AEL ENVIRO

Solutions To Reverse Global Warming

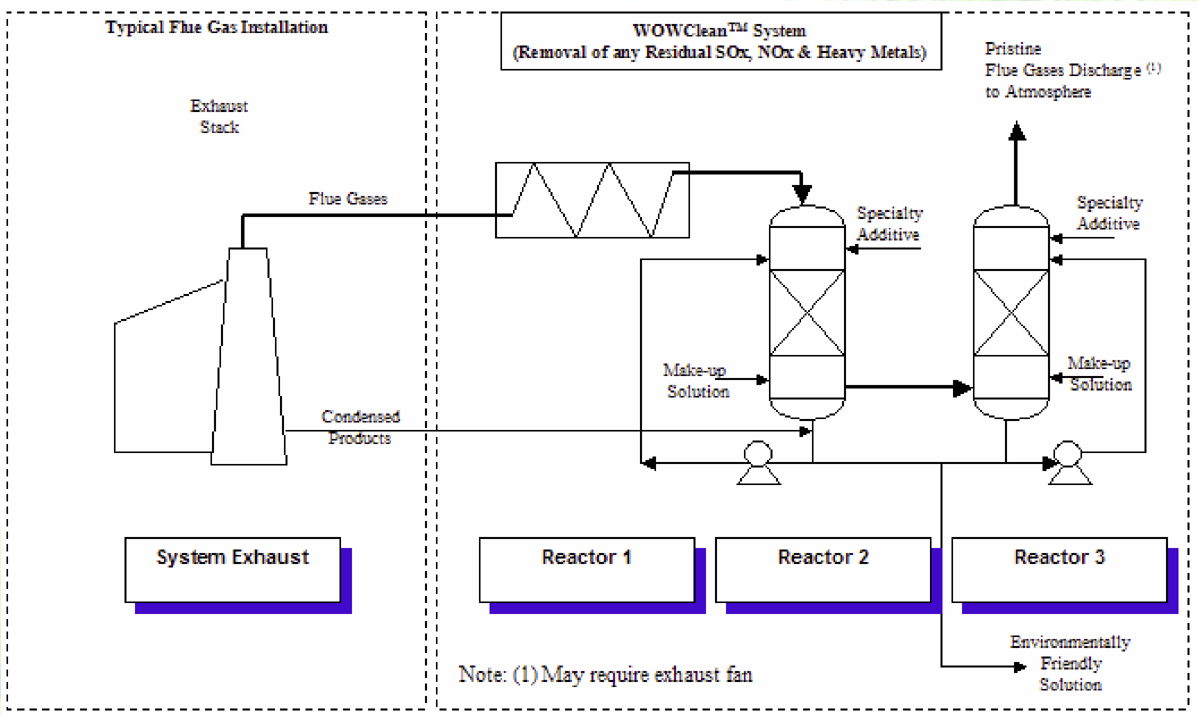
Toxic Waste Gas Cleaning System

INTRODUCTION

This waste gas cleaning system eliminates nearly all pollutants, particulates and heavy metals, including Mercury, from flue gases exiting industrial exhaust stacks while simultaneously reducing CO_2 greenhouse emissions by 25% or more. It was designed to operate in conjunction with the patented waste heat to energy system or as a stand-alone flue gas cleaning system.

The waste heat to energy power plant inherently reduces emissions and Greenhouse Gases (GHG) by producing power from waste heat without consuming fuel and without the use or consumption of valuable water resources. The combination of the waste heat to energy and waste gas cleaning system increases the overall energy efficiency of any industrial plant while simultaneously removing nearly all the pollutants from a flue gas without the need to install multiple pollution reduction systems such as a Flue Gas Desulfurization (FGD) unit for SOx; Selective Catalytic Reduction (SCR) system for NOx; or Baghouse/ESP for particulate removal.

