Sampling and Testing Guidance for Material Facilities

To be read in conjunction with the Environmental Permitting (England and Wales) (Amendment) Regulations 2014 and Materials facilities: how to report on mixed waste sampling, Defra 2014

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Front cover photography: Materials being tipped at a MF

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1.0 Introduction

As outlined in Defra's 'Quality Action Plan' and the Welsh Government's 'Towards Zero Waste', the English and Welsh Governments have an objective to not only increase the quantity of material recycled, but also promote the quality of recycling. To support this, the Environmental Permitting (England and Wales) (Amendment) Regulations 2014 (the *Regulations)* were laid on 11 February 2014 and came into force on 5 March 2014.

Schedule 9A of the *Regulations* automatically adds a condition into the environmental permits of all qualifying Material Facilities (MFs) to require them to routinely sample and test the composition of their input and output materials and to report this via the *Regulator*. The requirement to sample and test is effective from 1st October 2014. Qualifying MFs therefore have a period of 6 months to prepare for meeting this requirement. The purpose of the testing is to provide robust and consistent data regarding the input and output materials from MFs with the aim of improving the quality of recyclate nationally. Higher quality recyclate will improve confidence and participation in recycling, improve resilience in the recyclate market and ensure that output materials are suitable for reprocessors within the UK as well as for export.

This non-statutory good practice guidance has been principally developed to assist MF operators to implement the sampling and testing requirements of the *Regulations.* If operators follow this guidance it will help them to meet their obligations for sampling and testing under the *Regulations*.

Sampling weights, frequencies and reporting requirements presented in this guidance are taken from the *Regulations* and so are statutory. The ultimate aim of this guidance is to ensure that the sampling of materials and testing of composition carried out under the *Regulations* is undertaken by MFs in England and Wales to a high and consistent minimum standard using recognised and accepted procedures. Further guidance can be found in summary guidance produced by Defra[1]. Enforcement of the *Regulations* is carried out in England by the Environment Agency and in Wales by Natural Resources Wales under the existing Environmental Permitting regime.

Some MFs may implement more rigorous sampling and testing procedures than outlined in this guidance in order to collect additional data. Given the benefits of sampling both input and output materials this document provides information regarding additional sampling that can be undertaken to help improve the management and performance of a facility as well as the minimum requirements to satisfy the *Regulations*. Where additional sampling over and above the requirements of the *Regulations* is carried out by a MF then the data submitted to the *Regulator* must be representative as opposed to, for example, only data showing the lowest levels of contamination being selected for submission.

[1] *Defra, Materials facilities: how to report on mixed waste sampling, 2014. https://www.gov.uk/government/publications/materials-facilities-how-to-report-on-mixed-waste-sampling*

Benefits of testing materials

- Providing the market with the information and transparency necessary to improve recyclate quality whilst at the same time achieving compliance with the Environmental Permitting (England and Wales) (Amendment) Regulations 2014.
- Demonstrating that sorted recyclables leaving the MF are suitable for 'high-quality recycling' applications in line with industry best practice. This will assist in demonstrating compliance with Article 11 of the revised Waste Framework Directive (2008/98/EC).
- Improving processes and cost efficiency by using data on the quality and composition of materials to manage sorting facility performance and inform investments into operations and technical developments.
- Improving the quality of input materials by providing feedback to *Suppliers* on input material quality to help them improve their collection systems and associated communication activities.
- Increasing revenue from the sale of output materials by ensuring that output materials meet or exceed reprocessor specifications thereby reducing the likelihood of reprocessors seeking financial recompense due to poor quality, and potentially also increasing the market value of materials.

Flow diagrams that provide an overview of the sampling and testing procedures are provided as an addendum to this document. The intention is that these diagrams will provide 'at a glance' guidance to those undertaking the sampling and testing.

2.0 Definitions

The following definitions are used in this guidance and are taken from the definitions used within the *Regulations*. The singular includes the plural and the plural the singular.

Average — The arithmetic mean.

Materials Facility — A regulated facility or part of a regulated facility that receives *Mixed Waste Material* in order to separate it into *Specified Output Material* for the purpose of selling it, or transferring it to other facilities or persons to enable that material to be *Recycled* by those facilities or persons. It excludes a facility or part of a facility that undertakes the processing of WEEE, waste batteries or accumulators.

Mixed Waste Material — Waste that:

(a) originates

(i) from households, or

(ii) from other sources but is similar to household waste in terms of its nature or composition; and

(b) consists in the largest proportion of two or more of the following kinds of *Target Materials* mixed together:

(i) glass;

(ii) metal;

(iii) paper;

(iv) plastic.

Material Particles — (a) for *Specified Output Material* that is made up in the largest proportion of glass material, particles of that material that measure less than 13 millimetres along their longest dimension; and
(b) in relation to all other types of *Specified Output Material* and for *Mixed Waste Material*, particles of material measuring less than 55 millimetres along their longest dimension.

Non-Recyclable Material — Waste material that is not capable of being *Recycled*.

Non-Target Material — Material that is capable of being *Recycled* but is not a *Target Material*.

Paper — Includes cardboard and beverage cartons that include cardboard as a composite material.

Recycling — References to "recycled" or "recyclable" are to be construed in accordance with the meaning of "recycling" given in Article 3(17) of the Waste Framework Directive.

Regulations — The Environmental Permitting (England and Wales) (Amendment) Regulations 2014.

Regulator The body responsible for enforcing the *Regulations*. In England this is the Environment Agency and in Wales Natural Resources Wales.

Reporting Period Any of the following periods commencing after 30 September 2014:

(a) 1 January to 31 March;

(b) 1 April to 30 June;

(c) 1 July to 30 September;

(d) 1 October to 31 December.

Specified Output Material A batch of material (whether or not waste) that is:

(a) produced from a separating process for *Mixed Waste Material*; and

(b) is made up of one of the following kinds of *Target Material*, in the largest proportion

(i) glass;

(ii) metal;

(iii) paper;

(iv) plastic.

Standard Deviation Indicates how much variation there is from the mean or average.

Supplier In relation to a batch of *Mixed Waste Material* received at a *Materials Facility*:
(a) where that batch comprises material collected pursuant to arrangements made by a waste collection authority under section 45(1)(a) or (b) of the Environmental Protection Act 1990([1]), that authority is the *Supplier*;
(b) where that batch has been transferred from another *Materials Facility*, the *Material Facility* from which that material was transferred is the *Supplier*;
(c) in a case not falling within paragraph (a) or (b), the person who collected the material or, if that person is not known, the person responsible for delivering it to the *Materials Facility* is the *Supplier*;
(d) where the batch comprises material from more than one *Supplier*, and the proportion of that batch attributable to a particular *Supplier* cannot reasonably be ascertained, an estimate of the proportion is sufficient.

Target Material A material that is identified by the operator of a *Materials Facility* as destined to be separated out from *Mixed Waste Material* in order to produce bulk quantities of that identified material.

[1] 1990 c. 43.

3.0 Overview of the Regulation Sampling Requirements for England/Wales

This section summarises the key elements of the sampling requirements of the *Regulations*. The full *Regulations* are available at http://www.legislation.gov.uk/uksi/2014/255/pdfs/uksi_20140255_en.pdf and further details are provided throughout this document.

3.1 Facilities in scope

The *Regulations* apply to MFs that receive, or are likely to receive, 1,000 tonnes or more of *Mixed Waste Material* for sorting during the relevant year[2]. MF operators are required under the *Regulations* to self-assess whether their facility is in scope of the *Regulations* and notify the *Regulator*. The operator may withdraw the notification if operations change such that the facility is no longer in scope.

The definition of *Mixed Waste Material* describes waste originating from households but also notes that waste from other sources will fall under the definition if it is similar to household waste in terms of its nature or composition. Wastes 'similar to household waste' are those one might typically find in the household waste stream. This may include, plastic bottles (typically ≤5 litres), pots, tubs and trays used for food packaging (typically ≤25cm in their longest dimension), flexible plastic packaging, glass bottles and jars, food tins, steel or aluminium drinks cans, newspapers and magazines and cardboard packaging.

For non-household waste to fall under the definition of *Mixed Waste Material* the two or more fractions of glass, metal, plastic or paper that make up the largest proportion (≥50%) of the waste should be similar in composition to those wastes described above.

Facilities likely to be in scope under the *Regulations*:

- Material Recovery Facilities (MRFs) sorting household dry recyclables.
- Commercial waste sorting operations and transfer stations where materials similar to household wastes are sorted into two or more *Specified Output Materials* (e.g. a MF sorting plastics and cans would be in scope although one sorting a single stream such as paper and card would not).

[2] *The Regulations outline that "relevant year" refers to the period of 12 months that commences on the first day of a reporting period e.g. a "relevant year" could run from 1st of July in one year to 30th June in the next.*

Facilities not likely to be in scope under the *Regulations*:

- Waste transfer stations acting only as bulking points (so with no sorting activities).
- Waste transfer stations that sort commercial and industrial (C&I) wastes unless the commercial waste meets the definition of *Mixed Waste Material*. Industrial derived material does not fall under the scope of the *Regulations*.
- Household Waste Recycling Centres (Civic Amenity Sites).
- Commercial and Industrial MRF's (C&I MRFs) unless the commercial waste meets the definition of *Mixed Waste Material*.
- MRFs sorting only residual waste ('Dirty' MRFs).
- Mechanical Biological Treatment (MBT) plants including those used at autoclave facilities unless *Mixed Waste Material* is accepted for any MRF operations that form part of the process.
- Refuse Derived Fuel (RDF) production facilities.
- WEEE management facilities.
- MRFs separating materials from construction and demolition waste.

Note: should any of the aforementioned facilities accept *Mixed Waste Material* for sorting, even for a limited period, above the threshold levels, then they would fall within the scope of the *Regulations.*

3.2 Materials to be sampled

3.2.1 Incoming materials

Incoming mixed waste material must be sampled to identify *Target Material*, *Non-Recyclable Material* and *Non-Target Material*. The *Target Material* must as a minimum be separately identified by reference to glass, metal, paper and plastic. Cardboard and cartons that include cardboard as a composite material should be included in the paper category. Whilst there is no requirement to sort and record incoming material into further sub-categories it is recommended that this is done in order to provide comprehensive management information and maximise the benefits of the sampling.

The following can be classed within *Target Materials* categories:

- Any item that has been requested for collection. This might include some grades of materials that are technically challenging to *Recycle* but that have been included to keep the message to those using the service simple (for example clear PET food trays that have been included as part of a 'mixed plastics' collection). Where this is applicable, it should be highlighted to the *Supplier* so that they are aware of any fractions they may be collecting that will not ultimately be *Recycled.* This would include informing *Suppliers* if certain fractions are being sent for energy recovery as opposed to *Recycling*.
- Wet paper unless it is degraded or so wet that it is unlikely to be successfully separated by the sorting system.
- Plastic bottle tops and corks, caps, screw tops and neck rings from glass bottles (since these form an integral part of the targeted materials and can be separated and *Recycled*).

