EPA-452/F-03-009

Air Pollution Control Technology
Fact Sheet

Name of Technology: Settling Chambers

This type of technology is a part of the group of air pollution controls collectively referred to as "precleaners" because they are oftentimes used to reduce the inlet loading of particulate matter (PM) to downstream collection devices by removing larger, abrasive particles. Settling chambers are also referred to as gravity settling chambers, gravity collectors, expansion chambers, and outfall chambers. Multiple-tray settling chambers are also referred to as Howard settling chambers.

Type of Technology: Removal of PM by reducing the gas velocity to enable the dust to settle out by the action of gravity.

Applicable Pollutants:

Settling chambers are used to control PM, and primarily PM greater than 10 micrometers (μm) in aerodynamic diameter. Most designs only effectively collect PM greater than approximately 50 μm (Wark, 1981; Perry, 1984; EPA, 1998).

Achievable Emission Limits/Reductions:

The collection efficiency of settling chambers varies as a function of particle size and settling chamber design. Settling chambers are most effective for large and/or dense particles. Gravitational force may be employed to remove particles where the settling velocity is greater than about 13 centimeters per second (cm/s) (25 feet per minute (ft/min)). In general, this applies to particles larger than 50 μm if the particle density is low, down to 10 μm if the material density is reasonably high. Particles smaller than this would require excessive horizontal flow distances, which would lead to excessive chamber volumes. The collection efficiency for PM less than or equal to 10 μm in aerodynamic diameter (PM_{10}) is typically less than 10 percent. Multiple-tray chambers have lower volume requirements for the collection of particles as small as 15 μm (Wark, 1981; Mycock, 1995; EPA, 1998).

Applicable Source Type: Point

Typical Industrial Applications:

Despite low collection efficiencies, settling chambers have been used extensively in the past. The metals refining industries have used settling chambers to collect large particles, such as arsenic trioxide from the smelting of arsenical copper ores. Power and heating plants have used settling chambers to collect large unburned carbon particles for reinjection into the boiler. They are particularly useful for industries that also need to cool the gas stream prior to treatment in a fabric filter (Mycock, 1995).

Settling chambers have been used to prevent excessive abrasion and dust loading in primary collection devices by removing large particles from the gas stream, such as either very high dust loadings or extremely coarse particles which might damage a downstream collector in series with the settling chamber. The upstream use of settling chambers has declined with improvements in acceptable loading of other, more efficient, control devices and increasing space restrictions at facilities. In cases where sparks or heated material is present in the waste gas, settling chambers are still used to serve as "spark traps" to prevent a downstream baghouse or filter from catching fire (Wark, 1981; EPA, 1998; Josephs, 1999; Davis, 1999).

These devices are generally constructed for a specific application from duct materials, though almost any material can be used. Settling chambers have been replaced, for most applications, by cyclones primarily due to the lower space requirements and the higher collection efficiency of cyclones. Multiple-tray settling chambers have never been widely used because of the difficulty in removing the settled dust from the horizontal trays (Mycock, 1995; Josephs, 1999).

Emission Stream Characteristics:

a. **Air Flow:** The simple design and construction of settling chambers allows for almost any size and waste gas flow rate, but size is usually restricted to a 4.25 meter (14 foot) square shipping size. Units restricted by this shipping constraint will generally have flow rates which range up to 50 standard cubic meters per second (sm^3/sec) (106,000 standard cubic feet per minute (scfm)). Typical settling chamber waste gas flow capacity is 0.25 to 0.5 sm^3/sec per cubic meter of chamber volume (15 to 30 scfm per cubic foot of chamber volume) (Wark, 1981; Andriola, 1999).

b. **Temperature:** Inlet gas temperatures are only limited by the materials of construction of the settling chamber, and have been operated at temperatures as high as 540°C (1000°F) (Wark, 1981; Perry, 1984).

c. **Pollutant Loading:** Waste gas pollutant loadings can range from 20 to 4,500 grams per standard cubic meter (g/sm^3) (9 to 1,970 grains per standard cubic foot (gr/scf)). Multiple-tray settling chambers can only handle inlet dust concentrations of less than approximately 2.3 g/sm^3 (1.0 gr/scf) (Mycock, 1995; Parsons, 1999; Steinbach, 1999; Josephs, 1999).

d. **Other Considerations:** Leakage of cold air into a settling chamber can cause local gas quenching and condensation. Condensation can cause corrosion, dust buildup, and plugging of the hopper or dust removal system. The use of thermal insulation can reduce heat loss and prevent condensation by maintaining the internal device temperature of the above the dew point (EPA, 1982).

Emission Stream Pretreatment Requirements: No pretreatment is necessary for settling chambers.

