Beta Analytic Inc.

Please see Beta's comments in the file attached. We appreciate the opportunity to share our perspective, thank you!

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Washington State Department of Ecology
Washington Clean Fuel Standard (CFS) Program | Stakeholder Feedback

This comment is intended to recommend the use of the carbon-14 testing method to determine the share of biogenic carbon content of feedstocks, fuels and emissions under Washington's Clean Fuel Standard program. Biogenic content measurements following methods such as ASTM D6866 Method B currently provide critical value to existing state, federal and international clean fuel standard programs.

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Recommendations for Washington's Clean Fuel Standard

Our recommendation is that Washington's Clean Fuel Standard should include direct biogenic content testing (carbon-14) requirements following the ASTM D6866 Method B standard for any fuels or feedstocks seeking recognition of renewable (biogenic) content. Routine direct biogenic testing requirements are the only reliable method of incentivizing the use of biomass-derived content and guaranteeing compliance and currently play a critical role in prominent similar programs. This comment follows up on our previous remarks for this CFS rulemaking process.

This comment is specifically meant to address several topics included in the CFS Public Review Draft 2 and raised by Ecology during the webinar for this rulemaking. This comment will address updates to the program's 3rd party verification which would align the program with California's LCFS, Orgeon's CFP and the US RFS, the draft's requirements for co-processing, Ecology's plans to introduce a book and claim system for biomethane, introducing SAF to the program, and considerations as Ecology continues to work on plans to integrate the use of mass balance calculations for liquid fuels.

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Introduce Routine Biogenic Testing Requirements

Our first recommendation is that Ecology should introduce routine biogenic testing requirements in line with those in place for the US RFS, California's LCFS and Oregon's CFP. Washington's CFR is currently the only active low-carbon fuel standard in the US which does not include routine direct testing requirements. Introducing routine testing would also be in line with best practices established by Canada's CFR and the EU's RED.

Routine direct test results are currently used to verify biogenic content under the US EPA's Renewable Fuel Standard (RFS), California's Low Carbon Fuel Standard (LCFS), Oregon's Clean Fuels Program, Canada's Clean Fuel Regulations (CFR) and the EU's Renewable Energy Directive (RED). All of these programs except the EU RED specifically require the carbon-14 standard ASTM D6866, while the EU RED accepts ASTM D6866 or its European equivalents. ASTM D6866 is also required for prominent third-party verification programs, most notably the Roundtable on Sustainable Biomaterials (RSB).[1] Testing requirements allow clean fuel programs to exclusively incentivize the renewable portion of fuels. This is especially important given the recent history of attempted fraud in existing transportation fuel decarbonization programs.

Washington's Clean Fuel Standard program should specifically require direct biogenic testing for any fuels produced from co-processing, municipal solid waste (MSW) biogas & renewable natural gas (RNG) and any other fuels for which the final biogenic content is unknown. Current requirements of routine direct testing following ASTM D6866 under similar prominent programs includes (please see specific rules hyperlinked):

- The US RFS currently requires routine direct testing following ASTM D6866 for fuels produced from co-processing, municipal solid waste (MSW), biogas & renewable natural gas (RNG).[2]
- California's LCFS requires routine direct testing for fuels produced from co-processing and recommends for fuels produced from MSW.[3]
- Oregon's CFP requires routine direct testing following the protocols of the US RFS third-party engineering reviews.[4]
- Canada's CFR requires routine direct testing for any fuels produced from co-processing and their co-products.[5]
- The EU's RED requires routine direct testing for any fuels produced from co-processing or biogas & renewable natural gas (RNG).[6]

[1] 2023. "RSB Standard for Advanced Fuels." *Roundtable on Sustainable Biomaterials (RSB)*
[2] 2023. "40 CFR Parts 80 and 1090– Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes." *EPA*
[3] 2020. "Reporting Co-Processing and Renewable Gasoline Emissions Under MRR." *California Air Resources Board*
[4] 2023. "Oregon Clean Fuels Program." *Oregon Department of Environmental Quality*
[5] 2022. "Clean Fuel Regulations: Quantification Method for Co-Processing in Refineries." *Environment and Climate Change Canada*
[6] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*

