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Final Report

Hospitality Sector Glass Compactor Trials

Investigating the potential for small glass compactors to increase the quantity of glass returning to remelt from the hospitality sector.

Project code: MSG027

Research date: Nov 2009 to April 2010 **Date:** October 2010

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Front cover photography: Compacted glass

Executive summary

This work examined the suitability of sending glass from small compactor units (often known as crushers) in the hospitality sector back for glass manufacture. For the purpose of this report, hospitality is defined as pubs, clubs, restaurants, bars and hotels.

A brief review of the current market for glass compactors and discussions with suppliers suggests that fewer than 300 are used by the hospitality sector. However, the number of suppliers and distributors of small scale crushing equipment is on the increase and the number of units is forecast to rise dramatically over the next few years. There are approximately 200,000 establishments licensed to sell alcohol[1] in the UK which represents a large potential market for glass compactor companies.

Typically, glass from hospitality establishments is collected as mixed colour and then sent for further processing where the majority of it is believed to go to the aggregate market.

Four UK glass compactor suppliers were engaged and provided access to nine hospitality premises using a variety of equipment including a unit currently under development. The different compactors were trialled to identify the potential for diverting glass from the hospitability sector back to glass container manufacturers (commonly referred to as 'remelt'). This is because sending glass back to remelt gives the greatest saving in CO_2 compared to other uses. For example, compacting glass for an aggregate substitute gives a negligible CO_2 saving and effectively removes the material from the recycling loop permanently, whereas glass can be recycled infinitely. Also recycling glass back into the container industry saves 314kg of CO2 for every tonne used.

Operators of the compactors in the hospitality establishments provided feedback on using the compactor. Whilst difficult to quantify, all believed that their establishment had benefited from financial savings both in reduced glass collection costs and in improved use of staff time.

In the majority of cases over 60% of the glass was over 10mm in size (generally considered to be the lower size limit for passing through optical sorting equipment in the industry, which is necessary for remelt). However, some glass processors suggested that the level of fines in the samples would cause a problem as they would coat the larger glass pieces preventing effective colour sorting.

In terms of health and safety, all compactors were found to be designed to prevent operators coming into contact with the crushing mechanism. The main hazard associated with the use of the compactors was perceived to be cuts from the crushed glass. Collection procedures developed for the compactors were found to minimise the risk of contact with the glass and additionally the one imploder (implosion technology densifies the glass) trialled removed the sharp edges from the glass.

The report concludes that glass compactors produce crushed glass of a high quality. However, the current level of fine particles produced and size of the glass make the colour sorting of the glass problematic and so the material at present is likely to be used for aggregate or other lower environmental value applications. Further work is therefore required to determine what percentage of the glass produced from a glass compactor can be sent to remelt.

Acknowledgements

We would like to thank all the compactor suppliers, hospitality establishments and glass processors who assisted with this project.

[1] *Department of Culture, Media and Sport Statistic accessed at* *http://www.culture.gov.uk/images/research/Bulletin_tables_2009.xls* *12/01/10*

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1.0 Introduction

This project investigated the use of glass compactor units in the hospitality sector with the intention of increasing glass going back to glass manufacturers to be made into new containers or fibre glass insulation. This recycling route is commonly referred to as 'close loop recycling' or more specifically as 'remelt'. A review of current glass compactor suppliers to the hospitality sector was carried out to establish the level of use of compactors in the UK. This also involved analysing the output of the glass from the compactor units as the minimum requirement for glass is generally considered to be 10mm for remelt applications. Therefore the limiting factor is that the compactors are currently set up to produce small cullet sizes. The composition of the glass output from different compactor units was then compared with the PAS101 (Publicly Available Standard) and sample results shown to glass processors for comment.

1.1 Background

Glass collection from the hospitality sector lags significantly behind the recovery rates now being achieved in the domestic sector. A study for WRAP by Oakdene Hollins[2] in 2008 estimated waste glass arisings in the hospitality sector are between 588,000 and 652,000 tonnes per annum (this study focused specifically on licensed retail establishments). The same study estimated that between 113,500 and 141,700 tonnes of glass were recovered in 2007 approximately 21% recycling. The bulk of this recovered glass is collected colour mixed with only 15% (17,025 to 21,255 tonnes) colour separated. That said, many commercial collectors and local authorities now offer glass collection services for pubs, clubs, hotels and similar organisations. In these cases incentives are often offered for the uptake of glass recycling services, for example, glass collection is included at a low cost addition to the establishment if it has its residual waste collection from the same collector.[2]

A common problem for many premises in the hospitality sector is the space taken up by storing empty bottles before collection. The busier premises visited for this project reported requiring daily collections of glass to cope with the volume of waste glass being generated and the lack of storage space prior to the installation of a glass compactor. This problem arises because the majority of glass from this sector is currently collected as whole bottles which quickly fill a bin and result in the need for several glass bins per site. Although larger bins present handling and health and safety issues due to size and weight. The space required for locating these bins is also a particular issue for pubs and clubs in inner city locations. The lack of space, coupled with the staff time that would be required for colour sorting, results in glass being predominately collected as mixed colours. One solution to the storage problem is to compact the glass on site (using a glass compactor unit) and there is a small but increasing trend for 'behind-the-bar' in house compactors to be used to compact glass before collection. This reduces the amount of space required to store the empty bottles and/or the frequency of collections required. Several concerns that have been voiced in the supply chain regarding the use of glass compactors at hospitality premises are listed below:

- Due to the higher bulk density of crushed glass, do the larger bins present handling problems when full? Using smaller bins would alleviate this problem but would this then require more frequent collections.
- Is the size distribution of the mixed colour glass produced by the compactors suitable for colour separation through glass processors, and are fines levels acceptable? 10mm is generally considered to be the minimum size suitable for colour sorting by current technology.
- Does it preclude colour separated collection, or conversely, due to the lesser storage space required, does it open opportunities for increased colour separated collections?
- Are contamination levels acceptable for glass processing, and could 'shredded' contaminants potentially present quality issues?
- Does the use of compactors have implications (positive or negative) for required staff training in organisations that are often subject to high staff turnover rates?
- Does the use of compactors have resource implications due to the possible need to double handle bottles in busy bars (temporary storage followed by later compacting)?
- What are the implications for co-mingled collections of dry recyclables which include glass?
- What are the potential implications if crushed glass is mixed with whole bottles during collection from hospitality premises?
- What are the implications for particle size from subsequent processing of the mix?

This project has investigated these issues by visiting establishments using different glass compactors to consider whether these concerns are justified.

[2] *WRAP, Oakdean Hollins, 2008, Hospitality Glass Report, MSG027-01 internal WRAP report.*

As stated earlier, it is commonly accepted that the most environmentally beneficial use for recycled glass is to return it to glass manufacturers for remelting.[3] [4] This gives the greatest saving in CO_2 compared to other uses. For example, compacting glass for an aggregate substitute gives a negligible CO_2 saving and effectively removes the material from the recycling loop permanently, whereas glass can be recycled infinitely. Also recycling glass back into the container industry saves 314kg of CO2 for every tonne used. However, in order to be suitable for remelt, certain quality criteria must be met. The aim of this work is to establish whether the glass generated by small scale compactors can meet these criteria and therefore provide a tool to divert more glass to remelt use.

Whilst several different types of compactor were looked at from four different suppliers it should be noted that the aim of this project is to investigate the potential for glass compactors to increase the availability of cullet for the use in the manufacture of new glass containers and glass fibre. This report does not set out to directly compare the performance of individual compactors or make recommendations as to their suitability.

[3] *Enviros 2006 Resource Efficiency and Greenhouse Gas Emissions, Yorkshire Forward Internal report*

[4] *Enviros 2003 Glass Recycling- life Cycle Carbon Dioxide Emissions, British Glass Public Affairs Committee Internal Report*

2.0 Site Visits

2.1 Project Partners

GTS undertook a desk based survey of glass compactors to the hospitality sector, in order to identify all the key organisations in this sector. The companies involved in this project were Bottleworks, Ekko Glass, Krysteline and Smash and Grab Glass Recycling. These partners covered a wide range of hospitality premises and geographical spread as well as different crushing techniques and technologies. Each organisation identified three premises with glass compactors installed that would be suitable to participate in this project and provide samples of compacted glass for analysis[5].

