Final Report

MRF Output Material Quality Thresholds

A report on materials quality standards, quality measurement techniques and their implementation by UK MRFs and materials reprocessors.

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WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

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Front cover photography: A PET bale awaiting weight based quality assessment, Resource Futures

Executive summary

Resource Futures was contracted by the WRAP (Waste & Resources Action Programme) to carry out a project to investigate the quality requirements of UK reprocessors and their relationship to the output from UK materials recovery facilities (MRFs). In particular, the project aimed to assess the following:

- The quality levels required by UK reprocessors across a range of materials.
- The extent to which quality requirements are material specific or are specific to individual reprocessors.
- Whether these requirements are clearly stated in written form, or, if not, what form they take (informal client-supplier relationships, specified in contracts etc).
- How quality is measured and assessed, both by MRFs (output quality) and reprocessors (input quality).
- Whether MRFs are typically able to meet the quality requirements set out by reprocessors.
- Whether reprocessors' decisions to accept or reject loads are perceived by MRF operators as fair and well managed.
- Whether demand exists for the introduction of more formal material quality thresholds and methods for determining whether these have been met.

If demand for formal thresholds was assessed as high, the project was to make initial recommendations as to how these might be established. The key project deliverables were:

- A desk-based review of current reprocessor quality standards.
- A questionnaire for MRF operators and reprocessors to establish what quality control procedures are typically in use, perceptions of MRF output quality and reprocessor quality specifications and opinions on the value of material quality thresholds and other potential schemes to improve or guarantee MRF material quality.
- Site visits to reprocessors to gain insight into how input quality is managed and the consequences of low quality input.
- Convening a high-level steering group with representatives from MRFs and reprocessors across the range of materials to coordinate and shape the direction of the project.

A combination of desk based research, consultation with the steering group and responses to the MRF and reprocessor questionnaires were able to answer some of the initial research questions:

- The material quality standards in place are very much specific to reprocessors, with most issuing a written quality specification. Where standards and specifications (e.g. BS EN and PAS) have been published, these are generally borrowed from or adapted as suits the needs of reprocessors. As a result, not only are the standards for a given material variable, but they are also phrased and expressed quite differently depending on the specific reprocessor.
- While most reprocessors had a written quality specification document, this was not always the case, with a substantial minority of reprocessors relying on occasional, informal inspections, with no formal method of assessment or yardstick to measure against, and informal supplier–client relationships functioning in place of a quality management system. This was more common in some sectors (e.g. glass, steel and mixed plastics) than others.
- There was a disjunction between MRFs' claims about being able to meet quality standards and reprocessor claims of the proportion of MRF output that is of suitable quality. Across all materials without exception, most MRF operators claimed that their material "always" met the required standard, while almost all of the remainder claimed to "usually" meet the standards. By contrast, the majority of reprocessors across all materials said that MRF output only "sometimes" met their standards, with only one respondent saying that it "always" did.

- Most MRF operators said that their UK customers produced a clear, written quality specification. The UK compared well with overseas buyers in this respect, with more MRFs saying their UK customers had clear written standards than saying their overseas customers did. In addition, when asked if they believed UK reprocessors vary the quality of material they would accept depending on their demand, the majority of MRF operators said they did not believe this to be the case. This suggests that most MRF operators believe UK reprocessor standards to be reasonably clear and consistently supplied. It should be noted, however, that anecdotal evidence from several MRFs suggested that a minority of MRF managers do believe that reprocessors are prepared to move the goalposts depending on demand.

From the first steering group meeting it became apparent that there was little appetite for formal materials thresholds, among either MRFs or reprocessors. The overall feeling was that reprocessors should be able to issue quality thresholds as they see fit, and it was recognised that any such published standards would be secondary to individual commercial arrangements between reprocessors and their suppliers.

What did emerge from the steering group meetings was a demand for more consistency in how MRFs and reprocessors evaluate the quality of materials, and in how the results of these evaluations are described.

Production of a PAS for standardised weight-based testing

The steering group considered that the production of a standardised regime for weight-based material sampling and testing would help buyers and sellers and provide an incentive to improve product quality.

Suggestions as to what such a regime might look like were covered in a discussion document produced for the third steering group. This is discussed in the body of the report, and the document reproduced in Appendix 3. Following discussion of these suggestions, it was concluded that the next step should be formulation of a Publicly Available Specification (PAS) document covering material sampling and testing.

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1.0 Introduction

1.1 Project overview

In October 2008, Resource Futures was contracted by WRAP (Waste & Resources Action Programme) to carry out a project to investigate the quality requirements of UK reprocessors and their relationship to the output from UK materials recovery facilities (MRFs). This project was named **MRF010: MRF output material quality thresholds**. In particular, the project aimed to assess the following:

- The quality levels required by UK reprocessors across the main range of materials sorted at UK MRFs.
- The extent to which quality requirements are material specific or are specific to individual reprocessors.
- Whether these requirements are clearly stated in written form, or, if not, what form they take (informal client-supplier relationships, specified in contracts etc).
- How quality is measured and assessed, both by MRFs (output quality) and reprocessors (input quality).
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- Convening a high level steering group with representatives from MRFs and reprocessors across the range of materials to coordinate and shape the direction of the project.

1.2 Structure of this report

This report can be split into two main parts. The first addresses current practice, while the second formulates suggestions for improvement and looks at how these can be taken forward.

Chapter 2 addresses the perceptions of the quality gap mentioned briefly in the introduction, drawing on the findings of the MRF and reprocessor questionnaires to examine current attitudes to quality standards and the ability of MRF outputs to meet these standards.

Chapter 3 will provide an overview of current practice regarding material standards and thresholds, looking both at published standards and specifications and at quality standards set by individual reprocessors. This chapter is based mostly on the desktop review stage of the project, informed by additional information from the questionnaires, site visits and informal conversations with MRF operators and reprocessors. The chapter will conclude with some general observations on how material standards are currently framed and will make some suggestions as to how standards could be made simpler and more consistent.

Chapter 4 will present a review of current approaches to measuring and describing material quality. Again, this chapter will combine the findings of the desktop review with findings from the questionnaires and site visits. It will discuss the pros and cons of different approaches to assessing quality and identify areas where improvements might be made.

Chapter 5 will look at a range of next steps that were considered by the project team and the steering group, and will examine the questionnaire responses to these suggested steps. It will present an overview of the contents of a discussion document prepared for the third and final steering group meeting (the full document is included as an appendix) and present the response of the steering group.

Chapter 6 will recap and expand upon the project finding in terms of improving the consistency and transparency of quality standards and developing a common materials analysis methodology, and will conclude by indentifying some recommended next steps to move the agenda forward.

2.0 Attitudes to quality standards

As part of the MRF010 project, questionnaires were circulated to MRFs and reprocessors, to gather information on current quality management practices and to canvass opinion on the current situation. Copies of the questionnaires can be found in Appendices 1 and 2. 48 reprocessor questionnaires were distributed, producing 13 useable responses. 85 MRF questionnaires were distributed, with 27 useable responses received. While these numbers are relatively low, they did exceed the project targets of 20 MRF responses and 10 reprocessor responses.

The results provided a useful supplement to the opinions stated by members of the steering group and enabled a broader spread of opinions to be canvassed. While the responses do not provide representative data, from a statistical point of view, of the opinions of MRFs and reprocessors generally, they do give useful insight into their views from a range of key operators of each kind and so the results may be taken to give a strong indication on the issues covered.

2.1 MRFs attitudes to reprocessor standards

An initial question raised by the project brief was the appropriateness of current standards, including the extent to which MRF operators felt that standards were clear. MRF operators were asked the question: “For each material you produce, do the UK customers you sell to have clear, written quality threshold requirements?” The numbers of responses of each kind are shown in Table 1 below – don’t know responses and responses from MRFs that do not sell materials in the UK have been omitted for ease of comparison.

Table 1 Q16 – Do the UK customers you sell to have clear written quality requirements?

	Number of responses		
	Clear requirements	**Requirements not clear**	**Total**
Paper (news & pams grades)	20	3	23
Paper (mixed)	17	4	21
Cardboard	18	5	23
Aluminium cans	23	2	25
Steel cans	20	4	24
Plastic bottles (PET)	12	1	13
Plastic bottles (HDPE)	13	2	15
Plastic bottles (mixed)	16	7	23
Glass	13	3	16

The results suggest that, overall, MRF operators felt that the quality standards requested by UK materials reprocessors were clear. The worst performer in this regard was mixed plastic bottles, but even here 70% of respondents felt the standards were clear.

In order to compare these results with results from other markets, respondents were also asked: “For each material you produce, do the overseas customers you sell to have clear, written quality threshold requirements?” The responses are shown in Table 2.

Table 2 Q18 – Do the overseas customers you sell to have clear written quality requirements?

	Number of responses		
	Clear requirements	**Requirements not clear**	**Total**
Paper (news & pams grades)	9	5	14
Paper (mixed)	10	5	15
Cardboard	12	5	17
Aluminium cans	6	4	10
Steel cans	9	4	13
Plastic bottles (PET)	4	1	5
Plastic bottles (HDPE)	3	1	4
Plastic bottles (mixed)	8	4	12
Glass	3	1	4

For all materials, a lower proportion of respondents felt that overseas standards were clear, than felt UK standards were clear, suggesting that UK reprocessors are framing more clear cut standards than overseas, at least from the perspective UK MRF operators. The worst performers among overseas standards were aluminium cans (60% said standards were clear) and news and pams grades paper (64% said standards were clear). One criticism raised by some MRF operators during informal discussion was that reprocessors do not apply published standards consistently. The perception expressed was that reprocessors are more lenient when demand for material is high and stricter when demand is low. To test the prevalence of this belief, MRF operators were asked: "If demand for UK processors' products is running high, do they still demand the same quality as when demand is low?" The results are shown below.

Table 3 Q15 – If demand for UK processors' products is running high, do they still demand the same quality as when demand for their products is low?

	Yes	**No**	**Don't know**
Paper (news & pams grades)	18	4	4
Paper (mixed)	17	4	4
Cardboard	18	4	4
Aluminium cans	20	3	4
Steel cans	19	4	4
Plastic bottles (PET)	10	2	5
Plastic bottles (HDPE)	11	2	5
Plastic bottles (mixed)	18	5	4
Glass	14	2	7

These results suggest that most MRF operators do *not* believe that reprocessors alter standards in response to demand. The worst performer in these terms was PET bottles, where 59% said that standards were consistent. If one omits the "don't know" answers, the worst performer was mixed plastic bottles, with 78% saying that standards were consistent. These results, however, imply that a substantial minority of MRFs do believe that reprocessors vary their acceptance criteria depending on their demand for input. This problem could be resolved by improved communication and through a consistent method for assessing materials, such as the one suggested in this report.

Overall though, the answers to these questions suggest that MRFs think UK reprocessor standards are clearer than overseas standards and are consistent in the face of fluctuating demand. When asked: "Does your MRF output currently (over the past 3 months) meet the quality requirements discussed in question 16?", the following responses were obtained.

Table 4 Q17 – Does your MRF output currently (over the past 3 months) typically meet the quality requirements of your UK customers?

	Number of responses			
	Always	**Usually**	**Often not**	**Not at all**
Paper (news & pams grades)	17	7	-	-
Paper (mixed)	16	5	1	-
Cardboard	21	4	-	-
Aluminium cans	20	7	-	-
Steel cans	23	4	-	-
Plastic bottles (PET)	12	2	-	1
Plastic bottles (HDPE)	14	2	-	1
Plastic bottles (mixed)	21	3	-	-
Glass	12	4	-	-

MRFs overwhelmingly claimed that their material output always met the quality thresholds set by reprocessors. News and pams was the material where MRFs were least confident, but even here, 71% claimed always to meet the standards, with all the remaining 29% usually meeting them.

It is perhaps not surprising that most MRFs took the opportunity to promote the quality of their outputs. Some measure of how realistic their claims are can be gained by comparing their views with those of the reprocessors they supply.

2.2 Reprocessor attitudes to MRF output standards

While MRFs gave broadly positive responses on the issue of reprocessor standards, the responses from reprocessors seemed to show a lower degree of satisfaction. In a question analogous to that shown in Table 4 above, reprocessors were asked: "What proportion of MRF output typically meets your quality specification?" A summary of responses is shown in Table 5.