Waste Gas Cleaning System

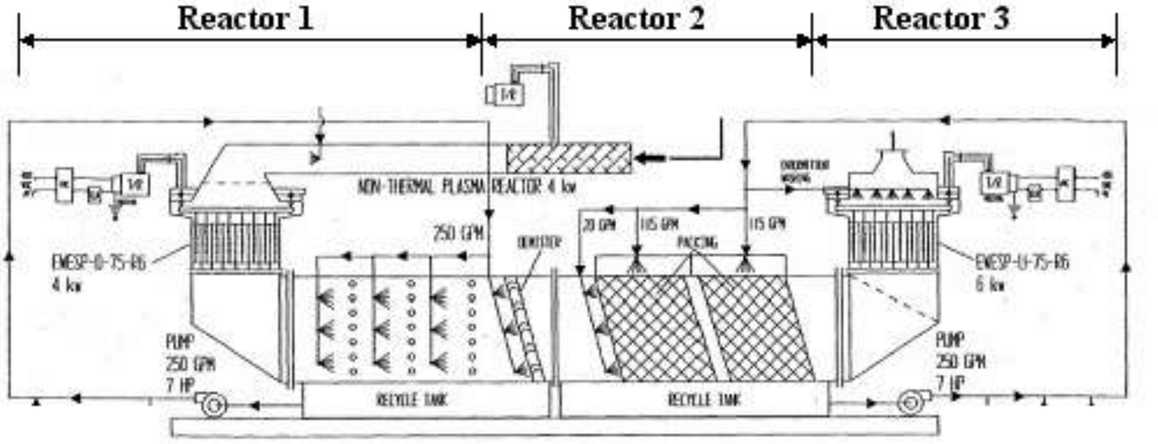


This is a standalone multi-pollutant removal system for installation on existing coal-fired power plants, boilers, furnaces, incinerators, gasifiers, recip engines, gas turbines and other flue gas waste heat sources. A typical flow path schematic shows with the contaminated flue gas exiting an exhaust stack, traversing through the three (3) cleaning stages of this cleaning system and ending with contaminant free flue gas exhausted to the atmosphere.

This cleaning system removes nearly all the pollutants from a flue gas without using multiple pollution reduction systems such as a Flue Gas Desulfurization (FGD) unit; Selective Catalytic Reduction (SCR) system; Thermal Oxidizers (TO); or baghouses, scrubbers and ESPs for particulate matter. In addition to removal of SOx, NOx and particulates, this system has demonstrated the capability of reducing Mercury and CO_2 by up to 85%.

Depending on the flue gas temperature, heat exchangers or quenching methods may be required to reduce flue gas temperatures to levels conducive to low temperature flue gas cleaning with this system. Key features of the three (3) reactors in the system are:

- Multi-pollutant control technology in one integrated unit
- Low temperature flue gas design
- Simultaneously removes
  - NOx & SOx >95%
  - Mercury & other heavy metals >85%
  - Particulates & VOCs > 99.5%
  - CO_2 removal > 25%



FIRST STAGE REACTOR: The first stage reactor has the capability to simultaneously remove acid gases, heavy and sub-micron particulates, acid mists, dioxins/furans, sulfur oxides, nitrogen oxides, mercury and other vaporized metals with efficiencies >95%. The first stage reactor incorporates a quenching system; a non-thermal plasma (NTP) generation system; integrated scrubbing system; and sump.

The first stage reactor is highly efficient where flue gas streams fall into one or more of the following categories:-

1. The flue gas has a high moisture content
2. The gas stream includes sticky particulates
3. The collection of sub-micron particulate is required
4. The flue gas has acid droplets or mist
5. The temperature of the flue gas approaches the gas dew point

The preconditioning quenching system allows reducing the flue gas temperature to near ambient while absorbing heavy particulates in the flue gas. This reduces flue gas temperatures that are not already at levels compatible with efficient scrubbing and rapid chemical reactions. At reduced temperatures, pollutants that exist in a vaporized state, such as oxides of Nitrogen, Sulfur, Mercury, Vanadium, Lead, Cadmium, and Volatile Organic

Compounds (VOCs) will automatically condense out for handling and safe disposal in the sump below the first stage reactor.

