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**NIPPON
INSTRUMENTS
CORPORATION**



RA-7000F | Mercury Analyzer

Cold-Vapor Atomic Fluorescence Spectrometry Technology
With Discrete Direct Purge Technology

RA-7000F Mercury Analyzer

Where Fluorescence Meets Flexibility



USEPA 1631E

Mercury in Water by Oxidation,
Purge and Trap, and Cold
Vapor Atomic Fluorescence
Spectrometry

USEPA 245.7

Mercury in Water
by Cold Vapor
Atomic Fluorescence
Spectrometry

ISO 17852

Water Quality – Determination
of mercury – Method using
Atomic Fluorescence
Spectrometry

Others

For any other application
using CVAFS with or
without Gold Amalgamation
Enrichment mode

Mercury:

A Transboundary and Global Pollutant That Requires Precision Monitoring

Understanding Mercury's Environmental Impact and the Need for Ultra-Trace Analysis

Mercury is a persistent and highly toxic element that poses severe environmental and health risks on a global scale. As it cycles through the atmosphere, water bodies, and soil, mercury can bioaccumulate in ecosystems, contaminating food chains and endangering both human and animal health. Its presence in the environment is attributed to both natural sources, such as volcanic eruptions, and anthropogenic activities, including industrial emissions, mining, and waste disposal.

Accurate mercury analysis is critical for monitoring and mitigating its effects, particularly when evaluating background mercury levels in different regions. Atmospheric ambient air, rainwater, and human exposure serve as key indicators of mercury contamination in each environment. Among these, rainwater analysis presents a significant challenge due to the ultra-trace concentrations of mercury, making precise and highly sensitive detection essential.

Beyond rainwater, pristine environments such as the Poles (Arctic & Antarctica) and remote rural regions with snow and ice precipitation also exhibit extremely low mercury levels, requiring sophisticated sampling and analytical techniques to ensure accurate evaluation.

Nippon Instruments Corporation Model RA-7000F Mercury Analyzer rises to this challenge, offering unparalleled precision and versatility to meet the demands of ultra-trace level of mercury detection challenging samples such as rainwater, snow precipitation, glacier water, ground water, natural water or more. By adhering to strict regulatory methods such as USEPA 1631E, the RA-7000F empowers authorities and researchers' laboratories to play a critical role such as ultra-trace level mercury monitoring and making informed policy in combating the global transboundary pollutant.

RA-7000F CVAFS Mercury Analyzer with Easy Modular Design

Experience the pinnacle of innovation of Cold Vapor Atomic Fluorescence Spectroscopy (CVAFS) — where fluorescence meets precision in NIC RA-7000F. The RA-7000F introduces a modular design concept, allowing the detector to pair seamlessly with various options to meet diverse analytical needs.

The standard configuration includes the SANPRA™ 3F autosampler, offering high throughput, reliable and efficient handling. With this configuration, RA-7000F fulfils the requirements in USEPA 1631E, USEPA 245.7, ISO 17852, and more.

