Clothes Cleaning Process

National Institute for Occupational Safety and Health

NIOSH

Instructional Materials

CDC

Workplace Safety and Health

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Notice to U.S. Operations:

This Clothes Cleaning Process is not currently approved by the Mine Safety and Health Administration (MSHA). To implement this technique, a 101 Petition for Modification must be submitted to MSHA for approval.

This pamphlet and the enclosed video describe a safe, effective and economical method for removing dust from work clothes.

Background Information

Dusty work clothes can increase a worker's exposure to respirable dust. Respirable dust is usually considered to be particles having an aerodynamic diameter of 10 microns or less and able to enter and deposit in the gas-exchange region of the human lung. A former U.S. Bureau of Mines report documented a 10-fold increase in worker dust exposure on a number of separate occasions from dusty work clothes.* It was found that once clothes become contaminated, they are a continual dust source until cleaned.

The only MSHA approved method to clean work clothes requires a HEPA-filter vacuuming system which is very time consuming and difficult to perform effectively. Therefore, most workers use a single air hose (not MSHA approved) which can elevate dust levels for the worker, co-workers, and the work environment.

A substantial amount of engineering technology has been developed that, when applied, can significantly lower respirable dust exposures of workers at mineral processing plants. But even with these improvements, some workers continue to exceed their permissible exposure limit. Elevated exposures increase the potential for developing debilitating or fatal lung diseases. The clothes cleaning method described within is an example of a continuing effort to reduce the potential for developing these lung diseases.

Information about engineering research by the former U.S. Bureau of Mines and NIOSH can be found online at www.cdc.gov/niosh. This website can also be used for obtaining NIOSH information about health hazards associated with crystalline silica.

**Cecala, A.B. & E. D. Thimons. Impact of Background Sources on Dust Exposure of Bag Machine Operator. BuMines IC 9089, 1986, 10 pp.*

Crystalline Silica and Health Risks

Crystalline silica is the combination of silicon and oxygen, chemically uncombined with any other element, where the atoms are arranged in a repeating 3D crystalline structure. The mineral quartz is the most common form of crystalline silica. This unique mineral has shaped human history since the beginning of civilization and has been used in glass; ceramics (china, porcelain, cookware, floor and wall coverings); fiberglass; water filtration; and to make steel. There are no known substitutes for this mineral.

The International Agency for Research on Cancer (IARC) currently ranks crystalline silica as a Group 1 substance, meaning that "if inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans."

Silicosis

Silicosis is a lung disease resulting from occupational exposure to silica dust. Silicosis causes slowly progressive fibrosis of the lungs, impairment of lung function, and tuberculosis. Crystalline silica of respirable size is primarily quartz dust occurring in industrial and occupational settings in the form of fine, breathable particles.

Intense exposure to silica dust can lead to rapid onset of silicosis. In Gauley Bridge, WV, in the 1930s, 764 workers died within months of exposure while digging the Hawk's Nest tunnel. This incident is widely regarded as the worst silica-related industrial disaster, and it brought silicosis to the nation's attention.

Silicosis can progress even after a person is no longer exposed to the dust, causing severe shortness of breath years later. The more years of exposure to dust, the greater the risk of the disease. Because there is no effective treatment for silicosis, prevention through exposure control is essential. Managing the dust and preventing the inhalation of particles are critical to reducing the risk of silicosis.

Project History

The Unimin Corporation plant in Marston, NC, grinds silica sand to a fine size. Tools and other equipment utilized to maintain this milling operation often become coated with finely ground silica dust. The plant's solution to clean this equipment was to construct a booth where compressed air could safely be used. The booth was constructed to accommodate down-draft ventilation, and the exhaust (containing the dust) was routed directly to the baghouse dust collector. The equipment cleaning system worked so well that the plant safety and health team suggested that the booth be modified so employees could clean their work clothes along with their tools. The intended result of this clothes cleaning process was to further reduce the potential dust exposure to employees in an already very clean facility.

"The Clothes Cleaning Process has been a cooperative research effort with NIOSH that Unimin Corporation has been pleased to be involved with..."

--Andy O'Brien, CSP
UNIMIN Health & Safety

In devising this clothes cleaning method, NIOSH researchers evaluated the effectiveness and time required to perform the existing methods: HEPA-filter vacuuming and a single-nozzle air hose (a method not approved by MSHA). As an alternative, several configurations of an air nozzle manifold were tested both in the laboratory and on-site using crushed limestone dust and coveralls made of cotton and a cotton-polyester blend. All subjects entered the booth wearing a fit-tested ½-face respirator equipped with N100 filters along with eye and ear protection. Respirable dust levels inside the respirators were below the Permissible Exposure Limits and the NIOSH-recommended exposure limits.

