captured dusts and particles as a sludge.

6.2.3 Bag-house filters

Bag-house filters are used to remove dust and particulates from many industrial processes. The system uses fabric bags as filters through which air, carrying the particulates, passes. Particulates are captured by the filter bags and are retained for later removal and collection. The removal process is typified by the type and style of the bag-house used.

At some time in the process the filter will reach its maximum capacity (the filter becomes blocked or choked) with the trapped dusts. The cleaning may be automatic on- or off-line which may require the processing to stop or cleaning to occur outside of processing hours.

Whilst the extent of bag-house filter use in the UK is not clear (information provided in the questionnaires does not mention their use), there is evidence of their use on some installations in mainland Europe.

The location of the bag-house would be placed to receive the stack exhaust from the cyclone air before it is emitted to atmosphere. It would not be possible to install them on the mill extraction side of dry mills.

6.2.4 Electrostatic dust removal

There is little evidence of this type of system being employed on the stack emissions from fragmentiser installations. Nevertheless, the use of this type of air cleaning system has been deployed to treat, for example, flue gases, and other process dusts in both low and high flow applications. It also has the added advantage of being able to treat and deal with vapours, fume and particulates. Since the process does not require moving parts – for example, water pumps as in a wet scrubber – it is a relatively low energy option.

6.2.5 Non-ferrous separation

This is a generic description of the downstream shredder non-ferrous (SNF) processing system. There appears to be no fixed version of the downstream processing system. Some installations have no online processing, with their SNF sent for offsite processing at other facilities. Operators in the UK appear to regularly add to and modify this section of their plant to increase the quantity and quality of the non-ferrous separation. These metals are the highest value fraction of the metals separation process. Significant investment is also being made to increase the quality of separated plastics.

The non-ferrous processing occurs following the magnetic removal of ferrous metals and the air suction separation of the lighter fraction.

It is usual for this aspect of the processing system to be calibrated for an ideal infeed mix and processing rate. Changes to this 'ideal' can interfere with and reduce the separation efficiency. For this reason bypass bunkers/bays are built in to the system, so that, if required, materials can be directed away from the processing plant to be stored for re-feeding at a later date.

6.2.6 Other processes

Most physical separation processes achieve greatest operational efficiency when the material presented to it is of similar size. Trommels are often used to size fraction materials entering the non-ferrous separation system.

Eddy current separation is used to remove and separate non-ferrous metals from one another and from non-metallic materials. It is a common downstream process at fragmentiser installations. Typically, the SNF output stream would be directed to an eddy current separation line following size fractioning.

6.2.7 Picking station

Manual picking stations are typically located downstream of the fragmentising process.

Their role in the process is to provide a final sorting/cleaning stage to the produced ferrous metals. This may include, for example, the recovery of copper wire windings and armatures which have a significant ferrous component, and therefore get caught and carried over by the drum magnets. Other materials may also include plastic and rubber items which have also been caught/tangled with ferrous materials. The picking station therefore ensures the quality of the ferrous product and recovers other materials of value, including copper.

6.3 Flame Events

The general term ‘explosion’ is often used to describe an audible ‘bang’ within a fragmentiser.

They will usually be the result of a deflagration and should be properly referred to as 'flame events'. An actual explosion is a very rare event within the fragmentiser.

Sources of bangs heard by the casual observer may result from for example the rapid release of pressure from pressurised or sealed containers, or the addition of unshreddable items, which may tumble around inside the mill, damaging the hammers, rotor and mill interior. For the sake of clarity and general understanding for this report, these audible bangs as a result of an ignition will be grouped as flame/audible events.

These audible events in shredders have several potential impacts;

- Noise and vibration nuisance
- Pulsed, uncontrolled emissions from the mill – dusts, fume and smoke
- Potential damage to the mill

The significance of these events in respect of emissions to the environment is discussed in more detail in Section 7.0 and in respect of the monitoring events undertaken to investigate emissions from the shredder. During the monitoring program, only one audible event was noted. This occurred during the establishment of equipment and so it did not feature in any of the monitoring data.

The source of flammable vapours may arise from, for example, fuel residues within ELVs, paints or thinners within other containers or other flammable volatile organic compounds. It is also possible that dusts or finely divided powders can ignite in the same way as a gas or vapour.

If the mill uses a dry fragmentising method, with mill extraction incorporated, flame events within the mill expand and travel rapidly up, through and out of the mill extraction ducting. In order to prevent damage to the ducting and cyclones, the expanding gases and combustion products have to be dissipated by venting to atmosphere. This venting process is facilitated by the forced opening of flaps on the ducting and cyclone. These are pushed open by the expansion but it will also result the uncontrolled emission of dusts and combustion products to the atmosphere. Plants are designed to deal with these types of event. Dry fragmentisers do not have water/steam injection to suppress ignitions within the mill during routine processing. However, it is usually possible to flood the chamber with water in the event of a fire to extinguish it.

Other audible events in addition to the flame or impact events may result from the puncture of compressed gas cylinders and LPG tanks on ELVs. In these events, the rapid expansion of the confined gas alone can result in an audible percussive event, even in the absence of an ignition. When combined with ignition and combustion, the rapidly depressurising gases can also generate a flame event.

The impact of the high speed rotor hammers on the materials as they enter the shredding chamber and the general attrition and abrasive nature of the mill will create heat through friction. There is also the potential for these impacts to generate sparks which might act as an ignition source.

The controlled injection of water or foam into the mill is designed to reduce the effect of the flame events. The design of the shredding chamber is such that they should be run full of material and fragmenting materials. These materials warm up and then enable the controlled injection of water and/or foam to replace the available amount of oxygen required to propagate a flame event and suppress ignitions.

A secondary issue with the presence of powders or dusts is the potential to have them released in the mill and then drawn via the suction system into the cyclone, vigorously mixed with air and then ignited. Cyclone fires are also possible under certain conditions.

The ‘combustion triangle’ is an important concept in respect of controlling and mitigating flame events in the mill.

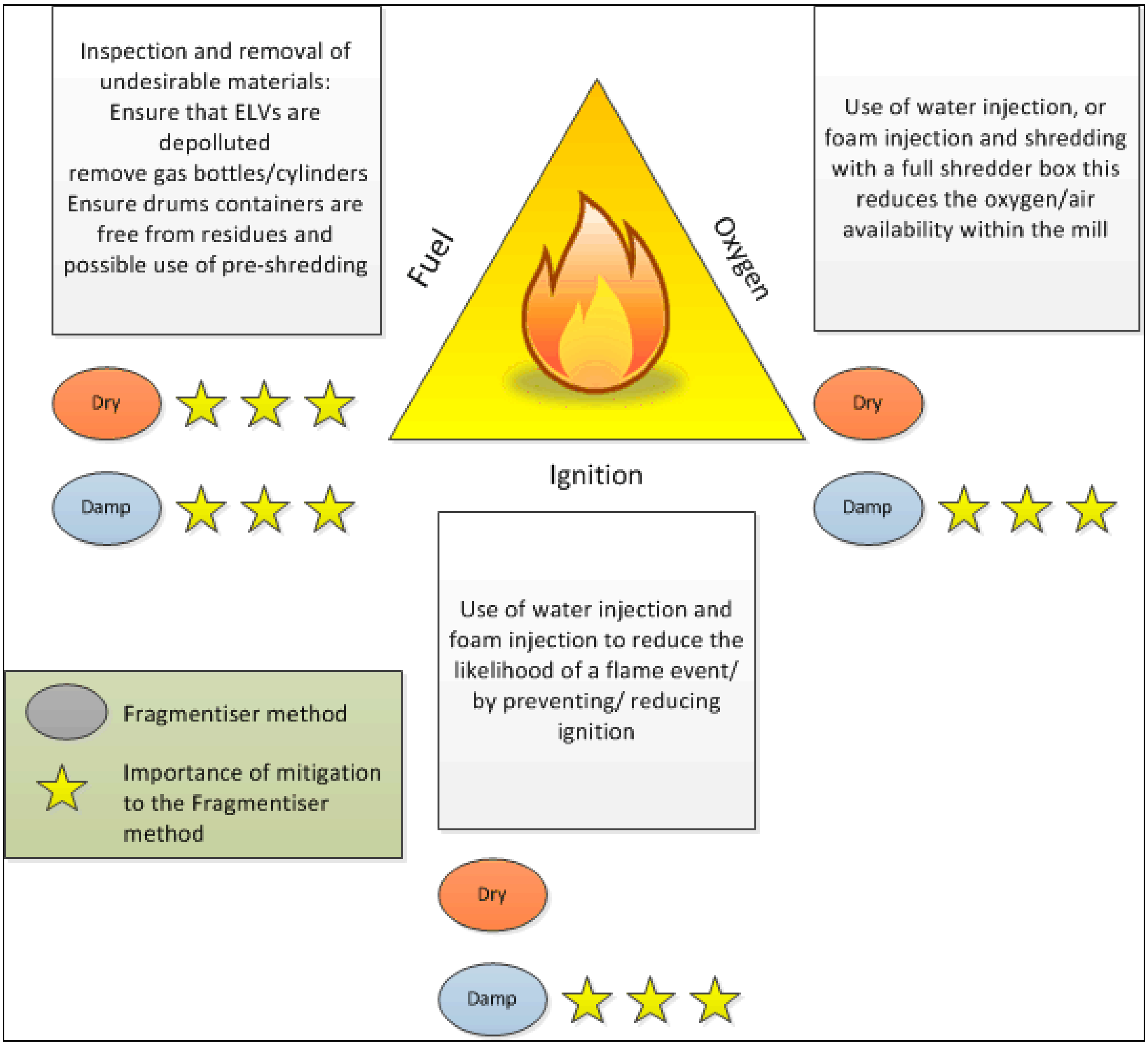


Figure 11: Simple 'combustion triangle' considering the source of fuel, oxygen and ignition required to generate a fire/flame event, and the importance of mitigation measures for the two fragmentiser methods. As there is no suppression of flame events in the dry mill chamber, this method relies heavily upon inspection procedures.

The use of experimentation to purposefully generate controlled flame events and/or explosions in a mill and then record the effectiveness of differing control and mitigation measures of fragmentising methods is clearly not a viable option. Information on the methods used (dry and damp) and how they work to reduce these types of events is based upon discussions with industry, plant manufacturers and other experts, and based upon site observations.

7.0 CURRENT EMMISSION AND CONSUMPTION LEVELS

The issues of consumption and emission levels are discussed in the terms of the information provided by responses to the survey and the monitoring undertaken during the project. Where possible, emissions are related back to the production tonnage.

However, the structure of the fragmentisers monitored is such that some fugitive emissions cannot be related to a production tonnage.

7.1 Scope of Monitoring Programme

Aspects of the emission monitoring were designed to be undertaken concurrently at the three selected shredding sites. However, due to the operational restrictions, this was not always possible to achieve. Other aspects were undertaken as spot sampling events whenever possible.

There are difficulties in respect of monitoring these types of installation; and safe protocols and methods need to be developed and agreed with the regulators and industry.

The location, type and method of monitoring equipment deployed on site were selected to ensure that the equipment could be located safely.

Subcontracting companies used to undertake the monitoring and analysis were appointed and managed by Mayer Environmental Ltd. Companies were selected based upon their specific areas of experience and to ensure the analysis undertaken was covered, where possible, by MCERTs and UKAS accreditations.

The reports and raw data from each of these contractors are provided in the appendices to this report. The interpretation of the data is based upon the monitoring event.

Three sites were selected, based upon the data returned in the questionnaires. It should be noted that the three sites agreed to the monitoring events on the understanding that their identity would not be disclosed and all data collected has been used anonymously and not reported against a specific company or site. In this respect the three sites are referred to simply as Site 1, 2 and 3.

Due to differences in the fragmentisers monitored, the data has been analysed to provide an indicative understanding of fragmentisers as a whole, and not as an assessment of individual operations.

7.1.1 Measured parameters

- Temperature of fragmentised steel/ferrous materials from the mill
- Airborne particulates – Continuous monitoring for four weeks (with weather data)
- Depositional dusts – Continuous accumulation for four weeks
- Analysis of the collected particulates, where sufficient, is collected for the above methods – to include metals and POPs
- Spot sampling directly adjacent and downwind of the mill chamber – Total Particulates (and metals analysis), asbestos (and other fibres), VOCs and SVOCs
- Analysis of accumulated dusts on the shredder and at locations that appeared to display historical material, accumulated over several years
- Airborne microbiological monitoring – methods typically used at waste recycling operations
- Stack monitoring for dusts, dioxins and furans and PCBs (in one case) measured on the cyclone extraction system
- Analysis of site drainage water from the site drainage/discharge point, taken at the point of compliance
- Analysis of the wet scrubber waters and accumulated sludges when applicable

These monitoring data are augmented by some monitoring data provided by the companies involved.

7.2 Mill Chamber Temperature – Dioxins and Furans

Mill temperature or processing temperature had been considered as a potential issue in respect of the generation of compounds typically created during combustion processes, even though metal fragmentising is not a combustion process. These compounds include dioxins and furans.

Dioxins and furans (PCDD/Fs) are listed in Annex C – Part 1 of the Stockholm Convention and are considered ‘persistent organic pollutants formed and released unintentionally from anthropogenic sources’.

7.2.1 Dioxin and furan creation

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are a group of aromatic hydrocarbon compounds with differing configurations of substituted chlorine atoms. These are commonly known as dioxins and furans. For the purpose of making reading easier, they will be referred to as ‘dioxins’ to represent the whole.

Dioxins represent a range of more than 200 congeners. They are chemically very stable and therefore persistent in the environment, have low water solubility but are soluble in fats, oils and lipids. For this reason they accumulate through food chains, and are passed from mother to infant in the breast milk of mammals.