2.2 Visit format

The visits provided examples of the different crushing equipment in action and provided feedback from the operators on the practical use of the equipment. Question sheets were developed in agreement with WRAP to guide the discussions with the operators. During the visit the compactors were observed in operation and sound level readings were taken. Particular regard was paid to any potential health and safety risks from the use of compactors and steps taken to reduce these by operators. A sample of the glass output was also taken from the compactor at each premise.

2.3 Comparison of the different compactors

This section briefly summarises the different compactors in use on the premises visited. Further details can be found in appendix 1. The information is summarised in Table 4 at the end of the section. It should be noted that there are other companies offering compactor units to the hospitality sector beyond those directly investigated in this project contact details and website information for these companies can be found in appendix 3.

[5] *Krysteline's existing compactors produced glass with too small a particle size to be acceptable for colour sorting. Therefore, instead of visiting establishments with the current Krysteline model, a visit was arranged to look at its latest machine at its testing facility.*

2.3.1 Bottleworks Ltd

Figure 1 Bottleworks glass crusher installation.

Bottleworks is based in Wakefield, West Yorkshire and sells or leases crushers across the hospitality sector in the North of England with agents in the South. Two premises were visited for the project: a ferry offering mini-cruises to Europe which provided an opportunity to review three crushers on board and a working men's club. An additional sample of the crusher output was also obtained from a night club. Details of the premises are given in Table 1.

Table 1 Bottleworks sites selected for the project.

Site	Type of Establishment	Location	Number of years with crusher	Crusher Model
Site 1	3 bars on board ferry	Hull	4	MK1 & MK2
Site 2	Working Men's Club	Knottingley	<1	MK2
Site 3	Night Club	Durham	2	MK2

Bottleworks is currently supplying its MK2 unit, although one MK1 unit was still in use in one of the bars on the ferry visited as it is slightly smaller than the MK2 and so fitted the available space. Further details of the Bottleworks compactors and service can be found in appendix 1

Contact details:

Bottleworks
Unit 19
Imex Business Centre
Ripley Drive
Normanton Business Park
West Yorkshire
WF6 1QT

Tel: 01924 896975
Email: sales@bottleworks.co.uk
Web: www.bottleworks.co.uk/bottle_crushers.htm

2.3.2 Ekko Glass Recycling

Figure 2 Ekko Glass Recycling glass crusher installation.

Ekko Glass Recycling is based in Ayr, Scotland and supplies crushers to the hospitality market in central and south west Scotland. It supplies two models of crusher the GJK121 which fits on top of a standard wheelie bin as shown in the image above, and the self- contained GJK221 which houses the crusher unit and a 20kg capacity collection container. Ekko Glass runs its own collection service for customers and offers outright equipment sales or lease and rental options. Three sites were chosen for the trial: a bar/restaurant; a night club and a hotel providing a range of different environments. Premise details are given in Table 2.

Table 2 Ekko Glass sites selected for the project.

Site	Type of Establishment	Location	Number of years with crusher	Crusher Model
Site 1	Bar Restaurant	Ayr	2	GJK121
Site 2	Night club	Ayr	2	GJK121
Site 3	Hotel	Ayr	2	GJK121

The premises visited for this project all operated the GJK121 and further details can be found in appendix 1. Both units reduce five wheelie bins down to approximately one.

Contact details:

Ekko Glass
41D Green Street
Ayr
Scotland
KA8 8BQ

Tel: 01292 270592
Email: info@ekkoglass.com
Web: www.ekkoglass.com

2.3.2 Krysteline/Glass Vac

Figure 3 Krysteline glass compactor installation.

Krysteline is based in Dorset and sells its glass imploders worldwide into the hospitality sector. It sells a range of different sizes of equipment depending on the throughput required. Traditionally the equipment has been set up to produce fine (<4mm), sharp free aggregate substitute material.

All models use its unique implosion technique rather than traditional milling/crushing techniques like hammers or cones. The technique is tuned for processing glass and leaves labels and metal caps intact enabling them to be removed easily from the glass by screening; these can then be recycled. Tuning also allows some control over the size distribution of particles.

The GP3 Glass Cube system was reviewed at Krysteline's development unit in Dorset. Krysteline is working with Glass Vac (an Irish based company) to market the new system to the hospitality sector. This system uses an imploder to compact the glass; this is then emptied via a hose linked to a vacuum truck, thereby eliminating the need for manual handling and allowing the compactor to be installed in a cellar or other hard to access place. Krysteline is modifying this equipment to maximise the proportion of glass of a suitable size for remelt applications.

The Glass Cube system was chosen for investigation under this project as this is the Krysteline unit most likely to be able to meet remelt size specifications therefore fitting with the aim of this project. Further details of the Krysteline compactors and service can be found in appendix 1.

Contact details:

Krysteline
One Thorne Way
Woolsbridge Industrial Park
Three Legged Cross
Wimborne
Dorset
England
BH21 6FB

Tel: 08706 00 00 33
Email: info@krysteline.net
Web: www.krysteline.net

2.3.3 Smash and Grab Glass Recycling

Figure 4 Smash and Grab Glass Recycling crusher installation (MK1 on the left, LS02 on the right).

Smash and Grab Glass Recycling is based in Surrey and has supplied "MK I" crushers to approximately 60 premises in London and the South East. In addition to new sales of the upgraded "LS02" The company anticipates that the majority of existing users will migrate to the new model in due course. The premises chosen for sampling were a wine bar/restaurant and two private members' clubs housing restaurants and bars. These are detailed in Table 3.

Table 3 Smash and Grab Glass Recycling sites selected for the project.

Site	Type of Establishment	Location	Number of years with crusher	Model of crusher
Site 1	Wine bar restaurant	London	2.5	Mk1
Site 2	Private members club	London	3	Mk1 & LS02 (LS02 sampled)
Site 3	Private members club	London	6 months	Mk1

Smash and Grab Glass Recycling initially supplied customers with its MK1 "Little Smasher" crusher; and this unit takes approximately 12 wine bottles at a time. Smash and Grab Glass Recycling is in the process of introducing its MK2 crusher which has a higher capacity (~18 wine bottles). Both units offer an 80% compaction rate for the glass. Further details of the Smash and Grab Glass Recycling compactors and service can be found in appendix 1.

Contact details:

Smash and Grab Glass Recycling
Vulcan House
Restmor Way
Hackbridge
Surrey
SM6 7AH

Tel: 020 8669 3390
Email: info@smashgrab.co.uk
Web: www.smashgrab.co.uk

2.3.4 Overview of the Compactor Units

Table 4 Comparison of the different compactors investigated under this project.

Supplier	Bottleworks	Ekko Glass	Ekko Glass	Krysteline	Smash and Grab Glass	Smash and Grab Glass
Model	MK2	GJK121	GJK221/ss	GP3 Cube	Mk1 "little smasher"	LS02
Dimensions W (mm) D H	 500 640 1520	 840 1100 1630	 440 550 940	 840 1120 1700	 420 600 800	 500 600 1120
Processing Speed	80 bottles/min	60-80 bottles/min	60-80 bottles/min	Multi-feed hopper	12 bottles at a time ~120 bottles/min	18 bottles at a time ~180 bottles/min
Compaction Ratio	5:1	5:1	5:1	8:1	5:1	5:1
Bin size/weight	60l (20kg weight limit)	180kg (3/4 full)	20kg (lifting limit set)	1-2.4 m^3	20kg (lifting limit set)	20kg (lifting limit set)
Approx capacity	300 bottles	800 bottles	80 bottles	5000 bottles	60-100	60-100 bottles
Power supply	230v single phase 3 pin	230v single phase 3 pin	230v single phase 3 pin	230v single phase 3 pin	230v single phase 3 pin	230v single phase 3 pin

The information collected shows that there are a number of similarities between all the different compactor units investigated. The current Krysteline system shows a higher compaction rate; this will reduce and become closer to that of the other suppliers as the unit is tuned to meet the size requirements for the remelt market. All the units operate using standard 240v single phase three pin sockets avoiding the need for dedicated electrical installations.

