environmental services association

A SAMPLING AND TESTING PROTOCOL TO ASSESS THE STATUS OF INCINERATOR BOTTOM ASH

JAN 2018

This document was produced by WRc plc on behalf of ESA.

WRc Report Reference UC 9390.05

A SAMPLING AND TESTING PROTOCOL TO ASSESS THE STATUS OF IBA

1. Context

1.1 Objective

This voluntary industry protocol has been produced by ESA and its members with the support of the Environment Agency (EA) to provide a reliable method for the classification and assessment of Incinerator Bottom Ash (IBA) from the combustion of municipal waste in an energy from waste (EfW) facility. The protocol will help ensure that IBA is managed in a manner that does not pose a risk of harm to human health or pollution of the environment.

1.2 Status

This protocol provides guidance to help EfW operators comply with the Hazardous Waste and List of Waste Decision.

The sampling and analysis methodology aims to provide a reliable and accurate classification of IBA in conjunction with the joint Agencies Technical Guidance WM3 (2015) - Guidance on the classification and assessment of waste (1st edition 2015) Technical Guidance WM3.

The protocol is appropriate for facilities accepting a wide range of waste inputs, but when processed they should produce IBA that is consistently non-hazardous i.e. a single population. Where facilities take in material or experience a process change that will compromise the non-hazardous status of the ash, the resulting IBA should be segregated and the quality evaluated as a separate sub-population.

For new sites which do not have the benefit of historical data, an accelerated programme of 'start-up' sampling can be used to generate an initial baseline dataset. This can be used by the EfW facility in conjunction with the EA to agree if it is appropriate to adopt the approach laid out in this protocol for undertaking a regular hazardous property assessment of IBA in the longer term.

Any samples collected using the ESA protocol are also suitable for use in routine compliance monitoring for the facilities' environmental permits.

1.3 Waste Acceptance Procedures

Objective To deliver a non-hazardous quality of IBA by preventing materials entering the incineration process that could compromise the hazard status.

To produce non-hazardous ash requires robust management of waste inputs.

For wastes other than domestic mixed municipal waste, the operator should ensure that they obtain sufficient information from the waste producer / supplier and / or on-site checks to determine if the waste may impact on existing IBA quality before acceptance to the facility.

Action: Before receiving waste from a new client the site should request information and undertake basic checks in line with Statutory Duty of Care and Environmental Permit compliance requirements. Typicaly this could include:

i. require evidence that the new customer is properly registered to transport waste e.g. Carrier Registration Certificate;

ii. confirm the code and description for the waste and ensure that it is an acceptable waste code for the site's permit; and

iii. require all new customers collecting commercial and industrial (C&I) waste/waste originating from C and I to complete a New Supplier Questionnaire to provide detailed information on the source of the waste, a summary of previous composition characterisation data and for mirror entry wastes analysis to confirm hazard status.

iv. establish that the waste is contained in a suitable manner for handling at site.

Checks after receipt should include:

v. a thorough visual inspection of initial loads to ensure that the waste matches the description on the Waste Transfer Note and identify any rogue components.

vi. random visual spot-checks on an inspection schedule to identify non-conforming wastes (for example wastes with high heavy metal content).

The site operator will keep records of waste inputs that could be used to support an investigation where there has been a change in ash quality.

(The above requirements are in line with the Duty of Care Approved Code of Practice (Section 4) and intended to identify generic actions, site-specific facility arrangements should be identified in site-based procedures).

2. Sampling Methodology

This section outlines the requirements for collecting samples and how they should be prepared prior to analysis. The overall process for sample collection and laboratory testing is summarised in Figure 1.

Objective: To take representative samples of IBA from an individual facility.

Note: At some facilities individual samples may be taken from each line where they are processing waste inputs from different clients.

Compliance with health and safety requirements is not covered by this protocol, but site specific requirements must be considered and adhered to during any sampling operation.

2.1 Scale

Action: The aim of sampling is to produce a 40 – 50 kg sample that is representative of a lorry load of IBA as it would be transported from site. The sample is produced in 2 stages: by incrementally sampling the IBA as it is produced to generate a composite sample of approximately 200 kg; and then cone & quartering the combined incremental samples down to 40 – 50 kg ('dust-bin') sized sample) to send to the analytical testing laboratory.

Commentary: It is important that the assessment of hazard is focused on the quality of individual vehicle loads of material. Samples do not necessarily need to be taken directly from the vehicle as it is loaded or leaves site, but should in all cases equate to the amount of material in a 'theoretical' vehicle load.

One vehicle load is a discrete quantity that can be ring-fenced for sampling irrespective of IBA production rates which vary considerably from facility to facility.

2.2 Sampling frequency and schedule

Action: The default sampling frequency is 2 samples per calendar month, collected on random dates and at times selected in advance. This produces 24 independent samples in a 12 month period. New facilities can generate an initial data set of 24 data points over an accelerated period using a separate protocol for start-up sampling.

Where the quality of IBA at a facility is consistently below relevant hazard thresholds and therefore the number of exceedances of a hazard threshold low, there may be scope to reduce the sampling frequency (see Section 5.1).

Where 6 exceedances in 24 samples, a 4-times exceedance, or 3 exceedances in a row (a '3 in a row' exceedance) of a hazard threshold is reached this would trigger a change in sampling frequency. The conditions for change are detailed in Figure 3 and Section 5.

Commentary: Energy from waste facilities are operated 24 hours a day, 7 days a week. Sampling dates and times should cover this range to avoid introducing bias. In principle IBA should not be produced on a date or at a time when it cannot be sampled. Foreseeable problems in sampling should be accommodated as far as is possible at the time of production of the sampling schedule.

