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A Rigaku Company

NIPPON INSTRUMENTS CORPORATION

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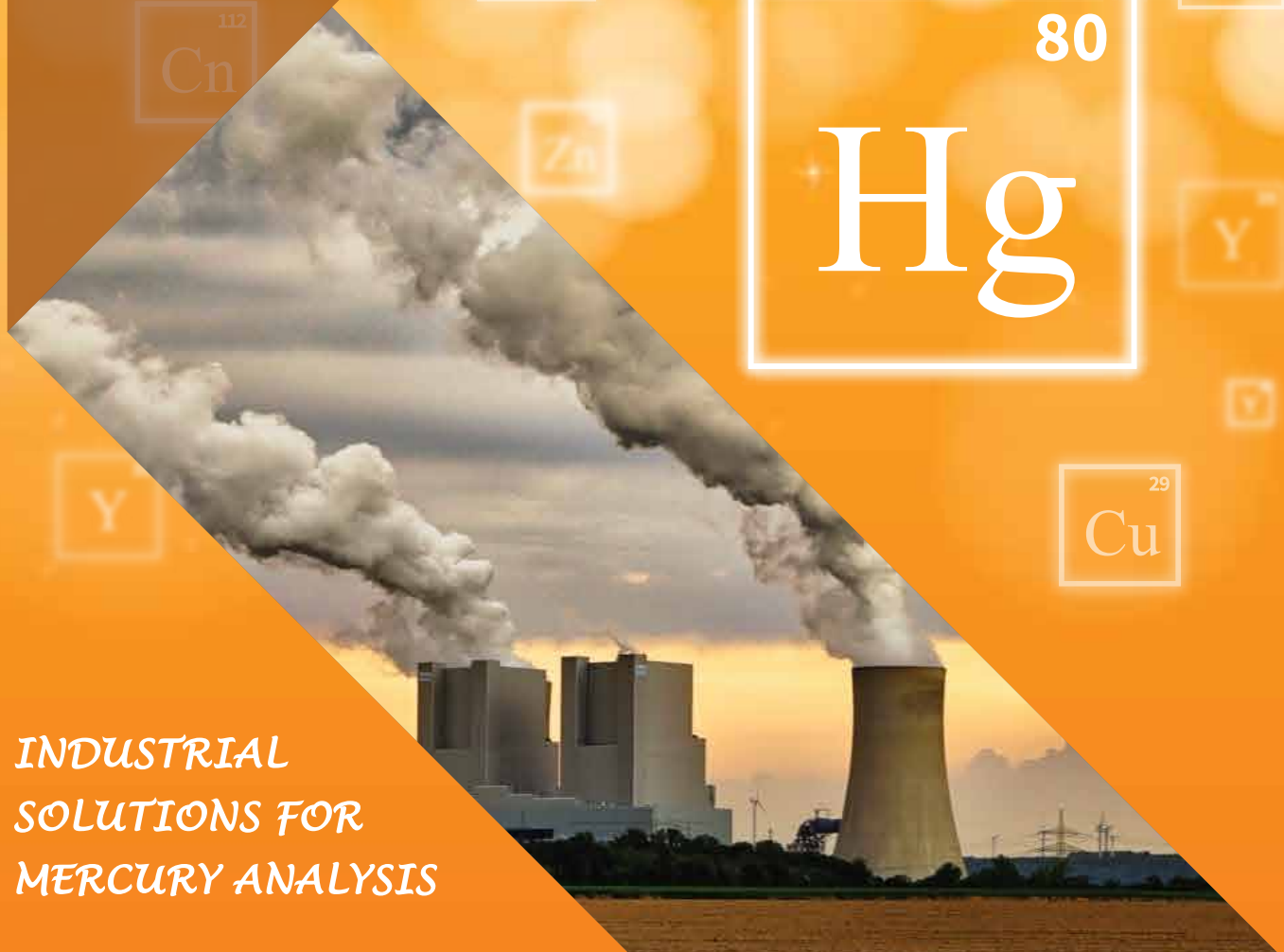