The major difference between the compactors is the capacity of the collection bins. Ekko Glass and Krysteline offer larger bins which require less frequent emptying whilst the other suppliers process smaller quantities of glass which may be more suitable for manual handling in more enclosed environments. There is also a difference in the feed mechanism. Smash and Grab Glass Recycling and Krysteline have multi bottle feed systems, whereas Ekko Glass and Bottleworks use a more labour-intensive single feed system.

All the compactor units investigated used relatively small motors of 1.5 or 1.6 kW. The amount of energy used for compacting will obviously depend on the amount of glass being compacted. If an operating time of one hour per day is assumed, then running costs are likely to be less than 15 pence per day. In reality, the actual time the motor is running is likely to be less than an hour, allowing for loading of the bottles and changing containers. Therefore, the energy cost of operating a compactor is negligible compared to savings made through use.

2.4 Literature and Training

All the compactor units investigated are simple to operate and in all cases operation involves emptying the bottles into the compactor either individually via the feed tube or by tipping from a storage bin into the hopper. Training includes information on cleaning the units and how to avoid contamination by only using the compactors for container glass i.e. no plates or ceramics. All suppliers provide manuals and user guides with the compactors. For further information and literature about each supplier please refer the suppliers websites detailed in section 2.3.

2.5 Health and Safety Considerations

Glass crushing operations could potentially present several health and safety hazards, including the possibility of cuts from the broken glass, injury from the mechanics of the compactors and noise from the operations. All the designs trialled prevent operators from coming into contact with the crushing mechanism whilst it is in operation. This is either by physically putting the mechanism out of reach or by safe switches on flaps or doors. Hazards are

generally perceived to be from the handling of the broken glass rather than the crushing operation itself due to the enclosed nature of the equipment. Gloves and eye protection are supplied and recommended by all suppliers. Other potential hazards come from the manual handling of heavy containers of glass and the mitigating steps taken by compactor designers are detailed in appendix 2.

2.5.1 Noise Results

Handling and crushing glass is a noisy process. In their normal running mode none of the machines produced sound levels above 80dB (decibel) which is the maximum weekly average defined by the 'Noise at Work Regulations[6]'. However, given that the readings obtained are approaching the threshold that requires the use of hearing protection (>85dB) then it is recommended that hearing protection is provided for operators to use, particularly if the machines are used for a prolonged period to crush all an establishment's bottles in a single session, perhaps at the end of a shift.

Once compacted, handling the glass becomes a much quieter operation. The process of decanting intact bottles from small glass bins into larger skips is a brief but very noisy activity that often attracts complaints from the near neighbours of pubs and clubs. Users of the compactor will at least eliminate this source of potential complaints. The reduction in collection frequency will also lessen the incidence of neighbourhood noise and traffic nuisance.

[6] *The Control of Noise at Work Regulations 2005, access at http://www.opsi.gov.uk/si/si2005/20051643.htm 11/01/10*

3.0 Analysis of Samples

Samples of between 5 to 10kg were collected from the output of the glass compactors. One sample was taken during each of the site visits and brought back to the GTS laboratory for analysis. A second sample was taken several weeks after the initial visit to check for consistency and returned to GTS by courier. The samples were analysed at the GTS laboratories to determine their characteristics and suitability for use in glass container furnaces. The results are detailed in the section below:

3.1.1 Results

The results of analysis carried out on the glass samples are displayed graphically in the following sections and are summarised in Table 5 Summary of sample data.

3.1.1.1 Size

The size distribution of the collected glass was determined by passing the dried samples through a 10mm sieve and weighing the different size fraction.

Figure 5 Particle size results from the initial glass sample collected during the site visit. (Results are displayed at greater and less than 10mm as this is the size commonly considered suitable for colour sorting)

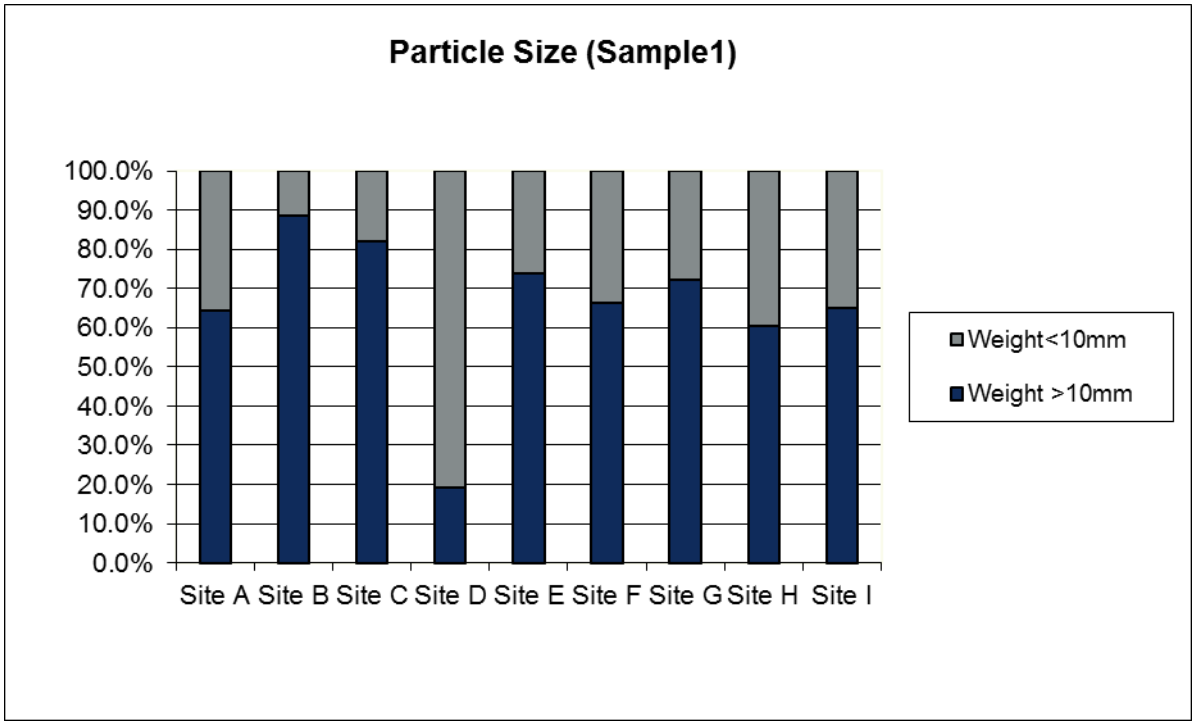
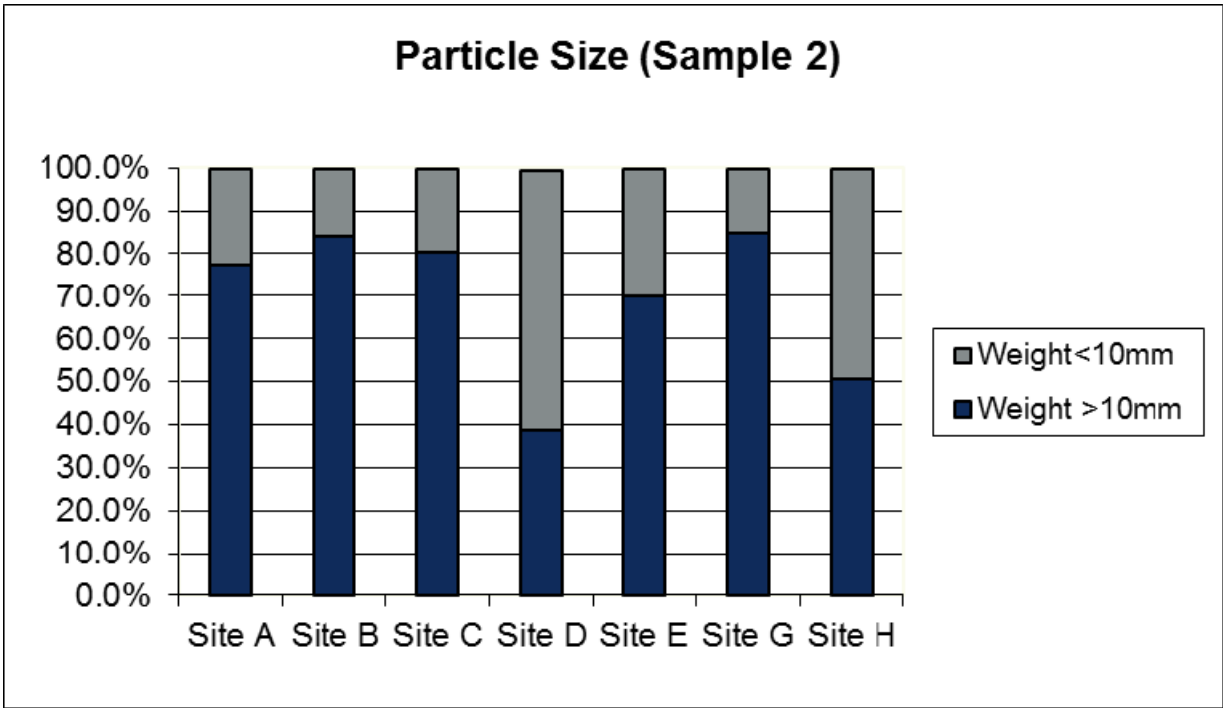


Figure 6 Particle size results from the repeat glass sample collected by the operator and returned by courier (The second sample from sites F and I were not received by the end of the project).

