ISO/IEC 17025:2017-Accredited Testing Laboratory

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California Air Resources Board (CARB)
SB 905 Carbon Capture, Removal, Utilization and Storage Program | Stakeholder Feedback

This comment recommends the use of the carbon-14 testing method following standards such as ASTM D6866 Method B to determine the biogenic carbon content of emissions reported under the SB 905 program. Bioenergy carbon capture and storage (BECCS) and biomass-based carbon dioxide removals (CDR) should play a critical role in California's decarbonization, and biogenic testing can verify the renewable portion of these projects, which drives the emission reductions they can provide.

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Recommendations for California's SB 905 Carbon Capture, Removal, Utilization and Storage Program

Our recommendation is that California's SB 905 program should incorporate specific language for bioenergy carbon capture and storage (BECCS) and biomass-based carbon dioxide removals (CDR), including routine direct biogenic testing requirements following ASTM D6866 Method B to validate any carbon content claimed as biogenic. Direct biogenic content testing is a well-established best practice for regulating biogenic carbon in prominent successful emissions reporting and fuel decarbonization programs.

Definitions

1. In addition to the terms defined in statute, are there other key terms that should be defined? Please provide any proposed definitions with applicable citations.

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Two other terms which are included as categories for this program but are not included in the definitions section are "Bioenergy with carbon capture and storage" and "Biomass-based carbon removal and storage." These terms should be defined independently from other carbon capture, removal and storage projects because these projects will be regulated slightly differently, with the potential to create very negative carbon intensities. The key difference is that both definitions should include reference to ASTM D6866 to determine the biogenic component of the carbon captured, removed and stored, so that only the portion of emissions that are verified as renewable can generate the credits and incentives for these projects.

Applicability

4. Are there suggestions for further description of these categories, or ways to group categories?

Both categories which rely on biogenic content, "Bioenergy with carbon capture and storage" and "Biomass-based carbon removal and storage," should be in a designated group which requires routine testing following ASTM D6866 Method B to demonstrate their biogenic content. Since the emissions reductions from both types of projects are based on their inclusion of biogenic content, this is the most effective way to regulate any projects making claims based on their renewable carbon.

Criteria and Toxics Monitoring

12.Are there examples of existing regulatory monitoring efforts being conducted in other sectors/sources that may be instructive for SB 905?

Biogenic testing requirements should play a significant role in this draft quantification protocol to verify that CO_2 captured and stored from bioenergy emissions has the biogenic content claimed by producers. 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 (including California's Cap-and-Trade and LCFS), to verify producers' claims of biogenic content pre- and post-combustion.

Leading emissions reduction programs with testing requirements for biogenic emissions, which may be relevant to review include (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.[1] California's Cap-and-Trade (AB 32)

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

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requires routine direct testing following ASTM D6866 for emissions from the combustion of biogenic feedstocks.[2]

- California's Cap-and-Trade requires quarterly testing following ASTM D6866 for biogenic emissions from co-firing and MSW combustion.[3]
- 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."[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]
- Ontario's Emissions Performance Standards (EPS) requires quarterly testing following ASTM D6866 to report biogenic content in fuel combustion and petrochemical production.[6]
- The UK's ETS requires routine direct testing following EN ISO 13833, ISO 18466, or ASTM D6866 for stationary source emissions claiming biogenic content.[7]

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 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 CCS regulations are in an early stage globally and SB 905 will be a pioneer program, there are already several programs requiring direct testing to verify biogenic CO_2 captured, which CARB should consider. One example is Alberta's draft TIERS Quantification Protocol for CO_2 Capture and Permanent Geological Storage.[8] 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 rule to consider is 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

[2] 2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *California Air Resources Board*
[3] 2016. "40 CFR Part 98 Subpart C– General Stationary Fuel Combustion Sources." *California Air Resources Board*
[4] 2020. "Canada's Greenhouse Gas Quantification Requirements." *Environment and Climate Change Canada*
[5] 2018. "Commission Implementing Regulation (EU) 2018/2066." *Official Journal of the European Union*
[6] 2020. "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions." *Ontario MECP*
[7] 2021. "UK ETS: Monitoring and Reporting Biomass in Installations." *UK Department for Business, Energy and Industrial Strategy*
[8] 2024. "Draft Quantification Protocol for CO2 Capture and Permanent Geologic Sequestration." *Government of Alberta*

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and which is used to replace fossil-derived CO_2."[9] 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. Including routine testing requirements in this draft protocol is the best way to emulate this approach of verifying the emissions savings achieved through bioenergy CCS.

Another important rule to consider is the US EPA's standards for fossil-fired power plants passed in 2024, which included landmark requirements for CCS as the best system of emissions reduction (BSER) for fossil-fired plants which plan on continuing to operate long-term.[10] Under this BSER any biogenic content involved in CCS 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 the SB 905 program. 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 CCS. While this program is among those targeted by the new administration's deregulation of the EPA, the SB 905 program is a great opportunity to take advantage of this strategy for facilities in California.

