InnoLab – Mercury 101

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It is surprising that in this day and age how much, or in fact how little, is known or understood of Mercury.

Mercury has been around for some 4½ billion years (since the Earth was formed) and even though there is evidence of man's use of this fascinating element dating back over 3,000 years to utilize its immense capabilities and inherent instability so little is actually known as a consensus. Still after vast analytical methodologies have been carried out and life altering health effects have been well documented through history there is still an educational or general knowledge gap that allows compromised judgment and in some cases, blind ignorance to creep in when compared to other elements such as oxygen, hydrogen and uranium to name a few.

With the current Industrial and Environmental impasse experienced within the Industrial Estates the potential for health and environmental exposure to harmful toxins is too great to ignore.

So what's the issue with Mercury? After-all, it's just a metal that happens to remain in liquid form right? No! Not quite. Mercury is actually a highly unstable metal that will readily react with most other elements, chemicals, metal alloys, etc and while doing so is also constantly evaporating to release its own toxic vapor.

For an element that is nearly 14 times heavier than water (SG = 13.534) its vapor is also very dense at 7 times heavier than air (6.93), while constantly vaporizing at 7µg/cm³/hour. Temperature has a direct linear effect of doubling the rate of vaporization for every 10°C increase. The International published acceptance levels are as follows:

<u>Workplace</u>

- **OSHA** (*Occupational Safety and Health Administration)*

  Permissible Exposure Limit (PEL) = 0.100 mg/m^3 *(100µg/m³)*
- **NIOSH** (*National Institute of Occupational Safety and Health)*

  Time Weighted Average (TWA) = 0.050 mg/m^3 over 8hrs/day for 40hrs/week *(50µg/m³)*
- **ACGIH** (*American Council of Government Industrial Hygienist)*

  TWA = 0.025 mg/m^3 over 8hrs for 40hrs/week *(25µg/m³)*

  Short Term Exposure Limit (STEL) = 0.150mg/m³ for 15 mins *(150µg/m³)*

<u>Residential</u>

- **EPA** (Environmental Protection Agency)

  Clean Up Action Level = 1,000ng *(1µg/m³)*

Mercury has a fantastic ability to react with almost anything and in doing so can accelerate corrosion. Coupled with the ability to degrade process facilities and in the presence of certain common contaminants can actually enhance the combined effects to produce catastrophic results. One of the more readily known destructive scenarios is the continuous oxidation of Aluminium in the presence of Mercury.

Normally Aluminium has a molecule thin layer of its own oxide on its surface which ordinarily protects it from further breakdown, however if Mercury comes into contact with the pure Aluminium below, through a recent scratch or surface cleaning process, this removes part of the protective oxide layer and a weak Mercury-Aluminium amalgam is formed. When this amalgam is exposed to air the Aluminium oxidizes and flakes away leaving behind the Mercury amalgam to continuously repeat the process until the supply of amalgam has been exhausted.

It is well documented, and known, of the corrosive effect Hydrogen Sulphide (H_2S) has on a carbon steel gas process system however under certain conditions and in the presence of Mercury the rate of corrosion can be up to 4 times greater. The presence of Mercury within a carbon steel gas processing system means that localized corrosion rates of up to 2-3 times the normal (liquid mercury-free) corrosion rate may be present in areas where large amounts of liquid Mercury albeit over long periods of time, and inhibition is not present or ineffective.

Notice the point here about Mercury within a carbon steel process system…. Mercury is absorbed by steel and as a rule-of-thumb, the higher the carbon content within the steel matrix, the greater the amount absorbed. There is no amalgamation or bonding involved in this phenomenon but Mercury is able to co-habit the steel grain boundaries alongside the carbon.

The process of absorption is reversible which means that the Mercury can be desorbed from the steel and allowed to either re-evaporate into a vapor phase or re-dissolve into its elemental (liquid) phase. Mercury contamination increases over time and Austenitic stainless steels (type 304 or 316) that would normally be corrosion resistant in a liquid Mercury-free condensate and gas environment can suffer pitting corrosion when liquid Mercury is present. The same can be said for other steels…

Monel is not resistant to liquid Mercury at room temperature and has a corrosion rate that ranges from circa 0.5 mm/yr at room temperature to extremely rapid corrosion above 400°C. Hastelloy B and Titanium may suffer corrosion above 100°C. The presence of liquid Mercury in an Austenitic stainless steel, duplex stainless or other normally corrosion resistant alloy system means the corrosion resistance cannot be taken for granted.

There are methods in which to remove the Mercury from the steel's matrix, usually prior to waste disposal or hot works (welding and/or grinding), involving chemicals or a combination of chemical and mechanical methods for faster results. Where normal working conditions within the hot Asian climate may generate Mercury vapor levels of anywhere between 0.001-0.200mg/m^3 (safe with the correct PPE), hot works can release over 17mg/m^3 within a 2-3 minute timeline.

