

A proposal from AD industry representatives to the PAS 110 Review Steering Group and environmental regulators to refine the existing limit level for the Residual Biogas Potential (RBP) test

1. Premise

Some AD operators including those who have come together to form the AD Operators Working Group¹ consider that the RBP test is not relevant to proving the quality and fitness for purpose of quality digestate, and therefore that it is not relevant within the context of PAS 110 specification. In addition they consider it to be a very costly and time consuming test to carry out.

Ideally, if the PAS 110 review had not already been considerably delayed (see section 2 below), the AD industry representatives recognise that it would have been possible for consideration to have been given to whether the RBP could be replaced by a simpler, cheaper and shorter alternative test method (or appropriate calculation). However, since the current PAS 110 review has already been considerably delayed, these AD operators fear that proposing an alternative method at this point would require further R&D and thus cause significant further delays to the review.

In view of this the AD industry representatives are now proposing to support the retention of the RBP test method in its current form but to change its limit level to a higher value based on sound, available evidence.

The members of the PAS 110 Review Steering Group requested on 24th October that a paper be drafted setting out the position of AD industry representatives and forwarded to them and the Environment Agency. This paper draws on available research including the data made available to the PAS 110 Review Meeting by Renewable Energy Association courtesy of the Biofertiliser Certification Scheme.

The paper does not consider the purpose of the Residual Biogas Potential Test (RBP) itself. However the AD industry representatives consider that clarity has not yet been fully obtained from the environmental regulator on the purpose of the RBP or an alternative test. For this reason we urge the regulator to clarify the purpose of the RBP or an alternative method in the context of compliance with End of Waste criteria, to assist the industry in developing alternatives in the future.

¹ TEG Environmental, Biogen, Andigestion, PDM, Agrivert, GWE, Lower Reule, Cannington, Gask Farm, Local generation, Tamar Energy, Swancote Energy, Eco Sustainable Solutions, Biffa, Future Biogas

2. Basis for the current RBP test, its limit level and the selection of the current virgin comparator

At the PAS 110 Steering Group meeting held on 13th May 2013 the environmental regulator agreed to provide a summary explaining the basis from European End of Waste criteria and relevant case law for requiring the Residual Biogas Potential or an equivalent test and for selecting an appropriate virgin comparator. This would guide suggestions for alternative comparative materials and limit levels.

On 4th July 2013, one and a half months later, the regulator provided a document entitled *Note on RBP Test and Alternatives*, which explains the basis for requiring the RBP or an equivalent alternative test.

Following repeated requests to the regulator from WRAP and the trade bodies (REA, ADDBA and ADOWG) for further clarity, in particular on how virgin comparators could be selected, and how equivalence with virgin comparators could be demonstrated, the Environment Agency supplied further feedback to WRAP on 12th September. Prior to that date, WRAP and the sector trade bodies were unable to secure a meeting with the regulators to obtain clarity on these aspects. This meant that the originally anticipated timescale for the review of PAS110 was subjected to a delay of at least 4 months. As a result, the industry was not sufficiently clear in advance as to whether further R&D work would be required to support the selection of a different virgin comparator, or what the criteria would be for the choice of an alternative test method and/or the setting of a new limit level for the current method.

As explained in the Environment Agency *Note on RBP Test and Alternatives* released last July, the residual biogas potential test (RBP) is required by the regulator to demonstrate equivalence of waste-derived digestates with a virgin comparator (raw material).

The RBP test method was developed by a consortium made up of the University of Southampton (SU), the Open University (OU) and consultancy WRc Plc². As clarified by the consortium in the associated report, at the time the test was developed there was 'a lack of evidence on which to base an RBP value that represents digestate stability and process efficiency'. Consequently it was decided to run parallel tests on a very limited number of other materials commonly applied to land, which included two cattle slurries, two pig slurries and five sewage sludges. It is unclear from the report which types or fractions of cow and pig slurries were analysed. As the budget available for this project was limited, the consortium was not able to analyse a sufficient number of samples to allow the limit level for the RBP to be set on a robust statistical basis.