Dioxins are not manufactured intentionally. However, their generation is known to be associated with certain industrial activities such as waste incineration, metals smelting and melting, paper production and other industrial operations that incorporate chlorine within their processes.

As might be expected, the characteristics of each congener vary considerably. For this reason, the concept of toxicity equivalents is used. The Toxicity Equivalency Factor (iTEQ) is based around the rating of toxicity for each congener relative to just one; 2,3,7,8,-TCDD. This is deemed to be the most harmful and the most studied. This is an international agreement and the iTEQ, is used in place of absolute concentrations of individual congeners, when considering assessments of the levels of dioxins.

Dioxins are known to begin forming from around 200°C up to temperatures approaching 800°. Higher temperatures result in the thermal decomposition of most organic materials including dioxins. However as, materials cool through this temperature range, it is also possible for them to reform.

Due to the waste processed by the metals recycling industry, it had been suggested that metal fragmentisers could be an unintentional source of dioxins. However, material processed within a fragmentiser are not burnt or generally heated to a point which would potentially generate dioxins or furans. Nevertheless there are rare occasions when small localised temperatures within the mill may reach above 200°C so formation cannot be completely disregarded.

7.2.2 Mill temperature

The process of fragmentising metals is very energetic, and will generate some heat through the friction, attrition and abrasion and tearing of metal through the impact of the hammers on infeed. The overall temperature will reach equilibrium, provided the mill is operated within the required tolerances.

To investigate mill temperature, the temperature of fragmented steel product was measured and recorded within the picking sheds of the three installations. The temperatures were taken using an infra-red temperature probe. The picking sheds were 60 – 90 seconds from the mill. Whilst not a direct temperature record of the material emitted from the mill, readings were made at a constant distance as the material passed the sensor on the conveyor belt.

Temperature readings were taken off the mixed processed ferrous metal passing through the picking shed. The general temperature of processed metals at site 1 was 30-40°C; site 2, 25-35°C and site 3, 40–45°C.

At site 1 and site 3 very occasional items of fragmentised steel came through to the picking station at greater temperatures than the general material stream. Field observations suggest that only five or six fragments per hour would be encountered based upon 200 – 300 tonnes of process materials. These items were typically heavier and thicker than the general product, and appeared to have been retained within the chamber for some time; evidenced by the numerous impacts over their surface. The longer the residence time within the mill, the more time the item has to convert the kinetic energy of the mill into heat. The thicker, heaver items require a long residence time to reduce in size sufficiently to pass through the grid, getting hotter as they do. These items were slightly coloured; some were blackened. Whereas, for example, plastics or thinner metal materials fragment easily, pass though the grid quickly, and are not heated significantly. Timing estimates suggest that a period of 60 - 90 seconds elapsed between the item exiting the mill and arriving in the picking shed. Extrapolating the temperature suggests that some items may have reached temperatures in excess of 200°C.

A report provided by a fragmentiser operator indicated that the internal temperature within one of their mills (not located within the UK) would reach around 50°C.

Whilst the high temperatures of very occasional items represent a small fraction of the overall ferrous throughput, it is nevertheless useful to understand the potential for some items to heat to a point of significance in respect of potential dioxin formation.

In addition to friction generated heat, there are occasions where ignition, or flame events, may occur producing short intense periods of localised heating/burning and therefore combustion products. These will be significantly hotter than the scrap measured above. These events are infrequent and not part of the routine operation. However, flame events in the mill could lead to pulsed small scale events which create the conditions conducive to the formation of dioxins.

Another consideration is that dioxins are introduced to the fragmentiser in the infeed. Burnt-out ELVs and other fire damaged scrap may have dioxin and furans associated with them which may then be released during the fragmentisation process.

Based upon the temperature information and the risk of flame events, the implication is that there is a small theoretical risk of dioxin generation during the fragmentisation of metals. Nevertheless; it should be noted that fragmentisation is not a combustion process and that, whilst there are chlorine containing materials (e.g. PVC) entering the mill, there is expected to be little or no liberation of chlorine or the creation of other dioxin precursors.

7.3 Consumption

Consumption of raw materials including power, water and wear parts have been estimated, based upon the outline information provided in the questionnaires and information requests within monitoring periods.

7.3.1 Power

It has become apparent that there is little detailed monitoring/metering by shredder operators of the power they use to run the installations. Gross monitoring and reporting of total consumption may be undertaken for cost purposes, and, for example, the rate at which the mill draws current on site may be monitored live, but it may not be recorded.

The configuration of a fragmentiser plant is such that the power used by the downstream separation and segregation components, and the conveyors that feed them, is typically fixed. The separation methodology is calibrated to deal with an average/ideal infeed rate and material type. There is some flexibility in the separation processes, i.e. flexibility to increase the plant suction, adjust conveyor speed though the magnets and eddy current magnets to deal with changes in the feed quality, quantity and environmental conditions at the time.

The key to controlling and minimising the power usage is down to the fragmentising operation. The process requires that the mill chamber/box is full and the feed is consistent. The mill under these circumstances would pull a consistent current. If the feed is 'lumpy' then the rotor will slow down during heavy loading and speed up during light loading.

In the situation of periodic heavy loading the rotor slows, losing momentum due to the greater resistance of the material. This requires more power from the motor to increase the rotor speed and replace the lost momentum. The efficiency of the mill is also reduced when it is left running empty or the load rate falls below the optimum.

Manufacturer information suggests the power use estimates are based upon the size (infeed and mill box size) and power rating of the mill and its production capacity. So, a 2,200kW (3,000hp) fragmentiser could process in the order of 100-130 tonnes hr^{-1}, therefore the power usage would be in the order of 22kWh to 17kWh per tonne. This would produce 70-90 tonnes of ferrous product per hour. From the information provided, on most installations it would appear that it is not currently possible to measure and record the actual use of power on a day-by-day, or material-by-material basis.

7.3.2 Water

Water is also not apparently routinely metered on many of the installations. Several of the fragmentisers confirmed that they do not meter or monitor water use. As a result, the volume of water used per tonne processed is based upon an average for those that provided data. Where operators employ damp processing, controlled use of water is critical to ensure efficiency of the method.

It was not therefore possible to review in detail the differences, for example, in respect of dry fragmentising with a wet scrubber/deduster and that used within a damp fragmentiser. Furthermore, without even gross/whole site metering there is no information to determine water use in the mill, conveyors, dust suppression, deduster processing or other uses.

Similarly there is little metering of water leaving site. It is not therefore possible to work out a mass balance of water use and evaporation rates, water disposal, or discharge.

7.3.3 Spares

Spare/wear parts are typically recorded by the installation. These are seen as operational cost and therefore installations have a store of spares available. In some cases, this includes large items such as rotors or other business critical parts.

The replacement of wear parts occurs on a need basis and is not specifically related to operational performance. Hammers may be replaced if the rotor is out of balance, or if plates inside the mill become worn then they may also be removed and replaced.

Hammers, when worn, are often turned around so that both sides are used. It is critical to reduce wear, and damage to the mill by ensuring the rotor is balanced by weighing the hammers. This is also an important consideration to reduce vibration from the plant. The rate of wear depends upon the infeed and how the mill is operated.

8.0 MONITORING EVENTS

Some monitoring events have occurred in the past at fragmentiser installations. However, as far as can be determined there has not been detailed systematic sampling, monitoring and analysis. Several issues have been raised in respect of certain emissions from fragmentisers.

The methodologies we employed are standard for use in the waste industry and cover a range of potential contaminants which may be associated with the operations.

Due to the health and safety risks associated with working in the vicinity of fragmentisers, the plant was required to stop processing in order for staff to deploy the monitoring equipment safely. This would typically require a 15 minute break in operations. The time between starting the sampling equipment and restarting the fragmentiser was no more than a few minutes, thus giving time for staff to retreat to a safe distance before the restart. The same process was followed at the end of each sampling event, but the recovery of the equipment was typically much quicker. Therefore is it acknowledged that at the start and end of the monitoring event the equipment would not be monitoring active operations.

8.1 The Operations

The monitoring events ran through 2011, with events lasting from a few hours to several weeks.

This helped develop an understanding of the type, location and significance of the emissions recorded. The operating hours and processing rates have been withheld to ensure the anonymity of the operators.

The breakdown for each particular operation has been provided in Appendix 2. The summary data is provided below but is reproduced in no particular order.

Summary Of Installation Operational Data - During Monitoring			
	SITE		
Criteria			
Number of days	**69**	**113**	**35**
Operational days	**51**	**77**	**21**
Total tonnage processed	**86,129**	**10,861**	**5,481**
Tonnage processed per day	**1,688.8**	**141.1**	**261.0**
Number of flame/audible events	**7**	**5**	**2**
Number of flame/audible events prevented	**6**	**57**	**9**
Total Vehicle Movements	**11,064**	**11,188**	**2,058**

Table 4: Summary of installation processing data

8.2 Air Emissions

Emissions were measured in several ways in order to understand the type and size of the aerial loading from the site. The guidance used to provide background and methodology for the airborne monitoring was the Environmental Agency Technical Guidance Document M17, *Monitoring of particulate matter in ambient air around waste facilities*. The suggested methods and scope of works are discussed below.

8.2.1 Depositional dusts gauges

Depositional dusts gauges (DDG) were located around and within each of the three monitored sites.

A total of 16 DDG were deployed across three sites in order to understand the likely depositional dust rates for the operations. The locations were chosen to be close to the installation and towards the boundary. These gauges are not directional and therefore accumulated materials are reported without a wind vector.

In cases where there was sufficient dust accumulation, it was also submitted for general analysis. However, even when apparently large accretion rates are determined, the volumes and mass of the collected dust can be too small to analyse.

Findings

The Environment Agency M17 guidance document provides a non-statutory limit threshold/annoyance level of 200mgm^{-2}day^{-1} for depositional dust for all waste facilities, clearly in industrial operations this level would be very conservative and the issue of nuisance can be a subjective one.

The quantities of depositional dusts varied significantly across and between sites. Locations close to the installation, detected significant levels, whereas those levels detected at locations further away and to the site's boundaries, were much lower. Significant accumulations in the DDG located close to the mills suggested that, although dusts were accumulating in these areas, it is not so likely that they would be transported in significant quantities to the installation boundary and then off site.

As a guide, the levels of deposited dust at some locations close to the mill reached in excess of 45,000 mg m^{-2}day^{-1}. Whilst this was a localised 'hotspot' close to the centre of an installation, and not at or beyond a boundary, it represented a significant dust accretion rate. If these deposited dusts are not captured by sweeping or damping down then they may remain available for re-suspension.

Observations of the facilities and their operation also suggested that it is not necessarily the mill which creates the most significant depositional dust loading, but the downstream processing and conveyors, and a lack of sweeping, damping down and housekeeping.

Monitoring locations over the other sites as a whole suggested that the deposit and accumulation of dusts is site and operation specific. The rates of deposition relate to the size of the plant, its operation and configuration.

Analysis of the captured depositional dusts indicated significant metal concentrations and organic contaminants. On one installation the detected metal levels were similar between the depositional gauges, although the depositional rates differed. This suggests that the character of the deposited dust is similar across a site, the proximity to the mill influencing the actual rate, not character of deposition.

Average concentrations for the four DDG locations which accumulated sufficient material to analyse, included levels of iron at 17.5%, aluminium 1.17%, calcium 4.35% and zinc 2.35%. These metals along with other potentially more significant metals included lead 4,075 mg kg^{-1}, cadmium 38mg kg^{-1}, nickel 397mg kg^{-1} and copper 1,425mg kg^{-1}. Mercury was detected at an average of 1.7mg kg^{-1}.

If these dusts were to fall and accumulate on unpaved ground soil quality could be affected.

The significance of these results relates to their metal content should they be discharged via the drainage system or be deposited on to unpaved ground or soils.

8.2.2 Airborne particulates

Short term sampling events were undertaken using high precision pumps fitted with sampling heads.

Once the samplers were constructed and calibrated, they were deployed at the sampling locations. In this case they were located within 5 metres of the fragmentiser mill and located down wind.

Findings

The results of analysis indicated total particulates trapped on the filters within close proximity to the mill were relatively low. These ranged from 0.4mg m^{-3} at site 3 to 29mg m^{-3} at site 1. Sampling was undertaken in duplicate and on two occasions, producing four results per site.

When related to process tonnages the values are relatively small due to the low sample volume collected. Nevertheless, this indicates that high volume ambient monitoring close to the mill would be required to measure the levels emitted.

8.2.3 Fibres

The method for this sampling is as follows; an open sampling head with a 5cm cowl was fitted with a cellulose nitrate filter. This sampling head was then attached to the sampling pump via a length of tubing. The air flow rate through the filter was measured using a ball flow meter and the flow rate was adjusted to 2 litres of air per minute. The filter head was sealed with a plastic bung to prevent contamination before deployment. The membrane filters samples were evaluated using the standard phase contrast microscope methods outlined by the Health and Safety Executive in MDHS 59.

Findings

During the monitoring events the results were as summarised in Table 5 below. It should be noted that the MDHS method does not allow for the discrimination of fibre type (e.g. asbestos, mineral, animal, vegetable or manmade):

Site Reference	No. of Fibres	Sample Volume (l)	Fibre concentration (Fibres ml^{-1})
1 A	2.5	406	<0.02
1 B	4.5	406	<0.02
2 A	3.5	424	<0.02
2 B	4.0	420	<0.02
3 A	4.5	480	<0.01
3 B	3.5	484	<0.01

Table 5: Results of fibre counting for all three locations.