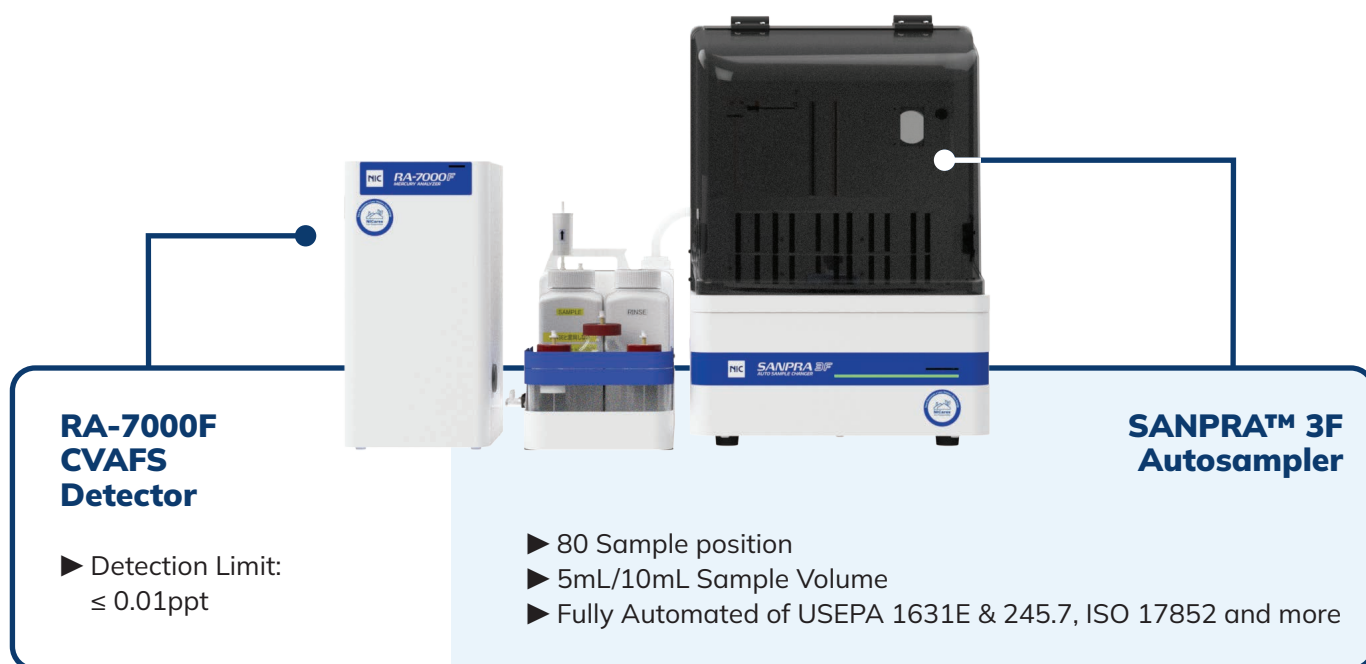


Figure 1

Methodologies Summary

USEPA 1631, Revision E

Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry

- ▶ Oxidation by Bromine Monochloride (BrCl)
- ▶ Addition of $\text{NH}_2\text{OH}\cdot\text{HCl}$
- ▶ Reducing Vaporization by SnCl_2
- ▶ Gold Amalgamation Enrichment
- ▶ Elemental mercury (Hg^0) is sent to CVAFS for measurement

USEPA 245.7

Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry

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ISO 17852

Water Quality – Determination of mercury – Method using Atomic Fluorescence Spectrometry

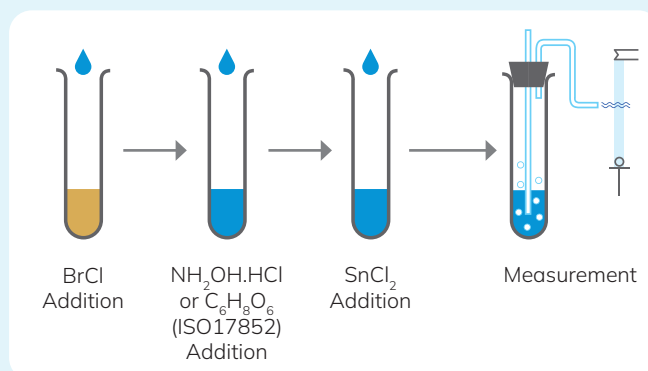
- ▶ Oxidation by BrCl
- ▶ Addition of L-ascorbic acid ($\text{C}_6\text{H}_8\text{O}_6$)
- ▶ Reducing Vaporization by SnCl_2
- ▶ Elemental mercury (Hg^0) is sent to CVAFS for measurement

TRiFLEX Operation Mode of RA-7000F

The TRiFLEX Mode of the RA-7000F offers versatility with 3 distinct operational modes in a single system. Designed to adapt seamlessly to diverse method requirements, TRiFLEX Mode includes:

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Direct Mode [Comply to EPA 245.7 & ISO 17852]



In **Direct Mode**, the RA-7000F, paired with SANPRA™ 3F Autosampler, enables reagent dispensing and measurement all within the same platform.

SANPRA™ 3F features an 80 position autosampler that allows 5mL (standard) or up to 10mL sample analysis volume on for each sample tube. User can simply pipette 5mL of sample solution into each sample tube or utilizes the Auto-level Adjustment function to precisely adjust it to 5mL.

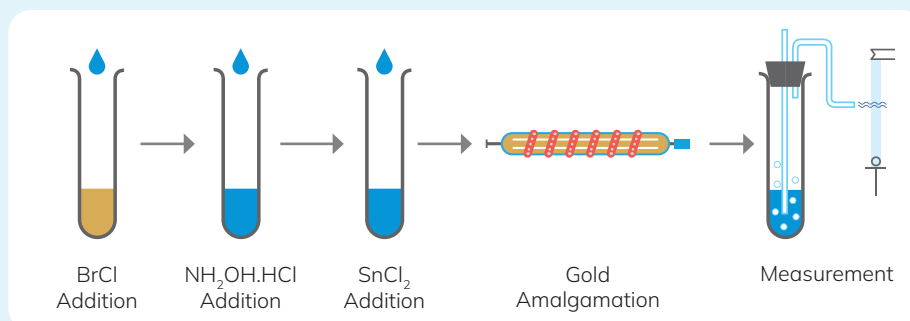
Bromine Monochloride Oxidation: Within the SANPRA™ 3F, the oxidizing agent Bromine Monochloride (BrCl) is dispensed automatically into each sample tube, to complete the oxidation of mercury compounds. The presence of excess BrCl is visually confirmed from its permanent **pale-yellow color formation**, which must persist throughout the initial **30-minute digestion process**. Once confirmed, the sample solutions are left up to 24 hours inside the SANPRA™ 3F for digestion and complete oxidation is visually confirmed the pale-yellow color remains unchanged within the sample solution.

Quenching by Hydroxylamine Hydrochloride (For EPA245.7 Method) or L-Ascorbic Acid Solution (For ISO17852 Method): Next, SANPRA™ 3F adds Hydroxylamine Hydrochloride (NH₂OH·HCl) or L-ascorbic solution (C₆H₈O₆) to quench the excess Bromine, followed by a purging step to remove the excess chlorine gas.