The date and time of sampling should be randomly selected. For example by randomly selecting 2 numbered tickets from a box or bag containing tickets numbered 1 to 31 representing the days of the month, to identify the sampling days for each month, or 1 to 24 to identify the time of day.

For operational reasons it may be necessary to pre-clear an area of the ash storage bunker, or level off ash in the bunker so that ash from the chosen period can be isolated. Alternatively, the equivalent of a lorry load of IBA could be set to one side (under cover) until trained sampling personnel are available to take a sample. This is acceptable provided sample integrity is not compromised.

Where it is not possible to sample the IBA from the facility due to unavoidable events e.g. staff sickness, health and safety issues or unplanned outages, the IBA should be sampled as soon as possible before or after normal operating conditions are resumed. This may mean that a sample needs to be taken in the preceding or following month (or following year in the case of December / January samples). The overall number of samples taken should not be less than that identified in Figure 2 and described in Section 5.

A log of proposed sampling dates should be maintained as evidence of the randomised approach. Any re-selection of date should be documented, with an explanation of why.

Note 1: If there is no adequate reason for not taking the sample, and ash was produced at that time, then the sample result should be regarded as an exceedance.

Note 2: *Additional samples* would be required for segregated sub-populations of ash which have an impact on the overall ash quality. These samples should be collected using incremental spot-sampling taking due care to gain access to as much of the sub-population as is possible.

2.3 Sample collection

Action: Take a minimum of 20 incremental samples each of approximately 10 kg from the chosen 'load' of IBA. A primary composite sample, of at least 200 kg, should be produced by combining the 20 increments. The sampling device should be able to collect the largest items in the ash to avoid sample bias.

Commentary: The 20 incremental samples should be equally spaced throughout the load using an approach which fits the production and storage arrangements at the plant. Possible approaches to sampling might include:

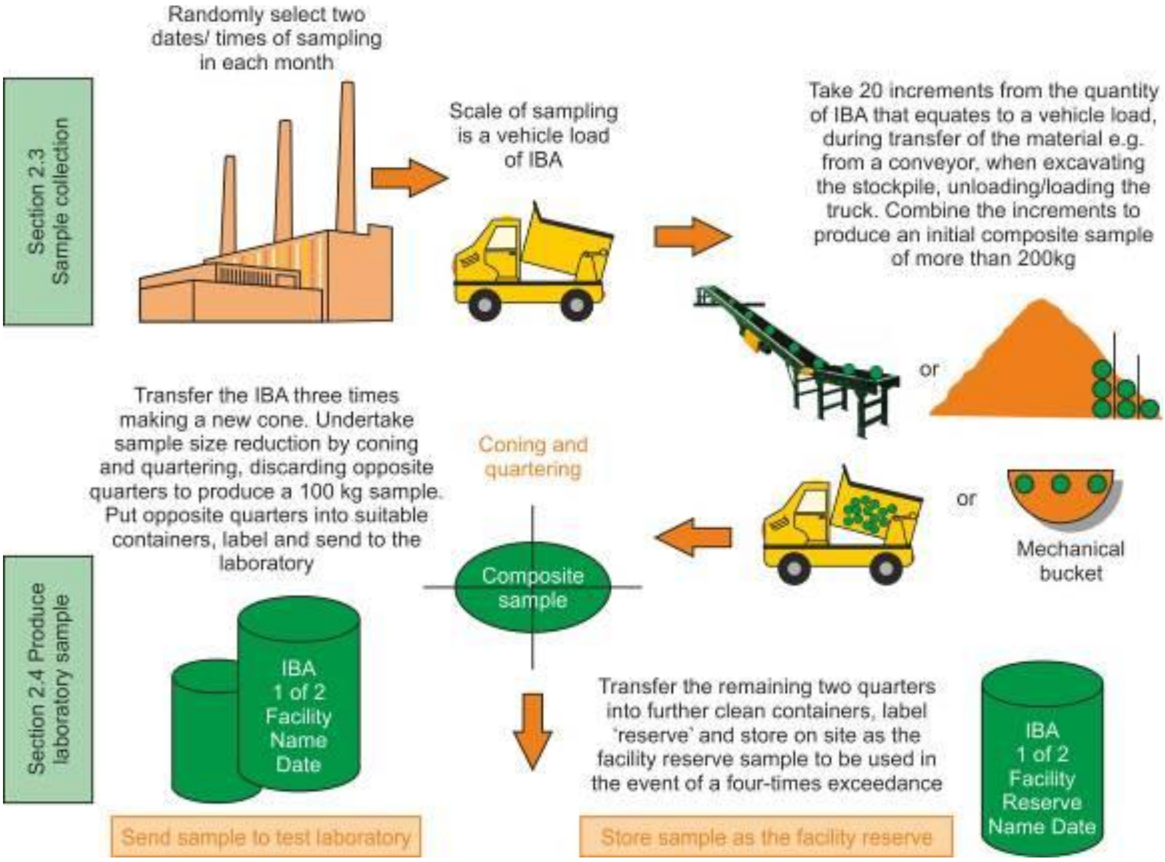
- the collection of regular swipe samples across the full width of a conveyor over the period of time it takes to generate a theoretical vehicle load of IBA, where this produces an increment that is less than 10 kg additional increments should be taken to generate the 200 kg initial sample;
- collection of spot incremental samples from a mechanical excavator bucket during loading of a vehicle;
- if the area has been cleared prior to the production of a stockpile that is equivalent to a load, the material should be thoroughly mixed using suitable mechanical equipment, the pile flattened and spread and 20 increments taken across the waste using a theoretical grid; and
- sampling from the leading face of a stockpile or grab undertaking this activity as the stockpile is excavated or added to. (Note: sampling should not be done around the external perimeter of a stockpile as this will not generate a sample that is representative of 'a vehicle load of IBA' within the pile).

