ASSESSMENT OF LOW COST NOVEL SORBENTS FOR COAL-FIRED POWER PLANT MERCURY CONTROL

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An assessment of the viability of lower cost alternatives to commercially available activated carbon was conducted at a pilot-scale where the goal was to identify and test sorbents capable of removing at least 90% of vapor-phase mercury from coal-fired utility flue gas at costs less than 75% of currently available commercial sorbents.

The prime contractor was Apogee Scientific, Inc.; host facilities and cost-share participants included We Energies, Midwest Generation, Electric Power Research Institute (EPRI), Illinois State Geological Survey (ISGS), Illinois Corn Marketing Board, and Williams Bio Energy; team members included URS Group, EPRI, ISGS, and ADA-ES. Numerous vendors provided sorbents at no cost to this project.

Three coal-fired power plants were selected for field testing of the novel sorbents: a generating station firing a Powder River Basin (PRB) sub-bituminous coal, a second plant firing a low sulfur bituminous coal/petcoke blend, and a third plant firing a PRB coal. Five sorbents were tested with a flue gas slipstream into the EPRI-provided pollution control test system configured with residence tubes and a COHPAC baghouse at the first PRB site; 17 sorbents were tested at the bituminous coal/petcoke site; and 19 sorbents were evaluated at the second PRB site. The baseline sorbent was Norit Americas' FGD lignite-based activated carbon and was evaluated at all three sites.

The best performing sorbents were carbon-based (i.e. corn-char, bamboo, tire-derived, and carbon soot) as demonstrated at the three coal-fired locations with mercury removals ranging from 83% to 99% at an injection rate of 2.0 lb/Mmacf. With the information presented on the two coal types, there is a wide range of sorbents that could be made available to satisfy utilities that require 30% to 70% mercury removal when using a similar particulate control scenario.

The project cost was $550,654 from DOE and $364,286 from cost-share participants. The final cost share was $134,286 greater than the original contract amount of $230,000.

Evaluation Methodology

Evaluating sorbent injection for mercury control began with a series of laboratory and field tests designed to evaluate mercury removal in flue gas specific to the sites tested. To be considered for laboratory evaluation during this program, the sorbent manufacturer was required to provide evidence that the cost for removing mercury (per pound of mercury removed) will be at least 25% less that that of Norit America FGD. This cost includes not only the cost for producing the carbon but transportation, handling, feeding, and waste handling costs that may differ from FGD. In addition, sufficient quantities of the sorbent would need to be available to supply at least 100,000 tons per year to the utility market by 2010.

Sorbents were screened by measuring their capacity in the laboratory using simulated low-sulfur eastern bituminous or PRB flue gas prior to field-testing in the actual host flue gas. The purpose of these laboratory tests was to evaluate a number of sorbents at conditions similar to those expected at Midwest Generation's Powerton Station (27 sorbents) and We Energies' Valley Power Plant (VAPP) (47 sorbents). The test results were used to determine the most appropriate sorbents for the field evaluations. A control sample, FGD carbon, was used as the benchmark sorbent for this program.

Following laboratory testing, small-scale fixed-bed screening tests on selected sorbents were performed at Powerton (8 sorbents) and VAPP (17 sorbents) using EPRI's mini sorbent test system. The results of these tests were used to determine which samples to test in a series of small-scale slipstream injection tests using EPRI's PoCT system. For VAPP, some mercury sorbents were later added to the slipstream screening process without going through the laboratory or field fixed-bed screening because of more recent developments in sorbent technology since the start of the program.

During slipstream injection evaluations, two particulate-control configurations were tested to assess mercury removal using sorbent injection upstream of a COHPAC baghouse and upstream of an ESP. A COHPAC module designed for sorbent injection is also called TOXECON. In the TOXECON configuration three sets of tests were conducted at both VAPP and Powerton. Sorbent evaluations were as follows:

1. Sorbent Screening. Each available sorbent was injected for about 20 minutes at Powerton (300°F) and 120 minutes at VAPP (315°F) utilizing a continuous injection.
2. Parametric Evaluations. The two most-promising sorbents from screening and economic criteria considerations were tested at various continuous injection rates and two gas temperatures. Each test condition was held constant for approximately 1.5 hours at Powerton and 4 hours at VAPP.