Tin (II) Chloride Reducing Vaporization: Finally, Tin (II) Chloride (SnCl₂) is added to induce reducing vaporization via Discrete-Direct-Purge (DDP) technique, converting all ionic mercury into elemental mercury (Hg⁰).

CVAFS Measurement: The sample solution is purged by Argon gas and the elemental mercury (Hg⁰) vapor is then transferred to the RA-7000F Cold Vapor Atomic Fluorescence Spectrometry (CVAFS) detector for measurement and quantification.

Gold Amalgamation Enrichment Mode



Comply to USEPA 1631E

Gold Amalgamation Mode enhances sensitivity and eliminates interferences by trapping and pre-concentrating elemental mercury on a collector tube before analysis.

In Gold Amalgamation Mode, the sample solution undergo:

Bromine Monochloride Oxidation: Within the SANPRA™ 3F, the oxidizing agent Bromine Monochloride (BrCl) is dispensed automatically into each sample tube, to complete the oxidation of mercury compounds. The presence of excess BrCl is visually confirmed from its permanent **pale-yellow color formation**, which must persist throughout **12-hours oxidation and digestion process**.

Quenching by Hydroxylamine Hydrochloride solution: Next, SANPRA™ 3F adds Hydroxylamine Hydrochloride (NH₂OH·HCl) to quench the excess Bromine, followed by a purging step to remove the excess chlorine gas.

Tin (II) Chloride Reducing Vaporization: Finally, Tin (II) Chloride (SnCl₂) is added to induce reducing vaporization via Discrete-Direct-Purge (DDP) technique, converting all ionic mercury into elemental mercury (Hg⁰).

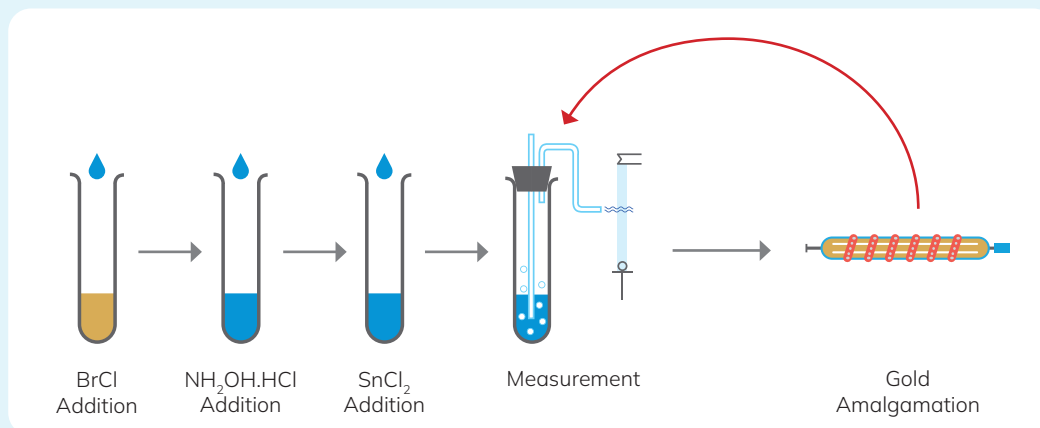
Gold Amalgamation: The sample solution is purged by a stream of Argon gas and the elemental mercury (Hg⁰) vapor is then purged out of solution and trapped, purified and preconcentrated on Mercury Collector Tube (Gold trap) via Gold Amalgamation within the RA-7000F.

CVAFS Measurement: After Gold Amalgamation, the concentrated and purified elemental mercury vapour is thermally desorbed into the Argon gas stream and sent to the RA-7000F Cold Vapor Atomic Fluorescence Spectrometry (CVAFS) detector for measurement and quantification.



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DUAL Mode



RA-7000F is capable of performing **DUAL Mode** (Both Direct and Gold Amalgamation Enrichment Mode) in single measurement.

Why Does DUAL Mode Matter?

When/what sample to use for USEPA 245.7 Direct Mode or USEPA 1631E Gold Amalgamation Mode is a common query in a laboratory. USEPA 245.7 has measuring range from 5ng/L up to 100ng/L, while USEPA 1631E can quantify from 0.5ng/L up to 100ng/L. With unknown samples, selecting the wrong mode/method, not just getting incorrect results, but also loses some precious and limited samples for repeating the test. Innovative DUAL mode eliminates the uncertainty to analyze the sample via both Direct and Gold-Amalgamation Modes in a single measurement yielding both results to choose from to suit and match the correct measuring range and method.

In **DUAL Mode**, the sample solution undergo:

Firstly, mercury compounds in the sample solution will undergo the measurement procedure of Direct Mode: **Bromine Monochloride Oxidation, Quenching by Hydroxylamine Hydrochloride solution, Tin (II) Chloride Reducing Vaporization** followed by **CVAFS** Measurement.

Right after the 1st measurement, the elemental mercury vapor is re-direct to undergo Gold Amalgamation where the elemental mercury (Hg⁰) vapor is then trapped, purified and preconcentrated on a mercury collector tube (Gold trap).

2nd CVAFS Measurement: After Gold Amalgamation, the concentrated and purified elemental mercury vapour is thermally desorbed into the Argon gas stream and is sent to the RA-7000F Cold Vapor Atomic Fluorescence Spectrometry (CVAFS) detector for measurement and quantification.