Results indicate that the manifold cleaned the clothes 10 times faster and removed approximately 50% more dust than the commonly used single air hose or vacuuming methods. Average cleaning time (inside the booth) was less than 20 seconds.

The Cleaning Process

Booth Dimensions[‡]

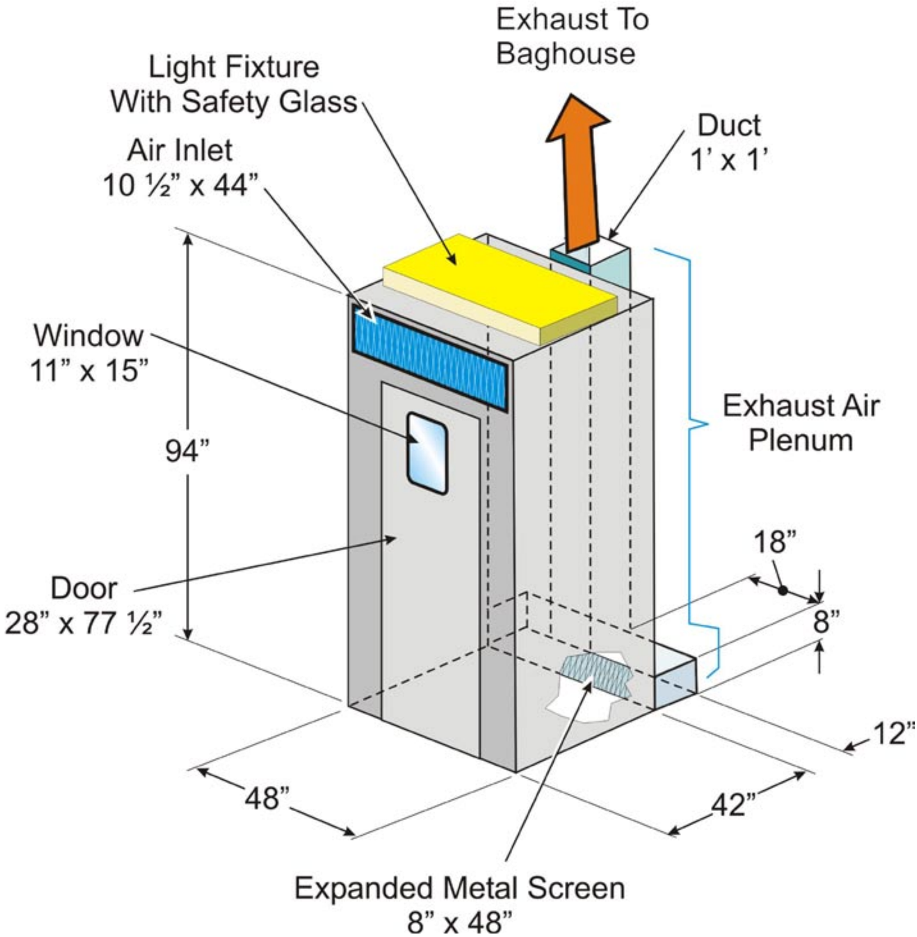

figure 1. Layout and design of booth used in this study.

[‡]*The excess capacity of the baghouse in the Marston plant determined the size of the booth used. For operations with different capacities, a smaller booth may be used thus lowering the cost.*