The 200 kg size of the composite sample ensures that it is representative of the total production of ash in the load over time or within the stockpile. If viewed at a small scale (<1 kg) the chemical composition of IBA is highly variable, so a large number of incremental samples, good subsequent mixing and methodical reduction of the sample size are vital to avoid arriving at a laboratory sample which may be unrepresentative and risk exceedance of a hazard threshold. The sample collection process is outlined in Figure 1.

Care should be taken to ensure that larger particle sizes do not fall off the sampling device during collection of the incremental samples, this can be minimised by use of an appropriately sized sampling device. The equipment (spade, bucket etc.) used to produce each incremental sample should be at least twice the size of the largest particle size in the IBA. This is to ensure that none of the load is excluded on the basis of size, except as below. CEN Technical Report 15310-2[1] details best practice sampling techniques for a whole range of waste arising scenarios and should be referenced to select the most appropriate approach for a specific plant.

Standard site practice requires the removal of large inert and metal items (for example, engine blocks or household goods) prior to dispatch of IBA for recovery or disposal. Removed items should be recorded on the Sampling Record. The 20 incremental samples are combined to produce a primary composite sample. As described in Section 2.4 and Figure 1, the composite will then be divided into a laboratory sample and reserve sample to be held by the facility.

Figure 1 Schematic summary of sampling and testing steps



2.4 Production of the laboratory sample

Action: Mix the 200 kg composite sample on-site and representatively sub-sample it to generate a 40 to 50 kg laboratory sample and a similar sized facility reserve sample. The laboratory sample should be placed in sealed plastic container(s) and sent to the designated testing house within 48 hours of sample collection to maintain the integrity of the sample. The facility reserve sample should be similarly contained and stored where it cannot be damaged or contaminated. This could be at the test facility. A Sampling Record should be completed and any specific features of the 200

[1] CEN Technical Report 15310-2. PD CEN/TR 15310-2:2006 – Guidance on Sampling Techniques

kg sample recorded. Figure 2 provides a summary of the laboratory sample preparation and testing procedure.

Commentary: The 200 kg composite sample should be placed in a suitable preparation area that is free of debris and contamination that could compromise the quality of the sample. The 200 kg heap is reduced down using a procedure based on the method of coning and quartering detailed in British Standard BS EN 932-1. This is done by using a hand shovel to transfer the material into a new cone-shaped pile 3 times, in such a way as to give thorough mixing. The resulting pile is then divided into 4 roughly equal segments and 2 opposite quadrants are discarded leaving approximately 100 kg of IBA. The material should be transferred to a new pile and split into 4 quarters each of approximately 20 to 25 kg of IBA. Opposite quarters should be combined to provide 2 samples – a sample for laboratory testing and the reserve sample to be retained at the facility (Facility Reserve Sample).

A 40 to 50 kg sample equates to approximately three 30 litre tubs. The entire sample is put into a number of suitable sample containers, labelled with the plant, date and time of collection prior to delivery to the analytical facility for preparation and testing.

2.5 Sample identification

Action: The sample code should contain the following information.

Plant name / IBA / Sample collection number – 1 or 2 / Date (of sample collection) / Batch no. in year/ Initial of Sampler. For multiple containers use codes 1 of 3 etc.

Commentary: The laboratory sample should be placed in secure plastic container(s). Each container should have an indelible label on the outside of the container and a paper label sealed inside a polythene bag placed inside the main container pre-sealing.

2.6 Sample preparation at the laboratory

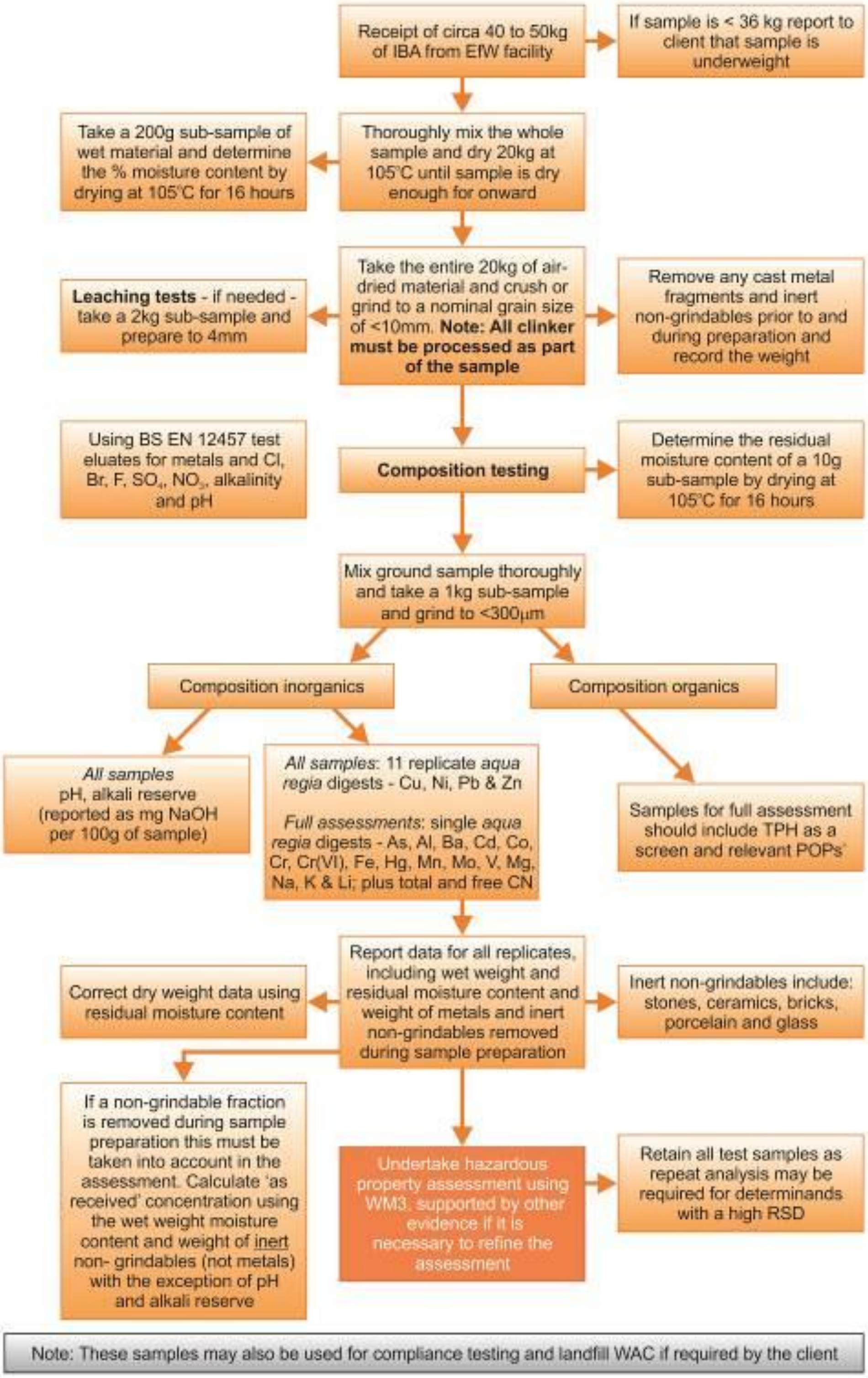
Action: The laboratory sample must be thoroughly mixed by the testing facility. It must be representatively sub-sampled using standard coning and quartering techniques to produce at least 20 kg for initial drying at 105ºC[2] to facilitate subsequent crushing and/or grinding. A 20 kg sub-sample should be dried and crushed to an appropriate particle size. For example, if leaching tests are specified in the site Environmental Permit or required to support a full annual hazard assessment an appropriate particle size would be 4 mm (BS EN 12457). The remaining 20 kg sample should be labeled as a 'Laboratory Reserve' and stored where it cannot be damaged or contaminated until chemical testing data has been produced by the laboratory. This sample can be stored without sample preparation.