With **TRIFLEX** versatility of RA-7000F, you can choose the suitable mode of operation required by the method of selection in the software.

Unparalleled Detection Limit of ≤ 0.01 ppt with Precision Flow Control by Superior MFC

Achieving ultra-trace level mercury analysis requires exceptional precision in flow rate control to ensure consistent and reliable performance. The new generation RA-7000F is equipped with an enhanced Mass Flow Controller (MFC) capable of precisely regulating highly stable flow rates as low as 0.04 L/min. This exceptional performance enables the RA-7000F to reach an outstanding detection limit of ≤ 0.01 ppt, meeting and exceeding the stringent requirements of regulatory methods such as USEPA 1631e, USEPA 245.7, and ISO 17852.

Why Does Precise Flow Control Matter?

Ultra-trace mercury detection demands a stable and controlled gas flow to ensure complete and efficient mercury capture and transfer. Fluctuations in flow rate can lead to inconsistent recovery, increased variability, which compromise detection limits, precision and accuracy. By integrating an improved reliably superior MFC, the RA-7000F ensures:



Unmatched Sensitivity

Detecting mercury at ≤ 0.01 ppt,



Day-to-Day Reproducibility

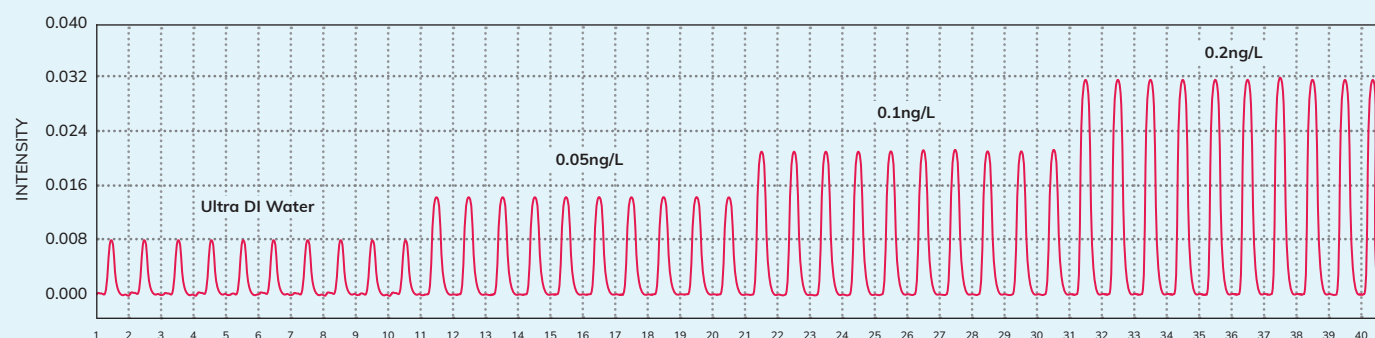
Delivering precise, reliable results with virtually no variability.

Proven Performance in Ultra-Low Mercury Detection

The RA-7000F's enhanced Gold Amalgamation Enrichment Mode allows mercury pre-concentration, capable of achieving ultra-trace detection down to ≤ 0.01 ppt in 10 mL water sample. Performance validation demonstrates consistent and reproducible results:

With its enhanced flow control technology, the RA-7000F delivers unparalleled precision and reliability, making it the ideal solution for cutting-edge ultra-trace mercury analysis.

Sample Name	Trials	Average (ng/L)	C.V. (%)
Ultra DI Water	10	≤ 0.01	-
0.05ng/L	10	0.0454	5.02
0.10ng/L	10	0.0996	1.77
0.20ng/L	10	0.1940	0.65



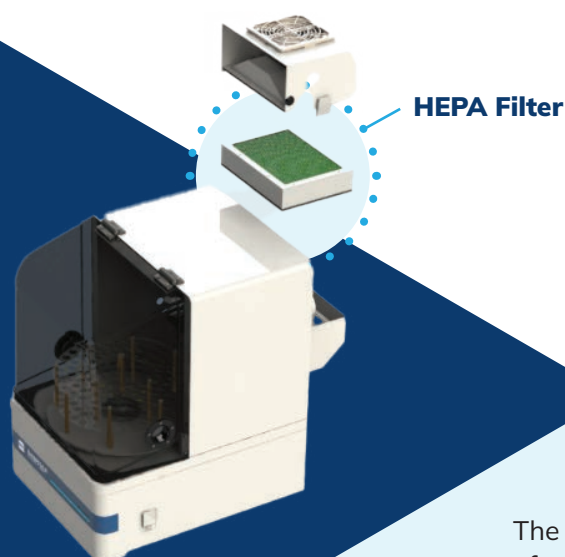
Highly Stable & Sensitive CVAFS Detector

Achieving reliable ultra-trace level mercury analysis requires a detector with exceptional sensitivity and stability. The RA-7000F is equipped with an advanced Cold Vapor Atomic Fluorescence Spectroscopy (CVAFS) detector, designed to deliver unparalleled performance in detecting extremely low concentrations of mercury.