Air Spray Manifold Design

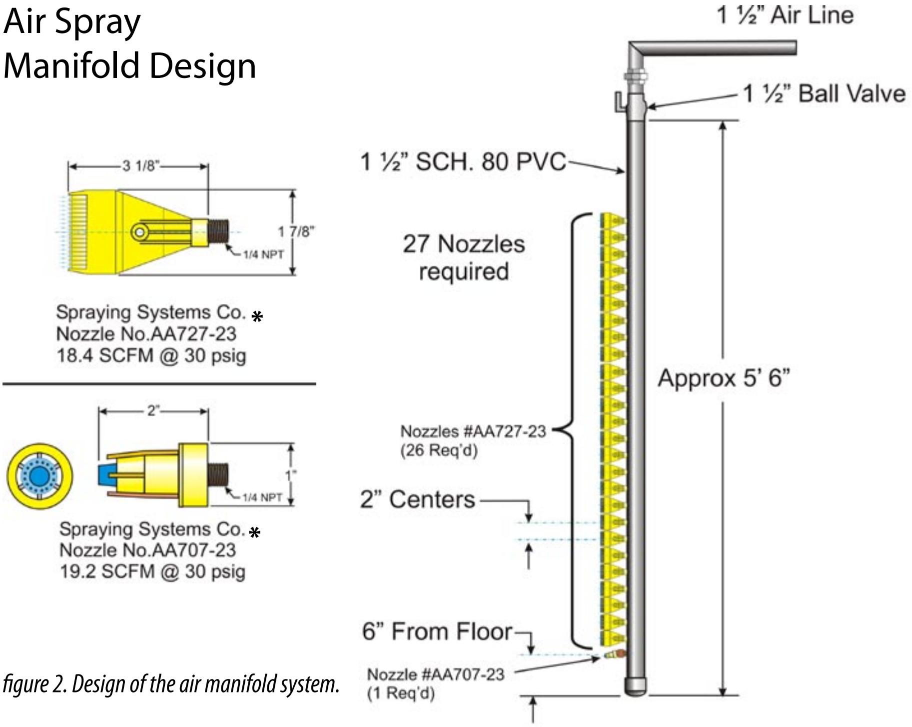

figure 2. Design of the air manifold system.

The air spray manifold consists of a piece of schedule 80 pipe, capped at the base and actuated by a manually controlled ball valve at the top. The first nozzle is located 6-inches from the floor and then spaced 2-inches apart for 27 total nozzles. This manifold was drilled and tapped to ¼" NPT to accept these air nozzles. The spray manifold (figure 2) used for testing was designed for an individual approximately 6 ft. in height.

Each of the top 26 nozzles (flat fan design - No. AA727-23), are $1^{7/8}$-inches in width, which maximizes the effective cleaning width per nozzle. The bottom air nozzle (circular design - No. AA707-23), is mounted with a ball-type fitting and directed downward. During laboratory testing, this circular design was more effective when cleaning at greater distances and thus would be better suited for cleaning the worker's boots.

**Vendor information provided does not imply endorsement or sponsorship by NIOSH or Unimin; it is furnished to provide cost estimates and comparison data.*

It is recommended that a side barrier be installed to protect the air spray nozzles, since the top 26 nozzles extend $3^{1/8}$ inches from the supply pipe and could easily be broken off if struck forcefully. During field testing, 1-inch wood sheeting was used along both sides of the nozzles, providing an effective barrier to minimize the potential for nozzle damage.

Compressed Air Volume Required

At 30 psi, 27 nozzles* expel 125 cubic feet of air from the reservoir tank in less than 20 seconds. The user must ensure that there is adequate pressure from the receiver tank (see table 1).

table 1. AIR RECEIVER CAPACITIES

TANK SIZE (inches)	TANK SIZE (gallons)	GAUGE PRESSURE ON TANK (PSI) 100	150	200
		CUBIC FEET TANK CAPACITY		
24 x 70	120	125	180	234
30 x 84	240	250	360	467

Exhaust Air Volume

The clothes cleaning booth at Unimin's Marston plant measured an exhaust air volume of 4,400 cfm with a negative static pressure of 0.16-inch w.g. in a booth with a volume of 110 cubic feet. It must be noted that while this facility had an excess exhaust air volume available in its baghouse collector, most operations will not have this luxury.

The volume delivered by the 27 nozzles must be added to the volume of the booth when calculating the required exhaust volume. Further, the exhaust volume must be sufficient to maintain the booth's

** 26 Flat fan nozzles (Spraying Systems #AA727-23) and 1 Circular nozzle (Spraying Systems #AA707-23)*

Reservoir

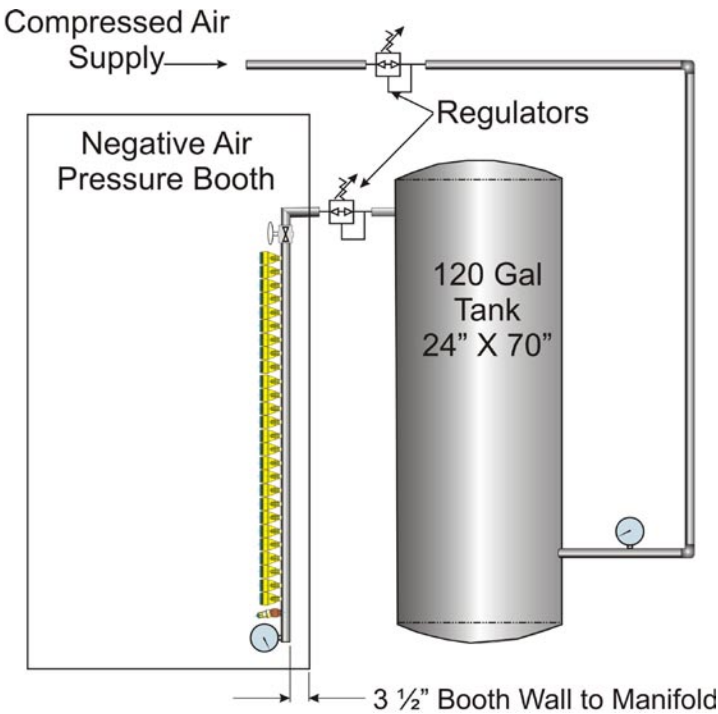

figure 3. The air flows from the plant's compressed air supply to the reservoir, and from there to the manifold.