Table 5 Q11 – What proportion of MRF output typically meets your quality specification? n=13

	Combined	Paper	Aluminium cans	Steel cans	Plastic botttles (PET)	Plastic bottles (HDPE)	Plastic bottles (mixed)	Other plastics	Glass
All	1	-	-	-	-	-	-	-	1
Most	4	-	-	1	1	1	1	1	2
Some	6	2	1	-	1	2	2	1	-
Hardly any	2	-	-	-	-	1	-	-	-

Table 5 shows that the reprocessors that were contacted did not share the MRFs' views as to the proportion of material compliant with their standards, with only one respondent saying that MRF material always met the required quality standard, and the majority saying that only "some" or "hardly any" was of a suitable quality. It should be noted that the MRF and reprocessor responses are theoretically compatible – it could be that MRFs sell the bulk of their material to a small number of buyers who operate with lower standards and who *are* generally happy with the quality of the material they receive, while a large number of reprocessors each buy very little MRF output and are generally less satisfied. Either way, the high opinion of MRFs of their own outputs is not shared by reprocessors.

Reprocessors were also asked: "How would you say the material you source from fully co-mingled MRFs compares to other waste and recycling derived inputs that you use?", and the results are shown in Table 6.

Table 6 How would you say the material you source from fully co-mingled MRFs compares to other waste and recycling derived inputs that you use? n=10

	MRFs typically better	MRFs typically same	MRFs typically worse	Don't know
Two-stream MRF	-	2	7	1
Source separated/kerbside sorted	-	2	7	1
Bring schemes	-	2	7	1

No reprocessors questioned said that MRFs typically produced a better standard of material than other sources; discounting the "don't know" responses, in each case 78% of respondents said they believed the material to be of a lower quality.

This opinion was generally backed up by the site visits[1] to reprocessors, though in all cases the reprocessor's representative stated that, while MRF product was generally of a lower quality, this was not universally the case, and that no collection method was in itself a guarantee of a quality product.

3.0 Overview of current quality thresholds

The review of existing written materials standards found a range of practices. However, it should be noted that this review covered only written documents - some MRFs asked to supply copies of the standards documents they had received from their brokers and reprocessors did not initially understand the question, and were not aware that such documents existed. Many appeared happy to leave quality inspection to buyers, accepting the occasional rejection without enquiry as to the requirements against which the load was assessed. Similarly, some reprocessors did not issue a written quality threshold, managing quality though informal inspection and through maintaining relationships with their suppliers.

Of the 13 reprocessors who responded to the questionnaire, 8 issued a written quality threshold and 5 did not. This latter approach which involves more informal agreements with a view to managing quality seemed to be more common in some sectors (such as glass, steel cans and mixed plastics) than in others (all the paper manufacturers and brokers contacted had written specifications). It therefore needs to be appreciated that there is an informal side to the management of quality in addition to the formal standards assessed in the review. The standards examined can be divided into formal, national standards (such as PAS specifications and BSI standards) and those issued by reprocessors as criteria for the acceptance of input material. These will vary across reprocessors, reflecting different technologies and end products.

The aim of a quality threshold is to ensure that the reprocessor is purchasing material suitable for the purpose to which it is to be put. Material delivered to a reprocessing facility is assessed against this threshold as a criterion for acceptance, with material that does not meet the standard being rejected or purchased at a reduced price to reflect its lower quality.

From this, it follows that standards must define what materials are allowed, and what are regarded as contaminants, and must determine how much contamination is acceptable in a load. To work effectively, a quality threshold needs to be clearly stated, and phrased in such a way that loads can be measured against its requirements without ambiguity.

The need for clear and unambiguous criteria for acceptance and rejection has a corollary – it is problematic to set material thresholds at 0% (where any presence of the material is automatic grounds for rejection) for contaminants that are likely to be reasonably common in a given recyclate stream. In such cases, setting a threshold at 0% introduces an element of arbitrariness into the evaluation, because most recovered material will have at least some prohibitive contamination[2]. The assessor is likely to be accepting loads where the contaminant

[1] Site visits were conducted at Aylesford Newsprint, UPM Shotton paper mill and the Novelis aluminium recycling plant.
[2] Studies examining the composition of MRF output quality on behalf of WRAP have shown that glass, for example, is almost always found, albeit in very small quantities, when analysing 75-100kg samples of paper or 25kg samples of plastics. The implication of this is that almost all loads will contain at least some glass, including those typically accepted by paper mills and plastics reprocessors.

is present in some amount (however small) and this means that the decision to reject is made at the discretion of the assessor rather than on objective criteria.

A range of standards and specifications was gathered for examination and analysis, across the following materials:

- Paper
- Plastics
- Glass
- Aluminium
- Steel

Standards were assessed primarily through a desktop review, with additional information gathered through the questionnaire, the steering group meetings and informal discussions.

3.1 Paper

By weight, paper is the single biggest input to, and product of, MRFs. It is also one of the more problematic output streams with regard to quality issues between MRFs and reprocessors. Consultation with paper reprocessors, questionnaire responses and site visits to paper mills found that glass is the most serious contaminant, as it damages mill equipment, particularly the fine screens that the fibre is passed through in order to clean it. Grease is also problematic in that it soaks into the paper, while some mills, depending on the technology they employ, have problems dealing with plastic film.

The most notable thing about all these contaminants is that they are hard to spot and hard to remove using a mechanical process. This situation is complicated when paper becomes damp during the collection or handling process, which changes the behaviour of the material. In addition, most co-mingled recycling is compacted during collection, which breaks the glass into small pieces that become embedded in the fibre. These are the potential problems that paper mills' material thresholds aim to identify and prevent, by preventing contaminated materials from entering the production process.

The project team assessed two national specifications, PAS 105 and the under-revision BS EN643. In addition, five company-specific standards from reprocessors and brokers were examined, along with a national standard from the US (the ISRI scrap specifications).

3.1.1 PAS 105: Recovered paper sourcing and quality for UK end markets

PAS 105 mostly concerns good practice in collection, storage and transportation of recovered paper from kerbside collections, bring sites and HWRCs. It bases its suggested quality standards loosely on the previous BS EN643, which did not contain contamination thresholds and functioned as a descriptive grading standard for material consignments. PAS 105 distinguishes between the following types of contamination:

- **Contaminants** (fibre detrimental to production).
- **Contraries** (non-fibre contamination).

PAS 105 does set standards for newspapers and magazines, OCC, mixed papers and office papers. These have a descriptive definition, some notes on typical requirements and a contraries threshold. This is set at 2% for all materials, except office papers, where it is 1%. PAS 105 states that the contraries in a load must not include wax, bitumen board or burnt material, effectively setting these up as a third type of contaminant, which is completely prohibited. It also sets a moisture threshold of 10%, in line with BS EN643.

3.1.2 BS EN634

The under-revision BS EN643, like its predecessor, concerns itself mostly with defining and describing different grades of paper. Grades are defined with a code, a title, a verbal description, and tolerances for non-paper components and total out-throws.

The revised BS EN634 sets quality thresholds in more detail than the previous iteration, dividing non-target materials into the categories of:

- Prohibited – including glass, bitumen, food and hazardous waste. This material has a default zero tolerance unless specifically included in the grade description.
- Total out-throws – which refers to all other contaminants, and is in turn subdivided into:
    - non-paper components (cans, plastics, sand, wood etc); and
    - paper and board detrimental to production (waxed papers and other non-target fibre).

The verbal description accompanying each grade includes tolerances for different types of recyclable paper, and includes notes on any prohibited materials (e.g. newspaper and magazines, with a minimum of 50% newspaper, with or without glue).

Tolerances for ordinary grades are typically abound 2-3% for total out-throws, of which 0.5-1% can be non-paper components.

3.1.3 ISRI standards for recovered paper
The US Institute of Scrap Recycling Industries (ISRI) specifications are a guide to assist buyers and sellers of secondary materials and products. These standards are also used outside the US, including by some UK MRFs. The ISRI defines 51 grades of paper that cover a wide quality range. These are described in a similar way to BS EN643, with the exception that contaminants are divided into prohibitives (such as glass, bitumen etc) and total out-throws, with no formal distinction between fibre and non-fibre contamination.

Several ISRI standards would be applicable to MRF output. Mixed paper is sub-graded as follows:

- Residential Mixed Paper – which includes all clean fibre as a target material, and specifies a maximum of 2% prohibitives and 5% total out-throw.
- Soft Mixed Paper – targets, maximum 1% prohibitive and 5% total out-throw.
- Hard Mixed Paper – targets all clean fibre with a maximum 10% groundwood content, with a maximum of 0.5% prohibitive and 3% total out-throw.

Other relevant grades would be News (newspaper of standard typically generated by kerbside collections, containing a maximum 1% prohibitive and 5% total out-throw); and Magazines (coated magazines, catalogues etc, which may contain a "small percentage" of uncoated news-type paper along with up to 1% prohibitive and 3% total out-throw).

3.1.4 Reprocessor standards
The project team assessed five company-specific paper standards. These were generally clear, though most had areas that deserved clarification and there was little consistency in how standards were framed. For example, one standard was based on a distinction between target material, objectionable material and prohibitive material, with contaminants categorised according to the damage that the material might do to the equipment and the difficulty of removing it. Another distinguished between contamination based on whether the contaminant is fibre based or non-paper, without regard to the damage it might cause. A third made a distinction between unusable materials (such as staples, tape etc, with 1% tolerance), detrimental paper and board (such as waxed or wet strength paper, with 1% tolerance) and non-paper components (with zero tolerance) – this leaves a potential confusion over whether a material is unusable or non-paper, exacerbated by the inclusion of waxed paper as a non-paper component, when it had already been given as an example of paper detrimental to production.

All the reprocessor standards examined, with one exception, took a zero tolerance approach to glass, food waste, grease and burnt material. Most also set a limit to moisture content, of around 10%.

Table 7 presents an overview of the standards examined. To enable comparison, these standards have been rephrased in terms of a distinction between Objectionable and Prohibitive materials. The table shows which category each material is classified under and gives thresholds at the bottom. Blank values indicate that this material was not referenced in the standard. There are 6 standards referenced in this table, as one of the reprocessors had two different standards documents in circulation.

Table 7 Summary overview of reprocessor's paper standards

	Reprocessor standard†					
	1	**2**	**3**	**4**	**5**	**6**
Glass	P	P	P	P	P	P
Food	P	P	P	P	P	P
Rubbish	P	P	P	P	P	P
Oil/grease	P	P	P	P	P	P
Burnt material	P	P	P	P	P	P
Bitumen board	P	P	P	O	P	P
Brown fibre	O	O	P			
Grey and white card	O	O	P			
Wet strength board	O	P	P	O	O	O
Wax or paraffin coated	O	O	P	O	O	O
Beverage cartons	O	P	P	O	O	O
Glue		O	P	O	O	O
Staples		O			O	O
Metal cans	O	O	P	P	P	O
Metal foil	O	O	P	P	O	P
Plastic bottles	O	O	P	P	P	O
Plastic film	O	O	P	P	P	P
Objectionable (O) max	1.0%	1 to 4%	N/A	2.0%	1.0%	6.0%
Prohibitive (P) max	0.0%	~0%	0.0%	0.0%	0.0%	0.0%

†Standards 3 and 4 were produced by the same reprocessor

3.2 Plastics

The project team was unable to recruit any plastics reprocessors to the steering group, despite approaching several representatives from this sector. As a result, it was difficult to engage in consultation about the issues faced by plastics reprocessors using MRF inputs.

In informal discussions, the major contamination issue that emerged was wasted revenue, through purchasing materials that are not of use to the manufacturing process. Plastics command a reasonably high price (as of May 2009, natural HDPE bottles were commanding around £300/tonne) and reprocessors have an incentive to ensure the plastics they buy are contaminant free.

These discussions also mentioned potentially harmful materials such as household bleach and broken glass, but the consensus seemed to be that most contaminants were easy to remove and that lost revenue was the main disadvantage.

The project team assessed one nationally published specification (PAS 103: Collected waste plastics packaging), the US ISRI Scrap Specifications, RECOUP guidance on plastic bottle sales and three reprocessor standards.

3.2.1 PAS 103: Collected waste plastics packaging

PAS 103 applies to unprocessed waste plastic packaging for mechanical recycling. It is built around a visual inspection methodology and an inspection sheet that lists original use of material, contamination etc. The PAS states that visual inspection is to be preferred on cost grounds, but that sorting may be required in the case of disputes.

PAS 103 defines material in terms of application category (A1 – Z40) and major polymer type (including categories for mixed polymer and unspecified polymer).

Polymer purity is graded A (99.9%) – J (<50%), and non-plastic contaminants are graded 1 (<0.1%) – 10 (>50%). Contaminants are divided into types A (prohibitive – e.g. hazardous), B (removable – e.g. cans) and C (acceptable within limits – e.g. labels or biodegradable polymers).