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Always Require Calculations to be Verified by Direct Testing

Beta believes it is not in the best interest of Washington's CFS to add mass balance calculations to the program for liquid fuels. If Ecology does implement mass balance calculations, it is critically important to require these calculations to be verified by routine direct testing. We stress the importance of reviewing other programs' experiences with these calculation based approaches to understand the risk they would introduce to the program.

Producers and industry lobbying groups favor calculation based approaches such as mass balance because they enable facilities to make claims solely based on material inputs in production. These calculations allow producers to assume that all of their biomass inputs end up in their facilities' outputs, despite it being well understood in the industry that the input of renewable feedstocks is not the same as the output because performance varies and renewable feedstocks don't produce the same quantity of material as their fossil counterparts.[7] By basing their calculations solely on production inputs rather than outputs these methods systematically over-report the renewable share of fuels.

Calculation based approaches also use a system of free allocation, meaning they do not have to guarantee that there is any renewable content in a given fuel. Producers prefer this because if 10% of their feedstocks are biogenic they can claim that 10% of their products are biogenic, even if that's not the case because biobased can go in different amounts to different products in the co-process. Even further, book and claim also allows them to claim that 10% of their products are 100% biogenic and the rest are 0%, even if all of the products should be 10% biogenic based on calculations (and would likely C14 test below that).[8]

These calculations' reliance on free allocation creates the potential for double counting of renewable content, leaving low carbon fuel programs susceptible to high risk of greenwashing and fraud. For example, this threat is highlighted by the recent mass balance fraud challenges faced by the ISCC regarding fraudulent biodiesel submissions from China which "caused a dramatic fall in biodiesel prices in European markets" in July 2023.[9] In response to this situation, the EU quickly updated the RED's co-processing rules to uniformly require direct testing, including to verify the calculations of producers choosing to use calculation based approaches.[10]

It is in the best interest of Washington's decarbonization goals not to allow any producers to report their biogenic content using mass balance calculations. However, if mass balance is introduced to lighten the burden on producers, it is critical that these calculations be routinely verified by direct testing. The advantage of the new RED protocol is that producers can choose to use calculations internally for their

[7] 2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.
[8] 2024. "The Mass Balance Approach." *International Sustainability & Carbon Certification*
[9] 2023. "ISCC Press Release July 27, 2023." *International Sustainability & Carbon Certification*
[10] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*

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convenience, while the program still ensures the information reported is accurate through direct Carbon-14 analysis. This is the only way to mitigate the risk to the program introduced by these calculations.

Requiring test results is especially important for Washington because there are no refineries in the state. The mass balance system is designed to allow producers to maximize the incentives they can receive from programs such as the CFS, without guaranteeing that they are actually providing the sustainability benefits those incentives are meant to produce. Facilities certified using these calculations are extremely difficult to audit as a result. There are multiple facilities across the globe successfully using Carbon-14 analysis of the actual output and it is the easiest and most trustworthy method.

Require Routine Testing for Co-Processing in Refineries

The proposed requirements for co-processing refineries in the public review draft are insufficient to regulate co-processed fuels in this program. As discussed above, refineries conducting co-processing are required to verify the renewable portion of their fuels under the US RFS, California's LCFS, Oregon's CFP, Canada's CFR and the EU RED. We re-emphasize the importance of the EU RED as a relevant example which allowed co-processed fuels to be submitted exclusively using calculations and was forced to quickly adopt C-14 testing requirements after discovering a massive case of fraudulent fuels last year.