negative pressure during the operation of the air nozzle manifold, providing a fresh air exchange rate that prohibits leakage into the surrounding work environment. NIOSH plans further testing to determine the minimum exhaust volume necessary for an effective clothes cleaning process.

table 2. Calculations

VOLUME OF AIR DELIVERED BY THE AIR NOZZLES
FLAT FAN NOZZLES: 26 nozzles X 18.4 cfm/nozzle = 478.4 cfm CIRCULAR NOZZLE: 1 nozzle X 19.2 cfm/nozzle = 19.2 cfm
TOTAL: (478.4 cfm + 19.2 cfm) X 1 min./60-sec X 15-second cleaning time = 125 cubic feet of air

Original Design

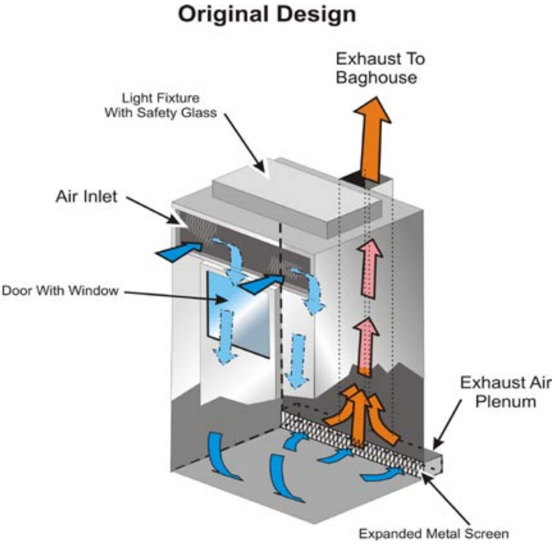

figure 4. The original design with airflow indicated. Air enters above the door and exits at the floor on the opposite side.

Design Problems:

- Air intake may create eddy currents (a deflector could be tried as a way to minimize these eddies)
- Air spray manifold and exhaust air flow are not in the same direction

Design Modifications

Modification #1 ➔

- Best airflow pattern - eliminates possible eddy currents in the air
- Eliminates dust residue on floor
- May further reduce dust in breathing zone
- Possibly more expensive because additional support may be required on floor

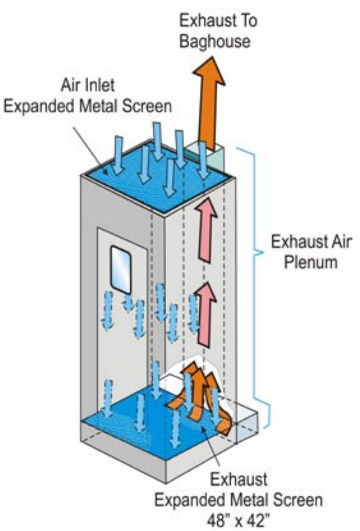

figure 5. The above modification features air intake through a mesh top and air exhaust through a mesh floor and plenum underneath.

Modification #2 ➔

- Air spray manifold and exhaust air flow in same direction
- Eddy currents possible in the air (similar to original design)

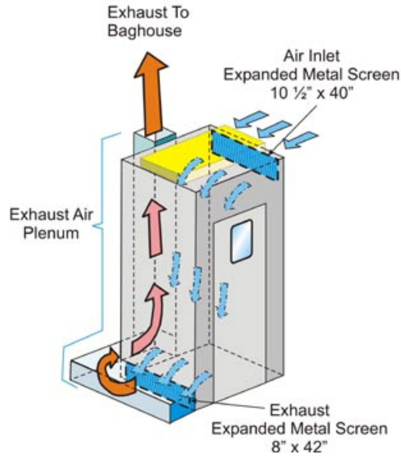

figure 6. Modification #2 features the return vent under the manifold with intake opposite.