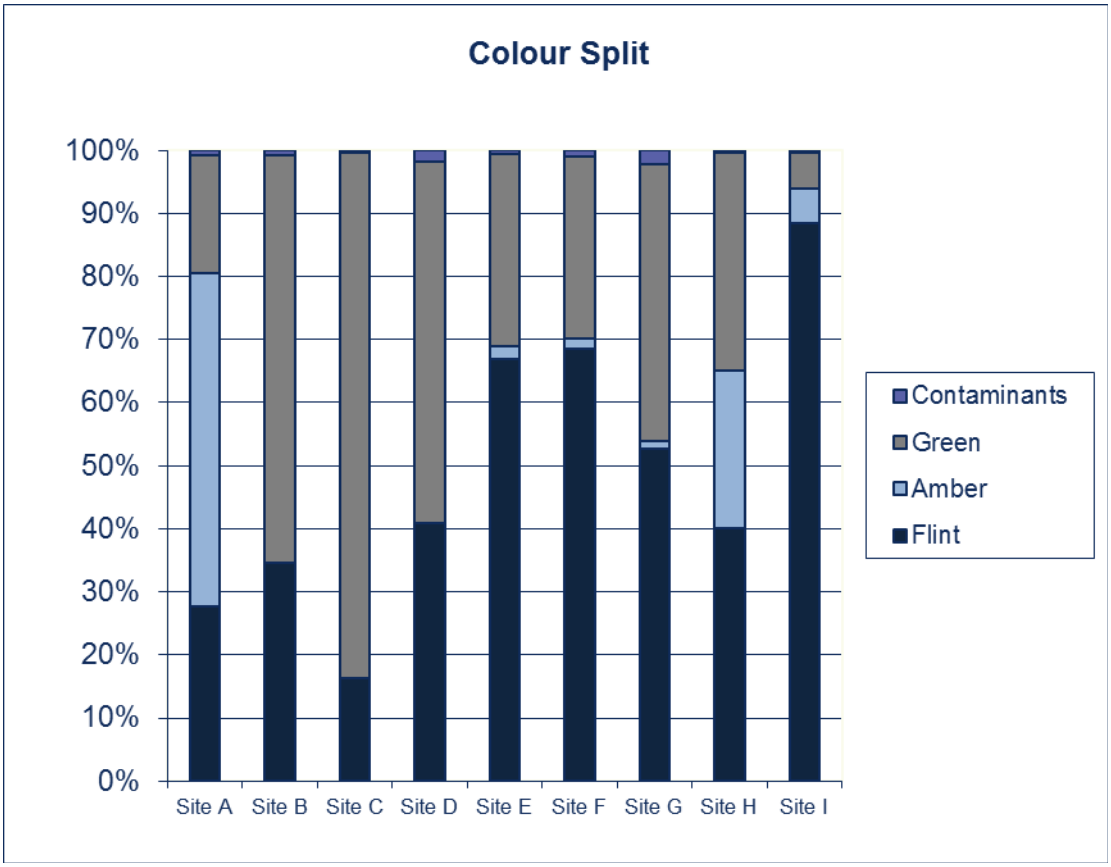


It can be seen from the data shown in Figure 5 and Figure 6 that all samples except one in the first batch and two in the second batch have at least 60% of particles greater than 10mm in size. This is generally recognised as the lower size limit for successful colour sorting. All samples would be considered grade D based on size according to PAS101. Results between the first and second samples are very closely matched, suggesting very little breakdown of samples has occurred during the transportation by the courier.

3.1.1.2 Colour

The colour split of the samples was determined by hand sorting the dried samples into the three different colours and contaminants. The different components were then weighed.

Figure 7 Colour split of samples collected from glass compactors.



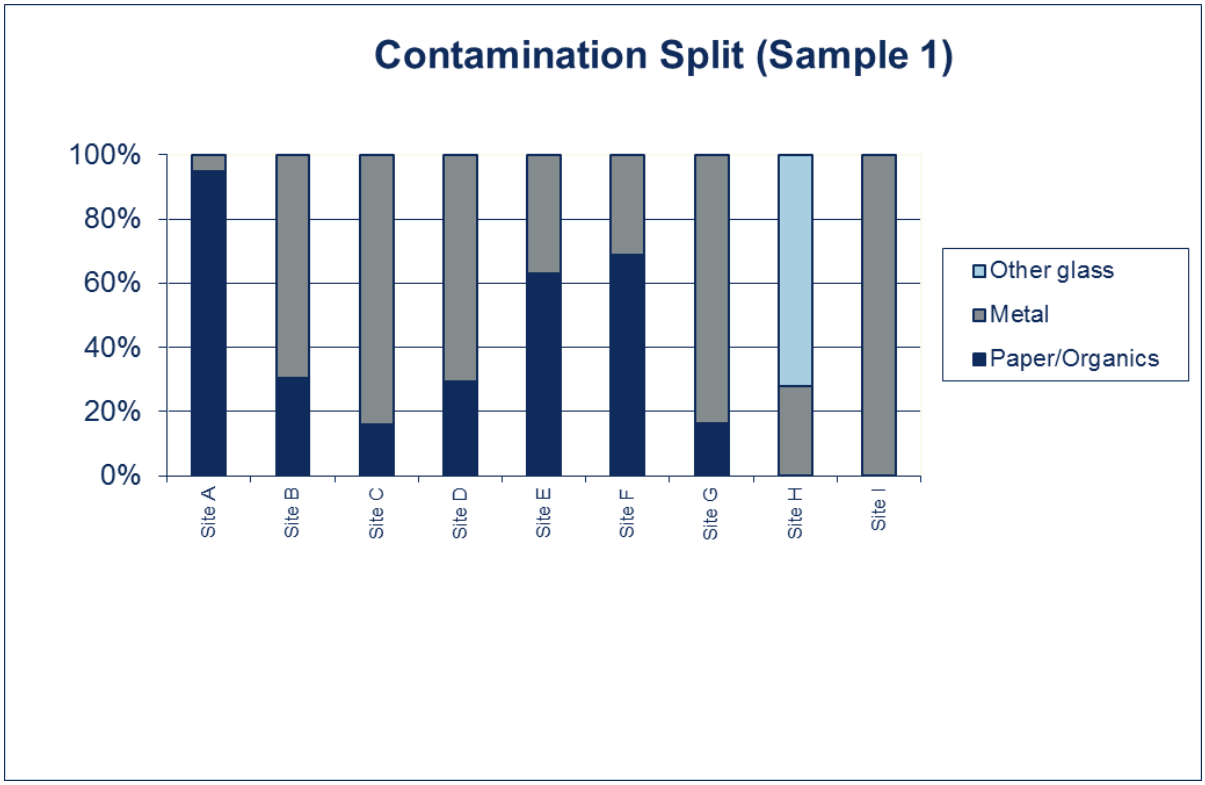
The results in Figure 7 show that there is a wide range of colour splits between the different establishments; this reflects the different product mixes. In most cases there is a significant quantity of flint cullet present that could be recovered. The exceptions to this are the two private clubs which serve more wine in green glass than other products. The colour splits measured mean that all samples except that from site 3 would be considered colour mixed according to PAS 101. As the result for the site I show it to be predominantly flint, there is still greater than 6% glass of other colours contained in the sample. Therefore it would not meet the criteria for colour separated flint glass as set out in PAS101. Contamination levels are very low in all cases consisting only of the labels and caps that are attached to the bottles when added to the compactor.