Biogenic testing following ASTM D6866 should specifically be required under (7)(b)(ii), which would currently only require "A detailed methodology for the allocation of biogenic feedstocks to the renewable products." As currently written this section would allow fuels to be approved exclusively using calculations such as mass balance which cannot be relied on as the only method of verifying renewable content. If calculations are allowed as a verification method in the program they must be paired with routine renewable testing requirements.

In addition to the regulations for other programs linked above in the, "Introduce Routine Biogenic Testing Requirements," section, we also urge Ecology to review the following studies on co-processing conducted by the ASTM D02 Committee on petroleum products, liquid fuels and lubricants. We specifically recommend reviewing RR:D02-2052, which compares the results of ^{14}C and mass balance in co-processing facilities.[11] The table below shows an example of that study's key findings.

[11] 2023. "RR:D02-2052." *ASTM International*

Standard	**Report #**					
D1655	RRD02-2052					
Findings						
Pre-Fractionation Blend Analysis						
	Component, vol %	**Blend 1 Pre**	**Blend 2 Pre**	**Blend 3Pre**		
	Petrochemical Stream	**60**	**80**	**80**	***This Pre-Fractionation verification of biogenic content of the blends demonstrates the accuracy of ASTM D6866***	
	Feed 1	**40**				
	Feed 2		**20**			
	Feed 3			**20**		
	D6866 Method B	**40**	**20**	**20**		
Biogenic %, per ASTM D6866 Method B	**Blend 1 Pre**	**Blend 1 Post**	**Blend 2 Pre**	**Blend 2 Post**	**Blend 3 Pre**	**Blend 3 Post**
	40	**17**	**20**	**7**	**20**	**5**

Standard	**Report #**					
D1655	RRD02-1886					
Findings						
Biomass Input 5%, yield in final product by ASTM D6866 2.1%						

The black font in the table shows the expected values of biogenic content based on mass balance calculations, while the red shows the actual values reported by direct testing. The study shows that mass balance consistently over-estimated the biogenic content which ended up in co-processed fuels because biomass does not behave the same as fossil feedstocks, and not all of the biomass inputs necessarily end up in the same output.[12]

We recommend further reviewing RR:D02-2052, as well as the rest of this collection of technical reports which includes RR:D02-1886, RR:D02-1929, RR:D02-2052, RR:D02-1739, RR:D02-1810, RR:D02-1776, RR:D02-1884, RR:D02-1828, and RR:D02-2039. Several of these studies specifically compare the results of ^{14}C and mass balance in co-processing facilities in the context of sustainable aviation fuel production in particular. These studies found that mass balance calculations are consistently unable to estimate the renewable portion of co-processed fuels and should not be relied on as the sole method of verification for clean fuel programs. All of these technical reports are available from ASTM upon request.

Introducing a Book-and-Claim System for Biomethane

As the biomethane industry accelerates in jurisdictions with clean or low-carbon fuel programs, properly regulating the industry in this early stage is key to its future success. Recent developments in the US RFS and EU RED have demonstrated best practices for regulating biogas, biomethane and renewable natural gas (RNG) based on these programs' early experiences with these fuels.

[12] 2023. "RR:D02-2052." *ASTM International*

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The only way to reliably differentiate biogenic biomethane from fossil fuel methane is to require mandatory routine test results following ASTM D6866 Method B for any entities seeking recognition of emission reductions from the use of biomethane. Since biomethane and fossil fuel, methane are chemically identical molecules, the only way to differentiate the two is to perform carbon-14 testing of the fuels or the emissions after combustion to assess what percentage of the mixture was biogenic.

The EU introduced biogenic testing requirements for fuels produced from biogas in a June 2023 update to the EU Renewable Energy Directive (RED) titled, "Renewable energy- method for calculating the share of renewables in the case of co-processing."[13] This update was specifically issued in response to the discovery of a major case of fraud within the RED program stemming from biodiesel submissions from China which were approved by mass balance calculations.[14] The EU investigation into this issue is still ongoing, and the full extent of the damage is not yet known, but this was a significant setback for the program and quickly plummeted biodiesel prices in the EU. The EU tied biogas and RNG into the update in order to address these concerns for any fuels containing a mixture of biogenic and fossil content.

