Pilot Testing of WRI's Novel Mercury Control Technology by Pre-Combustion Thermal Treatment of Coal

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1.0 Objectives

Under the proposed program in DoE's Phase III of Mercury Control Technology testing, WRI will conduct bench- and pilot-scale coal treatment and combustion testing to evaluate the effectiveness of WRI's patented (Patent No. 5,403,365) novel thermal pretreatment process to achieve >50% mercury removal, and at costs of <$30,000/lb of Hg removed. The objectives of the project are structured in three phases: Phase 0 (Task 0) - project planning; Phase I (Tasks 1-5) - coal selection and characterization, bench-and PDU-scale WRI process testing and pilot-scale PC combustion testing; and Phase III - design of an integrated boiler commercial configuration, its impacts on the boiler performance and the economics of the technology related to market applications.

A number of utilities as well as the Electric Power Research Institute and North Dakota Industrial Commission have sponsored the project with about one-third of the project funding. The project is planned to be executed over a 30-month period in two budget periods – Dec. 18, 2006 to Dec. 17, 2007 and Dec. 18, 2007 to Jun. 17, 2009.

2.0 Scope of Work

WRI has identified issues during the prior work on the pre-combustion process and the proposed scope of work combines these technical issues with the overall project objectives and involves the following key activities. The results of the proposed plan will define the commercial viability of the WRI process.

- Validate a range of PRB and lignite coals that can be treated by the process through bench-and pilot-scale testing (WRI/Etaa)

- Validate high temperature sorbents for mercury removal (WRI/GCEE)
- Validate the earlier combustion results with a wider range of treated coals (WRI/EERC)
- Integration of the technology at power plants for PRB and lignite coals (WRI/Foster Wheeler/Etaa)
- Assess the economics of the WRI pre-combustion thermal treatment process (WRI/Washington Group/Etaa)

3.0 WRI MERCURY REMOVAL PROCESS

The WRI process is based on a two-stage thermal pretreatment of the raw coal to remove both the moisture and mercury. In this process, the coal is heated to remove the moisture and then heated to a higher temperature in a separate zone to evolve the mercury. A conceptual diagram of the process is shown as Figure 3.1.

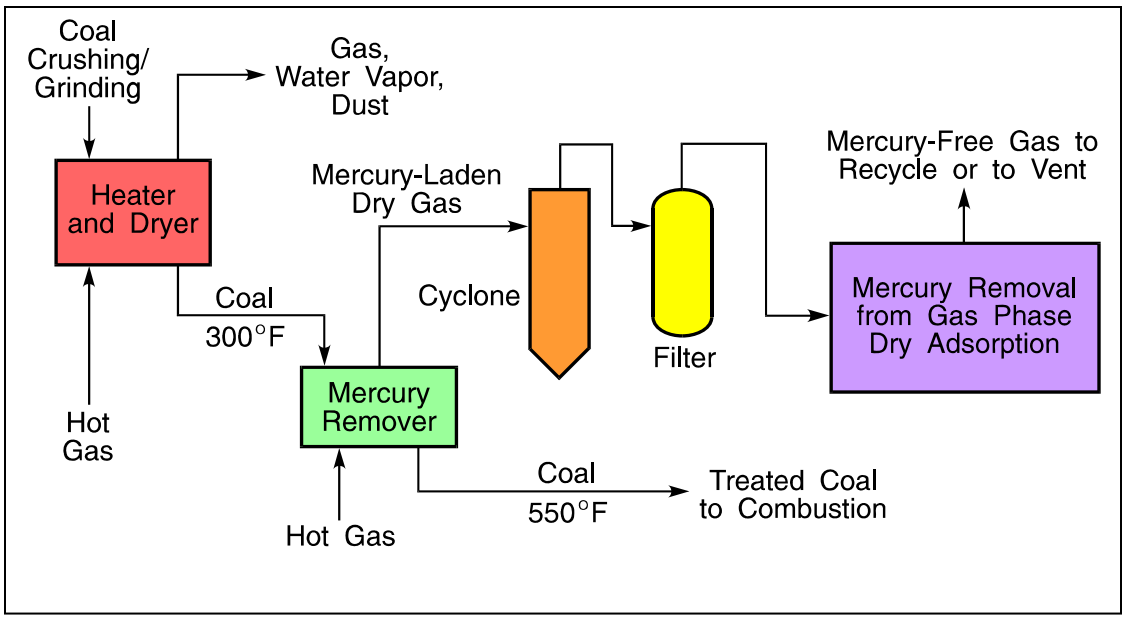

Fig. 3.1 Process flow diagram for WRI's mercury removal technology

Raw coal, crushed to a suitable size enters the moisture removal zone where it is heated to a temperature not exceeding 300°F. In this zone the free water and most of the more tightly bound water is vaporized and removed from the coal in a sweep gas. The coal is then transferred to the