8.2.4 Osiris monitoring gauges

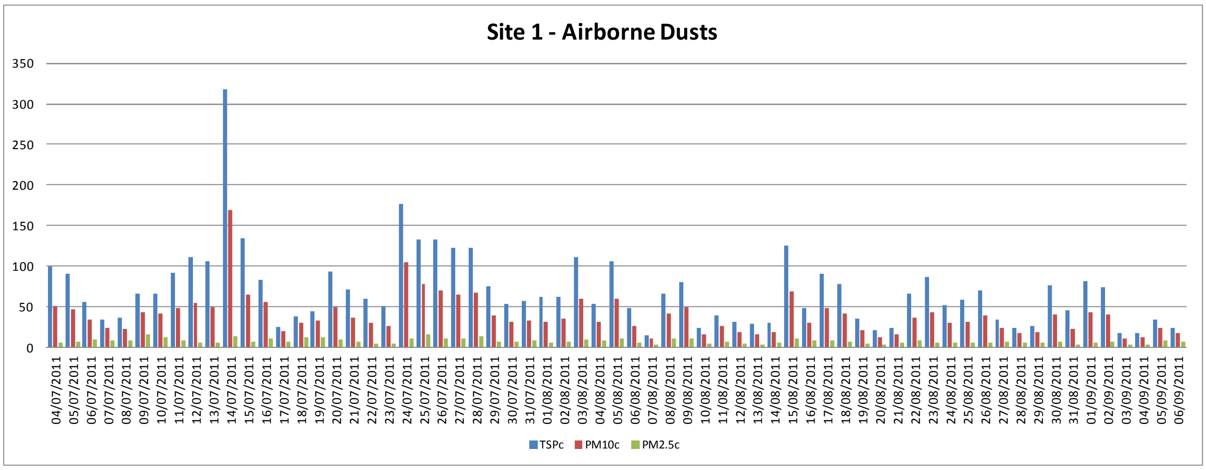
As part of the monitoring program, Turnkey Osiris (Optical Scattering Instantaneous Respirable Dust Indication System) Particle Monitors where deployed at the sites along with a weather station. They are designed to continuously monitor particle levels in particular TSP (Total Suspended Particles), PM_{10} and $PM_{2.5}$ (particles with an aerodynamic diameter of 10 microns and 2.5 microns, respectively). The monitors sample the air and particles, providing a 15 minute average level. These instruments are useful in determining temporal differences in airborne particle loading, when compared to the operations of the sites being monitored.

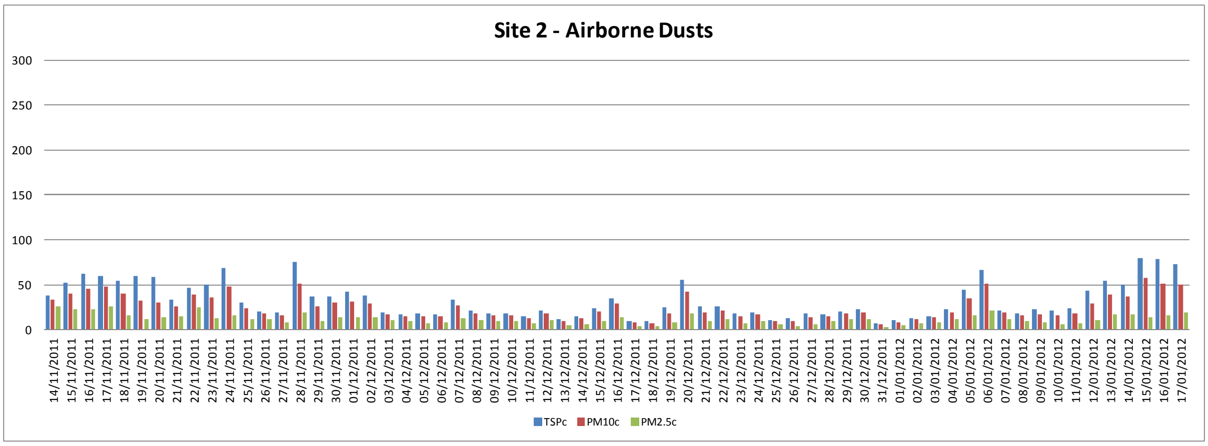
The monitors were also installed with a weather station, to record wind direction, speed and rainfall. This data is recorded and logged against the particle concentration data and a date and time stamp, enabling potential sources of dust from site operations to be recorded.

Four groups of activity within the installation were considered; reception, the mill (fragmentising), downstream process and outputs.

The data collected indicate that with the concentrations of total suspended solids that the mill is not the only source of airborne particulates. The reception and the downstream processing both generate significant concentrations of particulates.

The graphs presented below display the $PM_{2.5}$, PM_{10} and total suspended particles 24 hour concentrations (μg m^{-3}) for three installations.





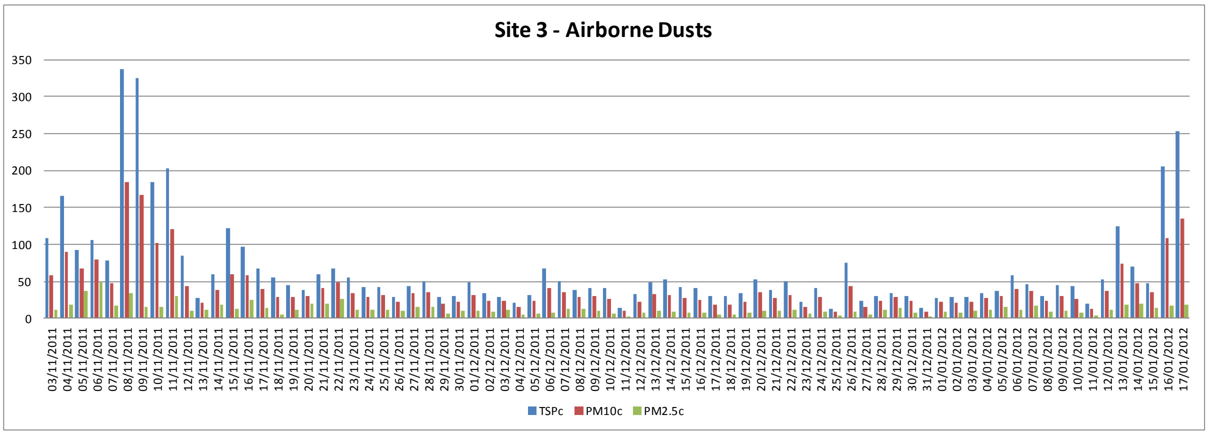


Figure 12. The 24 hour averages for each of the three sites displaying TSP, PM_{10} and $PM_{2.5}$ (μg m^{-3}) are included against date. The results have been corrected by a factor of x1.3 to allow for the heated inlet port on the equipment, which is why the annotations include the suffix 'c'. Site 3's fragmentiser was not operational for the middle period of the monitoring event which is reflected in the lower readings through the middle of the graph. Site 2 benefits from screening close to the mill.

8.2.5 Results

Data, once corrected as discussed above, indicate that on the whole the installations do produce a dust loading to the atmosphere. Comparisons between periods when the installations are not processing, and those when they are, show clear differences in dust levels.

The measured 15 minute concentrations of TSP, PM_{10}, and $PM_{2.5}$, have been averaged over a 24 hour period. These have been plotted on to graphs to clearly demonstrate the average concentrations and are included above and the raw data in Appendix 4.

The accepted threshold for PM_{10} concentrations is for the 24 hour average concentrations not to exceed 50µg m^{-3} on more than 35 occasions per year. When these data are factored up to potential average results for a year, at least two of the measured installations would be expected to be in breach of this threshold. However, a significant quantity of the PM_{10} is thought to be as a result of vehicle exhaust generated during delivery and dispatch from site.

The data indicates that background particulate concentrations have an impact upon the overall results. However, the data clearly indicate that during processing the particulate loading in the vicinity increases.

Monitoring events undertaken at other installations have found similar patterns of particulates. However, these emission levels have been and can be controlled and brought down by subsequent changes in management procedures at the site.

8.2.6 Volatile Organic Compounds (VOCs)

VOCs were sampled from the mill during short term sampling events, and by sampling on the cyclonic cleaning system vents, close to the mill chamber and downwind to enable the best possible opportunity of collecting VOC materials emitted by the mill. A handheld PID (photo ionisation detector) was also used to measure background total VOC concentrations.

Findings

The results of the analysis and calculations are included in Appendix 4.

The fugitive emission monitoring undertaken close to the mill using the activated carbon tubes detected a range of compounds. The analysis undertaken reports the ten most significant/highest concentrations of compounds present on the tube. These detected compounds are reported as a weight per compound captured by the tube. By using the captured weight and the known volume of air sampled, it is possible to estimate VOCs levels around the mill.

These emissions are fugitive in nature and therefore cannot be given a unit of time or unit per tonnage of material processed, they also do not allow a total mass or volume of VOC to be calculated, rather they represent a concentration at that point in time and indicate the range and types of compounds emitted by the mill.

In general, the greatest concentrations detected relate to those compounds associated with petrol and diesel fuels. These include for example xylene isomers, toluene and light hydrocarbon (low nC chain hydrocarbons).

In addition to the fuel derived compounds, there are others, including trichlorofluoromethane (R11), a CFC refrigerant. The sources of this compound may include for example air conditioning units in ELVs and refrigerants in refrigeration equipment.

Alpha-pinene is a plant-derived compound also used and found in pine-scented household products.

8.2.7 Fugitive high volume sampling – metals, particulates and dioxins and furans

Sampling and analysis for the range of potential ambient airborne materials was undertaken by REC Ltd. These reports and methods are included in Appendix 5.

The sampling equipment was deployed at each of the subject installations for a 3 day period, plus an additional installation whilst one of the fragmentisers was closed down for a couple of months of maintenance. However, during this time a background (or blank) monitoring event was undertaken to determine levels associated with an installation whilst it was not processing. During each operational deployment, the fragmentisers were processing during the day, but closed and not processing at night. The reader is referred to the processing and production number summary provided in Appendix 2, outlining the operations of each installation during the monitoring events.

One of the installations had an early shut down for maintenance which was used to monitor background for the operation, and a fourth installation was monitored in its place. In addition, one installation also experienced a fire/smouldering of material trapped between the rotor and the mill housing which affected the monitoring data. It was therefore decided to redeploy to this site, and repeat the sampling event. Results of all of the monitoring events are provided below.

Metals

The concentrations of metals in the ambient air are summarised from the individual reports in the table provided below:

Metals Concentrations ng m^{-3}														
Site	**As**	**Sb**	**Co**	**Cd**	**Cr**	**Cu**	**Pb**	**Mn**	**Hg**	**Tl**	**Ni**	**Sn**	**V**	**Zn**
1	1.6	6.8	3.6	4.4	20	110	221	78	0.2	<0.1	28	5	2.6	1,704
1 rp	17	8.7	18.2	92.9	17.4	494	989	593	1.8	<0.4	142	117	15	7,910
2	23	66	32	55	150	1,136	1,522	568	0.2	0.3	186	0.9	25	0.2
3$	13	19	11	3	849	1,661	332	1,661	<0.1	<0.1	114	35	12	0.2
3 rp	5.2	1.5	2	15	2.4	349	192	89	0.2	<0.4	18	20.3	2	676
4#	<1	9.6	4.3	2.6	24	117	319	96	0.9	<1	29	42	6.1	<0.2

- additional site
$ - sampled during non operational period to be sampled again whilst processing
rp - repeated monitoring event

Table 6: Metals high volume ambient air sampling data

The results from the monitoring display some interesting trends and suggest that dust management should not be limited to times when the fragmentiser is processing. Data from site 3, for example, indicated lower levels of metals during a period of processing than during a period of shut down for maintenance.

Dioxin and Furans

Results of on-site monitoring for dioxin have been reported as i-TEQ as discussed previously. The levels detected are in the range of 0.000011 ng m^{-3} to 0.001143 ng m^{-3} (11 fg m^{-3} to 1143.6 fg m^{-3}). Emission levels in the UK and EU have been set at 0.1ng m^{-3} for operations such as incinerators. The recorded results are significantly below this accepted level. These concentrations are determined by trapping and concentrating compounds from a large volume of air ('filtering' them from the air), and then dividing the measured concentration by the volume sampled.

EU guidance document on Air Quality Guidelines for Europe suggests that a concentration of PCDD - PCDF iTEQ of 0.0003 ng m^{-3} (0.3pg m^{-3}) could be indicative of a local source which may require controlling. Concentrations above 0.0003 ng m^{-3} were detected once at site 1, but this was deemed to be as a result of smouldering materials trapped in the rotor housing producing smoke, an unusual event. Repeat of the monitoring, under normal conditions, indicated a 10 times reduction.

Site	Sample ID	Lower Band Total PCDD and PCDF iTEQ – ng m^{-3}	Upper Band Total PCDD and PCDF iTEQ – ng m^{-3}
1	32853	0.0011436	0.0011436
1 rp	32899	0.0001144	0.0001248
2	32899	0.0000979	0.0000917
3$	32899	0.0000173	0.0000192
3 rp	32899	0.0000535	0.0000564
4#	32899	0.000011	0.0000133

- additional site
$ - sampled during non operational period to be sampled again whilst processing
rp - repeated sampling events

Table 7: Dioxin and furan ambient sampling data

The data collected would suggest that the fragmentisers are not significant sources of dioxins and furans.

8.2.8 Biological aerosol

Analysis on the site for bioaerosols was undertaken by D&F Associates Ltd. A copy of their report, Evaluation of Bioaerosols at Site 1, is included in Appendix 7. Whilst the techniques are standard for the measurement and estimation for bio aerosol emissions on waste sites such as open windrow composting operations, it is not usual for a fragmentiser site to be measured.