The advantage of this framework is that the EU was able to continue to accept calculation-based methodologies like mass and energy balance by requiring routine direct biogenic testing to validate the data. However, calculation-based approaches are much more common for co-processing, where all inputs and outputs are concentrated in a single facility, as opposed to biomethane and RNG which are often produced, upgraded and blended at multiple facilities.

The US introduced biogenic testing requirements for fuels produced from biogas in the 2023 Set Rule update to the US Renewable Fuel Standard (RFS), in a section called the Biogas Regulatory Reform Rule.[15] This update requires routine biogenic testing for any biogas or RNG fuels seeking to generate RINs under the RFS. Starting on July 1st, 2024 for new facilities and January 1st, 2025 for existing facilities, fuels produced from biogas will need to submit biogenic test results of the biogas at the point of production from the digester/landfill, at the point of upgrading, and after upgrading prior to pipeline injection.

Beta encourages Ecology to consider following a similar approach to enable a book-and-claim system for biomethane using routine direct testing. The US RFS model of testing at the point of production, at the point of blending with non-renewable components and at the point of injection into a pipeline, provides a comprehensive chain of custody for the renewable content in these fuels, making it possible to report and trade only real biogenic content introduced to the grid. Similarly, the EU RED model demonstrates that tying calculation-based accounting approaches to routine direct testing is the most secure way to access the benefits of a book-and-claim system without exposing the program to undue risk.

[13] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*
[14] 2023. "ISCC Press Release July 27, 2023." *International Sustainability & Carbon Certification*
[15] 2023. "40 CFR Parts 80 and 1090– Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes." *EPA*

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Introducing In-State SAF

As Ecology looks to introduce SAF used within the state to the program, we recommend that routine biogenic testing requirements following ASTM D6866 Method B be applied to any SAF produced by co-processing as well. Routine biogenic testing requirements are the only way to reliably verify the renewable content included in mixed fuels and therefore encourage the displacement of fossil content. Especially given the importance co-processing currently plays in the SAF industry's early development, requiring routine testing is the best way to incentivize renewable content and penalize fossil content. We specifically recommend that Ecology review the Netherlands' HVO Regulation as an example of a successful policy uniformly requiring direct testing for fuels where co-processing represents a significant share of the market.

Conclusion

Establishing this Clean Fuel Standard was a critical first step in the state of Washington's decarbonization journey. By implementing best practices for verification established by similar state, federal and international fuel decarbonization programs the Department of Ecology can protect and strengthen its ability to successfully achieve and measure the goals of this program. Routine direct testing following ASTM D6866 Method B is the most effective way to incentivize and validate biogenic content under this program.

What is Biogenic Testing (Carbon-14)?

Carbon-14 analysis is a reliable method used to distinguish the percentage of biobased carbon content in a given material. The radioactive isotope carbon-14 is present in all living organisms and recently expired material, whereas any fossil-based material that is more than 50,000 years old does not contain any carbon-14 content. Since Carbon-14 is radioactive, the amount of carbon-14 present in a given sample begins to gradually decay after the death of an organism until there is no carbon-14 left. Therefore, a radiocarbon dating laboratory can use carbon-14 analysis to quantify the carbon-14 content present in a sample, determining whether the sample is biomass-based, fossil fuel-derived, or a combination.