A summary of the sample preparation and testing programme for IBA is provided in Figure 2.

For compositional testing fine grinding of a representative sub-sample 1 kg sub-sample to a maximum particle size of < 310 µm is required. Depending on the available method of sample preparation at the test laboratory it may be necessary for non-grindable fraction(s) such as stones, porcelain, ceramics, brick and glass to be removed from the sample during crushing.

[2] IBA is generated from a thermal incineration process and drying at 105°C will not cause further changes to the sample but will allow acceleration of sample preparation and data reporting

Figure 2 Laboratory specification for IBA testing



The percentage weight of all removed fractions should be recorded (this may require compositional sorting) where these are not included as part of the test sample. Metal items should only be removed during sample preparation to prevent damage to grinding equipment, and the weight should be recorded. The number of any items containing hazardous substances must be separately quantified.

Only the weight of the inert non-grindable fraction should be used to back-calculate the 'as received' concentrations of parameters. The contribution from any components containing hazardous substances must be taken into account in the back-calculation to IBA as received.

Commentary: The laboratory sample should be dried by placing a thin layer of IBA in suitable weighed trays and placed in an oven at 105°C until no further weight loss is recorded. Record the final weight of each tray to determine the overall moisture content. Alternatively, a separate sub-sample of the as received material can be taken and dried at 105ºC for 16 hours to determine the moisture concentration if the bulk sample is being dried at a lower temperature. Following drying the content of all the trays should be combined in preparation for particle size reduction prior to analytical testing.

Samples requiring testing for organic parameters as part of quarterly or annual compliance testing should be dried at 30°C to prevent loss of relevant organic components e.g. Total Petroleum Hydrocarbons.

To undertake chemical analysis it is necessary to dry and crush / grind the sample to a fine grained powder. All standard sample preparation techniques require the removal of cast metal objects, batteries and stones prior to crushing as these items damage the grinding equipment or a safety hazard. The quantities removed by faction category should be recorded. If inert components are removed their weight can be taken into account in calculating the as received wet weight concentration data. It is **not** permitted to remove clinker type from the sample during the crushing process or if removed this should be separately crushed and returned to the sample. The metals contribution from any batteries removed during sample preparation should be taken into account in the back calculation.

3. Sample Analysis

Objective: To assess the quality of IBA against the 15 hazardous properties and POPs set out in WM3.

3.1 Hazardous property assessment

Action: Full characterisation and assessment against all 15 hazardous properties and POPs should be undertaken annually by all EfW facilities. For new facilities this will form part of start-up sampling.

Unless this full assessment indicates otherwise on-going monthly assessments could be limited to: HP4/HP8 irritancy / corrosivity, HP7 carcinogenicity and HP14 ecotoxicity.

The assessment of hazardous properties should be undertaken using the procedure and thresholds listed in WM3, current chemical classification guidance and any additional relevant evidence that can be used to refine the face value assessment. The work previously undertaken by WRc for ESA 'Assessment of Hazard Classification of UK IBA (2012)' has now been superseded and has been withdrawn.

Where, new input wastes are taken at the facility they should be accompanied by a comprehensive characterisation so that the facility operator can judge whether they are likely to impact on overall IBA quality. Where new or some existing input waste streams represent different quality sub-populations and are of a sufficient quality or quantity that they may impact on the overall quality of IBA at the facility, these should, in the first instance, be batched and processed separately to allow segregation of the resulting IBA from the overall population so that it can be tested separately. The testing suite should be comprehensive and assessed against all hazardous properties.

