United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S7-86/041 Mar. 1987

EPA

Project Summary

Pilot Demonstration of the Air Curtain System for Fugitive Particle Control

R. Lockwood Williams and Michael Duncan

Fugitive emissions are the major source of uncontrolled emissions for many industrial plants. There are presently no high performance, inexpensive control techniques available for many fugitive sources. The present technology is not only expensive, it is often marginally effective and typically consists of hooding at the source, or total building enclosure and evacuation.

A simpler and less expensive method is to divert the emissions with an air curtain (and fans in some cases) into a control device located near the source. This greatly reduces processing of uncontaminated air. The technical and economic feasibility of using an air curtain transport system for controlling buoyant fugitive particle emissions from mold pouring operations was demonstrated at a Naval foundry in California.

The pilot plant system used a horizontal air curtain to capture and convey the buoyant fugitive particle emissions to a particle collection filter unit. High Efficiency Particulate Air (HEPA) filters in the filter unit collected the particles with the aid of suction fans. Results from the pilot plant tests indicate that the air curtain capture efficiency, the measure of the air curtain's ability to capture and convey the fugitive emission plume, is between 63 and 105%, depending on air curtain slot exit velocity, and subject to a ±18% error limit. Results also indicate that collection efficiency of the HEPA filters for the particle size range of the mold emissions is 99%. The overall capture and containment efficiency of the pilot plant, when operating in the appropriate slot velocity range, can be expected to be between 90 and 99% when considered as a package.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Fugitive emissions are air pollution emissions which have not passed through a stack or duct. They are diffuse, and typically come from many small sources rather than from a single large source. Fugitive particle emissions tend to be site-specific: open operations, storage and disposal of materials and wastes, incompletely controlled point sources, and poor housekeeping all provide maximum potential for their release.

One method for controlling buoyant fugitive emissions is to gather and convey them to conventional air pollution control devices. Typical systems of this type involve hooding at the local source of emissions, or total building enclosure and evacuation. These systems often require high capitol and energy costs, especially when there are many small, diffuse sources.

A simpler and less expensive method is to divert the emissions with air curtains (and fans in some cases) into a control device located near the source. This greatly reduces the processing of uncontaminated air. An air curtain is a wedge-shaped flow field of air that is formed by blowing air through a slot. A major advantage of air curtains over hoods is that, for a given volumetric flow rate, an air curtain can cause air movement at a much greater distance than hoods (about 30 times greater). Another advantage is that air curtains allow free movement of equipment and personnel in the area to be controlled.

Extensive tests were conducted to determine the technical and economic feasibility of using an air current transport system for controlling buoyant fugitive particle emissions from mold pouring operations at a Naval foundry in San Diego, CA.

Objectives

The principal objective of this contract was to demonstrate the technical and economic feasibility of the use of an air curtain system at an industrial site.

The itemized objectives for this study were:

1. Select a pilot plant demonstration site with a suitable industrial participant.
2. Conduct a series of operational design verification tests of the emission control system.
3. Demonstrate the pilot plant at the selected industrial site in order to compile an extensive performance characterization of the emission control system.
4. Produce a detailed evaluation of the emission control system.

Pilot Plant Description

Pilot plant demonstration sites were investigated to determine an appropriate location with a significant source of fugitive emissions. After extensive investigation, a Naval maintenance foundry in San Diego, CA, was selected.

The SCAT scrubber developed under a previous EPA contract used air curtains and/or push jets to contain, divert, and convey the fugitive emissions of an industrial process into a charged spray scrubber. This scrubber would have used a low pressure drop entrainment separator to trap the spray drops and the collected particles for subsequent disposal. Investigations into the emissions to be controlled indicated, however, that the charged spray scrubber would not be applicable for two reasons: the particles were too small (0.2 to 0.4 μmA diameter), and the Navy did not want a wet system. It was determined that the appropriate particle collection device should rather be a filtration unit which would still operate in conjunction with air curtains and/or push jets to contain, divert, and convey the fugitive emission of the industrial process.

