NIC

Mercury Analyzer

MA-3 *Solo*

Affordable, High-Performance Direct Mercury Analysis

- USEPA 7473
- ASTM D 6722-01
- ASTM D 7623-10
- UOP 1009-15
- JIS K0102
- UOP 938-20 latest release

Thermal Decomposition Mercury Analyzer

MA-3 *Solo*
Direct Combustion Hg Analyzer

AFFORDABLE DIRECT MERCURY ANALYSIS

The applications and demand for thermal decomposition mercury measurements are expanding due to the amendment of laws and regulations regarding mercury measurement. In response to this trend, Nippon Instruments Corporation has released a new thermal decomposition mercury analyzer that meets the needs of the times and boasts excellent cost performance.

By removing the sample changer and other optional functions from high-end models and simplifying its operation, the new analyzer, MA-3 *Solo*, has realized a reduction in size and weight without sacrificing necessary performance. With the reduced installation cost, MA-3 *Solo* is best suited for users who perform measurements less frequently or intend to use it as secondary equipment.

WHY USE THERMAL DECOMPOSITION ANALYSIS?

Reducing vaporization mercury measurement requires acid pretreatment, which makes accurate measurements of some samples quite difficult due to the influence of interferences or to mercury vaporizing during acid decomposition. Thus it requires expertise to monitor and review pretreatment conditions.

Thermal decomposition mercury analysis does not require any such troublesome acid pretreatment, and therefore lets inexperienced users easily perform measurements. In addition, this analysis method is earth-friendly because no acidic effluent is discharged.

COMPACT, BENCHTOP Hg ANALYZER

The new MA-3 *Solo* is a portable desktop spectrometer that weighs only 13 kilograms (~28 lbs). This allows it to be easily transported to perform measurements on-site, even if there is no permanent installation space for it.

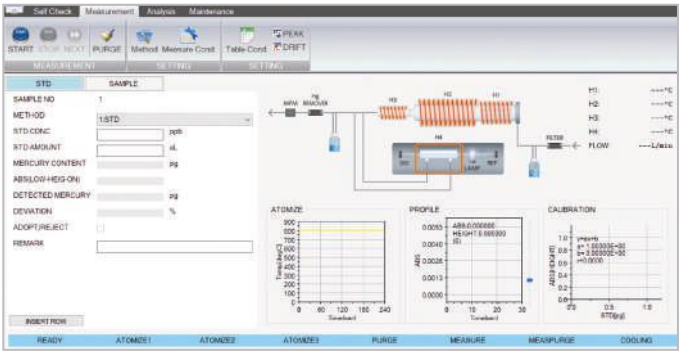
With an optional carrying case, MA-3 *Solo* may be used in a wide variety of settings, including short-term measurement at a distant location, such as a remediation or clean-up site, or to perform routine measurements in a mobile lab.

VISCOUS HYDROCARBONS AND RESIDUUMS

By purchasing the MA-3 *Solo* in combination with the petro-pyrolysis mercury analyzer PE-1000 for the analysis of light petroleum fractions, a wider range of petro samples – including heavy oils, sludges and wastewater – may be analyzed. This can significantly increase operational efficiency. (If you have a NIC SP-3D and are considering replacing it, this analyzer would be the most suitable model.) MA-3 *Solo* is now accredited under new UOP 938-20 revision, substituting obsolete SP-3D.

INTUITIVE WINDOWS® BASED SOFTWARE

Suitable for non-technical operators, MA-3 *Solo's* software runs under the Microsoft® Windows operating system.



SUPPLEMENT FOR YOUR REDUCING VAPORIZATION MERCURY ANALYZER TO REDUCE BOTTLENECKS

For certain complete unknowns, measured with the reducing vaporization technique, there can be a need to determine decomposition conditions. These extra steps can create measurement bottlenecks. Therefore, the direct combustion approach, as employed by the MA-3 *Solo*, is an ideal complementary technique for handling all the solid, non-aqueous liquids and or particulates-laden liquid matrices, where chemical preparation for such matrices is more complicated and tedious.

HOW IT WORKS

A weighed sample, in a boat, is loaded into MA-3 *Solo*. As purified air flow begins, the decomposition furnace temperature is increased in stages; first to dry the sample, then to decompose it. Evolved gases are carried through a heated catalyst to produce free mercury. Combustion products are swept through a gold amalgamation trap where the mercury is concentrated. The trap is then heated to release the mercury into a carrier gas which transports it into the measurement cell of an atomic absorption spectrometer.