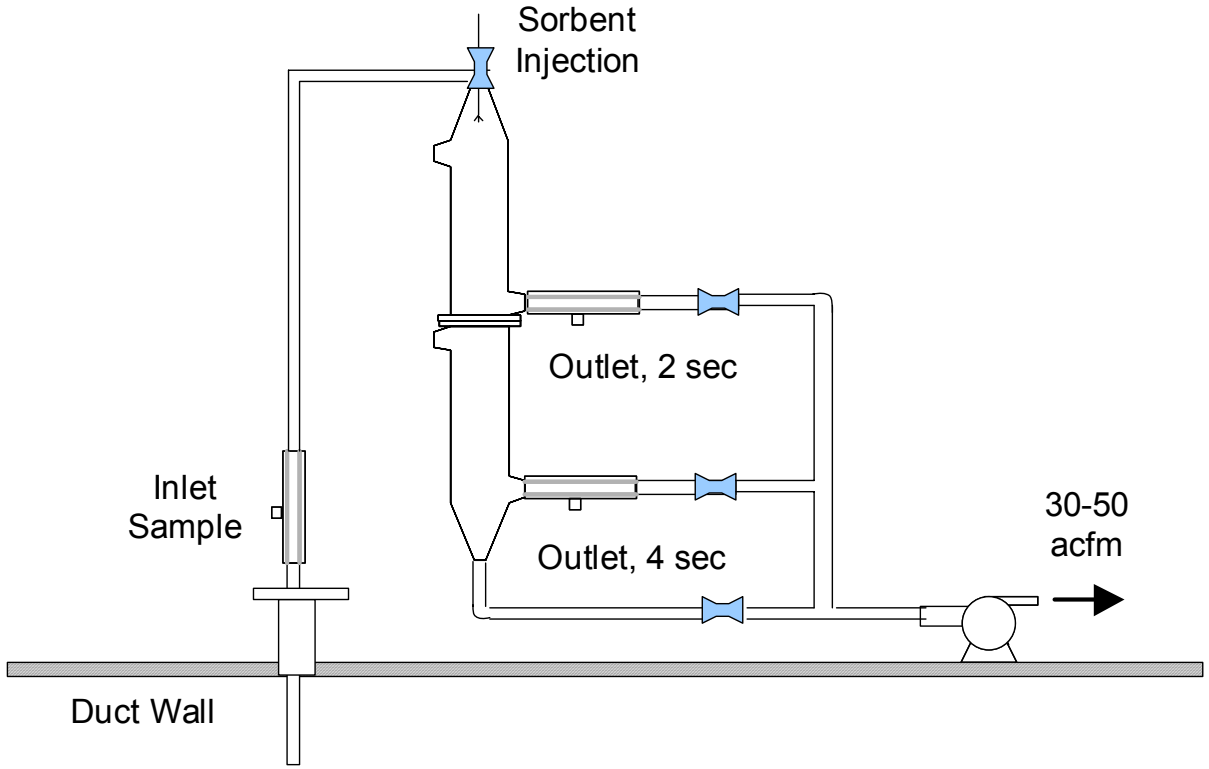
3. Long-term Evaluations. The two most-promising sorbents were tested continuously for 8-12 hours at Powerton and 48 hours at VAPP. The collected solids from the baghouse hoppers were retained for by-product characterization evaluations.

Sorbent injection screening at We Energies' Pleasant Prairie Power Plant (P4) was conducted at a single batch injection rate (equivalent to 1 lb/Mmacf for 1 hour) and a gas temperature (300^{o}F) using the PoCT system configured as a COHPAC baghouse. The batch injection rate was equivalent to 1.09 grams of sorbent batch injected into the system at two equal quantities (0.545 grams) four minutes apart. Parametric evaluations also utilized batch injections at various injection rates and two gas temperatures.

In the residence chamber configuration (performed at VAPP and Powerton), two selected novel sorbents and FGD were parametrically tested for 60-90 minutes each, with the variables being gas temperature, injection rate, and residence time (2 and 4 seconds).