A complete pilot plant-fugitive emission control system was evaluated. The high velocity air curtain airstreams entrain the fugitive particle emissions from foundry molds (plus some additional air), and carry them away from the source. At a convenient distance downstream, the particle laden airstream is pulled into a filter unit, and the emission particles are removed. The cleaned gases are then exhausted into the atmosphere by the fans used to pull the air through the filter unit.

The pilot plant consisted of an air curtain and a filter bank system as shown in Figure 1. The single slot air curtain was horizontal and adjustable in height and angle of air outlet orientation. The size and strength of the air curtain were determined by design verification tests.

The filter unit consisted of an array of High Efficiency Particulate Air (HEPA) filters (series 95) and suction fans with volume dampers to move the emission laden air through the unit. The filter bank was also adjustable in height.

The units are arranged so that the air curtain sweeps air across the top of the fugitive emission source, traps and conveys the emissions, and delivers them to the filter unit for cleanup.

Pilot Plant Test Methods

Overall effectiveness of the pilot plant depends on both the ability of the air curtain to capture and convey the fugitive particles and the ability of the filter to collect them. Consequently, two tests were used to evaluate pilot plant operation: air curtain capture efficiency and filter collection efficiency.

Air Curtain Capture Efficiency Tests

To determine air curtain capture efficiency, which is the measure of the ability of the air curtain to capture the plume of a foundry mold, the mold emission rate and the portion of this emission captured by the air curtain need to be known. Mold emission rate varies widely from mold to mold, and cannot be measured while the pilot plant is operating. Thus, the emitted particles cannot be used to determine capture efficiency.

Particles emitted from the molds are small, and behave similar to a gas. Therefore, the air curtain capture efficiency was determined with sulfur hexafluoride (SF_6) tracer gas. SF_6 is chemically and physiologically inert, nonflammable, and noncorrosive with a viscosity that is approximately the same as that of air.

The SF_6 was metered directly into the buoyant mold plume after a metal pour. The air curtain air stream conveys both the mold emissions and the SF_6 to the filter unit. Traverse gas samples were obtained at the outlet of the filter unit to determine the concentrations of tracer gas in the outlet streams. The ratio of SF_6 outlet mass flow rate to total SF_6 injection was used to determine the capture efficiency. Gas flow rate was determined with a standard pitot tube transverse of the duct. This was done to determine the overall flow rate of the unit and is required in order to assist in the determination of the SF_6 concentrations.

