NEC AMS Systems for ASTM D6866
National Electrostatics Corp.

ASTM D6866 Standard

The ASTM (founded as the American Society for Testing and Materials) D6866 Standard is a globally accepted sample preparation and test method that teaches how to experimentally measure biobased carbon content of solids, liquids, and gaseous samples using radiocarbon analysis. The method is applicable to any product containing carbon-based components that can be combusted in the presence of oxygen to produce CO_2 gas. This method can be used to quantify biofuel blends for the airline industry or race cars, look for fraud in essential oil production, and more.

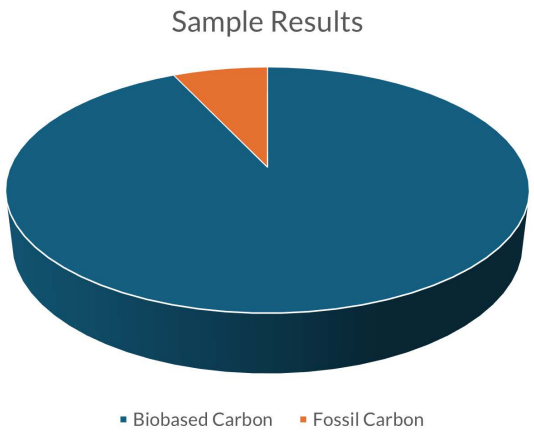
The NEC CEGS (Carbon Extraction and Graphitization System) isolates carbon from a sample and removes other elements. The SSAMS (Single Stage Accelerator Mass Spectrometer) measures the amount of ^{14}C in small graphite samples. The two systems operate together under the ASTM D6866 Standard to effectively measure and record the carbon content of a sample.

The results from the SSAMS are typically reported as "% Biobased Carbon". This indicates the percentage carbon from "natural" (plant or animal by-product) sources versus "synthetic" (petrochemical) sources. For reference, 0 % Biobased Carbon indicates that a material did not contain any carbon from plants or animal by-products while 100 % Biobased Carbon indicates that a material is entirely from plants or animal by-products. A value in between represents a sample has been mixed or adulterated.

The measurement is cited as percent modern carbon (pMC). This is the percentage of C^{14} measured in the sample relative to a modern reference standard (NIST 4990C) and compared to today's environment.

The NEC CEGS-SSAMS system will allow users to create reports to match the ASTM D6866 method, with an example shown below.

Submitter	National Electrostatics Corp.
Received Date	10/3/2025
Report Date	10/10/2025
Sample Code	Fuel Sample 1234
Reference Standard	NIST 4990C
Expected Value:	129.41 +/- 0.06 pMC
Measured Value:	129.43 +/- 0.29 pMC
Expected Value:	0.44 +/- 0.05 pMC
Measured Value:	0.44 +/- 0.04 pMC
Result	93% Biobased carbon (partially sythentic material)
Percent Modern Carbon (pMC)	92.51 +/- 0.20 pMC
dpm/gC	12.54 +/- 0.03 dpm/gC



The CEGS and SSAMS instruments can be seen below.

CEGS

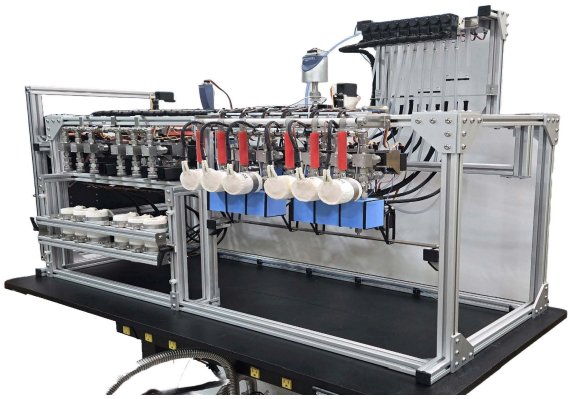
The CEGS isolates the carbon from a pre-treated sample, strips away everything else, and converts it into pure solid for radiocarbon analysis.

Design

Several CEGS models are available, each tailored to specific needs. All models share a common core consisting of: a sample inlet manifold, process section, and graphite manifold. Built-in subsystems - including vacuum, liquid nitrogen, and control sections - provide essential support. Specialized equipment such as tube furnaces, analyzers and other instruments is readily incorporated. Even complex systems like a dedicated DIC water processor can be integrated with the CEGS.