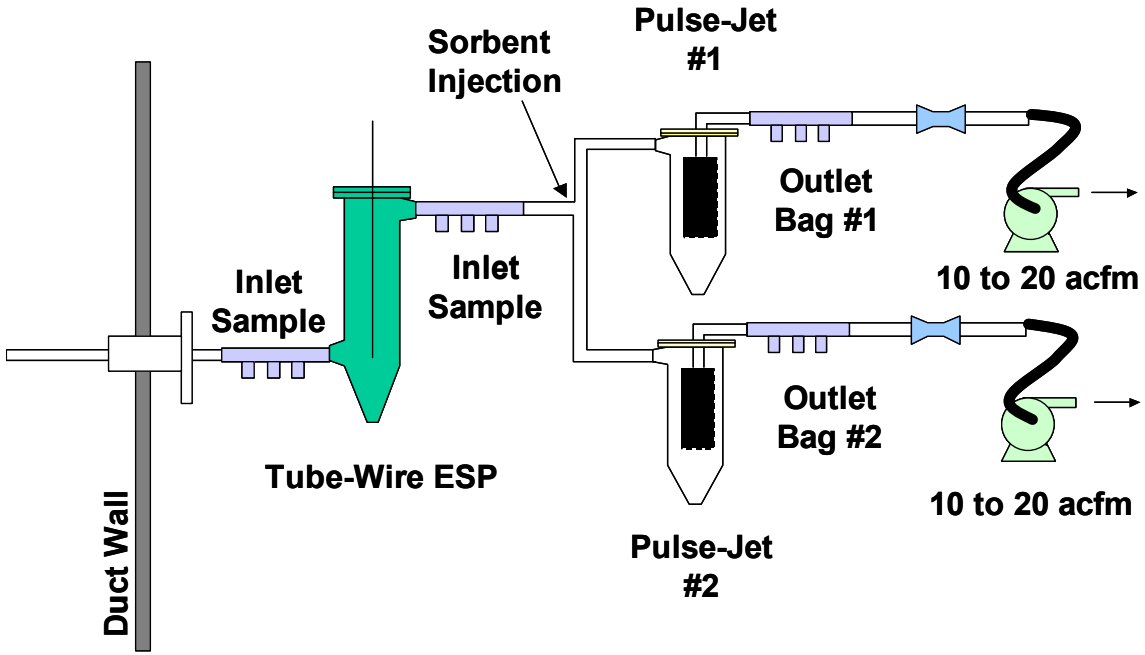
Slipstream Injection Equipment

The PoCT system is comprised of several small modules that can be configured in series or interchanged as required by the test progam. The gas extraction assembly uses a temperature controlled probe, flow meter, flow control valve, and several induced draft fans. The extraction probe is a 0.75 to 1.5-inch diameter stainless steel pipe, depending upon the flowrate for the configuration. The length of the probe is determined following a velocity traverse of the duct so that the gas extraction location is at the duct's average gas velocity. After extracting a slipstream of gas from the duct, the gas passes through a QSIS™ filter where a particulate-free sample can be obtained for vapor-phase mercury analysis. The gas then flows through the particulate control module(s), another QSIS filter, through a venturi to measure flow, and an automatic flow control valve. The gas flow is controlled from 10 to 50 acfm depending on the configuration and test parameters.

