APPENDIX A-1

OVERVIEW OF EMISSION CONTROL TECHNOLOGIES APPLICABLE TO WOOD-FIRED BOILERS

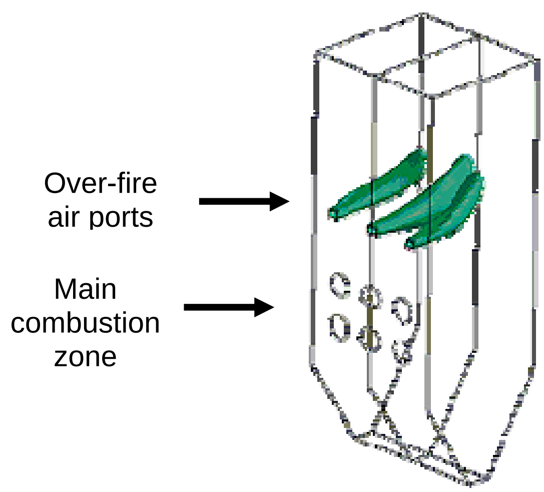
This appendix summarizes the key features of the emission controls applicable to the MGEC project.

1 LOW-NO_X COMBUSTION

Control of NOx emissions for wood-fired boilers can be achieved by means of good combustion practices (GCP) such as low excess air (LEA) and/or the use of over-fire air (OFA).

LEA refers to the practice of minimizing the excess air fed to the boiler furnace (i.e., the amount of air above what is theoretically needed for complete combustion of the fuel). This lowers the oxygen concentration in the furnace and results in reduced formation of NOx. In practice, LEA requires very good balance and control of the fuel and air feed systems to prevent excessive products of incomplete combustion, such as CO or unburned carbon, from being produced.

OFA systems involve installation of extra ports for injection of air above the main combustion zone in a furnace (Figure A-1). Air is supplied to the main combustion zone such that a slightly fuel-rich (i.e., air-starved) environment exists. Complete combustion is achieved by the introduction of additional air above the main combustion zone. Staging of the combustion process in this way reduces NOx formation by moderating peak combustion temperature and reducing the availability of nitrogen in areas of high combustion temperature.

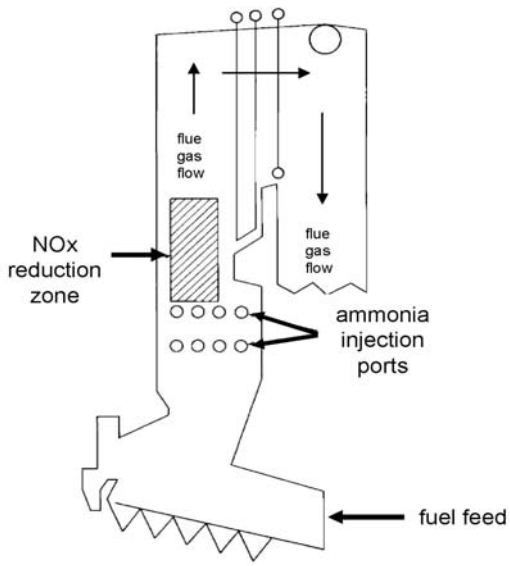


Source: U.S. EPA technical bulletin EPA 456/F-99-006R (1999)

Figure A-1 Over-Fire Air for NOx Control

2 SELECTIVE NON-CATALYTIC REDUCTION

Selective non-catalytic reduction (SNCR) is a method of reducing NO_x emissions by injecting an ammonia-based reagent (e.g., anhydrous ammonia, or urea) at 800-1000 °C (1500-1800 °F) as illustrated in Figure A-2. SNCR is a post-combustion NOx control technology that converts NOx into its benign chemical forms of molecular nitrogen and water. This method is demonstrated to reduce NO_x by approximately 50%. A side effect of this NOx reduction method is that, in practice, there is always a small amount of ammonia that passes through the SNCR system unreacted. This is commonly called "ammonia slip" and typically ranges from 5 to 10 ppm in the flue gas that exits the boiler.