Commentary: Where facilities have a sufficiently comprehensive historic monitoring dataset to indicate existing waste contracts lead to a relatively consistent IBA within the bounds of 'normal' variability the data set could be used to exclude those hazards that are not relevant to a facility. Testing of all new waste inputs should be undertaken by the waste producer to ensure they are not likely to compromise the quality of the overall population of IBA or require an extension of the hazards under examination.

A suggested analytical suite is provided in Section 3.2, which should be agreed with the local Environment Agency Officer as being appropriate to the wastes being accepted at the facility.

3.2 Constituents and analysis

Action: Tests should include all relevant parameters to allow assessment of relevant hazardous properties and POPs as listed in WM3. The analytical suite should include as a minimum, pH, alkali reserve (and *in vitro* tests to support this) and key metals (Cu, Ni, Pb and Zn).

A full hazardous property assessment requires as a minimum determination and assessment of the following parameters.

- pH, alkali reserve (with *in vitro* tests to support this) which are used as a surrogate chemical test for irritancy where an *in vitro* test has been used to set an envelope for non-irritancy.
- Composition: As, Al, Ba, Cd, Co, Cr, Cr(VI), Cu, Fe, Hg, Mn, Mo, Ni, Pb, V, Zn, Mg, Na, K, total CN, TPH, dioxins and furans and other relevant POPs as required.
- Leachable metals and ions: such as alkalinity, Cl, Br, F, SO_4, NO_3, and free CN. Leachable metals and ions are required to support the technical justification for the inclusion or exclusion of specific compounds in the hazard assessment.

A summary of minimum testing requirements for IBA is provided in Figure 2.

Commentary: The analytical sample must be very well mixed before removing portions for analysis to ensure representative sub-sampling.

The operator should ensure that the testing facility operates an approved quality assurance system and has suitable experience of preparing and testing IBA matrices. The test facility should ideally be audited by the waste operator to gain this assurance.

3.3 Test replication

Action: Key metals determinations submitted for *aqua regia* digestion should be replicated using eleven separate sub-samples, these should include Cu, Ni, Pb and Zn. The mean value of these replicates should be reported for each sample and used to determine the hazardous property assessment (e.g. HP7 and HP14) for waste classification.

Commentary. As mentioned in 3.1 agreement should be sought from the Environment Agency on the relevant parameters to be tested on a facility basis.

3.4 Timescales

Action: The EfW facility operator should dispatch the sample to the laboratory within 48 hours of sampling. From receipt of a 40 kg sample of IBA sample at the test laboratory all reports for the monthly hazardous property assessment should be sent to the EfW facility within 20 working days, and where possible data should be returned more quickly to allow prompt reporting of data to a third party reprocessor. If there has been a quality assurance failure at the test facility, the sample should be retested. Where a result is anomalous (either high or low) in comparison with historic data a retest on the same sample should be undertaken by the test facility. Where the sample has been lost or compromised by the test facility or courier the reserve sample should be sent for testing.

Each EfW facility should provide information on the IBA hazard classification and any exceedances to their nominated ash reprocessor immediately on receipt of sample data and if asked for by the Environment Agency. This is because the IBA cannot be processed until the result has been supplied (see 3.5).

As long as the ash was non-hazardous prior to this sample, and the operator is not aware of any other reason why the ash may be hazardous, and has followed this protocol, waste can be transferred to a suitably authorised reprocessor for storage (only) as presumptively non-hazardous whilst the result is awaited.

In the event of an exceedance investigations must be intensified by the operator to try and identify causal factors. At this point all future testing should be tested on rapid turnaround to limit the time period that IBA is 'under control' by third parties. In the event that the number of exceedances in the rolling assessment period triggers hazard status the reprocessor should be informed immediately. See section 3.5 for actions that need to be carried out by the reprocessor.

3.5 IBA control arrangements

Action: Arrangements should be put in place to ensure that IBA produced by a facility is separately stored (only) under suitable control at a suitably authorised facility at all times between the date of sampling and reporting of the test data for that sample that confirms the classification of the ash. This is designed to avoid the reprocessing of IBA that is classified as hazardous. If the place where the ash is stored is not authorised for the storage of hazardous waste, procedures must be put in place to ensure it is rapidly removed and taken to a suitably authorised state where a hazardous classification is identified.

Commentary: The quantity of ash produced between the time of sampling and reporting of analytical data should be segregated in such a way that it could be recovered or removed. The turnaround time of a maximum of 20 days will in many cases match ash aging activities but rapid reporting of test data will be needed to avoid sites reaching IBA storage capacity.

4. Data Interpretation and Reporting

Objective: To determine the mean concentration of each test parameter for IBA on an as received basis to represent the quality of the material as it leaves the facility as specified in WM3 and determine any changes in concentrations between monthly samples that relate to genuine and continued changes in IBA quality.

4.1 Calculating determinand concentrations

Action: Correct dry weight analytical test data for moisture, any inert non-grindable components and the contribution of any hazardous substances e.g. batteries removed during sample preparation. Where replication has been undertaken average concentration values should be reported.

Commentary: The analytical data will be reported by the analytical laboratory on a dry weight basis but should be assessed on a wet weight or as received basis to represent the ash as it leaves the facility. This is for compositional data only and excludes pH, alkali reserve and leachability data. Metal non-grindable components cannot be used for this calculation, therefore if inert and metal non-grindable components are quantified as a single total the data cannot be used in the calculation of the as received concentrations. The contribution from components containing hazardous substances must be taken into account in the back calculation.

4.2 Data interpretation

Action: Each result received should be reviewed individually and in the context of previous results. The results of this review should be recorded.

It is good practice to use simple statistical data trend techniques to provide information on quality changes in the IBA dataset set. These should include basic trend analysis to identify gradual and step changes in composition as well as identifying increases in the frequency of 'peaks' and 'near misses'. This analysis can be used to support identification of actions that may lower the risk of IBA exceeding permitted limits in future.