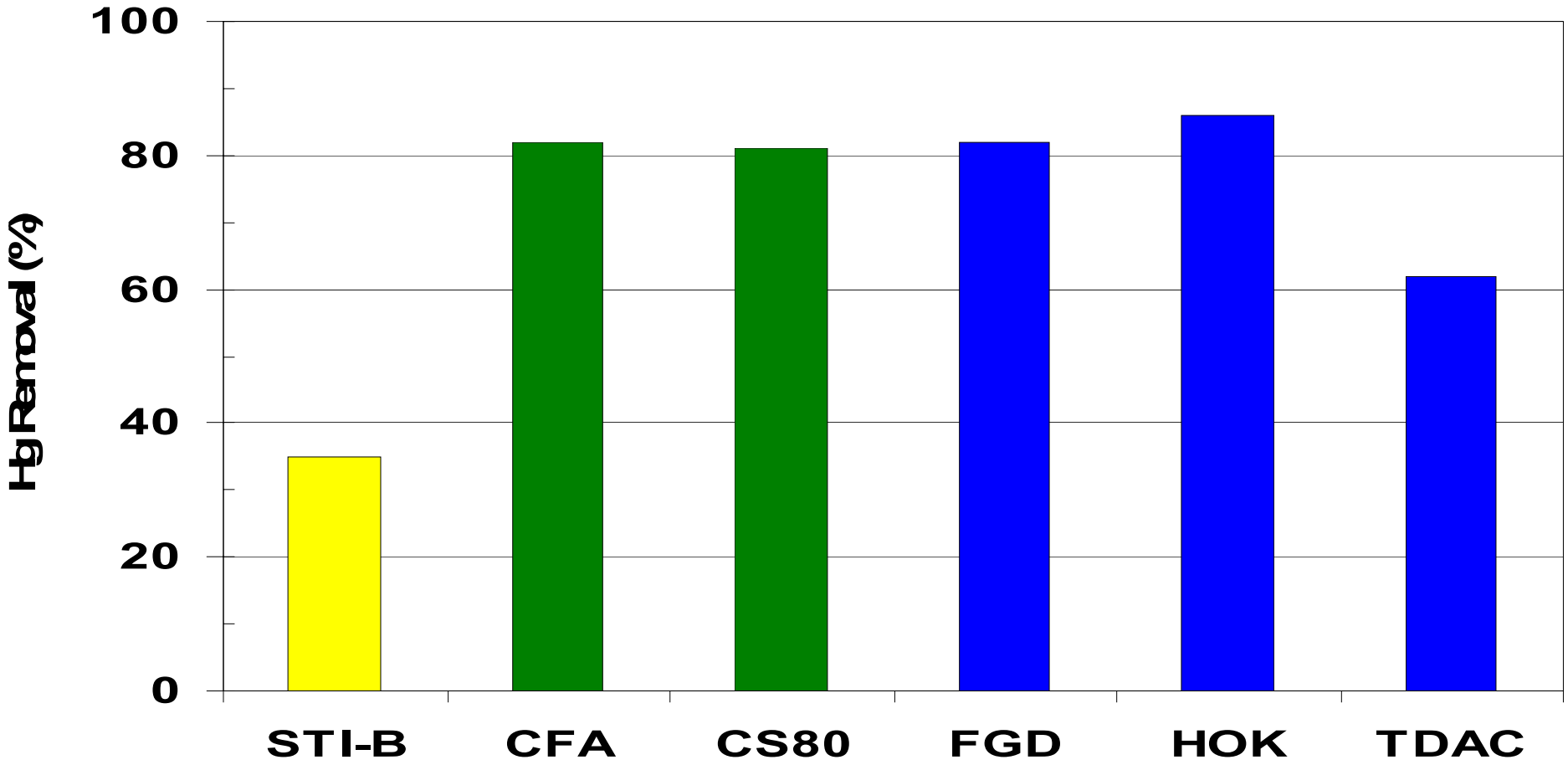


EPRI's PoCT Residence Time Chamber

During COHPAC testing, two pulse-jet modules were installed in parallel downstream of a tube-wire ESP to assess the differences in sorbent performance with different bag materials. A COHPAC module designed for sorbent injection is also called TOXECON. Sorbent was injected upstream of the pulse-jet baghouse module and collected on the bag. The filter bags were 24 inches long and had a flat width of 7.562 inches. Bag cleaning was initiated manually during testing and was performed off-line. A sketch of the PoCT TOXECON configuration is shown below. As shown, the PoCT pulse-jet module is a top-entry design, which minimizes particulate fall-out into the hopper that often is a concern in small-scale systems.



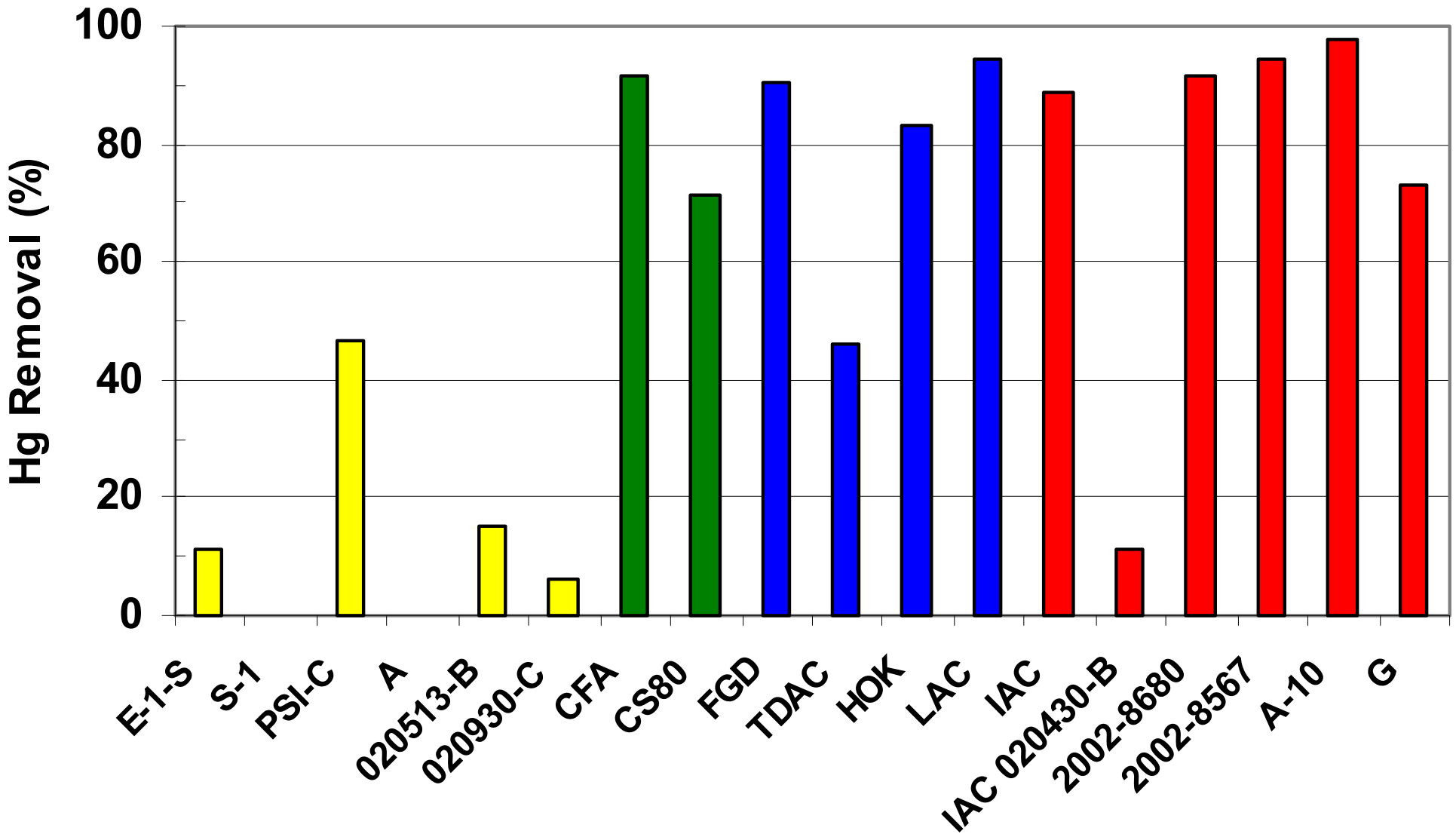
EPRI's PoCT configured for TOXECON evaluations



