ISO/IEC 17025:2017-Accredited Testing Laboratory

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California Air Resources Board (CARB)
Mandatory GHG Reporting and Emissions Cap Proposed Amendments | Stakeholder Engagement

This comment is intended to recommend the use of the Carbon-14 testing method to determine the share of biogenic carbon content of any heterogenous feedstocks, fuels and emissions under California's mandatory reporting of GHG emissions and emissions cap program. Biogenic content measurements following methods such as ASTM D6866 Method B currently provide critical value to leading emissions cap and reporting program's, including California's.

Included here you will find:

Recommendations for California's Mandatory GHG Reporting and Emissions Cap

Our recommendation is that CARB should uphold and re-affirm direct biogenic content testing requirements following the ASTM D6866 Method B standard to verify the renewable (biogenic) content of any heterogenous emissions. Direct biogenic testing requirements are the only reliable method of incentivizing the use of biomass-derived content and guaranteeing compliance in mixed bio- and fossil streams. In addition to the provisions for co-processing and waste incineration included in this rule, we recommend extending biogenic requirements to the following applications.

Landfill Gas Combustion and Upgrading
ASTM D6866 Method B standard for any landfill gas combusted for flaring or energy generation, and for landfill gas captured to be upgraded to biogas/RNG fuels.

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For reference, current requirements of quarterly biogenic testing following ASTM D6866 for landfill gas combustion under similar prominent programs include (please see specific rules hyperlinked):

- The US GHGRP currently requires quarterly routine direct testing following ASTM D6866 for biogenic emissions from co-firing and municipal solid waste (MSW) combustion.[1]
- California's Cap-and-Trade requires quarterly routine direct testing following ASTM D6866 for biogenic emissions from co-firing and MSW combustion.[2]
- Canada's GHGRP requires quarterly routine direct testing following ASTM D6866 for biogenic emissions from any renewable or biogenic fuels derived from biomass including landfill gas and biogas, as well as for any fuels or fuel mixtures containing an unknown biogenic component.[3]
- The EU's ETS requires quarterly routine direct testing for biogenic portions of obligated materials, fuels and emissions.[4]

Biogenic testing requirements are also important to require for landfill gas captured for the production of biogas/RNG fuels. Current requirements of quarterly biogenic testing following ASTM D6866 for landfill upgraded to biogas/RNG fuels under similar prominent programs include (please see specific rules hyperlinked):

- The US RFS currently requires quarterly routine direct testing following ASTM D6866 for fuels produced from co-processing, municipal solid waste (MSW), biogas and renewable natural gas (RNG).[5]
- The EU's RED requires quarterly routine direct testing for any fuels produced from co-processing or biogas and renewable natural gas (RNG).[6]

This is particularly important because the EPA's recently published rule on the RFS for 2026-2027 significantly limited biogenic testing for this industry, scaling back testing frequency from annually to every three years, and from sampling at three points of production to one.[7]

We also recommend reviewing Data/parameter table 2 of the UNFCCC Approved Consolidated Methodology (ACM) ACM0022 on "Alternative waste treatment processes" (pages 41-42). This protocol requires biogenic testing following ASTM D6866 to determine the biogenic and fossil fractions of MSW for any cases where the biogenic content of waste cannot be classified or is unknown, which is critical to quantifying the sustainability of landfill gas combustion.[8]

[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] 2022. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada*
[4] 2022. "Biomass issues in the EU ETS." *European Commission*
[5] 2023. "40 CFR Parts 80 and 1090– Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes." *EPA*
[6] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*
[7] 2026. "Final Renewable Fuel Standards for 2026 and 2027." *EPA*
[8] 2022. "Large-Scale Consolidated Methodology: Alternative Waste Treatment Version 3.0" *UNFCCC*

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Biogenic Carbon Capture and Storage (BECCS) & Biomass-Based Carbon Dioxide Removal (CDR)

We also recommend incorporating biogenic testing requirements to recognize emissions reduction for any bioenergy carbon capture and storage (BECCS) and biomass-based carbon dioxide removals (CDR) projects credited under these regulations. Biogenic testing requirements should play a significant role in any California program crediting CO_2 captured and stored from bioenergy emissions. Direct testing using radiocarbon analysis is the only reliable way to guarantee that a given sample of CO_2 contains the biogenic content claimed. There is a long, successful track record of Carbon-14 testing requirements enabling emissions reduction programs, as well as clean fuel standards, to verify producers' claims of biogenic content pre- and post-combustion.