Cost Information:

The following are cost ranges (expressed in third quarter 1995 dollars) for a single conventional expansion-type settling chamber under typical operating conditions, developed using a modified EPA cost-estimating spreadsheet (EPA, 1996), and referenced to the volumetric flow rate of the waste stream treated. For purposes of calculating the example cost effectiveness, flow rates are assumed to be between 0.25 and 50 sm^3/sec (530 and 106,000 scfm), the inlet PM loading concentration is assumed to range from approximately 20 to 4,500 g/sm^3 (9 to 1,970 gr/scf) and the control efficiency is assumed to be 50 percent. The costs do not include costs for disposal or transport of collected material. Capital costs can be higher than in the ranges shown for applications which require expensive materials. As a rule, smaller units controlling a low concentration waste stream will be more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow.

a. **Capital Cost:** $330 to $10,900 per sm^3/sec ($0.16 to $5.10 per scfm)

b. **O & M Cost:** $13 to $470 per sm^3/sec ($0.01 to $0.22 per scfm), annually

c. **Annualized Cost:** \$40 to \$1,350 per sm^3/sec (\$0.02 to \$0.64 per scfm), annually

d. **Cost Effectiveness:** \$0.01 to \$3.90 per metric ton (\$0.01 to \$3.50 per short ton), annualized cost per ton per year of pollutant controlled

Theory of Operation:

Settling chambers, which rely on gravitational settling as a collection mechanism, are the simplest and oldest mechanical collectors. Settling chambers are generally built in the form of long, horizontal, rectangular chambers with an inlet at one end and an exit at the side or top of the opposite end. Flow within the chamber must be uniform and without any macroscopic mixing. Uniform flow is often ensured by flow straighteners at the inlet to the chamber. Hoppers are used to collect the settled-out material, though drag scrapers and screw conveyers have also been employed. The dust removal system must be sealed to prevent air from leaking into the chamber which increases turbulence, causes dust reentrainment, and prevents dust from being properly discharged from the device (EPA, 1982; Wark, 1981; Corbitt, 1990; Perry, 1984; Mycock, 1995; Avallone, 1996; EPA, 1998).

There are two primary types of settling chambers: the expansion chamber and the multiple-tray chamber. In the expansion chamber, the velocity of the gas stream is significantly reduced as the gas expands in a large chamber. The reduction in velocity allows larger particles to settle out of the gas stream (EPA, 1982; Wark, 1981; Perry, 1984; Mycock, 1995; EPA, 1998).

A multiple-tray settling chamber is an expansion chamber with a number of thin trays closely spaced within the chamber, which causes the gas to flow horizontally between them. While the gas velocity is increased slightly in a multiple-tray chamber, when compared to a simple expansion chamber, the collection efficiency generally improves because the particles have a much shorter distance to fall before they are collected. Multiple-tray settling chambers have lower volume requirements than expansion-type settling chambers for the collection of small particles (15 μm or greater) (EPA, 1998).

The efficiency of settling chambers increases with residence time of the waste gas in the chamber. Because of this, settling chambers are often operated at the lowest possible gas velocities. In reality, the gas velocity must be low enough to prevent dust form becoming reentrained, but not so low that the chamber becomes unreasonably large. The size of the unit is generally driven by the desired gas velocity within the unit, which should be less than 3 meters per second (m/s) (10 feet per second (ft/sec)), and preferably less than 0.3 m/s (1 ft/sec) (Wark, 1981; Corbitt, 1990; Mycock, 1995; EPA, 1998).

Advantages:

Advantages of settling chambers include (Wark, 1981; Corbitt, 1990; Perry, 1984; Mycock, 1995; and EPA, 1998):

1. Low capital cost;
2. Very low energy cost;
3. No moving parts, therefore, few maintenance requirements and low operating costs;
4. Excellent reliability;
5. Low pressure drop through device;
6. Device not subject to abrasion due to low gas velocity;
7. Provide incidental cooling of gas stream;
8. Dry collection and disposal; and
9. Temperature and pressure limitations are only dependent on the materials of construction.

Disadvantages:

Disadvantages of settling chambers include (Wark, 1981; Mycock, 1995; and EPA, 1998):

1. Relatively low PM collection efficiencies, particularly for PM less than 50 µm in size;
2. Unable to handle sticky or tacky materials;
3. Large physical size; and
4. Trays in multiple-tray settling chamber may warp during high-temperature operations.

Other Considerations:

The most common failure mode of settling chambers is plugging of the chamber with collected dust. In expansion settling chambers the plugging can result from hopper bridging or hopper discharge seal failure. Multiple-tray settling chambers may experience plugging of the individual gas passages. Such failures can be prevented or minimized by use of hopper level indicators or by continuous monitoring of the dust discharge. Scheduled internal inspection can determine areas of air leakage and condensation, both of which may cause hopper bridging. Normal instrumentation for a settling chamber generally includes only an indicator of differential static pressure. An increase in static pressure drop can indicate plugging (EPA, 1982).

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