SORBENTS EVALUATED AT MIDWEST GENERATION'S POWERTON STATION

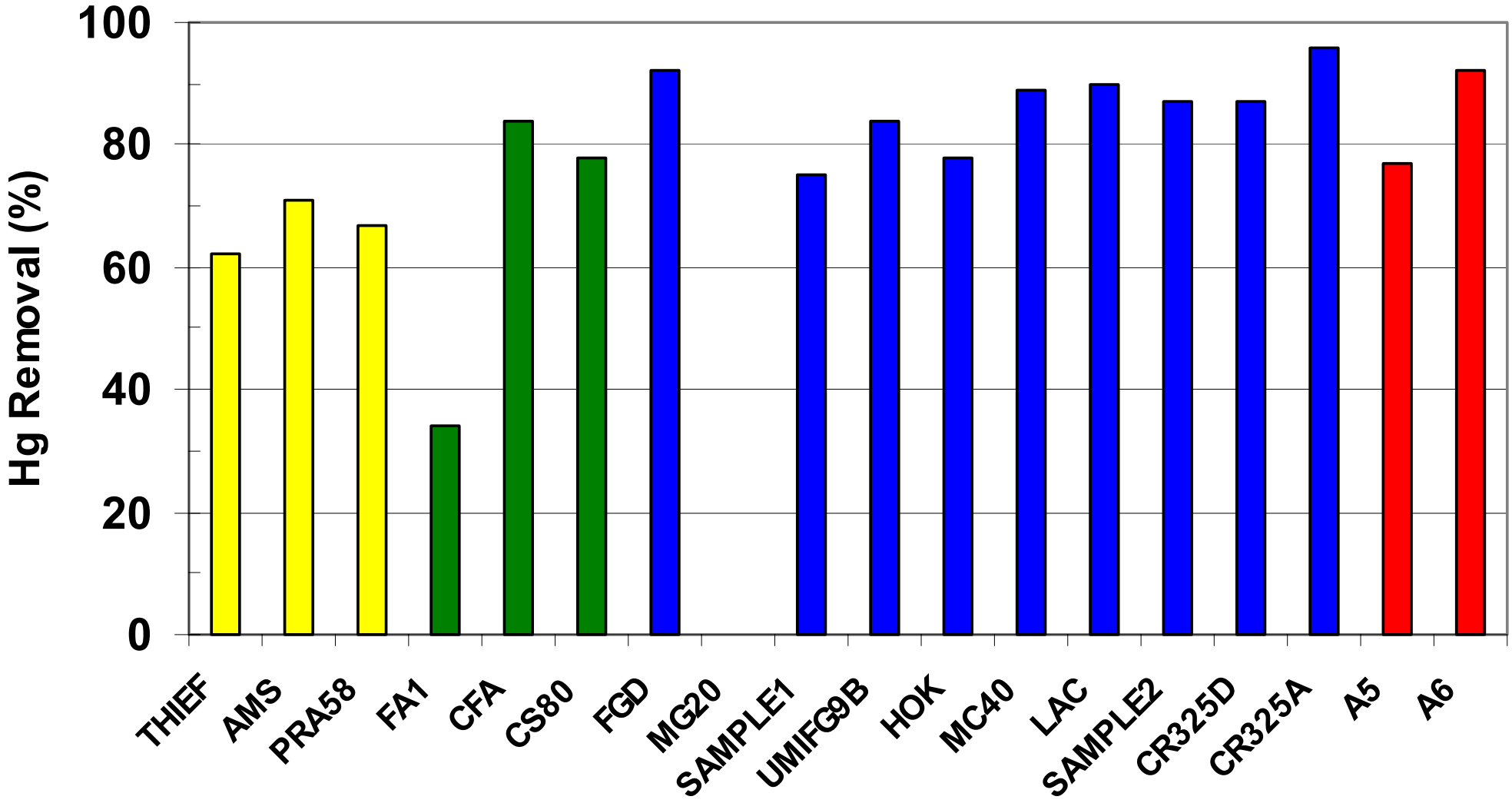
Continuous Injection Concentration of 1.5 lb/Mmacf at 300ºF

The yellow bars indicate sorbents that are not carbon-based, green bars indicate sorbents that are carbon-based but no activation, blue bars indicate carbon-based sorbents with activation, and red bars indicated carbon-based sorbents with additional treatments.