PAS 103 does not specify limits but provides a means of grading material. For example, a bale of plastic bottles, mostly PET, but with 2% HDPE and 0.5% cans would be A5(E): CB(6) – original application plastic bottles with caps and labels, polymer contamination E (2%), with contamination category B (removable) at 6 (meaning 5%). Again, PAS103 is not a threshold, but an approach to inspection and description. It does, however, have some flaws. It is based on a visual inspection approach that requires the assessor to estimate the relative proportions of materials in a load, and cannot be presumed to give very accurate results. The system for description of materials is complex, counter-intuitive and unlike systems typically in use for describing other materials. Perhaps because of this, in discussions with plastics reprocessors carried out as part of the desktop review, most said that they did not make much use of PAS 103, and did not use the labelling system it advocated.

3.2.2 ISRI standards for recovered plastics

The ISRI standards define different grades of plastics, using a grade code and a brief verbal description. They also define contamination thresholds. The ISRI standards categorise contamination in plastics as:

- allowable contamination (easily removed materials such as cans, cardboard etc); and
- prohibited material, which refers to hazardous wastes, highly flammable materials, all free-flowing liquids and plastics detrimental to the production process.

For most grades, a contamination threshold of 2% is set for allowable contamination, but prohibitives are completely excluded, with a 0% threshold. The downside of a zero tolerance approach to prohibitives, in terms of undermining the consistency of application, has been discussed above. This seems especially likely to cause problems where liquids are concerned, as baled plastic bottles often contain traces of their original contents, and, in the case of coloured HDPE, this is not uncommonly household bleach, which could be defined as hazardous.

3.2.3 RECOUP guidance

Guidance published by RECOUP suggests: "Typically, 2 – 5% by weight of general contamination can generally be tolerated in baled bottles", but adds that, "Deliveries with bales found to contain critical or hazardous contaminants will not normally be accepted".

The RECOUP guidance divides contaminants into general contamination, such as cans, cardboard, carrier bags etc and critical contamination, such as glass, sharps and hazardous wastes.

3.2.4 Reprocessor standards

Two reprocessor-specific standards and one produced by a broker were assessed as part of the desktop review, in addition to conversations conducted with other reprocessors who did not supply a written standard.
Most plastics reprocessors used financial penalties to deal with non-compliant loads, rather than rejecting them. The two reprocessor standards state that no material will be rejected, and contain a method for reducing price depending on the contamination level. One standard makes no distinction between types of contamination (it refers once to contamination with non-target plastics and makes no mention of other materials), merely reducing price once the overall level passes 5%. The other distinguishes low-grade plastics (2% threshold) from non-plastic out throw (1% threshold). This latter also has a method for calculating a higher price for materials that exceed the quality specified by the standard.

The broker's standard bears closer resemblance to the RECOUP or ISRI standards, distinguishing between general contamination (3% threshold) and critical contamination (0% threshold). Table 8 below summarises the reprocessors' and broker's standards in tabular form.

Table 8 Summary overview of reprocessor's plastics standards

	Reprocessor 1	Reprocessor 2	Broker
	1	**2**	**3**
Glass	P	Not defined	P
Food	P	Not defined	O
Rubbish	P	Not defined	O
Oil/grease	P	Not defined	O
Fibre	P	Not defined	O
Metal cans	P	Not defined	O
Metal foil	P	Not defined	O
Plastic bottles	Target	Target	Target
Other plastics	O	O	O
Objectionable max	2% / financial penalty	5% / financial penalty	3%
Prohibitive max	1% / financial penalty	Not defined	0%

3.3 Glass

The two key contamination issues for glass recycling are cross-contamination by colour and contamination by inorganic materials such as ceramics and stones, which are difficult to remove. Glass output from MRFs has proved difficult to use for remelt, due to non-glass contamination and the cross-contamination of different colours that occurs during co-mingled collection.

Secondary glass for remelt is taken to a glass reprocessor for further treatment, which results in the production of finished glass cullet. Quality of material is critical for the glass industry, with the contamination tolerance for finished cullet typically less that 20g per tonne.

While modern near-infrared sorting equipment can sort glass by colour, the effectiveness of this equipment is seriously reduced by compaction and the presence of other contaminants; cost and technical requirements associated with separating fully co-mingled material of non-standard size have so far proved prohibitive. As a result of this, very little glass output from MRFs goes to remelt applications, with the majority going to aggregate[3].

The project team assessed two quality documents that have potential industry-wide application, PAS 101: Recovered container glass and the European Committee for Standardisation (CEN) document "Packaging – Materials recycling – Reports of requirements for substances and materials to prevent a sustained impediment to recycling". Four remelt reprocessors were consulted, but only one was able to provide a written standard of the type sought for review, as the others took so little MRF material that an input contamination threshold was not felt to be needed. Informal discussions with the aggregate industry provided one example of a reprocessor quality threshold for aggregate, the area where most MRF glass output finds application.

3.3.1 PAS101: Recovered container glass

PAS 101 covers untreated cullet, and divides material into a 4 tier grading system, based on colour mix, non-glass contamination and particle size. The grades are:

A: Whole or broken containers, colour separated.
B: Whole or broken containers, colour separated but to a lesser standard.
C: Whole or broken containers, mixed.
D: Compacted glass.

[3] In the words of David Workman of British Glass, speaking at the 2009 Futuresource event: "Although glass processors over the years have invested in and introduced technology to assist with colour sorting, the technology is not quite advanced enough to pull good quality cullet out of the waste stream once it has been compacted to a high degree. And the proof that it's not working is that the UK's glass packaging manufacturers are crying out for more good quality cullet – as indeed are the producers of flat and fibre glass."

PAS 101 sets contamination limits for ferrous metals, non-ferrous metals and organic material, but leaves inorganic contamination (such as ceramics) to negotiation between suppliers and reprocessor. The contamination limits for the different cullet grades are shown in Table 9.

Table 9 Contamination limits in PAS101

	Grade A	Grade B	Grade C	Grade D
Other colours	4-5%†	6-30%†	Any	Any
Organic	0.5%	0.5%	1%	N/A
Inorganic	Unspecified	Unspecified	Unspecified	Unspecified
Ferrous	0.1%	0.1%	0.2%	N/A
Non-ferrous	0.2%	0.2%	0.4%	N/A
All contaminants	N/A	N/A	N/A	3%

† Depending on the colour of the cullet supplied. Clear is the least tolerant, while green is the most.

Grading of loads is carried out by visual inspection and estimation of colour distribution, non-container-glass contaminants and particle size. There is also a weight-based testing method that involves taking a 100kg bulk sample from various parts of load and then selecting from this a number (unspecified) of 5kg samples for analysis.

PAS 101 is not a threshold, but a means for grading unprocessed cullet. However, this system is not very applicable to MRF output, which tends to be at a less processed stage than that addressed in the PAS. It is unlikely that most MRF output would make grade D, the lowest grade on the PAS101 scale with an allowed contamination level of up to 3%.

PAS101 also suffers some flaws. It leaves allowable levels of ceramic contamination to individual arrangements between buyers and sellers, despite this being the most important category of non-glass contamination and the one that causes reprocessors most difficulty.

In addition, PAS101 is based on visual inspection, despite evidence that visual approaches are less reliable than weight-based sorting. The complementary weight-based sorting methodology is not specified in detail, requiring an unspecified number of 5kg sub-samples to be taken and sorted from a 100kg bulk sample. The reason for talking an initial bulk sample is not specified, while the 5kg sub-samples are so small as to be unlikely to provide any meaningful results unless a very large number of them are sorted.

3.3.2 CEN/TC 261/SC 4/WG 3 "Material recovery"

The CEN Material recovery document is not a standard, but a working document on the requirements for quality standards if they are to fulfil the requirements of the Packaging and Packaging Waste Directive. It sets out a framework similar to that used by PAS101, with the addition of example thresholds for inorganic materials.
The document distinguishes between quality thresholds for processed cullet (material supplied by glass reprocessors to manufacturers) and unprocessed cullet (the material supplied by collectors to glass reprocessors). The example requirements for unprocessed cullet are summarised in Table 10 below.

Table 10 CEN example specification for unprocessed cullet

Material	Maximum
All contaminants	5%
Ceramics, porcelain and stones <10mm	0.01%
Total ceramics, porcelain and stones	0.25%

Between the two documents (PAS101 and CEN) it is possible to formulate what we might expect a typical material requirement for unprocessed cullet to look like, with thresholds for all relevant materials. It should be noted that compositional research conducted on behalf of WRAP suggests that MRF output is currently some way off achieving this standard.

3.3.3 Reprocessor and end user standards

Of the three remelt reprocessors that were the subject of phone interviews, two had no suitable standards document that could be reviewed. Most of the detailed quality control took place at the back end – for example, a glass reprocessor had a quality control procedure in place operating as a miniature version of the main sorting plant that processes 15kg of output every 20 minutes, in order to screen the material against quality control standards laid down by the glass works being supplied.

The written standard that was supplied distinguished three types of contamination:

- **unacceptable** contamination includes medical and chemical refuse, and is grounds for automatic rejection;
- **critical** contaminants include ceramics, pyroceramics and light bulbs – the document states that none of these are acceptable and that their presence may lead to rejection; and
- **hazards** include non-magnetic metals, wood, plastics and textiles – the document states that every effort must be made to keep these to a minimum.

The document does not set measurable thresholds for rejection due to contamination by foreign bodies, but does set thresholds for colour cross-contamination, as shown in Table 11 below.

Table 11 Colour-contamination standard for glass, supplied by reprocessor for remelt applications

Clear	Brown	Green
Brown 2% Green 2%	All other colours 5%	All other colours excluding blue 5% Blue is acceptable

One aggregate manufacturer was also interviewed. The company's representative (the Quality Control Manager) stated that the company operated with a 4% contamination threshold, and that this requirement had been imposed by the Environment Agency. Material was sorted and weighed, with loads with more than 4% non-glass contamination rejected, or subjected to a visual inspection, with the rejection criterion being more than 2% of surface area. The manager stated that MRF glass is a problematic material, as high levels of contamination mean it requires significant processing before it can be used as aggregate.

3.4 Aluminium

The project team examined two written standards – the IRSI Scrap Specifications for used aluminium beverage cans and the input standards for used aluminium drink cans produced by Novelis.

The Novelis site was visited by the project team as part of this work. The major problem caused by contamination at the facility is delays to the production process, particularly due to plastics catching fire during the de-lacquering process, which takes place in a contained environment, causing the plant to automatically shut down. Novelis has recently constructed trialled a front-end sorting facility line where cans are shredded and plastics removed before material is fed into the plant. This is mostly used for cans sourced from the UK, which have a high proportion of plastic widgets that are not removed by the usual sorting procedures. It will become a permanent facility from Autumn 2009.

3.4.1 ISRI standards for used beverage cans

The IRSI standards for used beverage classify scrap material according to how it presented, distinguishing between loose cans, shredded material, biscuit bales, mill-sized bales and briquette. In all cases, contamination is dealt with in the same way. No thresholds are set. Instead, the guidance states that the material must be free of steel, lead, bottle caps, plastics, glass, wood, dirt, trash and other foreign substances, including aluminium other than beverage cans. Interpreted literally, this implies that there is no tolerance for other materials. This is likely to mean that contaminants are tolerated, but that material is rejected at the discretion of the buyer. The standard's statement that any free lead is a basis for rejection suggests that some materials will be tolerated more than others, without providing measurable thresholds.

3.4.2 Novelis specification for used beverage cans

The Novelis material specifications state that material must be free of steel, lead, iron, plastics, sand, paper, glass, foil, dirt, grease and any other foreign substance. The specifications do not put a measurable threshold on contamination by foreign bodies – however, in conversation, the company's commercial manager said that, in practice, there is an operational limit of around 1%. The specification also states that no more than 2% of the weight of the load may be made up of aerosols, and sets a moisture limit of 4%.

Companies that fail to meet the quality requirements laid down by Novelis have the option of having the material rejected or decontaminated, with the cost of decontamination taken off the price paid for the load.
Overall, the ISRI and Novelis specifications are not dissimilar, and the standards situation with regards to aluminium is perhaps the simplest and clearest for all the materials looked at.

3.5 Steel

No steel reprocessors provided examples of quality thresholds for examination. However, discussions were conducted with CORUS Steel Packaging Recycling and other reprocessors of steel scrap, and MRF product quality was not generally felt to be a problem. This is due to the relatively straightforward nature of magnetic separation, combined with the fact that specifications for steel are typically more lenient than those for other materials – the high temperatures involves tend to oxidise most contamination, which is removed as dross.