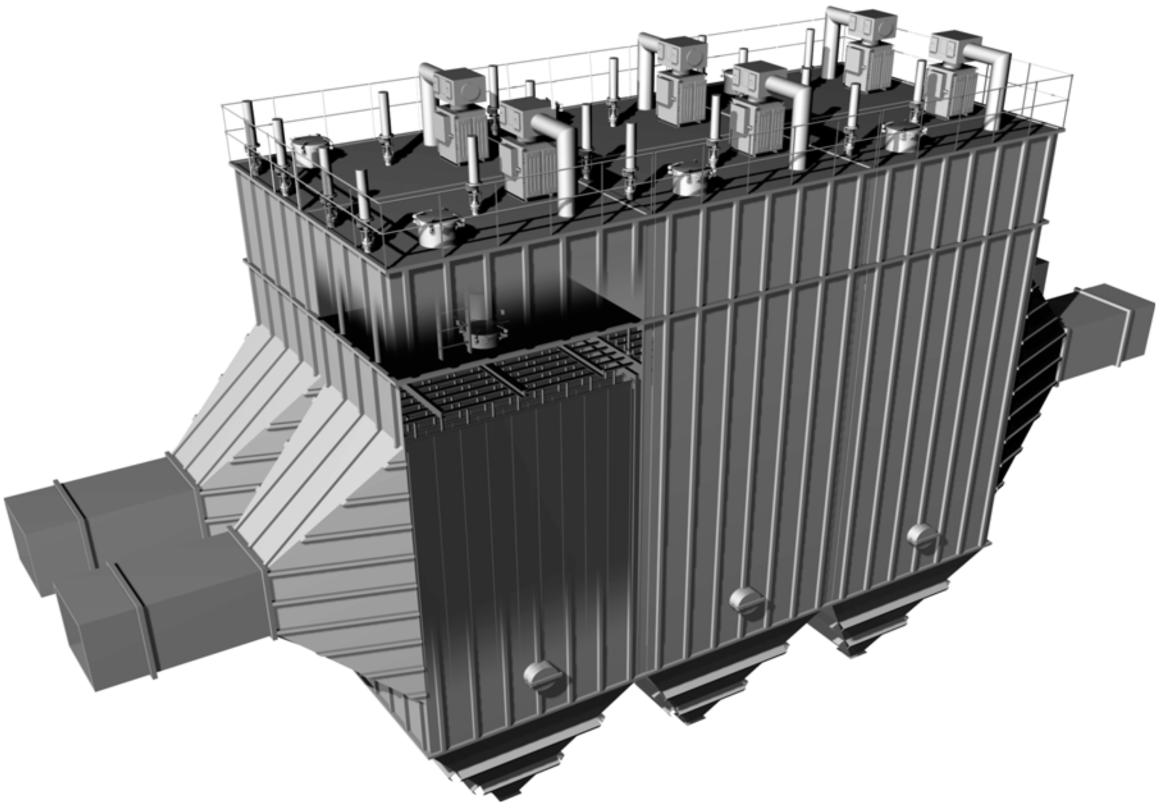
Source: Air pollution control for industrial boilers.
Babcock & Wilcox Company BR-624 (1996)

Figure A-2 Selective Non-catalytic Reduction (SNCR) NOx Control for a Stoker Boiler

3 ELECTROSTATIC PRECIPITATOR

Electrostatic precipitators (ESPs) remove particulate matter by imposing an electrostatic charge to particles and then collecting these particles on high-voltage plates (or pipes) by means of the electrostatic force. There are two types of ESPs. In "wet" ESPs, particles that build up on the plates or pipes are sprayed with water or other liquid (such as calcium hydroxide to enhance SO_3 capture, or some proprietary reagents to enhance mercury capture – these are sometimes used in coal-fired systems) continuously or intermittently to discharge the collected particles to a drainage and hopper disposal system. In "dry" ESPs, charged particles are collected on electrodes the same way as in wet ESP's. However, instead of using a liquid to remove the collected particles, dry ESPs accomplish this by shaking or "rapping" the electrodes so that collected particles are gathered in an ash hopper. As a result, wet ESPs require handling and disposal of solid and liquid waste, while dry ESPs require disposal of dry waste only. Generally, ESPs (wet or dry) remove over 99% of particulate matter.

Achieving a high collection efficiency of particulate matter in an ESP requires a slow moving gas and large collection areas to capture particles. Therefore, ESPs are designed with a large cross-sectional area to reduce gas velocity where the collection plates are located and incorporate transitional duct work in advance of this section to distribute the gas flow evenly and smoothly across collection plates, as shown in Figure A-3. This means that ESPs are relatively large structures that require sufficient installation space.