The analysis is based on standards such as ASTM D6866 and its international equivalents developed for specific end uses, such as ISO 13833. ASTM D6866 is an international standard developed for measuring the biobased carbon content of solid, liquid, and gaseous samples using radiocarbon dating.[16] There are also many international standards based on the specific use of direct Carbon-14 testing, such as ISO 13833, which is an international standard developed for measuring the biogenic carbon content of stationary sources emissions.[17]

[16] 2021. "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis." *ASTM International (D6866-21)*

[17] 2013. "ISO 13833:2013 Stationary source emissions: Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide." *International Organization for Standardization*

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Carbon-14 analysis yields a result reported as % biobased carbon content. If the result is 100% biobased carbon, this indicates that the sample tested is completely sourced from biomass material such as plant or animal byproducts. A result of 0% biobased carbon means a sample is only fossil fuel-derived. A sample that is a mix of both biomass sources and fossil fuel sources will yield a result that ranges between 0% and 100% biobased carbon content. Carbon-14 testing has been incorporated into several regulations as the recommended or required method to quantify the biobased content of a given material.

ASTM D6866 Method B - The Most Reliable Method

Carbon-14 is a very well-established method which has been in use by many industries (including the fossil fuel industry) and academic researchers for several decades.

Carbon-14 measurements done by commercial third party testing is robust, consistent, and with quantifiable accuracy/precision of the carbon-14 amount under **ASTM D6866 method B**. The EN 16785 is the only standard that allows a variant of the Mass Balance (MB) method of ‘carbon counting’ under EN 16785-2. The EN 16785-1 requires that the biocarbon fraction be determined by the carbon-14 method. However, when incorporating this EN 16785 method, certification schemes like the “Single European Bio-based Content Certification” **only** allow the use of EN 16785-1 due to its reliability and the value of a third-party certification. http://www.biobasedcontent.eu/en/about-us/

In ASTM D6866 method B, the carbon-14 result is provided as a single numerical result of carbon-14 activity, with graphical representation that is easily understood by regulators, policy makers, corporate officers, and more importantly, the public. The overwhelming advantage of carbon-14 is that it is an independent and standardized laboratory measurement of any carbon containing substance that produces highly accurate and precise values. In that regard, it can stand alone as a quantitative indicator of the presence of biobased vs. petroleum feedstocks. When carbon-14 test results are challenged, samples can be rapidly remeasured to verify the original reported values (unlike mass balance).

The quantification of the biobased content of a given product can be as low as 0.1% to 0.5% (1 relative standard deviation – RSD) based on Instrumental error for Method B (AMS). This error is exclusive of indeterminate sources of error in the origin of the biobased content, and manufacturing processes. As such a total error of +/-3% (absolute) has been assigned to the reported Biobased Content to account for determinate and indeterminate factors.[18]

[18] 2021. Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis. *ASTM International (D6866-21).* pp 1-19. doi: 10.1520/D6866-21.

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It is also important that the program should always require ASTM D6866 Method B, rather than allow Method C for any use. Where ASTM D6866 Method B uses the AMS Instrument to measure ^{14}C, Method C uses Liquid Scintillation Counting (LSC). In Method B, the AMS Instrument directly measures the ^{14}C isotopes. However, in Method C, scintillation molecules indirectly absorb the beta molecules that release with the decay of ^{14}C and convert the energy into photons which are measured proportionally to the amount of ^{14}C in the sample. Since Method B directly measures the ^{14}C isotopes and Method C measures them indirectly, Method B is significantly more precise and should be prioritized in regulations.[19] LSC measurements, like those used in Method C, are commonly used as an internal testing tool when samples are limited and accuracy does not need to be extremely high.

About Beta Analytic

Beta Analytic was among the originators of the use of Accelerator Mass Spectrometry (AMS) for the ASTM D6866 biobased / biogenic testing standard using Carbon-14 to distinguish renewable carbon sources from petroleum sources. Beta began testing renewable content in 2003 at the request of United States Department of Agriculture (USDA) representatives who were interested in Beta's Carbon-14 capabilities for their BioPreferred® Program (www.biopreferred.gov). At their request, Beta joined ASTM under subcommittee D20.96. Beta's previous president, Darden Hood, was positioned as a technical contact for the USDA and within 3 months completed the ASTM D6866-04 standard. The Carbon-14 technique is now standardized in a host of international standards including ASTM D6866, CEN 16137, EN 16640, ISO 16620, ISO 19984, BS EN ISO 21644:2021, ISO 13833 and EN 16785. Carbon-14 analysis can be used on various types of samples (gas, liquids and solids). Beta Analytic continues to be a technical contact for ASTM D6866 with current president Ron Hatfield and is involved with all their latest ASTM D6866 versions.