Two standards for steel cans were procured – the ISRI specification and one from a recycling broker.
The ISRI standard for steel cans (code 213: Steel can bundles), specifies that baled cans must be free of non-metallics other than paper labels. Steel cans are subject to the general specifications for ferrous scrap. These state that the material should be free of dirt, nonferrous metals and foreign materials, but add that the restrictions "are not intended to preclude the accidental inclusion of negligible amounts where it can be shown that this amount is unavoidable in the customary preparation and handling of the particular grade involved."
The merchant's quality standard allows up to 25% contamination by aluminium cans and 1% by labels and food and drinks residue. It states a 0% tolerance for other contamination, such as cardboard, plastics, glass or textiles.

As stated above, from conversations with representatives from CORUS Steel Packaging Recycling, most reprocessors are more lenient when it comes to accepting these materials, so long as they are within reasonable limits.

3.6 Overview of written standards

Overall, the standards examined were clear and straightforward, although a few contained areas that deserved clarification. A number of issues stood out:

- Lack of a consistent language and structure for categorising contamination, both between material sectors, and within sectors.
- Some standards do not place measurable limits on contaminants, making acceptance or rejection a matter of the buyer's discretion and providing little or no guidance to MRFs.
- Few standards express a threshold for prohibitive materials, instead stating that the presence of the material is grounds for rejection. This does not constitute clear guidance, since most recovered material is likely to have some prohibitive contamination. As a result, any decision to reject based on a prohibited contaminant is made at the discretion of the assessor, since they will be accepting other loads where the same contaminant is present.

Although the direction of the project shifted away from materials thresholds, the review was able to identify a range of issues with existing quality threshold documents, and to recommend the production of a framework for issuing details of quality requirements. The three key requirements of such a framework would be:

- Consistency within (and preferably between) materials – acceptable material and contaminants should be divided into the same series of general categories (e.g. objectionable material and prohibitive material). The existence of a common language would enable straightforward comparison of different specifications.
- It must be clear and unambiguous – in any given standard, each material must be clearly defined and must fit into only one category of contamination (although individual reprocessors will vary in terms of what materials are placed in each category, and how much they are prepared to accept).
- It must be objectively measurable – any claim about conformance or non-conformance with a standard must be empirically falsifiable.

The project team carried out some informal modelling of what a standards framework might look like, based on a distinction between target, acceptable-within-limits, objectionable and prohibitive materials. In all cases, it was possible to formulate specific manufacturers' standards in terms of a standardised approach, although in some cases to do so would require the clarification of ambiguities.

3.7 Addendum: MRF input standards

WRAP-funded work[4] on the quality of MRF inputs and outputs has suggested that contamination levels in inputs to a MRF are correlated with contamination in product. Not only does some of this non-target material end up in the product, but it also leads to an increase in cross contamination, with recyclables that would have been valuable in one stream ending up as contamination in another. This is hardly surprising – most MRFs are designed to separate dry recyclables, not to handle residual waste.

Although not the main scope of the project, MRF operators were asked if they imposed standards on input materials (i.e. recycling) supplied by local authorities, and if so, what happened if material failed to meet the standard. The replies are summarised in Tables 12 and 13 below.

Table 12 Do you have a contamination threshold on input materials that you will accept from local authorities?

Yes, for all authorities	14
Yes, for some authorities	4
No	9

Table 13 If you do operate a threshold on input material, what happens if the material fails?

Sent back to local authority	7
Landfilled at local authority expense	11
Impose a cost penalty on the local authority	8

The majority of MRFs did impose some form of control on input from local authority recycling collections, but the fact that one in three did not illustrates the unusual market position that MRFs occupy as, on one hand, suppliers of a quality raw material to manufacturers and, on the other, as a means of diversion of waste from landfill, driven by tonnage targets and funded by gate fees. With competition for local authority gate fees high, it makes economic sense for some MRFs to agree to take any material a local authority chooses to supply despite the negative impact on product quality.

It is the view of the project team that lack of control over input material is likely to remain a problem for MRF output quality. MRFs should be encouraged to introduce input standards, and to work in collaboration with local authorities and reprocessors to improve the quality and recyclability of material collected at the kerbside.

4.0 Measuring quality

4.1 The importance of measurement

WRAP has already conducted several projects on assessing MRF input and output quality. MRF001 was conducted by Resource Futures in 2007, and aimed to develop a coherent approach to sampling and assessing MRF outputs. The method devised as a result of MRF001 was further developed in the projects MRF011 and MRF015, which used the MRF001 approach to assess the quality of MRF outputs across the UK.

4.1.1 Visual and weight-based approaches

The two main approaches to assessing materials are visual or weight-based (gravimetric) inspection.
Visual inspection has a number of operational advantages. It is quick; it does not require a dedicated space, as it can be carried out in the delivery area; it does not require dedicated staff to be taken off other jobs, but can be managed by staff in the delivery area as part of their overall duties.

The major disadvantages of visual inspection are that it can assess only the surface of a load and that it is based on an individual's assessment, which may differ from person to person. If a load contains materials of different sizes and densities then the materials on the surface may not be representative of the material as a whole, and a

[4] *Wrap MRF001 project.*

visual inspection would be liable to give misleading results. In addition, if a material is difficult to see (such as clear plastic film in a load of paper) then a visual inspection will tend to underestimate its presence. Weight-based sorting, by contrast, takes longer and requires its own space and dedicated personnel. On the other hand, it produces more precise results in terms of the weight of contaminants, being able to distinguish between, say, a 1.5% contamination rate and a 2% rate. It is also not limited to the surface of a load, and is likely to pick out materials that a visual inspection would miss.

As part of WRAP project MRF001, on developing materials quality testing methodologies for MRFs, both visual inspections and weight based sorting of the same load, for paper, plastics and aluminium cans were undertaken, and the results of both approaches compared. In all cases, there was no significant correlation between the results of the visual assessment and the results of the sort.

It should be borne in mind that these tests were carried out using a crew that was predominantly used to weight-based sorting. It may be that, with time, the results of their visual inspections would have become more consistent with the weight-based results – however, there is no evidence to support this conjecture.

4.1.2 Case study: the INGEDE system

A useful case study on the challenges of both visual and weight-based inspection is presented by the example of the INGEDE system, and its implementation by a leading UK paper mill that was involved with the project, and which was visited by the project team.

The INGEDE system number 7 is an approach to measuring input quality, produced by the International Association of the Deinking Industry[5]. It combines both visual inspection and weight-based sorting. The system is based on a standardised visual inspection, assessing 30m^2 on one side of a tipped load of loose paper. Visible contaminant items are counted and a tally of the number of items counted is kept.

In addition, random samples of material are collected and subjected to weight-based sorting. This weight-based analysis is used to calibrate the visual inspection using a regression model (so that a given count of items can be assumed to indicate a particular proportion of material by weight present in the load).

To be regarded as reliable, the INGEDE system specifies that the coefficient of correlation (r) between the visual inspection results and the results of the weight-based sorting should be at least 0.75. This is equivalent to an r^2 value of 0.56, meaning that the visual inspection results could be taken to account for at least 56% of the variation in contamination by weight.

The INGEDE approach is interesting, aiming at a workable compromise between the speed and convenience of visual assessment and the accuracy of weight-based sorting. However, the evidence gathered by the project team from the site visit suggested that there was not a strong enough relationship between visual inspection and weight based sorting results to achieve the required correlation coefficient. The mill had been carrying out the INGEDE calibration on visual and weight-based results for brown board, and had gathered several hundred results. Even for this material, which should be straightforward to assess visually compared with problematic materials such as glass or clear plastic film, the r-value was not higher than 0.5. While there was a correlation between visual and weight-based results for brown board, the range of possible weight-based results that had given rise to a given visual inspection result was so broad that it was not possible to infer with a meaningful degree of accuracy the percentage weight contamination of any given weight-based inspection from a load from the results of a visual inspection of the same load.

These results could be taken to suggest that visual inspection methodologies are not generally able to attain a high degree of accuracy. Due to their inability to look beneath the surface of loads, problems associated with hard-to-spot materials and the individual differences that will be produced by differences in personnel, it is likely that this statement is correct. However, the weight-based data was gathered by taking a single 40-50kg sample from the load. Taking a single sample of this size is likely to produce a significant degree of sample error. One could turn the argument on its head by claiming that the failure to find a tight enough fit in the regression model is the result of errors in the weight-based sampling rather than a problem with the visual inspection.

This case study highlights the serious weaknesses of visual inspection (for example, the mill had been unable to use it at all for glass, and did not regard it as worthwhile to attempt a regression model for materials other than

[5] *The updated (April 2009) method can be found at: http://www.ingede.com/ingindxe/methods/meth07pe-2009.pdf*

board), but also the difficulties associated with weight-based sorting and the need to construct a reliable sampling regime.

The project team concluded that visual inspection is not able to provide accurate measurements of product composition, and is not suitable for testing materials against objective thresholds, especially where the acceptable contamination levels are low.

This is not to say that visual inspection does not fulfil a useful role. Its speed and ease of application means that all loads can be visually inspected, and such inspections may be useful as an early warning system in identifying loads with unusually high levels of contamination. The mill mentioned above had benefitted through implementing a more standardised quality control system. Maintenance of long-term records enabled trends to be identified and increases in observed contamination over time reported to the MRF. The mill maintained good communications with suppliers, and relationships with suppliers had improved since it had taken steps to standardise its quality control procedures, helping to overcome fears that loads may have been rejected arbitrarily.

4.2 Current practice

4.2.1 Reprocessor approaches to measuring quality

As part of the survey questionnaire, reprocessors were asked: “Do you carry out sampling and testing of input materials for contamination?” The answers are summarized in Table 14.

Table 14 Q9 – Do you carry out sampling and testing of input materials for contamination?

	Regularly, for each supplier	Regularly, at random	Occasionally, for each supplier	On first delivery	Never
Paper	2	2	-	-	-
Glass	2	-	1	-	-
Plastics	3	1	2	1	-
Aluminium	1	-	-	-	-
Steel	1	-	-	-	-
Total	9	3	3	1	0

All reprocessors responding to the questionnaire had some form of sampling in place. The most common regime was to sample by supplier rather than randomly.

Reprocessors were also asked “What form does this sampling take?” The answers are summarized in Table 13.

Table 15 Q10 – What form does this sampling take?

	Sorting, weight based	Sorting, item count based	Visual inspection
Paper	2	1	2
Glass	2	-	1
Plastics	4	-	3
Aluminium	-	-	1
Steel	1	-	1
Total	9	1	8

Weight-based sorting was the most common approach to analysing material quality, with 9 respondents carrying out weight-based sorting of some kind according to a regular regime. Of the three that did not regularly use weight-based sorting, one was a glass reprocessor, one a plastics manufacturer and one an aluminium recycler. The aluminium recycler does, however, break open and sort bales when a problem is suspected; in addition, it’s new front-end sorting equipment will enable it to produce accurate weight-based data on the levels of contamination in materials that are fed through it.

The majority of respondents also used visual inspections, often carrying out an inspection of every load on delivery and sorting material on a random or a scheduled basis.

The methods used for carrying out weight-based inspections differed between companies. The two paper mills visited, for example, used slightly different lists for categorising the sorted material. One mill sorted all of the material it sampled from a solid table, while the other sorted from a screen so as to speed the sort by examining only the larger material. Even the samples were taken in a different way, one facility sampling from the side of the tipped load and the other sampling from the bottom as it emerged from the truck. None of these differences is huge, but taken together they do mean that the results of the two methodologies are not directly compatible.

4.2.2 Quality assessment at MRFs

MRF operators were asked: "Do you conduct sampling/testing for materials?" and, if so, "What form does this sampling/testing take?" The answers are summarized in Tables 16 and 17 below.

Table 16 Q3 – Do you conduct sampling/testing for materials?

	Number of responses			
	Regularly	**Occasionally**	**Only as part of WRAP projects MRF11 or MRF15**	**Never**
Input	17	4	3	3
Product – Paper	20	2	2	3
Product – Cardboard	15	4	2	4
Product - Aluminium cans	17	4	2	4
Product - Steel cans	15	4	2	5
Product - Plastic bottles (PET)	7	3	2	6
Product - Plastic bottles (HDPE)	8	3	2	6
Product - Plastic bottles (mixed)	15	4	3	3
Product – Glass	10	2	1	9
Residual	11	3	1	6

Paper was the material most frequently subjected to quality inspection, with 74% of respondents saying that they regularly inspected their news and pams grade paper. Even so, this implies that 26% of MRFs do not have regular output quality control on their single biggest output. If one excludes the work conducted as part of the WRAP MRF analysis projects, 81% of respondents have some form of output quality inspections on their news and pams.