The virgin comparator currently selected by the regulator is cattle slurry. Based on the RBP values reported by the consortium for the two samples of cattle slurries, a limit of 0.20 l/gVS was considered for PAS110 digestates. However, given the very small size of the UK's AD sector at the time, and the paucity of information available, a higher value (0.25 l/gVS) based on a very limited number of samples was adopted instead. Sewage sludge was also considered as a comparator and, if adopted, would have led to much lower RBP limit.

² Walker M., Banks, C., Heaven S., and Frederickson J, 2010. Residual biogas potential test for digestates. Development and evaluation of a method for testing the residual biogas potential of digestates. Sponsored by WRAP.

It follows from the above that the environmental regulator regarded the evidence provided in the original SU/OU/WRC consortium's report sufficient to support the setting of the current threshold.

3. Selection of a more appropriate virgin comparator

As highlighted in the Environment Agency's *Notes on the RBP Test and Alternatives* issued in July 2013, cattle slurry was selected as the virgin comparator since this is considered to have undergone a 'natural' anaerobic digestion process.

The AD industry representatives on the PAS 110 Steering Group consider that this is not the correct comparator for digestates that are based on food wastes and that pig slurry would be a more appropriate virgin comparator. This is because pig slurries are much more similar in their physical form and nutrient content to food-based digestates than cow slurries. This has been confirmed by Prof. Brian Chambers FACTS/0646 (ADAS) (personal communication):

'There is no question that pig slurries are more similar to food-based digestates than cattle slurries. They are more similar in terms of physical form and nutrient content (particularly readily available nitrogen). It is for this reason data related to pig slurries are presently used as a surrogate for food-based digestates in nutrient planning software, such as MANNER-NPK and WRAP guidance on "Using Quality Anaerobic Digestate to Benefit Crops" (page 6).'

The charts shown below, which illustrate some of the results from DC-Agri project³ (field experiments for quality digestate and compost in agriculture and field horticulture, see <http://www.wrap.org.uk/content/digestate-compost-agriculture> for more information), confirm that, from the point of view of the nutrient content (total nitrogen and readily available nitrogen), food based digestates are much more similar to pig slurries than cow slurries.

³DC-Agri project is a four year research project looking at the use of quality anaerobic digestate (biofertiliser) and compost in agriculture, integrated with an extensive knowledge exchange network. The project is funded jointly by Defra, WRAP, WRAP Cymru and Zero Waste Scotland.

Total nitrogen (N) in food-based digestate and livestock slurries (kg/m³)



Figure 1. Total nitrogen in food-based digestate and livestock slurries

Readily available nitrogen (RAN)

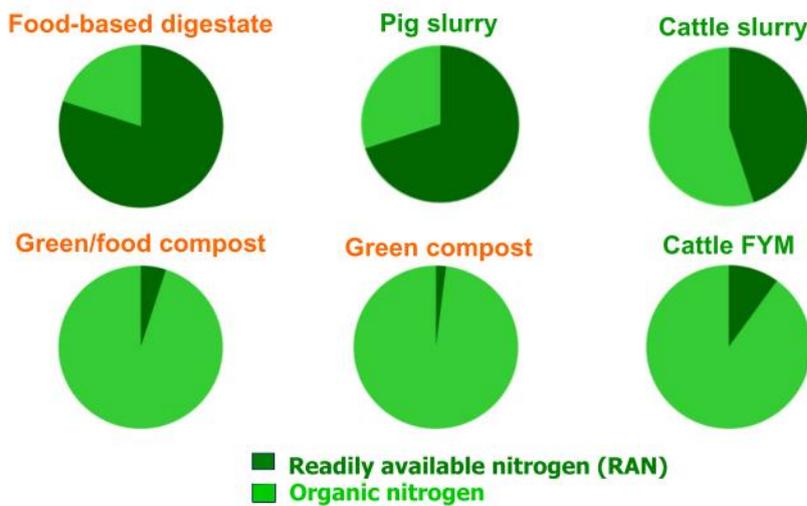


Figure 2. Readily available nitrogen in food-based digestate and livestock

4. Revision of the existing RBP limit level

WRAP-supported work⁴, carried out subsequent to the original test method development, tested a number of similar materials including five cow slurries, one mixed cow & pig slurry, four pig slurries and one sewage sludge.

⁴<http://www.wrapcymru.org.uk/sites/files/wrap/Digestate%20odour%20management%20%20Cymru.pdf>

RBP values for the four pig slurries tested ranged between 0.501 and 0.876 l biogas / g VS.