The NIC MA-3 *Solo* works on the principle of cold vapor atomic absorption spectroscopy, where monochromatic light at a wavelength of 253.7 nanometers is attenuated by mercury vapor in a measurement cell according to the Beer-Lambert Law: Absorbance is equal to the molar absorptivity times the concentration times the path length. In the simplest case, since epsilon and path length are constant, absorbance is proportional to concentration.

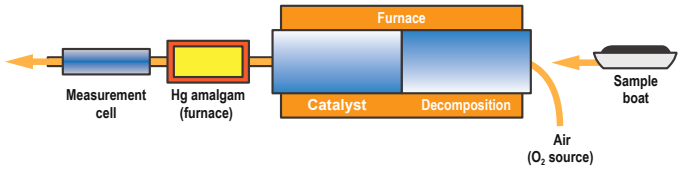


Figure 1. Schematic of thermal decomposition method

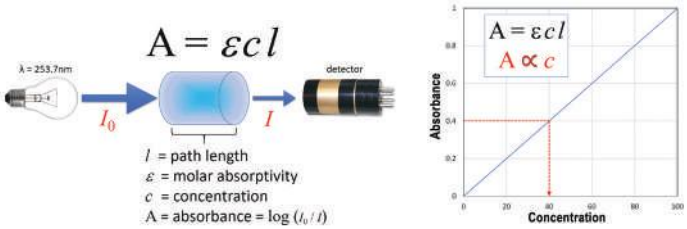


Figure 2. Cold vapor atomic absorption spectroscopy

LIGHTWEIGHT DESIGN IS EASILY TRANSPORTED

Engineered for portability, the MA-3 *Solo* has built-in ergonomic handles and weighs just 13 kg (~28 lbs). An available carrying case allows safe transport to brown field sites and other short-term survey expeditions. So configured, the instrument is ideal for placement in mobile environmental laboratories for studies of soil pollution at remediation or construction sites.

MA-3000 compared to MA-3 *Solo*

PETROLEUM HEAVIES

Supplement your PE-1000 for analysis of heavy oils, sludge and wastewater to increase operational efficiency. If you have a NIC SP-3D, MA-3 *Solo* (UOP 938-20 compliance) is the best upgrade choice.

PE-1000 plus MA-3 *Solo*

PERFECT COMPLEMENT

An ideal complementary technique for handling all the solid, non-aqueous liquids and or particulates-laden liquid matrices where chemical preparation on such matrices is complicated and tedious.

Reduction vaporization mercury measuring device plus *MA-3 Solo*

PERFORMANCE EXAMPLES

The data shown illustrates the excellent comparability to other mercury methods and the analysis precision for a repeated measurement.

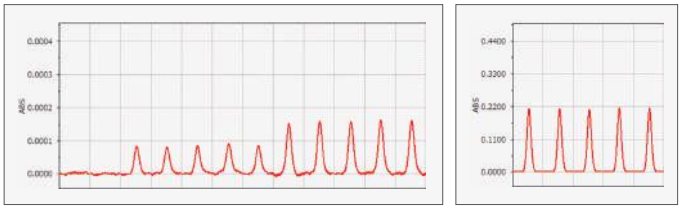
Data example #1

	Sample name	Authentication range or measurement result	Measurement result by MA-3 *Solo*			
			Amount of sample	No. of samples	Mean value	CV (%)
Standard sample (SRM)	Coal (NIST 1632d)	0.0895 ~ 0.0961 mg/kg	50 ~ 57 mg	5	0.0915 mg/kg	2.1
Actual samples	Wastewater	11.6 mg/L*1	200 µL	3	12.3 mg/L	3.7
	Crude petroleum	3.75 mg/kg*2	200 µL	5	3.88 mg/kg	2.4
	Naphtha	0.31 ug/kg*3	200 µL	10	0.45 ug/kg	12.19
	Condensate	2.75 ug/kg*3	200 µL	3	2.41 ug/kg	1.76
	Crude petroleum	62.9 ug/kg*3	90 ~ 125mg	3	64.2 ug/kg	3.12
	Fuel Oil	395.2 ug/kg*3	60 ~ 75mg	3	396.8 ug/kg	0.12

*1 Measured by the reducing vaporization mercury analyzer RA-4500 (JIS K0102)
*2 Measured by the petro-pyrolysis mercury analyzer PE-1000 (UOP 938-10)
*3 Measured by the thermal decomposition mercury analyzer SP-3D (UOP 938-10)

Data example #2

Sample name	Number of samples	Mean value (ng)	CV (%)
Mercury standard solution 0.05 ng	5	0.050	4.6
Mercury standard solution 0.1 ng	5	0.099	2.9
Mercury standard solution 100 ng	5	101	0.4



MA-3 *Solo*
Key Features and Benefits

AFFORDABLE ROBUST DESIGN WITH A WIDE MEASUREMENT RANGE

Engineered for affordability, with easy-to-use manual boat loading and a sturdy "quick twist" load lock, the rugged MA-3 *Solo* is simple to operate and delivers a wide measurement range of 0 to 10,000 ng with quick analysis times ranging from 5 to 12 minutes.