The RA-7000F's enhanced detector circuits improve signal processing, reducing noise and enhancing precision. Additionally, the optimized gold amalgamation mechanism ensures efficient mercury capture and release, resulting in higher sensitivity and reproducibility. These advancements make the RA-7000F an ideal choice for laboratories requiring accurate and consistent mercury measurements in compliance with stringent regulatory standards.

RAir™ Filter Unit

RA-7000F Integrated Air Filtration System



More than

90%

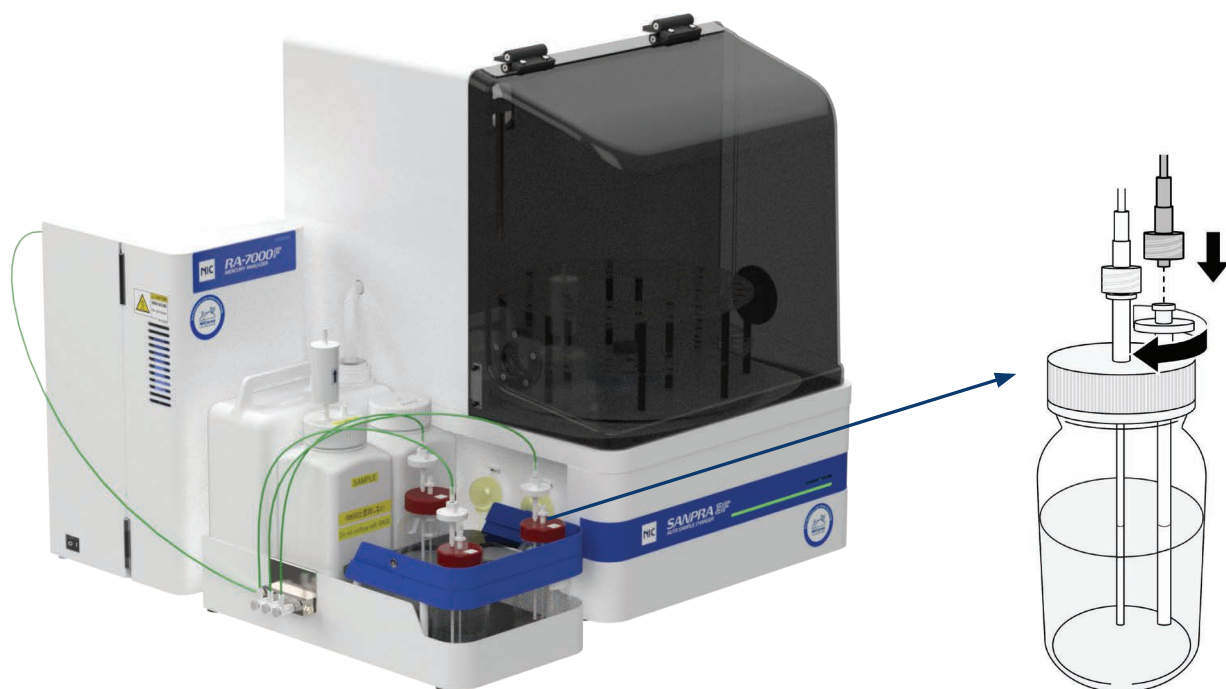
of ambient air airborne mercury removal

The RA-7000F features a built-in activated carbon filter, capable of removing over 90% of airborne mercury contaminants, ensuring a clean analytical environment. Ambient air will pass through the activated carbon filter that essentially removes more than 90% of the airborne mercury and mercury-free air is introduced within the SANPRA™ 3F chamber. This is essential for compliance with EPA 245.7, EPA 1631e, and ISO 17852, which require ultra-clean conditions to prevent contamination.

- ▶ **Maintains Sample Integrity:** Prevents external airborne mercury from contaminating sample, ensuring accurate measurements.
- ▶ **Enhances Compliance:** Supports regulatory clean-lab requirements by reducing airborne mercury contamination. While a Class 100 cleanroom environment and mercury-free air are still required, the built-in activated carbon filter provides an additional layer of protection, minimizing external contamination risks.
- ▶ **Optimizes Digestion Conditions:** Provides a controlled, activated carbon-filtered environment for sample that will be left in SANPRA™ 3F for Bromine Monochloride for digestion.

By integrating advanced air filtration, the RA-7000F ensures precise, contamination-free mercury analysis.

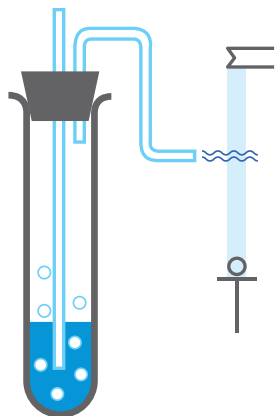
Argon Purge Function for Enhanced and Maintain Reagents Cleanliness & Stability



The RA-7000F features a dedicated argon purge function for each reagent to help maintain reagent integrity and manage Mercury blank level for measurement reliability. By securely connecting the reagent purge tube to each reagent bottle using a Luer fitting, Argon purge flow can easily be adjusted and visually confirmed through gentle bubbling. The argon purges residual Mercury out from the reagents, displaces oxygen and other reactive gases, maintaining an inert environment in the bottle.



