

Massachusetts Department of Energy Resources (DOER) CO2 Budget Trading Program | Stakeholder Feedback

This comment recommends the use of the Carbon-14 testing method following standards such as ASTM D6866 Method B to report the biogenic carbon content of fuels and emissions seeking credit for their renewable content under Massachusetts CO2 Budget Trading Program. Direct biogenic content testing is a well-established best practice for regulating biogenic carbon under prominent successful emissions reporting and fuel decarbonization programs.

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Recommendations for Massachusetts CO2 Budget Trading Program

Our recommendation is that DOER's program should require ASTM D6866 Method B test results to verify the renewable content of fuels and emissions claiming to be biogenic, as required under prominent emissions reporting programs at the state, federal and international levels. Since this program intends to credit electricity produced by biomass combustion, DOER should require ASTM D6866 test results to verify the biogenic CO2 content which can be claimed. This is the only way to guarantee that only the biogenic portion of these emissions are able to generate certificates, and that each certificate directly represents the exact emissions reduction claimed.

Co-Firing

The first critical application of Carbon-14 testing requirements under this program is for biogenic emissions from co-firing biomass with fossil fuels. Routine testing following ASTM D6866 has been required by prominent emissions reductions programs at the state, federal and international levels over

two decades. The following prominent emissions reduction programs also require routine C-14 testing for emissions from co-firing:

- The US GHGRP currently [requires](#) routine direct testing following ASTM D6866 quarterly for emissions from the combustion of biogenic feedstocks.¹
- California's Cap-and-Trade [requires](#) quarterly testing following ASTM D6866 for biogenic emissions from co-firing and MSW combustion.²
- Canada's GHGRP [requires](#) routine direct testing following ASTM D6866, "if combusted fuels or fuel mixtures contain a biomass fraction that is unknown or cannot be documented."³
- Ontario's Emissions Performance Standards (EPS) [requires](#) quarterly testing following ASTM D6866 to report biogenic content in fuel combustion and petrochemical production.⁴
- The EU's ETS [requires](#) routine direct testing following the European standard EN ISO 13833 for emissions claiming biogenic content, as well as EN ISO 21644 for any combusted biomass seeking an emissions factor of 0.⁵
- The UK's ETS [requires](#) routine direct testing following EN ISO 13833, ISO 18466, or ASTM D6866 for stationary source emissions claiming biogenic content.⁶

This requirement is critical for DOER's CO₂ Budget Trading Program because replacing a portion of existing fossil combustion with biomass is an accessible first step to decarbonization which can help companies reduce their carbon footprint in the immediate future. Since electricity generators can begin to offset their fossil fuel consumption by displacing a portion of their feedstock with biomass, this practice is easier to implement in the short term than constructing new facilities. Given the urgent need to decarbonize, this practice will play a key role in Massachusetts' climate goals.

MSW Combustion

Another key application of biogenic testing requirements which should be applied to this program is for reporting emissions from municipal solid waste (MSW) combustion. Since MSW is a heterogeneous feedstock by definition, routine direct measurement is necessary to determine the biogenic portion of emissions. As with co-firing, routine C-14 testing following ASTM D6866 has been required at the state, federal and international levels for over two decades. The following prominent emissions reduction programs also require routine C-14 testing for emissions from MSW incineration:

- The US GHGRP currently [requires](#) routine direct testing following ASTM D6866 quarterly for emissions from the combustion of biogenic feedstocks.⁷

¹ 2016. "40 CFR Part 98 Subpart C— General Stationary Fuel Combustion Sources." *National Archives Code of Federal Regulations*

² 2016. "40 CFR Part 98 Subpart C— General Stationary Fuel Combustion Sources." *California Air Resources Board*

³ 2020. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada*

⁴ 2020. "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions." *Ontario MECP*

⁵ 2018. "Commission Implementing Regulation (EU) 2018/2066." *Official Journal of the European Union*

⁶ 2021. "UK ETS: Monitoring and Reporting Biomass in Installations." *UK Department for Business, Energy and Industrial Strategy*

⁷ 2016. "40 CFR Part 98 Subpart C— General Stationary Fuel Combustion Sources." *National Archives Code of Federal Regulations*