INEXPENSIVE OPERATION – NO GASES OR CONSUMABLES REQUIRED

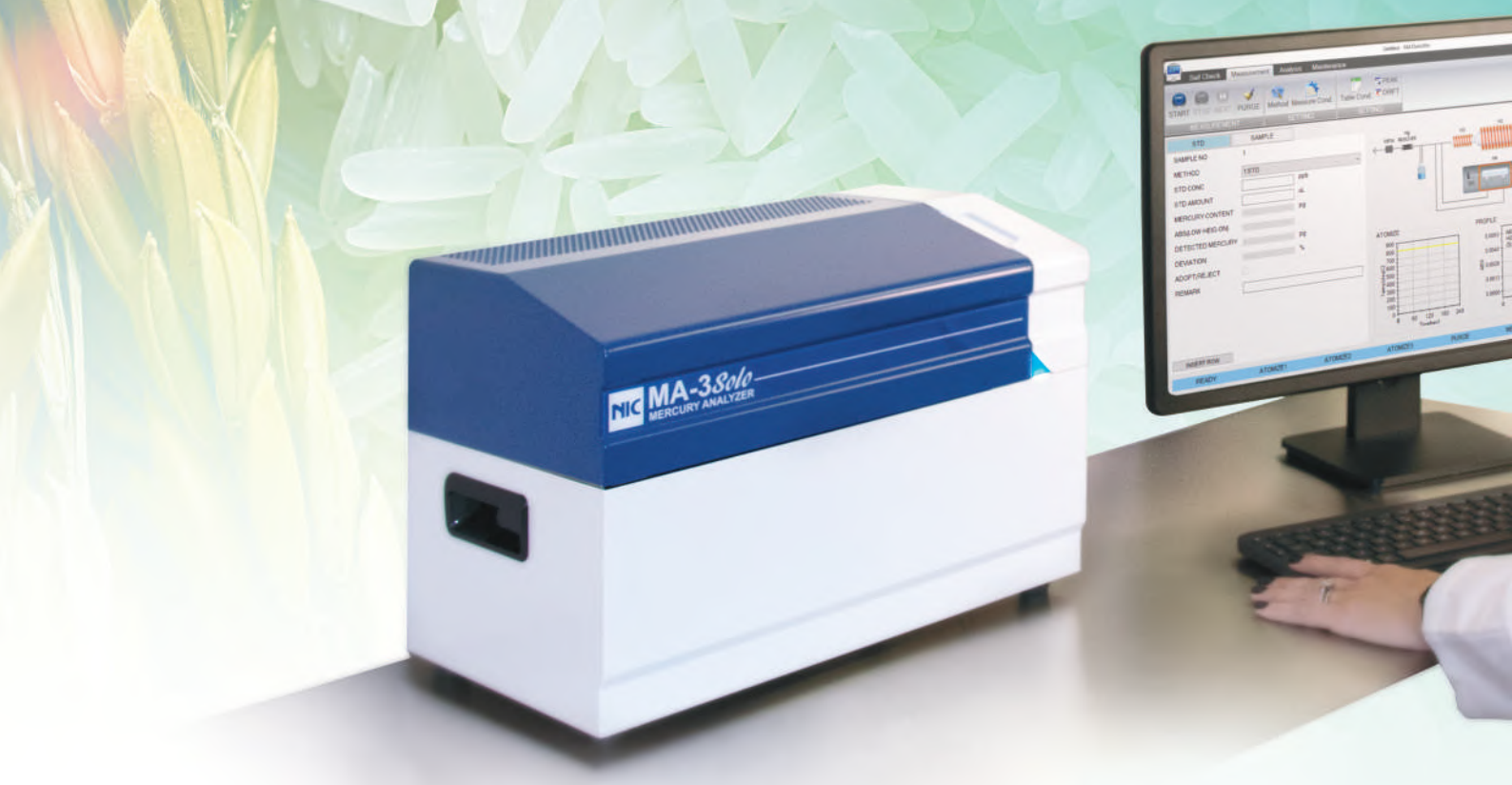
MA-3 *Solo* was designed to be as simple to use as possible. Unlike other systems that require purified oxygen gas, purified air is used as the combustion and carrier gas. This design concept makes the instrument perfect for field portable operation or for use in mobile laboratories. The ceramic sample boats are easily cleaned for reuse. No gas requirement and reusable boats keep operating costs low.