Discrete Direct Purge (DDP) Technique for Minimal Mercury Memory Effect



In traditional wet chemical decomposition methods, the persistent challenge of mercury memory effect often undermines analytical accuracy. Therefore, **Discrete Direct Purge (DDP) technique** is set out to minimize this issue.

With DDP, each sample is isolated in its individual sample tube. From addition of BrCl for oxidation to reducing vaporization by SnCl₂ is conducted individually in each tube, no sample-to-sample contact, thus no cross-contamination.

During reducing vaporization, the sample solution is sparged by a stream of Argon using a PEEK nozzle. All ionic mercury will be converted into elemental mercury vapor Hg⁰. The Hg⁰ is then transferred through a dry and inert pathway to the CVAFS detector for **Direct** detection or pre-concentrated onto a gold trap for **Gold-Amalgamation Enrichment** mode measurement.

DDP technique RA-7000F eliminates the use of pump to transfer sample fluids, reaction coils or liquid-gas phase separator which present a common contact and flow path for all samples. DDP design minimizes carryover and contamination risks. DDP approach is highly beneficial to ensure RA-7000F delivers precise and accurate ultra trace level measurement result routinely without any mercury memory effect.

Mercury Memory Effect Evaluation in RA-7000F

Mercury **memory effect** occurs when residual mercury from high-concentration samples affects subsequent measurements. Using DDP technique, the **RA-7000F** is designed to **minimize carryover**, ensuring fast recovery and reliable ultra-trace mercury analysis.

Performance Demonstration

A **500ng mercury sample** is analyzed to simulate an extreme high-mercury scenario.

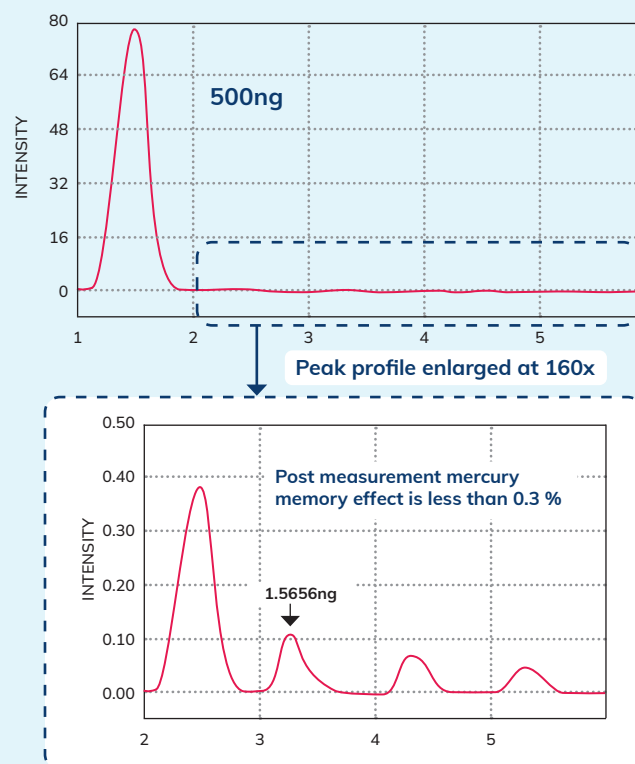
- ▶ After measurement, the blank reading in the next run was **1.5656ng**.
- ▶ Repeated blank measurements **returned to baseline within 10 runs**, demonstrating rapid recovery.

Key Benefits

- ▶ **Minimize Cross-Contamination:** Ensures high-sensitivity analysis remains uncompromised.
- ▶ **Fast Recovery:** Minimal downtime between high and low mercury samples.
- ▶ **Reliable and Consistent Results:** Meets stringent regulatory requirements

**Note: The mercury memory from 500ng Hg and its subsequent runs are conducted under High mode to demonstrate its carryover effect.*

Sample Name	Sample Vol. [mL]	MEAS [ng]	CONC [ppb]
500ng	5	500	100
Blank No 1	5	1.5656	0.3131
Blank No 2	5	0.4759	0.0952
Blank No 3	5	0.2873	0.0575
Blank No 4	5	0.2157	0.0431
Blank No 5	5	0.1633	0.0327
Blank No 6	5	0.1335	0.0267
Blank No 7	5	0.1159	0.0232
Blank No 8	5	0.0999	0.0200
Blank No 9	5	0.0852	0.0170
Blank No 10	5	0.0783	0.0157



As shown in data above, post measurement memory effect of abnormally high mercury measurement 500ng is less than 0.3%. With well proven Discrete Direct Purge Technique in RA-7000F, RA-7000F delivers precise mercury analysis with minimal memory effect, ensuring high sensitivity and accuracy in every measurement.