- California's Cap-and-Trade [requires](#) quarterly testing following ASTM D6866 for biogenic emissions from co-firing and MSW combustion.⁸
- Canada's GHGRP [requires](#) routine direct testing following ASTM D6866, "if combusted fuels or fuel mixtures contain a biomass fraction that is unknown or cannot be documented."⁹
- Ontario's Emissions Performance Standards (EPS) [requires](#) quarterly testing following ASTM D6866 to report biogenic content in fuel combustion and petrochemical production.¹⁰
- The EU's ETS [requires](#) routine direct testing following the European standard EN ISO 13833 for emissions claiming biogenic content, as well as EN ISO 21644 for any combusted biomass seeking an emissions factor of 0.¹¹
- The UK's ETS [requires](#) routine direct testing following EN ISO 13833, ISO 18466, or ASTM D6866 for stationary source emissions claiming biogenic content.¹²

Biomethane/RNG Combustion

Another important consideration of biogenic testing for this emissions reporting program is the use of biomethane or renewable natural gas (RNG) combustion. Similar to co-firing, these fuels are a key strategy for immediate decarbonization because they can serve as drop-in replacements compatible with existing infrastructure. Fuels produced from biogas are often mixed with fossil components when upgrading to biomethane/RNG to reach the energy content required for utilities, and are often commingled with fossil natural gas in order to transport through existing pipelines. As a result, routine direct testing is the only reliable method for reporting the biogenic portion of emissions when combusting biogas-derived fuels. The following prominent clean fuel and emissions reduction programs also require routine C-14 testing for biomethane/RNG production and/or combustion:

- The US RFS [requires](#) routine direct testing following ASTM D6866 for biogas-derived fuels upgraded with non-renewable components.¹³
- The EU's RED [requires](#) routine direct testing for any fuels produced from co-processing or biogas and renewable natural gas (RNG).¹⁴
- Australia's NGER [requires](#) routine biogenic testing for any blended gaseous fuels, including biogas and RNG fuels which are blended with non-renewable components.¹⁵
- Canada's GHGRP [requires](#) quarterly C-14 testing following ASTM D6866 to recognize biogenic emissions from the combustion of biogenic gaseous fuels including biogas and RNG. Canada's

⁸ 2016. "40 CFR Part 98 Subpart C— General Stationary Fuel Combustion Sources." *California Air Resources Board*

⁹ 2020. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada*

¹⁰ 2020. "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions." *Ontario MECP*

¹¹ 2018. "Commission Implementing Regulation (EU) 2018/2066." *Official Journal of the European Union*

¹² 2021. "UK ETS: Monitoring and Reporting Biomass in Installations." *UK Department for Business, Energy and Industrial Strategy*

¹³ 2026. "Final Renewable Fuel Standards for 2026 and 2027." *EPA*

¹⁴ 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*

¹⁵ 2025. "National Greenhouse and Energy Reporting (Measurement) Determination 2008" *Australia DCCEEW*

Clean Fuels Regulation (CFR) also [requires](#) quarterly results for gaseous hydrocarbon co-products of co-processing.

We recommend that DOER require routine testing at the point of combustion for Scopes 1-2 reporting under this program. This would further enable Scope 3 users of electricity from biomethane combustion to have direct evidence for their reduction claims.

Bioenergy Carbon Capture and Storage (BECCS)

One other critical application of C-14 testing which DOER should consider incorporating in this regulation is the biogenic portion of carbon capture and storage (BECCS). In recent years leading carbon credit registries have published methodologies for reporting the biogenic portion of captured CO₂. Many of these quantification protocols require or recommend routine C-14 testing to generate credits, including:

- Puro.Earth's [Geologically Stored Carbon Standard](#), which requires C-14 results for any biogenic CO₂ claims.¹⁶
- Verra's [VT0013 Standard on Differentiating Reductions and Removals in CCS Projects](#) recently added C-14 testing for BECCS in an approach similar to Isometric's standard, providing the option to choose direct testing or calculations.¹⁷
- [Isometric's BCCS v1.3 protocol](#) follows the same approach as Verra for co-firing, allowing operators to report using C-14 results or calculations, but any biogenic content from waste feedstocks must be reported by direct C-14 testing.¹⁸
- CarbonDirect's [High Quality Criteria for Bio-CDR Removals](#), which was created in partnership with Microsoft, currently the largest purchaser of biogenic removal credits.¹⁹ Their criteria include Carbon-14 testing as the best practice for reporting the biogenic portion of CO₂ under any relevant standards.
- While CCUS regulations are in an early stage globally, there are already several programs requiring direct testing to verify biogenic CO₂ captured. One example is Alberta's TIERS Quantification Protocol for CO₂ Capture and Permanent Geological Storage.²⁰ Under the draft protocol published, direct C14 testing using the ASTM D6866 is required to report the biogenic content of CO₂ captured. Testing is required at least every 3 months if the biogenic CO₂ is within a mixed stream, or every 2 years if the biogenic CO₂ is not within a mixed stream.