The unique NTP is a "cold" combustion process that produces free radicals from electrical energy to generate favorable chemistry for oxidizing pollutants (decompose) to more manageable chemical compounds. Of primary importance is converting the entire quantity of NO in the flue gas to water-soluble nitrogen compounds (NO_2, NO_3, N_2O_5) in the initial reactor stage, which can then be neutralized with chemical scrubbing in the second stage reactor. This is achieved "electrically" by using high intensity electrodes. NO is the one of most difficult pollutants to remove and oxidization of NO and low temperature flue gases are important for the thermal stability of hydroxyl radicals and ozone generated by the NTP. Thermal decomposition of the favorable oxidizing chemicals released in the first stage reactor is known to proceed rapidly at temperature ranges above 212 °F and can increase by a factor of 13 when flue gases are above 300 °F. Removing as much NOx and SOx as possible in the first stage oxidization process also serves to reduce chemicals costs in the downstream scrubbing processes.

The first stage reactor incorporates an integrated scrubbing section to spray water-diluted chemicals in a concurrent flow arrangement to immediately react with the decomposed compounds and remaining pollutants in the flue gas stream. The wet scrubbing process also provides simultaneous removal of SOx and vaporized metals and neutralization of condensed acids with the chemical injection to optimize removal of other pollutants in the flue gas. Remaining pollutants are removed in the downstream reactors.

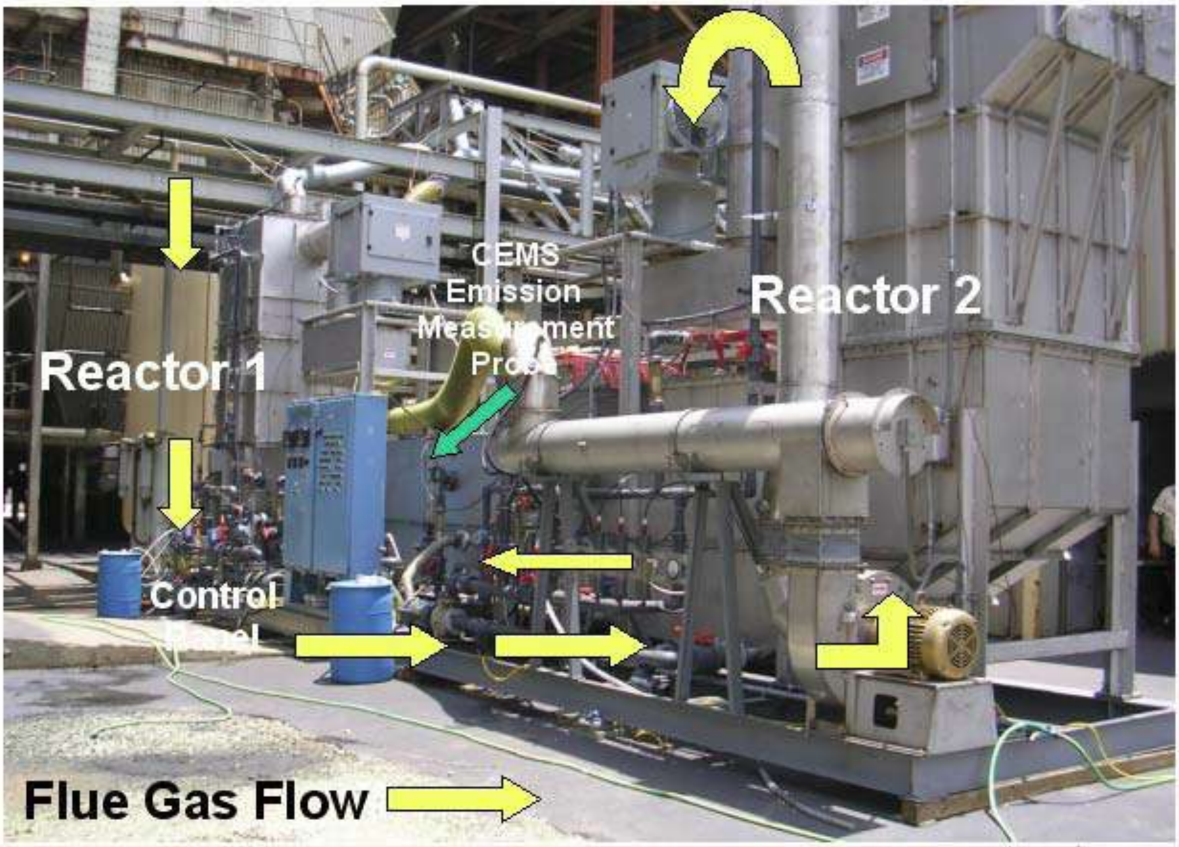
SECOND STAGE REACTOR: The second stage reactor is a transition section that changes the flow direction from vertical to horizontal and incorporates water/chemical injection spray nozzles; demisters and a packing media with both concurrent and cross-flow chemical spraying that assures efficient scrubbing. The second stage reactor is a low velocity section which also provides higher residence time for efficient chemical reactions. Heavy metals and neutralized pollutants are trapped in the wastewater as they are condensed and collected in the sump below the packed bed of this second stage reactor. The chemicals used in this stage react with water-soluble pollutants from the first stage to produce stable salts and other safe or saleable compounds, including metals.