Carbon-14 testing requirements for biogenic emissions have been the best practice for leading emissions reduction programs for over a decade, including the following, which are relevant to review when drafting a potential BECCS standard for Canada (please see specific rules hyperlinked):

- The US GHGRP currently requires routine direct testing following ASTM D6866 quarterly for emissions from the combustion of biogenic feedstocks.[9] California's Cap-and-Trade (AB 32) requires routine direct testing following ASTM D6866 for emissions from the combustion of biogenic feedstocks.[10]
- California's Cap-and-Trade requires quarterly testing following ASTM D6866 for biogenic emissions from co-firing and MSW combustion.[11]
- 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."[12]
- Ontario's Emissions Performance Standards (EPS) requires quarterly testing following ASTM D6866 to report biogenic content in fuel combustion and petrochemical production.[13]
- 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.[14]
- The UK's ETS requires routine direct testing following EN ISO 13833, ISO 18466, or ASTM D6866 for stationary source emissions claiming biogenic content.[15]

All of these emission reduction programs rely on quarterly direct testing requirements to verify the biogenic portion of CO_2 emissions claimed as renewable. The US EPA's GHGRP is especially important to consider because it has successfully required mandatory quarterly testing and reporting of biogenic content using ASTM D6866 for over 12 years. Programs adopt these requirements because routine direct

[9] 2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *National Archives Code of Federal Regulations*
[10] 2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *California Air Resources Board*
[11] 2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *California Air Resources Board*
[12] 2020. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada*
[13] 2020. "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions." *Ontario MECP*
[14] 2018. "Commission Implementing Regulation (EU) 2018/2066." *Official Journal of the European Union*
[15] 2021. "UK ETS: Monitoring and Reporting Biomass in Installations." *UK Department for Business, Energy and Industrial Strategy*

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testing is the only way to verify claims of biogenic content in mixed stream emissions, which is the portion of those emissions that these programs intend to mandate or incentivize.

While CCUS regulations are in an early stage globally, there are already several programs requiring direct testing to verify biogenic CO_2 captured. One example is Alberta's draft TIERS Quantification Protocol for CO_2 Capture and Permanent Geological Storage.[16] Under the draft protocol published, direct C14 testing using the ASTM D6866 is required to report the biogenic content of CO_2 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 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 requirements and requires biomass to reflect the same sustainability criteria as the EU RED, the requirements for which are discussed above.[17] 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 CO_2 is limited to emissions avoided through the capture of CO_2, of which the carbon originates from biomass and which is used to replace fossil-derived CO_2."[18] Direct test results are included in the required information on the origin of the CO_2 that is captured and the origin of the CO_2 that is replaced by biomass. This is a strong example to consider in this rulemaking because it provides an existing model for biogenic CO_2 capture and storage, which also relies on routine testing to verify claims.

Another 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.[19] 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 California incorporate the same requirements for any biogenic CO_2 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 CO_2 for CCUS. While this program is among those targeted by the

[16] 2024. "Draft Quantification Protocol for CO2 Capture and Permanent Geologic Sequestration." *Government of Alberta*
[17] 2024. "Certification for Carbon Removals and Carbon Farming." *European Commission*
[18] 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*
[19] 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*

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new administration's deregulation of the EPA, CARB's mandatory emissions reporting program is a great opportunity to take advantage of this strategy for facilities in California.

There are also several prominent third-party certification standards which have set the precedent for requiring direct Carbon-14 test results to claim the biogenic portion of captured emissions. First is Puro.Earth's Geologically Stored Carbon Standard, which requires C-14 results for any biogenic CO2 claims.[20] 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.[21] 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.[22] One other major verifier to consider is CarbonDirect's High Quality Criteria for Bio-CDR Removals, which was created in partnership with Microsoft, currently the largest purchaser of biogenic removal credits.[23] Their criteria include Carbon-14 testing as the best practice for reporting the biogenic portion of CO2 under any relevant standards.

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, notably including Alberta's protocol for bioenergy CCUS. In terms of costs, 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.

Never Rely Exclusively on Mass Balance for Quantification of Biogenic Content

It is critical that CARB continue to 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.

[20] 2024. "Geologically Stored Carbon: Methodology for CO2 Removal." *Puro.Earth*
[21] 2025. "VT0013 Differentiating Reductions and Removals in CCS Projects." *Verra*
[22] 2025. "Biogenic Carbon Capture and Storage Protocol v1.3" *Isometric*
[23] 2025. "Biomass Carbon Removal and Storage." *CarbonDirect*
[24] 2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.

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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 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.

[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 Sánches-Bordona Delivered on 11 January 2024: Case C-624/22." *Court of Justice of the European Union*
[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*

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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]

It is in the best interest of India's 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 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

The introduction of these draft methodologies for India's Carbon Credit Trading Scheme (CCTS) is a critical step in India's decarbonization journey. By implementing best practices for verification established by similar state, federal and international fuel decarbonization and emission reduction programs, India's Bureau of Energy Efficiency can best prepare this program to successfully achieve and measure its goals. Routine direct testing following ASTM D6866 Method B is the most effective way to incentivize and validate the use of biogenic content under this program. As India continues to develop programs to advance its decarbonization goals we recommend reviewing the use of biogenic testing in leading programs around the world.

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

[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*

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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.[36] 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.[37]

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

[36] 2021. "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis." *ASTM International (D6866-21)*
[37] 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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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.[38]

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.[39] 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.

[38]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.
[39]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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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)
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)

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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.

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

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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.

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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 (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

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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 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."

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"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
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"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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