The idea of colour sorting on site was raised during the site visits then crushing each colour into separate containers. However, this was considered to be too time consuming and currently collection vehicles are not set up to deal with split colour collections.

3.1.1.3 Contamination Breakdown

The contaminants separated during the colour sorting were hand sorted in to metal, other glass (flat glass), and paper, plastics and other organic material (mainly food scraps)

Figure 8 Breakdown of contamination collected from glass compactor samples. (The second sample from sites F and I were not received by the end of the project).



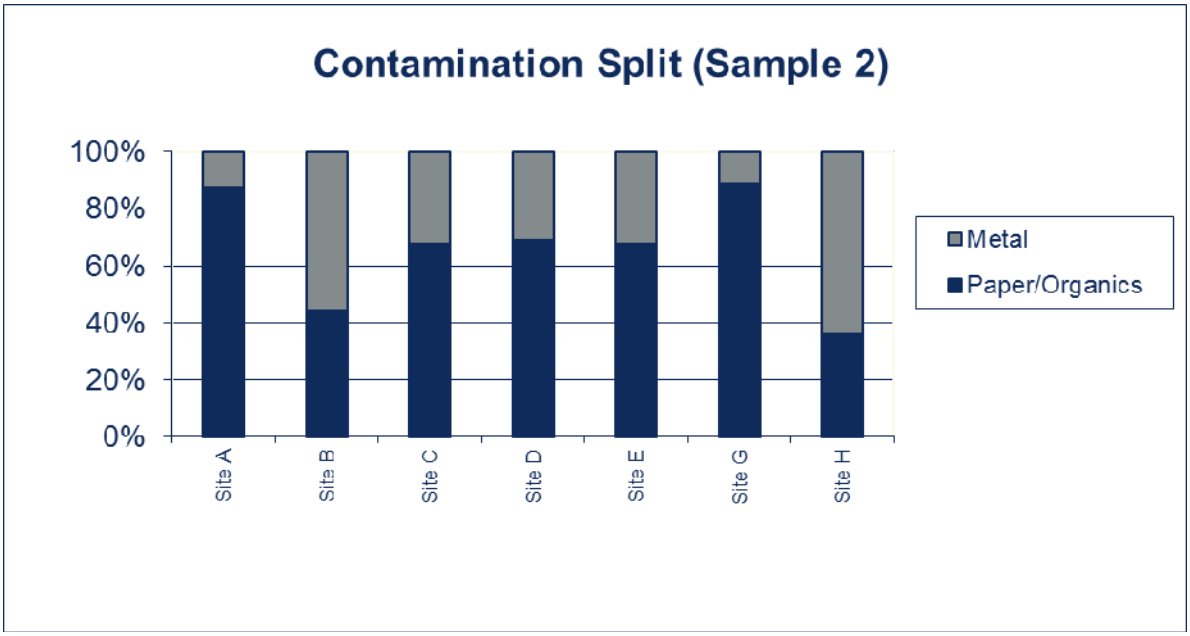


Table 5 Summary of sample data.

	Sample 1		Sample 2								
	Weight >10mm	Weight<10mm	Weight >10mm	Weight<10mm	Flint	Amber	Green	Total Contaminants	Paper/ Organics	Metal	Other glass
Site A	64.5%	35.5%	77.3%	22.4%	21.3%	40.5%	14.4%	0.6%	0.6%	0.0%	0.0%
Site B	88.5%	11.5%	84.0%	15.9%	32.3%	0.0%	60.1%	0.7%	0.2%	0.5%	0.0%
Site C	82.0%	18.0%	80.4%	19.3%	14.4%	0.0%	73.7%	0.3%	0.0%	0.2%	0.0%
Site D	19.2%	80.8%	38.5%	60.8%	15.8%	0.0%	22.2%	0.7%	0.2%	0.5%	0.0%
Site E	73.9%	26.1%	70.0%	29.6%	54.9%	1.6%	25.1%	0.5%	0.3%	0.2%	0.0%
Site F	66.3%	33.7%	-	-	52.3%	1.2%	22.0%	0.8%	0.5%	0.2%	0.0%
Site G	72.2%	27.8%	85.0%	14.7%	42.7%	1.0%	35.6%	1.8%	0.3%	1.5%	0.0%
Site H	60.3%	39.7%	50.7%	49.0%	29.2%	18.1%	25.1%	0.3%	0.0%	0.1%	0.2%
Site I	65.0%	35.0%	-	-	66.5%	4.1%	4.4%	0.2%	0.0%	0.2%	0.0%

The results in Figure 8 show

- contamination levels were very low in all cases;
- contamination consists mainly of labels and caps;
- the contaminants that were present comprised mainly of paper and metal which are relatively easy to remove from the cullet during sorting; and
- the levels of contamination found suggest that operators are adhering to the rules set by compactor suppliers.

A small quantity of flat glass was found in one sample - this may have been put through the compactor by mistake or added to the waste glass skip before collection.

Differences between the two samples from the same site can be explained by slight changes in product mix between sample dates, for example, if sampling was carried out after a Christmas party an increase in metal foil from the tops of wine bottles might be recorded.

3.1.1.4 Shape

To collect information on the shape of particles found, 10 pieces were selected at random from each sieved size fraction and these were measured at their longest length and at 90 degrees to the longest length to find the width.

Figure 9 Ratio of height to width of particles selected at random from the glass compactor samples.

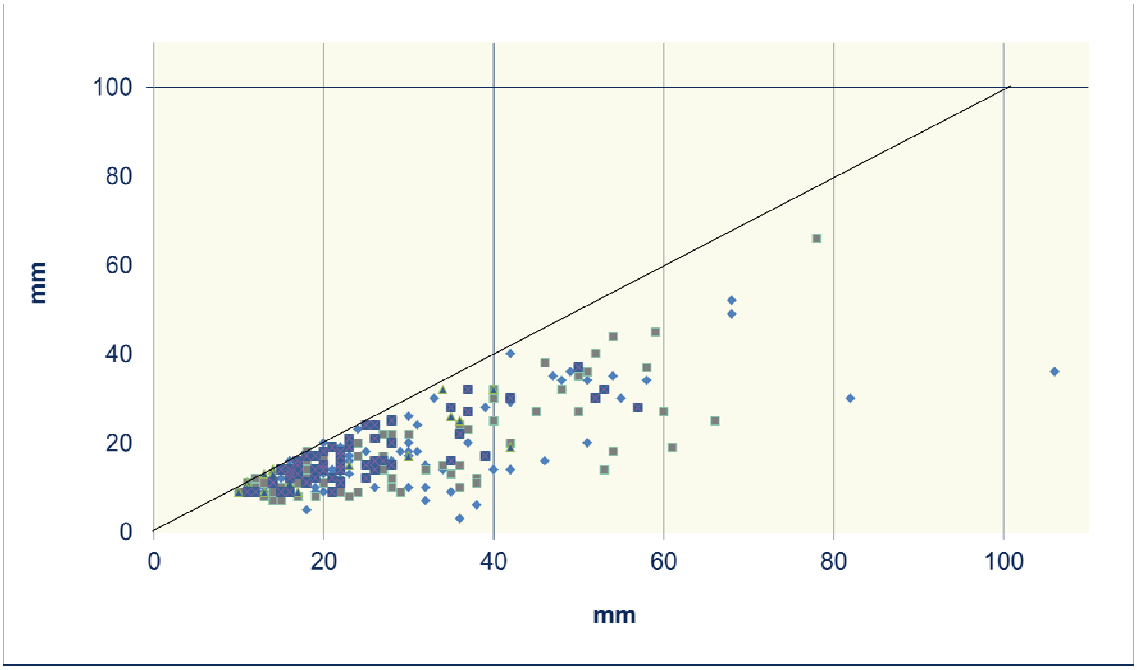


Figure 9 shows that there is a spread of different shapes (based on the ratio of height to width) of particles. There is a cluster of square and spherical particles i.e. those with height and width of similar dimensions,

represented by the black line. The graph also shows that there is also a large proportion of particles which may be smaller than the mesh size in one dimension but significantly larger in the other i.e. they are more rectangular in shape (the further from the black line the point is, the more rectangular is its shape). This may mean that some material is suitable to colour-sort but is screened off unnecessarily and used for lower value applications because it passes through a 10mm mesh due to its orientation as it passes over the screen.