The Carbon-14 standardized method is also incorporated in a variety of regulatory programs including the California AB32 program, US EPA GHG Protocol, US EPA Renewable Fuels Standard, United Nations Carbon Development Mechanism, Western Climate Initiative, Climate Registry's Greenhouse Gas Reporting Protocol and EU Emissions Trading Scheme.

We are currently technical experts on Carbon-14 in the following committees:

ASTM D6866 (D20.96) Plastics and Biobased Products (Technical Advisor)
ASTM (D02.04) Petroleum Products, Liquid Fuels and Lubricants (Technical Advisor)
ASTM (061) US TAG to ISO/TC 61 Plastics (Technical Expert)
USDA BioPreferred Program TAC (Technical Advisor)
ISO/TC 61/SC14/WG1 Terminology, classifications, and general guidance (Technical Expert)

[19] 2022. "Testing the methods for determination of radiocarbon content in liquid fuels in the Gliwice Radiocarbon and Mass Spectrometry Laboratory." *Radiocarbon*

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CEN/TC 411 Biobased Products
CEN/TC 411/WG 3 Biobased content
CEN/TC 61/SC 14/WG 1 Terminology, classifications, and general guidance (Technical Expert)

ISO/IEC 17025:2017 Accredited Laboratory

To ensure the highest level of quality, laboratories performing ASTM D6866 testing should be ISO/IEC 17025:2017 accredited or higher. This accreditation is unbiased, third party awarded and supervised. It is unique to laboratories that not only have a quality management program conformant to the ISO 9001:2008 standard, but more importantly, have demonstrated to an outside third-party laboratory accreditation body that Beta Analytic has the technical competency necessary to consistently deliver technically valid test results. The ISO 17025 accreditation is specifically for natural level radiocarbon activity measurements including biobased analysis of consumer products and fuels, and for radiocarbon dating.

Required tracer-free facility for Carbon-14

For carbon-14 measurement to work, be accurate, and repeatable, the facility needs to be a tracer-free facility, which means artificial/labeled carbon-14 is not and has never been handled in that lab. Facilities that handle artificial carbon-14 use enormous levels relative to natural levels and it becomes ubiquitous in the facility and cross contamination within the facility, equipment and chemistry lines is unavoidable. Results from a facility that handles artificial carbon-14 would show elevated renewable contents (higher pMC, % Biobased / Biogenic values), making those results invalid. Because of this, Federal contracts and agency programs (such as the USDA BioPreferred Program) require that AMS laboratories must be 14C tracer-free facilities in order to be considered for participation in solicitations.

To learn more about the risks associated with testing natural level Carbon-14 samples in a facility handling artificially enhanced isotopes please see the additional information provided after this comment.

References

2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.

2010. "40 CFR Part 80 Subpart M– Renewable Fuel Standard." *National Archives Code of Federal Regulations* https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-80/subpart-M

2013. "ISO 13833:2013 Stationary source emissions: Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide." *International Organization for Standardization*

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2020. “Reporting Co-Processing and Renewable Gasoline Emissions Under MRR.” *California Air Resources Board* https://ww2.arb.ca.gov/sites/default/files/2020-09/MRR_coprocessing-slides_Sept_2020.pdf

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2023. “Oregon Clean Fuels Program.” *Oregon Department of Environmental Quality* https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1560

2023. “RSB Standard for Advanced Fuels.” *Roundtable on Sustainable Biomaterials (RSB)* https://rsb.org/wp-content/uploads/2024/03/RSB-STD-01-010-RSB-Standard-for-advanced-fuels_v2.6-1.pdf