mercury removal zone where it is heated to a temperature of approximately 550°F. In this zone, 75-80% of the mercury in PRB and lignite coals is volatilized and removed from the zone by an inert sweep gas. The coal is then ready for additional size reduction before combustion or gasification. The sweep gas stream, containing the evolved mercury, passes into the mercury removal equipment and the mercury is captured. For the first stage of heating, it is proposed to use flue gas, to maximize the regenerative efficiency of the boiler flue gas heat. The quantity of flue gas depends upon the moisture content of the coal and the temperature of the flue gas. A major feature of the WRI process is the fact that the moisture and mercury can be evolved separately (Fig. 3.2). The two-stage approach results in a water/moisture phase containing no mercury and a mercury-containing sweep gas with very low moisture.

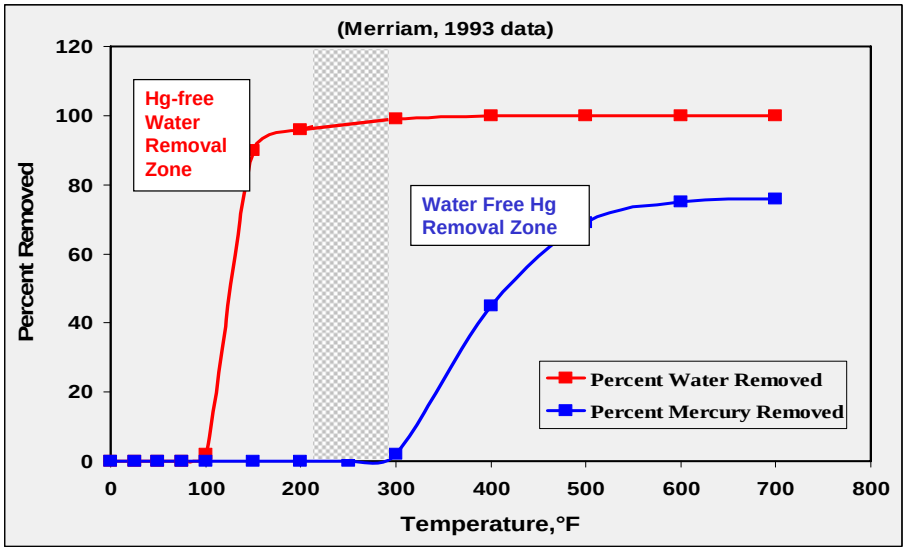

Fig. 3.2 Evolution of moisture and mercury in the WRI mercury removal technology

4.0 Progress To-date

4.1 Coal Characterization:

Seven (of the eight) coals planned for the project have been identified and procured with DOE and sponsors participation. These include three PRB subbituminous coals and four lignites. Coals have been characterized for the chemical constituents and physical properties. Mercury and moisture contents varied between 0.023 and 0.266 ppmw(dry) and 26.24 and 36.55% respectively.

4.2 Bench-Scale Testing

Bench scale testing has been performed on seven coals using the dedicated test rig built at the WRI. Typical test results are shown in Figures 4.2.1 and 4.2.2. Initial findings include:

- Residence time is an important parameter for mercury release in some coals (Fig. 4.2.1). It is shown that an increase of 8 min of residence time results in almost 80% of mercury released from coal.
- The percentage of mercury released from coals varies from 40 to 80% (Fig. 4.2.2)