Another key CCS regulation to consider is the EU's [Carbon Removal and Carbon Farming Regulation](#) (CRCF), which specifically differentiates between biogenic and fossil CO₂ capture and relies on the ETS

¹⁶ 2024. "Geologically Stored Carbon: Methodology for CO₂ Removal." *Puro.Earth*

¹⁷ 2025. "VT0013 Differentiating Reductions and Removals in CCS Projects." *Verra*

¹⁸ 2025. "Biogenic Carbon Capture and Storage Protocol v1.3" *Isometric*

¹⁹ 2025. "Biomass Carbon Removal and Storage." *CarbonDirect*

²⁰ 2024. "Quantification Protocol for CO₂ Capture and Permanent Geologic Sequestration." *Government of Alberta*

requirements and requires biomass to reflect the same sustainability criteria as the EU RED, the requirements for which are discussed above.²¹ The CRCF further relies on the EU ETS requirements to quantify the biogenic portion of CO₂ captured, which lists C14 testing as one of the options to do so. The CRCF Regulation builds on the EU's Regulation 2022/996 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria. Article 14 of this regulation requires auditors to "verify that the estimate of emissions savings from capture and replacement of CO₂ is limited to emissions avoided through the capture of CO₂, of which the carbon originates from biomass and which is used to replace fossil-derived CO₂."²² Direct test results are included in the required information on the origin of the CO₂ that is captured and the origin of the CO₂ that is replaced by biomass. This is a strong example to consider in this rulemaking because it provides an existing model for biogenic CO₂ capture and storage, which also relies on routine testing to verify claims.

One other important rule to consider is the US EPA's [standards for fossil-fired power plants](#) passed in 2024, which included landmark requirements for CCUS as the best system of emissions reduction (BSER) for fossil-fired plants which plan on continuing to operate long-term.²³ Under this BSER any biogenic content involved in CCUS at these plants will be required to submit quarterly biogenic testing as evidence under the EPA's Greenhouse Gas Reporting Program (GHGRP). We recommend that Massachusetts incorporate the same requirements for any biogenic CO₂ seeking recognition under a potential CCUS tax credit. The EPA has over a decade of experience with Carbon-14 testing requirements from the GHGRP and intentionally relied on this testing for a significant role in this major emissions reduction program, which would be its first attempt at regulating biogenic CO₂ for CCUS. While this program is among those targeted by the new administration's deregulation of the EPA, DOER's creation of this emissions reporting program is a great opportunity to take advantage of this strategy for facilities in Massachusetts.

For BECCS and biomass CDR projects, biogenic testing following ASTM D6866 should be required at least quarterly to demonstrate the renewable carbon reported. This is in line with the established requirements for emissions reporting and fuel decarbonization programs discussed above.

²¹ 2024. "Certification for Carbon Removals and Carbon Farming." *European Commission*

²² 2022. "Commission Implementing Regulation (EU) 2022/996 of June 14, 2022 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria." *Official Journal of the European Union*

²³ 2024. "40 CFR Part 60- New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units" *Environmental Protection Agency*

Avoid Relying on Mass Balance for Quantification of Biogenic Content

It is critical the SB 253 program should always rely on direct measurements for biogenic content under this program, rather than recognize any mass balance calculations for biogenic claims. Producers and industry lobbying groups continue to promote 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.²⁴ 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).²⁵

These calculations' reliance on free allocation creates the potential for double counting of renewable content, leaving low-carbon fuel programs susceptible to a 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 2023.²⁶ In response to this situation, the EU quickly updated the RED's co-processing rules to uniformly require direct testing, including verifying the calculations of producers choosing to use calculation-based approaches.²⁷

The importance of limiting the role of mass balance for reporting the biogenic content of fuels is articulated very well by a [recent opinion](#) of the Advocate General of the EU Court of Justice (CJEU) on the roles of mass balance and C-14 for reporting biogenic content in co-processing. The official opinion found that mass balance calculations are not intended to quantify the share of biogenic contained in a biofuel produced by co-processing.²⁸ The opinion was reiterated in the [final ruling](#) of the case which differentiates between determining the sustainable criteria for biofuels (mass-balance) and determining

²⁴ 2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.