2023. “RR:D02-2052.” *ASTM International* https://www.astm.org/rr-d02-2052.html

Demand a Tracer-Free Laboratory for Radiocarbon Dating

As part of its commitment to provide high-quality results to its clients, ISO/IEC 17025-accredited Beta Analytic does not accept pharmaceutical samples with "tracer Carbon-14" or any other material containing artificial Carbon-14 (14C) to eliminate the risk of cross-contamination. Moreover, the lab does not engage in "satellite dating" – the practice of preparing individual sample graphite in a remote chemistry lab and then subcontracting an AMS facility for the result.

High Risk of Cross-Contamination

Pharmaceutical companies evaluate drug metabolism by using a radiolabeled version of the drug under investigation. AMS biomedical laboratories use 14C as a tracer because it can easily substitute 12C atoms in the drug molecule, and it is relatively safe to handle. Tracer 14C is a well-known transmittable contaminant to radiocarbon samples, both within the AMS equipment and within the chemistry lab.

Since the artificial 14C used in these studies is phenomenally high (enormous) relative to natural levels, once used in an AMS laboratory it becomes ubiquitous. Cross-contamination within the AMS and the chemistry lines cannot be avoided. Although the levels of contamination are acceptable in a biomedical AMS facility, it is not acceptable in a radiocarbon dating facility.

Biomedical AMS facilities routinely measure tracer-level, labeled (Hot) 14C samples that are hundreds to tens of thousands of times above the natural 14C levels found in archaeological, geological, and hydrological samples. Because the 14C content from the biomedical samples is so high, even sharing personnel will pose a contamination risk; "Persons from hot labs should not enter the natural labs and vice versa" (Zermeño et al. 2004, pg. 294). These two operations should be absolutely separate. Sharing personnel, machines, or chemistry lines run the risk of contaminating natural level 14C archaeological, geological, and hydrological samples.

Avoid the Risks

Find out from the lab that you are planning to use that they have never in the past and will never in the future:

- accept, handle, graphitize or AMS count samples containing Tracer or Labeled (Hot) 14C.

- share any laboratory space, equipment, or personnel with anyone preparing (pretreating, combusting, acidifying, or graphitizing) samples that contain Tracer or Labeled (Hot) 14C.

- use AMS Counting Systems (including any and all beam-line components) for the measurement of samples that contain Tracer or Labeled (Hot) 14C.

Tracer-Free Lab Required

Recently, federal contracts are beginning to specify that AMS laboratories must be 14C tracer-free facilities in order to be considered for participation in solicitations.

A solicitation for the National Oceanic and Atmospheric Administration (NOAA) has indicated that "the AMS Facility utilized by the Contractor for the analysis of the micro-samples specified must be a 14C tracer-level-free facility." (Solicitation Number: WE-133F-14-RQ-0827 - Agency: Department of Commerce)