The **average** wet weight compositional data (obtained by taking an average of any replicate testing on the same sample) should be compared with the thresholds listed in WM3 (or the most recent version agreed nationally with the Agency), current chemical classification guidance and other evidence that can be used to refine the face value assessment

Commentary: Actions identified from investigation of data trends should be used to reduce the risk of IBA exceeding permitted limits. Where replicate data exhibits a low relative standard deviation (RSD), this provides a higher level of confidence in the test data.

Where a single low or high replicate or high RSD (e.g. greater than 100%) is identified for a relevant determinand a retest on the same sample could be undertaken in conjunction with a discussion with the test laboratory. Further testing could be used to identify that a near miss is a genuine non-exceedance and that an exceedance can be corroborated.

Where two sets of 11 replicates have been undertaken on the same sample the adjusted reported concentration would be the average of 22 replicates unless the laboratory can provide information to show that the first 11 determinations are invalid. In this instance the second set of 11 replicate should be used in isolation.

If the concentration equals or exceeds a hazard threshold, the sample is classified as an exceedance; if the mean concentration is below the hazardous property concentration limit it is classified as a pass.

5. The 24 sample rolling assessment programme

Objective: Evaluate the hazard status of IBA and implications to on-going sampling using the evaluation scheme identified in Figure 3.

As specified in Section 3.4, when any exceedance occurs the EfW operator

(i) must inform the reprocessor and if requested the Environment Agency

(ii) undertake and document an investigation that should be made available to the Environment Agency on request (see 5.5).

Additional actions are necessary if that exceedance

- Is the 3rd exceedance in a row
- Is the 6th exceedance in the last 24 samples, or

Is 4 x any hazardous waste threshold

5.1. Hazardous Waste Classification and the 24 sample rolling assessment period

Action: The test dataset is considered over a 24 sample rolling assessment period. This considers the sample result just received and the 23 previous results and includes any samples collected during an authorised accelerated sampling programme.

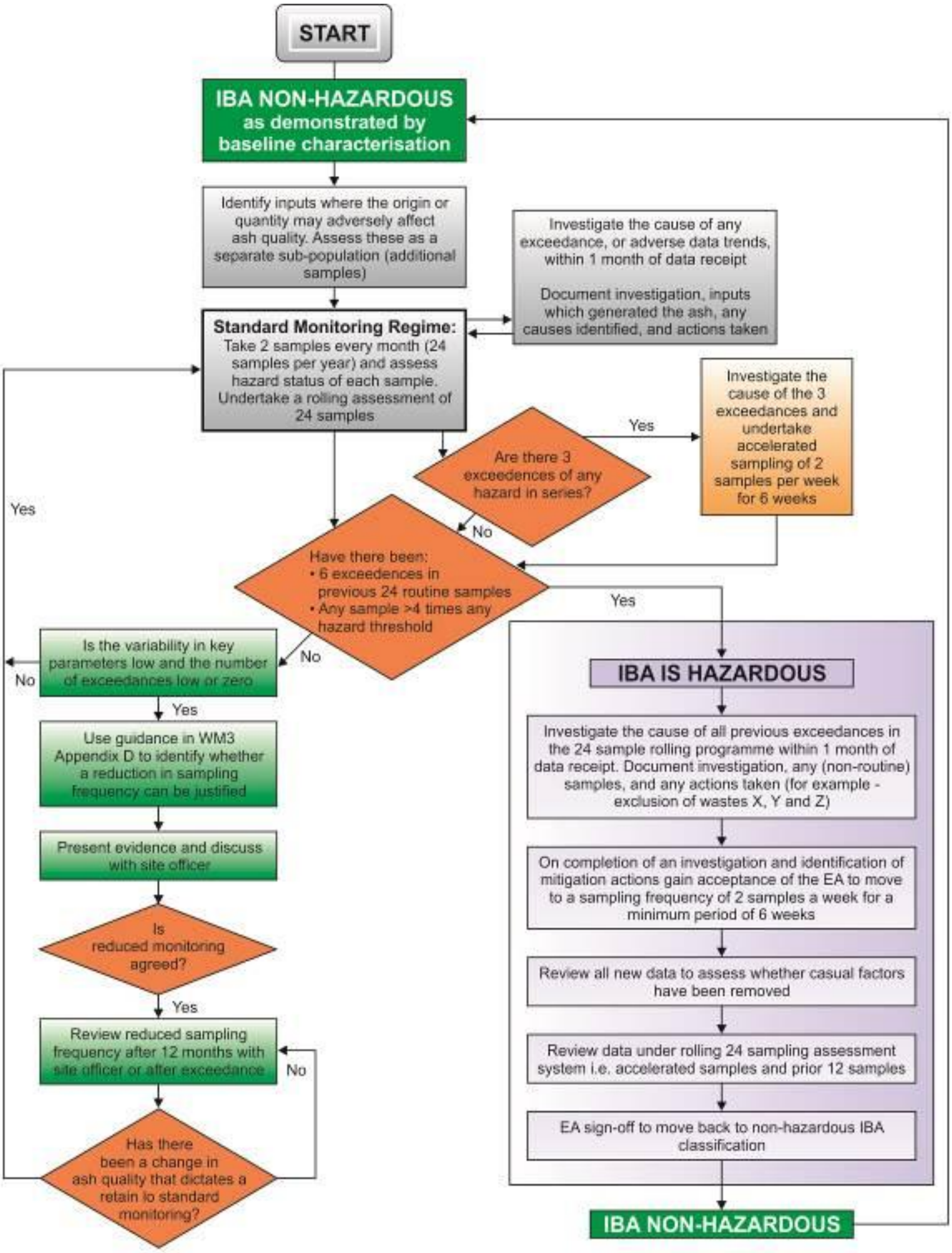
Five single exceedances of a relevant hazardous property concentration limit are allowed in any 24 samples.