ADVANCED OPTICS FOR SUPERIOR SENSITIVITY AND STABILITY

Employing a high-quality thermally stabilized Hg-discharge lamp that emits a very strong, stable line emission at 253.7 nm eliminates the need for any intensity-robbing optical filtering of the source. Two rugged semiconductor detectors provide the quantitative and reference measurements, ensuring a long lifetime of trouble-free operation. Other systems use inexpensive 50% transmittance mirrors to redirect the light source, but this reduces the intensity, lowering sensitivity. Instead, MA-3 *Solo* uses high quality optical gratings to redirect the full intensity through the sample cell and to the reference detector, for superior sensitivity and stability.

REAL TIME CONTINUOUS DIAGNOSTICS

MA-3 *Solo's* software continuously monitors key diagnostics, such as all heater temps, flow rates, valve actuations, and voltages. This allows the software to automatically prompt the user if there is an issue, and it also allows for quick and easy troubleshooting for maximum uptime and reliability.

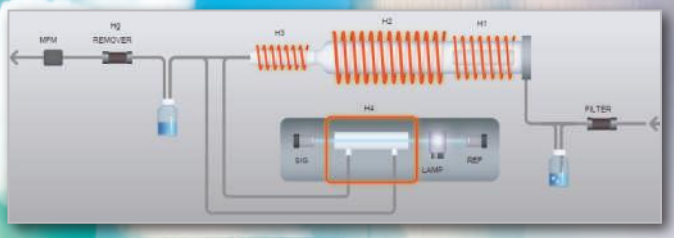


■ COMPACT, LIGHTWEIGHT DESIGN FOR PORTABILITY

Engineered for portability, the MA-3 *Solo* has built-in ergonomic handles and weighs just 13 kg (~28 lbs). It can run on any standard single-phase wall power, from 100 to 240 VAC (50/60 Hz). The rugged design is perfect for field operation or for use in mobile labs.

■ WINDOWS BASED AND USER FRIENDLY GRAPHICAL SOFTWARE

Running under the Microsoft Windows operating system, the MA-3 *Solo's* modern software is intuitive to use and provides a real-time graphical representation of the measurement status (shown below).



■ TEST METHODS

USEPA 7473; ASTM D 6722-01; ASTM D 7623-10; UOP 1009-15; JIS K0102; UOP 938-20 (latest revision).

■ APPLICATIONS

Thermal decomposition: Sediment, soil, food, biological tissue, blood, urine, ore, coal, plastics, crude oil, wastewater, refined petroleum liquids and more.

■ PERFECT ACCESSORY TO OTHER SPECTROMETRIC TECHNIQUES

Addition of a trace Hg analyzer can enhance most labs as Hg's volatility makes it difficult to analyze by other methods. Furthermore, trace elemental analyzers can be contaminated by analysis of high-concentration samples. Thus, MA-3 *Solo* can protect your other instrumentation and guide sample preparation by providing fast, accurate results.

■ SUPERIOR CATALYST AND GOLD AMALGAMATOR

MA-3 *Solo's* catalyst and gold traps have such long lifetimes and superior designs that users never have to correct the calibration curve. Calibration curves generated for each catalyst will typically continue with the same level of response right up until it must be replaced (9-12 months later, depending on usage).

■ BEST-IN-CLASS-ENGINEERING

In summary, better optics, better components, and a better compact design are the hallmarks of all Nippon Instrument's direct combustion mercury analyzers dating back to the 1970s. Being dedicated to only mercury analysis makes NIC the first choice for your mercury analysis needs.

MA-3 *Solo*
Applications and Specifications

CORK STOPPERS

In a 2014 study (Lopes, C.B., et al. *Environ Sci Pollut Res* (2014) 21: 2108), it was shown that stopper-derived cork is an effective biosorbent towards bivalent mercury at environmentally relevant concentrations and conditions.

COAL

Since mercury occurs naturally in coal and other fossil fuels, when these fuels are burned for energy, the mercury becomes volatilized and airborne into the atmosphere.

CRUDE OIL

While the low mercury average levels found in crude oil (ca. 3.5 µg/kg) do not seem to represent an environmental hazard, the refining process tends to concentrate and collect the mercury components and direct the emissions to air release, petroleum products and waste products.