Bioaerosol is a broad description of potentially biologically active matter including micro-organisms and their constituent parts, bacteria, fungi, viruses, spores, moulds, rusts, protozoa, pollens etc. Present in nature and a natural aspect of everyday life, bioaerosols from waste management are not normally a significant public health issue.

There are no current specific guidelines for protocols for assessing bio aerosols at metals recycling sites and there are currently no workplace exposure limits (WELs) for airborne micro-organisms and their associated toxins in the UK. This is partly due to the difficulty in determining cause and effect in respect of an infectious dose.

Works were undertaken over two site visits; the first when the site was not processing, and the second during normal operations, so that there was a background control. In addition, sampling occurred both upwind and downwind of the plant on both occasions.

Findings

The results did indicate the presence of biologically-active materials such as bacteria, fungal spores and other microbial agents. However, the results gathered during the non-operational period were not significantly different to those collected during processing, and did suggest that an off-site source may be contributing to the levels detected.

During initial consideration of this monitoring event it was thought that the nature of the infeed (very low biological/organic fractions), the heat within the mill, and the general containment of the fragmentising process would have a low potential to produce a significant level of viable bio-aerosol.

Of the nine conclusions provided in this report (Appendix 8), the most significant is that:

'*Mesophillic bacteria and environmental fungi (20°C) were estimated at higher levels upwind of the shredder when the shredder was not operating than were estimated downwind of the shredder with shredding operations in progress.*'

This implies that a source off site contributed to the levels of biologically active materials detected in and around the fragmentiser.

8.2.9 Stack emission monitoring

These sampling events were undertaken by IES Ltd and Redwing Ltd. These reports are included in Appendix 6. To enable the monitoring to be undertaken, modification of the fragmentisers was required. This aspect of the monitoring program represented significant challenges in respect of general access and health and safety.

In addition, there are significant health and safety issues to be resolved in respect of the monitoring crews. Where mill and stack are located close together, safe access during processing is not possible. This meant that they could not be on the stack whilst the plant was running, slowing the sampling process.

Of the sites monitored; two utilised a wet scrubber system and one used a multiple cyclone system without the addition of water. The actual emissions reflect the fragmentisers at the time of the monitoring events and a reflection of the materials being processed at those times. The monitoring was undertaken in two stages:

(1) collection of dusts and particulates, and samples for metals and hydrocarbons analysis,

(2) collection of samples for dioxin and furans analysis, and for one site PCB assessment.

8.2.10 Results of monitoring

The monitoring data has been provided in terms of concentration and in terms of an emission rate per hour. In addition, the data has also been presented as a ratio of emission to tonnage processed.

The stack emission flow rates ranged from 16,081m^{3}hr^{-1} to 76464 m^{3}hr^{-1}. The stack emission rates have a significant impact upon the total quantity of material ejected from the stack at each site. In addition, the processing rate should also be considered to normalise the emissions to the tonnage being processed through the plant as a unit of particulate emitted. It should be noted that at the largest site, one of the emission stacks was monitored, so the results have been doubled to reflect the single monitoring point investigated.

Due to slight differences in the reporting format by Redwing and IES, it is not possible to directly compare all results between the three sites.

Recorded Particulate Emissions

Site No	Total Particulates (mg m^{-3})	Total Particulates (g hr^{-1})	Production Tonnage ^ (hour^{-1})	Total Particulates per production rate (g tonne^{-1})	Estimated annual stack emission based on operating hours$ (kg)
1#	7.0	1074	200	5.35	1,887
2*	1.46	23.5	20	1.17	41
3*	3.06	156	27	5.8	275

* - average of three readings taken during the monitoring event

- Monitoring data provided was taken from one of two stacks, it has been assumed that due to the same plant configuration on both emission locations, the data would be representative of both and could be doubled to reflect the single emission source monitored.

$ - Operating hours are based upon an average of the hours reported by 17 of the respondents to the questionnaire for 2010 processing. This figure is 1,763 hours. However, it should be noted that the total operating hours reported ranged from 833 hours/year up to 3,000 hours/year.

^ Production tonnage - based up on the production during the monitoring event where available

Table 8 : Particulate emissions from fragmentiser stacks.

It should be noted that all three of the installations demonstrated a particulate concentration below the level recommended/stated design parameters by the manufactures of the equipment (~20mg m^{-3}).

Recorded Metal Emissions

The total metal emission rates largely follow the particulate levels determined. The totals ranged from 0.21mg m^{-3} to ~ 2.4mg m^{-3} and were comprised of broadly similar metals across the three installations.

Of most significance during the monitoring events was iron with levels of 1.9 to 27 g hr^{-1} followed by zinc up to 167g hr^{-1}, lead 0.99 to 3 g hr^{-1} and cadmium up to 1.6 g hr^{-1}.

Recorded VOC Emissions

The levels of VOCs measured are similar for sites 2 and 3 with slightly higher levels detected at site 3. It should be noted that the VOCs, when speciated, are similar to those compounds detected on the activated carbon sampling tubes, and are again indicative of those compounds which might be found within petrol-range hydrocarbons. These compounds include BTEX range – ethylbenzene, xylene isomers, and other lighter hydrocarbons.

Recorded Dioxin, Furan and PCB Emissions

Levels of PCDD and PCDF iTEQ for site 1 was measured as 0.005ng m^{-3} with an error of ±0.003ng m^{-3} and site 2 was 0.001ng m^{-3} with an error of ±0.001ng m^{-3}. These stack emission rates are significantly below those typically required of incinerator plants 0.1ng m^{-3}.

Site 3 was not monitored because the sampling required an operative to accompany the equipment and adjust it during the sampling event. At site 1 and 2 this was possible to achieve (due to separation and shielding of the stacks from the mill and the fragmentising method used).

PCBs iTEQ recorded on-site installation 1 indicated an emission level of 3.3ng m^{-3} ± 1ng m^{-3}. This concentration is around the level suggested in the *Air Quality Guidelines for the EU 2nd edition* of 3ng m^{-3} PCB, estimated to be the ambient air concentration in an urban environment. It is felt that this result, as with the other data collected from the stack, indicates relatively low levels of emissions via this route.

It should be noted that installations, draw air from the local atmosphere and use it through the process without prior cleaning. For those installations located in an urban or industrial location they will be re-circulating ambient air which may contain concentrations of the parameters determined above. Parameters such as PCBs for example, were detected only marginally above the level suggested to be indicative of an ambient urban environment *Air Quality Guidelines for the EU 2nd edition.* Furthermore, the margin of error in the data of ±1ng m^{-3}, due to the low levels detected, would also indicate they are consistent with urban background.

8.3 Water

Water comprises an important aspect of the fragmentising operations. Whether the water is added to the mill or to the cyclones in a wet scrubber there can be a significant water demand and therefore a contamination risk for the waste water.

Samples of drainage waters were collected from the agreed compliance points for the respective discharges. The three installations discharged to foul sewer. In addition, where waters are used in the fragmentising process, for example in the de-duster/wet scrubber (two installations), samples of these waters were also collected for analysis.

Results of all water analyses, including the discharge waters and the wet scrubber/de-duster waters, are included in Appendix 3.

8.3.1 Site discharge water

All three installations had consented discharges to foul sewer. Each had a sealed surface composed of concrete paving, which drained via grit traps or settlement tanks to a class 1 oil/water interceptor fitted with coalescing filters and then to a discharge point. Samples were collected from the compliance points at each location. This was located after the interceptor and prior to discharge from the system.

The waters collected and drained in this way include rainwater runoff, and any water released by processes on site, including damping down for dust suppression or process water releases. Surface water run-off also included those waters which percolate through the infeed materials, and output materials. During percolation it is possible for the waters to leach soluble components and to suspend and carry insoluble materials in to the drainage system.

The water samples were submitted for a general suite of potential contaminants, which included parameters which might be expected of a typical water quality package and those determined when monitoring a discharge consent, for example; metals, suspended solids and BOD and COD (biochemical and chemical oxygen demand). In addition, a range of other potential contaminants were also included such as POPs including polychlorinated biphenyls (PCBs), dioxins, VOCs and SVOCs.

8.3.2 Results of analysis

The results of analysis are discussed as a group of data rather than on a site by site basis. To provide some comparison to the recorded data, and whist nevertheless not specifically relevant to waters from this source, the Environmental Quality Standards (EQS) from Directive 2008/105/EC 16 December 2008 are provided after results for which there is a relevant EQS. The values presented are maximum allowable concentrations (MAC) and reported as [MAC #] or when MAC are not available annual average (AA) are used [AA #].

The waters were weakly alkaline with a pH range of 7.0 - 7.4. These pH levels are not unexpected given the installations have concrete paving. The electrical conductivity (a measure of dissolved salts) indicated they are also relatively saline in respect of measurements of 3100 µs cm^{-1} to 1500 µs cm^{-1}. This salinity may be a reflection of the ambient environment in which the fragmentisers are located.

The chemistry also indicated that the waters had experienced some anaerobic conditions. These conditions may arise as a result of prolonged residence time within the drainage systems. Anaerobic indicators include ammoniacal nitrogen detected at 3.7mg l^{-1} to 18mg l^{-1}, and significantly elevated BOD and COD results. COD levels ranging from 16mg l^{-1} to 3,700mg l^{-1} and BOD levels from 75mg l^{-1} to 1,700mg l^{-1} indicate the waters, particularly those expressing the higher end concentrations, have a significant oxygen deficit. Total organic carbon was detected at 40mg l^{-1} to 600mg l^{-1}, indicating a significant organic loading. Whilst discharges to foul sewer of waters with these concentrations may be possible, it is unlikely they would be acceptable for discharge to a controlled water.

Of the metals analysis, mercury (Hg) and cadmium (Cd) were below detection. Iron (Fe) and manganese (Mn) were at greater concentrations in the samples with the greatest oxygen debt, which is not unusual as the reduced forms of these metals tend to be more soluble. The level of Fe in one of the samples was quite elevated. Reduced ferrous iron (Fe^{2+}) is more soluble than the more oxidised ferric iron (Fe^{3+}), and this may have contributed at least in part to the elevated COD discussed above.

Other metals of note include: Lead (Pb) at concentrations of 16 – 29 µg l^{-1} [AA 7.2µg l^{-1}], nickel (Ni) 10 - 160 µg l^{-1} [AA 20µg l^{-1}] and zinc (Zn) 0.13 – 3.3 mg l^{-1}. Dioxins were detected at the limit of detection up to 0.32ngl^{-1} i-TEQ.

PCBs were determined based upon the seven congeners: 101,118, 138, 153, 180, 28, 52 which are determined individually.

Sample	Site 1	Site 2	Site 3
Units	µg l^{-1}	µg l^{-1}	µg l^{-1}
Congener 101	0.12	0.014	<0.005
Congener 118	0.77	0.011	<0.005
Congener 138	0.10	0.013	<0.005
Congener 153	0.084	0.011	<0.005
Congener 180	0.019	<0.005	<0.005
Congener 28	0.16	0.027	<0.005
Congener 52	0.12	0.018	<0.005

Table 9: PCB results for site drainage discharge waters

PCBs were detected within the discharge waters. It is thought that the low relative solubility of PCBs in waters suggests that they are probably associated with suspended solids or oils/hydrocarbons within the waters.

8.3.3 Wet scrubber

Samples of waters were collected from wet scrubber systems on two of the installations. These waters were also submitted for an extensive analytical package. In this case, as wet scrubber waters are re-circulated and generally become warm in the plant, they were also subjected to a general bacteriological assessment including *Legionella*. The quality of these waters may be determined in part by their residence time in the circulatory system.

The waters were slightly alkaline in reaction with pH values ranging from 7.3 to 8.0. Electrical conductivity values indicated a moderate level of soluble salts accumulation.

COD and BOD indicated a wide difference between the two samples with results of 2,000mg l^{-1} and 1,400mg/l^{-1}, and 650mg/l^{-1} and 45mg/l^{-1} respectively. TOC followed a similar pattern with values of 170mg l^{-1} and 40mg l^{-1}. These results, along with the detected ammoniacal nitrogen (NH_3-N) levels, indicate a general oxygen deficient environment within the wet scrubber system. All of these parameters are used to determine the oxygen debt within a water. In well oxygenated waters the levels of these parameters are greatly reduced.

Suspended solid levels were elevated, as might be expected of waters used to trap solids within the scrubber, and ranged from 900mg l^{-1} to 2,600mg l^{-1}.

The levels of metals detected were also significant. Whilst Hg was not detected, Cd was present in both samples at concentrations of 54µg l^{-1} and 120 µg l^{-1} [MAC 1.5 µg l^{-1} for class 5]. Other metals of note include; Pb at 4.3mg l^{-1} and 5.3mg l^{-1} [AA 7.2 µg l^{-1}], Fe 46mg l^{-1} and 80mg l^{-1} {200µg l^{-1} UK drinking water standard} and Zn 16mg l^{-1} and 19mg l^{-1}.

Dioxins were detected in these waters ranging from 0.003ng l^{-1} to 0.2ng l^{-1}. The POP-based compounds PFOS and hexabromocyclodecane (HBCD) were also present. PFOS was detected at 0.4µg/l^{-1} and 1.5µg l^{-1} and HBCD at <1µg l^{-1} and 1,600 µg l^{-1}. In addition, at one site traces of organochlorine herbicides were also detected in the scrubber waters.

PCBs were present in both waters at broadly similar concentrations.