²⁵ 2024. "The Mass Balance Approach." *International Sustainability & Carbon Certification*

²⁶ 2023. "ISCC Press Release July 27, 2023." *International Sustainability & Carbon Certification*

²⁷ 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*

²⁸ 2024. "Opinion of Advocate General Campos Sánchez-Bordona Delivered on 11 January 2024: Case C-624/22." *Court of Justice of the European Union*

the share of biogenic carbon (C14 testing).²⁹ This judgment was issued in response to a case brought by BP France against the French government regarding a tax incentive requiring C-14 testing to verify claims of renewable content. BP is also notably a board member of the ISCC.³⁰

Recently in the US issues with mass balance in the recycling industry have received increasing attention. A [ProPublica investigation published in June 2024](#) that products advertised as 30% recycled through mass balance often contained less than 1% recycled content.³¹ Similar concerns were shown by the US EPA as early as 2023, which described the mass-balance methodology as deceptive and advised against promoting it. In August 2024, the US Environmental Protection Agency (EPA) launched a federal action against the mass-balance methodology used in the recycling sector.

In September 2024, California Attorney General Rob Bonta filed [a lawsuit against ExxonMobil](#) claiming that the oil major “deceptively” promoted chemical recycling as a solution to the plastic crisis, citing their use of mass balance calculations such as ISCC Plus.³² That lawsuit directly challenges the standard’s use of ISCC’s free allocation method as a system designed to enable greenwashing.³³ The New York Times also recently [published a relevant article](#) on the challenges that mass balance presents to the recycling industry, which aligns with the challenges experienced in the renewable products industry.³⁴ Recently, the ACC dropped a separate lawsuit against the state of Colorado for limiting the use of mass balance in recycling reporting as well.³⁵

Relying on mass balance rather than direct testing would also be prohibitive to small businesses seeking to take advantage of opportunities in the renewable fuel and emissions markets. In terms of costs, ISCC certification requires thousands of dollars in membership fees, annual fees, and members must then hire their own independent auditors to check their facilities.³⁶ ASTM D6866 testing costs a one-time charge between \$300 and \$500, depending on your choice of laboratory, which has helped to make it an efficient tool for quarterly reporting under these established programs.

It is in the best interest of Massachusetts’ decarbonization goals not to allow any producers to report their biogenic content using mass balance calculations. However, if mass balance is used at all in this methodology, it is critical that these calculations be routinely verified by direct testing. The advantage of the updated RED protocol is that producers can choose to use calculations internally, while the program

²⁹ 2024. “Judgement of the Court (Third Chamber) of 29 July 2024.” *Court of Justice of the European Union*

³⁰ 2024. “Board Members of the ISCC Association.” *International Sustainability & Carbon Certification*

³¹ 2024. “Biden EPA Rejects Plastics Industry’s Fuzzy Math That Misleads Customers About Recycled Content.” *ProPublica*

³² 2024. “The People of the State of California v. Exxon Mobil Corporation.” *Superior Court of the State of California*

³³ 2024. “ExxonMobil Accused of “Deceptively” Promoting Chemical Recycling as a Solution for the Plastics Crisis.” *ProPublica*

³⁴ 2024. “Is Your Water Bottle Really Made From Recycled Plastic?” *The New York Times*

³⁵ 2026. “Colorado Mass Balance Debate Underscores Industry Faultlines.” *Waste Dive*

³⁶ 2024. “The Mass Balance Approach.” *International Sustainability & Carbon Certification*

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.

Conclusion

As discussed throughout this comment, Carbon-14 testing currently plays a key role in prominent emissions reporting programs around the world, and these requirements should be applied to this regulation to create a successful CO₂ Budget Trading Program in Massachusetts. Direct test results are the only reliable way to accurately report the biogenic share of heterogeneous emissions and fuels. By relying on the globally established best practice for biogenic content reporting, DOER can enable this program to successfully deliver on emissions reductions through the use of renewable bioenergy.

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, through a series of half-lives, 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.³⁷ 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 CO₂ stationary sources emissions.³⁸

Carbon-14 analysis yields a result reported as percent (%) 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

³⁷ 2021. "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis." *ASTM International (D6866-21)*

³⁸ 2013. "ISO 13833:2013 Stationary source emissions: Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide." *International Organization for Standardization*

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 using AMS is the “gold standard” for determining biogenic carbon content of solids, liquids, and gases.