3.2.2 Specified Output Materials

Sampling of *Specified Output Materials* must be undertaken with consideration given to the grade of material output from the MF. Example grades might include clear PET bottles and green glass. A more comprehensive list of example *Specified Output Materials* is included within Appendix A. It should be noted that material streams that are already separated when delivered (e.g. a stream of source separated glass) would not fall within the sampling requirements of the *Regulations.*

For all *Specified Output Material* each MF must define which waste fractions are *Target Material*, *Non-Target Material* and *Non-Recyclable Material* based on the purchase specification they have agreed with the reprocessor, or company acting on their behalf. Purchase specifications should be kept on record to support decisions made on the categorisation of the different material fractions. Details of the categorisation should also be documented and included within the relevant forms used for sampling and testing materials. Sampling of the residual waste fraction, e.g. residues, is not required under the *Regulations*; however, it is considered good practice.

Materials should only be identified to be separated out as *Target Material* if:

- the reprocessor has not classified the fraction as a contaminant in their specification. This applies even if the contaminant is acceptable within defined limits and if the contaminant has the same physical properties as the *Target Material* e.g. newspapers and magazines in corrugated board specifications or glass of the wrong colour in specific colour glass collections. By defining a material as a contaminant the reprocessor is stating it is non-target;
- the fraction can be *Recycled* by the reprocessor directly or is purposefully separated by the reprocessor for *Recycling* by a third party. Any *Target Material* fraction of *Specified Output Material* that is not directly *Recycled* by the reprocessor to which it is initially supplied should be highlighted on records kept by the MF. The *Regulator* may request evidence that a particular fraction is being *Recycled* if it is being classed as a *Target Material*; and
- their inclusion is permitted from a legal perspective, for example, their inclusion is consistent with the requirements of the Waste Shipment Regulations if the material is to be exported to a given destination country.

The following may be *Target Materials* unless they are classed as a contaminant in the purchase specification:

- Aluminium aerosols in UBCs.
- Aluminium foils in UBCs.
- PET trays in PET bottles (of the required colour).
- HDPE trays in HDPE bottles (of the required colour).
- Plastic bottle tops in grades containing plastic bottles.
- Caps, screw tops and neck rings in grades containing glass bottles and jars.
- Wet paper grades unless the material is degraded to the point where it is not fit for recycling.

Residual waste

Sampling of the residual waste fraction, e.g. MF residues, is not required under the *Regulations*; however, it is considered good practice.

Sampling and testing of the residual waste fraction (post sorting) allows operators to:

- Identify the types and quantity of *Target Materials* that are being lost during processing. This information can be used to improve operational practice and identify shifts where the equipment is being operated incorrectly and where additional training may be required. It can also be used to identify where new, or additional, sorting technologies may be beneficial.
- Identify common types of *Non-Target* and *Non-Recyclable* material. This information can be passed back to *Suppliers* for use in communication campaigns.
- Perform mass balance calculations which might be used for business planning purposes.

3.3 Sample weights required

Sample weights are detailed in the *Regulations*. The minimum required sample weight for *Mixed Waste Material* inputs is 55kg and the average weight of all samples of *Mixed Waste Material* inputs in a reporting period must be 60kg or more. For *Specified Output Materials* the minimum required sample weights are shown in table 1. All samples of *Specified Output Materials* should be equal to or greater to the sample weight required by the *Regulations.*

A full sample must be collected in one go and it is not acceptable to take smaller sample sizes at more regular intervals in order to collect a sample, for example it is not acceptable to take 6 small samples of 10kg to obtain the required 60kg sample size for incoming *Mixed Waste Material*. The purpose of sampling is to illustrate the variation of incoming *Mixed Waste Material* and *Specified Output Materials*, 25 samples of 60kg each will exhibit one level of variation whereas 150 samples of 10kg each will exhibit greater variability which is not related to the actual incoming materials. The size of the samples affects the amount of variation that the sampling will show and larger samples will have less variability and will be more representative of the actual material. It is therefore important that all samples meet the minimum sampling requirements and are of a standard size.

Table 1: Sampling requirements for *Specified Output Materials*

Material	Sample size (kg)
Paper	50
Glass	10
Metal	10
Plastic	20

3.4 Sampling frequency

The composition and quality of incoming *Mixed Waste Material* can fluctuate depending on the *Supplier*, collection round and even season. These variations, combined with operating factors such as the throughput speed of the sorting process, can impact on the quality of *Specified Output Materials.* It is therefore important that sampling and testing of materials is an on-going process and that inputs from different *Suppliers* are assessed.

The number of samples a MF needs to take depends on the overall weight of *Mixed Waste Material* delivered by each *Supplier* and how much *Specified Output Material* is produced. In order that an appropriate sampling schedule can be established the incoming weight of

Mixed Waste Material (by *Supplier*) and weight of *Specified Output Material* needs to be monitored and recorded.

Until 1st October 2016 a sample must be taken for every 160 tonnes of *Mixed Waste Material* delivered to the MF by each *Supplier.* From 1st October 2016 onwards a sample must be taken more frequently, for every 125 tonnes of *Mixed Waste Material* delivered by each *Supplier*. For some small *Suppliers* this may mean that sampling does not take place during every reporting period or even every year. In recognition of the commercial and operational benefits that can be obtained from frequent sampling some MFs may choose to implement more rigorous sampling procedures than required by the *Regulations*.

From a best practice perspective, as opposed to a regulatory perspective, where a *Supplier* is likely to take a significant time to deliver the quantity of *Mixed Waste Material* required to trigger a sample to be taken and tested, then more frequent sampling for that *Supplier* should be considered in order to effectively control input *Mixed Waste Material* quality at the MF. For *Specified Output Materials*, there are different requirements depending on the material type, see table 2 below.

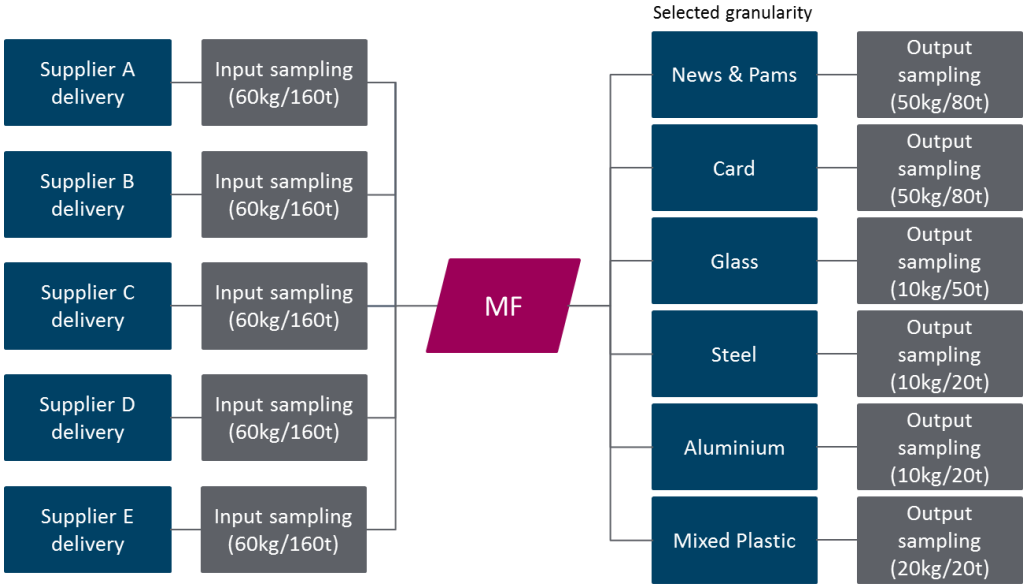
Table 2: Sampling requirements for *Specified Output Materials* including sample size

Material	Sampling frequency until 1st October 2016	Sampling frequency From 1st October 2016	Sample size (kg)
Paper	Every 80 tonnes produced	Every 60 tonnes produced	50
Glass	Every 50 tonnes produced	Every 50 tonnes produced	10
Metals	Every 20 tonnes produced	Every 20 tonnes produced	10
Plastic	Every 20 tonnes produced	Every 15 tonnes produced	20

Indicative annual sampling schedules are provided in Appendix B for illustrative purposes.

Figure 1, below, gives a summary of the sample weight and frequency requirements.

Figure 1: MF sampling requirements until 1st October 2016



4.0 Sampling Options for Inputs and Outputs

This section provides step by step guidance on suitable minimum methods for obtaining a representative sample of incoming *Mixed Waste Material* and *Specified Output Materials*. The MF can select the most suitable methodology to use according to the available equipment, space and presentation of the materials (e.g. loose, bagged or baled).

Guidance regarding Health and Safety (H&S) is provided in Section 13 of this document and should be considered in conjunction with this section. Sampling and testing of materials should be undertaken only by staff that have received full training, both from practical and H&S perspectives.

4.1 Step one: Plan the sampling schedule

It is recommended that MFs develop a quarterly plan for sampling of input materials from different *Suppliers* and for *Specified Output Materials* based on the requirements set out in the *Regulations* (as outlined in Section 3.4 of this document) combined with projected delivery tonnages and production figures.

Sampling should be scheduled to ensure it is as representative as possible. This can be achieved by scheduling sample taking so that:

- For a given *Supplier*, *Mixed Waste Material* samples are taken to ensure that they represent as many of the collection routes as possible. This might be achieved by working with the *Supplier* to identify the source of the incoming material and arranging the sampling to be undertaken at different times and on different days.
- *Specified Output Material* samples are taken at different times and on different days. Samples should be taken from all shifts including night and weekend shifts, if applicable.

The MF should be able to demonstrate to the *Regulator* that the sampling being carried out is structured and managed to provide representative results. An example sampling schedule is provided in Appendix B.

4.2 Step two: Isolate the material

The incoming *Mixed Waste Material* or *Specified Output Materials* for sampling should be isolated. This should be done in an area that has been cleared of all other material (or in the storage bay for *Specified Output Materials*). Care should be taken to prevent cross contamination of the sample with materials from other sources. Any exceptional items, e.g. particularly large or heavy items that might damage equipment or impact on the sorting process and that would ordinarily be removed, should be removed at this stage and do not need to be weighed. No other picking of the waste should occur prior to the sample being taken.

4.3 Step three: Taking a sample

4.3.1 Sampling loose incoming Mixed Waste Material

1. Randomising the sample. An example approach for incoming *Mixed Waste Material* would be to tip the load on the floor and mix it with a loading shovel, or similar plant. This can be achieved by separating a proportion of the material (approximately four times greater than the required sample size) and lifting it up and dropping it back on the floor at least twice using a loading shovel. This will help redistribute heavy items (such as glass bottles) that have settled to the bottom of the load. A push wall will help with the mixing process. This step is not necessary for *Outgoing Materials*.
2. Either of the following techniques can then be used to take a sample:
    a. Slice of pie: use shovels and brooms to remove a whole section of waste, i.e. a slice of pie or a section from each end of the sample. Shovel the sample into sample containers (e.g. containers or bulk bags) taking care that all *Material Particles* are captured.

b. Direct input: tip the sample directly into a robust container with the loading shovel. The container should be of a size that when full (or filled to a certain known level) will contain the correct sample weight.

Some larger MFs may choose to sample incoming *Mixed Waste Material* using a divert conveyor at the start of the sorting process. If this is done, then the line must be cleared of all other material so that a *Supplier* specific sample can be taken. The sample must be taken prior to any removal of material, including *Material Particles*.