Sample	Site 2	Site 3
Units	µg l^{-1}	µg l^{-1}
Congener 101	0.27	0.18
Congener 118	0.17	0.10
Congener 138	0.2	0.13
Congener 153	0.11	0.097
Congener 180	0.035	0.022
Congener 28	1.2	0.43
Congener 52	0.5	0.31

Table 10: PCB concentrations in wet scrubber waters

Hydrocarbon levels detected in one of the installations was significantly greater than the other. This included some of the more volatile BTEX range of compounds, the more significant differences appeared in the heavier hydrocarbon fractions with 2-3mg l^{-1} in total detected. Furthermore, concentrations of isophorone, phenol and styrene were also detected.

The bacteriological suite determined indicated that many of the microbes analysed for were detected. This included *Esherichia coli*, faecal coliforms and sulphate reducing *Clostridia* sp., indicating that there is a potential faecal contamination of the de-duster waters. The microbial species and their presence are potentially pathogenic to humans. The environment within the deduster systems may be suitable for these particular potential pathogens to survive longer than would be expected once outside of an animal host, due to the warm sub-oxic to anaerobic conditions indicated by the other determinants.

Legionella pneumophila was not detected in samples from either of the installations.

8.4 Solids

The analysis of solid samples from the installations involved collecting samples from four principal sources,

- Accumulated material on the plant and on nearby structures;
- Deduster sludge;
- Cyclone cake; and
- ELV-derived Polyurethane (PUR) foam

Not all of these samples were available for collection from each of the installations.

8.4.1 Accumulated materials

There have been suggestions that fragmentisers are a potential source of POPs, and that as a source, they have generated an increase in particular compounds in the areas surrounding installations.

The fragmentisers that formed this research are located in largely industrial commercial areas, as are many in the UK. Therefore, the availability of open ground from which soil samples could be collected and which would have been largely unaffected by other industrial inputs was low. As an analogue for potential soil contamination, the sampling described here and the use of depositional data described in Section 8.2.1 could be considered.

However, at one of the trial installations there were locations, which had been largely undisturbed for many years (anecdotally ~15 years), where dust and other debris had accumulated. A sample of this material was taken along with a more recent accumulation taken from an area of the installation which was thought to be no more than a few years old.

The samples are described in the certificates of analysis as ‘new’ and ‘old’.

These materials were analysed for a range of POPs and other potentially persistent compounds.

PCBs were detected in both samples, with lower concentrations detected in the more recent material. The sum of EC7 congeners was 9.75 mg kg^{-1} for the old accumulated material and 3.15 mg kg^{-1} for the newer accumulation. For general comparison and to provide a context for these data, dioxins, furans and dioxin like PCBs in soils for tier 1 screening soil guideline values (SGVs) indicate concentrations of 8 mg kg^{-1} for domestic gardens and allotments and up to 240 mg kg^{-1} for industrial commercial land use (see context within: SC050021 *Supplementary information for the derivation of SGVs for dioxins, furans and dioxin like PCBs* and SC050021/TOX12 *Contaminants in soil: Updated collation of toxicological data and intake values for humans for dioxins, furans and dioxin-like PCBs*).

Perfluorooctane sulphonate (PFOS), a compound used in fabric protection, stain repellents and fire fighting foam, was detected at slightly higher concentrations in the ‘new’ sample 72µg kg^{-1} than the ‘old’ at 47µg kg^{-1}.

Both samples were fibrous in character suggesting that the PFOS could be present as a result of fabric, carpet and upholstery fibres which had been treated with these compounds.

Within the SVOC suite, polyaromatic hydrocarbons (PAHs) were detected at relatively low levels, as were some phthalates. Phthalates are typically used as plasticizers and may be as a result of small plastic fragments in the samples.

8.4.2 Deduster sludge

Samples of deduster sludge were taken from the settlement tanks of the wet scrubber systems. The materials were, by their nature, very wet and the results are reported on a dry weight basis.

PCBs were detected in the sludges at concentrations 1.2mg kg^{-1} and 1.06mg kg^{-1} (total EC7). This could be expected given that they were also detected in the fragmentiser stack emissions. In respect of the POPs, levels of PFOS of 14µg kg^{-1} and 51µg kg^{-1}, and HBCD of <1mg kg^{-1} and 62mg kg^{-1} were detected.

8.4.3 Internally accumulated material

These materials were collected from accumulations lining the inside of two cyclones mounted on a dry fragmentiser. One received mill extraction materials, and the other received the air used following removal of the fragmentiser residue.

The samples in the certificates of analysis are labelled as ‘cyclone 2’ and ‘mill extraction’. Both samples were submitted for an extensive suite of analysis including general metals and a range of potential organic contaminants. The results for both samples when discussed are listed as ‘cyclone 2’ first followed by ‘mill extraction’.

Both samples displayed the presence of dioxins i-TEQ of 14ng kg^{-1} and 19ng kg^{-1}. In respect of the POPs, whilst PBDE was below the limit of detection of 1mg/kg, PFOS was found to be present in both, at concentrations of 170µg kg^{-1} and 25µg kg^{-1} respectively. In addition, PCBs were detected in both, with the greater levels within the mill extraction sample. The sum of the EC7 congeners was 0.6mg kg and 1.45mg kg^{-1} respectively.

PAHs as a total of the EPA 16 were detected in both samples at 24 mg kg^{-1} and 16mg kg^{-1} respectively with benzo(a)pyrene (BaP) present in both at less than 1mg kg^{-1}. In general concentrations up to around 40 mg kg^{-1} for total PAHs (sum of EPA 16) and <1 mg kg^{-1} for BaP are general SGV values for soils for use in domestic gardens and allotments (see caveats above).

Similar ranges and concentrations of petroleum hydrocarbons were detected in both samples. This included both the lighter fractions within the BTEX range as well as the heavier ranges typically associated with oils and fuel oils.

Of particular note in the VOC suite undertaken is the presence of trichlorofloromethane (Freon – 11 or R 11) a refrigerant gas, in both of the cyclone samples. The greater concentrations were detected in the mill extraction sample (concentrations of 1,700μg kg^{-1} and 5,800μg kg^{-1}). Others within the CFC family were also detected including dichlorodifloromethane (R12) at 20 μg kg^{-1} in the mill extraction sample. The presence of these CFCs suggests the presence of refrigerant and foam propellant gases which have been phased out of use. It is not possible to age the accumulations within the stacks however it is thought that during routine maintenance cyclones would be cleaned. Materials containing these compounds, should not be processed through a fragmentiser but through appropriately designed plants.

There are several other VOCs within the broad scan which were detected. These include plasticizers and other solvents which may or may not be associated with petrol and compounds including, for example, styrene.

8.4.4 Foam grab samples - ELV samples

Samples of seat foam materials within the shredder residue fraction were collected from the fragmentiser installations used for this research and from a couple of other installations.

The sampling was a simple random grab of similar-sized foam pieces taken from the fragmentiser residue materials within storage bays. The individual foam pieces were taken from various random locations over and around the stockpile. The weight of the samples was around 5kg each, all of which was reduced in size by milling to less than 10mm, mixed and coned and quartered to produce a subsample of around 1kg. This was ground down to a 'powder' to pass through a 2mm sieve for analysis. A total of two samples were prepared and then submitted for POP determination. Rather than determine the full range of POPs, the analysis was targeted at PFOS which has been used in fabric treatments and polybrominated diphenyl ethers (PBDE) used in the treatment of automotive PUR foams.

The use of POPs particularly within the production of new vehicles has been phased out over the last 20 years. Based upon the assumption that the average age of ELVs arising in the UK is around 14 years, it is expected that the presence of POPs in ELVs would be diminishing.

Concentration of PBDE in PUR foam was expected to be around 40 g kg^{-1} (~4%) (Interim Report "Study on waste related issues of newly listed POPs and Candidate POPs" No ENV.G.4/FRA/2007/0066 BIPRO 26 August 2010).

However, the results of analysis for the two samples indicated that the presence of PBDE was below the limit of detection (1mg kg^{-1}) and PFOS was detected only in one of the samples at 7.5μg kg^{-1}.

Further investigation was also undertaken by sampling the PUR seat foam, and fabric, from 4 ELVs which were of differing make and age. The vehicles were a BMW - 26 years old, Vauxhall - 18 years old, Ford - 16 years old and Peugeot - 11 years old.

The results of this analysis indicated that PBDE was below detection for both foam and fabric in all of the samples. In addition, PFOS was detected at low levels in the seat fabric from the BMW, Ford and Peugeot samples, and in the foam of the Ford and Peugeot. The highest concentration of PFOS, 54 µg kg^{-1}, was detected in the Ford seat cover. Of the other results the BMW seat cover produced the next greatest concentration of 17 µg kg^{-1}. In three of the samples PFOS was below the level of detection (<5µg kg^{-1}).

The results of this analysis suggests that motor manufacturers were reducing and phasing out the use of these compounds within their vehicles even before the general cessation in use was acknowledged. When POPs are detected in the fragmentiser in-feed, they appear at low concentrations. It is therefore considered unlikely that processing of ELVs would result in the installation acting as a significant source of these compounds.

8.5 Noise

Noise measurements were taken over a few days of operation and as spot sampling events to record levels associated with specific activities. The monitoring report/data is included in Appendix 9.

The dB is a logarithmic scale used to describe sound pressure and sound intensity. Therefore a change of 10dB represents an equivalent change by a factor of 10 in the sound pressure. Therefore subjectively this might be perceived as a doubling of the loudness of sound.

Recordings indicate both operational/processing levels and idle non processing levels, and levels associated with the installation when the mill was shut down.

Operational – 87dB at 20m

Idle - 77.8dB at 20m

During periods of shut down the average recorded levels fall to ~65dB at 30m.

The loading and tipping operations produced levels of an average of 76.4dB at 50m for the operations. At the ferrous product discharge conveyor end recordings were taken at ~20m for the conveyor and the falling materials; this produced an average of 80.6dB at 20m.

When the levels are normalised to a distance of 50m for the plant or operation, the levels in the following summary table apply.

Activity	Measured sound Level	Sound level at 50m
Fragmentiser Idle	LAeq 77.8dB @20m	LAeq 69.8dB
Fragmentiser Idle	LAeq 67.7dB @20m	LAeq 63.4dB
Fragmentiser Operational	LAeq 87dB @20m	LAeq 79dB
Fragmentiser Operational	LAeq 83.5dB @20m	LAeq 79dB
Feed conveyor and tipping	LAeq 76.4dB @20m	LAeq 76.4dB
Discharge conveyor	LAeq 80.6dB @20m	LAeq 72.6dB

Table 11: Summary of recorded noise data

The information indicates that the mill is the main source of noise on the site even though the other operations would generate a significant contribution.

It should be noted however, that it is not just the level of noise which is significant, but the characteristics of how and when the noise is produced. So for the outfall conveyor the noise tends to be higher pitched.

Furthermore, continuous noise tends to be less intrusive and less noticeable than irregular events. This may mean that the tipping events generate a more noticeable intrusion than the continuous sound of the mill. This may be more significant when the average level of tipping and feed conveyor area was found to be only 3dB below that of the mill.

There were no significant explosions/flame events during the monitoring and these would be expected to produce significant peak level outputs. The same is true for these peak/pulsed events, in that although the mill average represents a background level, an explosion or flame event would be significantly more noticeable and intrusive.

The main mitigation/attenuation measures for noise are distance and screening. When considering the layout of an installation it is unlikely that the relocation of certain operations within a site would achieve a significant reduction in noise at the site boundary. For example: an installation located 100m from a sensitive receptor would have to be located a minimum of 80m further away to achieve any significant (perceptible) noise reduction.

The limited ability for relocation on many installations means screening and operational/management changes may be necessary to control noise. Local screening and localised noise barriers placed around particular activities or processes would achieve significant noise reductions. With use of the appropriate noise absorbing materials this could be 5-10dB on the screened side.

Other alternatives are to screen the site, or place screening between the site and sensitive receptors. These should be of a non-reflective material, located as close to the installation as possible and of sufficient height to shield the operations.

There are examples of this type of screening located along the entire length of fragmentisers and enclosing whole metals recycling yards in order to control and mitigate noise levels.

9.0 SUMMARY OF ANALYSIS AND MONITORING

Throughout the process the analysis and measurement of water, solids and aerial emissions from fragmentisers suggested that whilst particulate emissions have been detected above the recommended guidelines, associated potential contaminants are not detected at particularly significant levels.

The point source emissions for the mill and the stack, whilst difficult to measure, do not appear to be the major source of aerial output. Levels of particulates, metals and VOCs appear to be largely controlled. Other site operations, including the movement of materials, conveyors, tipping and dropping, sorting and segregation operations, would appear to be the main source.

Waters draining from the site and coming in to contact with the infeed and processed materials appear to be the main source of contaminants within them. The drainage waters on site were found to be of generally low quality, in terms of low levels of oxygenation and the accumulation of potential contaminants, albeit the actual water quality is dictated by the consent to discharge. Interceptors and grit traps on site do play a role in improving water quality by reducing the levels of contaminants prior to discharge; however, these measures have a small role to play in the overall water quality management. Suspended solids within the waters have a significant impact in respect of the presence and level of other potential contaminants and measures should be used to ensure their removal or reduction.

Waters used within the operations and processing, for example, wet scrubber or deduster waters are, as a result of their exposure to significant quantities of dust and other debris, of poor quality. Whilst there is no evidence to suggest these waters could propagate microbial activity, they do appear able to host viable microorganisms, some of which may be pathogenic.

The presence of PCBs within some of the solid residues, dusts and site drainage waters, albeit at relatively low levels, is an issue that will be addressed in the sections to follow. The results indicated that low levels of PCBs are present in most of the media on site. In addition it should be noted that PCBs have, along with many POPs, been phased out of production and use. The issue of managing this family of potential contaminants is therefore one which is naturally diminishing.