3.1.1.5 Bulk Density

The bulk density of the glass is indicative of the level of compaction of the samples and hence the size of the particles. The higher the bulk density, the more compacted the glass and therefore the greater number of smaller particles in the sample. High compaction levels are desirable in that more glass can be stored and collected in a given space; however this means that the glass is less suitable for further processing for remelt applications as it is more difficult to colour sort due to the particle size. The level of compaction is therefore a trade off between storage efficiency and the desired end use of the glass. Table 6 shows the bulk density of samples from the compactors investigated for this project. Bulk density was calculated by measuring the volume that the glass occupied in the collection bucket and the weight of the sample.

Table 6 Bulk Densities of samples taken from glass compactors, approximate values for whole and broken bottles are included for comparison purposes. (The second sample from two sites was not received by the end of the project).

Site	Bulk Density tonne/m^3 sample 1	Bulk Density tonne/m^3 sample 2
A	1.06	1.21
B	0.95	1.06
C	1.11	1.10
D	1.95	1.55
E	1.13	0.89
F	1.14	-
G	1.07	1.05
H	1.11	1.16
I	1.26	-
Broken bottles	0.76	
Approximate whole bottles	0.32	

The range of densities for the glass from the three ‘standard’ compactors are similar (i.e. not the Krysteline unit). When compared with the size distribution range, this suggests that all compactors are compacting to a similar level. Table 6 shows that there is a wide range of bulk densities from the different premises even between premises with the same model of compactor. This is likely to be for two reasons; first, compactor suppliers have indicated that particle size is influenced by the age and wear on the compactor mechanism, with newer crushing surfaces resulting in smaller particle size and higher bulk density values. The second reason is because different establishments also have different product mixes. Therefore glass thickness will vary between premises for example champagne bottles are made from thicker glass than wine or beer bottles, this will influence the size of the compacted glass. It should be noted that at a commercial scale, every time glass is handled it will suffer further breakage, reducing the particle size and increasing the bulk density even more.

4.0 Specification Review and Processor Feedback

The quality standards required for glass cullet vary between different processors and their suppliers; however the Publically Available Standard (PAS) 101 document published in 2004 by WRAP and BSI (British Standard Institution) gives indicative standards which recovered glass must meet for recycling. Table 7 below summarises the requirements.

Table 7 Extract from PAS101 detailing the requirements for recovered glass.

Grade	A	B	C	D
Description	Whole or broken containers that are colour separated	Whole or broken containers that are colour separated but do not meet the Grade A colour specification	Mixed colour glass that is not compacted	Compacted glass
Colour requirements	Clear: no more than 4 % other colours Brown: no more than 5 % other colours Green: no more than 5 % other colours	Clear: no more than 6 % other colours Brown: no more than 15 % other colours Green: no more than 30 % other colours	Exceeds Grade B colour requirement, i.e.: Clear: more than 6 % other colours Brown: more than 15 % other colours Green: more than 30 % other colours	As per Grade C
Contamination limits	No more than 0.5 % organic, 0.1 % ferrous and 0.2 % non-ferrous Inorganic and other glass types subject to agreement between processor and collector No medical, toxic or hazardous materials	As per Grade A	No more than 1.0 % organic, 0.2 % ferrous and 0.4 % non-ferrous Inorganic and other glass types subject to agreement between processor and collector No medical, toxic or hazardous materials	No more than 3 % of surface area is organic, inorganic, ferrous or non-ferrous Other glass types subject to agreement between processor and collector No medical, toxic or hazardous materials
Particle size	Containers which are not intentionally crushed or broken	As per Grade A	As per Grade A	Nominal particle size subject to agreement between processor and collector

NOTE all percentages are % by mass by mass

Based on the requirements of the PAS101, all the glass coming from the compactors would be classed as grade D due to its broken nature. All samples, except the one taken from the members clubs which was predominantly green glass, would be classified as mixed colour under the criteria set in PAS101. However, contamination levels measured in the samples were all low enough to meet the requirements of the grade A category. Currently all the collected glass is kept separate from other waste. Mixing the crushed glass with a co-mingled collection would dramatically increase the contamination of both the glass and other materials and further reduce the ability to successfully return the glass to remelt.

For Grade D, the particle size distribution is to be decided between the supplier and processor. Previous work on the secondary processing of cullet using optical sorters suggests that 10mm is the minimum size that can be processed effectively. Most processors screen off material below this level prior to processing.

As part of this project, major UK glass processors were sent anonymised copies of the sample results and were invited to view the samples to comment on the suitability for reprocessing. Based on this the following points were made:

- there is some potential for extracting material for remelt from the material;
- ideally the glass should be predominantly of a larger size, (25-30mm);

- there needs to be less fines in the sample as these coat the larger particles affecting the colour sorting efficiency;
- weight would be an issue with the crushed glass when uploading traditional storage containers designed for broken bottles. This could possibly result in damage to existing storage containers used by glass recyclers;
- broken bottles rather than crushed material are preferable;
- glass from compactors would not be processed separately but will be mixed with other mixed cullet prior to processing; and
- processors would be amenable to meeting with WRAP and compactor manufacturers to identify improvements which could result in more material being available to remelt.

5.0 End Destinations

The majority of the glass from the compactors investigated in this project is sent to glass processors, the exception to this being glass going to Days Aggregates who only produce glass aggregate material. The glass collected for further processing is added to the other mixed broken glass either during collection or at the glass processors. Initially the glass is screened at a level determined by each reprocessor varying between 10 and 18 mm to remove the fine material. The sub-10mm material is sent to aggregate use directly. The material that is above 10mm will be assessed to see if it is suitable for colour sorting and if so it will be passed through an optical sorting plant to separate the material into the three different colours.

The main barrier to colour sorting with regard to the glass from compactors is the level of fines that adhere to the surface of the larger pieces of glass resulting in a false colour reading. This would result in a high value piece of flint glass appearing brown or green to the sorting machine and therefore being diverted to the lower value green or amber glass pile.

For this reason, two of the five processors expressed concern at the level of fines found in the samples. Whilst this glass is still likely to be processed, the yield of high value glass is likely to be reduced with a large portion of glass being diverted to the lower value glass piles reducing the profitability of processing. Some work has been carried out in the field of cullet cleaning but at the moment this is not a commercially viable proposition. Investigating an economic method of removing fines from the surface of cullet to optimise the yield of colour sorting equipment would be the next step.

6.0 Financial Review

Payback calculations for the use of the compactors are complicated by the various purchase and collection schemes on offer which include but are not limited to:

- direct purchase of compactor and disposal of glass;
- free installation of compactor conditional on tied (collection arranged by compactor supplier) collection service; and
- leased purchase of compactor with optional (tied) collection service.

Payback calculations are also influenced by the volume of glass produced by an establishment and thus the following cost/savings data is by necessity indicative.

6.1 Savings

The principal savings arise from reduced collection frequencies as the volume of glass after crushing falls by a factor of five, giving a corresponding saving on the number of bin uplifts. Typical contracts are based simply on the number of bins and/or number and regularity of uplifts. Uplift prices vary considerably with larger users paying a smaller unit price. Table 8 below shows some indicative savings.

Table 8 Glass disposal cost - indicative values based on uplift costs.

Bins per Week		Annual Savings @		
Uncrushed	Crushed	£4 per uplift	£6 per uplift	£8 per uplift
5	1	-	£1200	£1600
10	2	£1600	£2400	£3200
15	3	£2400	£3600	-

A comparison of the savings calculated in Table 8 suggests that annual maintenance costs of compactors are easily covered by the potential savings in uplift costs. The payback time required for the purchase of the equipment will depend on the number of bins of glass produced per week but could be as little as one year for all units on high throughput sites.