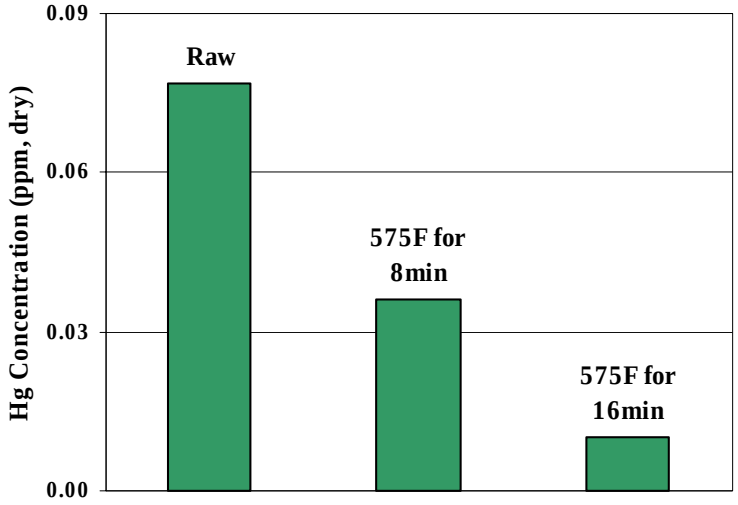

Fig. 4.2.1 Impact of Residence Time on Mercury Release

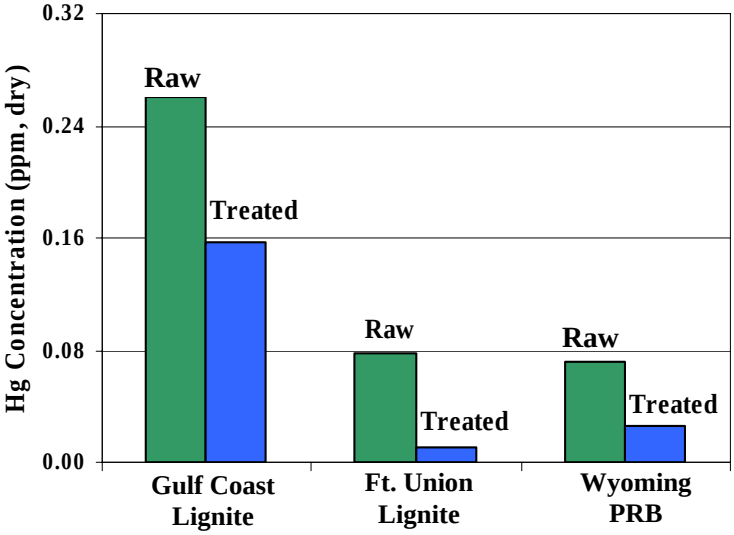

Fig. 4.2.2 Mercury Release from Three Coals (Bench-scale)

4.3 Sorbent Testing

A well instrumented sorbent test unit to evaluate high temperature (typically 550°F) sorbent has been designed and built to evaluate potentially high temperature sorbents in a fixed bed mode (Fig. 4.3.1.). Key instruments include a mercury generator (PSA) and a continuous mercury monitor (Tekran M 2600). Four sorbents-Norit activated carbon as a baseline, one high temperature activated carbon and two metal-based-sorbents are undergoing tests.