The main issue with the presence of Mercury for people is that, unknown to most people; it is highly toxic and in some instances can be fatal. The body is able to accept Mercury through ingestion and skin absorption but by far the most dramatic is the inhalation of its vapor. So when most people were being taught chemistry in schools and were given that fascinating liquid metal to play with, what no-one knew, was in fact vaporizing and releasing a readily absorbed gas which has no smell and cannot even be seen by the naked eye.

Of the Mercury vapor that may be inhaled by an unprotected individual, approximately 80% will be absorbed by the body and despite the human body's ability to excrete absorbed Mercury it does take time. Inhaled Mercury vapor is quickly oxidized to mercurous Mercury in the blood and plasma. It accumulates in body tissues and organs where it is further oxidized and can cause serious neurological problems, including premature blindness, memory loss, loss of balance and bowel movement. Severe chemical poisoning causes death. The half-life of Mercury in the blood, bladder and bowels is typically 7 days although Methylmercury can take up to 50 days to be removed.

The concentrations are much higher in the kidneys and if Mercury is able to pass the blood-brain barrier (which it is more than capable of) into the brain. Typical half-life of mercuric Mercury in the kidneys is 60-90 days with it taking several years to be removed from the brain. Of course, the amount of Mercury absorbed will depend on a number of facts including contaminant levels, temperature etc and will ultimately have detrimental effects on the human body during its absorption period. It is also bioaccumulative, in that additional exposure will only add to the amount in the body to create further problems and this chronic poisoning is possible with low levels repeatedly over a long period of time that will result in the same afflictions. Mercury has already been linked to autism, deformation, mental retardation and death in unborn babies.

Even as recently as August 1996 a well known professor of chemistry at Dartmouth College in the US succumbed to the fatal effects of dimethylmercury poisoning while studying mercury interaction with DNA repair proteins. Unfortunately the professor, a specialist in toxic metals, was poisoned in her lab when only a few drops of the highly toxic dimethylmercury penetrated her latex gloves. Tests later showed that the compound would've percolated her glove and rapidly perfuse through her skin in about 15 seconds. Symptoms were not immediately apparent but when the professor was admitted to hospital five months later, after suffering loss of balance and slurred speech, it was discovered that she had a blood mercury level of 4,000 μg (micrograms)/liter, which is 114 times the toxic threshold (toxic blood level is now reported to be > 35μg/L with a normal range of 1-8μg/L).

There are numerous other documented cases ranging from;

- Klondike Gold Mines – Miners subject to occupational poisoning
- Basra-Iraq, poison grain disaster – Methylmercury treated grain (used to prevent rot) stolen and given to locals, 6,500+ cases resulting in 459 'recorded' deaths

- South Thailand, welding on Mercury contaminated steel pipe – 2 x welders killed when trapped Mercury was released, from previously cleaned steel pipe being modified, as Mercuric Oxide vapor proving fatal within minutes

- Singapore, Cargo ship tank cleaning – 4 x grit blasters sent into an empty tank to blast prior to inspection. Mercury vapor released and collects in the bottom of the tank killing the personnel

- Japan, Minamata Disease – infamous pollution incident in which local people from Minamata Bay were poisoned by industrial effluent, poisoning the fish and passed on through the diet.

- Thailand, skin whitening products - reported in Thailand only last month, the continued use of ammoniated Mercury to whiten the skin. Applied as a paste this is rapidly absorbed through the skin for severe poisoning and can be fatal

- Worldwide, Swine Flu Vaccine – contains Thiomersal which is a Mercury based preservative used to prevent deterioration. Although now banned in children's vaccines are still used in some others. The research on this is still controversial but very compelling.

The list goes on and it is hugely extensive across the globe and as we continue to use Mercury in a myriad of different industrial and household uses, such as thermometers, barometers, float valves, LCD screens, paints, caulks, fertilizers, cosmetics, light bulbs, cars, gold and silver mining, medicine, batteries, dental amalgams, with little or no open education on the subject it will continue to cause us problems. This shouldn't be the case!

Thailand has some of the best waste disposal facilities in the world and while Mercury cannot be destroyed (because it is an element) it can be encapsulated and deemed inert, without ending up in the ground at some landfill. Chemicals and sophisticated methods are available to stabilize Mercury within a process stream whether in production or more so during maintenance or repair works. There is a wide choice of analyzers and detectors available, both portable and fixed, that can help monitor the systems that have this contaminant present and provide a warning for the applicable response to be carried out. PPE has advanced over the years to protect against this and other contaminants, even in a combined toxic environment.

Further information on monitoring, decontamination and waste management is available from the author.

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