4.3.2 Sampling bagged incoming Mixed Waste Material

1. Push the bagged material into a circular pile with the loading shovel.
2. Then use either of the following techniques:
    a. Points of a compass: take one bag from north, south, east, west and then north-east, north-west, south-east and south-west. Take a mixture of large and small bags and repeat this until the desired sample size is reached.
    b. Bagged section: remove one whole section of the pile from top to bottom, centre to outside edge. The decision on which section will be taken should be made prior to the material being pushed into the pile to ensure the sample is random and not influenced by how the material looks.

4.3.3 Sampling loose Specified Output Materials

The most representative, and often the easiest way, of taking a sample of *Specified Output Material* is to collect it directly from a conveyor at a point in the MF when all sorting processes are complete (i.e. the material is representative of that which would be delivered to the reprocessor). There are two main options:

1. *Specified Output Material* is diverted from the end of the conveyor leading to the storage bay.
    a. Diverts should be added to the conveyors taking sorted output material to the storage bays.
    b. When a sample is required, the divert should be activated until the required sample weight is collected.
2. *Specified Output Material* is taken as it falls from the conveyor into the storage bay.
    a. At a convenient time, typically after the bay has been emptied, a suitable container or bulk bag should be placed under the conveyor that feeds the storage bay.
    b. The required sample weight should be taken prior to the container or bulk bag being removed.

In option 2, the sorting line should be turned off whilst the container is placed under the feed conveyor as well as when said container is removed , should staff be required to enter the storage bay to do so. Picking should stop while the conveyor is stationary to ensure the sample is representative.

In both options, care must be taken that throughput rates when the sample is taken are typical for the MF, as the speed at which the sorting line is run can impact on the sorting efficiency of the equipment and therefore the *Specified Output Material* quality. Sampling should be carried out at the last point possible in the MF, to represent the output accurately.

For H&S reasons, it is not recommended that samples are taken from feed conveyors to balers unless this can be automated.

Where sampling of *Specified Output Material* is not possible directly from a conveyor, then a sample can be taken from the storage bay (option 3). Where this is done the sample should be taken using the slice of pie method.

4.3.4 Sampling baled material (incoming Mixed Waste Material or Specified Output Material)

It is envisaged that most sampling will be of loose or bagged material; however, it is possible that some *Suppliers* may deliver baled material or that it is not possible to safely sample loose *Specified Material Outputs*. Here, the following process should be followed:

1. A bale of material is chosen at random after production and prior to it entering stock.
2. The bale is broken open and a weight of material approximately four times that required for the sample taken. This should include material from the middle as well as one end of the bale (the latter picked at random).
3. The material should be mixed manually with shovels to ensure it is randomised.
4. The slice of pie technique (see section 4.3.1) should be used to take the sample.

It should be noted that *Regulators* will compare *Specified Output Material* quality data submitted to them with both loose and baled stock held on site. Where sampling of baled material is not used, it is therefore important to ensure that contamination is not introduced during the baling process to ensure that testing results are representative of the actual *Specified Output Material* leaving the MF.

4.4 Step four: Label the sample

Once the sample has been taken it should be labelled with the required information; date of sample, time of sample and sample weight. Care should be taken that the samples are labelled securely to prevent labels becoming damaged during transit or due to inclement weather. If a sample is not to be tested immediately, it should be stored in a sealed or covered container to avoid cross contamination with other material. Samples should be tested as soon as possible after being taken to prevent degradation (e.g. samples should not be taken and stored throughout the week for testing at the end of the week).

4.5 Step five: Transport to testing area

The sample should be moved to the sample testing area. This can be done using a pallet truck or fork lift truck. If the container in which the sample was taken has wheels, then it can simply be pushed.

Good practice in sampling

- Ensure that staff undertaking the sampling and testing are fully trained (as per section 12 of this guidance) and have more than one person trained. This will provide cover during periods of staff absence and will enable sampling results carried out by different people to be compared. The latter may highlight anomalies and the need for additional training.
- Modify the day and time that the sample is taken from *Suppliers* so that samples are not always taken from the same collection route, which may have particular quality characteristics. Likewise, modify the day and time that output samples are taken to ensure that variances in staffing, operations and input materials are reflected.
- Automate the sampling wherever possible to ensure samples are taken randomly and without human intervention, for example by taking samples directly from a suitable conveyor. For larger facilities, this may also prove cost effective as it should reduce labour costs.
- When sampling bagged materials pick a range of bags sizes and weights.
- Ensure that samples are correctly labelled and stored in a way that protects them from cross contamination with other materials and wind, rain or snow.
- Containers can be marked with the approximate level to which they must be filled to get the required sample weight. This will vary depending on the material (and grade) and whether the material has been compacted or baled.
- Undertake regular spot checks to ensure that sampling is being undertaken correctly.

Bad practice in sampling

- Avoid taking a sample from only the top or bottom of a pile of material as heavier items may have settled.
- Do not include large, heavy items of contamination that would need to be removed manually prior to processing, e.g. items that might damage equipment such as bricks, large metal items, etc.
- A sample should not be taken from an input load that is rejected from the MF.
- Avoid relying on built in scales on equipment such as loading shovels, telehandlers, mechanical grabs, etc, when assessing the sample size as they tend to be inaccurate. These scales can be used for estimation but the final weights must be determined from a calibrated bench or platform scale.
- Do not test more than one sample at a time due to the risk of cross contamination of different samples.
- Staff should not adjust the composition of the sample in an attempt to make it 'representative'.
- Under no circumstances should fictitious results be reported.

5.0 Material Testing Procedure

This section provides step-by-step guidance on suitable minimum methods for testing sampled materials. Sorting and weighing of materials should be carried out in a separate undercover area and away from moving equipment and vehicles, including, fork lift trucks and loading shovels, etc.

5.1 Step one: Prepare the area and equipment

Ensure that all the equipment required is available and ready for use (a summary of equipment required is provided in Section 6). Preparation should include the following tasks:

- Prepare appropriate sample record sheets. The name of the *Supplier* (and source, e.g. the bulking point if applicable), grade of material, delivery vehicle registration, incoming weighbridge ticket number as well as the date and time the sample was taken is entered onto the sheet. Details of the person who has taken the sample and who tests it should also be recorded.
- Ensure that the area and containers to be used for sorting are clean, dry and free from any materials that might cross contaminate the sample to be sorted.
- Test the bench scales with a 1kg and 5kg weight on a daily basis to ensure accuracy.

5.2 Step two: Weigh the entire sample

Weigh the entire sample prior to any sorting taking place and enter the weight into the sample sheet. This is to ensure that the sample weight meets the requirements of the *Regulations* and to allow the combined weight of sorted materials to be cross checked with the original sample weight.

5.3 Step three: Sort the sample

1. Tip the sample onto a sort screen ensuring no loss of material from the sides. It is recommended that a maximum size steel mesh of 45mm x 45mm should be used for all materials other than glass, where a maximum size steel mesh of 12mm x 12mm should be used. These mesh sizes will allow *Material Particles* of the sizes defined in the *Regulations* (55mm and 13mm along their longest dimension) to pass through[3]. See Figure 2 for an example picture of a sort screen.
2. Any liquids within bottles should be emptied into a bucket. The weight of liquids should be included as a *Non-Recyclable* fraction.
3. Any clumped materials should be broken apart into their component parts.
4. Hand sort the materials that have not fallen through the screen into the correct containers based on the categories on the sampling sheet (split under the headings of *Target Material*, *Non-Target Material* and *Non-Recyclable Material*).
5. Each hand-sorted category of waste should be weighed on scales with taring[4] of the scales between each weighing. The weights should then be recorded on the sampling sheet against the appropriate category. The *Non Target Material* and *Non-Recyclable Material* fractions should have an 'other' category to capture the weight of any material that does not have a specific category.
6. All materials that fall through the screen are classed as *Material Particles*. The *Material Particles* should be captured directly within a container, if possible.
7. The total weight of *Material Particles* should be recorded and allocated as *Target Material*, *Non-Target Material* and *Non-Recyclable Material* in the same proportions as

[3] *See definition of Material Particles within Section 2 for further information*

[4] *Taring means removing the weight of the container used to hold the materials for measurement, usually by setting the scales to zero once the empty container is in position.*

the non-*Material Particle* fraction. For further details regarding this apportionment please see Section 14.12 of this document.

8. The total weight *of Target Material, Non Target Material and Non-Recyclable Material* should be summed and a check made that the combined weight of the three fractions equals the original weight of the sample to ensure no errors have been made. There may be a small difference in the two weights caused by, for example, rounding but the weights should be within 5% of each other. If this is not the case, then weights and calculations should be checked.

It may be possible to automate the testing of samples to some degree and for larger facilities this may have cost benefits. Where this is done, then the MF must be able to demonstrate to the *Regulator* that the testing results are as accurate as would be expected if testing was done by hand. This may, for example, involve verifying that the sorted fractions only contain the intended fractions and the correction or any automated sorting errors with manual intervention. Where an automated approach is used, the original sample weight should still be taken prior to the material being batch fed into the testing equipment.

It is recognised that some MF's produce <12mm *Specified Output Materials* as a discrete grade of *Specified Output Material*, notably of glass where it has been collected and processed co-mingled with other materials. The *Regulations* require that this material is sampled and tested as a discrete grade. However there are significant technical difficulties for MF operators in sampling and testing for less than 12mm grades and it may be necessary to find different methods of measurement. If for example a MF is producing both a <12mm glass fraction and >12mm fraction, then it may be appropriate to apply the composition of the larger glass fraction size stream to that of the smaller size stream. However, this should only be done where the composition and contamination within the two streams are determined to be if same, for example by way of a visual inspection of samples. If levels of contamination in the glass streams are different then a suitable testing procedure applicable to the particle size should be developed by the MF. Alternatively, for <12mm output fractions, the MF operator could procure the services of a suitably qualified contractor in order to obtain the required compositional analysis.. Records should be kept of the reasons for decisions made in regard to the testing methodology selected.

5.4 Step four: Clear up

The area should be cleared ready for testing the next sample. *Target Materials* should be placed back in the incoming material bay and the other fractions in the residual bay. Equipment should be cleaned and stored correctly ready for next use.

Good practice in testing

- Ensure that the ergonomics of the testing area are optimal by locating containers for sorted materials close to the operatives (this will reduce risks from manual handling and increase sorting speed) and use a suitably sized table, set at a height where sorting can be done comfortably.
- Provide a sufficient number of containers for each operative to sort the sample into all the required material categories.
- Ensure the operatives undertaking the testing are fully trained (including being trained in safe systems of work) and understand the different material categories.
- Place full containers near the scales ready for weighing and do not overfill the containers.
- Containers used for sorting and weighing different fractions should be clean and dry. From time to time they should be washed to remove any residue that might distort the weight of the samples.

Bad practice in testing

- Not clearing the containers and work area between sample testing.
- Using untrained staff.
- Not isolating the testing from other activities on site leading to H&S risks and cross contamination of materials.
- Forcing or persuading materials to fall through the sorting mesh during testing.
- Weighing samples in a windy area or where there are a lot of vehicle movements. This may introduce weighing errors and is also a H&S risk.

6.0 Sampling and Testing Equipment

Table 3 summarises the typical equipment used to undertake the sampling and testing of materials as outlined in Sections 4 and 5 of this guidance.

