Reducing emissions of mercury from coal-fired power plants is a vital concern in the United States and around the world. Mercury is a naturally occurring neurotoxin that can be released into the air when coal is burned to generate electricity. There are a variety of mercury emission control technologies in use today, and our understanding and deployment of effective controls is evolving due to the social, political and economic importance of providing clean sources of energy.

The environmental considerations for controlling mercury emissions are paramount, but there are environmental considerations associated with the affect of the emission controls on coal fly ash, a byproduct of the combustion process. When emission controls do not compromise the physical and chemical characteristics of the fly ash they can be put to beneficial use in the cement, concrete and other industries and minimize the diversion of fly ash to landfills. The American Coal Ash Association estimates that approximately 45% of the fly ash generated is put to beneficial use.

Fly ash is used as a cement feedstock or as a supplementary cementitious material (SCM) to make blended cements by the cement industry. In doing so cement manufacturers reduce the generation of greenhouse gas emissions from the manufacture of traditional, portland cement and by a corresponding amount in the manufacture of blended cement. Fly ash is also used by the concrete industry as a supplementary cementitious material (SCM) that imparts long-term durability to our nation’s infrastructure and buildings. The use of fly ash and other SCMs by the concrete industry reduces the consumption of portland cement and the associated greenhouse gas emissions. Where safe and practicable, this use should be maximized because of the greenhouse gas benefits and the associated disposal of fly ash that will not comply with standards for use in cement and concrete.

In 2005, the U.S. Environmental Protection Agency (EPA) issued the Clean Air Mercury Rule (CAMR) to address the need to control mercury emissions. The emission targets specified in the rule will significantly reduce emissions of mercury, but some of the mercury control technologies change the characteristics of fly ash, rendering it incompatible with the engineering requirements for use as an SCM. While CAMR was vacated by the D.C. Circuit Court in 2008, the EPA is reviewing the court’s decisions and it is highly likely that mercury emissions will be regulated in the future. Amongst various regulatory scenarios under discussion at the state and federal level, target levels for mercury capture range from 70 to 90%.

In order to evaluate the kind of mercury emission control necessary to achieve a given standard, the degree of mercury capture already in place or planned at the facility due to the co-benefit of sulfur dioxide and nitrogen oxide emission controls must be considered first.

These co-benefit control technologies can be deployed in different configurations and combinations that result in mercury capture ranging from 20% to 90%. The removal rate is affected by the halogen content of the coal and the level of unburned carbon, among other factors. Srivastava et al. (2006) present a discussion of the effectiveness of mercury capture among different control systems and types of coal. These technologies generally do not affect the suitability of the fly ash as a cement feedstock or an SCM.

To achieve a high degree of mercury removal where co-benefit technology is insufficient, it may be necessary to deploy a mercury-specific control technology. To preserve the concrete-compatibility of the ash, utility managers and other stakeholders have a number of options. The following is a brief description of mercury control technologies and the resulting ash impacts. These technologies are either currently available or in development. Utility managers, working with their state regulators and other stakeholders, should make mercury control technology decisions based on the circumstances of the particular facility. Any references in this discussion to specific entities or products are not intended to imply any federal endorsement. The EPA does not endorse any particular product, service or enterprise.

**Injected Mercury Sorbents**

Powdered Activated Carbon

The Technology: Standard powdered activated carbon (PAC) is usually injected upstream of the fly ash collection system (electrostatic precipitator or baghouse), where mercury in the flue gas absorbs onto the carbon particles. Therefore, standard PAC is most effective with low-sulfur, bituminous coals; lower rank coals tend to be too
low in chlorine (Srivastava et al. 2006). The thief process, developed by the Department of Energy’s National Energy Technology Laboratory (NETL) is similar, but the carbon sorbent used is less expensive.

Ash Impacts and Other Issues: Standard PAC injection often raises the levels of carbon in fly ash beyond acceptable levels for use as SCM in concrete, as does the thief process. If the use of fly ash as a SCM is not an important consideration, the use of PAC to capture mercury is an option. However, unless the PAC system can be deployed after particulate removal, which can pose engineering difficulties due to size and other considerations, the PAC remains in the fly ash, usually resulting in fly ash that cannot be used as an SCM. The PAC interferes with air-entraining agents—compounds added to the concrete mix to capture tiny air bubbles—which are necessarily employed in many concrete applications.

Chemically Treated PAC

The Technology: The use of a PAC with chlorine or other halogen added improves the effectiveness of PAC for mercury capture from subbituminous coal and lignite (Srivastava et al. 2006). Four companies involved in developing these technologies are Alstom, Sorbent Technologies, Norit, and Calgon Carbon Corporation.

Ash Impacts and Other Issues: The addition of halogen to the PAC does not reduce the amount of carbon in the fly ash; therefore this technology is generally incompatible with the use of fly ash as SCM in concrete.