SHALE OIL

Research has shown that many shale deposits are high in mercury content and that significant quantities of mercury can be released during oil shale processing.

SEDIMENT

Sediment mercury is mercury that has become embedded into the bottom substrates of aquatic ecosystems.

ATMOSPHERIC AIR

Atmospheric elemental mercury, although present only in trace amounts, has been established as a significant source of Hg to aquatic environments.

DRIED KELP

Kelps have been found to be highly absorptive of mercury from aqueous solutions. Also, high levels of mercury in kelp supplements have been widely reported.

HIJIKI (SEAWEED)

Edible seaweeds of all kinds contain 1–50 parts per billion (ppb) of mercury.

SHARK LIVER OIL

Bioaccumulation in shark liver oil carries over into human populations, where it can result in mercury poisoning.

TUNA LEAN

Fish and shellfish concentrate mercury in their bodies, often in the form of methylmercury, a highly toxic organic compound of mercury.

COPPER ORE

Mercury occurs in elemental form as a natural amalgam in native metals like copper.

BAUXITE

The mercury content of bauxite ore can vary significantly, in the range of 20–2000 ppm.

SILICA

Silica mining and production can be contaminated with naturally occurring forms of mercury found in the abiotic environment, including: metallic mercury, mercuric sulfide, and the salts mercuric chloride and mercurous chloride.

SULFIDE

When rain falls on sulfide ore waste, sulfuric acid is produced. Sulfuric acid leaches out metals and chemicals from the waste and creates acid mine drainage, which contaminates lakes, rivers, and groundwater with mercury and mercury compounds.

SLUDGE

Sludge is typically a soup-like material containing significant quantities of interstitial water and is often contaminated with heavy metals including mercury.

CALCIUM FLUORIDE

Fluorite (the mineral form of calcium fluoride) can be contaminated with mercury and processing and use of fluorite can lead to environmental mercury contamination.

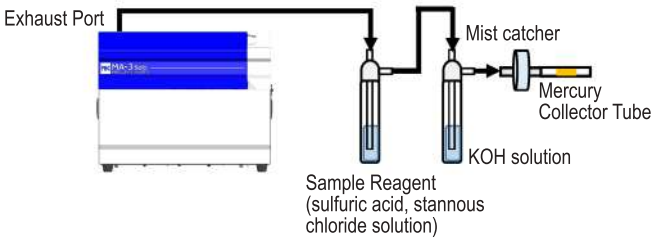
WHOLE BLOOD

Elevated mercury in blood usually indicates exposure to organic mercury (usually in the form of methylmercury) or recent exposure to a high level of elemental mercury vapor.

Optional Attachment for MA-3 *Solo*
AQUA Kit

Aqueous samples like drinking water, spring water, oceans, rivers & lakes usually have relatively low levels of Mercury where it is a challenge to analyze by direct combustion analysis. For these applications, NIC has incorporated an optional attachment, called the AQUA Kit, to enable the MA-3 *Solo* to easily perform reducing vaporization at low, sub-ppb detection limits.

PRINCIPLE OF OPERATION (AQUA KIT)



Specification	
Measurement Range	5ng/L – 50 µg/L (For measurement of 20ml)
Precision	RSD 3% (for 15ng/L or more)
Sample volume	20 ml
Dimension	464 x 366 x 176 (Carrying case)
Weight	6 Kg (Including carrying case)

Note: To determine for Total Mercury by reducing vaporization, the aqueous samples have to be pre-acid-digested.

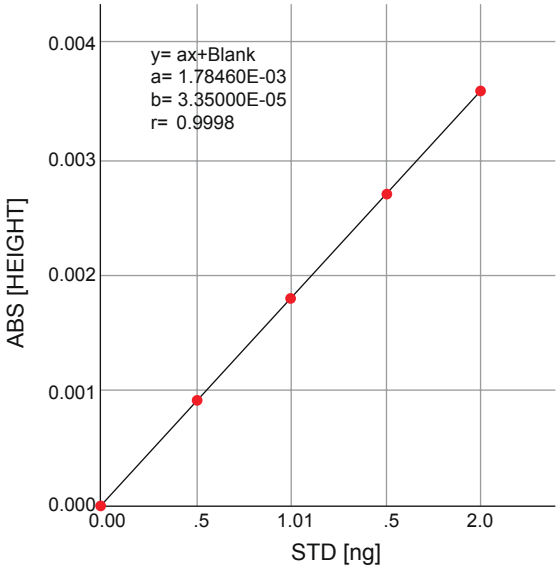
An impinger set is used in the AQUA Kit. Water samples are filled into the sample tube. H_2SO_4 and $SnCl_2$ are added subsequently to reduce the oxidation state of the mercury in the sample. All Hg^{2+} in the water samples is converted into Hg^0 by the $SnCl_2$ reagent.