THIRD STAGE REACTOR: The third stage reactor is not required for most applications but is available as a final "polishing" section when removal of minute amounts of residual pollutants when near-zero emission levels are critical. The third stage reactor incorporates a pre-spray system for injection of final polishing chemicals in a counter-flow arrangement; a non-thermal plasma (NTP) generation system; and the exhaust fan used to discharge the cleaned flue gas to the environment. If the third stage reactor is not required, the exhaust fan is connected to the flue gas exiting the second stage reactor.

The resulting flue gas is nearly free of heavy metal oxides, SOx, NOx, PM2.5, PM10 and any acid mists, dioxins/furans and VOCs. The clean flue gas is discharged from the this gas system via the exhaust fan and the final flue gas, free of contaminants, can be naturally dispersed and diffused into the environment since its molecular weight is now equivalent to the surrounding air.

The by-products from this system can be a broad range of liquids and solids including heavy metals, acids and stable salt solutions, depending on the concentration of pollutants in the flue gas. The process neutralizes these by-products with the resulting effluent discharged in the form of stable salts and other precipitated pollutants. Since heavy metals, including Mercury, are removed from flue gases, these by-products require careful assaying and handling and can be safely disposed of or sold in the case of fertilizers, acids or metals.

RESULTS FROM VARIOUS TYPES OF PLANTS



AES 150 MW Petcoke Fired Power Plant

Pollutant	Inlet	Exhaust (3)
SO_2	2200 ppm to 2500 ppm	~ 0 ppm
NO (1)	350 ppm to 450 ppm	~ 0 ppm
NOx (2)	350 ppm to 450 ppm	50 ppm to 75 ppm
CO_2 - %	13.9	~ 11.3% (19% reduction)
Particulates/SFC	-	~ 0 (1.0 x E-7)
Vaporized Metals (3)	-	~ 0

(1) Converted to water soluble NOx
(2) NO converted to water-soluble NOx (NO_2, NO_3, N_2O_5). Reduced to zero at Boralex test site. Verified by third party testing per EPA/TCEQ test procedures
(3) Vanadium/Copper/Zinc/Cadmium/Aluminum and others precipitated out in the wastewater effluent

Boralex 40 MW Wood Fired Power Plant

Pollutant	Inlet	Exhaust (7)
SO_2	< 20 ppm	~ 0 ppm
NO (1)	130 ppm	~ 0 ppm
NOx (2)	80 ppm	~ 7 ppm
Total NOx (3)	130 ppm	~ 0 ppm
CO_2 - % (6)	11.6	7.25 (38% reduction)
Mercury µg/DSCM (5)	2.18	0.37 (83% reduction)
Vaporized Metals (4)	-	~ 0