Where a historic data set indicates that the IBA is consistently non-hazardous and exhibits a low variability in the concentrations of key contaminants, the sampling frequency could be reviewed using the principles laid out in WM3 Annex D and a reduction in sampling frequency discussed with the site Environment Agency officer.

The IBA is classified as hazardous waste if:

(i) Any parameter exceeds a hazardous property concentration limit by a factor of 4 (a 4 x exceedance).

Figure 3 Flow chart for determining IBA monitoring frequencies



(i) 6 or more exceedances have occurred in 24 samples.

This classification applies to the ash being held under control awaiting the test result and ash subsequently produced from the EfW facility until a non-hazardous waste classification can be demonstrated.

If 3 exceedances of any hazardous property concentration limit are experienced in a row, whilst a hazardous waste classification is not immediately triggered further actions are required to establish whether the problem is on-going and a change in waste classification is required. All exceedances must be assessed in the context of the 24 sample rolling assessment regime. Section 5.4 provides further details.

5.2 Actions to be taken in the event of a the waste being classified as hazardous

Action: When the waste is classified as hazardous the operator must ensure that all ash produced by the EfW facility, including that held awaiting the result at the reprocessor, is managed as hazardous waste.

Any exceedances in the period of accelerated testing should be reviewed in the context of historic monitoring data to identify if they are ‘out of character’ for the facility or whether they are consistent with variable and potentially erratic prior data. The former might point to a problem with waste inputs from recent new customers, the latter a longer term issue. Reviewing statistical data analysis will also be important to identify the timescales over which the IBA may have been changing.

The operator should conduct an investigation into the cause of the hazardous waste classification as outlined in Section 5.3, identify the cause, remove it, report to the regulator, and if the regulator accepts that this has been done may commence rapid reassessment of the IBA.

The objective of the rapid re-assessment is to demonstrate that:

- the cause has actually been removed, **and**
- the IBA is now consistent and non-hazardous

The re-assessment should consist of a minimum of 2 samples per week for a minimum of 6 weeks (i.e. a minimum of 12 samples). The hazard status of the waste should be assessed on the basis of the last 24 results (including these 12) in line with the rolling assessment programme.

Where a cause cannot be found despite an intensive investigation it is important that the accelerated testing and on-going monitoring is used to demonstrate that levels of the pollutant(s) of concern have returned to ‘normal’ levels, and that there are no exceedances that could indicate that the underlying cause remains.

The ash produced during this period of additional testing can either be:

- classified as hazardous waste, or
- classified as ‘unknown status’ whilst awaiting the results of the reassessment. In which case it would need to remain under control and not reprocessed.

It is important to note that there are three potential outputs from reassessment:

- the ash is consistently non-hazardous
- the ash is consistently hazardous, or

- the ash is inconsistent, and is not a single population under the protocol. The waste inputs contributing to this inconsistency should be removed or considered separately.

The latter is more likely where the results suggest the initial cause has not been remedied and may remain or reoccur.

5.3 Investigation when testing shows IBA to be hazardous

Action: An investigation must be completed by the facility operator to identify the cause(s) of the move to hazard status. As detailed in Section 4.2 it will be important to review historical data and statistical trend analyses to help fingerprint the cause of the change in IBA quality.

Objective of an investigation: Undertake an investigation to attempt to find the cause of exceedances within the 24 sample programme and prevent re-occurrence. Establish whether the exceedance is an indicator of a wider problem. Expert assistance may be sought to design a suitable investigation and provide independence.

Investigation actions: The EfW facility should transpose the steps outlined below into a site specific procedure that is agreed with the local EA inspector in advance. This should expedite the investigation and reclassification process in the event of a hazardous IBA trigger.

The site specific procedure should as a minimum include the following steps.

i. Verify that the facility-specific sampling plan was correctly adopted (collection of a sample at a much smaller scale will lead to a higher variability in test data).

ii. Identify whether there has been an analytical error (Note: where an extremely high data point has affected the overall mean, a retest should have already been undertaken – see Section 4.2).

iii. Review all previous test data to identify prior warning of the event and establish a possible time frame for any causal factors.

iv. Review all wastes accepted in the previous month (or longer where the data analysis indicates that concentrations of a specific parameter have been: increasing over time, become more variable or exhibit a step change in concentration) to identify those which may be relevant to the observed exceedance (i.e. they may contain the relevant contaminant). This must include all mirror entry wastes as identified in the List of Wastes Decision.

v. Visually examine all loads of waste coming into the facility from any target suppliers as identified in (iv) for a period of a week to try and identify any visual abnormalities.

vi. Discuss any changes in the source or content of the waste delivered at the time of the exceedance with relevant waste suppliers as identified in (iv) and request characterisation data to confirm with the waste supplier that all wastes delivered conforms to stated EWC codes.

Following the investigation, and where a causal factor has been identified, quantifiable measures should be implemented to improve ash quality. This may involve exclusion of inputs identified as the cause, and additional sampling (outside of the protocol) to ascertain if this has succeeded. The investigation and remedial action must be recorded and available for audit by the Environment Agency.

Commentary: It is important that a relevant level of information is held on all waste streams being accepted at a EfW facility to avoid delays in identifying target waste producers in the event of an exceedance and move to accelerated sampling.

Specific Action to be taken in the event of a four-times exceedance:

Objective: To undertake an investigation to establish the validity of the 4-times exceedance and take all practical measures to improve ash quality.

In the event of a 4-times exceedance the EfW facility should inform the Environment Agency and third party ash reprocessor immediately.