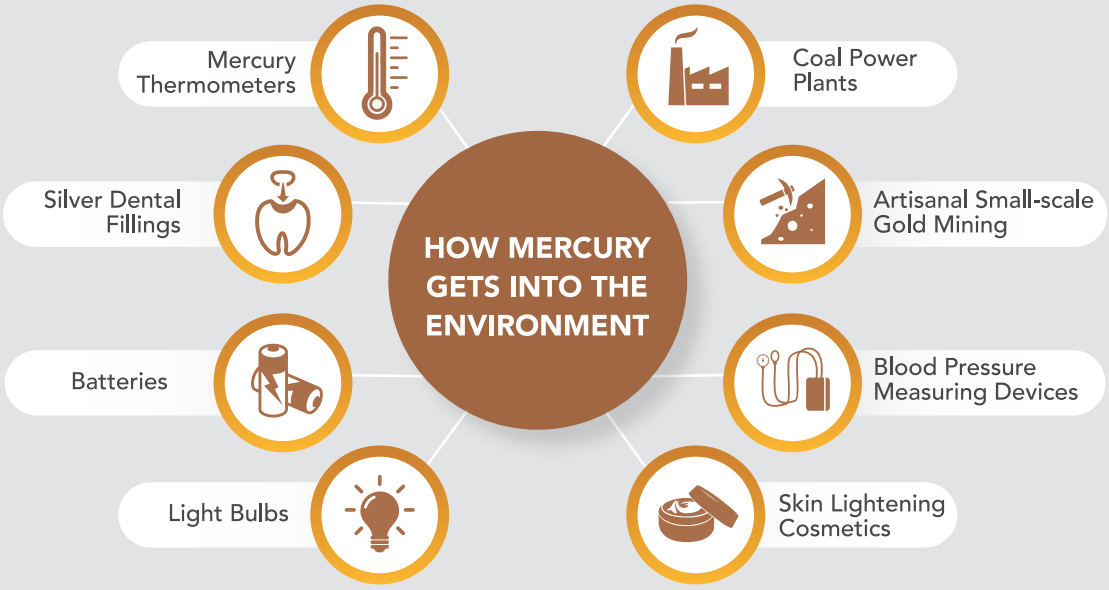
INDUSTRIAL SOLUTIONS FOR MERCURY ANALYSIS

ABOUT MERCURY & THE MINAMATA TREATY

Mercury is a toxic metallic element that poses serious health risks to our lungs, kidneys, nervous system, and more, while being especially concerning for the development of unborn children. Mercury exists in multiple forms: elemental (or metallic), typically found in air or gases; inorganic (e.g. mercuric chloride), typically found in water; and organic (e.g. methyl- and ethyl-mercury), which is commonly found in fish, each with different toxicity and pathways into our bodies.

WHAT IS MERCURY?

Mercury is a naturally occurring metal. When released into the environment, it can be toxic.



The primary sources of anthropogenic (human-related) mercury emissions include coal-fired power generation, residential heating systems, waste incinerators, and the mining of mercury, gold & other metals. Once released into the environment, elemental mercury transitions into our water sources and naturally transforms into methylmercury that bioaccumulates in fish and shellfish. In the end, mercury makes its way into the air we breathe, the water we drink, and even the food that we eat.

Minamata Disease, also known as Mercury Disease, is a neurological syndrome caused by severe mercury poisoning. Signs and symptoms include ataxia, numbness in the hands and feet, general muscle weakness, loss of peripheral vision, and damage to hearing and speech. In extreme cases, insanity, paralysis, coma, and death follow within weeks of the onset of symptoms. A congenital form of the disease can also affect fetuses in the womb.

The first known case occurred in the 1950's on the island of Kyushu in Japan in the Yatsushiro Sea off the coast of Minamata City. Industrial mercury pollution in the Minamata Bay bioaccumulated in the fish and shellfish, which were consumed daily by the local inhabitants. Over 1,700 of the over 2,200 victims of this tragic event lost their lives, as wells as many dogs, cats & other animals. In the wake of this tragedy, the local community also suffered through social and political issues in addition to long lasting economic effects.