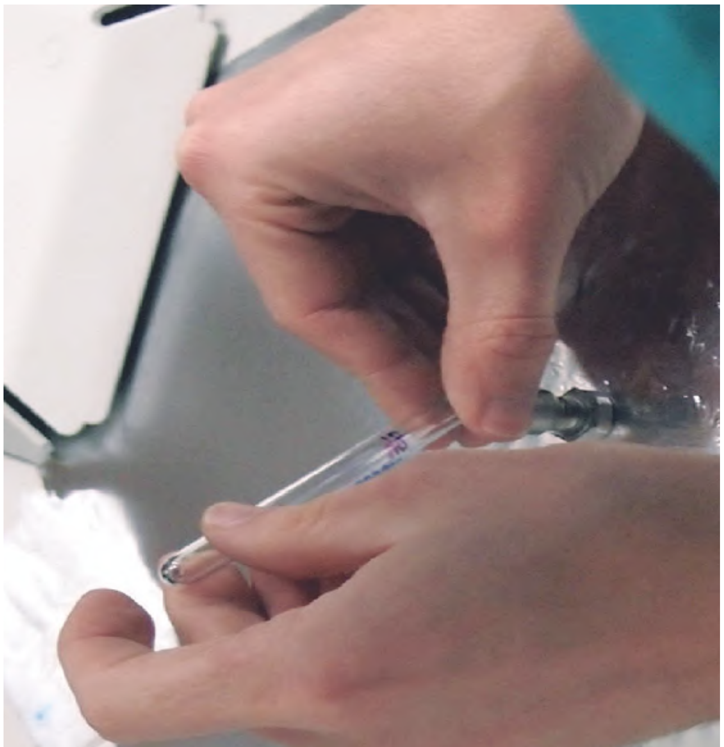
As a natural level radiocarbon laboratory, we highly recommend that researchers require the AMS lab processing their samples to be Tracer-free.

No Exposure to Artificial Carbon-14

According to ASTM International, the ASTM D6866 standard is applicable to laboratories working without exposure to artificial carbon-14 routinely used in biomedical studies. Artificial carbon-14 can exist within the laboratory at levels 1,000 times or more than 100 % biobased materials and 100,000 times more than 1% biobased materials. Once in the laboratory, artificial 14C can become undetectably ubiquitous on materials and other surfaces but which may randomly contaminate an unknown sample producing inaccurately high biobased results. Despite vigorous attempts to clean up contaminating artificial 14C from a laboratory, isolation has proven to be the only successful method of avoidance. Completely separate chemical laboratories and extreme measures for detection validation are required from laboratories exposed to artificial 14C. Accepted requirements are:

(1) disclosure to clients that the laboratory working with their products and materials also works with artificial 14C
(2) chemical laboratories in separate buildings for the handling of artificial 14C and biobased samples
(3) separate personnel who do not enter the buildings of the other
(4) no sharing of common areas such as lunch rooms and offices
(5) no sharing of supplies or chemicals between the two
(6) quasi-simultaneous quality assurance measurements within the detector validating the absence of contamination within the detector itself.

ASTM D6866-22 – Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis.



Useful Reference

1. Memory effects in an AMS system: Catastrophe and Recovery. J. S. Vogel, J.R. Southon, D.E. Nelson. Radiocarbon, Vol 32, No. 1, 1990, p. 81-83 doi:10.2458/azu_js_rc.32.1252 (Open Access)

"... we certainly do not advocate processing both labeled and natural samples in the same chemical laboratory." "The long term consequences are likely to be disastrous."

2. Recovery from tracer contamination in AMS sample preparation. A. J. T. Jull, D. J. Donahue, L. J. Toolin. Radiocarbon, Vol. 32, No.1, 1990, p. 84-85 doi:10.2458/azu_js_rc.32.1253 (Open Access)

"... tracer 14C should not be allowed in a radiocarbon laboratory." "Despite vigorous recent efforts to clean up the room, the "blanks" we measured had 14C contents equivalent to modern or even post -bomb levels."

3. Prevention and removal of elevated radiocarbon contamination in the LLNL/CAMS natural radiocarbon sample preparation laboratory. Zermeño, et. al. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms
Vol. 223-224, 2004, p. 293-297
doi: 10.1016/j.nimb.2004.04.058

"The presence of elevated 14C contamination in a laboratory preparing samples for natural radiocarbon analysis is detrimental to the laboratory workspace as well as the research being conducted."

4. High level 14C contamination and recovery at XI'AN AMS center. Zhou, et. al. Radiocarbon, Vol 54, No. 2, 2012, p. 187-193
doi:10.2458/azu_js_rc.54.16045

"Samples that contain high concentrations of radiocarbon ("hot" samples) are a catastrophe for low background AMS laboratories." "In our case the ion source system was seriously contaminated, as were the preparation lines."

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