Biogenic testing is also notably the existing best practice for quantifying biogenic content under leading renewable fuel programs around the world, including California's LCFS. Current requirements of quarterly biogenic testing following ASTM D6866 for the production of biofuels under similar prominent programs include (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 and renewable natural gas (RNG).[11]
- California's LCFS requires routine direct testing for fuels produced from co-processing and recommends for fuels produced from MSW.[12]
- Oregon's CFP requires routine direct testing following the protocols of the US RFS third-party engineering reviews.[13]
- Washington's CFS requires routine direct testing following the protocols of the US RFS third-party engineering reviews.[14]

[9] 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*
[10] 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*
[11] 2010. "40 CFR Part 80 Subpart M– Renewable Fuel Standard." *National Archives Code of Federal Regulations*
2023. "40 CFR Parts 80 and 1090– Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes." *EPA*
[12] 2020. "Reporting Co-Processing and Renewable Gasoline Emissions Under MRR." *California Air Resources Board*
[13] 2023. "Oregon Clean Fuels Program." *Oregon Department of Environmental Quality*
[14] 2022. "Chapter 173-424 WAC: Clean Fuels Program Rule." *Washington State Legislature*

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- Canada's CFR requires routine direct testing for any fuels produced from co-processing and their co-products, as well as to verify biogenic feedstocks.[15]
- British Columbia's LCFS requires monthly testing for any fuels produced from co-processing and quarterly testing for their co-products, as well as to verify biogenic feedstocks.[16]
- The EU's RED requires routine direct testing for any fuels produced from co-processing or biogas and renewable natural gas (RNG).[17]

13.What frequency of monitoring and reporting should CARB consider, and should this differ by project type? Do you have estimates on costs for monitoring and reporting?

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 CCS. 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.

Integration with Existing State Programs and Potential New Policy Support

22.What role could projects developed under SB 905 play in these programs and are there other programs or policies in which carbon capture removal, storage, and utilization could play a role for compliance?

Projects developed under SB 905 could play an important role in all of these programs. There are clear implications for direct emissions reductions under the state's Cap-and-Trade program, and to drive carbon intensity reductions under the Low Carbon Fuel Standard by combining carbon capture and storage and carbon removals with low carbon fuel production. This program would also play a critical role in the state's Net Zero Emissions Strategy for the Cement Sector, which is one of the sectors with the most reductions available from the types of projects incentivized by SB 905. Biomass co-firing is currently one of the most common paths for emissions reductions used by the cement industry, but combining co-firing with biogenic CCS and biomass CDR could make a far more significant contribution to the industry's decarbonization. The same goes for other hard-to-abate sectors which produce building materials relevant to the state's program for Embodied Carbon in Buildings, such as steel, aluminum and other metals.

[15] 2022. "Clean Fuel Regulations: Quantification Method for Co-Processing in Refineries." *Environment and Climate Change Canada*
[16] 2025. "Low Carbon Fuel Regulation: Co-Processing Methodology" *British Columbia Ministry of Energy and Climate Solutions*
[17] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*

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Protocols

25.Are there certain carbon capture, removal, utilization, and storage project type methodologies that should be prioritized based on existing science, existing methodologies, or implementation experience?

Bioenergy CCS and biomass CDR projects should be prioritized because they have a much more significant potential for emission reductions and to create net-negative carbon intensity projects. Since the goal of implementing carbon capture, removal and storage projects is to reduce the amount of carbon emitted to the atmosphere (and therefore driving climate change), biogenic carbon is far more impactful. This is because while fossil carbon which is captured and sequestered prevents new carbon from entering the active carbon cycle, when biogenic carbon is captured and sequestered carbon is actively removed from the active carbon cycle. This is the rationale behind promoting the use of biogenic carbon through low carbon fuels and co-firing, but in the case of CCS and CDR it enables net-negative projects which can make a significant impact toward California's decarbonization. As a result, these projects should be prioritized through SB 905, and these projects should be required to routinely report their exact biogenic content since it is their renewable carbon that delivers this impact.

26.Should CARB consider adopting project type specific protocols or defining more widely applicable standards, or a combination of both? If CARB were to define key standards applicable to all methodologies as opposed to individual methodologies based on specific technology or storage, what could those look like (i.e. recommendations on existing standards), and would that approach help to scale and innovate in this space faster than development of individual protocols?

As discussed above, bioenergy CCS and biomass CDR projects should have specific requirements to report their biogenic content through ASTM D6866 Method B testing. This is necessary to measure the renewable portion of these projects, which is the basis for their net-negative carbon intensities. In addition to its role in early methodologies for the biogenic portion of CCS, routine C-14 testing is recommended by Carbon Direct's "Criteria for High-Quality Carbon Dioxide Removal" methodology, for any biomass-based CDR.[18] Carbon Direct also recommends C14 testing to determine the renewable portion of BECCS, biochar and Waste to Energy plants. Relying on the use of C-14 testing under existing emissions reporting programs and CCS protocols will be the most effective way to regulate these projects under SB 905.