Plastics were the poorest performers in these terms – only 42% of respondents carried out regular checks on their HDPE output, and only 39% did so with their PET. Again, excluding the WRAP MRF analysis projects, only 55% of respondents had any form of output quality inspections at all on PET bottles.[6]

[6] Of 26 respondents to the question "Are you planning to introduce regular sampling in future (or improve it, if you do so already)?", 7 had plans to improve their output monitoring systems within 6 months, 5 had plans to improve but not within 6 months and 14 had no plans to improve.

Table 17 Q4 – What form does this sampling/testing take?

	Number of responses			
	Sort, weight based	**Sort, item count based**	**Visual inspection**	**Don't sample**
Input	12	-	14	5
Product - Paper	9	1	15	5
Product - Cardboard	8	-	14	6
Product - Aluminium cans	9	1	15	6
Product - Steel cans	7	-	14	7
Product - Plastic bottles (PET)	4	-	9	9
Product - Plastic bottles (HDPE)	4	-	9	9
Product - Plastic bottles (mixed)	10	-	14	6
Product - Glass	3	-	9	9
Residual	8	-	6	7

Table 17 shows that, for all materials, visual inspection was the predominant method of monitoring product quality. The product streams most subjected to weight-based sorting were news and pams (30%) and mixed plastic bottles (33%).

4.3 Conclusions

We saw in the conclusion to the previous section that high levels of disparity in the ways in which different materials quality thresholds are defined can make comparison difficult. We have argued that this situation could be improved by issuing guidance on a standardised form that materials quality thresholds could take, without making any effort to define the content of these standards.

In examining approaches to assessing material quality across MRFs and reprocessors, a number of similar issues stand out:

- There is a major disparity between the way in which MRFs are assessing the quality of their output (predominantly through visual assessment) and how reprocessors are doing it (where weight-based sorting is the most common method).
- There is a lack of consistency in assessment methodologies even within these two broad types of assessment. Visual assessments can vary from an informal appraisal to a highly standardised procedure, looking at particular materials over a tightly circumscribed sample area. Weight based methodologies differ by sample size, sampling frequency, sample selection method, category list and approach to sorting.
- Many sampling and testing approaches are not formally written down and available for inspection. For example, a plastics reprocessor might carry out a sort of 50kg of material randomly each day, using a simple split between target material and contamination, but have no documentation explaining how this is done so that the work could be replicated by other parties.
- There is evidence that visual assessments, while they may be able to identify anomalous loads with unusually high levels of contamination, lack the high levels of accuracy needed to monitor fluctuations in product quality on a day to day and load to load basis. This is a problem for both MRFs and reprocessors, but is likely to be especially problematic for MRFs, many of which rely on visual inspection as their only method of monitoring quality.

As a result of this, MRFs and reprocessors are carrying out materials quality analysis that, while perhaps useful for internal monitoring or decision making, is not standardised enough to be comparable with data from other MRFs or reprocessors. This lack of a level playing field where material quality might be assessed and compared is a potential impediment to smooth functioning of materials markets. At the very least, considering the effort being invested by all parties, it represents a wasted opportunity.

The major recommendation to emerge from the analysis of material testing methodologies is the need for a standardised approach that can be applied by both MRFs and reprocessors. Such a system would have to be practical for both MRFs and reprocessors, and should be as similar as possible across material streams in order to make implementation at the MRF more straightforward.

This would enable MRFs to produce clear descriptions of product quality, and reprocessors would be able to test the material they receive using the same method and compare the results. This would help to prevent and resolve disputes; in addition, the information produced by both MRFs and reprocessors could be shared, reducing the overall testing workload.

This emphasis on the importance of testing methodologies was given strong support by the steering group, which felt that having a standardised and shared protocol for material testing and description was of more value than attempting to impose material-specific quality thresholds that would suit some and not others. The following chapters discuss the consultation that took place, with the steering group and through questionnaires and informal discussions, the conclusions that emerged from this consultation and the next steps that should be taken to move things forward.

5.0 Outlining the options for change

5.1 Responses to consultation

The initial steering group discussions and the questionnaires considered a range of options, in order to assess the level of demand. This chapter draws on the feedback of the steering group, questionnaire responses and informal conversations, examining the range of responses to the different options. These can broadly be summarised as:

- Introducing published materials thresholds for MRF outputs.
- Publishing guidance on the typical requirements of UK reprocessors for each end market.
- Guarantee certificates issued by MRFs presenting a guarantee of material quality.
- Production of an accredited Quality Management System for MRF operators.
- Producing an standardised methodology for measuring and describing material quality.

5.1.1 National thresholds

The steering group felt strongly that the introduction of standardised thresholds would be unworkable, and rejected this proposal. Main reasons given were that MRFs have different quality of inputs and that the ability of each MRF to handle contaminants is based upon their individual MRF configuration.

The unambiguous rejection of national thresholds by the steering group was not quite so clear cut among questionnaire respondents. Questionnaire respondents were asked: “In your opinion, would national material-specific thresholds outlining the maximum level and type of contamination allowed for each MRF output product be desirable and useful?” The answers are shown in Table 18.

Table 18 In your opinion, would national material-specific thresholds outlining the maximum level and type of contamination allowed for each MRF output product be desirable and useful?

	MRFs (Q20)	Reprocessors (Q18)
Yes	16	4
Yes, but only apply when demand is high	2	Option not given
No	6	8
Don't know	3	1

The table above shows that, while reprocessors were opposed to the idea, MRF operators consulted via questionnaire generally favoured the introduction of thresholds. Those MRF operators supporting the idea said that it would “eliminate grey areas” and “provide a level playing field”. Those opposed tended to point to the differences in reprocessor requirements or to argue that the issue should be decided by the market.

Given the strong opposition from reprocessors, and from the MRF operators on the steering group, as well as the strength of the arguments against trying to impose a single standard on a diverse market, the decision was made not to follow up on the development of national thresholds. The review of standards did succeed in identifying a number of issues with existing reprocessor standards, however, and the project team would recommend the production of guidance on framing quality standards in a clear, objectively measurable way.

A range of other options were offered to MRFs in the questionnaire. MRFs were asked a specific question about the value of issuing quality guarantee certificates and a further question about other options, while reprocessors were asked just the latter question, with the option of MRF quality guarantee certificates included as an option. The level of support for these options is shown in Table 19 below, which shows how many respondents selected guidance in response to the question: "Which of the following other options do you think would be beneficial in terms of product quality and market confidence?".

Table 19 Which of the following other options do you think would be beneficial in terms of product quality and market confidence?

Option	Reprocessor	MRF
Formal guidance	6 (46%)	12 (44%)
Standardised testing regime	8 (62%)	13 (48%)
QMS for MRFs	5 (38%)	15 (56%)
Quality guarantee certificate	7 (53%)	12 (44%)†

† The MRF questionnaire asked this question differently, with a yes, no, don't know answer. The figure of 12 represents those that answered yes. There were 2 don't knows. Each of these options is discussed briefly below.

5.1.2 Guidance on typical requirements

Issuing official guidance on the typical requirements of reprocessors in a range of markets was considered by the project team as a fallback position from fully blown national thresholds, but this suggestion met with no support from MRFs or reprocessors in any forum. The other questionnaire results did suggest that MRFs already understand what their clients need, bring the value of additional guidance into question, especially as this guidance will not refer to a binding standard and will not be the same as the quality standards issued by many reprocessors.

5.1.3 A quality guarantee certificate

Table 19 shows that a small majority (53%) of reprocessors actually supported this idea, while only 44% of MRF operators felt it would be beneficial. There were no reprocessor comments relating to this question. The responses from MRFs included the following statements:

- "It would help to give buyers of materials reassurance over quality and could help to secure better prices".
- "Unnecessary paperwork and the more unscrupulous in the industry would just produce the paperwork regardless of the quality of the material".
- "Consistency is going to be an issue, but yes - we are selling a product after all".
- "It would be another piece of paper to fill in and the quality could always be argued over, with the buyer having the final say".
- "The level of sampling required to issue a quality guarantee certificate would be unworkable for most MRFs".
- "Contamination levels for each batch can not be guaranteed".
- "There is no need to offer a quality that is not required from certain buyers".

Overall, MRFs offered a wide range of views, but the overall response was one of scepticism. A quality guarantee certificate without anything to back it up would be unlikely to produce any benefits. However, given the positive response from MRFs towards the idea of an accredited quality management system, and the support of reprocessors for standardised measurement protocols, some form of process or output certification remains on the agenda.

5.1.4 A quality management system

The idea of an accredited quality management system (QMS) for MRFs was raised by a number of MRF operators at the first steering group, as a possible alternative to materials thresholds. Overall, the steering group was less keen to follow up on this idea than on standardised methods of assessing quality, but did not dismiss the idea.

Questionnaire respondents were also asked whether they thought a QMS for MRFs would be beneficial, with the results shown in Table 19 above. While the idea did not carry much weight with reprocessors, MRF operators were generally supportive of the idea.

While the decision was made not to follow up on the details of any potential QMS, it should be borne in mind that the support among reprocessors for (accredited) certification and standardised quality testing systems fits with the overall quality management idea, and this should be considered as a potential future development.

5.1.5 A standardised testing regime

Questionnaire responses concerning the benefits of a standardised quality testing regime were somewhat negative (48%) for MRFs and positive (62%) for reprocessors. Opinion on the steering group, however, was more generally positive, with a clear demand for work to be carried out in this area.

In order to move this work forward, the project team was tasked by the steering group with producing a discussion document, setting out suggestions and recommendations for how a standardised, reliable testing regime might operate, and how such a regime might be established.

5.2 Discussion over the testing regime

The discussion document was presented to the third and final steering group meeting, on 18 May 2009. This document is reproduced in Appendix 3. The key contents of the discussion document were:

- Introduction of a standardised visual inspection system. Due to the resource constraints on weight-based testing, the document envisaged that visual inspection would remain as the primary means of testing input quality at the point of delivery and reception. A standardised visual inspection regime was suggested in order to standardise decision-making criteria and to enable comparison of results.
- A standardised weight-based approach to sorting, with pre-defined sample sizes and category lists specific to each material type. The document suggested that weight-based sorting be used to gather data over time on the quality of and variation within materials, with the results presented as a mean for each contaminant along with confidence intervals and data on the first and last quartiles of material sampled (in order to give an idea of the range of material quality that might normally be expected from a facility).
- A random sampling regime, with the number of samples required determined by facility size.
- A discussion point as to whether this system should be independently administered and audited, and the roles that an administrator might play, particularly concerning certification.

The steering group response to the document was as follows:

- In general, it was felt that a standardised approach to visual inspection was not required. The group was of the opinion that, if visual inspection is less accurate than weight-based sorting, then it makes more sense to concentrate effort on the latter.
- There was a broad consensus about the benefits of a shared approach to weight-based sorting. There was discussion of the technical difficulties that may be encountered in carrying out a weight-based analysis, and the resource implications of implementing a quality control system, but the principal of weight-based sorting was agreed.
- Consensus on the steering group was that it was too early to discuss the administration, auditing and certification until the system had been refined and subjected to trials.

The steering group concluded that further work should be conducted on developing and trialling the materials analysis methodology and that a technical working group should be constituted and charged with the production of a PAS for the new system.

6.0 Recommendations and next steps – project outcomes

At the request of the steering group, the project focused primarily on establishing a standardised quality testing methodology for MRF output material, and the production of a PAS document outlining this approach.

6.1 Production of a PAS for standardised weight-based testing

The main output of the project was the belief of the steering group that the production of a standardised regime for weight-based material sampling and testing would help buyers and sellers and provide an incentive to improve product quality.

Suggestions as to what such a regime might look like were covered in a discussion document produced for the third steering group. This is discussed in the body of the report, and the document reproduced in Appendix 3. Following discussion of these suggestions, it was concluded that the next step should be formulation of a Publicly Available Specification (PAS) document covering material sampling and testing.

In order to move this process forward, the following steps are recommended:

- Carry out a desk-based analysis of the data from MRF011: *Material quality assessment of UK municipal MRFs* and *MRF015: Material quality assessment of Scottish municipal MRFs* in order to augment the data set on which current estimates of the accuracy and reliability of different weight-based approaches are based. Combining the results of MRF001, 011 and 015 will provide a more robust basis from which to recommend a sampling and analysis strategy.
- Convene a technical group to modify and refine the content of the discussion document and produce options for materials testing. This process should involve discussion and consultation with all stakeholders, including local authorities, MRFs and other recycling system operators, reprocessors and brokers across the full range of materials to be covered by the PAS and the Environment Agency.
- Carry out trials of the testing methodology with key stakeholders, in order to ensure that it produces reliable results and is practicable across a wide range of operations.
- Produce and publish of a formal PAS document covering sampling and weight based testing of MRF-output and other post-consumer recycling outputs.