In addition to equipment, suitable areas for sampling and testing are required.

- Sampling area: the area used to take and mix samples should allow for staff to be protected from vehicle movements while samples are taken and should be of a suitable size to allow wastes to be isolated to avoid cross contamination. Ideally a pushing wall will be available to allow samples to be more easily mixed with a loading shovel. The area should be sheltered and protected from the elements.
- Testing area: the area used to sort the sample should be covered and protected from the elements with good lighting (ideally a cabin). It should protect staff from vehicle movements and protect the sample from cross contamination.

Table 3: Equipment for sampling and testing materials

Equipment Type	Detail	Sample Taking	Sample Testing
Platform scales	With a calibration certificate and a minimum accuracy of +/- 500g[5]	Yes	Yes
Bench scales	With a calibration certificate and an accuracy of +/- 10g	No	Yes
1kg and 5kg weights	To check calibration of scales	No	Yes
Shovels, brooms and containers	For mixing samples, cleansing areas of spillages and sweeping up *Material Particles* for measurement	Yes	No
Long handled wire cutters	For cutting straps on baled material	Yes (if baled material is sampled)	No
Containers	Stillages, bulk bag, other containers suitable for storing, transporting and weighing materials	Yes	Yes
Pickers	To remove hazardous items such as hypodermic needles	Yes	Yes
Sharps bins	For safely disposing of sharps	Yes	Yes
Fork lift truck or hydraulic trolleys	For transporting material from the sampling area to the testing area	Yes	Yes
Loading shovel / telehandler	For mixing samples and loading containers	Optional	Optional
Waterproof labels and pens	For labelling samples	Yes	Yes

[5] *These mesh sizes will allow Material Particles of the sizes defined in the Regulations (55mm and 13mm along their longest dimension) to pass through*

Equipment Type	Detail	Sample Taking	Sample Testing
Screens	With a maximum 45mm and 12mm mesh sizes	No	Yes
Sorting table	Either with built in mesh or trestle legs to support screens. The table should be solidly constructed and easy to clean (e.g. stainless steel topped)	No	Yes
Flat table	For containers and bench scales	No	Yes
Mini sort conveyors	May be used to aid the sorting process	No	Yes
Automated bin lift	For emptying samples collected in wheeled bins onto the sorting area	Yes	No
Sample sheets	To record the outcomes of the testing	Yes	Yes
Personal Protective Equipment (PPE)	Overalls, hi-visibility jacket, puncture resistant gloves, boots (steel sole and toe), ballistic trousers, hard hat, ear protection, eye protection, dust masks	Yes	Yes
Safety equipment	Fire extinguisher and spill kit	Yes	Yes

Good practice
A copy of this guidance and the summary diagrams along with any MF specific training documents should be available to staff at all times. This should include H&S training material and copies of safe systems of work. Images of common *Target Materials, Non-Target Materials and Non-Recyclable Materials* should also be provided.

Figure 2: Mesh used for sorting materials

7.0 Sampling and Testing Timing Indicators

Guide sample times are shown in Table 4, below, for illustration purposes. They are estimated based on experience of similar sampling and testing activities. They are indicative of the combined time of those involved in sample taking, and assume one person sorts the sample. It is recognised that actual times will vary depending on:

- The sampling technique being used.
- The *Specified Output Material* grade being tested.
- The degree of sorting being undertaken. For incoming *Mixed Waste Material* it is assumed that sorting is only by glass, plastic, paper, metal which is the minimum requirement in the *Regulations*.

Table 4: Guide sampling and testing times

Material	Weight	Minimum time for sample taking and testing (minutes)
Incoming *Mixed Waste Material*	60	90
Paper	50	75
Metal	10	60
Plastic	20	75
Glass	10	60

In addition, times would increase when:

- Input *Mixed Waste Material* is highly contaminated or wet.
- Sampling baled materials, as clumps of material might need to be separated for certain *Specified Output Material* grades.
- The ergonomics of the area used for testing are not optimised making it more difficult for operatives to sort materials.

8.0 Information Required by the Regulators

8.1 Reporting requirements

The *Regulations* require reports to be submitted to the *Regulator* every 3 months. The first reporting period will start on 1 October 2014. The four reporting periods each year are:

- 1 January to 31 March. Returns due by 30 April.
- 1 April to 30 June. Returns due by 31 July.
- 1July to 30 September. Returns due by 31 October.
- 1 October to 31December. Returns due by 31 January.

Reports must be submitted to the *Regulator* electronically within one month of the end of the *Reporting Period*.

The following information will be required for incoming *Mixed Waste* Material in a given *Reporting Period*:

- The total weight in tonnes of *Mixed Waste Material* received at the MF from each *Supplier* requiring sampling under the *Regulations.*
- The total number of samples taken for each of these *Suppliers*.
- The total weight in kilograms of all samples taken for each of these *Suppliers*.
- The *Average* percentage composition of target glass, metal, paper and plastic in *Mixed Waste Material* delivered by each of these *Suppliers*, based on all applicable sample results.
- The *Average* percentage composition levels of *Target Materials*, *Non-Target Material* and *Non-Recyclable Materials delivered* by each of these *Suppliers*, based on all applicable sample results.
- The standard deviation of the *Average* percentage composition level of *Target Materials* for each of these *Suppliers*, based on all applicable sample results.

The following information will be required for material leaving the MF in a given *Reporting Period*.

- The total weight in tonnes of each *Specified Output Material* that leaves the MF
- The total weight in tonnes of *Mixed Waste Material* transferred to other MFs for the purposes of separating into *Specified Output Materials* and the destination of each MF transfer.
- The total weight in tonnes of all other waste that leaves the MF and details of where it has been sent.
- The total number of samples taken for each *Specified Output Material*.
- The total weight in kilograms of all samples taken for each *Specified Output Material.*
- The *Average* percentage of all samples by reference to grades of glass, metal, paper and plastic
- The *Average* percentage of *Target Materials*, *Non-Target Materials* and *Non-Recyclable* materials by grades of glass, metal, paper or plastic in the samples
- The standard deviation of the *Average* percentage composition levels for the *Target Materials,* based on all of the applicable sample results.

8.2 Recording requirements

Examples of data input templates are shown in Appendix C. It is advisable for data to be backed up daily to avoid data loss. It should be noted that the *Regulations* require that the following information should be kept for a minimum of four years from the date it was recorded:

- The total weight in tonnes of *Mixed Waste Material* received by the *Materials Facility*, from each named *Supplier*, during a *Reporting Period*.
- The weight and composition of each *Mixed Waste Material* sample taken at the *Materials Facility* from each named *Supplier* during a *Reporting Period*.
- The weight of other waste (residual waste) that leaves the *Materials Facility* during a *Reporting Period* and where it is sent.
- The weight of *Mixed Waste Material* that leaves the *Materials Facility* for separation at another *Materials Facility* during a *Reporting Period* and where it is sent.
- The total weight in tonnes of *Specified Output Material* by reference, as a minimum, to grade of glass, metal, paper or plastic that leaves the *Materials Facility* in each *Reporting Period*.
- The weight and composition of each *Specified Output Material* sample taken at the *Materials Facility* by reference, as a minimum, to grade of glass, metal, paper or plastic.
- Details of where the *Specified Output Material* that leaves the *Materials Facility* in a *Reporting Period* is sent to.
- Details of the amount in tonnes of *Specified Output Material* by reference to the grade of glass metal, paper and plastic material that is produced by the *Materials Facility* in a *Reporting Period*.

The information should be available to be produced for inspection by the *Regulator* within the four year period.

9.0 Calculating the Mean and Standard Deviation

The *Regulations* require that the mean (average) and standard deviation (SD) are calculated from the samples taken and reported at the end of each *Reporting Period*.

Those interpreting standard deviation should note that statistically meaningful results will only be obtained when more than around 25 samples are taken in a *Reporting Period*. Some care must therefore be taken when interpreting standard deviation data where fewer samples than this have been taken.

Calculating the standard deviation

The standard deviation can be calculated using one of the built in formulae in Microsoft Excel. The cell in which the standard deviation is to be displayed should be selected. The text: =STDEV.S(insert results here*) should be entered into the formula bar. The standard deviation for the selected range of cells will be displayed after pressing return. An example of such a calculation being executed is presented in Appendix D.

*The cell references for the results should be entered here e.g. C3:C27, these can be typed in manually or selected with the mouse while entering the standard deviation formula

For normally distributed data, nearly all of the values in a data series lie within 3 standard variations of the arithmetic mean (the *Average*):

- 68% are within 1 standard deviation;
- 95% are within 2 standard deviations; and
- 99.7% are within 3 standard deviations.

For example, for *Mixed Waste Material*, if the standard deviation of *Target Material* is 2.1%, as in the worked example in Appendix E, this means that 68% of the values are within 2.1% of the arithmetic mean. A smaller standard deviation might be expected on many *Specified Output Materials* if the quality is to be considered consistent.

The aim for *Suppliers* should be to have a high percentage of *Target Material* in incoming *Mixed Waste Material* with a low standard deviation and for MFs to have a high percentage of *Target Material* in *Outgoing Materials* with a low standard deviation.

The standard deviation can be used to estimate the confidence intervals of the reported *Average* percentage composition for *Target Materials* and further detail is provided in Appendix E.

10.0 Enforcement of the Regulations

The Environmental Permit condition imposed by the *Regulations* will be enforced by the national environmental *Regulator*, i.e. the Environment Agency in England and Natural Resources Wales in Wales. Operators currently, or expecting to, process the requisite quantity of qualifying waste will have to notify the *Regulator*.

The *Regulator* will enforce the sampling and reporting requirements. It is envisaged they will initially make two inspections of MFs per year (one of which would be unannounced) to review the sample-taking, testing and reporting procedures. They would compare reported information with wastes seen on site and with site records.

Additional visits might also be undertaken based upon intelligence, outcomes of previous inspections or quarterly returns data. It is envisaged that the planning of inspections would change when the sampling and reporting regime has become established to focus more on poor performing sites, in terms of sampling and reporting. It will not be part of the specific remit of inspections related to the *Regulations* for the *Regulator* to advise on how to improve quality of recyclates. However, advice may be provided through other related activities, perhaps on the same visit.

Inspections may also be used to check related obligations are being properly implemented, for example, related to Duty of Care and Transfrontier Shipments of wastes.

The *Regulator* will employ the usual enforcement powers available to them under the Environmental Permitting Regulations in England and Wales.

An additional subsistence charge will be necessary to fund the *Regulator's* work

11.0 Staff Training

In addition to H&S training, which is covered in Section 13 of this document, all staff involved in sampling and testing should be fully trained in its operational aspects. This training should cover as a minimum:

- Background information on the benefits of sampling and testing.
- The requirements of the *Regulations.*
- Use of equipment and its maintenance.
- Taking a representative sample.
- Maintaining the integrity and identity of a sample (i.e. labelling, storage and transport).
- Sample testing.
- Recording data.
- How to use the wall chart included within this guidance document.

All training material should be documented and be available to those sampling and testing material. It is recommended that records of training are kept and that staff receive regular refresher courses at least once a year.