Prioritize Direct Testing Over Calculations

One other important consideration for implementing BECCS and biomass CDR under this program is the need to prioritize direct testing requirements over calculation-based methods like mass balance calculations. This is critical because similar programs in the US are facing lobbying pressure from major

[18] 2025, "Criteria for High-Quality Carbon Dioxide Removal", Carbon Direct

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petrochemical companies to abandon direct testing and accept mass balance calculations as verification. These calculations consistently overestimate renewable content and would open the door to greenwashing, undermining the success of the program.[19]

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.[20] By basing their calculations solely on production inputs rather than outputs, these methods systematically over-report the renewable share of fuels and emissions.

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 sample. This reliance on free allocation creates the potential for double-counting of renewable content, leaving emission reduction 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.[21] 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.[22]

Notably, California Attorney General Rob Bonta filed a lawsuit against ExxonMobil in September 202,4, 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.[23] That lawsuit directly challenges the standard's use of ISCC's free allocation method as a system designed to enable greenwashing.[24] This is the same issue facing the biofuels industry from ISCC certifications and other alternative approaches. California's lawsuit followed a ProPublic investigation published in June 2024, which found that products advertised as 30% recycled through mass balance often contained less than 1% recycled content.[25]

The SB 905 program is an important first step toward implementing CCS in California. By adding provisions for biogenic CCS in this program, CARB could promote the most carbon-efficient practices that can be enabled by this technology, opening the door for significantly carbon-negative projects. The best

[19] 2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.
[20] 2006. "Determining the modern carbon content of biobased products using radiocarbon analysis." *Bioresource Technology*, 97(16), 2084-2090.
[21] 2023. "ISCC Press Release July 27, 2023." *International Sustainability & Carbon Certification*
[22] 2023. "Renewable energy- method for calculating the share of renewables in the case of co-processing." *European Commission*
[23] 2024. "The People of the State of California v. Exxon Mobil Corporation." *Superior Court of the State of California*
[24] 2024. "ExxonMobil Accused of "Deceptively" Promoting Chemical Recycling as a Solution for the Plastics Crisis." *ProPublica*
[25] 2024. "Biden EPA Rejects Plastics Industry's Fuzzy Math That Misleads Customers About Recycled Content." *ProPublica*

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way to regulate BECCS projects and verify their biogenic CO_2 claims is to require routine direct testing following ASTM D6866 Method B. Combined with California's current use of biogenic testing in the LCFS and Cap-and-Trade programs, this data could enable CARB to track biogenic carbon throughout a circular supply chain in which it is sourced from biomass feedstocks, used to produce renewable fuels, combusted and captured as biogenic CO2, and sequestered back into soil to produce biomass feedstocks.

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.[26] 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 CO_2 stationary sources emissions.[27]

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 regulations as the recommended or required method to quantify the biobased content of a given material.

[26] 2021. "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis." *ASTM International (D6866-21)*
[27] 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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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 ^{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.[28] 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.

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

[28] 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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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.[29]

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

[29]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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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 ^{14}C 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.

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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)

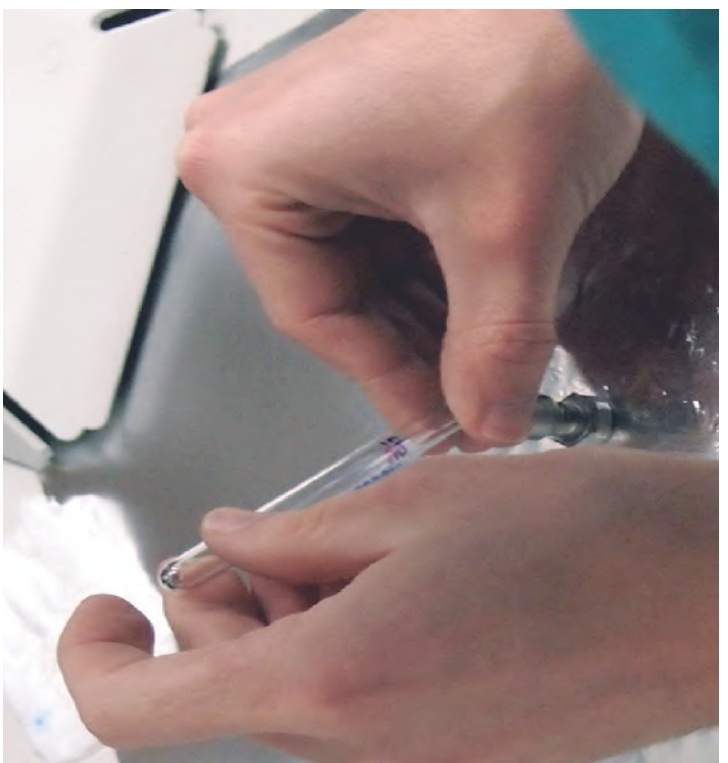
As a natural level radiocarbon laboratory, we highly recommend that researchers require the AMS lab processing their samples to be Tracer-free.

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.



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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."

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
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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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