Capabilities

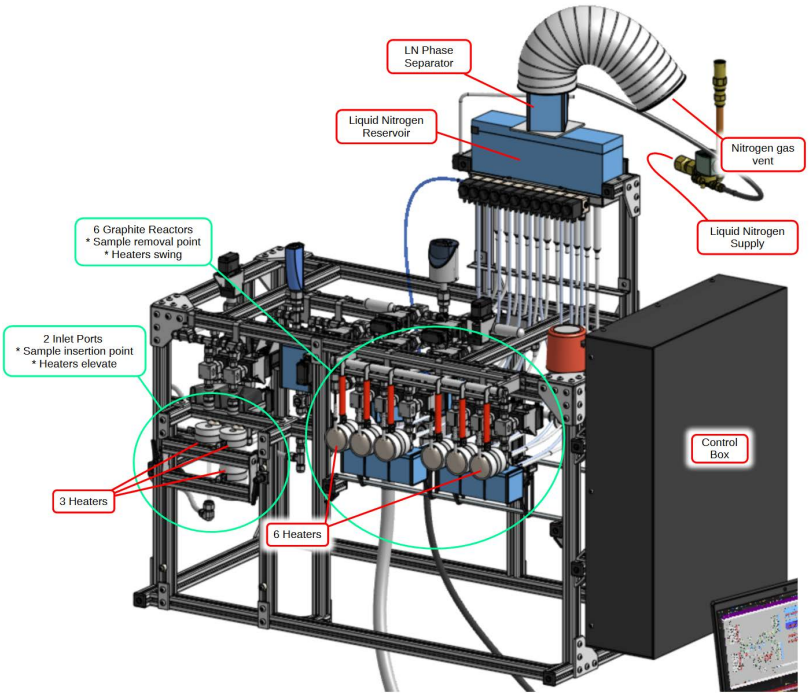
- Organic, carbonate, & gas samples supported
- Total sample mass up to 400 mg
- Huge sample size range 5-2,700 micrograms total carbon content)
- Wide carbon concentration range (from ppm levels to 100%)
- Superb capture & transfer efficiencies (>99% typical, >97% guaranteed)
- Precise cryogenic distillation ensures highest purity carbon
- Allows for very small and old samples (<50 µgC, > 35 ka)



CEGS LL6 Model

Performance

This system automates the methods developed and still employed by the world's leading radiocarbon research laboratories. Automation improves consistency and repeatability, decreases scatter, and significantly reduces per-sample labor. The CEGS is designed to capture all carbon and remove everything else. The system can capture more than 99% of a sample's CO2 at better than 99.9% purity. Competing systems may only capture 90-95% of a sample. This type of system is essential for small (<200 µgC) dilute (<3% C), or contaminated samples.



LL6x1+1+VP Model

CEGS 12X Model

SSAMS

Once the CEGS has isolated the carbon and created graphite, the sample can be inserted into NEC SSAMS System to measure the amount of ^{14}C in the sample.

Experience

The NEC Single Stage Accelerator Mass Spectrometer (SSAMS) is based around a 250 kV high voltage deck for beam energies around 285 keV. The system is optimized for world-class precision, superb throughput, and low background of radioisotope samples. The NEC SSAMS is a complete system with all necessary hardware and software for both on-line and off-line radiocarbon isotope measurements.

Design

Once a sample has been appropriately processed and inserted into the ion source (either as graphite or CO_2), the sample is converted to negative ions and is accelerated through the first bending magnet. This first mass spectrometer has a biased chamber to allow sequential injection of the negative ions of interest, allowing low energy ^{12}C- and ^{13}C- to be measured in offset Faraday cups. As the negative ions exit the magnet, they accelerate to higher potential energy (around 285 keV) into a gas stripper that breaks up negative molecules and converts the resulting single nuclei ions to positive ions. In this way, such ions as ^{12}CH-, $^{12}CH_2$-, ^{13}CH-, and others are converted to single nuclei ions, ^{12}C+, ^{13}C+, and ^{14}C+. This eliminates interferences that might be caused by molecular ions when counting ^{14}C+ ions later in the system. The higher energy ions pass through the second spectrometer, resulting in an improved mass separation, allowing the abundant isotopes ^{12}C+ and ^{13}C+ to be measured with high precision current integrators. The rare isotope ^{14}C+ continues through a 90° electrostatic spherical analyzer (ESA) which removes any outstanding interferences and the beam is measured in a solid state particle detector. NEC AMS systems include full computer control with AMS analysis software to provide chronological ages, carbon content in dpm/gm, or pMC (percent modern carbon) values.