Once the PAS document has been published, the project team would recommend that further consultation be carried out concerning how accreditation to the PAS is to be managed, in order to ensure that the methods being employed by MRFs and reprocessors are audited and the results independently validated.

In addition to a standardised material testing methodology, the project team would argue that several other areas that were initially explored are worth discussing in more detail. These are discussed below.

6.2 Quality control workshops on implementing the new PAS

One of the greatest barriers to the improvement of MRF output quality is product variance. The initial benefits of a weight-based analysis regime are likely to lie less in providing accurate compositional data, thus helping to incentivise improvements in quality, than in measuring process variance, thus helping to incentivise improvements in consistency across loads. Until the very high levels of variation in MRF output quality can be brought under control, merely knowing a MRFs average output quality is of little value.

A key recommendation of this project is therefore that a series of quality workshops for MRF operators is established, with the aim of communicating basic concepts of statistical process control (use of control charts) to MRF operators. The research suggested that the level of understanding of process control among MRF operators is generally low, and a series of workshops of this kind has the potential to greatly increase the impact of any material sampling and analysis regime.

6.3 Standardised visual testing

Although the steering group felt that effort would be better concentrated on developing a weight-based sampling and testing methodology, there is no doubt that visual assessment will remain as the front-line approach to assessing the quality of loads at the point of delivery. The resources required to carry out weight-based testing mean that only a minority of loads will be subjected to such testing. This data can be used to build a model of typical composition and its variance, and regular sampling of the output stream can be used by MRFs for process control applications. At the point of shipping and delivery, however, visual inspection is likely to remain the primary means of assessing quality, whatever weaknesses it might have.

Given these circumstances, there is still a great deal of value in exploring the standardisation of visual inspection methods. A standardised visual inspection procedure would have the advantage of enabling comparison of visual inspection results. It would also make clear to the MRF the process through which the material would be put pending a decision to accept or reject, and as such would prove an aid to decision making.

6.4 Guidance on framing standards and thresholds

The project team believes that issuing guidance on the subject of producing and presenting quality thresholds has the potential to add value to the outcomes of this project. The benefits of measuring material quality accurately will only be felt fully when all players in have a clear understanding of the criteria against which quality is assessed. Well-produced standards should be:

- **Consistent.-** Acceptable material and contaminants should be divided into the same series of general categories (e.g. objectionable material and prohibitive material) wherever possible. The existence of a common language for framing quality standards would remove ambiguity and straightforward comparison between different specifications.
- **Unambiguous** - Each material must be clearly defined and must fit into only one category of contamination (although reprocessors will vary over what materials are placed in each category, and how much they will accept).
- **Measurable** - Any claim about conformance or non-conformance with a standard must be empirically falsifiable, with reasonable, achievable limits against which material can be tested. (Note, however, that for material found in very small quantities, this measurement is likely to be across a number of loads over a period of time, as the effect of sampling error for determining the amounts of such material in an individual load is likely to be high).

Appendix 1: MRF questionnaire

MRF operator questionnaire

The aim of this survey is to gather information on the quality of MRF inputs and outputs and how this relates to both the practicalites of MRF operations and the requirements of reprocessors. The questionnaire should be completed by a member of the MRF management. Managers of MRFs that were involved with the materials analyses programmes conducted by Resource Futures and Enviros should complete Parts 1 and 2. All others should complete Part 1.

Part 1: For all MRF operators

Q1 **Please list your name, job title and contact number**

____
____
____
____

Q2 **Please list the name and address of the MRF**

____
____
____
____
____

Q3 **Do you conduct sampling / testing for materials?**

	Regularly	*Occasionally*	*Only as part of Resource Futures /Enviros project*	*Never*
Input	▪	▪	▪	▪
Product - Paper	▪	▪	▪	▪
Product - Cardboard	▪	▪	▪	▪
Product - Aluminium cans	▪	▪	▪	▪
Product - Steel cans	▪	▪	▪	▪
Product - Plastic bottles (PET)	▪	▪	▪	▪
Product - Plastic bottles (HDPE)	▪	▪	▪	▪
Product - Plastic bottles (mixed)	▪	▪	▪	▪
Product - Glass	▪	▪	▪	▪
Residual	▪	▪	▪	▪
Other_________________________	▪	▪	▪	▪

Please state nature of "other", if used. ____

Q4 **What form does this sampling / testing take**

	Sort, weight based	*Sort, item count based*	*Visual inspection*	*Don't sample*
Input	▪	▪	▪	▪
Product - Paper	▪	▪	▪	▪
Product - Cardboard	▪	▪	▪	▪
Product - Aluminium cans	▪	▪	▪	▪
Product - Steel cans	▪	▪	▪	▪
Product - Plastic bottles (PET)	▪	▪	▪	▪
Product - Plastic bottles (HDPE)	▪	▪	▪	▪
Product - Plastic bottles (mixed)	▪	▪	▪	▪
Product - Glass	▪	▪	▪	▪
Residual	▪	▪	▪	▪
Other_________________________	▪	▪	▪	▪

Please state nature of "other", if used. ____

Q5 **Do you sample / test your products for moisture content, and if so how?**

Paper	*Cardboard*	*Aluminium*	*Steel*	*Plastics*

Loss of mass at 105°C	▪	▪	▪	▪	▪
Electrostatic testing	▪	▪	▪	▪	▪
Don't test for moisture	▪	▪	▪	▪	▪

Other (please state materials and test)

____
____
____
____

Q6 Are you planning to introduce regular sampling in future (or improve it, if you do so already)?

	Yes, within 3 months	*Yes, within 6 months*	*Yes, in more than 6 months*	*No*
Input	▪	▪	▪	▪
Output	▪	▪	▪	▪
Residual	▪	▪	▪	▪

Q7 If you answered no to any of question 6, please give reasons

____
____
____
____

Q8 If you answered yes to any of question 6, was this as a result of participation in the WRAP sampling and analysis project?

Yes ▪
No ▪
Did not participate ▪

Q9 Do you have a contamination threshold on input materials that you will accept from local authorities?

Yes, for all authorities ▪
Yes, for some authorities ▪
No (go to question 11) ▪

Q10 If you do operate a threshold on input material, what happens if the material fails

Sent back to local authority ▪
Landfilled at local authority expense ▪
Impose a cost penalty on the local authority ▪
Other (please state)

____
____
____
____

Now go to question 12

Q11 If you do not operate a threshold on input material, are you considering specifying one

Yes ▪
No ▪
If not, please state why

____
____
____
____

Q12 Do you pre-sort incoming material to remove non-target material before it enters the MRF process?

Yes ▪
No ▪
If not, please state why

____
____
____
____

Q13 Do you have plans to take action on material in your residual waste that could be recovered?

Investing in additional equipment ▪
Introducing a second pass for residual ▪
Additional sorting of residual at the back end ▪
Other (please state) ▪
No (please state why not) ▪
If other or no, please give details

____
____
____
____

Q14 What single factor most determines the speed you operate your equipment at? Please tick only one box.

Only ever operate at design speed ▪
Varies to cope with volume of input ▪
Determined by quality requirements of customer for main material product ▪
Varies with availability of staff, sickness, holiday etc ▪
Other (please state)

____
____
____
____

Q15 If demand for UK processors' products is running high, do they still demand the same quality as when demand is low? Please state for each material

	Yes	*No*	*Don't know*
Paper (news & pams grades)	▪	▪	▪
Paper (mixed)	▪	▪	▪
Cardboard	▪	▪	▪
Aluminium cans	▪	▪	▪
Steel cans	▪	▪	▪
Plastic bottles (PET)	▪	▪	▪
Plastic bottles (HDPE)	▪	▪	▪
Plastic bottles (mixed)	▪	▪	▪
Glass	▪	▪	▪
Other____________________	▪	▪	▪

Please state nature of "other", if used. ____________________________

Q16 For each material you produce, do the UK customers you sell to have clear, written quality threshold requirements?

	Clear requirements	*Requirements not clear*	*Don't sell in UK*	*Don't produce product*
Paper (news & pams grades)	▪	▪	▪	▪
Paper (mixed)	▪	▪	▪	▪
Cardboard	▪	▪	▪	▪
Aluminium cans	▪	▪	▪	▪
Steel cans	▪	▪	▪	▪
Plastic bottles (PET)	▪	▪	▪	▪
Plastic bottles (HDPE)	▪	▪	▪	▪
Plastic bottles (mixed)	▪	▪	▪	▪
Glass	▪	▪	▪	▪
Other____________________	▪	▪	▪	▪

Please state nature of "other", if used. ____________________________

Q17 **Does your MRF output currently (over the past 3 months) meet the quality requirements discussed in question 16?**

	Always	*Usually*	*Often not*	*Not at all*
Paper (news & pams grades)	▪	▪	▪	▪
Paper (mixed)	▪	▪	▪	▪
Cardboard	▪	▪	▪	▪
Aluminium cans	▪	▪	▪	▪
Steel cans	▪	▪	▪	▪
Plastic bottles (PET)	▪	▪	▪	▪
Plastic bottles (HDPE)	▪	▪	▪	▪
Plastic botles (mixed)	▪	▪	▪	▪
Glass	▪	▪	▪	▪
Other______________________	▪	▪	▪	▪

Please state nature of "other", if used. ______________________________

Q18 **For each material you produce, do the overseas customers you sell to have clear, written quality threshold requirements?**

	Clear requirements	*Requirements not clear*	*Don't sell overseas*	*Don't produce product*
Paper (news & pams grades)	▪	▪	▪	▪
Paper (mixed)	▪	▪	▪	▪
Cardboard	▪	▪	▪	▪
Aluminium cans	▪	▪	▪	▪
Steel cans	▪	▪	▪	▪
Plastic bottles (PET)	▪	▪	▪	▪
Plastic bottles (HDPE)	▪	▪	▪	▪
Plastic bottles (mixed)	▪	▪	▪	▪
Glass	▪	▪	▪	▪
Other______________________	▪	▪	▪	▪

Please state nature of "other", if used. ______________________________

Q19 **Does your MRF output currently (over the past 3 months) meet the quality requirements discussed in Q18?**

	Always	*Usually*	*Often not*	*Not at all*
Paper (news & pams grades)	▪	▪	▪	▪
Paper (mixed)	▪	▪	▪	▪
Cardboard	▪	▪	▪	▪
Aluminium cans	▪	▪	▪	▪
Steel cans	▪	▪	▪	▪
Plastic bottles (PET)	▪	▪	▪	▪
Plastic bottles (HDPE)	▪	▪	▪	▪
Plastic botles (mixed)	▪	▪	▪	▪
Glass	▪	▪	▪	▪
Other______________________	▪	▪	▪	▪

Please state nature of "other", if used. ______________________________

Q20 **In your opinion, would national material-specific quality thresholds outlining the maximum level and type of contamination allowed for each type of product be desirable and useful?**

Yes ▪
Yes, but only apply when demand is high ▪
No ▪
Don't know ▪

Please give reasons for your answer

____
____
____
____
____
____

Q21 **In your opinion, would it be worthwhile for MRFs to issue quality guarantee certificates stating the maximum contaminant levels for each product?**

Yes ▪
No ▪
Don't know ▪

Please give reasons for your answer

____
____
____
____
____
____

Q22 **Which of the following other options do you think would be beneficial in terms of product quality and market confidence? Tick as many as you wish.**

Official guidance on the typical tolerance levels of reprocessors and the levels and types of contamination that are likely to cause problems ▪
An accredited and shared methodology for sampling and analysing material, recording the results and describing what loads contain ▪
An accredited quality control system for MRF operations ▪

Please give reasons for your answers and list any other measures that you think would be beneficial

____
____
____
____
____
____
____

Part 2: For MRFs participating in the data analysis projects with Resource Futures and Enviros. This section should be completed by someone directly involved with the project in a management role

Q23 **Did you find the sampling/testing worthwhile?**

Yes ▪
No ▪

If no, then why not?