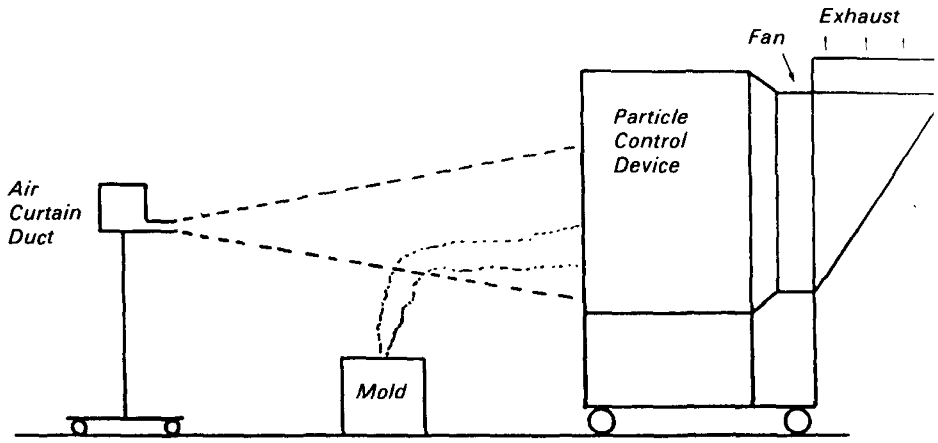

Figure 1. *Pilot plant arrangement.*

Filter Collection Efficiency Tests

To measure the collection efficiency of the filters used in the pilot plant unit, the particle concentrations in both the inlet and outlet airstreams of the pilot plant unit needed to be measured simultaneously. Because of dilution by the air curtain, particle concentrations at the inlet and outlet of the pilot plant filter unit were found to be too low to allow measurement with cascade impactors. Consequently, a small scale unit was built to duplicate the pilot plant unit, incorporating the same filters and filter surface velocities while minimizing dilution of the mold emissions. This small scale unit consisted of a hood to place over the emission source, ducting, and a small version of the same HEPA filter material. A blower conveyed the mold emissions through the system while particles were sampled both up- and downstream of the filter.

Particle size distributions and concentrations were measured with both cascade impactors and an electrical aerosol size analyzer. Cascade impactors were used to obtain data on the larger particles (greater than 0.5 μmA) of the mold plume, and the electrical aerosol size analyzer was used for the smaller particles (less than 0.5 μmA). Fractional efficiency was calculated from the measured size distributions and concentrations.

Results

Air Curtain Capture Efficiency

Results from the pilot plant tests indicate that the air curtain capture efficiency is between 63 and 105%, depending on the air curtain slot exit velocity of between 8.40 m/s (1653 ft/min) to 13.53 m/s (2662 ft/min). This capture efficiency is subject to a $\pm$ 18% error limit. The capture efficiency increases with increasing air curtain exit slot velocity. For the pilot plant arrangement at the demonstration site, the slot velocity for 100% capture of the mold plume is in the range of 12.19 to 13.72 m/s (2400 to 2700 ft/min). This information can be seen in Figure 2.

Filter Collection Efficiency

Results of cascade impactor sampling are shown in Figure 3. Penetration scatters from 0.01 to above 50%. The scattering of data points is caused by low mass gain of each impactor substrate. Most of the weight gains of the substrates were in the range of 0.1 mg which, unfortunately, is within the error range of the electronic balance being used to weigh them.

Results of electrical aerosol size analyzer sampling are shown in Figure 4. The measured penetration is less than 1% for particles between 0.1 and 0.4 μmA diameter, which is better than the 5% rating at 0.3 μm of the HEPA series 95 filters.

Conclusions

The pilot plant installed at the demonstration foundry site, consisting of an air curtain transport system and a HEPA filter bank with suction fans, constituted an efficient, economical, and versatile system for the control and entrapment of buoyant fugitive particle emissions from foundry molds. The overall capture and containment efficiency of the pilot plant is between 90 and 99%. It is highly probable that the type of system quantified here will find widespread utility in many other industrial applications related to fugitive particle emission control.

The quality control evaluation in the full report discusses data accuracy determinations and applicability limitations.