NEC AMS systems can support several configurations from a single, 40 sample source, to dual 134 sample sources for a maximum throughput of 2,000 samples to 2% precision per week. Sample wheel loading takes less than 30 minutes with full 40 sample wheels typically measured to precision within about 24 hours. NEC ion sources have no noticeable memory effects and are extremely reliable. NEC has provided more than 125 MC-SNICS sources around the world.

The system proceeds automatically to switch from sample to sample as the required precisions, time constraints, or other criteria are met. The system can be monitored remotely and is fully interlocked in case of power, water, or air failure to protect personnel and precious samples.

Specifications

HV Deck

Voltage Range:	to 250 kV @ 1mA
Single Charged Energy Range:	to 285 keV
Voltage Stability:	0.01% per hour after 1/2 hour warmup

Primary Components

Beamline Height:	1.4 m (40 MC-SNICS) or 1.5 m (134 MC-SNICS)
Pumps:	Turbo molecular pumps, rough backing pumps
Vacuum System Base:	$5e^{-7}$ Torr, or better (without beam)
Ion Source(s)/Injector:	Injection voltage, ~30-40 keV 40 or 134 MC-SNICS (carbon)

Acceptance Test Values

Carbon, Terminal Potential:	250 kV
$^{12}C^-$ (Pulsed Beam):	Current > 40 µA
Beam Transmission:	> 40%

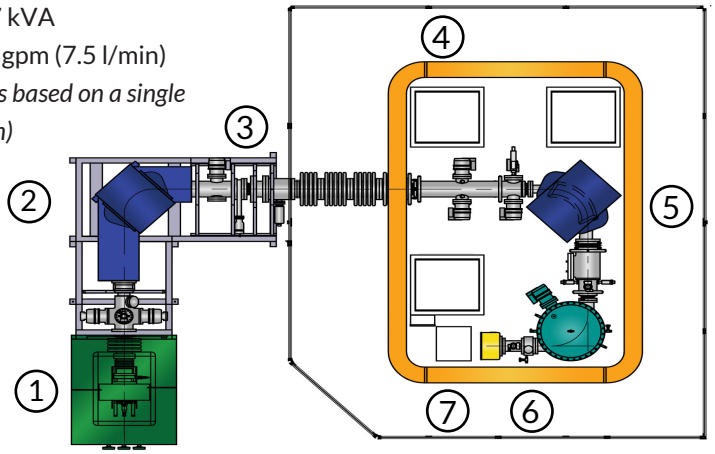
AMS Ratios

$^{14}C/^{12}C$ (abundant ratio $1e^{-12}$)	Precision < 0.2%	*$^{14}C/^{12}C$ (CO_2 abundant)*	Precision < 0.8%
$^{13}C/^{12}C$ (abundant)	Precision < 0.2%	*$^{14}C/^{12}C$ (CO_2 background)*	Ratio < $8e^{-15}$
$^{14}C/^{12}C$ (background)	Ratio < $1e^{-15}$		

NEC will provide Alfa Aesar unprocessed graphite for carbon machine background tests. All acceptance tests are verified using a minimum of three samples.

Facility Requirements:

Compressed air: 80 psig
Electrical Power: 7 kVA
Cooling water: 2.0 gpm (7.5 l/min)
(Approximate values based on a single source configuration)



1. 40 sample or 134 sample cesium sputter source
2. 90° injector magnet with insulated chamber for sequential injection
3. 250kV acceleration tube
4. 250kV insulated deck
5. 90° analysis magnet with wide exit pole for abundant isotope measurement
6. 90° electrostatic spherical analyzer
7. Solid state particle detector for measuring ^{14}C events

Contact NEC

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