____
____
____
____
____

Q24 **What would you consider to be the most important outcome for you of the sample testing. Please tick one box.**

Insight into MRF processes and potential for improvement ▪
Information about quality of MRF products ▪
Information about input composition ▪
Other (please state)

____
____
____
____
____

Q25 **Were there any negative aspects of the sampling and testing? Tick as many as apply.**

Data was not useful ▪
Demands on staff time ▪
Space requirements ▪
Equipment requirements ▪
Disruption to MRF operations ▪

Other (please state)

____

Q26 **The aim of this project is to show UK municipal MRF contaminant levels, by material, in three ranges of low, medium and high. If you find out that your levels are medium or high, will you take action?**

Yes	▪
No	▪

If you answered no. please give reasons

____

Q27 **Which actions are you likely to consider taking?**

	Very likely	*Quite likely*	*Quite unlikely*	*Very unlikely*
Invest in additional equipment	▪	▪	▪	▪
Alter the operating speed of the plant	▪	▪	▪	▪
Take on additional staff	▪	▪	▪	▪
Provide additional training for staff	▪	▪	▪	▪
Introduce more rigorous quality control	▪	▪	▪	▪
Demand higher quality recycling input / reject lower quality input	▪	▪	▪	▪

Other (please state)

____

Thank you for your time!

Appendix 2: Reprocessor questionnaire

Reprocessor questionnaire

The aim of this survey is to gather information on the quality standards for input materials operated by UK reprocessors, and to relate these to the output standards typically met by MRFs. The results of this questionnaire will be used by WRAP to facilitate the improvement of MRF output quality. Your response will be treated in confidence and will not be disclosed to any third party

Q1 **Please give your name, job title and contact number**

____
____
____
____

Q2 **Please list the name and address of your company**

____
____
____
____
____

Q3 **Which of the following materials does your company procure from MRFs for reprocessing (fill in as many as apply)**

- *Paper* ▪
- *Old corrugated card (OCC)* ▪
- *Aluminium cans* ▪
- *Steel cans* ▪
- *Plastic bottles (PET)* ▪
- *Plastic bottles (HDPE)* ▪
- *Plastic bottles (mixed)* ▪
- *Other plastics* ▪
- *Glass* ▪
- *Other (please state)*______________________ ▪

If you answered other, please state which materials ____

Q4 **Do you use material sourced from MRFs directly or blended with other sources of input?**

- *Always directly* ▪
- *Usually directly* ▪
- *Usually blended* ▪
- *Always blended* ▪

Q5 **What products does your company use these materials to produce**

____
____
____
____
____

Q6 **Do you produce a single, written quality requirement for each recycled material that you buy?**

- *Yes (go to q. 8)* ▪
- *No* ▪

If not, please state why not

Q7 If you answered no, what quality standards do you operate?

We have a single quality threshold, but not in written form ▪
We agree quality thresholds with the supplier, and place these in writing ▪
We agree quality thresholds with the supplier, but not in writing ▪
We do not operate a quality threshold ▪
Other (please give information)

Now go to question 9

Q8 Is this written quality requirement enforced?

Always ▪
Usually ▪
Rarely ▪
Never ▪

Q9 Do you carry out sampling and testing of input materials for contamination?

Regularly, for each supplier ▪
Regularly, at random ▪
Occasionally, for each supplier ▪
Occasionally, at random ▪
On first delivery ▪
Only when a problem is suspected ▪
Never ▪

Q10 What form does this sampling take?

Sorting, weight based ▪
Sorting, item count based ▪
Visual inspection ▪
Don't sample ▪
Other arrangement (please state)

Q11 What proportion of MRF consignments typically match your input quality criteria?

All ▪
Most ▪
Some ▪
Hardly any ▪
Don't know ▪

Q12 Do you sample / test your products for moisture content, and if so how?

Loss of mass at 105°C ▪
Electrostatic testing ▪
Do not test for moisture ▪
Other (please state)

____

Q13 What is your response if a batch of material fails a check?

Material is always rejected and returned to MRF ▪
Material may be rejected depending on supplier relationship and market conditions ▪
Material is not rejected, but failure may inform future purchase decisions ▪
The price for the contaminated batch is renegotiated ▪
The material is kept, but you do not pay for it ▪
We do not test ▪
Other (please state)

____

Q14 How would you say the material you source from fully comingled MRFs compares to other waste and recycling derived inputs that you use?

	MRFs are typically better	*MRFs are typically the same*	*MRFs are typically worse*	*Don't know*	*Do not take material from this source*
Two-stream MRF	▪	▪	▪	▪	▪
Source separated/kerbside sorted	▪	▪	▪	▪	▪
Bring schemes	▪	▪	▪	▪	▪
Other (please state)_____________	▪	▪	▪	▪	▪

Q15 Please state the contaminant that causes you the most difficulty?

____

Q16 What is the main effect of this contaminant

Interruption to production process ▪
Negative effect on product quality ▪
Wasted revenue from purchasing waste ▪
Environmental regulation issues ▪
PRN system issues ▪
Health and safety of production process ▪
Health and safety of final product ▪
Other (please state)

____

Q17 If the most problematic contaminants were removed from the material you sourced from MRFs (or very much reduced), which of the following statements most applies to your operations? Please tick one.

We would be able to accept a higher level of non-critical contaminants, within agreed limits ▪
We would be prepared to consider accepting a higher level of non-critical contaminants, at a reduced price to offset the cost of their removal ▪
We would not be able to accept any more non-critical contaminants than we do at present ▪
Other (please state)

Q18 **In your opinion, would national material-specific quality thresholds outlining the maximum level and type of contamination allowed for each MRF output product be desirable and useful? Please give reasons for your answer.**

Yes ▪

No ▪

Don't know ▪

Please give reasons for your answer

Q19 **Which of the following other options do you think would be beneficial in terms of product quality and market confidence? Tick as many as you wish.**

Official guidance on the typical tolerance levels of reprocessors and the levels and types of contamination that are likely to cause problems ▪

An accredited and shared methodology for sampling and analysing material, recording the results and describing what loads contain ▪

An accredited quality control system for MRF operations ▪

A quality certificate from the MRF guaranteeing the maximum proportion of contamination in any load ▪

Please give reasons for your answer and list any other measures that you think would be beneficial

Thank you for your time!

Appendix 3: Discussion document

MRF010: Material quality thresholds for MRFs.
Third steering group
Discussion paper
11.05.09
Document prepared by Billy Harris, Resource Futures, on behalf of WRAP.

Introduction

This discussion paper follows the suggestion from the first and second steering group meetings that the emphasis of this project should shift from discussing materials quality thresholds to examining the scope for a shared materials testing methodology. It is anticipated that this will have four major benefits:

- It will create a common understanding of quality achieved across the supply chain.
- It will enable commercial decisions to be based on more reliable information about the composition of the materials being bought and sold.
- It will provide MRFs with an incentive to improve product quality and a reliable means of measuring quality improvements.
- It will have regulatory benefits through improving the quality of data that MRFs are able to submit to WasteDataFlow.

Use of a reliable testing methodology for assessing input, output and residual quality will also provide MRFs with a tool for use in process control, and can be used to give insight into how the process and product quality react to variations in input, staffing levels, line speed, introduction or reorganisation of equipment etc.

It should be noted that this document concerns itself primarily with the monitoring activities to be carried out by MRFs, for the reason that output quality control is the responsibility of the MRF. This paper does, however, suggest a *shared* methodology for inspection and analysis of loads.

We would ask that all steering group members take the time to read this document thoroughly. In particular, members should consider the practical issues that the following suggestions might entail, including cost, space required and impact on operations. In addition, a list of some of issues to be addressed when taking the project forward can be found at the end of the document.

Background – existing approaches to quality control

Our understanding of the current state of materials testing is based primarily on the following material:

- PAS 101: Recovered container cullet.
- PAS 103: Collected waste plastics packaging.
- PAS 105: Recovered paper.
- INGEDE Method 7: Entry inspection of unbaled sorted graphic paper.
- INGEDE Method 8: Entry inspection of baled sorted graphic paper.
- Questionnaire data from UK MRFs and reprocessors.
- Discussions with and site visits to reprocessors.

Our research shows that – although there are some significant exceptions – current quality control approaches at MRFs, and at reprocessors when assessing input quality, have a number of failings:

- They are not standardised, meaning that one MRF's findings cannot be compared with another's and that a MRF's findings cannot be compared with the reprocessor's.
- They are carried out on a piecemeal basis, without recourse to a formal sampling strategy. Sampling may be sporadic (e.g. when staff are available) or based on suspicion that a particular load may be contaminated. While the latter may be useful in identifying a contaminated load, it does not provide information on typical product quality from a given MRF.
- The visual inspection methods in use vary widely. While some at least adopt a standardised approach, others are based purely on estimation by an individual, with the result that the inspection result cannot be compared with any other.

- Although some facilities include an element of gravimetric (weight-based) sorting, most approaches are based on visual inspection. Empirical evidence suggests that visual inspection is not an accurate tool for assessing material composition[7]. Visual inspection is adequate for detecting high levels of contamination (outside the normal levels of variation), that could cause serious problems for a reprocessing plant. However, evidence suggests that even the best visual inspection approaches do not produce a strong correlation with the results of weight-based sorting. In particular, visual inspection is poor at detecting specific contaminants that may not be readily visible (e.g. clear plastics, materials of a similar colour to the main material in the load, material with a small particle size etc.).

Extent of demand for a more rigorous testing regime

The questionnaire results and the results of informal discussions with MRFs and reprocessors suggests that there is a demand for a more rigorous system. This demand is not uniform[8], but most appear to support the idea, and there is support among reprocessors.

A rigorous testing regime would likely provide substantial cost benefits to MRFs, including better material prices due to improved market confidence, fewer rejected loads and reduced landfill costs.

Conversely, one issue that has been expressed as a concern is the potential cost of any quality control system. Any system will inevitably involve costs, and there is a desire that the resource demands of any system be kept as light as is reasonably possible. We believe the proposals that follow take notice of this requirement and do not pose a serious cost burden on MRFs or reprocessors.

Overview of proposal

We would suggest the following proposal for discussion, which we believe would address the issues outlined above without putting an unnecessary burden on MRFs and reprocessors.

- A formal, shared approach to visual inspection, as a check to be applied to all outgoing and incoming loads. While not particularly accurate, visual inspection is less expensive and can be applied to every load sent out or received. It is therefore likely to continue as the “front line” approach to material inspection, as a means of identifying loads that have an *abnormally* high level of contamination. It is important to formalise a methodology in order that claims about the results of a visual inspection are clear to both parties and so that visual inspections can be reproduced or queried.
- A formal, shared approach to gravimetric inspection, with a prescribed sampling programme so that a given proportion of loads sent out or received are selected for random sampling. This will produce longer-term data on the average quality, and crucially, the variability of MRF product, with a higher level of accuracy and reliability than visual inspection. The gravimetric sampling system would produce a quality description for each material category, stated as percentage target product and percentage of each contaminant, each figure accompanied by a 95% confidence interval and figures for the lower and upper quartiles[9].

Suggestions for visual inspection methods

The inspection method for each material will vary somewhat. However, training and implementation are likely to be more straightforward if the inspection method is as similar as is reasonably possible across all material streams. There now follows a brief suggestion as to how these inspection methods might be implemented. These are not intended as final recommendations but as a basis for further discussion.

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[7] Visual inspections carried out during WRAP’s MRF01 trial of material testing methodologies found no meaningful correlation between visual and gravimetric inspection results. Analysis of data from a major UK paper reprocessor found a better correlation, but with an r^2 value of around 0.25, meaning that the visual inspection accounted for only around 25% of the actual variation in the material.

[8] Of 29 MRFs responding to the MRF010 questionnaire, 13 explicitly identified the need for a shared material testing methodology, while, 15 agreed with the need to introduce a formal quality management system (which implies product testing). Of 13 reprocessors, 8 identified the need for a shared material testing methodology.

[9] The 95% confidence interval gives a measure of the reliability of the average figure, while the presentation of lower and upper quartiles will give an indication of the variance between samples analysed when deriving this average. The steering group may wish to consider the value of presenting the top and bottom 10% instead of, or in addition to, the quartiles, in order to provide information on the range of variation in the central 80% of samples analysed.

Sampling frequency and location

We would recommend that MRFs attempt to visually inspect every load before it leaves the premises. For space reasons, most MRFs will find it easiest to carry out inspections of loose material in the bulking bay, prior to the material being loaded. If this approach is adopted, it may be an option to carry out a visual inspection at, say, one hour intervals, rather than inspecting each load individually. Inspections of baled material can be carried out where the bales are stored prior to dispatch. It is important to note that inspections *must* be carried out on undressed bales.

Many reprocessors will visually inspect every load entering the facility, in which case sampling frequency is not an issue. For those reprocessors that do not inspect every load, we would recommend that a random sample selection strategy is put in place. While reprocessors might also wish to carry out visual inspections on suspicion that a given load is not acceptable, we would recommend that these inspections are not allowed to interfere with the programme of random inspections.