In summary, the following RBP values for six pig slurry samples are now available from the original development work and the subsequent WRAP-supported work.

Table 1. RBP values for six pig slurry samples	
Sample	RBP results⁵ (l biogas/g VS)
Pig slurry 1	0.260
Pig slurry 2	0.140
Pig slurry 3	0.501
Pig slurry 4	0.638
Pig slurry 5	0.638
Pig slurry 6	0.876

As you can see from the RBP values of pig slurries shown in Table 1, five out of six samples of pig slurries show RBP levels above the limit currently set in PAS 110 for digestates (0.25 l biogas / g VS). Most notably, four out of six samples present values equal or above **0.5 l biogas / g VS**, peaking at approximately **0.9 l biogas / g VS**.

5. Testing RBP levels on whole digestate only

Feedback from the Open University and NRM is that the RBP should not be tested on separated liquors, particularly the very diluted ones (i.e. those with a very low dry matter content) as these have very low volatile solids content which can lead to distorted values and test failures), given how the RBP result is expressed (l biogas / g VS).

According to the OU, it is feasible to perform the test on separated digestate fibre fractions. These are more likely to pass the RBP level test as they contain high contents of volatile solids, some of which are typically recalcitrant.

However, the latest Southampton University R&D report on the RBP⁶ recommends that, given the purpose of the RBP, the test is only applied to whole digestate.

⁵ Note that the source and type of pig slurries used for WRAP supported development work and subsequent work are unknown.

⁶ Charles J. Banks, Dr Sonia Heaven, Dr Yue Zhang, Dr Melanie Sapp and Richard Thwaites, 2013. Review of the application of the residual biogas potential, sponsored by WRAP.

6. Sampling point

AD industry representatives are happy to retain the current sampling approach, which requires the digestate to be sampled at the point of dispatch, after full treatment. This is because we consider that digestate should be sampled in the form in which it will be delivered to the customer.

For AD plants that are separating the whole digestate, it is proposed that samples for the RBP test be taken just prior to separating whole digestate into separate fractions.

7. RBP results related to BCS digestates

The data collected on the RBP test results for digestates were courtesy of the BCS and were kindly provided by NRM (the only lab appointed under the BCS).

The original dataset included 151 samples from 21 operators that are currently certified to PAS 110 or working towards certification. Only two of the operators registered on the BCS refused to disclose their data.

Contextual information about the samples was provided by all the operators e.g. when the AD plant start-up phase finished, the plant average retention time, and the point of sampling. This led to the removal of 35 samples that were obtained during the AD plants start-up phase and, thus, were not considered representative of digestate produced by a plant operating under stable conditions.

The **116** samples left included:

- **72** samples of whole digestate, of which **64** were from food waste only
- **21** samples of separated liquor
- **23** samples of separated fibre

Based on the recommendations from Southampton University, RBP should only be tested on whole digestates. Thus we have shown below basic statistics derived from the 72 samples of whole digestates in the available dataset and on the 64 food waste only digestates included in the same dataset⁷. These include RBP results on digestates from 13 operators. Results from 4 out of the 13 operators showed occasional or consistent RBP failures. Digestate from a further 3 operators showed occasional or regular failures for separated liquors and separated fibre fractions.

The normal distribution of the data obtained was confirmed by preparing a frequency histogram and conducting a Kolmogorov-Smirnov test for normality on it.

⁷ Data from different operators have not been directly assessed or compared, and the influence of operators' results on the outcome of the statistical assessment has not been performed.