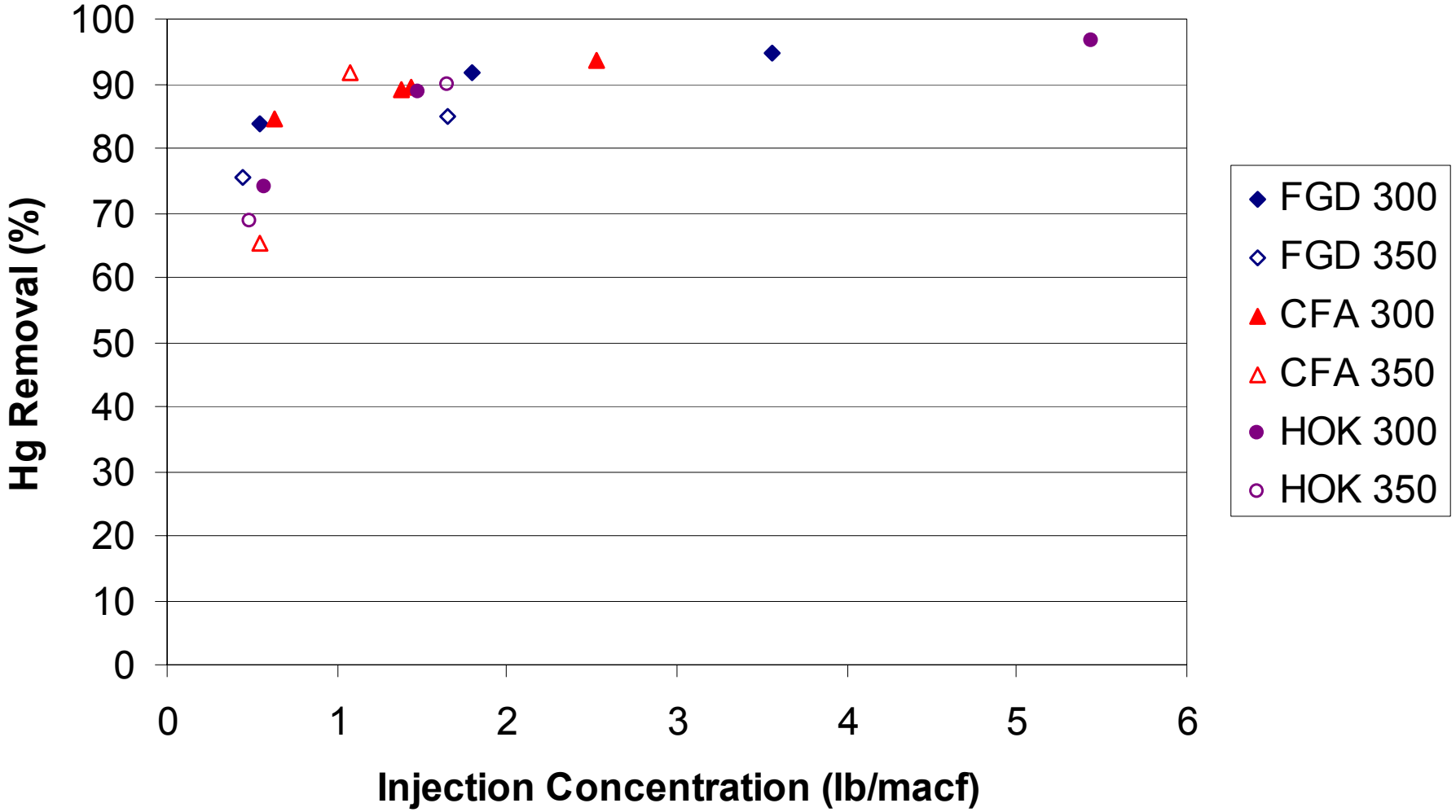
SORBENTS EVALUATED AT WE ENERGIES' VALLEY POWER PLANT