Paper (loose)

Inspection would take place prior to loading at the MRF and on tipping at the paper mill or merchant.
One side of the load should be picked at random from among those sides that can reasonably be accessed for inspection. On this side an area of approximately $30m^{2\dagger}$ should be selected for the inspection – it is important to note that this area should be marked out in some way, so that only this part of the load is inspected – the number of contaminants spotted will vary with the area inspected.

The inspection should be carried out as an item count, identifying only the contaminants. In addition, only the visible surface area of any object should be counted (e.g. a visible area of a cardboard box equal in size to an A4 sheet will be counted as one A4 sheet, regardless of the size of the box).

Table A3.1 Suggested categories and their units

Material	**Unit**
Grey/white board	Area, expressed as A4[†] sheets.
Brown board	Area, expressed as A4 sheets.
Paper detrimental to production	Individual item (e.g. paper cup, sheet of wrapping paper
Non-paper contamination	Individual item (e.g. can, bottle, piece of film, garment)

[†] The choices of $30m^2$ for the sample area and A4 as the unit size for paper are based on practices already in use at some mills. In addition, A4 is a paper unit that most people will find easier to identify by sight than an arbitrarily chosen area.

The inspection sheet for any given load should also include observations about smell, general appearance and estimated age of fibre, observed soiling and whether the load contains any burnt material.

Paper (baled)

Baled paper presents the difficulty that differences in consistency throughout the bale are not visible from the surface, and this is usually compounded by the practice of dressing bales to remove excess visible contamination. A completely satisfactory way to overcome these problems has not been found, and we would suggest that, for baled fibre, gravimetric inspection may occupy an even more important place than for loose material. Nevertheless, we would suggest that visual inspection is likely to continue to play a role and would suggest the following approach.

In the section that follows, it is important to note that it is pointless to carry out a visual inspection of dressed bales. The steering group will need to consider how the delivery of undressed bales to reprocessors can be guaranteed.

When sampling from a load, it is important to examine the contents of more than one bale, as consistency between bales can vary. An agreed proportion of bales from the load (e.g. one in ten) should be randomly selected – in any event, we suggest a minimum of two bales should be selected.

In the first phase of inspection, the five visible sides of the bale should be examined closely, using an item-count approach. We would suggest that the same category list is used as for loose material, but that in all cases the unit of measurement should be the **individual item**, without reference to particle size.

The bale should then be split into three sections, effectively creating four new faces on each bale, supplying a cross section of the interior of the bale. These should then be inspected in the same way as the outside surfaces. Where this process is carried out by a MRF rather than a reprocessor, the most effective way would most likely be to select every 10th bale leaving the line for sampling, rather than selecting a proportion of bales from a particular load – this way of managing the process is less likely to interfere with the operation of the MRF.

Steel and aluminium cans

In general, it will not be possible to conduct a visual inspection based on particle count on biscuit bales, as the level of compaction is simply too high.

For inspection of mill-sized bales we would suggest that an agreed number of bales (e.g. one in ten) is broken open and spread over an agreed area (we would suggest that 4-6m^2 per bale would be suitable) before an inspection is carried out. The material should then be inspected on an item count basis using the following category list.

Table A3.2 Category list

Aluminium categories	Steel categories
Aluminium foil and aerosols	Other ferrous metal
All other materials (including laminated aluminium foil such as pet food pouches)	All other materials

Loose steel and aluminium can be inspected according to a similar methodology. MRFs may find it preferable to visually inspect loose material prior to baling, as this is a more straightforward process, may produce more accurate results and has a readily available space (the bulking bay). However, this will only work if the material is baled direct from the bulking bay without further picking (if there is a picker on the line to the baler, visual inspection in the bulking bay will overestimate the level of contamination).

Plastics

Loose plastics should be inspected by selecting an area on one side of the load of approximately 30m^2 (again, for a MRF, this would be best carried out on a timed basis, inspecting material in the bulking bay).

Baled plastics should be inspected by breaking 10% of the bales and spreading them over an area of 4-6m^2 per bale (again, these figures are only suggestions based on what seems practical, and would require further discussion prior to confirmation).

They should then be subjected to inspection on an item-count basis, using the following list of categories.

Table A3.3 List of categories

Non-target polymer
Other contaminants

Loose plastics can be inspected according to a similar methodology. MRFs may find it preferable to visually inspect loose material prior to baling, as this is a more straightforward process, may produce more accurate results and has a readily available space (the bulking bay). However, this will only work if the material is baled direct from the bulking bay without any further picking (if there is a picker on the line to the baler, any visual inspection in the bulking bay will overestimate the level of contamination).

Glass

This paper has not made any new recommendations regarding glass, primarily due to the lack of examples of current practice. Few reprocessors accept glass for re-melt applications, and the ones that we were able to contact did so only on a sporadic basis, and had not developed a formalised inspection methodology.

If MRFs or reprocessors do wish to carry out inspection of glass, we would recommend as a starting point the visual inspection method set out in PAS 101, which can be summarised as follows:

1. Tip the lot.
2. Estimate and record the percentages (by mass) of the different colours.

3. Record approximate number, type and size of non-glass contaminants.
4. Record an estimate of predominant particle size (whole containers, broken containers, compacted containers).

The contaminant list recommended by PAS 101 is given below, along with a suggestion for shortening this list and removing ambiguities.

Table A3.4 Contaminant list recommended by PAS 101

PAS 101 list	Alternative list
Medical, toxic and hazardous	Non container glass
Glass, non-container	Organic material
Organic material	Stones and ceramics
Inorganic material	Metals
Ferrous metal	All other contamination
Non-ferrous metal	

Suggested sampling methodology for gravimetric inspection at MRFs

We would advocate that samples taken are of the following size. The ± figures are intended to reflect the fact that operational concerns can interfere with the sampling process and make it difficult to select samples of a precise weight.

Table A3.5 Sample sizes

Material	Sample weight
Paper	75kg ± 10kg
Aluminium cans	25kg ± 5kg
Steel cans	40kg ± 8kg
Plastics	25kg ± 5kg

Samples should be selected randomly throughout the working year. One way to achieve this would be to draw lots for each working day. The number of samples we suggest should be selected is based on the size of the MRF. The table below shows our recommendation, along with an estimate of the number of staff required to carry out this work, expressed as number of days full time equivalent.

Table A3.6 Sample recommendation

MRF size (tpa)	# paper samples	# aluminium samples	# steel samples	# plastics samples	Estimated days FTE
20000	80	60	60	60	65
50000	200	150	150	150	162
75000	300	225	225	225	243
100000	400	300	300	300	324

The above figures are a compromise between achieving a reasonable number of samples and keeping staffing costs to a reasonably low level. At the levels suggested, only around 0.06% of output is gravimetrically sorted for composition. Statistically, the number of samples taken is more important than the proportion of total output; however, the amounts selected above may be a subject the steering group wishes to discuss in more depth. The precise method for sampling each material type needs to be standardised, and we would suggest that this would be best done in consultation with each industry. In general, however, sampling of loose material using a shovel loader is relatively straightforward, while bales simply have to be split and a number of vertical "slices" taken from different parts of the bale to assume a representative sample has been selected.

This document does not discuss suggested sorting frequencies at reprocessors, primarily because the reprocessor is not responsible for processor control and will likely wish to use gravimetric inspection as an occasional tool.

Suggested methodology for carrying out gravimetric inspection

In all cases, we would advise sorting on a mesh screen with an aperture of 45mm. Material that falls through this screen should not be sorted as part of the standard sorting regime, but should be weighed off as a separate category. This has the advantage of speeding sort times considerably. The methodology suggested below requires a minimum of equipment (a table, a 45mm wire screen, scales and containers for the materials sorted), which can typically be sourced for less than £500.

Suggested category lists for gravimetric inspection

Table A3.7 Paper

Category	Examples
News and pams type paper	Newspapers, magazines, office white.
Grey board	Greeting cards, food packaging.
Brown board	Cardboard boxes, food packaging.
Paper detrimental to production	Waxed paper, festive wrapping paper, laminated paper, heavily soiled paper.
Non-paper contaminants	Bottles, cans, plastics, glass, textiles.
Fines <45mm	

Table A3.8 Aluminium

Category	Examples
Aluminium UBC	Aluminium beverage cans.
Aluminium foil	Tinfoil, ready meal trays, soft pet food cans.
Aluminium aerosols	All aluminium aerosols.
All other material	Includes laminated foil (pet food pouches)
Fines <45mm	

Table A3.9 Steel

Category	Examples
Steel cans	Steel food and drinks cans
Other steel	Biscuit tins, steel scrap
All other materials	Aluminium, plastics, glass, paper etc.
Fines <45mm	

Table A3.10 Plastics

Category	Examples
Target polymer	
Target polymer (wrong colour)*	Additional category when sorting by colour
Non-target plastics	All non-target polymer
All other material	All other contaminants
Fines <45mm	

It should be noted that these lists are short, having been optimised to enable the most material to be sorted in the shortest time. These data will have limited use for MRF process monitoring and mass flow modelling. We would therefore suggest the preparation of a more detailed category list that can be used for this purpose should any MRF wish to develop such a model.

Presentation of results of gravimetric inspection

The gravimetric sampling system would produce a quality description for each material category, stated as percentage target product and percentage of each contaminant, each figure accompanied by a 95% confidence interval and figures for the second and fourth quartile.

The example below shows what this might look like for a MRF. The material selected for the example is plastic (let us assume HDPE bottles, not colour specific). Please note that the figures here are entirely hypothetical and do not represent a "typical" result.

Table A3.11 Example of a gravimetric result for plastic bottles based on 30 samples

Material: HDPE bottles. Number of samples: 30.				
Sort category	**Average comp.**	**Lower quartile**	**Upper quartile**	**95% conf.**
HDPE bottles	94%	90%	96%	± 2.4%
Non-target polymer	3%	1.5%	5%	± 1.1%
All other material	2%	1%	4%	± 1.3%
Fines <45mm	1%	0.5%	2%	± 0.6%

Addendum regarding input quality

This document has concerned itself so far with the quality of MRF product materials. However, research suggests that input quality may be the single biggest determinant of MRF outputs, and any MRF seeking to address quality issues will inevitably have to address the issue of its input stream. Analysis of the input stream also benefits MRFs in terms of setting gate fees or input quality criteria for local authorities.

We would therefore also suggest a methodology for MRFs to evaluate their input stream.

We would suggest that sampling is carried out randomly, and that, over the defined sampling period, at least 3 samples are taken from every *municipal collection round* that the MRF takes material from. This should enable the MRF to work out an overall input quality *and to pinpoint specific problem rounds*. Evidence suggests that an overall poor input quality can often be due to a few rounds, and if these can be identified, measures can be taken to deal with the problem (such as subjecting problem material to an additional pre-sort before it enters the MRF). This type of work is best carried out in close conjunction with the local authority, as they will find this information useful for targeting recycling promotions and educational campaigns.

Table A3.12 Suggested category list for input sorting

Recyclable paper	Depends on target stream
Non-recyclable paper	All other paper
Brown and grey and white board	All board
Recyclable plastics	Depends on target stream
Non-recyclable plastics	All other plastics
Steel and aluminium cans	All steel and aluminium cans
Aluminium foil*	Only if foil is a target
Glass	Glass
Textiles	Textiles
All other materials	Everything else
Fines <45mm	

Taking the project forward

If the steering group does decide to support these proposals, or an amended version of them, a number of decisions would need to be made about setting up such a system. Key points for discussion are likely to include:

1. Any sampling and sorting regime would require more elaboration than contained in this document. We would propose the establishment of a number of expert working groups to further consult with the industry.

2. The form of the sampling regime and inspection methodology. Should the document produced by the working group be established as a PAS, or is some other form more suitable?

3. Should the output of this project simply be the sorting and inspection methodologies, or should these form the basis of some sort of accreditation system, overseen by an independent auditor that could ensure uniformity of approach, record keeping etc, and act as a clearing house for the information gathered?

4. What are the steering group's thoughts on how this information should be managed and presented? A key point here is that if a MRF does not disclose *all* of its testing results its finding will be misleading – how is full disclosure to be guaranteed.

5. It would seem appropriate to begin by establishing a number of volunteer MRFs and reprocessors that would serve as a trial for the system for a period of several months before the scheme is put fully online. This could be used to iron out problems with the methodologies and to fine tune the number and frequency of testing linked to MRF size etc. How should this trial process be managed?

6. What operative training would be required to establish uniform visual inspections?

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