Other savings, albeit hard to quantify, include staff time and increased storage space. Bottle compaction reduces the need for bar staff to leave their posts to empty the bins, often at busy periods, allowing more time to sell products and generate income for the business. The increased storage area also allows for more efficient stocking and has led in some cases to supply contracts being renegotiated on more favourable terms.

6.2 Payback Period

As discussed earlier the variety of purchase and operating options coupled with the variability of throughput makes the any payback calculation site-specific. However, based on the evidence collected it is apparent that in the majority of cases the payback period will be less than 12 months.

7.0 Sector Review

The four glass manufacturer companies involved in this project are understood to represent the vast majority of compactors currently supplied to the hospitality sector with approximately 250 units in the market. The other companies contacted were reluctant to divulge the numbers of units that they had supplied but the number is thought to be small. A reasonable estimate of units in the hospitality sector is around 300.

The distribution of compactors around the country is currently fairly regional, centred around the supplier's location, although this is likely to change as companies branch out through distributors. Given the number of Licensed Retail Establishments in the UK and the benefit to these suggested by this trial, there is a large potential for the number of compactors to increase dramatically over the next few years.

As detailed below there are several relatively new companies in this sector acting as distributors and resellers for existing compactors suggesting that this is a growing market. Furthermore, forecasts received for companies suggest a large increase in the number of units supplied in the next two years to over a 1000. In 2009 there were just fewer than 200,000 licensed premises in the UK[7] and given the potential opportunities of using compactors in establishments with limited space - it seems likely that the number of compactors will continue to grow in the coming years.

[7] *Department of Culture, Media and Sport Statistic accessed at* *http://www.culture.gov.uk/images/research/Bulletin_tables_2009.xls* *12/01/10*

8.0 Conclusions

There is a small but increasing use of glass compactors by the hospitality sector with approximately 10 suppliers of units in the UK. Although it is difficult to confirm the exact numbers of compactor units in operation, the suppliers involved in this project are the major suppliers and they have approximately 250 units installed between them in the UK, suggesting that the total number of compactors currently installed in the UK is below 300.

The average glass crushed for the nine sites was 24 tonnes/annum, and with 300 premises using glass compactors this would equate to approximate 7,200 tonnes/annum. The average glass waste arising from licensed retail establishments is 620,000 tonnes[8]; therefore approximately 1% of glass from the hospitality sector is currently processed with onsite glass compactors.

All the users of the glass compactors reported opportunities of using compactors in their establishment, saving cost, time and space. Firm estimates of exact cost savings are difficult to attain but the collection service offered by the compactor suppliers is generally between 20 and 25% less than the cost of traditional collections.

In addition to the financial benefits gained from the reduced number of uplifts required for waste glass, additional savings have been achieved through the additional space that is now available with between a 5:1 and 8:1 reduction in the number of glass bins required. Additional space has been used to store extra crates of full bottles this has enabled the negotiation of cheaper prices for drinks because of reduced deliveries and bulk purchase discounts. This also reduces the amount of time staff spend when unloading deliveries and restocking the bar.

In all of the traditional type of glass compactors investigated, over 60% of the glass was greater than 10mm in size. This is the minimum size that is commonly considered suitable for further economical colour sorting using optical technology. In practice, glass from the hospitality sector that had passed through a glass compactor would be mixed during transportation and/or at the glass processors with glass collected from other sources such as kerbside, bring sites and hospitality sector (not crushed). The mixed colour glass from the various sources would need to be colour sorted to enable the glass to go back into new containers (remelt). The contamination (non-glass material) levels in the glass were very low, consisting of metal and plastic caps and paper/plastic labels as would be expected in bottle cullet. The level of contamination meets grade A cullet under the PAS101 standard. However, some of the glass processors expressed concerns about the size of the glass and the remaining level of fines in the samples as these can become stuck to the larger pieces of glass and interfere with the optical sorting process.

The colour mix of the collected glass varies, with the mix of products sold, for example bars tend to have greater quantities of flint glass (beer, spirit and soft drinks bottles) and restaurants have more green (wine bottles). In the majority of cases the glass sampled would have to be classified as mixed colour under the PAS101 criteria.

All the glass compactors observed were safe to use and hazards were related to the handling of broken glass rather than the crushing process, with equipment designed to keep the mechanism out of reach of the operator. Suppliers included appropriate Personal Protective Equipment (PPE) to mitigate the hazards of handling the crushed glass. Most compactors investigated have a weight cut off to prevent containers becoming too heavy. The new Glass Cube system from Krysteline eliminates the need for manual handling of the broken glass altogether by using a vacuum to transfer the glass to a collection truck.

All the establishments were enthusiastic in recycling the glass produced and in the majority of cases, those clients asked stated that they wanted the waste glass to be recycled rather than going to landfill. However, they had little if any preference whether recycling should be back into new glass containers or alternative uses such as aggregate.

In conclusion, whilst the project has demonstrated benefits to using a glass compactor unit, the environmental benefit of sending glass back into remelt is currently not possible due to the current level of fine particles produced making the colour sorting of the glass problematic. Therefore, the material at present is likely to be used for aggregate or other lower environmental value applications.

[8] *WRAP, Oakdean Hollins, 2008, Hospitality Glass Report, MSG027-01 internal WRAP report.*

9.0 Recommendations

- A project to investigate removing the fines from the surface of the larger particles. This is a problem area also highlighted in the recent work carried out on glass from material recovery facilities;
- If more glass can be processed back into remelt the production of case studies to highlight the efficiency and financial savings potential to others in the hospitality sector could be beneficial in encouraging other premises particularly those with a shortage of space to separate their glass; and
- Further investigation of the use of compactors in other space-restricted recycling areas such as apartment blocks and inner city developments; and
- Examine the impact of transporting bulk glass from source to reprocessor. Also to test larger samples of mixed glass to determine what amount is suitable for remelt.

Appendix 1
Detailed descriptions of compactor units

Bottleworks

Both the MK1 and MK2 units are stand-alone wooden laminate constructions containing the crusher unit and a 60 litre collection container which holds up to 300 bottles. The unit needs no special electrical wiring as it uses a standard domestic three pin socket. The crushers reduce glass volume by a ratio of five to one. The units are single feed and designed with health and safety in mind so that the operator is unable to come into contact with the crusher mechanism. They are capable of processing 80 bottles per minute. In operation the crusher is initially turned on and off via switches on the control panel and the motor runs only when bottles are added. The control panel incorporates an emergency stop button and the door to the collection container has a switch on it to ensure that it is closed prior to operation. The unit has a weigh cell under the container to prevent operation once the 20kg limit is reached; this illuminates a light on the control panel. Health and safety considerations regarding weights and lifting are discussed in section 2.5 of the report and further in appendix 2. The design of the units means that the casing can be customised to meet the décor of the establishments.

Depending on customer requirements and its contracts for collection of other waste materials, Bottleworks carry out glass collections as required. These are bulked at its site before being collected by Berryman for further processing. Other sites arrange collections themselves. Bottleworks engineers carry out maintenance and servicing on the equipment as required and the operators clean the units regularly with soapy water to remove residues.

The establishments visited were generally pleased with their glass crushing units and the space, time and money savings achieved. One of the sites visited had experienced some initial problems with jamming caused by thick bottle bottoms and pint drinking glasses being fed into the machine. This has been resolved by staff being instructed to feed bottles neck first and not disposing of drinking glasses in the crusher. The staff at another site had experienced problems with fruit flies taking advantage of the damp wood and sticky residues inside the unit, which provide an ideal breeding habitat. This has been resolved by cleaning every night and leaving the unit to dry thoroughly during the day when not in use. The wooden construction in contact with the floor was noted as a design issue as this remains wet. Bottleworks is rectifying this by including stainless steel legs on their newer models.

Ekko Glass

The GJK121 unit consists of a feed chute where bottles are fed one at a time through rubber flaps to prevent particles from flying back towards the operator. The feed chute is of sufficient length and height to prevent the operator coming into contact with the crusher. The crusher is turned on by means of an ‘on/off’ switch and the unit operates using a standard three pin domestic socket. The GKJ121 does not incorporate a weigh cell to prevent overfilling; however, the fill level of the wheelie bin is clearly visible to the operator.