Good practice

High performing MFs will recognise the importance of training staff regarding sampling and testing. This is likely to include:

- Training for all staff upon induction and as part of refresher training regarding the purpose and importance of sampling and testing and the use of the data to improve operations.
- A live or video demonstration showing the methodology that should be used for sampling and testing supported with simple written documentation for reference.
- The importance of robust sampling and testing including the use of the data gathered.
- Inclusion of information in all appropriate documents and activities (e.g. training handbooks, risk assessments, customer service policies and training sessions).
- Consideration of how training materials can be made readily accessible by staff that do not speak English as a first language e.g. through the use of images or translation.
- Providing on-going reminders to support the training e.g. images of common *Target Materials, Non-Target Materials* and *Non-Recyclable Materials* displayed on the wall of the sorting area.
- Including staff performance in relation to sampling and testing as part of Continued Professional Development plans and performance appraisals (or similar).

12.0 Health and Safety Considerations

This section provides advice with regards to the H&S considerations for the sampling and testing of materials. This section should be used as guidance only. Each MF should ensure that they have adhered to applicable legal requirements, made use of relevant Health and Safety Executive (HSE) guidance, carried out appropriate risk assessments (specific to their operations), implemented required control procedures and sought further advice from bodies such as the HSE where necessary.

The main areas of focus for H&S control procedures are:

- The sampling area.
- Transport segregation.
- Manual handling.
- Slips and trips.
- Hygiene.
- CoSHH.
- Other considerations; bale wire cutting/bursting.

12.1 Layout and structure of sampling areas

Sampling areas should ideally be climate controlled, well lit, dust free and in a separate or cordoned off area to provide physical protection to personnel undertaking sampling from vehicles.

Options could include:

- Using an existing waste bay with walls on three sides to provide a dedicated area.
- Using an existing push-wall arrangement to provide a safer area.
- Using a separate building or physically separated section of a larger building.
- The construction of a dedicated sampling area using 'A' or "L" concrete frames or similar.

It is important that the layout and structure of the area allows for the safe use of plant to drop and randomise (mix) the sample as necessary.

In any area considered, it is essential that personnel are kept clear of any transport that also may operate in the area; hazard tape, cones or tensor barriers are not considered suitable, any barriers used must be highly visible to plant operators.

Sampling should not take place where there is limited physical protection for personnel from vehicle movements.

12.2 Transport

Inevitably, vehicles will need to access the sampling and testing areas at times to deliver, drop, turn or level out waste to make it easier to extract a sample.

Vehicle/plant access points should be protected with a suitable barrier which could be manual or powered, or an alternative system, e.g. drop barrier, hinged gates etc.

Where provided, barriers should be:

- Robust, so that any driver will be aware of any collision with the barrier.
- Clearly visible (hazard stripes, painted in bright colours or similar).
- Clearly signed to indicate which vehicle/plant has permitted access.
- Capable of being closed/lowered/put in place from inside the sampling area.

The objective is the protection of personnel therefore skips, un-stacked bales or any other temporary items that require plant or a vehicle to move them may also be used to form temporary protection barriers.

12.3 Transport operating procedures

It is important that:

- Drivers never start or continue vehicle movements unless all personnel can be seen in the agreed safety zone, before and throughout any material transfer, depositing, levelling and removal activity.
- Drivers stop whenever any personnel are not visible in the pre-agreed safety zone.
- Personnel do not approach the sample unless the vehicle has withdrawn to its pre-agreed and demarcated safe place and has stopped or has exited the area.
- All other pedestrians are excluded from the sampling area.

12.4 Personnel accessing the sampling area

Any sampling area should have the following features:

- A separate pedestrian access point, i.e. vehicles and pedestrians should not use the same access point.
- Pedestrian routes to and from the sampling area situated away from other traffic movements.

Separate access for pedestrians can be achieved by creating a rear access door in an existing waste bay, for example, by leaving a gap in "A" / "L" frames to construct a protected sampling area. Every site will be different and this will be down to an individual site risk assessment of their sampling zones.

12.5 Personal Protective Equipment (PPE)

When undertaking sampling and testing personnel should:

- Wear personal protective equipment (PPE) as appropriate.
- Be adequately trained and provided with sufficient information and instructions about the tasks they are undertaking.
- Keep to the recognised safety pathways and protection zones when vehicles are operating.
- Be fully familiar with, and adhere to, the safe systems of work developed.

12.6 Safe systems of work

A safe system of work for sampling, should be available, this should include:

- When personnel can enter the sampling area.
- When vehicle/plant can enter the sampling or testing area.
- The safety protection zone to give personnel a protected area when vehicles/plant are in the sampling area.
- Clear instructions to vehicle drivers/operators to stop operating or moving if a sampler enters the sampling area.
- The route to be taken by the samplers to get to the sampling area.

When sampling and testing is aided by the use of mobile plant/plant, a safe system of work should reflect how:

- The vehicle will deposit the sample and then withdraw from the sampling area.
- The personnel approach the material from the safety zone and removes the requisite sample.

- The personnel return to the protected area.
- The vehicle enters the sampling area and turns the sample before withdrawing.

12.6.1 Sampling from a bale

In some instances the sample may have to be taken from a bale of material which necessitates cutting of the wires that hold the bale in place, this activity is a significant hazard. In these instances a recommended safety procedure for personnel is as follows:

- Place protective matting over the bale.
- Ensure that full face eye protection and forearm protectors are worn (along with other appropriate PPE).
- Proceed to cut the wire that is visible through the hole in the protective matting using long handled wire cutters.
- Remove the wire that has been cut from around the bale and continue to cut the wire into smaller manageable lengths. Ensure that these lengths will fit into a dedicated skip.
- Ensure all material has been removed from the wire.
- Do not leave any wire hanging over the edges of the skip.

Figure 3: Sampling material from a bale

12.6.2 Sampling from a conveyor with diverters

A MF may be considering taking samples directly from a conveyor through the use of a diverter, via either an automatic or a manual operation. Due to the variety of systems in place it is not possible to give specific guidance; each MF should carry out their own risk assessment and put in place a safe system of work to deal with the hazards and risks identified. Further information is provided in HSE Guidance 'Conveyor belt workstation design' available from www.hse.gov.uk.

In general when working near any conveyor personnel should:

- Wear hard hat/bump cap and safety shoes.
- Tie back (and tuck in) long hair.
- Know the location of the emergency "shut-off" devices and how to use them.
- Not wear loose clothing or jewellery.
- Not climb on the conveyors.

Sampling materials from a conveyor diversion point brings the potential for serious accidents therefore appropriate controls must be put in place and strictly adhered to at all times. All personnel must be trained and authorised to carry out this operation.

The general hazards for personnel performing a sampling operation will include material falling onto them, conveyors starting and trapping hands and working at height. These hazards will need to be considered on a site by site basis, however, for the purpose of this general guidance the operations have been separated into two areas, use of automatic and manual diverters.

Ideally diverters, whether automatic or manual should be located so that they are not above head height to avoid risks associated with falling objects, for example the divert might be placed at the end of a conveyor in a quality control cabin prior to discharge into the storage area. As it is recognised that this will not always be possible, the scenarios presented in below consider the use of diverts above head height.

Automatic diverters

Automatic conveyors delivering materials from above head height into a container or directly onto the floor can result in materials hitting any personnel stood beneath the conveyor. The basic control measures required will include:

- The controls to activate the diverter should be far enough away from the sampling point so that personnel can control the sample and watch it being taken but are protected during the operation, ideally behind a Perspex/protective screen.
- An alarm that is built into the system that sounds as soon as the diverter is activated to inform personnel that a sample is being taken from the line.
- A delay that should be built into the system to allow all personnel to clear the area.
- All personnel should remain clear of the sampling area until the diversion operation is completed.
- When there is a sufficient sample the conveyor operator should re-position the diverter to the normal operating position.
- The alarm should switch off when the operation is completed.
- Appropriate PPE should be worn (as per all sampling operations).

Manual diverters

With a manual diverter delivering materials from above head height into a container or directly to the floor the risks to personnel undertaking the sampling are significantly higher than where an automatic diverter is used as they have to manually carry out the operation whilst being in close proximity to the diversion area. The basic control measures required will include:

- An alarm that should sound when the conveyor is stopped in order to allow sampling to be undertaken.
- The conveyor must come to a complete stop, with a restart button positioned only in the area used by the personnel undertaking the sampling (in order to prevent the conveyor from being restarted from an external area).
- Personnel should access the conveyor via a hop-up or wheeled fixed step ladders (as shown in figure 4) that can be positioned next to the sampling area. The use of ladders or step ladders is not considered suitable.
- A hinged diversion point in the conveyor side wall should be dropped and the diverter placed into position.
- All personnel and access equipment should then be cleared from the area.

- An alarm should be activated informing all staff that a diversion sample is being taken and the conveyor is about the start.
- Once a sufficient sample has been taken the conveyor should be stopped and the access equipment repositioned.
- The material sampled should be cleared from the area, the diverter removed and the conveyor wall replaced.
- All personnel and access equipment should again be cleared from the area.
- An alarm should sound to indicate that the conveyors are about to re-start.
- When all samplers are clear of the area the conveyors can be restarted.
- Appropriate PPE should be worn (as per all sampling operations).

Figure 4: A wheeled fixed step ladder

12.6.3 Removal of materials from sampling area

Once sampling and testing is complete, the sample will need to be removed from the area to be returned to the sorting process.

The safe system of work for such a procedure should be based on a full risk assessment, but may include the following:

- The vehicle/plant arrives and stops at sample barrier/vehicle entrance.
- A member of staff will open the barrier and then clear the area.
- The vehicle/plant enters the area and collects the sample and removes it from the sampling area.
- The staff member closes the barrier.

12.7 Manual handling

Manual handling operations are a significant hazard within the waste industry: lifting, pushing, pulling and carrying can incur many types of musculoskeletal injury; predominantly to the back, but also sprains, strains, crushes and cuts to other parts of the body. To carry out any sampling and testing some form of manual handling is necessary.

All manual handling tasks should be assessed before being carried out. To assist in the risk assessment process, the HSE Manual Handling Assessment Chart tool (MAC) provides a step-by-step guidance.

Understanding the manual handling tasks provides information on various control measures that will be required. In general, these measures centre around a widely used industry acronym TILE:

- T - Task - what is the actual task that is going to be undertaken?
- I - Individual - is the person capable of completing the task safely?
- L - Load - what is the size and weight of the sample that the personnel will be moving?
- E - Environment - what is the sampling area like and is it suitable to perform the task?

A specific manual handling assessment is required under the Manual Handling Operations Regulations 1992 (as amended) and will need to take into consideration TILE. This is a matter though for individual assessment based on site operations and the nature of the wastes to be sampled.

Reducing manual handling
To reduce manual handling risks associated with sampling and testing, MF operators should consider:

- Using hand-operated grabs (sometimes called pick-up sticks) to reduce the need to bend/stoop.
- Using rakes or other reach tools to pull samples out.
- Providing basic manual handling training and instructions to all personnel who will be sampling and testing materials, which highlight associated risks.

12.8 Slips and trips

Slips and trips are one of the most common types of accidents suffered in the waste management industry and should be considered in the risk assessment of activities to help identify the control measures to put in place.

To reduce the potential of slips and trips consider:

- Designing sampling and testing areas that are well controlled, flat and even.
- Establishing good housekeeping standards in the sampling and testing area.
- Clearing the appropriate areas as soon as the sampling and testing is completed.
- Providing suitable footwear for the task.