"Courtesy photo taken by W. Eugene Smith, Copyright belongs to Aileen Archive"

In October 2013, under the United Nations Environment Programme (UNEP), delegates from 128 countries gathered in Kumamoto, Japan to officially adopt and sign the "Minamata Convention on Mercury". The objective of the Minamata Convention is to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. It contains provisions that relate to the entire life cycle of mercury, including controls and reductions across a range of products, processes and industries where mercury is used, released or emitted.

UN environment programme

MINAMATA CONVENTION ON MERCURY

MERCURY FROM INDUSTRIAL SOURCES

In any developing or developed countries, industrialization is inevitable. By far, the biggest negative effect and impact of industrialization is on the environment. Pollution is the most common by-product of industrialization.

Industrial activities to produce power and other commodities, together with a range of intentional uses of mercury in processes and products, result in anthropogenic emissions of mercury to the atmosphere. Predominantly, stationary combustion of fossil fuels, especially coal, and high temperature processes involved in industrial activities such as metal smelting and cement production give rise to mercury emission as a by-product. The use of mercury-added products such as lamps, batteries, and dental fillings also result in mercury emissions to air (and releases to water), largely during waste disposal. Mercury is also used in industrial processes such as Chlor-alkali production and the vinyl-chloride monomer (VCM) process, though many countries have already phased them out.

Artisanal and small-scale gold mining (ASGM), with the intentional use of mercury, consumes, and discharges the largest amount of mercury where mercury is used to extract gold from gold-bearing sediments and rocks. ASGM activity is typically found in impoverished areas of the world where a lack of understanding of the health risks combined with inadequate environmental regulations leads to the toleration of such dangerous practices.

These emission activities, both air and water discharges, give rise to global pollution. Mercury in the atmosphere has the ability to travel for hundreds or thousands of miles, being transported around the world, where it is eventually deposited in the earth's soil, waters, and plants, contaminating our food chains and eventually affecting to human life.

As such, it is extremely crucial that we are able to reliably and accurately quantify mercury emissions & releases into every aspect of our environment (air, water & soil) with proven technologies and solutions. This is what drives Nippon Instruments Corporation to continuously advance & improve mercury analyzer technologies, and it's why we are The Global Leading Provider of Mercury Analyzers & Monitors.

MERCURY FROM COAL-FIRED POWER UTILITIES

Coal is a fossil fuel produced from decayed vegetation which has been buried in the earth for millions of years, eventually forming this carbonized black or brownish-black, combustible rock. It is reported to be present in abundance and is a very economical source of energy from exploration to production. Coal is used to produce approximately one-quarter of the world's generated energy. Together with other naturally occurring minerals, mercury can be found in coal in varying concentrations, depending on the source.

When combusting coal for energy, mercury is emitted with the flue gas into the atmosphere via its chimney or stack. Per the UNEP global mercury assessment report, coal combustion emission is the largest anthropogenic (human-related) source responsible for mercury emitted into our atmosphere.

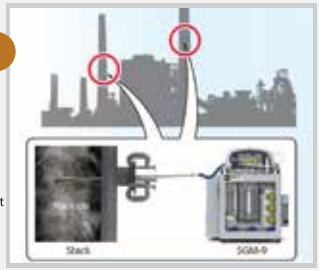
MODEL MA-3000 SERIES

Sample Types: Coal, Ores, Sludges, Wastewater, Sorbent Trap, and more.

Test Methods: USEPA 7473; ASTM D 6722; JIS K0102

MODEL SGM-9 SERIES

Sample Types: Stack, Flue, Chimney Exhaust Gases.



MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MERCURY FROM MINING & SMELTING

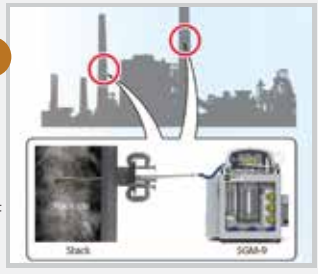
MODEL MA-3000 SERIES

Sample Types: Coal, Ores, Sludges, Wastewater, Sorbent Trap, Crude Oil and more.