10.0 TECHNIQUES TO CONSIDER IN THE DETERMINATION OF BAT

The fragmentising of metal-rich wastes is considered by the metals recycling industry, for its recycling and recovery efficiency, to be BAT. The technique was developed as a response to the tighter environmental regulation of metal melters, and their subsequent demand to reduce the deleterious fractions within the metals they were melting. It is against the conclusion that fragmentising metal-rich material to separate the differing metals and non-metal fractions is BAT, that the following recommendations are made.

Some recommendations are standard for BREF guidance and appear in The Waste Treatment Industries BREF. However, in this context they have been adapted to suit the nature of the metals fragmentising industry.

In some circumstances recommendations are made for particular operations or processes, these are in no way intended as an endorsement of any particular manufacturer or supplier.

No preference for a specific fragmentising method over another is presented. It is for the operator of a particular installation to consider what would be considered BAT for their specific type of operation. When possible, some indication of costs is provided within the table 1, of the executive summary, nevertheless these are site specific and therefore provided as a guide.

10.1 Management Systems

Environmental management involves having a system in place whereby the operator, and the regulator, can take comfort from the fact that a facility's potential environmental impacts are understood and managed. It also ensures that installations strive for continual improvement in respect of the facility's environmental performance.

10.1.1 Environmental Management Systems

BAT Recommendation: Operators should implement a formal environmental management system, with certification to the ISO 14001 standard or registration under EMAS (EC Eco Management and Audit Scheme).

An operator implementing such a system will not only find it easier to meet the BAT requirements for management of the facility, but also many of the other technical/regulatory requirements listed in other sections of this document.

Both certification and registration provide independent verification that the EMS conforms to an auditable standard. It is recommended that any system be externally accredited to, for example, UKAS or equivalent EU certification.

The use of an EMS has become an important aspect of running a site with an Environmental Permit (EP), replacing the traditional Working Plan.

Whilst formally accredited EMS are not obligatory for EPs, the use of EMS appears to be a favoured route for the EA (Environment Agency), and maintaining an EMS does demonstrate an understanding of the requirements for environmental protection and importantly a requirement to continually improve environmental performance.

Information described below includes those issues to be considered in more detail within an EMS and does not include those issues which are dealt with elsewhere in this chapter on BAT.

a) Effective operational and maintenance systems should be employed on all aspects of the process whose failure could impact on the environment. In particular there should be:

   - Documented procedures to control operations that may have an adverse impact on the environment.
   - Defined procedures for identifying, reviewing and prioritising items of plant for which a preventative maintenance procedure is appropriate
   - Documented procedure for monitoring emissions or impacts
   - A preventative maintenance programme covering all plant whose failure could lead to an adverse impact on the environment, including regular inspection of major non-productive items.

b) Maintenance systems should include an aspect of auditing performance and reporting of this performance to senior management.

c) Other management aspects which would demonstrate good practice are provided below. The significance of these in respect of any particular operation will be dependent upon the specific circumstances and setting of an individual site:

d) The company should have demonstrable procedures which consider the environmental impact for the management, and operation of their installation.

e) Annual audits to check that the operations are undertaken in accordance with the company procedures and requirements suggested here. It is recommended that the audits are independent.

f) The company should produce annual reports on environmental performance, and future planned improvements. Ideally these would be published environmental statements.

g) The company should have a clear and logical system for the keeping of records, procedures and systems.

10.1.2 Quality Management

BAT Recommendation: Operators should implement a quality management system with certification to ISO 9001:2008 or similar for the installation.

In addition to the systems required for the Environmental Management System and the general management system, an externally certified Quality Management System ISO 9001:2008 or similar should also be implemented. These systems focus the installation management on efficiency and consistency of production.

Companies employing a QMS will often have done so at the request of their suppliers or customers.

The use of QMS in the metals fragmentisation industry has assumed additional significance as it is one of the requirements for metal recyclers seeking to apply for 'end-of-waste' status for their processed material under EU Regulation 333/2011.

10.1.3 Activity detail

BAT Recommendation: Operators should create and maintain a comprehensive list and description of each activity undertaken by the installation.

A full list of the installation's activities should be provided. This should include detail and breakdown of each operational stage of the process.

For each stage there should be a description of the equipment used, environmental protection measures in place and the minimum training requirements of the operating staff.

In general terms the activities could be divided in to:

- Reception, inspection and validation of wastes
- Sorting, movement and storage of the wastes on site
- Processing activities
- Storage of products and residues
- Dispatch of materials from site

These general headings should be broken down to reflect the complexity of the site and the protection measures in place.

Detailed flow diagrams and engineering drawings should be used to outline the site activities in full. It will therefore be possible for auditors and regulators to inspect and review the operations.

10.1.4 Housekeeping

BAT Recommendation: Operators should ensure the installation maintains good housekeeping procedures to prevent or reduce emissions from the installation and its operations.

Management of the installation should be in accordance with good practice including on site storage and organisation of waste, products, quarantined items, raw materials, spares, liquids, and any other material stored at the installation. The storage locations should be clearly marked on a detailed site plan.

The housekeeping requirements are to ensure protection of the environment, careful storage, and removal or minimisation of materials at the installation that are no longer required for the operations.

Those materials which have become worn out, broken or have passed their useful life should be removed from site as soon as possible for recycling, recovery or disposal. The amount of worn out unusable materials stored on site should be kept to a minimum.

Spares should be stored in a clearly designated area and stored in accordance with the manufacturer's instructions so they are not permitted to deteriorate beyond use. The spares area should be clean, tidy and organised with a clear and detailed inventory of material.

The installation should not be allowed to accumulate dusts and debris, including areas on, below and around the installation.

10.2 Improving Knowledge of Waste Input

The improvement of metal fragmentiser environmental performance can be dealt with in two principal ways; one is to control outputs and emissions at 'end of pipe', the other is to control the quality and type of infeed to the plant in the first place. In basic terms, what goes in to the fragmentiser will come out. The outputs may be to air, solid wastes or metal products or within liquid for example drainage or deduster waters.

Operators do not want scrap infeed which contains dirt or other added non metals, concealed items such as gas cylinders, or contaminated materials such as undepolluted or poorly depolluted ELVs and contaminated drums. There are significant environmental and health and safety issues associated with inadvertent processing of these types of poor quality material.

10.2.1 Control of incoming materials

BAT Recommendation: Operators should ensure that materials received at the installation are suitable for fragmentising.

This aspect of the operation is critical to the overall performance of the installation and the efficiency of the abatement measures installed.

The characteristics of the infeed are fundamental to the character of the installation's outputs, in terms of potential contaminants (the range and concentration), the location of the outputs, be it to air, water or land, and the significance of the outputs. Materials delivered to the site should be subjected to strict inspection, reception and validation procedures.

Waste materials known or suspected to present a high environmental, human health or installation risk should be subjected to greater scrutiny prior to fragmentising, for example baled scrap metals, CA scrap, and ELVs. These materials were identified by the operators as significant sources of flame or audible events during processing.

10.2.2 Implementation of acceptance procedure

BAT Recommendation: Operators should select only appropriate infeed for processing, to achieve low emission levels in line with overall BAT objectives.

It is in the operator's interest to ensure that the materials received at an installation are suitable for fragmentising, are within the scope of their Environmental Permit, and will not pose an unacceptable risk to the environment, the local amenity, human health or the installation.

The installation acceptance procedures should be detailed and documented. They should include, but not necessarily be limited to:

a) Radioactivity screening
b) Screening of delivery paperwork – confirming the suitability of EWC (European Waste Catalogue) codes - provision of identification
c) Weighing of all materials as they arrive
d) Confirmation that sufficient storage capacity is available to receive the incoming load
e) Confirmation of the potential risk of the material and supplier
f) Visual inspection of load pre tipping
g) Immediate visual inspection of load post tipping
h) Spot sampling of materials to confirm their suitability
i) Notification of non-compliance with paperwork descriptions
j) Rejection of unsuitable material

10.2.3 Waste inputs

BAT Recommendation: Operators should follow a clear documented and auditable procedure for the assessment of potential infeed.

The large variety of waste types and the varied nature of the materials arising in the metals waste stream make this aspect of controlling the fragmentiser's environmental/emission performance essential.

The infeed is a mix of metal rich material, but it does have the potential for a range of various non metallics and other potential contaminants. Fragmentiser infeed is deemed to be a non-hazardous waste stream, providing that potential residual contaminants are controlled and their presence minimised.

The infeed delivered and intended for the fragmentiser should be recorded using the appropriate EWC code. Detailed recording of detected and rejected unacceptable materials should be kept. This should include gas cylinders, kegs, roll cages and sealed containers, undepolluted vehicles, radioactive sources or detections made on the weighbridge.

Materials and suppliers should be graded/risk assessed so that inspection protocols can be targeted against the materials. For example, poor performing operators who are rated higher risk should receive greater more targeted inspection.

BAT Recommendation: Operators should confiscate and repatriate gas cylinders, and other prohibited items, to the appropriate owner to remove them from the waste stream.

Cylinders found in delivered materials should be confiscated and repatriated to their owner and not processed. Cylinders loaded back on to the delivery vehicle may remain within circulation and could be concealed again in an attempt to discard them at another location. Gas cylinders always remain the property of the gas supplier.

Operators should have discretion to implement a suitable deterrent to prevent the delivery of the concealed cylinders. However, as a minimum, details should be recorded for reporting to the EA for follow up Duty of Care investigations.

BAT Recommendation: Operators should ensure the reception and acceptance of drums and tanks is done only with a certificate of cleanliness, with prior notice and with hazard warning symbols obliterated.

The delivery should be recorded against the weighbridge ticket; and the certificate of cleanliness should also be recent, ideally no older than 24 hours. The relevant hazard codes/symbols on the drums and containers, if appropriate, should be obliterated or removed to indicate they are empty and largely free from residues. The operator should have final discretion in respect of managing customers, poor quality materials or misdescribed materials should be inspected more closely or rejected.

BAT Recommendation: Operators should produce and follow a detailed baled material inspection and acceptance procedure before bales may be accepted for processing.

BAT Recommendation: Operators should undertake risk based assessments for baled and other infeed materials to base their inspection and pre-processing procedures before fragmentising.

Unless a detailed documented management procedure to trace and inspect bales delivered to the site can be implemented, the acceptance of baled scrap for fragmentising should not be permitted. This includes detailed monitoring and management of bale suppliers and processing, of flame / audible events associated with processing, or concealed items/materials, such as dirt, or other non metallic materials, undepolluted ELVs, cylinders/sealed containers or heavy non-shreddable items.

Alternatively bales and other materials, based upon risk based assessment, could be pre-shredded, or torn open, for example, using a crane and spike, to open and loosen them for inspection before fragmentising.

- it is not possible to properly inspect the content of a bale delivered to site, unless significant time and energy is spent pulling the bale apart,
- bales are a significant cause of flame and audible events in fragmentising mills,
- non-shreddable materials may be concealed within a bale leading to damage in the mill and shut down and repair or maintenance, and health and safety implications,
- once an ELV has been baled, it is not possible to determine whether it has been depolluted,

Existing Duty of Care requirements require suppliers to appropriately describe the materials to be delivered. The physical concealment of unauthorised materials within a load, and the concealment / omission of information on a waste transfer note is an offence. The waste input to the installation has a direct relationship to the outputs, and how the plant is designed to mitigate them. Reception, inspection and validation procedures are required to control the overall emissions from site.

10.2.4 Implementation of waste screening

BAT Recommendation: Operators should establish quarantine areas for materials that are prohibited, awaiting full inspection, or awaiting testing or removal.

Areas for quarantined materials should be provided to store materials which require further investigation prior to processing. For materials which are beyond the scope of what might be considered typical infeed, or that have been identified as higher risk, samples of the material should be requested for analysis before delivery; pre delivery audits may also be required to view the material before arrival at the installation.

10.2.5 Dedicated reception area

BAT Recommendation: Operators should clearly designate a material reception area, with staff controlling the inspection, reception and validation of materials at the installation, trained in their role.

As a minimum the inspection area should have sufficient impermeable concrete paving to hold the stored materials. In addition, there should be sufficient space for the tipped materials to be inspected before/as they are added to the general infeed stockpile.

The reception area should drain to a sealed sump or consented discharge and ideally there should be a facility to isolate it from the rest of the drainage system as and when required, such as in the event of a spillage.

The reception area should be controlled by a trained operator or site foreman and the materials delivered and tipped should be inspected immediately, and at least whilst the delivery vehicle is still on site.

Items identified as being unsuitable, incompatible or unacceptable or those that pose an unacceptable risk to human health, installation, or the environment should be segregated. There should also be a clear procedure for the handling and removal of materials which are deemed to be unsuitable, and do not fulfil the required acceptance criteria.

10.3 Management of Process Generated Residues

BAT Recommendation: Operators should ensure the management and storage of all materials prevents or reduces emissions from site.

Outputs generated by the fragmentisers should be managed and controlled.

Total volumes of material should not be allowed to build up to a point whereby the site infrastructure and management procedures on site are overwhelmed or become ineffectual.

Those installations with additional processing and treatment steps should consider the implications of the differing waste streams produced by their operation in accordance with general BAT objectives.

10.3.1 Residue management planning

BAT Recommendation: Operators should ensure that all materials are stored in such a way as to prevent or reduce emissions from the installation.

Residues from the process (not including the ferrous output) should be stored undercover. This is to reduce the percolation of rain water, and the escape from site via windblown dusts or litter.