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, carbon-14 can stand alone as a quantitative indicator of the presence of biobased vs. petroleum feedstocks and in complex mixtures and products. When carbon-14 test results are challenged, samples can be rapidly remeasured to verify the original reported values (unlike mass balance).

It is critical that testing be required to follow ASTM D6866 Method B. ASTM D6866 Method B uses Accelerated Mass Spectrometry (AMS), while Method C uses Liquid Scintillation Counting (LSC). In Method B, the AMS instrument directly measures the ¹⁴C isotopes. However, in Method C, scintillation molecules indirectly absorb the beta molecules that release with the decay of ¹⁴C and convert the energy into photons which are measured proportionally to the amount of ¹⁴C in the sample. Since Method B directly measures the ¹⁴C isotopes and Method C measures them indirectly, Method B is significantly more precise and should be prioritized in regulations.³⁹ LSC calculations 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.

³⁹ 2022. “Testing the methods for determination of radiocarbon content in liquid fuels in the Gliwice Radiocarbon and Mass Spectrometry Laboratory.” *Radiocarbon*

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 as well as sample heterogeneity.⁴⁰

About SGS Beta

SGS 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 P.G., 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 Mr. Ronald E. 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.

Beta Analytic currently serves as 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)
CEN/TC 411 Biobased Products
CEN/TC 411/WG 3 Biobased content

⁴⁰2021. "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.

CEN/TC 61/SC 14/WG 1 Terminology, classifications, and general guidance (Technical Expert)

Require a 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.

Require a 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.

Areas where cross-contamination might occur include but are not limited to; biomedical or nuclear reactors, isotope enrichment / depletion columns, water, soil, plant, or air samples collected near or at biomedical / nuclear reactor sites, medical, industrial, or hazardous waste sites, samples specifically manipulated to study the uptake / fractionation of stable isotopes due to biological or metabolic processes. To learn more about the risks associated with testing natural levels Carbon-14 samples in a facility handling artificially enhanced isotopes please see the additional information provided after this comment.

References

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2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *California Air Resources Board* https://ww2.arb.ca.gov/sites/default/files/classic/cc/reporting/ghg-rep/regulation/subpart_c_rule_part98.pdf
2018. "Commission Implementing Regulation (EU) 2018/2066." *Official Journal of the European Union* https://eur-lex.europa.eu/eli/reg_impl/2018/2066/oj/eng
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
2020. "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions." *Ontario Ministry of the Environment, Conservation and Parks* <https://www.ontariocanada.com/registry/showAttachment.do?postingId=30247&attachmentId=42676>
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2021. "UK ETS: Monitoring and Reporting Biomass in Installations." *UK Department for Business, Energy and Industrial Strategy* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033859/uk-ets-monitoring-reporting-biomass-installations.pdf
2022. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada* https://publications.gc.ca/collections/collection_2023/eccc/En81-28-2022-eng.pdf
2022. "Clean Fuel Regulations: Quantification Method for Co-Processing in Refineries." *Environment and Climate Change Canada* <https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations/compliance/quantification-methodco-processing-refineries.html>
2022. "Biomass issues in the EU ETS." *European Commission* https://climate.ec.europa.eu/system/files/2022-10/gd3_biomass_issues_en.pdf
2022. "Chapter 173-424 WAC: Clean Fuels Program Rule." *Washington State Legislature*

<https://app.leg.wa.gov/WAC/default.aspx?cite=173-424&full=true>

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ISO/IEC 17025:2017-Accredited Testing Laboratory

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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 (^{14}C) 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 ^{14}C as a tracer because it can easily substitute ^{12}C atoms in the drug molecule, and it is relatively safe to handle. Tracer ^{14}C is a well-known transmittable contaminant to radiocarbon samples, both within the AMS equipment and within the chemistry lab.

Since the artificial ^{14}C 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) ^{14}C samples that are hundreds to tens of thousands of times above the natural ^{14}C levels found in archaeological, geological, and hydrological samples. Because the ^{14}C 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 ^{14}C 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) ^{14}C .

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

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

Tracer-Free Lab Required

Recently, federal contracts are beginning to specify that AMS laboratories must be ^{14}C 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 ^{14}C 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 ^{14}C 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 ^{14}C 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 ^{14}C . Accepted requirements are:

- (1) disclosure to clients that the laboratory working with their products and materials also works with artificial ^{14}C
- (2) chemical laboratories in separate buildings for the handling of artificial ^{14}C 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

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

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"The presence of elevated ^{14}C 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 ^{14}C 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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