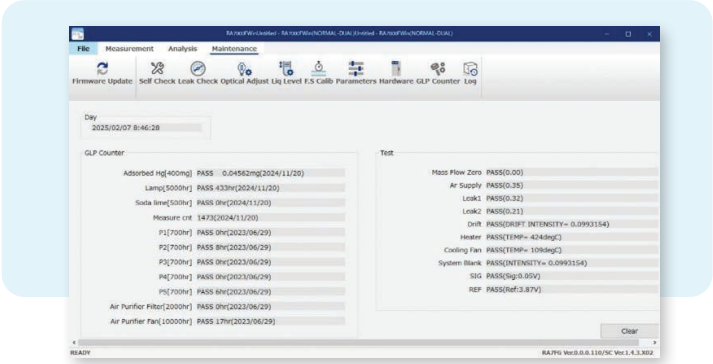


RA-7000F Software

To complement to the performance-proven RA-7000F, RA7000FWin software offers a complete range of intuitive and user-friendly functions with plug-in based architecture for extended Quality Control options to choose from to provide maximum flexibility to meet your analytical requirements and compliance of now and in the future. RA7000FWin software delivers the highest functionality combined with ease-of-use, all at your fingertips.

Smart Monitoring - Know Your Instrument Condition through RA7F GLP Counter

RA-7000F software comes with GLP Counter where all essential parts of the instruments' state are being recorded. All essential parts such as usage of air pump, lamp, number of measurements and pump tubes usage and recommended threshold are recorded.

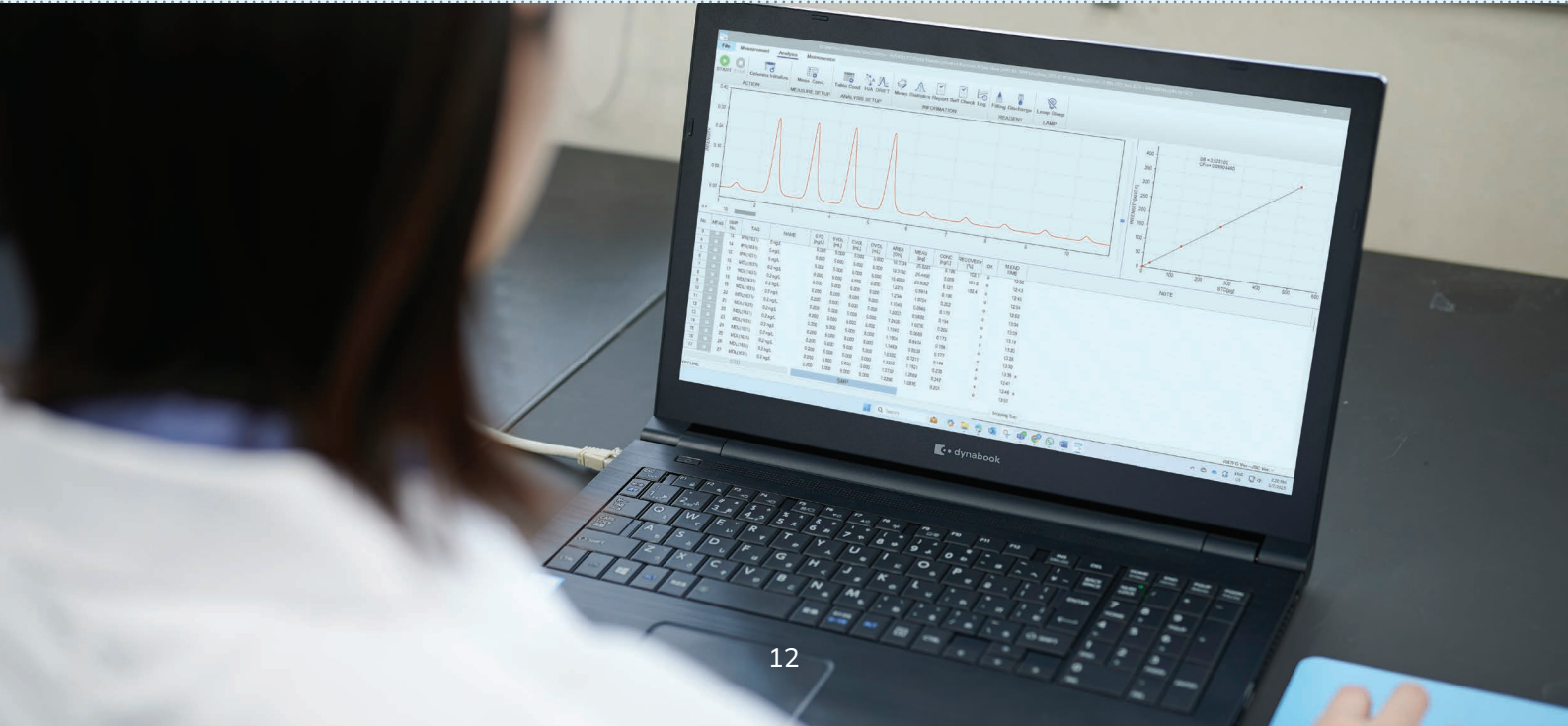


RA-7000F EPA QC Software Plug-In

Before starting any routine measurements, the RA-7000F performs an automated Self-Check to ensure all components are fully functional before any measurement started. This step ensures:

- Optimal instrument performance
- Early detection of potential issues
- Reduced downtime and consistent reliability

All measurement reports are equipped with Self Check data to show that RA-7000F was fully functional at the time of measurement. Since the instrument verified its own status before measurement, it ensures that results are generated under optimal conditions, reinforcing the credibility of the data.