The appropriate storage of material is a fundamental requirement to prevent or reduce emissions. Storage areas should be clearly identified with the material type, volume or maximum weight of storage, the maximum height and any potentially hazardous characteristics.

Storage areas should be appropriately located so as not to be close to watercourses, sensitive receptors and to reduce or eliminate the need for double handling.

There should be a clear and unambiguous statement outlining the maximum quantity of the differing materials and their location to be stored on the site, and a suitable method which may be used to determine the actual qualities against this maximum.

The total quantity should be within the limits for which the site's established environmental protection measures can safely handle.

Suitable access for vehicles (and pedestrians if required) between and around stockpiles should be maintained. This is to enable site inspections, volume measurement and to provide some measure of fire break. Furthermore, their residence time on site should be kept to a minimum.

BAT Recommendation: Operators should ensure that all waste products, residues and other materials are characterised and assessed for appropriate further processing, recovery or disposal.

Outputs from the fragmentising process should be characterised to enable appropriate recovery/recycling or disposal. Records of the outputs and weights produced should be recorded and maintained. This would include the production of worn parts removed for replacement and disposal and as part of repair, as well as records of ferrous and other operational residues.

Analysis of all outputs destined for disposal should be undertaken on a regular basis to confirm the consistency of the materials in respect of appropriate duty of care designations.

10.3.2 Fragmentiser residue

BAT Recommendation: Operators should store fragmentiser residue under cover to prevent or reduce emissions.

Fragmentiser residue is normally composed of plastics, lighter rubber, and materials including fabric, carpet, dust, fibres and dirt (mineral fraction), wire and other smaller metallic fragments. The nature of these materials is such that they are of low density and light and susceptible to being windblown.

Storage undercover will prevent the ingress of rainwater that might lead to the leaching or washing of materials in to the site drainage system. It also prevents rainwater increasing the weight of this material prior to movement or disposal.

10.3.3 Techniques for materials separation

BAT Recommendation: Operators should ensure that all emissions from downstream processing are prevented or reduced.

Once mixed fragmented materials have passed out of the mill they are transported by conveyor to the downstream separation phase of the installation.

As configurations for this aspect of the process are not fixed, and may be entirely absent, mitigation measures should be in line with overall BAT objectives. The downstream separation processes should also be optimized to ensure efficient processing and operations should be enclosed or covered to prevent or reduce emissions from this aspect of the process.

10.3.4 Shredder non-ferrous

BAT Recommendation: Operators should store shredder non-ferrous materials in a way to prevent or reduce emissions.

BAT Recommendation: Operators should process shredder non-ferrous materials undercover to prevent or reduce emissions.

This is the non-ferrous fraction including aluminium, copper, stainless steel and often includes heavy plastic, rubber, aggregate and glass.

These materials are not usually susceptible to being wind-blown, but may have a leachable component. Whilst enclosure may not be important, cover would prevent rainwater ingress to the materials.

The separation and processing of these materials through the downstream process of the installation requires control. The SNF processing aspect of the installation should be enclosed in a building, or by covering aspects of the operation for example conveyors, trommels, transfer points, and the use of covered bays and water sprays to damp down the materials.

10.3.5 Wear parts

BAT Recommendation: Operators should remove used, end of life wear parts from site for recycling or recovery.

Worn out components for example, wear parts, hammers, and conveyor belts should not be allowed to accumulate at the installation. When these items are stored, should be only in such a way as to prevent or reduce emissions from site, and for only short periods of time.

10.3.6 Material handling techniques

BAT Recommendation: Operators should prevent or reduce emissions including dust and noise from material handling and transport.

BAT Recommendation: Operators should produce and update a documented detailed material handling plan.

Handling and movement of the wastes on site should be managed to ensure that all emissions are kept to a minimum. The site should operate within the hours provided by the planning permission and the Environmental Permit.

Tipping should be within 'sympathetic' areas of the site, for example, away from site boundaries or close to sensitive neighbours. The pushing or dragging of scrap metals across the site surface should be avoided. Some operators are known to only permit the tipping of particularly noisy materials (for example tubular scrap, alloy wheels) at designated times of the day. Tipping operations should take consideration of the following:

1) Operating hours,

2) Type of materials to be offloaded,

3) Subsequent location, where the materials are to be moved,

4) Noise - tipping should be undertaken in areas to protect from significant noise generation and transmission from site to sensitive receptors,

5) Inspection locations and availability of trained staff to check the tipped loads,

6) Available capacity and storage for the materials received and the outputs,

7) Available capacity for quarantined materials,

8) Possible release of contaminants.

10.3.7 Covering conveyor belts

BAT Recommendation: Operators should prevent or reduce the generation of dusts or other emissions by the movement and handling of materials by conveyor belt.

BAT Recommendation: Operators should ensure that conveyors, transfer points and drop points downstream of the mill, are covered to prevent the release of dusts and particulates.

All conveyor systems (apart from the infeed conveyor) should be covered to prevent wind blow and dust raising. Transfer points between conveyor belts and processes should also be covered.

At the top of the infeed conveyor it is recommended that water sprays/misters should be used to dampen the infeed before it enters the mill.

Areas, where materials are dropped from conveyors should be either covered; for example, in to covered storage bays. The ferrous product conveyor belts are typically set at much greater height to allow for a significant accumulation below the drop point; in addition many are fitted with a swinging arc to allow for a significant material accumulation. These types of conveyor drops should be curtained to provide protection from wind blow and noise.

Water spray and misting should be used when weather conditions dictate, for example dry windy conditions. The misting should be located within the curtains to ensure the materials are dampened down before they fall.

The speed of the conveyor belts should be optimised to ensure that materials are presented to separation processes in the most efficient way.

Configuration should also use belt energy to throw the materials, to help with separation processes. Product presentation to the handpicking stations should ensure the materials are spread thinly enough to view and enable item removal.

10.3.8 Storage of liquids

BAT Recommendation: Operators should ensure that all potentially polluting liquids are stored and handled in such a way as to prevent their escape.

All storage of liquids, including fuels, oil and lubrication, hydraulic oils and grease should be within bunded areas. Detailed guidance on the design, location, construction and maintenance of storage bunds is provided within the guidance document PPG 2. The reader is referred to this document for more detail and information.

Tanks for liquids including fuel and oils should be above ground. This enables the tanks to be inspected easily and leaks to be identified and sealed.

BAT Recommendation: Operators should ensure that there are no uncontrolled leaks from tanks or pipes within the installation.

The use of pipe work on fragmentiser installations is typically related to the bunded storage areas. All pipe work associated with the filling and use of the liquids within tanks should be retained within the bunded area for protection.

All other pipework should ideally be located above ground and inspected regularly for leaks.

BAT Recommendation: Operators should minimise the use of below ground installations.

For most fragmentiser installations there is little requirement to locate items, for example, fuel lines, or storage tanks below ground. Nevertheless, preference should be given to the above ground location and storage of infrastructure that may pose a risk to the environment if damage was to go unnoticed.

10.4 Process Efficiency

BAT Recommendation: Operators should monitor and manage the installation's processing efficiency.

The process efficiency should be monitored as a routine. Measurement and recording of electrical power use and water consumption both on the mill and downstream, processing rate in tonnage per hour, metal to residue ratios, density of the ferrous product, wear part use/replacement and wear rates are required to understand the plant efficiency and consumption rates per unit of production.

Plant modifications and long term trends may be identified so the installation's performance can be optimised or fine tuned to ensure improved efficiency.

As many installations are altered, repaired and augmented following the initial installation, records of production outputs enable assessment of the effects such alterations have on the process.

10.4.1 Accident Management Plan (AMP)

BAT Recommendation: Operators should ensure that the installation is prepared to deal with unusual events/accidents to prevent and control the uncontrolled release of emissions to the environment.

The installation should develop and maintain an accident management plan (AMP). The plans are required to prepare the installation to deal with issues including spillages, fire, discovery and handling of non permitted materials, but should also include issues such as flame and audible events. Measures to be included in an AMP should include but not be limited to:

1. Detailed site specific assessment of the AMP in terms of the installation,
2. Establishing and maintaining procedures/risk assessments identifying the potential for an accident,
3. Outlining measures required to mitigate the environmental impact of an accident,
4. Provision and location of equipment required to tackle an incident on site,
5. Training of site staff to identify potential accidents and the responses required to mitigate them,
6. Division of staff responsibility for actions undertaken in response to an accident,
7. Routine review and updating of the AMP and to reflect changes in the site staff, operations, processes and, in response to accidents.

10.4.2 Site diary

BAT Recommendation: Operators should keep a detailed site diary or other similar method to record daily events for the installation.

The site diary is a key management tool in respect of day to day operations. It should reflect the status of the site and record events relevant to that day's operation. The diary should be available for inspection at any time and retained on site for at least 12 months. Recording of site operations need not necessarily be in one place.

10.4.3 Noise and vibration management plan

BAT Recommendation: Operators should reduce noise and vibration from relevant sources in the installation.

BAT Recommendation: Operators should undertake a detailed noise and vibration assessment of their installation.

BAT Recommendation: Operators should produce a detailed noise and vibration management plan, with annual reporting on improvement targets and on noise and vibration mitigation.

Noise and vibration assessments should be undertaken at each installation. The information gained will provide details of the site specific requirements. It is expected that the noise and vibration management would be included within an installation's EMS. Where noise is mentioned below this should be read to include the requirements for vibration.

The plan would describe the following:

1. Description of the main sources of noise and vibration (including infrequent and occasional sources) and the nearest sensitive receptors. The description should include:
    - The source and location on a scaled plan of the site
    - Whether the source is continuous or intermittent, fixed or mobile
    - The hours of operation
    - Description of the noise type
    - Its contribution to the overall site noise emission categorised as high, medium or low.
2. Provision of the same information as above for the operation of infrequent sources of noise. This may include maintenance, seasonal operations and out of hours operations,
3. Details of appropriate noise surveys, measurements and investigations. Modelling may be required for either new or existing installations to account for potential noise problems,
4. Adhering to the noise management plan encourages maintenance of operational plant or machinery, which as a result of deterioration, may increase noise,
5. Use of screening and shielding of particular aspects of the installation's noisy areas or activities,
6. Adjustment of operating hours.

Other noise mitigation measures may be required between the mill and sensitive receptors. The most effective of these would be to place non-reflective acoustic wall or shielding between the source and the receptor. Shielding is most effective when located close to the source.

Vibration should be considered in the context of the plant operation, for example the balancing of hammers on the rotor, consideration of the foundation and dampening mounts for the mill and an assessment of resonance during mill operation. Consultation may be required to alter aspects of the mill to change the resonance of particular plant operations.

10.5 Utilities and Raw Material Management

To improve the efficiency of the installations, the use of raw materials and utilities and the flow and use of the materials within the installation is required. The point of use of the materials, for example, power, fuel and water should be understood and recorded.

10.5.1 Energy consumption

BAT Recommendation: Operators should reduce the consumption of energy/ power per unit of production.

BAT Recommendation: Operators should meter the consumption of electrical power within the installation to produce detailed power use assessments.

BAT Recommendation: Operators should produce detailed production/power reports to inform on the improvements to energy efficiency.

The use of electrical power is a significant consumable and its use should be reported annually by tonne of material processed, and by location of use. An energy management plan should be produced to develop and improve energy efficiency. In relation to maintenance and replacement of components, energy efficiency should be considered as part of the procurement process. Consideration of annual and lifetime savings would be recommended. Reporting can be adjusted to indicate environmental benefits in terms of CO_2 savings.

The reporting on the use of electricity by and within the installation is essential to understanding the consumption and ultimately to manage and reduce its use. Gross energy use by the plant should be recorded and reported. This would include electricity, gas, liquid fuels (diesel for example) and other sources of energy. Measures to improve energy efficiency would typically be provided in an EMS.

10.5.2 Water use

BAT Recommendation: Operators should reduce the amount of water used within the installation per unit of production, and reuse / recycle waters where possible.

BAT Recommendation: Operators should meter water use and produce a detailed water management plan.

Water use within the installation should be reported annually as a gross volume consumed per tonne of materials processed, and broken down by use. A water management plan should be produced to encourage an increased efficiency of use, and to improve reuse, of water resources.

It should be metered so the installation's use may be monitored and managed by individual process.

Use of newer methods, for example, the addition of a foaming agent to the mill injection would reduce the quantity of water consumed.

When waters are used they should, where possible, be re-circulated and reused.

The use of water sprays for dust suppression should be carefully managed to ensure that the site is damped down and not saturated, so not wasting water, and spray dust suppression should be linked with site sweeping to reduce the overall available levels of dust.

10.5.3 Effluent specification

BAT Recommendation: Operators should prioritise discharge to foul sewer over that to controlled water.

BAT Recommendation: Operators should reduce the volume, and improve the quality of waters discharged from the installation.

The objectives are to reduce the quantity of any water to be discharged from the installation, and to reduce the degree to which these waters are exposed to potential contaminants.

Waters arising from processes within the installation should be characterised to determine the most suitable disposal route in line with the overall BAT objectives.

Preference for discharge waters should be to foul sewer. Only where locations or other engineering constraints prevent connection to foul sewer should the discharge be connected to a controlled water. Connection of discharge to controlled water may require more treatment to meet the consent limits.

10.5.4 Water treatment/discharge points

BAT Recommendation: Operators should ensure that waste waters do not bypass the drainage or water treatment systems at the installation.

A detailed drainage plan should be provided as part of the site management system. This plan should outline the drainage system and the final destination of the drains on site. A statement as to the integrity of subsurface drains should be provided. This should also include the specifications for any storage tanks, sealed sumps, sediment traps and interceptors.