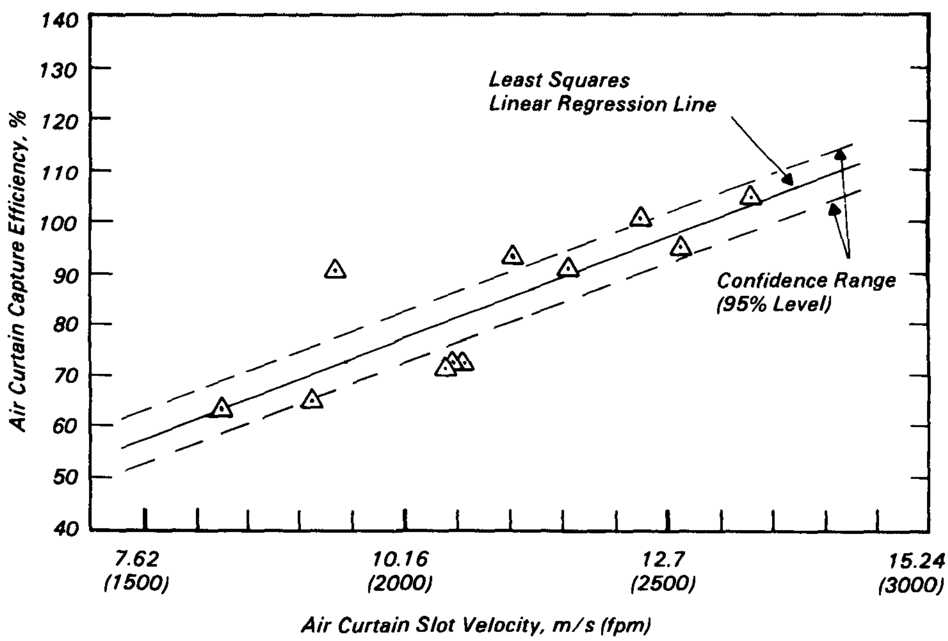

Figure 2. Air curtain capture efficiency.