$$Sn^{2+} + Hg^{2+} \longrightarrow Sn^{4+} + Hg^0$$

Hg^0 is then purged from the sample tube and trapped onto a Mercury Collector Tube. The Mercury Collector tube is loaded into MA-3 *Solo*. The MA-3 *Solo* works on the principle of direct thermal decomposition with gold amalgamation-cold vapor atomic absorption spectroscopy (CVAAS). By placing the Mercury Collector Tube in MA-3 *Solo*, the trapped mercury is released during the direct thermal decomposition stage and subsequently trapped on the MA-3 *Solo*'s Gold Amalgamation Trap, isolating and concentrating the mercury. This trap is then heated to release the mercury into a carrier gas which transports it into the optical measurement cell of the CVAAS detector.

DATA EXAMPLE #1

CALIBRATION



CALIBRATION DATA

STD [ppm]	SVOL [µL]	STD [ng]	LOW [Height]	MEAS [ng]	Dev. [%]
0.01	0	0	0.000036	0.001	-
0.01	50	0.5	0.000908	0.490	2.0
0.01	100	1.0	0.001826	1.004	0.4
0.01	150	1.5	0.002664	1.474	1.7
0.01	200	2.0	0.003638	2.020	1.0

RESULT

No.	Concentration	Trials	Ave [ppt]	SD [ppt]	C.V. [%]
1	50 ppt	5	48.89	0.81655	1.67
2	25 ppt	5	24.27	0.15652	0.64
3	10 ppt	5	9.88	0.38503	3.90
4	5 ppt	5	4.89	0.25836	5.28

Optional Attachment for MA-3 *Solo*
Gas Analysis Kit

Mercury can exist in the ambient air due to anthropogenic activities and natural events such as volcanic eruptions. Industrial activities to produce power such as stationary combustion of coal-fired power plants and other commodities with intentional use of mercury-added products in the process are some of many reasons for elemental mercury emissions due to anthropogenic activities. Since elemental mercury is the least water-soluble form of mercury and thus it has the tendency to stay longer in the atmosphere. Monitoring of elemental mercury will be a good indication of mercury pollution in the air and the working environment.

Geologically, mercury deposits naturally in the earth's crust, together with crude oil and natural gas wells. In the exploration and processing of these fossil fuels, if mercury is not being treated properly, it brings corrosion and eventually Liquid Metal Embrittlement (LME), leading to catastrophic accidents in the processing plants of the oil and gas industry. Thus, measuring elemental mercury is crucial and helpful to prevent such disastrous events from happening.

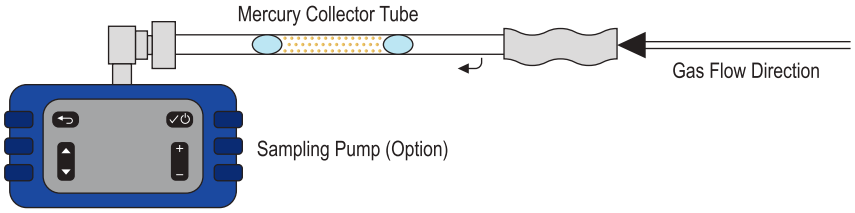
The main form of mercury in ambient air or LPG/LNG is primarily elemental mercury (Hg^0) with a concentration ranging from few nanograms per cubic meter (ng/m^3) to micrograms per cubic meter ($\mu g/m^3$) depending on the geological locations and sources of emission. To analyze elemental mercury with MA-3 Solo in all gaseous matrices, NIC has developed a Gas Analysis Kit, providing a solution to analysts with a single platform of MA-3 Solo without any hardware and software modification.

