
Mercury (Hg)

Mercury is present in coal in trace amounts (approximately 0.1 ppm on average). Much of the mercury in coal is associated with pyrite. Other forms of mercury are organically bound, elemental, and in sulfide and selenide minerals. During combustion the mercury is released into the exhaust gas as elemental mercury vapor, Hg^0 . This vapor may then be oxidized to Hg^{2+} via homogeneous and heterogeneous reactions.

Mercury may be present in the flue gas in several forms. The specific chemical form has a strong impact on the capture of mercury by boiler air pollution control (APC) equipment. The primary homogeneous reaction is that with gas-phase chlorine. As the combustion exhaust gases exit the boiler and cool, thermodynamic equilibrium shifts to favor formation of HgCl_2 vapor. The temperature window where this transformation occurs varies, based upon coal conditions, from about 620°F to 1250°F. At the temperature after the last heat exchanger, normally around 300°F, one would expect all of the mercury to be in the oxidized form if the reactions went to equilibrium. However, gas-phase mercury oxidation is slow and highly dependent upon the amount of chlorine in the flue gas and, in practice, the amount of oxidized mercury in the flue gas can range from a few percent to over 90%. Therefore, the transformation of elemental mercury to oxidized mercury is kinetically limited, i.e., the chemical reactions associated with mercury oxidation do not go to completion.

Heterogeneous (gas-solid, surface catalyzed) mercury oxidation is more complex and depends upon the availability of surfaces having electrophilic groups that attract the electron-rich Hg^0 atom. The heterogeneous reactions occur mostly on fly ash surfaces or boiler surfaces, especially if the fly ash contains high amounts of unburned carbon.

The mercury that is adsorbed onto solid surfaces, such as fly ash or unburned carbon, is the particulate-bound mercury, Hg_p , which can be captured by downstream PM control devices. Hence, fly ash characteristics – especially carbon – as well as coal chlorine content play an important role in mercury speciation and capture.

Other flue gas species – especially SO_3 and H_2O – have also been shown to affect mercury speciation, tending to suppress Hg^0 oxidation to Hg^{2+} . This is due to competition for active sites on the surface of carbon or other flue gas solids. In general, bituminous coals tend to have higher chlorine contents and also tend to produce higher levels of unburned carbon in the fly ash. As a result, the flue gas from the burning of bituminous coals tends to contain higher amounts of Hg^{2+} species while that of subbituminous and lignite coals tends to contain more Hg^0 vapor.

Dry Scrubbing

In dry scrubbing, a sorbent is deposited into the solution or slurry, which is then injected into the duct to dry, prior to reacting. Dry scrubbing is typically used for SO_2 or SO_3 control. Soda ash, sodium sulfite or lime can be used in this type of process. The advantage is the small size and large surface area of the particle generated. The disadvantage of this process is the increased complexity of the system and plugging of nozzles and duct work. These systems typically cost less than wet scrubbers but more than DSI systems.