Modifications for Worker Height

The air spray manifold was designed for a person 6 ft. in height. Taller workers will have to stoop and drop their shoulders to effectively clean their upper body. When a person is shorter, the top air nozzles can be covered with deflectors to prevent the air sprays from directly hitting the face. During a field test, the top four nozzles were modified with deflectors attached to the side barriers (figure 7) fabricated from a 4" PVC pipe that was cut in half and then into 2"-wide strips. Latches were attached on both sides of these deflectors so they could be locked in either the open or closed position.

figure 7. Shorter worker shown with 2 deflectors closed.

It should be noted that the air spray manifold can be modified to account for height characteristics of workers at individual operations. Additional air nozzles could be added for taller workers; likewise, as many deflectors as necessary could be added to make the system applicable to the shortest individual. If additional air nozzles are added or if an operation anticipates that workers will be using the clothes cleaning process one after another, the larger air receiver tank size of 240 gallons would be required to provide adequate cleaning time.

Care & Maintenance

Regular User Checks

- Examine the valve and nozzles for damage or malfunction.
- Be sure the door is fully closed before opening air valve.

Periodic Maintenance Checklist:

- Check all connections, fittings, valves, and air nozzles for leaks and proper operation.
- Determine that the cleaning booth is at an acceptable negative pressure. This can be achieved by measuring the air velocity or pressure in the exhaust duct or the static pressure in the booth.
- Make sure all air nozzles on the spray manifold are working properly.
- Determine that 30 psi of air pressure is being delivered to the air nozzles.
- Check receiver tank air pressure to determine that an acceptable air pressure is maintained.
- Ensure that air inlet and exhaust metal screen are completely open and free of debris.

Resources & References

Silica and Silicosis sites on the Internet:

NIOSH: http://www.cdc.gov/niosh/topics/silica/default.html

MSHA: http://www.msha.gov/S&HINFO/SILICO/SILICO.HTM

OSHA: http://www.osha.gov/Training/Silicosis.html

WHO: http://www.who.int/inf-fs/en/fact238.html

OK State Univ: http://www.pp.okstate.edu/ehs/training/silicos.htm

National Industrial Sand Association: http://www.sand.org

Videos:

"Stop Silicosis" - MSHA #VC-826
"Silicosis: A Preventable Disease" - MSHA #VC-929

Works Cited:

Background information taken from:
"Crystalline Silica Primer" U.S. Bureau of Mines, 1992. http://geology.usgs.gov/pdf/silica.html; MedicineNet.com; "Hawk's Nest Incident Summary," Ashley Lucas and Ariadne Paxton Cherniack, 1999; "Impact of Background Sources on Dust Exposure of Bag Machine Operator," U.S. Bureau of Mines Information Circular #9089, 1986.

Estimated Costs:

Booth as tested ....$1500-2000‡
27 Nozzles $375
Air Tank.............................$600
1½" Regulator $150
Fittings/pipe/misc. $200

TOTAL................................$2825 - 3325 ‡‡

Possible Booth Vendor*

The S. K. Bowling Company
P.O. Box 8
Wilson, NC 27894
phone: 252.243.2383
fax: 252.237.5289

‡*The excess capacity of the baghouse in the Marston plant determined the size of the booth used. For operations with different capacities, a smaller booth may be used, thus lowering the cost.*

‡‡*This total does not include the cost of the exhaust (baghouse) and duct work.*

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Clothes Cleaning Process Instructions

(as seen on the video)

1. **Don Required Personal Protective Equipment**
   - ☑ ½-Face, fit-tested respirator w/ N100 filter
   - ☑ Hearing protection
   - ☑ Eye protection (full seal goggles required)

2. **Enter booth**

3. **Open valve**

4. **Rotate**

5. **Close valve**

6. **Exit booth clean**

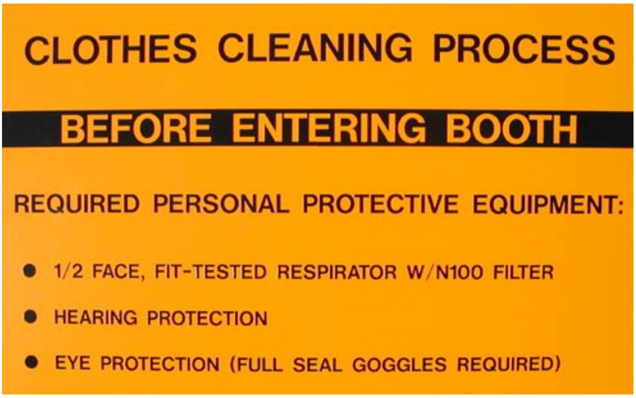

figure 7. Signage used on the door of the booth indicating the personal protective equipment required.

For more information on
the Clothes Cleaning Process contact:

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National Institute for Occupational Safety and Health

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