PRINCIPLE OF OPERATION

A. Sampling Setup

Ambient Air

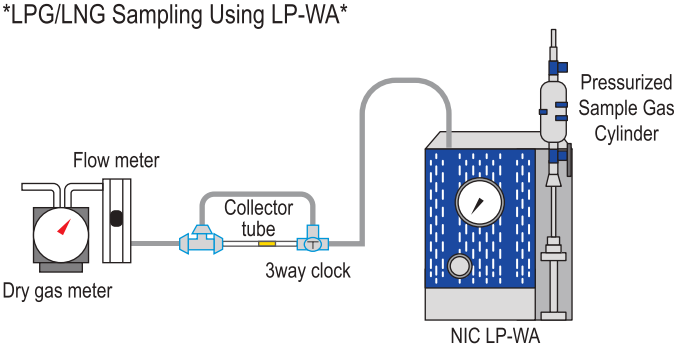
Gas Sampling Using Collector Tube



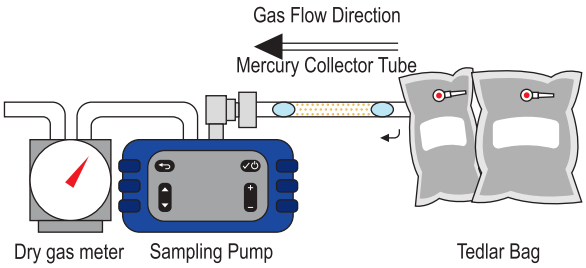
A Mercury Collector Tube (N-65) and a sampling pump are used to perform on-site gas sampling. An external gas volume meter can be connected to measure on the total sampling volume during gas sampling if the sampling pump does not have the function to record the total sampling volume. During gas sampling, elemental mercury will be trapped onto the mercury collector tube. The mercury collector tube is brought back to the laboratory for analysis by MA-3 Solo directly.

LPG/LNG

LPG/LNG Sampling Using LP-WA



LPG/LNG Sampling Using Tedlar Bag



For LPG/LNG and NG application, the sampling onto Mercury collector tube can be done in various ways, namely directly via Liquefied Gas Vaporizer sampling or Tedlar Bag sampling. Using LP-WA Liquefied Gas Vaporizer, the liquefied gas (eg. propane or butane) is vaporized by the heated pressure reducing regulator to a constant flow of gas during sampling. Elemental mercury in the gas is collected onto the mercury collector tube. If the hydrocarbon gases are collected in Tedlar bags, since the gas is at atmospheric pressure in the bag, a sampling pump is required to draw a constant flow of gas for sampling. Elemental mercury in the gas is collected into the mercury collector tube. After completion of sampling, the mercury collector tubes are brought for analysis in MA-3 Solo directly.

Optional Attachment for MA-3 *Solo*
Gas Analysis Kit

PRINCIPLE OF OPERATION

B. Measurement of Mercury Collector Tube

To analyze the gas sample collected, the mercury collector tube is loaded onto MA-3 Solo. The MA-3 Solo works on the principle of direct thermal decomposition – gold amalgamation – cold vapor atomic absorption spectroscopy (CVAAS). The thermal decomposition stage releases the Mercury from the collector tube and subsequently trapped onto MA-3 Solo's Gold Amalgamation Trap, re-concentrating and purifying the mercury. This trap is then heated to release the purified mercury into carrier gas which transports into optical cell of CVAAS detector for measurement.

RESULT:

DATA EXAMPLE #1

Mercury Analysis of Propane

Mercury in propane gas is spiked with elemental mercury standard to verify its recovery and repeatability performance.

Name	Trials	STD Add (ng)	Recovery (%)	SD (%)	C.V. (%)
Propane	3	1.701ng	96.60	0.8888	0.92

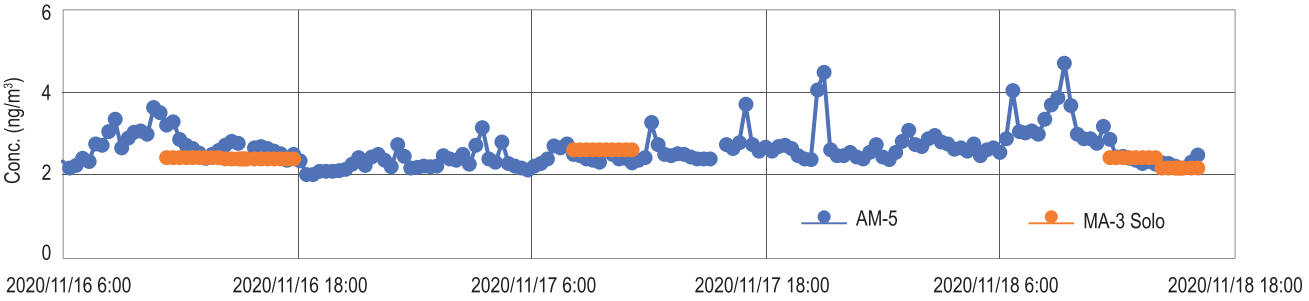
DATA EXAMPLE #2

Mercury Analysis of Ambient Air

Mercury (Gaseous Elemental Mercury - GEM) in ambient air is being collected onto the mercury collector tube. The measurement result from MA-3 Solo is compared against AM-5 (NIC Continuous Mercury Ambient Air Monitoring system).