12.9 Hygiene risks of sampling

Sampling and testing puts personnel in close contact with many waste products that have the potential to cause injury or ill health. These include:

- Contaminated sharps such as needles.
- Other sharps e.g. glass.
- Biological hazards.
- Chemical hazards from substances.
- Materials that produce hazardous dust i.e. asbestos.

All those undertaking sampling should be trained to be aware of the potential risks, what to look out for, PPE requirements and what action they should take if they find potentially hazardous materials.

12.10 Contact with hazardous waste

Preventing exposure to toxic chemicals is a primary concern at waste sites. Most sites will process product that may contain a variety of chemical substances in gaseous, liquid, or solid form. These substances can enter the unprotected body by inhalation, skin absorption, ingestion, or through a puncture wound (injection). An adequate risk assessment for sampling and testing should:

- Take into account all tasks that personnel may undertake and the foreseeable incidents that could lead to an exposure.
- Take into account exposure to chemicals via inhalation, ingestion and skin, eye or mucous membrane contact.
- Identify the control measures taken which are critical to the success of the control strategy.

12.11 Provision of personal protective equipment (PPE)

PPE should be provided to personnel to protect against hazards as identified in the sites risk assessment.

PPE provided could include any of the following but will be dictated by the sites risk assessment and may include:

- High-visibility clothing.
- Suitable gloves, forearm protection, taking into account the nature of the wastes being tested e.g. needle stick protection will be necessary.
- Safety boots/wellingtons (including mid-sole protection).
- Overalls/lab coat.
- A safety helmet or bump cap.
- Dust /respiratory protection.
- Hearing protectors.
- Eye and full face protection.

All PPE should have been assessed for their suitability to the task of undertaking sampling. Signage should be prominently placed to remind personnel of PPE requirements.

12.12 Training

Sampling activities should not be carried out unless those involved (including vehicle/plant operators) have been trained on the safe systems of work.

All vehicle/plant operators involved in sampling activities should be fully trained and competent in operating the plant they will be using.

13.0 Q&A

13.1 What are the benefits of sampling?

Beyond the regulatory requirements sampling and testing input and output materials can have a number of benefits for MF operators:

- Addressing contamination. Assessing contamination within the input stream allows:
    - Feedback to be provided to *Suppliers* in order that they can adapt their operations and communication activities to improve the quality of materials.
    - Consideration to be given to procedures used at the MF to assess and remove contamination before materials are processed, as well as to whether the MF operations and equipment are suitable to manage the type and quantity of contamination entering the MF.
    - The MF operator to identify whether *Suppliers* are meeting contractual requirements related to objectionable and prohibited materials.

- Understanding input composition. Assessing the type and weight of input materials can inform:
    - How the mix of materials may change seasonally allowing for operations to be adjusted to manage fluctuations efficiently and effectively.
    - An understanding of the value of the materials being input to the MF in order to ensure that value is retained and enhanced during processing.

- Understanding output composition. Assessing the type and weight of material outputs from the MF can:
    - Ensure that operations are effectively sorting materials to provide a clean end product free of contamination and cross contamination of other output materials, and inform operational improvements where this is not the case.
    - Demonstrate the quality of the product to reprocessors and assist in gaining higher prices for products.
    - Ensure that outputs remain consistent over time without significant variation in output quality.

- Understanding the composition of the residual fraction. Assessing the type and weight of residual materials can:
    - Help identify whether target materials are being lost due to sub-optimal sorting.

13.2 Who is responsible for choosing the sampling technique I use?

The MF can select any minimum sampling technique outlined in this document to best suit available equipment, space and presentation of the materials (e.g. loose, bagged or baled). The MF may use a combination of techniques as appropriate, for example where MFs receive bagged as well as loose material from suppliers or where the configuration of the MF means that different methods are required to sample input and output materials. Any new method used to sample materials should produce representative results to the standards and rigour outlined in this document. The *Regulator* may check the procedure during inspections.

13.3 What wastes need to be sampled?

Only material meeting the definition of *Mixed Waste Material* and *Specified Output Materials* needs to be sampled, regardless of what other wastes are handled at the MF. This will predominantly be mixes of household dry recyclables. Wastes 'similar to household wastes' from other municipal and commercial sources that are sorted and contribute to tonnages of *Mixed Waste Material* above the de minimis tonnage, must also be sampled. This would include mixtures of materials containing plastic bottles, glass bottles and jars, cardboard, drinks cans, etc, with typical sources being pubs, restaurants, universities and offices (further description is included in Section 3.2 of this document).

Input materials from households, or those which are similar in composition to materials from households (such as from small businesses), should be sampled. Samples should be taken for every 160 tonnes of material that an individual *Supplier* delivers during the first two years after the *Regulations* are introduced and then every 125 tonnes after this. *Specified Output Materials* must be sampled by grade (for example, as newspapers and magazines and cardboard as opposed to simply paper) and with a frequency of every 50 tonnes produced for glass, 20 tonnes for metals, 20 tonnes for plastic (then every 15 tonnes after 1 October 2016) and 80 tonnes for paper (then every 60 tonnes after 1 October 2016).

13.4 What will happen with the data I report?

Operators will submit their data to the *Regulator* and this will be published by the *Regulator* on a public register. A more searchable version of the data will also be provided in an online database.

13.5 How will the data from the online database be used?

It may include search functions to help users select the information they wish to view, for example, information related to a particular MF or local authority.

13.6 What if I change my *Specified Output Material*?

If an *Output Material* is changed then *Target Material, Non-Target Material and Non-Recyclable Material* must be re-defined to reflect the changes. If it is a completely new *Specified Output Material* for the MF that is significantly different from previous grades, for example a new material is being recovered from the incoming *Mixed Waste Material*, then it should be considered that zero tonnes have previously been produced and sampling scheduled accordingly. Where the change is minor, for example as a result of a change in the purchase specification of a reprocessor, then the tonnage of the related *Specified Output Material* produced since the last sampling was carried out should be considered when scheduling the next sampling exercise.

13.7 What if I supply *Output Material* to more than one reprocessor and each has a separate purchase specification?

Where the purchase specifications are broadly similar and the *Specified Output Material* supplied to all of the reprocessors interchangeably then a common sense approach should be taken to define what is *Target Material*, *Non-Target Material* and *Non-Recyclable Material* that will satisfy all reprocessors. The decisions taken regarding the definitions should be documented. Where any reprocessor's specification differs significantly from the norm for that grade of material, then it should be classified as a separate *Specified Output Material*.

13.8 I am a MF that handles more than 1000 tonnes of *Mixed Waste Material* per year. How do I class wastes derived from trade waste collections (or similar) that meet the definition of *Mixed Waste Material* but that is made up of collections from many small premises?

This *Mixed Waste Material* should be sampled in accordance with the *Regulations* and the *Supplier* should be determined in line with the *Regulations*. This typically will be the waste management company or local authority that collects the waste or, if this is not known, whoever is responsible for delivering the material to the MF. There is no need to sample from individual shops or premises.

If *Mixed Waste Material* from a *Supplier* is made up of co-collected waste from both household and commercial sources, the waste load must still be sampled and recorded. The presence of waste from commercial sources within a load of *Mixed Waste Material* makes no difference to this.

13.9 I have a MF sorting facility but also receive at the site materials that are already separated. How do I sample *Specified Output Material*?

You only need to sample *Specified Output Materials* generated from *Mixed Waste Materials*. In an example where you are producing glass from *Mixed Waste Materials* via sorting processes and also receiving separated glass from bring banks you only need to sample the glass that has been sorted from *Mixed Waste Materials*.

13.10 Can I undertake sampling from bulking points in order to assess the material from different sources before it is mixed?

In some instances *Mixed Waste Material* may be bulked prior to delivery to the MF. In such cases the *Supplier* should be attributed in accordance with the *Regulations*. Defra and the Environment Agency are looking into whether sampling at bulking points prior to *Mixed Waste Material* being delivered to the MF, and necessary compliance checking, might be feasible.

13.11 What is the maximum weight that can safely be lifted manually while sampling and testing?

The Manual Handling Operations Regulations 1992 (as amended) set no specific requirements such as weight limits. An ergonomic approach shows clearly that such requirements are based on too simple a view of the problem and may lead to incorrect conclusions.

This is backed up by modern medical and scientific opinion that emphasises the importance of an ergonomic approach to remove or reduce the risk of manual handling injury. Ergonomics is about 'fitting the job to the person, rather than the person to the job', it looks at manual handling as a whole. It takes into account a range of relevant factors, linked to TILE (as outlined in Section 13.7 of this document), the nature of the task, the load, the working environment and individual capability and requires worker participation. Further guidance on Manual Handling can be found in the *HSE guidance note L23: Guidance on the Manual Handling Regulations.*

13.12 How do I allocate the weight of *Material Particles*?

For the purposes of reporting it should be assumed that the composition of *Material Particles* reflect the overall composition of material being tested. Therefore the weight of *Material Particles* should be allocated as *Target Material*, *Non-Target Material* and *Non-Recyclable Material* in the same proportions as the non-*Particle* fraction. For example, if 7% of the material sorted is assumed to be *Non-Target Material* then 7% of the *Material Particles*

should also be assumed to be *Non-Target Material*. An example of this is provided in Table 5 below.

Table 5: Example categorisation of *Material Particles*

Allocation	Total retained weight (kg)	Particle weights (kg)	Total percentages (%)
Total weights	50	5	100
Target Material	40	4	80
Non-Target Material	7	0.7	14
Non-Recyclable Material	3	0.3	6

Assumed composition of the known total particle weight

13.13 What happens if the MF that I operate targets material that is not paper, plastic, glass or metal in *Mixed Waste Material*?

It is recognised that some MFs may be targeting materials, such as textiles, that are not a *Specified Output Material* (i.e. that are not paper, glass, metal or plastic). In this instance the material would still be considered to contribute towards to the tonnage of incoming *Mixed Waste Material* (i.e. it should not be deducted when deciding if the tonnages received by a facility would put it in scope of the *Regulations*) and it should be considered to be a *Target Material*. However, since it is not considered a *Specified Output Material* the *Regulations* would not require it to be separately sampled or separately reported. It should be included in the category of 'other' outputs (see Appendix C first table). Similarly, MF operators are only required to report average composition levels of input samples by reference to their glass, metal, paper or plastic content. As an addition to their legal obligation, they might choose to include target inputs such as textiles in their data on input averages (see Appendix C second table).

13.14 Where can I get help if I have further questions?

For general questions regarding sampling and testing at MFs you can contact WRAP (The Waste and Resources Action Programme). Local authorities could also address queries to their MF operator and waste management stakeholders to the Environmental Services Association or Resource Association. Telephone numbers are provided below:

- WRAP: 0808 100 2040
- ESA / WESA: 020 7824 8753
- Resource Association: 01943 464778

For questions regarding enforcement please contact the appropriate *Regulator*.

Appendix A: Example Specified Output Material Grades

Sampling of *Specified Output Materials* must be undertaken with consideration given to the grade of material output from the MF. Example grades of *Output Materials* are presented within the tables below.

Paper Grades	
Grade	**Comment**
Cardboard	Corrugated and non corrugated cardboard.
Newspapers and magazines	Including pamphlets.
Mixed paper	A mix of household paper and board grades. This would include office type paper grades.