TOXECON™

The Technology: This system, developed by EPRI, employs PAC technology but is designed to preserve the quality of the fly ash and is compatible with an installed electrostatic precipitator (ESP). A small baghouse is added downstream of the ESP and the PAC is injected between the baghouse and the ESP. TOXECON™ can be effective at removing mercury across coal ranks (Srivastava et al. 2006). TOXECON II™ is a less-expensive adaptation of the TOXECON™ technology, where the sorbent is injected between the last set of ESP plates and the ash is segregated, leaving the bulk of the ash without additional carbon contamination.

Ash Impacts and Other Issues: Since the fly ash is removed from the flue stream upstream of the injection of the PAC, nearly all the fly ash collected remains a suitable candidate for use as a SCM in concrete. The disadvantage is that the system is expensive to install, relative to the use of PAC alone, although TOXECON II™ has the potential to mitigate costs significantly.

Silica-Based Sorbents

The Technology: Silica-based sorbents are being introduced by Amended Silicates, LLC. The sorbents are injected into the flue gas in much the same manner as PAC, but contain no carbon. Tests of a silica-based sorbent at an operating power plant have shown mercury capture rates above 70% (IIT 2005).

Ash Impacts and Other Issues: Silica-based sorbents do not add carbon to fly ash, therefore, the suitability of fly ash as an SCM in concrete is unaffected by the use of silica sorbents.

Other Sorbent Systems

Metal Oxidation Catalysts

The Technology: Mercury oxidation catalysts using metals such as gold, palladium and iridium appear to be promising systems for mercury removal. Iridium and iridium alloys are particularly corrosion-resistant and have high temperature resistance. Investigations of these metal catalysts have been at the bench-scale to date, but have shown good results in mercury reduction (Granite 2004).

Ash Impacts and Other Issues: Metal oxidation catalysts have no effect on the suitability of fly ash for use as an SCM in concrete. However, this technology assumes the existence of a wet scrubber (FGD) downstream of the ESP and catalyst and is likely to be more expensive than PAC (exclusive of the loss of ash sales revenue and cost of disposal).

MerCAP™ and MercScreen™

The Technologies: MerCAP™ and MercScreen™ are new technologies that are being developed by EPRI. MerCAP™ is a static adsorption system that employs fixed plates coated with a noble metal (usually gold). EPRI recently conceived the MercScreen™ concept, a variant of MerCAP that uses a continuously moving, sorbent-coated band-like screen. This process is still in early development.

Ash Impacts and Other Issues: As either MerCAP™ or MercScreen™ would be located downstream of the particulate control, neither would have an impact on fly ash use viability. This is one of their primary benefits and reason for development.

Fuel Cleaning or Upgrading

The Technology: Fuel cleaning and upgrading are pre-combustion treatments of coal to remove mercury and other contaminants. A number of patented processes exist, including the Western Research Institute and K-Fuel processes for Powder River Basin and lignite coals. In addition, currently available deep cleaning processes are being investigated as a means of reducing the mercury content of eastern bituminous coals (in addition to providing other air pollution benefits).

Ash Impacts and Other Issues: This technology does not add carbon to the flue stream. However, limited research has been undertaken on the engineering properties of the resulting ash; therefore, the ready usability of this ash, while expected to be as good as current ash from those fuels, is not known with certainty.

Emerging Technologies

The removal of mercury from coal power plant emissions is an area of intense ongoing research. Some technologies that show promise for mercury removal but are not yet commercially viable include:

- Several sorbent variations using non-carbon materials, specially treated carbon-based sorbents that don’t impact ash use, or highly effective carbon-based sorbents (thereby keeping the resulting carbon-in-ash content low enough to be acceptable for use as a partial replacement for portland cement in concrete).
- Advanced filter technologies that enable the use of a compact second particulate control into which carbon could be injected without affecting the primary particulate capture system and, hence, the ash.
- A number of integrated environmental controls, such as Airborne, ECO, possibly EnviSrScrub™, all of which would follow the particulate control and not impact the fly ash.
- Additives or electrochemical methods (e.g., Photochemical oxidation [PCO™] or PEESP) to enhance capture by SO2 scrubbers (so that additional upstream capture using carbon sorbents is not needed). PCO was developed by DOE-
NETL (Pavlish 2007) and licensed to Powerspan; PEESP is being developed by EPRI and Siemens.

Information about these and other technologies is available from:
- The Energy and Environmental Research Center at the University of North Dakota, http://www.undeerc.org
- ADA Environmental Solutions, http://www.adaes.com/mercury/overview/

In promoting further discussion and development of these technologies, EPA has listed mercury control technologies on the Coal Combustion Product Partnership (C2P2) Web site at http://www.epa.gov/c2p2. On a trial basis, we invite submissions of additional information to WasteWise@icf.com which we will post on the Web site as appropriate. This is in keeping with the practice of providing information concerning products that have been designated in the Comprehensive Procurement Guidelines for preferential purchase by the federal government. The Comprehensive Procurement Guideline for the purchase of concrete with cement made from coal fly ash was issued in 1983.

References


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