The GKJ221 uses the same crushing mechanism but it is built into a self contained units made of stainless steel suitable for sites with less space and lower throughput. The housing contains the crusher unit and a plastic tub for collecting the glass. The rectangular plastic collection tub has a 20 kg capacity and sits on a weight cell to prevent it overfilling. The health and safety considerations regarding weights and lifting are discussed in section 2.5 of the report and in appendix 2.

The collections are then bulked up and collected for further processing for a variety of end uses.
Ekko Glass carries out the maintenance of crushers and collects the crushed glass from all its clients. Training is provided for operators when a unit is first installed.

The operators spoken with were happy with the performance of the crusher units and the space, time and money savings achieved through their installation. However, the weight of full wheelie bins was identified as a possible issue by some bar staff. This is discussed further in appendix 2.

Krysteline

The Glass Cube unit occupies the same footprint as a 1200 litre bin and consists of a multi-bottle feed hopper on the top designed so that the operator cannot come into contact with the mechanism. The unit uses a standard three pin domestic socket and its 1.6kW motor is claimed to use “less power than a toaster”. It is operated via an ‘on/off’ switch on the front panel which also contains an emergency stop button with a key. The unit offers compaction ratios of up to eight to one with various different capacities up to 2.75 tonnes, equivalent to approximately 13,750 beer bottles. The amount of glass in the collection container is monitored remotely by the collection agent who can then schedule collections when the container is nearing capacity.

The Glass Cube system is currently being rolled out in the Republic of Ireland and the USA; contract negotiations are underway to use it in the UK. It is believed that the imploder technology results in less wear on machinery so requires less frequent servicing reducing maintenance costs; these are included in the contract price. Pilot sites in Ireland have received favourable comments from users as have other Krysteline units installed in the hospitality sector. Training is provided to site managers on the correct operation of the equipment when the machinery is installed.

Smash and Grab Glass Recycling

To prevent injury through contact with the crushing mechanism, the MK I unit will only operate when the lid is closed, whilst the new LS02 uses an integral double hopper system, shielding the operator from the mechanism whilst running and which allows continuous feeding of bottles. The crusher will cease to operate once the 20kg limit is reached causing an indicator light to illuminate on the control panel. The health and safety considerations regarding weights and lifting are discussed in section 2.5 of the report and in appendix 2.

Prior to installation, Smash and Grab Glass Recycling carry out a pre-installation survey with the premises manager, a tailored package is then prepared for the establishment. A training session is also carried out with operators on the safe use of the system. Smash and Grab Glass Recycling operate a 24/7 helpline and promise to fix any problems within 48 hours. Routine maintenance is required approximately twice a year depending on the level of use and an annual fee is charged to cover the maintenance. Operators may need to sweep the base of the unit clean of broken glass occasionally. Operators are instructed to only place glass in the units and this is enforced by site management; signs were noted to this effect during the site visit.

Collections are carried out by a commercial collector and the material is currently sent to be recycled as an aggregate replacement. Also, collectors utilise a Cargo Master powered trolley to enable access to cellars in city locations. Smash and Grab Glass Recycling is currently working with Brunel University to tailor the crushing mechanism and speed in order to produce larger glass fragments making the product suitable for remelt use.

The staff at all the establishments visited appeared very impressed with both the unit and service provided by Smash and Grab Glass Recycling and thought that it had been beneficial to the operating of their establishments, saving time, space and money. The only issue identified by one operator was the weight of the full crates for smaller bar staff to handle.

Appendix 2
Health and Safety Considerations

Lifting containers

The weight of the crushed glass gives rise to the potential for manual handling concerns when emptying collection containers. To address this all the compactors that empty into internal containers have weigh cells to prevent overfilling; these tend to be set at 20kg. The Health and Safety Executive (HSE) has published a set of guidelines outlining recommended maximum weights for a single person to lift depending on the level object being lifted. When starting to lift from floor level, as would apply in the case of the glass bin from compactor units, the recommended weight is 10kg for men and 7kg for women[9].

Moving full containers

The other area where the weight of crushed glass may be of concern is when full wheelie bins need to be moved for collection. The HSE guidance for pushing and pulling loads suggests a maximum force required to move the loads as 20kg for men and 15kg for women. This force is unlikely to be exceeded if a full bin of glass is moved on flat ground however the stability of wheelie bins once tilted may be a problem and should therefore be considered as should the weight specification of the wheelie bin. In cases where crushed glass needs to be moved up stairs then mechanical assistance such as that used by Smash and Grab Glass Recycling for collecting from cellars would need to be considered. Consideration must also be given to the lifting weight of containers specified by manufacturers when setting fill levels for wheeled bins.

The values provided by the HSE are issued as guidance rather than regulations and the weight an individual is able to lift will vary depending on the individual. However, consideration must be given by managers of establishments to the issue of handling the containers of crushed glass and a proper risk assessment should be carried out to ensure that staff are not put at risk when emptying the containers. This will include making sure that staff are trained in safe handling and lifting techniques and that sufficient staff are available to assist with lifting if required. A full risk assessment should also be carried out on the movement of wheelie bins full of glass. This would include procedures to be put in place to prevent overfilling, and the planning of the access routes used to collect the full bins to avoid slopes and stairs. The Glass Vac system removes most hazards by eliminating the need for the crushed glass to be handled manually.

[9] *Health and Safety Executive, 2004,Getting to grips with manual handling accessed at http://www.hse.gov.uk/pubns/indg143.pdf 11/01/10*

Appendix 3
Other Suppliers and Manufacturers of Compactors

Bottle Crusher Manufacturers

The following companies are manufacturers of bottle crushers and supplying to the UK market.

Bottle Eater

Bottle Eater Ltd
Building 3 Brentworks
Catherine Wheel Road
Brentford
TW8 8BD
Tel: 0208 7582136
Email: info@thebottleeater.com
Web: www.thebottleeater.com

European Bottle Crusher

European Bottle Crusher Ltd
Red Squirrels
Birds Green Road
Fyfield
CM5 0PR
Tel: 01277 899616
Email:
Web: http://www.eurobcrusher.co.uk

Glass Compaction Services

(www.glasscompactionservices.co.uk).

PEL Recycling Equipment

PEL Recycling Equipment
Brownhall
Balla
County Mayo
Ireland
Tel: +353 (0) 949366923
Email: info@pelmfg.com
Web: http://www.pelmfg.com

Bottle Crusher Suppliers

The following companies are suppliers of bottle crushers from the manufacturers are listed in the section above.

Agritel

Agritel Ltd
Bryn Y Plentyn
Middleton
Oswestry
Shropshire
SY11 4LP
Tel: 01691 671496
Email: info@agritel.co.uk
Web: www.agritel.co.uk

Bergmann Direct

Bergmann Direct Limited
Address Jubilee Place
Lindum Business Park
Station Road
North Hykeham
Lincoln
LN6 3QX
Tel: 0845 226 5803
Web: www.bergmanndirect.co.uk

Bottlecrusher

Bottlecrusher
Unit 1, Abbey Trading Point
Canning Road,
Stratford
E15 3NW
Tel: 0208 522 0123
Email: info@bottle-crusher.com
Web: www.bottle-crusher.com

Glasscycle

Glass Cycle,
32 Stanton Drive,
Pegswood,
Morpeth,
Northumberland
NE61 6YW
Tel: 01670 505606
Web: www.glasscycle.co.uk

Orwak Environmental Services

Orwak Environmental Services
Unit 6 Alpha Industrial Park
Bevan Way
Smethwick
B66 1BZ
Tel: 0121 565 7431
Email: orwak@phs.co.uk
Web: www.orwak.co.uk

Pressing Solutions

Pressing Solutions
No 18 Enterprise Units, Maes Y
Clawdd Industrial Estates
Maesbury road
Oswestry,
Shropshire
SY10 8NN
Tel: 01691 670891
Web: www.pressingsolutions.co.uk

Smashing Solutions

Smashing Solutions Ltd
5th Floor
No 2 Wellington Place
Leeds
LS1 4AP
Tel: 0113 366 2070
Email: info@smashingsolutions.co.uk
Web: www.smashingsolutions.co.uk

Waste & Resources Action Programme

The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
E-mail: info@wrap.org.uk

Helpline freephone
0808 100 2040

www.wrap.org.uk/glasscollection

recycle