Plastic Grades	
Grade	**Comment**
High Density Polyethylene (HDPE) bottles	Not colour sorted.
Natural HDPE bottles	Only natural HDPE bottles.
Coloured HDPE bottles	Predominantly coloured HDPE bottles.
Polyethylene Terephthalate (PET) bottles	Not colour sorted.
Clear PET bottles	Typically clear and light blue tint PET bottles.
Coloured PET bottles	Predominantly coloured PET bottles.
Polypropylene (PP)	Sorted PP pots, tubs, trays and bottles.
Mixed plastic bottles	Plastic bottles only.
Pots, tubs and trays (PTT)	A mixture of pots, tubs and trays that has not been polymer sorted.
Mixed rigid plastic	A mixture of rigid plastic packaging including bottles, pots, tubs and trays.
Mixed plastic	A mixture rigid and flexible plastic packaging including plastic bottles, pots, tubs, trays and films. Carrier bags may are likely to also be acceptable.
Household plastic film	A mixture of household derived films including carrier bags.

Metal Grades	
Grade	**Comment**
Aluminium	Aluminium drinks cans. This may include aluminium aerosols and foils if permitted by the reprocessor.
Steel	Steel drinks cans and food tins. This may include steel aerosols if permitted by the reprocessor.

Glass Grades	
Grade	**Comment**
Mixed coloured glass (container / glass fibre)	A mix of glass bottles and jars that has not been colour sorted.
Mixed coloured glass (aggregate / glass sand)	A mix of glass bottles and jars that has not been colour sorted.
Green glass	Green glass bottles and jars.
Clear (flint) glass	Clear glass bottles and jars.
Brown (amber) glass	Brown glass bottles and jars.

Appendix B: Annual Sampling Schedule

Indicative schedules based on sampling frequencies and weights required between 1 October 2014 and 1 October 2016 have been provided below for MF's with 1,000, 10,000 (three *Supplier*), 45,000 and 100,000 (five *Supplier*) tonne inputs of *Mixed Waste Material*. The input of *Mixed Waste Material* is shown in table B1 for each *Supplier*. The MFs in the example cases are all assumed to have the following output grades: newspaper and magazines, cardboard, mixed glass, steel, aluminium UBCs and mixed plastics. It should be noted that these schedules are examples of what would be required in these specific circumstances and are for illustrative purposes only. The taking of samples should be scheduled so that they give representative data on the *Supplier*. This can be achieved by changing the day of the week and time of the day that sampling occurs so that material is tested from a range of different collection routes.

The requirements in year one of the *Regulations* for sampling of input materials in this example are shown in Table B2 for each *Supplier*. To make the scenario more realistic each *Supplier* is presumed to be delivering a different tonnage to the MF. The sample frequencies are then multiplied by the required sample size to demonstrate the tonnage of material that would need to be sampled on a weekly and annual basis (shown on the right hand side of the table). Weekly figures are *Averages* based on sampling throughout the year.

Table B1: Assumed tonnes material input from each *Supplier*

	MF size (tpa)			
(throughput t)	**1,000**	**10,000**	**45,000**	**100,000**
Supplier 1	500	5,000	15,000	50,000
Supplier 2	300	3,000	10,000	15,000
Supplier 3	200	2,000	10,000	15,000
Supplier 4	-	-	5,000	10,000
Supplier 5	-	-	5,000	10,000

Table B2: MF input sampling schedule (based on sampling every 160 tonnes)

	MF size (tpa)			
(# samples pa)	**1,000**	**10,000**	**45,000**	**100,000**
Supplier 1	3	31	93	312
Supplier 2	1	18	62	93
Supplier 3	1	12	62	93
Supplier 4	-	-	31	62
Supplier 5	-	-	31	62

	MF size (tpa)			
(summary)	**1,000**	**10,000**	**45,000**	**100,000**
Sample t/pa	0.3	3.7	16.7	37.3
Sample #/wk	0.1	1.2	5.4	12.0
Sample kgs/wk	6	71	321	717

Table B3, below, shows the number of samples that would need to be taken from the *Specified Output Material* grades in year one of the *Regulations* in this example. Firstly the number of samples required for each grade per week is shown on the left hand side of the table and this is then scaled up to the number of samples per quarter and year in the right

hand side of the table. The latter also shows the tonnage of material that would have to be sampled based on the minimum required sample sizes under the *Regulations.* The taking of output samples should be spread across the different operating shifts (e.g. day and night shifts, weekends as well as weekdays, etc) to ensure the testing results are representative of the output of the MF.

Table B3: MF *Specified Output Material* sampling schedule

(# samples/wk)		MF Size (tpa)			
Granular output		1,000	10,000	45,000	100,000
News & Pams	40%	0.10	1.0	4	10
Card	15%	0.04	0.4	2	4
Glass	22%	0.08	0.8	4	8
Steel	3%	0.03	0.3	1	3
Aluminium	1%	0.01	0.1	0.4	1
Mixed Plastic	11%	0.11	1.1	5	11
Residual	8%	-	-	-	-

	MF size (tpa)			
Summary	1,000	10,000	45,000	100,000
Samples (#)/wk	0.37	3.7	16.4	37
Tonnes/wk	0.01	0.1	0.45	1
Samples/Q	4.8	48	213	481
Tonnes/Q	0.14	1.4	6	14
Samples/anum	19.3	192.	853	1,924
Tonnes/anum	0.54	5.4	24	54

Frequencies are rounded based on a bottom up calculation

Table B4 below shows an example monthly schedule for both input and output material sampling at a 45,000tpa MF.

Table B4: Example monthly sampling schedule for a 45,000tpa MF

An example sampling schedule for incoming *Mixed Waste Material* in the 45,000tpa MF (before 1 October 2016)

Action	Week 1	Week 2	Week 3	Week 4
Sample **Supplier 1** comingled input				
Sample **Supplier 2** comingled input				
Sample **Supplier 3** comingled input				
Sample **Supplier 4** comingled input				
Sample **Supplier 5** comingled input				

An example sampling schedule for outgoing *Specified Output Material* in the 45,000tpa MF (before 1 October 2016)

Action	Week 1	Week 2	Week 3	Week 4
Sample **Card** output				
Sample **Glass** output				
Sample **Steel** output				
Sample **Aluminium** output				
Sample **Mixed Plastics** output				
Sample **News & Pams** output				

Appendix C: Presenting the reported data

The tables below give an indication of the data from an MF for a reporting period that may be presented in the online database. The MFs are required to provide the data highlighted green within the tables below to the *Regulator.* Data highlighted in blue is not required but some of this may be calculated automatically and may appear on the online database. Data is fictitious and for illustration purposes only. Other' output streams means material leaving the MF which is not *Specified Output Material* (i.e. target paper, metal, glass or plastic). 'Other' output material might include targeted material that is not paper, metal, glass or plastic (e.g. textiles in *Mixed Waste Material* are a target material for some MFs) as well as residual waste.

General Tonnage Data	INPUT			SPECIFIED OUTPUT MATERIAL				OTHER OUTPUTS	
	Input	MF to MF Transfer		Paper	Glass	Metals	Plastics		
	(Tonnes)	(Tonnes)	Destinations	(Tonnes)	(Tonnes)	(Tonnes)	(Tonnes)	(Tonnes)	Destinations
TOTAL (Tonnes)	**12,046**	**46**	**Full List**	**5832**	**2802**	**1176**	**990**	**1100**	**Full List**
Local Authority 1	6505								
Local Authority 2	3132								
Local Authority 3	1320								
WM Company 1	1089								

INPUT DATA	Samples Taken	Total Sample	Average Composition By Target Material (%)					Average target			Average non-target	Average non recyclable
Supplier	(number)	Weight (kg)	Paper	Glass	Metal	Plastic	Other	Material %	SD	SE	Material (%)	Material (%)
Local Authority 1	49	2940	63	17.3	4.1	7.7	0	92.1	2.9	0.41	6.9	1
Local Authority 2	23	1380	57.6	8.1	5.3	18.7	0	89.7	1.6	0.33	6.4	3.9
Local Authority 3	10	600	50.1	14.9	3.3	28.1	0	96.4	2.3		0.4	3.2
WM Company 1	8	480	49.2	15.7	4.5	20.4	0	89.8	5.2		4.5	5.7
TOTAL/WEIGHTED AVERAGE (By sample)	**90**	**5400**	**58.90%**	**14.50%**	**4.40%**	**13.9%**	**0.0%**	**91.8%**			**5.8%**	**2.4%**

OUTPUT DATA	Samples	Total	Average Target Material %			Average	Average non
Material	Taken	Sample				non-target	recyclable
(unique to each MRF)	(number)	Weight (kg)		SD	SE	Material (%)	Material (%)
OCC	16	800	92.1	4.7		2.6	5.3
News & pams	40	2000	94.4	0.6	0.1	3.8	1.8
Mixed paper	42	2100	83.9	0.8	0.1	7.5	8.6
PAPER	**98**	**4900**	**89.5**			**5.2**	**5.3**
Mixed coloured container glass	38	380	82.7	2.2	0.4	10.6	6.7
Mixed coloured aggregate glass							
Green glass							
Clear glass							
Brown glass							
GLASS	**38**	**380**	**82.7**			**10.6**	**6.7**
Aluminium	6	60	99.4	5.1		0.2	0.4
Steel	16	160	92.6	2.7		1.8	5.6
METALS	**22**	**220**	**94.5**			**1.4**	**4.1**
HDPE bottles							
Natural only HDPE bottles							
Coloured HDPE bottles							
PET bottles							
Clear PET	11	220	94.6	2.2		2.8	2.6
Coloured PET bottles							
Polypropylene							
Mixed bottles	53	1060	92.8	0.7	0.1	1.3	5.9
Pots, tubs, trays							
Mixed rigid plastic	7	140	93.8	4.5		1.9	4.3
Mixed plastic	8	160	85.4	5.1		2.8	11.8
Household Film	3	60	87.3	6.8		6.2	6.5
PLASTICS	**82**	**1640**	**92.2**			**1.9**	**5.9**
TOTAL/WEIGHTED AVERAGE (By sample)	**240**	**7140**	**89.8%**			**4.6%**	**5.6%**

Calculating the weighted average for paper, glass, metal and plastic based on the individual grade sampled

The average *Target Materials, Non-Target Materials* and *Non-Recyclable Materials* content for each of the main material streams (glass, metal, paper and plastic) should be reported. However since the sampling itself focuses on the *Specified Output Material* by grade a weighted average of sampling results is needed for reporting by material streams. As an example, within the broad category of paper there are likely to be a number of grades such as News and Pams, Card and Mixed Paper, each with different compositions of *Target Materials, Non-Target Materials* and *Non-Recyclable Materials* and each will be produced by the MF in different quantities. In the example given, the average *Target Material* for paper would be based on the *Target Material* content of the News and Pams, OCC and Mixed Paper and each of these should be represented in the overall average for paper based on their relative weight. As the sample sizes of all *Specified Output Materials* for a particular material type are the same, the number of samples taken can be used to determine the weighting. An example is below.