	MA-3 Solo (Gas Tube Analysis Kit)			AM-5 (AFS) (Continuous Ambient Air Monitor)
	Vol. (L)	Hg (ng)	Conc. (ng/m^3)	Ave. (ng/m^3)
11/16 11:25~14:03	69.5	0.169	2.43	2.75
11/16 14:05~17:41	93.2	0.224	2.40	2.63
11/17 8:00~11:00	61.8	0.161	2.61	2.42
11/18 11:25~14:14	82.6	0.201	2.43	2.41
11/18 14:14~15:54	50.3	0.109	2.17	2.32

MERCURY COLLECTOR TUBE GEM GRAB-SAMPLING (MA-3 SOLO) VERSUS CONTINUOUS GEM MONITORING (AM-5) AMBIENT AIR IN TAKATSUKI CITY, OSAKA



Specifications

Thermal decomposition mercury analyzer MA-3 *Solo*	Measuring objects	Solid sample; liquid sample; gaseous sample [*1] [*2]
	Analysis method	Thermal decomposition-gold amalgam collection cold atomic absorption spectrometry
	Measurement principle	Non-dispersion double-beam cold atomic absorption spectrometry
	Light source	Low-pressure mercury discharge lamp
	Detector	Semiconductor detector (with 254 nm bandpass filter)
	Detection limit; Precision	Detection limit: 0.01 ng; Precision: RSD 3% (0.1 ng or greater) [*3]
	Measuring range	0 to 10,000 ng
	Analysis time	5 to 12 minutes
	Flow rate at measurement	0.2 L/min
	Exhaust gas treatment	Activated carbon filter for removing mercury
	Sample heating temperature	Up to 850°C
	Heating control	3 Step setting (temperature time arbitrary setting possible)
	Carrier gas	Self-purified ambient air
	Sample bottle	Dedicated ceramic boat (Capacity: 1.5 mL)
	Size/Weight	403 W × 252 D ×300 H (mm), 13 kg (~28 lbs)
	Power source	AC100-240 V, 50/60 Hz, 1.1 KVA
	Usage environment	Temperature: 15 to 35°C; Humidity: 10 to 80% RH (no dew condensation)
	Standard accessories	Sample boat (10); boat stands; boat tongs; L-cysteine
Control/Data processing system MA3Solo_Win	OS	Windows 10 Pro
	Communication	USB
	Display (Japanese/English)	Peak waveform; calibration curve graph; measurement process; measurement result; equipment status
	Data processing	Calibration curve (linear formula ×3 types; cubic formula × 3 types); unit setup; concentration computation; baseline correction; statistical calculation (mean value; standard deviation; CV%)
	Precision control	Equipment check; evaluation of calibration curve; blank check; recovery calculation
	Printing	Memo; calibration formula/graph; measured value table; statistical calculation; peak waveform Measurement date and time; result of equipment check

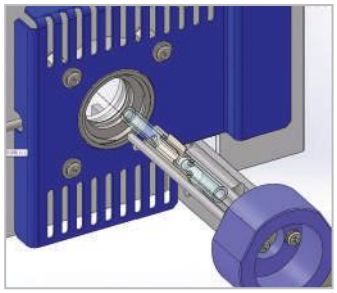
[*1] For some samples, measurement may be impossible.
[*2] For measurement of gaseous samples, an optional collector tube measurement kit is required.
[*3] Certain conditions are prerequisite for low concentration measurement.

Spare parts / Consumables

Sample boat (10 pcs/set); sample heating tube; mercury collector tube; tubing/joint set, additive B and Charcoal pellets (for UOP 938-20 applications)

Option for collector tube measurement

Collector tube measurement kit (a set of 5 collector tube L= 65 mm + holder for measurement)



Nippon Instruments Corporation

Identify the right mercury analyzer for you
http://www.hg-nic.com

Osaka office /Tech. center: 14-8 Akaoji-cho, Takatsuki-shi, Osaka 569-1146 Japan
TEL +81-72-694-5195 FAX +81-72-694-0663
E-mail hg-nic@rigaku.co.jp URL www.hg-nic.com

Singapore office: 61 Bukit Batok Crescent, #04-04A, Singapore 658078
TEL +65-6873-7068 FAX +65-6873-6372

ISO 9001: 2015 CERTIFIED Tech-center, Factory & Osaka office/2017.12.27
ISO 14001: 2004 CERTIFIED Tech-center, Factory & Osaka office/2007.6.8

Distributors

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