Continuous Injection Concentration of 2.0 lb/Mmacf at 315ºF

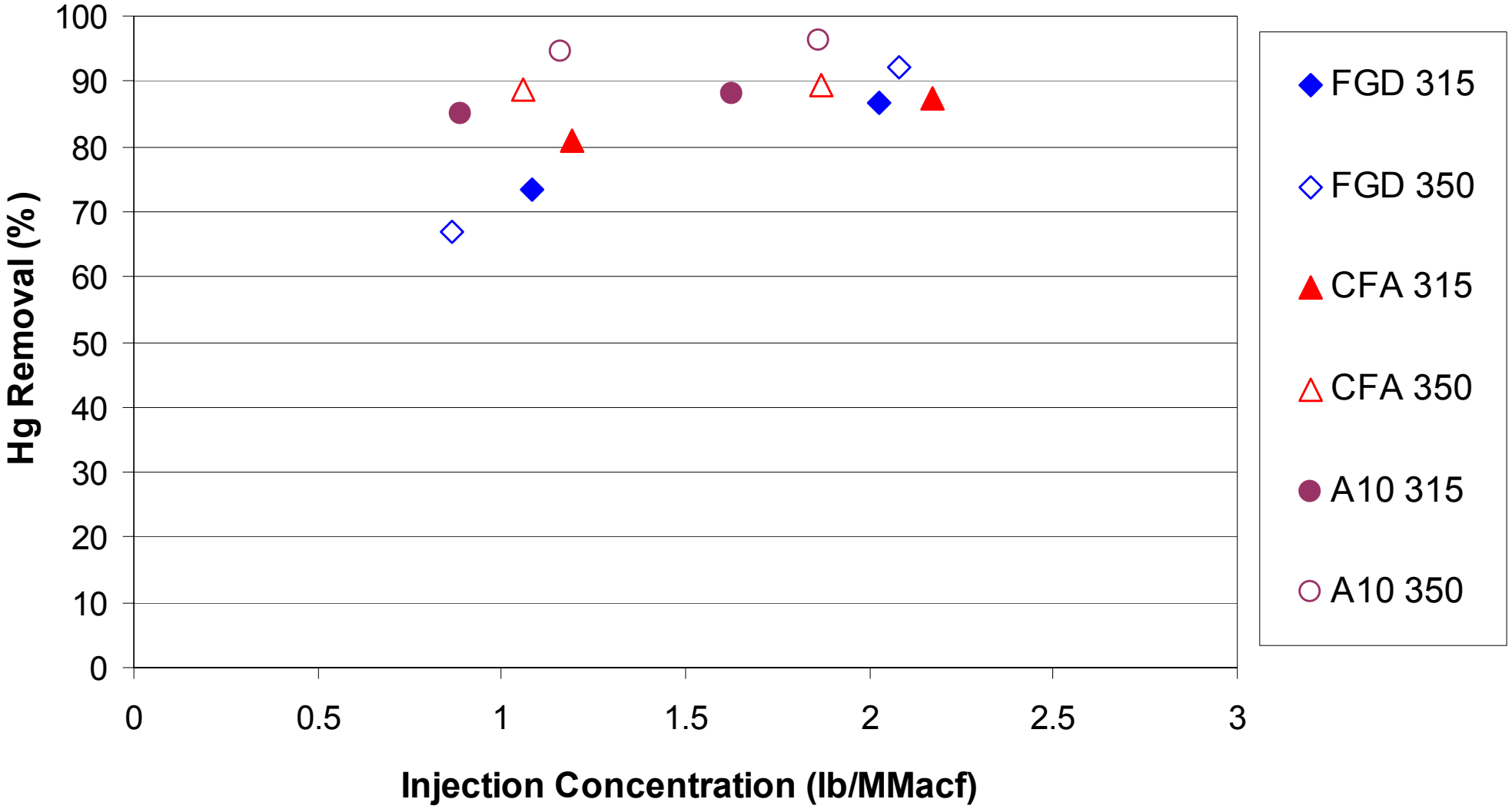


SORBENTS EVALUATED AT WE ENERGIES' PLEASANT PRAIRIE POWER PLT

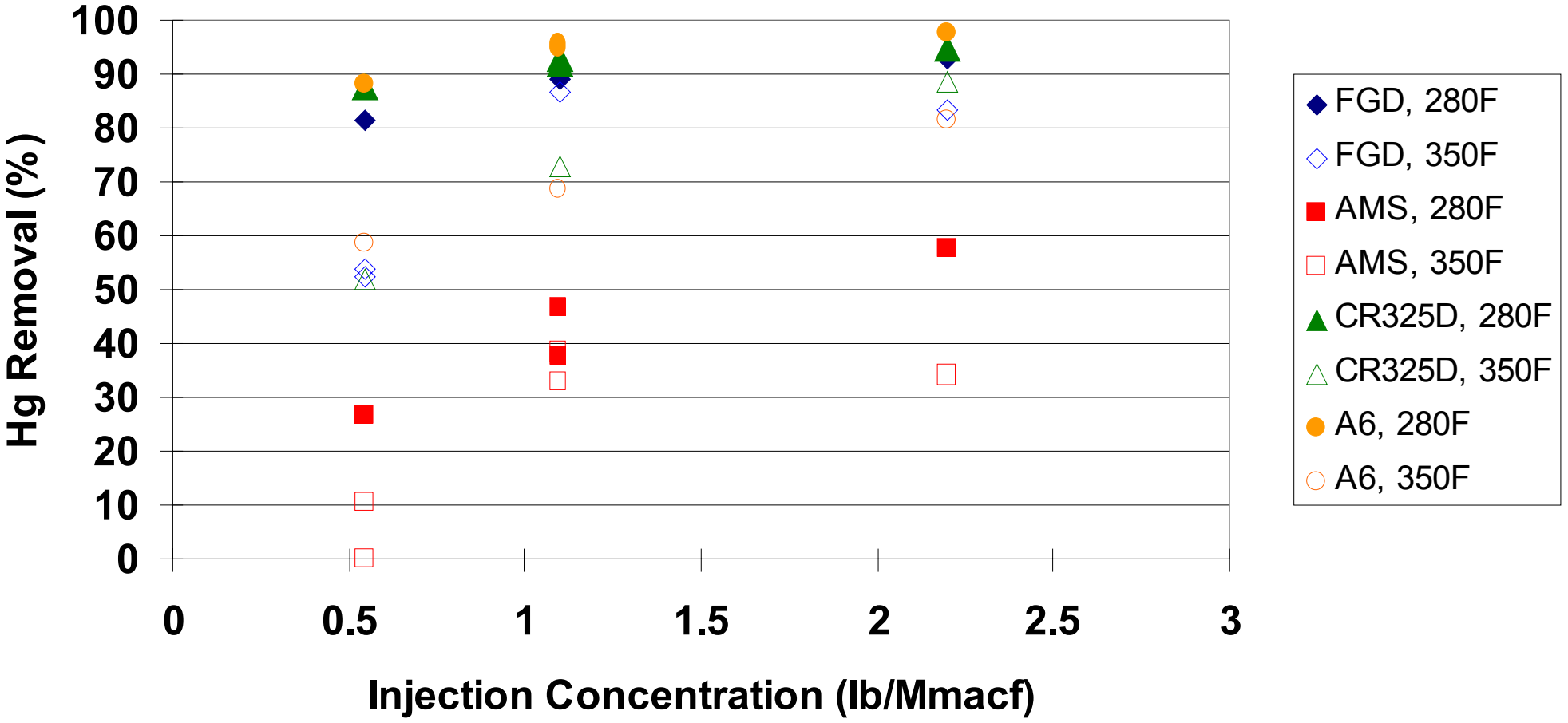
Batch Injection Concentration Equivalent to 1 lb/Mmacf for 1 Hour at 300ºF