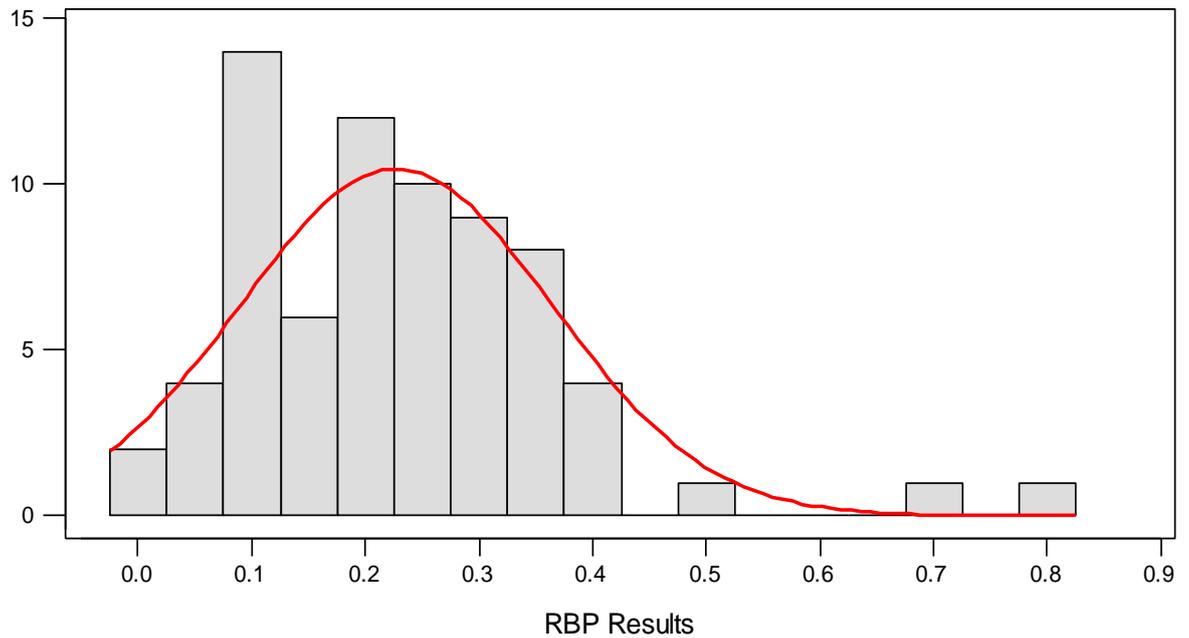
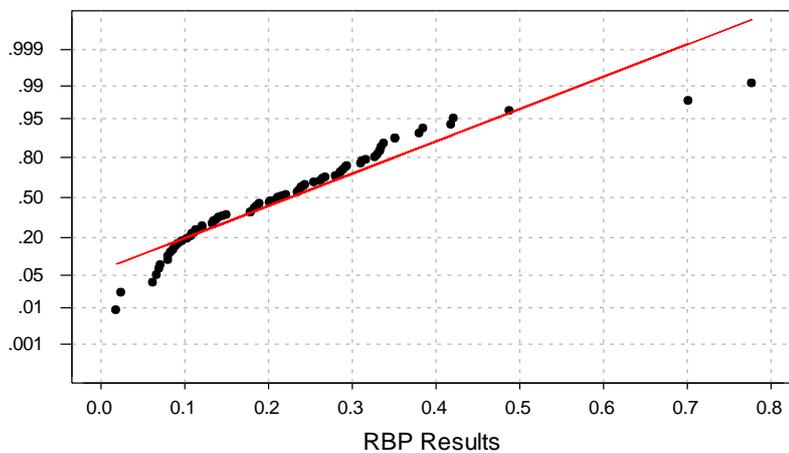


Figure 3. Histogram of RBP results, with normal curve

Normal Probability Plot



Average: 0.227236
 StDev: 0.137404
 N: 72

Kolmogorov-Smirnov Normality Test
 D+: 0.085 D-: 0.088 D: 0.088
 Approximate P-Value > 0.15

Figure 4. Normality probability plot on RBP results from BCS digestates

The histogram and the normality probability plot above confirm that the distribution is not significantly different from normal.

Table 2 below show basic statistics carried out on the **72** samples of whole digestate and the **64** samples of whole digestates based on food waste only.