(1) Converted to water soluble NOx
(2) Water-soluble NOx (NO_2, NO_3, N_2O_5) – client required 35 ppm
(3) Demonstrated subsequent to 3rd party testing
(4) Verified via effluent assaying
(5) Hg precipitated out in the wastewater effluent
(6) Reduced by as much as 85% during CO_2 reduction trials
(7) Verified by third party testing per EPA/TCEQ test procedures

Natural Gas Fired Reheat Furnace at Steel Mill

Pollutant	Inlet	Exhaust (2)
SO_2	< 3 ppm	~ 0 ppm
NOx (1)	80 ppm to 100 ppm	5 ppm to 20 ppm
NOx (1)	0.16 to 0.20 lb/MMBTU	0.016 lbs/MMBTU
NOx (3)	80 ppm to 100 ppm	~ 0 ppm
CO_2 - %	5.0 % to 5.5%	4.6 % to 4.9% (10% reduction)
Particulate Matter	TBD	(4)
Vaporized Metals (3)	-	~ 0

(1) Primarily NO - 4 ppm in the form of NO_2
(2) Verified by third party testing
(3) Reduced to zero but not 3rd party verified
(4) Particulate matter should be close to zero based on prior testing

Diesel Fueled Reciprocating Engine

Pollutant	Inlet	Exhaust (1)
SOx (2)	45 to 65 ppm	0 to 7 ppm
NOx	350 ppm to 450 ppm	0 to 15 ppm
Particulate Matter	TBD	~ 0
CO (3)	80 to 90 ppm	70 ppm to 80 ppm (10% reduction)
CO**2** - %	4.0 % to 5.5%	3.5 to 5 % (10% reduction)

(1) Verified by third party testing
(2) Pollutant levels depended on load
(3) Ran as high as 305 ppm depending on load

CO2 Removal from Atmospheric Air

Pollutant	Inlet	Exhaust (1)
CO**2** - ppm	400 ppm	35 ppm to 70 ppm

Two separate tests at two separate locations.

Coal Fired Boiler flue gas exhaust

Pollutant	Inlet	Exhaust (1)
SO**2**	191ppm	0 ppm
NOx (3)	342 ppm to 430 ppm	18 ppm to 24 ppm
Particulate Matter	TBD	(4)
CO (3)	80 to 90 ppm	70 ppm to 80 ppm (10% reduction)
CO**2** - %	4.7 % to 5.3%	3.7 % to 4.4%

(1) Verified by third party testing
(2) Pollutant levels depended on load
(3) Ran as high as 478 ppm depending on load
(4) Particulate matter should be close to zero based on prior testing

Biomass Gasifier flue gas exhaust

Pollutant	Inlet	Exhaust
SO_2	3ppm to 17 ppm	0 ppm
NOx	21ppm to 50ppm	1 ppm to 4 ppm
Particulate Matter	TBD	(4)
CO_2 - %	2.1 % to 0.9%	1.1 % to 0.4%

(1) Verified by third party testing
(2) Pollutant levels depended on load
(3) Ran as high as 50 ppm depending on load
(4) Particulate matter should be close to zero based on prior testing

Other Usage

There are several options to use this system, such as a Carbon Sequestration and Storage (CSS) system. An important criteria required by all CO2 removal/sequestration technologies is a "low temperature" and "clean" flue gas to work with. Its removes nearly all of the contaminants (SOx, NOx, particulates, mercury, heavy metals) in the steps described above. Hence, the flue gases exiting in this unit consist essentially of low temperature air and CO2. The CO2 can then be removed using different techniques (depending on the ultimate use of the CO2) as follows:

1. Using selective membranes or condensed with mechanical chilling systems. In these techniques, the CO2 can be used for commercial purposes such as carbonation or enhanced oil recovery/storage after pressurizing to 2,500 psig (high energy costs);
2. Feeding it to a living organism (algae systems);
3. Feeding it to a greenhouse to enhance plant growth;
4. Using amine-based technologies to strip the CO2 from the fluegas;
5. Chemically binding by reacting it with lime kiln dust or cement kiln dust; or
6. Chemically binding by reacting it with other caustic waste chemicals readily available in industry.

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