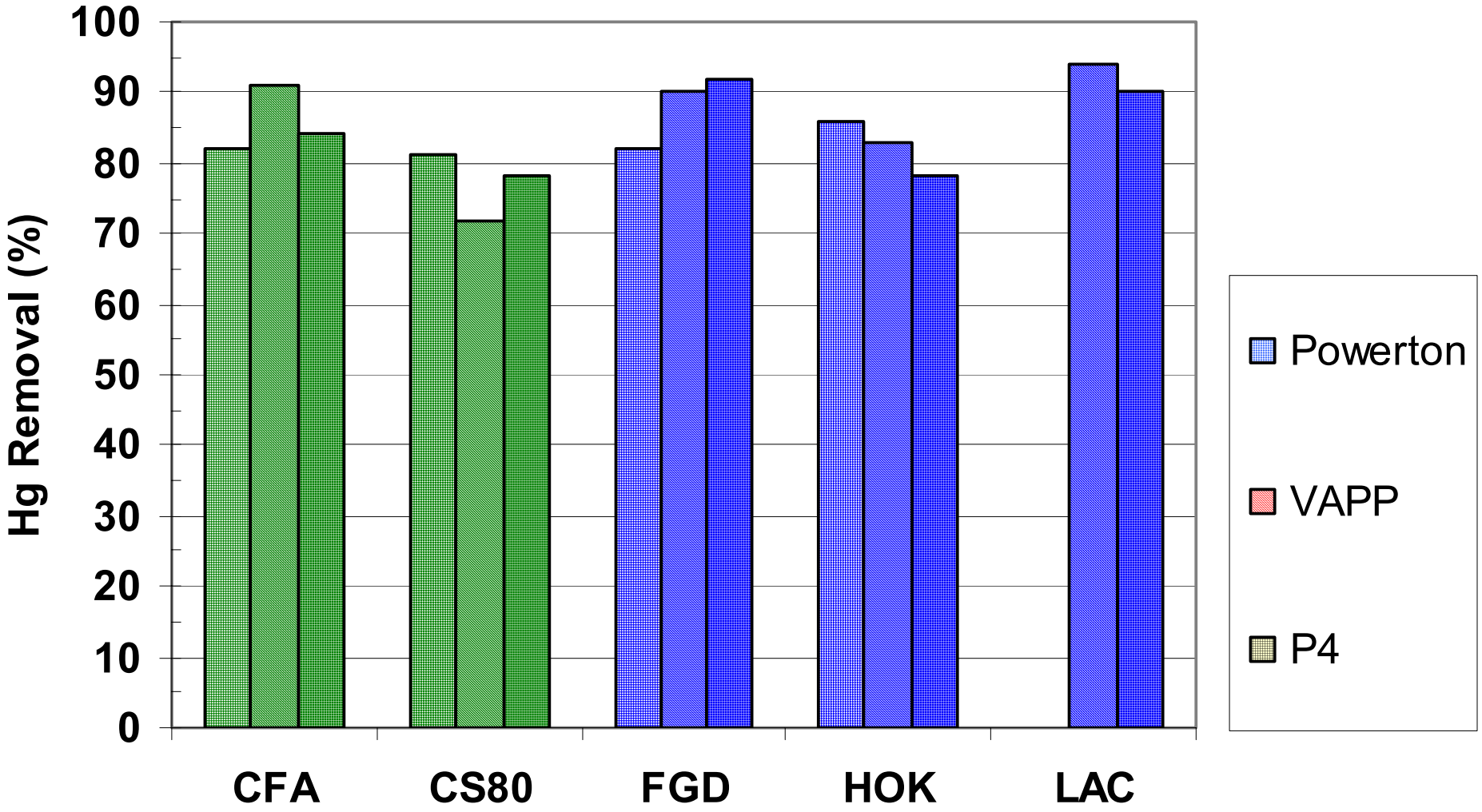
Sorbent Parametric Tests at Midwest Generation's Powerton Station



Sorbent Parametric Tests at We Energies' Valley Power Plant



Sorbent Parametric Tests at We Energies' Pleasant Prairie Power Plant



SELECTED SORBENTS EVALUATED AT MULTIPLE SITES