Test Methods: USEPA 7473; ASTM D 6722; ASTM D 7623; JIS K0102

MODEL SGM-9 SERIES

Sample Types: Stack, Flue, Chimney Exhaust Gases.



MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

Mercury is a naturally occurring chemical element that exists in the earth's crust. In its inorganic form, it is present abundantly as a mineral called cinnabar (mercury sulfide), commonly mined to produce metallic mercury. It can also naturally exist as an amalgam to other non-ferrous metals, such as Copper, Zinc, Lead, Aluminum, Tin, Nickel, & more. As a result, the mining and smelting of non-ferrous metals can release mercury into our environment through air emissions as well as solid & liquid wastes. Further complicating the issue, coal is usually burned to power the smelting operations, emitting even more toxic gaseous mercury into the environment.

During the mining process, mercury can readily combine with chlorine, sulfur, and other elements forming inorganic salts. Inorganic mercury salts can leach into underground springs, rivers, lakes, and our oceans, polluting our water sources in addition to the aquatic and marine life that live within them.

AT EMIT AND DISCHARGE SIGNIFIC

MERCURY FROM WASTE TREATMENT & RECYCLING

Mercury waste generated from various industries must be carefully sorted, processed, and treated for disposal to prevent polluting the environment and causing health hazards to people and animals. Typical mercury-containing wastes include mercury-containing devices from medical & industrial use, waste sludges, spent catalysts, used pipelines & valves from petrochemical industries, exposed metals and more.

Electrical/Electronic Waste (e-Waste) is a major contributor of harmful substances to the environment, including mercury. Mercury can also easily enter the environment from improper disposal of fluorescent lamps, alkaline batteries, old TVs (CRT and LCD), printed-circuit boards (PCB), and more. In addition to the harmful effects to the environment, workers in these industries may be directly impacted by mercury exposure in their workplace.

MODEL RA-7000 SERIES

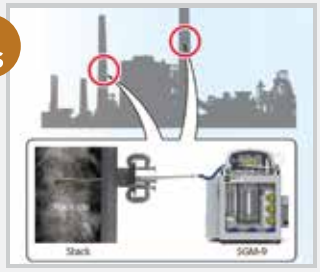
Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MODEL SGM-9 SERIES

Sample Types: Stack, Flue, Chimney Exhaust Gases.



MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL MA-3000 SERIES

Sample Types: Crude Oil, Heavy Oil, Wastewater, Sludges, Catalysts, Light Hydrocarbon Liquids - MA3 Solo only.

Test Methods: ASTM D 7623; UOP 1009-15; USEPA 7473, JIS K0102, UOP 938 (MA3 Solo only)

MERCURY FROM INDUSTRIAL DISCHARGES

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MODEL MA-3000 SERIES

Sample Types: Raw materials, Process wastes, wastewater, and more

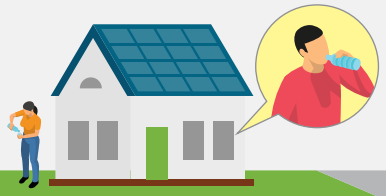
Test Methods: ASTM D 7623; UOP 1009-15; USEPA 7473, JIS K0102, UOP 938 (MA3 Solo only)

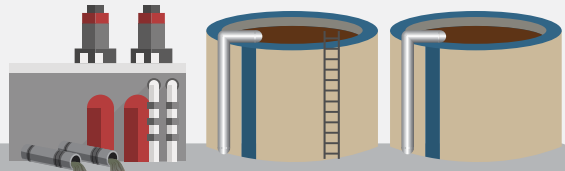
In industrial settings, mercury can come from many different sources – raw materials, additives, incoming waste streams and more. It is critical that any industry that discharges air or gases, solid wastes, or liquid wastes into our environment monitor the mercury levels in their discharged wastes. In most countries, government regulations place limits and reporting requirements on the mercury in waste discharges. Without such regulated monitoring, mercury contamination could permeate the air we breathe, the water we drink, and into the foods that we eat.

MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more





MERCURY FROM FERTILIZER PRODUCTION

The primary components of most chemical fertilizers are nitrogen, phosphorous, and potassium. Natural gas and steam are used to synthesize ammonia as the nitrogen component of most fertilizers. Phosphorous and potassium are mined from underground deposits of phosphate rock and potassium salts (potash), respectively. Chemical fertilizers play an important role in providing crops with the nutrients they need to grow and be harvested for nutritious food. With the global population steadily growing, it is important that enough crops are produced each year to provide food, clothing, and other agricultural products to people around the world.

Natural gas (methane) is a key feedstock for fertilizer production, especially for the synthesis of ammonia & urea, which accounts for 85% of the fertilizers used. Since natural gas is a fossil fuel, it contains mercury at varying concentration levels depending on the regional source. Mercury, if not removed before use, can adversely affect the production process through corrosion by liquid metal embrittlement, contamination of liquid and solid wastes, pollution in the workplace and environment air, and contamination of finished product. As a result, toxic mercury will transfer to our agricultural soils, to our food crops, and eventually to us as consumers.

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MODEL EMP-3 SERIES

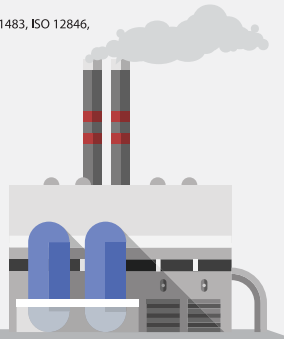
Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL WA-5-SERIES

Sample Types: Natural Gas

Test Methods: ASTM D 9594: ASTM D 6350; ISO 6978



CANT LEVELS OF MERCURY IN THE

MERCURY FROM CEMENT PROCESSING

Cement production is a critical industry for any developing country, as it is widely used in the construction of roads, buildings, and other infrastructure. The primary raw materials of cement are limestone, clay, iron sand (oxide), and fly ash, which are ground and mixed before being fed into a cement kiln to produce what is commonly called "clinker". The clinker is ground into a very fine powder and mixed with gypsum to create cement. This powdered cement is then mixed with water and aggregates to form concrete that is commonly used in construction.

There are multiple potential sources of mercury emissions from cement production. Mercury is present as a contaminant in varying levels within the raw materials used for making cement, especially fly ash. In the high-temperature kiln processing to anneal all the mixtures, mercury is heated and released into the environment as a gas. In addition, to operate these kilns, fuel is required. Usually Coal, other fossil fuels, or any materials that can be combusted to produce heat will be used. The process requires a lot of energy production, which can be visualized by the large smokestacks that tower above cement plants. Through the burning of fuels and the processing of multiple raw materials, mercury is continuously discharged into the air, as well as our water sources through the release of process waters and solid wastes.

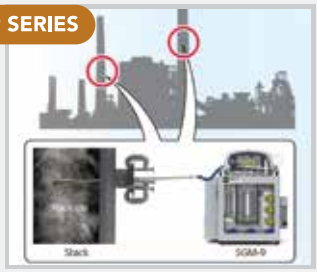
MODEL MA-3000 SERIES

Sample Types: Coal, Ores, Sludges, Wastewater, Sorbent Trap, Crude Oil and more.

Test Methods: USEPA 7473; ASTM D 6722; ASTM D 7623; JIS K0102

MODEL SGM-9 SERIES

Sample Types: Stack, Flue, Chimney Exhaust Gases.



MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

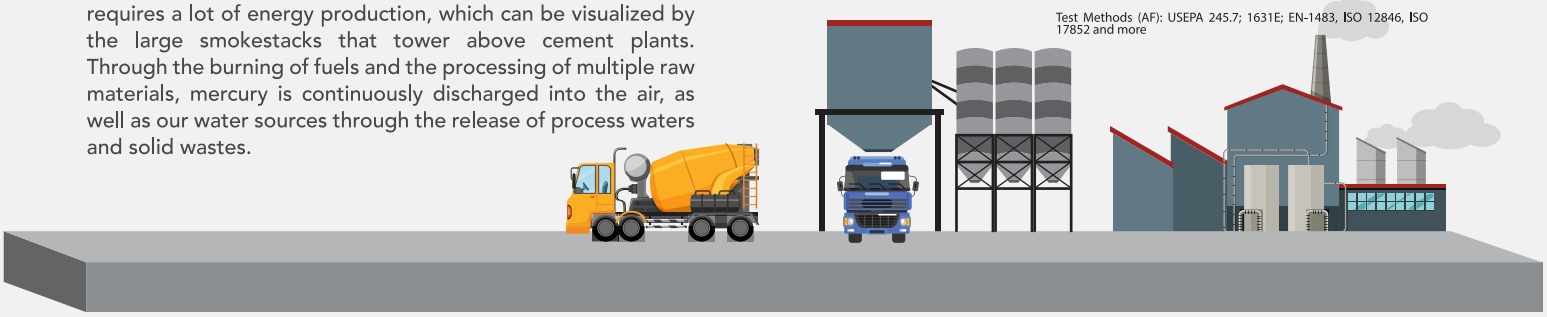
Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more



MERCURY FROM OIL & GAS EXPLORATION & REFINING / LIQUEFICATION

MODEL MA-3000 SERIES

Sample Types: Crude Oil, Heavy Oil, Wastewater, Sludges, Catalysts, Light Hydrocarbon Liquids(MA-3 Solo only)

Test Methods: ASTM D 7623, UOP 1009-15; USEPA 7473, JIS K0102, UOP 938 (MA3 Solo only)

MODEL PE-1000 SERIES

Sample Types: Liquid Hydrocarbons

Test Method: UOP 938

MODEL WA-5-SERIES

Sample Types: Natural Gas, LPG/LNG

Test Methods: ASTM D 9594: ASTM D 6350; ISO 6978; JLPGA-S-07

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

Mercury levels in crude oil and hydrocarbon gases can vary widely by geography, as well as from reservoir to reservoir. Concentrations typically range from low ppb (parts per billion) to low ppm (parts per million) levels. As hydrocarbon exploration expands, more and more mercury is extracted along with the hydrocarbons, increasing the damage to our environment and the hydrocarbon processing refineries, while also increasing the occupational health hazards for plant operators.

Mercury poses several issues for refineries. During refinery distillation, the segment of elemental mercury vapor is predominantly distributed in liquefied petroleum gas (LPG) and light distillate (Naphtha) streams. Due to mercury's high density, it can also be found in the residual fraction and sludges, which also contain the majority of the insoluble forms as well as inorganic mercury salts. Of particular concern are LNG and LPG cryogenic heat exchangers made of aluminum alloys, which are highly affected by corrosion through a process called liquid metal embrittlement (LME). In addition to aluminum, mercury also causes liquid metal embrittlement to other metals and alloy materials used in the refineries, which poses hazardous risks to workers due to increased failures during operation and while performing service or maintenance work. This process is accelerated if any hot work is carried out (e.g. cutting or welding) and can be particularly problematic in confined spaces where the mercury concentration could be above the occupational exposure limit.

As for downstream petrochemical processing, mercury in hydrocarbon feedstocks causes catalyst poisoning and reduces production yields and process-integrity, resulting in significant economic losses.

ENVIRONMENT

MERCURY FROM CHEMICALS (e.g. H_2SO_4) PRODUCTION

Sulfuric acid is the highest volume industrial chemical produced in the world, as it is widely used in the manufacture of fertilizers, explosives, dyes, and petroleum products. The starting material for sulfuric acid production is clean, dry sulfur dioxide (SO_2) gas. This can be obtained by burning molten sulfur, from metallurgical off-gases or by decomposing spent sulfuric acid.

In fact, many sulfuric acid plants can be found near the vicinity of smelting plants where the off-gases can be readily used as sulfur dioxide feedstock (SO_2). Such metallurgical off-gases usually contain varying concentrations of mercury from the high-temperature ore smelting process. Mercury, if it is not monitored and managed, can be detrimental to the production process (corrosion due to LME), contaminate the liquid and solid waste streams, pollute the workplace and environment air, and appear as a contaminant in the finished product which can have additional effects anywhere it is used.