Table 2. Data on the failure rate of 72 samples of whole digestates and 64 samples of food-based only whole digestates which have been tested using the RBP test against the current PAS 110 limit.		
	Whole digestates (all samples)	Food-based only whole digestates
Statistical parameter	RBP (l biogas/g VS)	RBP (l biogas/g VS)
Test failure rate (%)	40.3	45.3
Mean of sampling distribution	0.227	0.240
Upper confidence limit (95%)	0.259	0.274
Lower confidence limit (95%)	0.195	0.206
Standard Deviation (SD)	0.137	0.140
Median of sampling distribution	0.215	0.238
75th Percentile	0.298	0.313
90th percentile	0.352	0.372
95th percentile	0.419	0.421
Mean + 1 SD	0.365	0.380
Mean + 1.96 SD	0.497	0.514
N samples	72	64

From the above statistics we can deduce few key points:

- The current failure rate when considering the existing RBP limit level of 0.25 l biogas/g VS is high (40 % for the full dataset of whole digestates and 45% for the dataset of whole digestates based on food waste only), even despite the fact that these AD plants are operating under stable conditions and are either working toward certification or are already certified. This implies these plants should have an appropriate quality management system and a HACCP plan in place aligned to the requirements of PAS 110 to ensure the production of a quality digestate. In the case of certified plants, this quality management system and HACCP plan has been audited by independent certification bodies and has proved to be effective.

- 90 - 95% of the samples would have passed the test if the limit had been set at approximately 0.4 l biogas/g VS.
- For both set of data (whole digestates and food-based only whole digestates), the 95th percentile is lower than most of the values reported for pig slurries. This clearly shows that digestates registered on the BCS can be recovered to a point that not only is comparable but it's much lower than the values reported for pig slurries.
- 98% of the values of the whole population in a normal distribution should lie within 1.96 times the standard deviation of the mean, namely between **0** and **0.5 l biogas/g VS**.

The data obtained from RBP testing has shown that 0.4 l biogas/g VS is a level that AD operators registered on the BCS can reasonably achieve, but even achieving that level remains challenging and that there may be occasional spikes measured at higher levels.

The AD operators present at the meeting pointed out that, as the gate fees continue to drop (as competition for feedstocks increases) and more and more local authorities require compliance with PAS 110 for the treatment of their wastes, it is in their interest to maximise biogas production and achieve compliance with PAS 110. Any AD operator that has invested the significant sums required, in most cases millions of pounds, considers it extremely unlikely that an operator would chose to put feedstocks through the system quickly as this would reduce the amount of biogas produced and, thus, reduce the main source of income for the operator.

8. Minimum sampling frequency proposed for validation and on-going compliance with regard to RBP

It is proposed that at least three samples be tested for RBP during validation, over a minimum period of 3 months, with a minimum interval of one month between consecutive samples. This is a change from the existing approach, based on which the interval between two consecutive samples is the average retention time of the plant. The new proposed approach should ensure that samples of digestate are taken sufficiently far apart in time to ensure that each sample represents a different portion of production. This is confirmed by the statistics shown in table 3, related to the RBP results from an AD plant with an average retention time of 55 days. The table compares the mean and standard deviation of RBP results from samples obtained at a monthly frequency and samples obtained every other month. The means and standard deviations of the sampling distributions suggest that there is no significant difference in the RBP results for this plant whether it is sampled on a monthly basis or every other month.

AD operators should be able to justify alternative sampling programmes (e.g. a number of samples higher than the three minimum required or a higher time interval between two consecutive samples) to reflect potential fluctuations in the input materials.

It is proposed that the frequency of sampling after validation (for checking on-going compliance with the RBP limit level) is retained from the current approach (2 samples per 12 months, not within 3 months of each other or sooner if and when a significant change

occurs). It is proposed that the frequency is not increased in view of the considerable cost of the current RBP test (approximately £500 per sample). The cost would become prohibitive for small AD operators if the frequency was to be increased to more than two samples per year. The standard must be proportionate and cost-effective for all AD operators.

Table 3: RBP results from an AD plant with 55 days average retention time from samples obtained on a monthly and bi-monthly frequency

Sampling month	RBP mean result - monthly frequency	RBP mean result: bimonthly sampling frequency	RBP mean result: bimonthly sampling frequency
Jun-13	0.317	0.317	
Jul-13	0.242		0.242
Aug-13	0.292	0.292	
Sep-13	0.268		0.268
Oct-12	0.352	0.352	
Nov-12	0.294		0.294
Dec-12	0.333	0.333	
Jan-13	0.280		0.280
Feb-13	0.238	0.238	
Mar-13	0.289		0.289
Apr-13	0.266	0.266	
May-13	0.312		0.312
Jun-13	0.355	0.355	
Jul-13	0.237		0.237
Aug-13	0.150	0.150	
No samples	15	8	7
Mean	0.282	0.288	0.275
Standard Deviation	0.053	0.069	0.027