Designation of the drains should be provided and the site staff trained to understand the significance of the drains and their designations. The recognised convention is that surface water drains should be marked in blue, with those leading to foul sewer marked in red.

As a minimum, site drainage waters should pass through sediment/grit traps and to an oil/water interceptor before discharge. All waters to be discharged from site should be via an appropriately consented discharge. The scope and design of the interceptor should be sufficient to deal with the size of the drained area and estimated peak storm event.

Additional water treatment may also be required to suit the specific operations or to achieve the required water quality for discharge. These may include filtering, oxygenation or settlement to improve quality and ensure compliance.

Water audits should be undertaken to reduce the water consumption and to prevent water contamination.

10.5.5 Drainage

BAT Recommendation: Operators should ensure that waters discharged from the installation site comply with the relevant consents in line with overall BAT objectives.

BAT Recommendation: Operators should ensure the installations water treatment systems are appropriately designed and fit for use.

BAT Recommendation: Operators should ensure the installations waste water treatment systems are managed and maintained.

Waters draining from the installation should all be directed through the site drainage system. The trapped and accumulated oils and sediments washed from the site surface require periodic removal. Without removal, the interceptor and drainage system will cease to operate efficiently.

Sediments and oily waters removed from oil interceptors are Hazardous Wastes as classified in the European Waste Catalogue (EWC) and should be removed from site as such. As waste arisings in some circumstances will be hazardous, then each installation should be registered to gain a Hazardous Waste Premises code.

Daily visual checks on the drainage infrastructure are required to ensure compliance. This should include checking to ensure drains are not blocked, the interceptor and grit traps are functional and the discharge waters are visually compliant with the consent of discharge.

Management should include the collection and analysis of discharge water samples. Sampling and analysis of discharge waters should be undertaken every six months or in response to a significant event or issue on site, for example, fire, spillage or reception of contaminated materials to confirm continued compliance. The program for sampling and analysis should be documented and the results of the regular visual inspections and analysis retained for inspection.

10.5.6 Discharge water quality

BAT Recommendation: Operators should use routine analysis to demonstrate compliance and improvement in discharged water quality.

The acceptable levels of potential contaminants or other parameters will already be set within the existing consent to discharge to either foul sewer or controlled water.

The existing consent to discharge should be confirmed along with the drainage and interceptor design. There was little in the information received to suggest that the consents granted so far are inadequate or that the thresholds currently used for installations are too high. The discharge consents do not appear to consist of a standard set of limits provided across the whole of the fragmentising industry, and are typically dependent upon the receiving sewerage processing plant's available capacity for water volume and quality.

10.5.7 Control and abatement of emissions to air

BAT Recommendation: Operators should prevent or reduce dust and other emissions to air from the installation.

Air emission treatment options are available for fragmentisers. Many installations have cyclonic air cleaning systems. These systems should be cleaned and maintained regularly and their performance monitored to ensure they meet the required efficiency. The monitoring may include visual inspections of, for example, the seals to the rotary valves at the cyclone base, visual inspections of the outputs and output quality, through to formal stack monitoring of emissions.

Monitoring, inspections, repairs and maintenance should all be recorded for audit purposes and management of the installation, and will form part of any Environmental Management System.

The use of mill extraction for dry processing will require different management and monitoring than for that expected for a damp process. With no flame event mitigation within a dry mill, care should be taken with the air emission mitigation measures. Cyclonic air cleaning systems are primarily designed to remove particulates and not the gaseous or vapour phases within the air emissions. The use of water in wet scrubbers will assist and improve the emission but monitoring of dusts and vapour and fume should be considered.

There are examples of bag house filters being used to improve air quality emissions. These are fitted to the air outlet on cyclonic cleaning systems and not to the mill extraction systems on dry processes. These filters are used to remove the fine particulates from the air before final discharge.

Other aspects which would benefit from the control of air emissions include the downstream processes. It is possible to fit covers and air extraction and treatment equipment on the downstream systems to prevent and reduce the release of particulates. These might include:

Point source

- a method statement for the provision of a safe method of monitoring stack emissions,
- provision of suitable fixed or temporary platforms for the stack monitoring,
- allowance should be made for data collected when using 'non compliant monitoring methods',
- cyclones should be inspected, maintained, and cleaned to ensure they are operating as

specified,

- damp fragmentisation processes should be managed and maintained to ensure appropriate levels of water or foam injection are used,
- dry processes should ensure that the mill extraction is functioning and the seals are maintained, and the wet scrubbing system is working appropriately,
- baghouse or similar filters used to reduce air emissions where required.

Fugitive

- materials received at the site are largely free from materials which may produce an aerial emission,
- undesirable items are removed from the infeed to prevent flame events,
- plans for fire fighting are in place, equipment is provided, and staff are trained in its use,
- processed materials are stored under cover to reduce windblown dusts,
- cover conveyor belts, along with curtains and covering of down-stream separation,
- cover and enclose the non ferrous separation processes,
- water misting/sprays are used in sensitive locations, for example, infeed conveyor, the exit from the mill, or the ferrous drop, road ways,
- monitoring of emissions to be undertaken at fixed and agreed locations around the installation on an annual basis to record improvement and to target areas of concern,
- site surfaces are regularly swept to reduce dust and debris accumulations and water (ideally captured rainwaters or reused waters) is used to dampen down the site surfaces to suppress dusts,
- consideration of sensitive receptors in respect of the weather conditions.

Water sprays might be used on an infeed conveyor or dampening site surfaces, where as mists would be used in storage, conveyor deposit areas or as a misted area for loading vehicles.

BAT Recommendation: Operators should undertake regular air emission and stack emission monitoring on their installations.

Note : Safe and secure stack sampling locations should be provided with standard 100mm diameter sampling ports fitted to facilitate the sampling and monitoring of stack emissions.

Note : It is advised that the regulators for IED, the Health and Safety Executive, stack monitoring companies and the industry should undertake a health and safety consultation to determine how stack monitoring may be achieved as a routine on fragmentiser installations.

10.6 Training

10.6.1 Training of operatives and management

BAT Recommendation: Operators should provide appropriate training to operatives to meet the overall BAT objectives.

BAT Recommendation: Operators should ensure that all staff receive training relevant to their role, and document it.

BAT Recommendation: Operators should ensure the installation is run and staffed by competent operatives.

Training systems for all relevant staff covering, for example:

- Awareness of the regulatory implications of the permit for the activity and their work activities,
- Awareness of environmental effects from the operations under normal and abnormal circumstances,
- Awareness for the need to report deviation from the permit,
- Prevention of accidental emissions and action to be taken when accidental emissions occur,
- Awareness of the QMS and EMS systems, their importance in the management of the business and their role within it.

Compliance with the Operator Competence regime administered by WAMITAB for the management of fragmentising operations is already a requirement under the Environmental Permitting regulations. This award assesses waste management knowledge and understanding and the practical application of this knowledge to operations.

Consideration should be given to industry specific training to cover issues such as the engineering principles, environmental implications, quality and management/financial issues and the overall operation of fragmentiser installations.

It is recommended that additional training is designed and provided for operatives and management so they understand the process of fragmentisation within the context of engineering, plant design, management systems, raw materials, sustainability and the environment.

It is recommended that the industry and manufacturers are involved in developing this program to run alongside the Operator Competence award.

10.7 Ground Contamination and Decommissioning

10.7.1 Preventing soil and groundwater contamination

BAT Recommendation: Operators should prevent the contamination of soils/ ground and groundwater below the installation.

BAT Recommendation: Operators should, when installations are located on high risk sites (for example those located over major aquifers or permeable geology), undertake site investigations to confirm ground conditions and maintain a system whereby site conditions may be monitored.

BAT Recommendation: Operators should ensure that installations are located upon an impermeable concrete paved surface, designed and constructed under the supervision of a suitably qualified civil engineer.

Contamination of the underlying ground and groundwaters should be prevented. The development of new sites will be accompanied by the provision of a Site Condition Record (SCR). This may range from the inclusion of evidence demonstrating that the site was fully concreted from the start of operations (evidenced by photographs and the inclusion of civil engineering drawings/specifications and purchase orders and invoices), through to a site investigation including groundwater monitoring where appropriate.

The SCR should be considered a live document to be updated with site infrastructure improvements, repairs, significant events including spillages, damage, fires etc throughout the lifetime of the installation. At the installation's point of closure, the SCR should be used to assist with the surrender of the site's Environmental Permit.

Existing installations and those installations developed upon sites used historically for potentially contaminating activities should develop a SCR.

This may include desk based research to identify a risk rating for the location, and may be based upon the site's historical uses, the underlying geology and hydrogeology and the significance and sensitivity of the current environmental setting.

It should be noted that during decommissioning site investigation and remedial works may be required in order to facilitate surrender of the site permit.

The installations should be based upon a concrete paved site. Any paving should be assessed and designed by a suitably qualified civil engineer.

The design and maintenance of the concrete paving should be adequate to prevent both fluids running off the pavements (other than via the drainage system), and the transmission of fluids through the pavement or pavement joints.

10.7.2 Decommissioning

BAT Recommendation: Operators should prevent pollution upon decommissioning.

BAT Recommendation: Operators should agree a Site Condition Record (SCR) for the facility so at decommissioning a comparison can be made.

To minimise the costs associated with the decommissioning of operations, the careful management of the installation during its operational lifetime is required, and the design decisions for the installation should take account of the requirements of the decommissioning process.

The usual minimum requirements for the protection of the underlying ground/land and groundwater are required. For example; impermeable paving, bunded storage areas, sealed drainage, detailed drainage plans, above ground storage tanks and pipework, baseline site investigations and the management and maintenance of SCR are required as a minimum.

Other decommissioning plans should consider the plant and equipment and any residues which may accumulate on site. For example, the recyclability / reuse of equipment, ease of dismantling and the risks posed by the dismantling process.

11.0 EMERGING TECHNIQUES

In the general context of the operations the capital outlay for a fragmentiser and its associated separation processes is significant. This financial barrier to entry in to an industry which already has significant processing capacity, limits the development and installation of new plant. The overall method of fragmentising using a hammer mill is a long-established process, and there is no significant cycle of renewing or replacing installations. Due to the significant initial financial investment, many installations have been processing for many years. The average age of the shredder operation referred to in the questionnaires is 15.3 years, with some up to 30 years old.

However, during their operational lifetime, installations undergo significant replacement and renewal of parts (in addition to the consumable wear parts) resulting in installations being fundamentally younger than the original installation.

In this report emerging techniques include those that have not seen wide acceptance or implementation within the UK. These include the use of foam injection, bag house filters (a well used mitigation measure in other industries), electro static precipitators and closed loop air cyclonic cleaning systems.

Much of the recent investment in this sector has been directed to the downstream processing operations. The pressures of producer responsibility, recycling and recovery targets, and the ever increasing cost of landfill, has driven the need to recover more from the material processed. This includes targeting metals which, due to their small particle size, unusual shape or type have been difficult to segregate in the past, and to target materials including plastic, rubber and glass for recovery. For this reason, significant research and development in to downstream separation have produced sophisticated material processing plants.

Some operators have stated an objective of achieving zero waste. To achieve this operators are directing residues from the extended downstream material recovery operations, to be processed within energy recovery plants. This is also an area of process improvement which has seen significant investment, to support extensive R&D and development.

12.0 CONCLUDING REMARKS

This report has been compiled and researched to provide a BREF style summary of the Metals Fragmentising Industry (MFI) to assist in the development of BAT.

It is widely appreciated that the fragmentising of metal and metal-rich end-of-life products to produce; dense ferrous secondary raw material (for steel melting), non ferrous metal rich outputs and more recently, high value plastic rich product streams, from mixed non-hazardous metal-rich waste, is in itself BAT. This report has therefore considered metal fragmentising and its downstream processes to help produce BAT conclusions for the process as a whole.

The use of fragmentisers for the processing of metal-rich materials and their subsequent separation is a long-established process. It is also a process which is used around Europe and the rest of the world for the same purpose. It enables the mass processing of mixed metal-rich infeed, including end-of-life vehicles, to produce, for example, ferrous and non-ferrous metals to industry recognised standards for sale. It also enables the separation of non-metals, for example, plastic, making these materials also available for recovery.

The evidence and monitoring data collected suggests that fragmentisers have a low overall environmental risk associated with their operation. They also facilitate significant energy and resource savings when compared to the production and manufacture of metals and other materials from raw materials.

The materials processed as a routine are non-hazardous and where emissions, for example, dust and noise, have been identified, they can be easily controlled by relatively simple measures.

The monitoring undertaken during the trial suggests that the operation of fragmentisers to the standards required by the IED, and in accordance with BAT requirements, could be achieved with relatively few process modifications. These modifications would include, for example; certification to EMS and QMS systems, to standardise overall installation management. Inspection procedures for infeed, to reduce flame and audible events are required. Partial enclosure of some processes and storage areas may be necessary to reduce the generation of dust. Improvements to site drainage and water treatment may be necessary to reduce water usage and to improve the quality of discharge waters. There is a need for the routine monitoring of consumption of power, water and raw materials, and of emissions to demonstrate and record improvements, and to help direct specific management changes.

BAT recommendations should deliver the required environmental objectives at a cost that the industry and the individual operators of all installations are able to afford. If BAT is not delivered in this way, the fragmentising industry will become commercially distorted.

It is recommended that all operators and interested parties continue to collect and accumulate data on their installation's consumption and emissions so that when the formal BREF consultation process starts there is more information to contribute and inform the process.

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We would like to thank the BMRA for entrusting Mayer Environmental Ltd with this commission. If there are matters arising from our report which merit further attention, we would be pleased to offer any assistance.

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Director

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