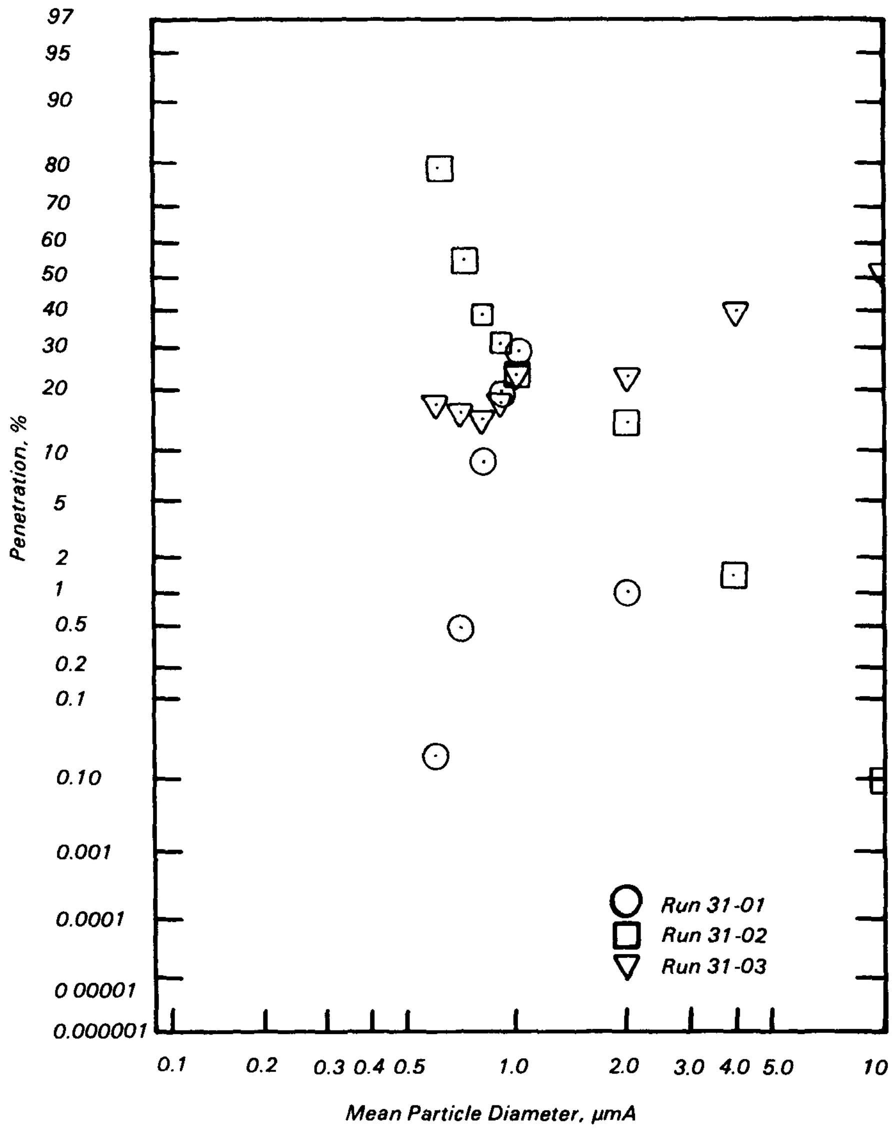

Figure 3. *HEPA filter penetration by cascade impactor.*

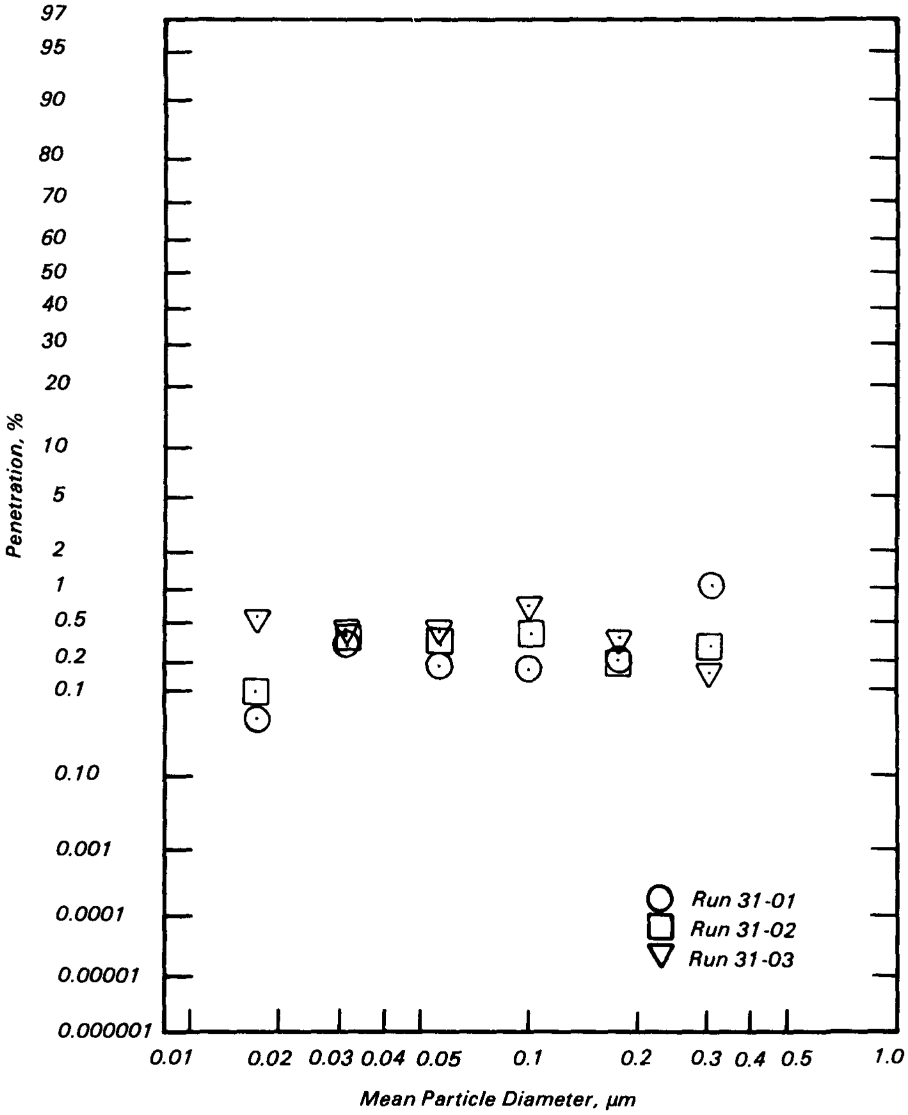

Figure 4. *HEPA filter penetration by electrical aerosol size analyzer.*

R. L. Williams and M. Duncan are with Air Pollution Technology, Inc., San Diego, CA 92109.
***Dale L. Harmon** is the EPA Project Officer (see below).*
The complete report, entitled "Pilot Demonstration of the Air Curtain System for Fugitive Particle Control," (Order No. PB 87-132 817/AS; Cost: $18.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Official Business
Penalty for Private Use $300

EPA/600/S7-86/041