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

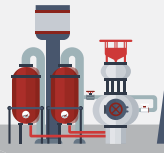
MODEL EMP-3 SERIES

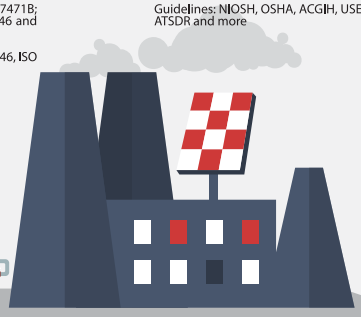
Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL WA-5 SERIES

Sample Types: Off-Gas, Exhaust Gases.





MERCURY FROM WASTE INCINERATORS

MODEL RA-7000 SERIES

Sample Types: Raw water, Process water, industrial wastewater, solid digestates (sludges, soil, etc)

Test Methods (AA): USEPA 245.1; 245.2; 245.5; 7470A; 7471B; ASTM D 3223; EN-1483; APHA-3112; JIS K0102, ISO 12846 and more.

Test Methods (AF): USEPA 245.7; 1631E; EN-1483, ISO 12846, ISO 17852 and more

MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more

MODEL SGM-9 SERIES

Sample Types: Stack, Flue, Chimney Exhaust Gases.

Waste incineration is an effective way to manage solid waste generation in many developing countries. However, if any wastes containing mercury are improperly disposed of with other wastes for incineration, mercury gas is released into our atmosphere in the incinerator flue gas, increasing mercury pollution in our environment. Mercury in the atmosphere has the ability to travel for hundreds or thousands of miles, being transported around the world, where it is eventually deposited in the earth's soil, waters, and plants. From there, mercury can be re-volatilized into the air, transported by rivers and streams, and absorbed into plants and animals that humans consume for food.

MERCURY FROM ASGM

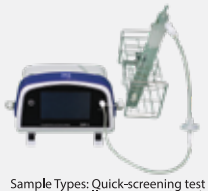
In ASGM activities metallic mercury is mixed with ore containing traces of gold through the panning process, whole ore amalgamation in sluice boxes, and using ball-mills, trommels or little rotating drums. The mercury/gold amalgam resulting from the process is roasted using a blow torch in the burning unit on site, at the gold kiosk and / or in the backyard of the houses. As the amalgam is heated, the mercury vaporises into gaseous form, leaving behind a small amount of gold. The mercury vapors are highly toxic if inhaled and can lead to devastating health impacts. Most mercury vapour from this type of gold processing enters the atmosphere, contributing to widespread global pollution via atmospheric deposition.

The remaining processed water from ore concentration, in conjunction with mercury, usually will be discharged to the river, on the ground, in ponds or fish ponds, and in rice fields, contributing to the reemission of mercury to the food web.

MODEL EMP-3 SERIES

Sample Types: Ambient Air at Workplace, Storage Sites and more.

Guidelines: NIOSH, OSHA, ACGIH, USEPA, ATSDR and more



Sample Types: Quick-screening test of any mercury (metallic / inorganic) leached in the process / discharge water into ponds, rivers, rice fields

Nippon Instruments Corporation

A Rigaku Company

Nippon Instruments Corporation (NIC), the global leader in Mercury Analyzer automation and instrumentation, commercialized the world's first direct thermal decomposition Mercury Analyzer back in the 1970s'. Since that time, we have continued to develop, sell and install a vast range of Mercury Analyzers and customized solutions around the world for regulatory agencies and institutions, universities, research groups, oil & gas refineries, petrochemical industries, food providers, biology & toxicology science groups and more.

Thanks to our strong R&D capacities and technological innovations, NIC is the driving force in the Mercury Analyzer market, setting the standards for functional scope and user-friendliness. With a dense network of knowledgeable sales partners and qualified service partners, we provide scientifically sound and environmentally responsible solutions for our customers around the globe.

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