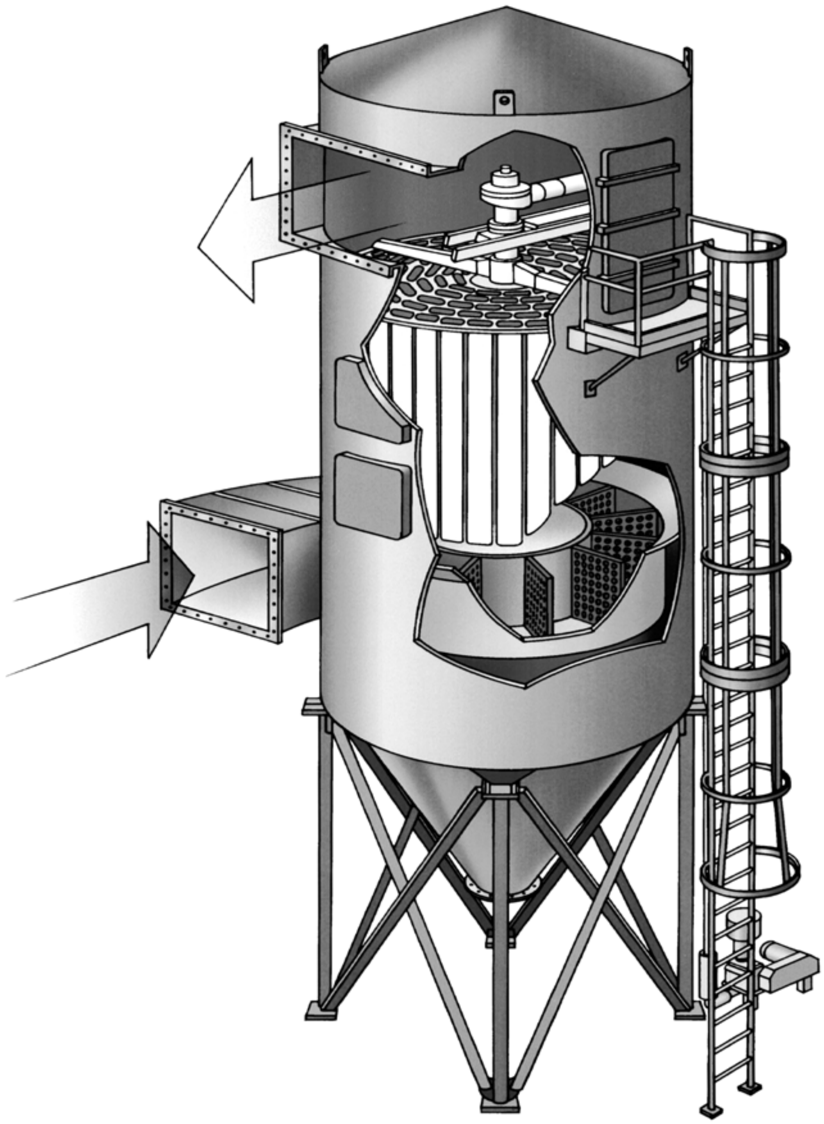


Source: Shifftner "Air Pollution Control Selection Guide (CRC Press) 2002

Figure A-3 Typical Configuration of an Electrostatic Precipitator.

4 BAGHOUSE

A fabric filter system, commonly known as a baghouse, is a device where particle-laden gas is passed through a tightly woven or felted fabric, causing particles to be captured in the fabric by impingement and other mechanisms. Collected particles caked on the filter also enhance the collection efficiency. The filters may be in the form of sheets, cartridges, or bags, with a number of the individual fabric filter units housed together in a group. Figure A-4 illustrates a typical baghouse packaged system. Methods of removing caked particles include using air jets (e.g., pulsed air or reverse air) or mechanical shaking. Groups of bags are placed in separate compartments to allow cleaning of the bags or replacement of some of the bags without shutting down the entire fabric filter. The basic design parameter for a baghouse is the air-to-cloth ratio (m/s), which is the volumetric flow (m^3/s) divided by the cloth area (m^2). Larger air-to-cloth ratios result in lower pressure losses and more efficient collection, but at a higher cost. Baghouses are commonly designed to remove over 99% of particulate matter.



Source: Shifftner “Air Pollution Control Selection Guide (CRC Press) 2002.

Figure A-4 Typical Configuration of a Baghouse (fabric filter)