Note: If any sample produces a result that is more than 3.5 times a hazard threshold, the reserve laboratory sample or the facility reserve sample from the original sample collection process should be retested and the mean of the 22 replicates used.

The waste must be kept under control until the retest result is obtained.

If the retest confirms a 4-times exceedance, the waste, from the date of the taking of that sample, should be regarded as hazardous.

Additional chemical speciation tests may be appropriate to refine the original hazard assessment calculation and identify whether the 4-times hazard threshold is still valid and whether the IBA should continue to be classed as non-hazardous.

If the 4-times exceedance stands an investigation should be carried out as detailed in Section 5.3. In the event of a confirmed 4-times exceedance, and despite completion of an initial investigation (as detailed in steps i to vii) identification of the cause of the exceedance and proof of remedial action has not been possible, the facility should be permitted to move to an accelerated sampling frequency. This should be used to confirm the exceedance to be due to an exceptional event and provide confidence that ash quality has returned to acceptable limits and should be started as soon as possible after the 4-times event. Investigations should be continued to find the causal factor of the 4-times exceedance.

Agreement that the IBA can be reclassified as non-hazardous should be determined with the Environment Agency.

Commentary: The purpose of testing the facility reserve sample is to establish that a critical high level of contamination in the original test sample is consistent across the 200 kg sample rather than just the 20 kg initially prepared for testing.

5.4 Actions to be taken in the event of a 'three in a row' exceedance

Action: If 3 exceedances of any hazard threshold are experienced in a row i.e. 3 in a row', whilst hazard status is not immediately triggered further actions are required to establish whether the problem is on-going and a change in hazard classification required. The Environment Agency and reprocessor should be informed of the 3 in a row event. An intensive investigation is required in conjunction with an immediate programme of accelerated testing to identify causal factors.

A detailed investigation as detailed in Section 5.3 should be instigated to identify waste inputs and processing arrangements which may have led to the change in IBA quality.

Specifically the exceedances should be reviewed in the context of historic monitoring data to identify if they are 'out of character' for the facility or whether they are consistent with variable and potentially erratic prior data. The former might point to a problem with waste inputs from recent new customers, the latter a longer term issue. Reviewing statistical data analysis will also be important to identify the timescales over which the IBA may have been changing.

Concurrently with the investigation 12 accelerated samples should be taken to provide further data on the characteristics of the ash within the standard 6 week timeframe.

Where a causal factor is identified and a change implemented, or additional testing indicates improved ash quality for the hazard thresholds exceeded agreement should be sought from the Environment Agency that the IBA can remain as non-hazardous. If no obvious cause for the 3 in a row exceedances can be found subsequent steps should be determined through dialogue with the Environment Agency.

Note: Where the 3 in row exceedances trigger the 6 exceedances in 24 sample limit the ash would be immediately designated as hazardous and the specific actions identified in Section 5.1 would apply.

GLOSSARY OF TERMS

Term	Description
90^{th} percentile	The value below which 90% of all observations fall. In this case, 90% of all loads.
95% confidence	The point at which you can be 95% sure that a given value (or range of values) lies within a specified range.
As received	Test data from the analytical laboratory must be back-calculated for any inert non-grindables removed during the sample preparation process and the moisture content lost on sample drying pre testing. This back-calculation converts the test data so that it represents the quality of the material as it leaves the facility prior to undertaking any assessment of hazardous properties as specified in WM3.
Clinker	Silicate rich hard material formed during the combustion process that may contain metal rich inclusions.
CLP Regulation	Chemicals, Labelling and Packaging Regulation.
C&I	Commercial and Industrial waste
Confidence Interval	The interval within which a particular population parameter may be stated to lie at a specified confidence level. The bounds of the confidence interval are termed the upper and lower confidence limits.
DM	Dry matter. Mass of test material after complete drying (to constant weight) at 105^{o}C. Expressed as % wet weight.
EfW	The combustion of waste in an Energy from Waste facility
Four-times exceedance	The concentration of a relevant hazardous property concentration limit is exceeded by a factor of four times
Grab	A large sample taken from nominated load that are placed in a single pile and mixed to form a primary sample.
IBA	Incinerator Bottom Ash
Increment	Individual portions of waste that are taken from the same primary sample and combined to produce the laboratory sample. This activity would commonly be undertaken manually using a spade or shovel.
Laboratory sample	Sample sent to the laboratory for testing, which is produced by taking increments from a mixed primary sample.
MSW	Municipal Solid Waste.
Population	The population represents the total volume of waste about which information is required. In this case this is the full year input to or output from the plant.
Precision	The measure of precision usually is expressed in terms of imprecision and computed as a standard deviation of the test results. A lower precision is reflected by a larger standard deviation. The precision of a result is half the confidence interval.
Primary Sample	Represents any large sample taken at the scale of sampling e.g. 1 load or 1 day. The primary sample should consist of a number of large grab samples, which are combined and mixed and a representative sample taken for analysis – the laboratory sample.
RSD	Relative Standard Deviation is the positive square root of the variability of a dataset and is calculated by dividing the standard deviation by the mean and reporting as a percentage.
Sampling event	The sampling event describes the actions required to take a sample. For an EfW plant, each sampling event should take place on a separate day unless information on within-day sample variability is specifically required.
Scale of sampling	The scale defines the total volume of waste from which the sample is to be taken. In

Term	Description
	this case, this is a day's input or output to the EfW.
Sub-sample	Any portion of material taken from the sample as part of laboratory tests.
Three in row exceedance	Three consecutive samples of IBA all have an exceedance of a relevant hazardous property concentration limit
Variability	Variability is a characteristic of the waste that cannot be changed without intensive manipulation of the waste. Its investigation is important because the more that is understood about the causes of variability affecting the material under investigation, the greater will be the opportunity for that knowledge to be exploited in designing the sampling programme.