9. Approach for evaluating compliance with the RBP limit level

With the current approach for evaluating compliance with PAS 110 minimum quality criteria, each portion of production sampled and tested for RBP is evaluated against the existing RBP limit level (0.25 l biogas / g VS). If the sample fails to comply with the limit, the impact is considerable:

- If the portion of production sampled is still on site (e.g. in the storage tank), any digestate mixed with the failed portion of production is non-conforming ('waste'), thus it needs to be either re-processed or spread under deployments as waste; under the HACCP approach, all digestate produced following the failed portion of production is also classed as non PAS 110 conforming (waste), until three consecutive passes for RBP have been regained⁸. Given that the RBP test results are often delivered by the laboratory up to 35 days after the sample was taken, it follows that the AD operator will have to store and deal with considerable amount of waste digestate that has been produced subsequently to the failed sampled portion.
- If the portion of production is no longer on site (e.g. it has already been dispatched to a customer), then the implications are even more severe, as the AD operator will have to inform his customers and the regulator of the failure and will have to obtain deployments retrospectively.

The main criticism with this approach is the severity of the impact of one failure on any one operator. We believe that these impacts are disproportionate to the actual implications of a failure, and have therefore proposed some alternative approaches.

Option 1

The first alternative approach that could be included in the PAS 110 is a rolling average approach, based on which compliance with the standard is evaluated on the basis of the arithmetic average calculated from a suitable number of samples. This would be a moving average, which is updated every time a new sample is tested for RBP.

Based on the considerations made in sections 4 and 7 above, we would suggest that an absolute maximum limit of 0.5 l biogas / g VS is set on a rolling average basis.

A rolling average approach should encourage more AD operators to try producing PAS 110 digestate, as AD operators perceive that the likelihood of having to obtain 'back-up' customers with Environmental Permits to landspread failed portions of production as waste is lower.

Such an approach is similar to that proposed by JRC-IPTS in the End of Waste proposals for composts and digestates.

Actions in the event of test failures:

⁸ After validation, under clause 13.4 a re-test may be conducted after pumping more material into the tank from which the sample was taken. If this passes, this can be counted as the first of the three consecutive passes required.

- In the event that the arithmetic mean exceeds 0.5 l biogas / g VS, extra samples should be tested for the RBP until the rolling arithmetic mean returns to be within 0.5 l biogas / g VS.
- With regard to the latest sampled portion which caused the rolling average to exceed the limit, this should be dealt with as a non-conforming portion of production. Any other portion mixed with it would also be classed as non-conforming. Any portion subsequently produced is also non-conforming until the rolling average conforms to the limit level.

Option 2

This option is based on the current approach for evaluating compliance, but with the RBP limit level increased from 0.25 l biogas / g VS to 0.5 l biogas / g VS, based on the mean value of the six slurry samples tested for RBP.

Operators who are members of the AD Operators Working Group have a preference for Option 1.

The Biofertiliser Certification Scheme and other stakeholders in the PAS 110 Steering Group expressed a preference for Option 2 as it appears simpler and clearer.

10. Novel approaches

We strongly recommend that a clause is included in the revised PAS 110 which enables the Competent Authority to approve an alternative method (either test or calculation) provided that this achieves the Competent Authority's objectives. This approach is similar to that already allowed for demonstrating pathogen eradication under Notes 2 and 3, Annex A of PAS 110.

Proposed text of the clause: "the competent authority (e.g. the regulator) may approve an alternative method that achieves their objectives".

It should be made clear that the method need not be an equivalent to RBP, but should be derived from the stated objectives of the regulator. This clause should facilitate the addition of an alternative test method or other suitable approach (e.g. calculation method or a mass balance approach) in the future and the development of new tests which are quicker to conduct and cheaper than the current RBP. The RBP test is expensive and time consuming and the need for a replacement is widely supported by the industry; allowing for the development of an equivalent alternative has the advantage of avoiding a long wait for a full review of PAS110.

Finally, as highlighted below, it is crucial that the regulator clarifies the purpose of the RBP test or any alternative method. We therefore request that clear text explaining the purpose of requiring this test or an alternative method is provided by the regulator at the earliest opportunity.