A MF has a target material content in Card of 98% (based on 3 samples), in News and Pams of 96% (based on 4 samples) and in Mixed Paper of 92% (based on 2 samples). The average *Target Material* for paper can be calculated to be:

Average Target Material Paper (%) = (98 x 3)+(96 x 4)+(92 x 2) / 9

This comes to 95.8%.

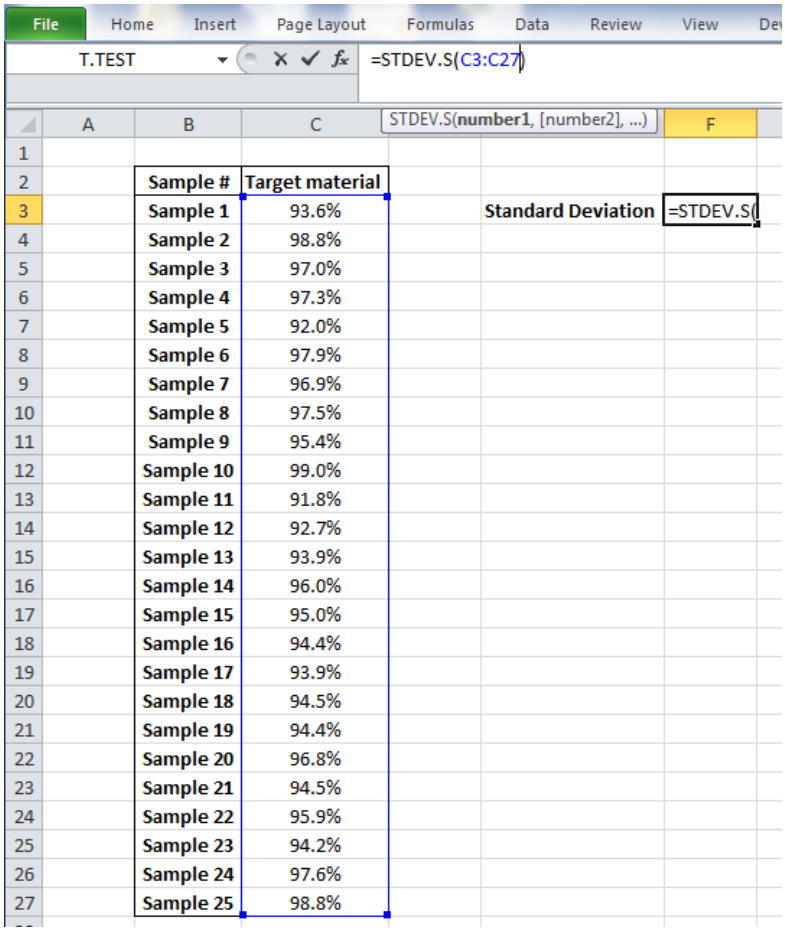
This calculation would need to be repeated for *Non-Target Material* and *Non-Recyclable Material* content also.

It should be noted that there will be a minor error associated with the weighting as, although sample sizes for each grade of material within the same category should be the same, it is likely that in reality there will be slight variations.

Appendix D: Calculating Standard Deviation using Excel

The standard deviation of a set of results can be calculated using one of the built in formulae in Microsoft Excel. The cell in which the standard deviation is to be displayed should be selected. The text: =STDEV.S(insert results here*) should be entered into the formula bar. The standard deviation for the selected range of cells will be displayed after pressing return. An example of such a calculation being executed is presented below.

*the cell references for the results should be entered here e.g. C3:C27, these can be typed in manually or selected with the mouse while entering the Standard Deviation formula



Sample #	Target material
Sample 1	93.6%
Sample 2	98.8%
Sample 3	97.0%
Sample 4	97.3%
Sample 5	92.0%
Sample 6	97.9%
Sample 7	96.9%
Sample 8	97.5%
Sample 9	95.4%
Sample 10	99.0%
Sample 11	91.8%
Sample 12	92.7%
Sample 13	93.9%
Sample 14	96.0%
Sample 15	95.0%
Sample 16	94.4%
Sample 17	93.9%
Sample 18	94.5%
Sample 19	94.4%
Sample 20	96.8%
Sample 21	94.5%
Sample 22	95.9%
Sample 23	94.2%
Sample 24	97.6%
Sample 25	98.8%

Appendix E: Further Use and Interpretation of Statistics to Aid Operations

Although it is not a requirement of the Regulations it is recommended that the standard deviation information is used by operators to calculate the 'standard error of the mean' (SEM) and confidence interval for the reported mean (average).

The SEM is an indication of how close the calculated arithmetic mean of the samples taken is to the true mean of the waste stream under consideration. The SEM is influenced by both the standard deviation and the number of samples that have been taken. In the worked example, shown graphically below, the SEM is 0.42%, which is relatively low.

The SEM can in turn be used to calculate the confidence interval. A 95% confidence interval is 1.96 standard errors either side of the calculated arithmetic mean. So, for example, if the arithmetic mean level of Target Material in a sample is calculated to be 95.6% and the SEM is 0.42%, then there is a 95% confidence level that the true arithmetic mean is 95.6% +/- 0.82% (i.e. between 94.78% and 96.42%, as shown in the worked example below).

It should be noted that, as with standard deviations, more than 25 samples are needed to produce statistically meaningful SEM and confidence interval results.

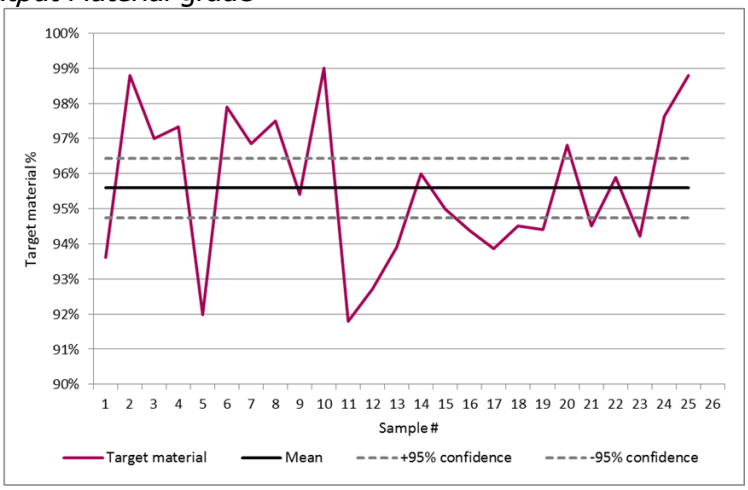
Worked example of calculating and interpreting statistics

The statistical analyses outlined above are applied to the 25 samples of a *Specified Output Material* to calculate the percentage *Target Material*, collected by the example MF in Figure 3.

- The MF operator inputs the number of samples they have taken (25), the *Average* of these 25 samples (95.6%), and the standard deviation of the 25 samples (2.1% as calculated using the instructions in Appendix D) into the data input tables for the *Regulator* (see Appendix C). This value shows how varied the samples are.
- The standard error of the mean is calculated automatically; this calculation is the standard deviation (2.1%) divided by the square root of the number of samples taken (√25), which in this case is 0.42. This figure indicates the confidence that the sampled values represent the actual ones.
- The confidence interval is calculated by multiplying the SEM by 1.96 (0.42 x 1.96), which in this case is 0.82. With this statistic, the MF operator can be 95% confident that the *Average* they calculate is +/- the CI.
- With these statistics, the MF operator knows:
    - The *Average* percentage of *Target Material* in the samples from this grade was 95.6%;
    - Approximately 68% of the 25 samples were within 2.1% of 95.6%, so the % *Target Material* for the samples from this grade were very consistent; and
    - Based on the sample, the MF can be 95% confident that the *Average* percentage *Target Material* for this *Specified Output Material* is 94.78% - 96.42%.

Example statistics for a *Specified Output Material* grade

Sample #	Target material
Sample 1	93.6%
Sample 2	98.8%
Sample 3	97.0%
Sample 4	97.3%
Sample 5	92.0%
Sample 6	97.9%
Sample 7	96.9%
Sample 8	97.5%
Sample 9	95.4%
Sample 10	99.0%
Sample 11	91.8%
Sample 12	92.7%
Sample 13	93.9%
Sample 14	96.0%
Sample 15	95.0%
Sample 16	94.4%
Sample 17	93.9%
Sample 18	94.5%
Sample 19	94.4%
Sample 20	96.8%
Sample 21	94.5%
Sample 22	95.9%
Sample 23	94.2%
Sample 24	97.6%
Sample 25	98.8%



RootN	5	Mean	95.6%
Standard error	0.42%	Std Dev	2.1%

$$95\%\ \text{Confidence} = \left(\frac{\text{Standard Deviation}}{\sqrt{\text{Number of samples}}}\right) \times 1.96$$

Standard error

Although it is not a requirement of the Regulations it is recommended that where a MF carries out less than 25 samples on a given material stream in a Reporting Period that they carry out additional standard deviation, SEM and confidence calculations on a cumulative basis once a suitable number of samples have been taken for their own internal purposes. It may also be beneficial to calculate the standard deviation for the Non-Target Material and Non-Recyclable Material content for each Supplier's Mixed Waste Material and also for Specified Output Materials.

Assessment of statistical error associated with individual samples

Again, although it is not a requirement of the Regulations to assess the statistical error associated with samples, operators should be aware that, when interpreting the variability of target material content across a range of sample results, they can also assess the statistical error associated with an individual sample, which is linked to the number of items within that sample.

This error is an estimate of the standard deviation for material sampled at that time, assuming that the size of items of the target material is similar to the size of non-target items. It does not account for variation over time (for instance, related to seasonal variation or variation linked to where material has been sourced).

The error relates to the probability that the Target Material content of an individual sample is the same as that of the entire population (i.e. the load of Mixed Waste Material being delivered or the entire run of a Specified Output Material). It should be noted that in some instances, particular individual sampling errors may vary (sometimes greatly) from the overall standard deviation calculated from many samples.

The larger the weight of the sample taken, and consequently the more items it has in it, the more likely it will be that the target material content in the sample will be similar to that of the waste stream at the time of sampling and as such the more robust the sample will be.

Should an operator wish to understand the potential impact of the error associated with individual samples then the standard statistical formula used is known as the "Cochran's formula for determining sample size". Details of the formula and its appropriate use can be found on a variety of websites and in statistics text books.

An example of the output of the calculation is provided below.

$$95\%\ confidence\ interval\ around\ sample\ mean = \ 1.96\sqrt{\frac{p(1-p)}{N}}$$

Where:
N = number of items
p = probability of picking = composition in master population

As a worked example, a 50 kg sample of News & Pams is considered in which each item present (a newspaper, a magazine, etc) weighs an *Average* of 150 grams there will be 333 items. If this *Specified Output Material* contains 96% *Target Material*, then…

N = 50 kg/0.15 kg = 333 items

P = 0.96 (for 96% target material)

95% confidence interval = 1.96 x √ [0.96 x (1 – 0.96) / 333] = 0.011 = 1.1%

So, the individual sample error (or confidence interval) calculated by using Cochran's formula is ±1.1% at a 95% confidence level. As such, the observed composition based on an assumed 96% level of target material is likely to be between 94.9% and 97.1%. This assumes that target items are of a similar weight to non-target items. Furthermore, it gives no information about the variation over time in target material within a waste stream (e.g. seasonal effects).

Waste & Resources Action Programme

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