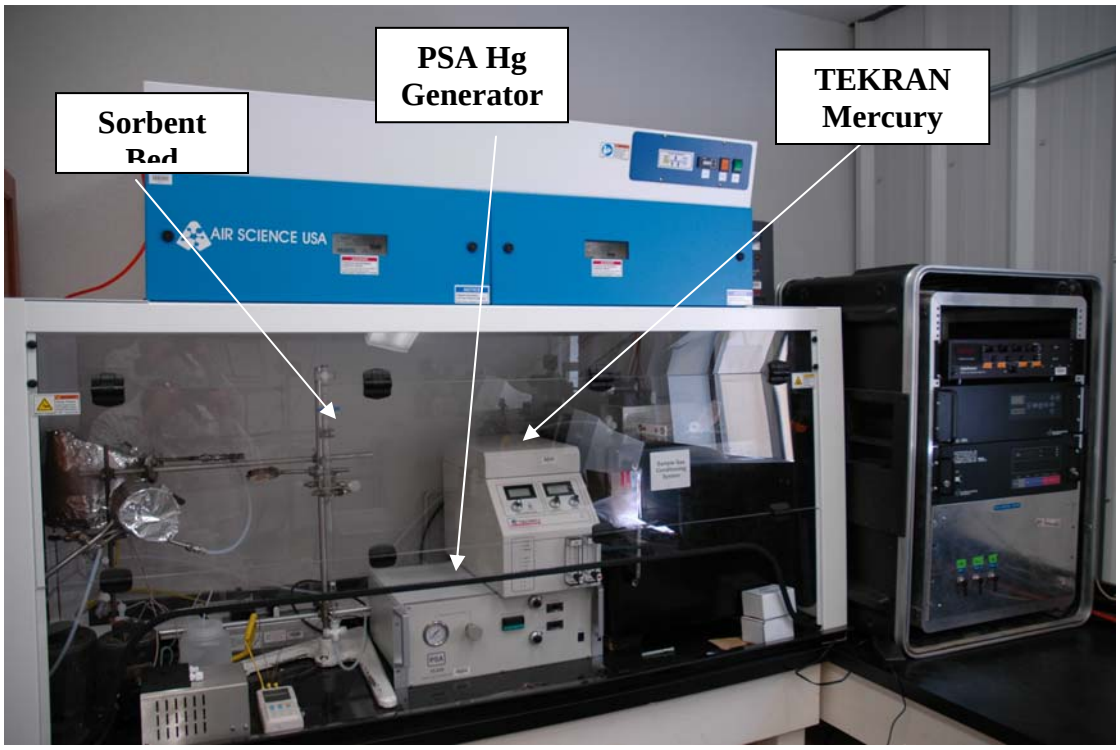

Fig.4.3.1. Photograph of the sorbent test unit assembly

Initial results indicate that high temperature sorbents will be available to remove mercury from the process recycle sweep gas.

4.4 Pilot Testing:

Pilot testing is being conducted to assess and scale-up the results from the bench-scale tests. The pilot unit at WRI is designed to operate up to 100 lb/hr and is being upgraded to evaluate alternative mercury removal configurations. The pilot unit will examine two different mercury removal configurations (1) vibratory fluid bed and (2) proprietary vertical reactor. Three coals will be tested. The pilot unit contains each of the components of the commercial installation,

with the exception of an electrical heater which is used for process heat instead of the use of waste and process heat from the power plant. The pilot unit is instrumented for temperature and pressure across the drying and mercury removal steps. All equipment and parts are on-site and construction of the modifications to the pilot plant is in progress. A 3D view of the facility is shown in Fig. 4.4.1.

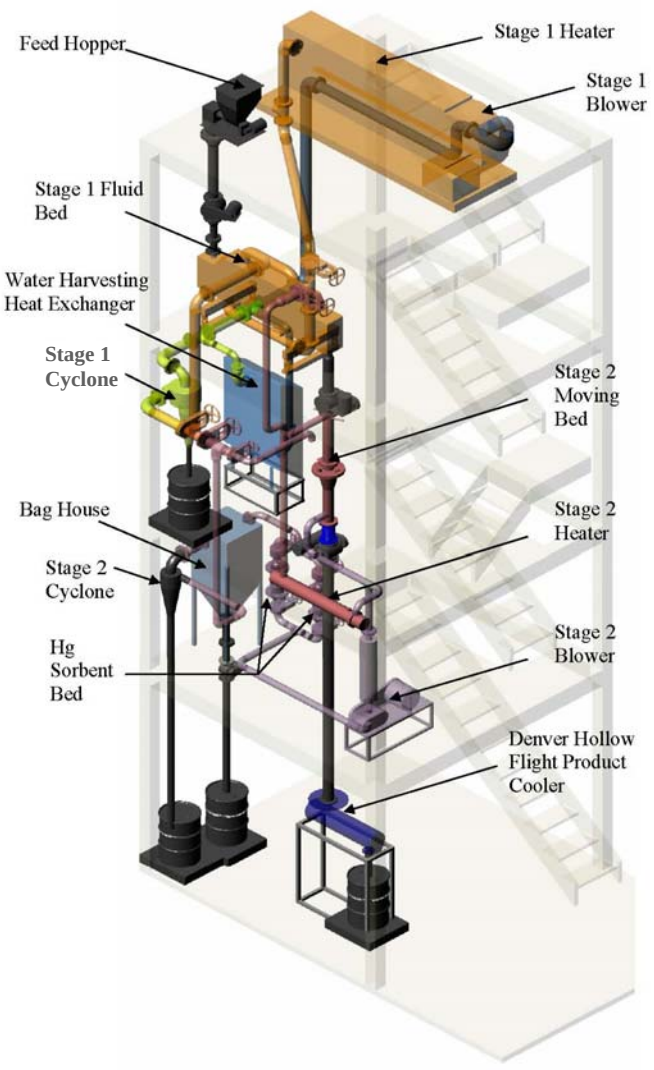

Fig. 4.4.1 Process Development Unit at WRI

5.0 Acknowledgement

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