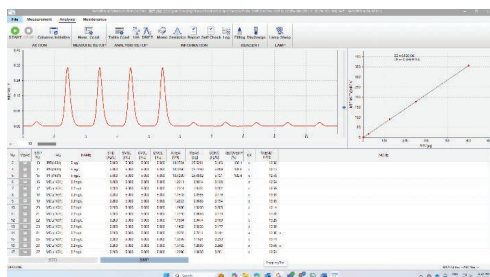


The RA-7000F software offers an **optional EPA QC Software (Support both USEPA 1631E and USEPA 245.7 Method) upgrade**, enabling **real-time automated QC verification** for seamless compliance, accuracy, and reliability with minimal manual effort. This upgrade fully adheres to the **stringent requirements of USEPA 1631E and USEPA 245.7**.

Parameter	Value	Acceptance Limit	Action
Calibration Blank Ave[ng/L]	0.00	0.10	Stop
Calibration Blank SD[ng/L]	0.10	0.10	Stop
CF RSD[%]	15	15	Stop
CF Recovery[%]	75	125	Stop
IPR RSD[%]	21	21	Stop
IPR Recovery[%]	79	121	Stop
MDL[ng/L]	0.2	0.2	Stop
Method Blank[ng/L]	0.5	0.5	Stop
MS[%]	71	125	Stop
RPD of MS[%]	24	24	Stop
OPR[%]	77	123	Stop
QCS[ng/L]	5.0	6.0	Stop

EPA Method QC Parameters Control

- ☒ **User-Defined QC Criteria:** Users can manually input **acceptance limits** for critical quality control parameters required by either EPA 1631e or EPA 245.7 such as **Calibration Blank, CF RSD, CF Recovery, IPR Recovery, MDL, and Method Blanks**.
- ☒ **Customizable QC Actions:** Users can choose **“Stop”** as an action when a criterion is not met, ensuring immediate intervention for non-compliant results.



Tag-Based Data Organization

The Tag column allows users to label and classify measurement data with specify tags, improving tracking and retrieval, and data handling.

Automated Data Processing: The software associates each measurement data with corresponding QC categories based on the assigned tags. All measurements will be automatically verified against the predefined thresholds in QC Criteria.

QC Items	Acceptance Criteria	Result	Pass
Calibration Blank Ave	0.1ng/L	0.151ng/L	OK
Calibration Blank SD	0.1ng/L	0.047ng/L	OK
CF RSD	15 %	6.32 %	OK
CF Recovery	75 ~ 125 %	88.9 %	OK
IPR RSD	21 %	0.24 %	OK
IPR Recovery	79 ~ 121 %	102.1 %	OK
MDL	0.2ng/L	0.05ng/L	OK
MS(1)	71 ~ 125 %	99.5 %	OK
MSD(1)	71 ~ 125 %	102.6 %	OK
RPD of MS(1)	24 %	1.54 %	OK
MS(2)	71 ~ 125 %	104.3 %	OK
MSD(2)	71 ~ 125 %	101.9 %	OK
RPD of MS(2)	24 %	1.15 %	OK
OPR(1)	77 ~ 123 %	102.0 %	OK
OPR(2)	77 ~ 123 %	102.9 %	OK
Accuracy	101.4 ~ 103.0 %	101.4 %	OK
QCS	5 ~ 6ng/L	5.1ng/L	OK

Audit-Ready Reporting: Automated QC Verification in Post-Measurement Reports

After measurement completion, all QC parameters required by USEPA methods (e.g., USEPA 1631E & USEPA 245.7) are automatically compiled in the Post-Measurement Report.

- ☒ **Automated Report Generation:** This report provides a comprehensive summary of compliance status, displaying Pass/Fail results at a glance. Audit-ready Reporting can be generated without additional intervention.
- ☒ **Error Prevention & Data Integrity:** Failed QC parameters are **clearly flagged**, enabling users to take corrective actions immediately. This feature also helps to reduce human errors from the manual verification and reduce reporting time.

Flexi Connect

RA-7000F can easily be paired with other Options

The RA-7000F features **Flexi Connect**, an effortless capability of RA-7000F to transform its sampling size capability. Apart from pairing it with SANPRA™ 3F, RA-7000F can work with large-volume sampler (20mL Impinger) for ultra-trace level of aqueous sample such as river water, ground water, natural water and more.

Flexi Connect enable RA-7000F to connect and switch between different attachments easily – Analysis scopes can be expanded with ease!

Among the choices for Flexi Connect for RA-7000F are:



RA-7000F + 20mL Large Volume Impinger

Operating Principle of RA-7000F + 20mL Large Volume Impinger Kit

1. In the usage of RA-7000F and 20mL Large Volume Impinger Kit, Bromine Monochloride oxidation is done manually and externally by user.
2. After the oxidation process with visual confirmation of pale-yellow color formation, Hydroxylamine hydrochloride is added into the sample solution to quench the excess bromine. The pale-yellow formation will disappear.
3. The oxidized sample solution is then poured into the 20mL impinger unit where user is to add Tin (II) Chloride (SnCl_2) to induce reducing vaporization, turning all mercury into elemental mercury (Hg^0).
4. Choice of **TRiFLEX** Mode (Direct, Gold-Amalgamation Enrichment or Dual) can be selected to operate.



Product images are for illustrative purposes only and may differ from the actual product



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